10R 14

July 7, 1982

SECY-82-288

RULEMAKING ISSUE
(Information)

For: The Commissioners

From: William J. Dircks, Executive Director for Operations

Subject: 10 CFR PART 60--DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITIORIES: TECHNICAL CRITERIA

Category: This paper involves a major policy question.

Purpose: To provide early opportunity to the Commission to review the staff's current recommendations with respect to final amendments to 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," the technical criteria for regulating geologic disposal of high level-radioactive wastes (Enclosure A) and the staff's rationale for the performance objectives of 10 CFR Part 60 (Enclosure C).*

Discussion: In November 1978, the Commission published for comment a proposed General Statement of Policy (43 FR 53869; SECY-78-366) which set forth a regulatory framework for licensing geologic repositories for the disposal of high-level radioactive wastes (HLW). In December 1979, the Commission published for public comment a proposed rule--10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories; Proposed Licensing Procedures" (44 FR 31393; SECY-79-580). This proposed rule addressed the specific procedures under which geologic disposal of HLW by the Department of Energy (DOE) would be regulated. The final licensing procedures were published on February 25, 1981 (46 FR 13971; SECY-80-474 and SECY-81-48).

*This package does not include the final detailed analysis of public comments received and is not the final recommendation of the staff. The final recommendation must await this detailed analysis and associated legal review. Staff expects to forward the complete rulemaking package with its full recommendation to the Commission within a month.

CONTACT:
P. A. Comella 427-4616
M. J. Bell 427-4173

7-1-82

On May 13, 1980 the Commission published for public comment an Advance Notice of Proposed Rulemaking on the technical criteria for regulating geologic disposal of HLW (45 FR31393; SECY-80-177). Proposed technical criteria against which license applications will be reviewed under 10 CFR Part 60 were published for public comment on July 8, 1981 (46 FR 35280; SECY-81-267). A copy of the proposed rule, as published in the Federal Register is provided as Enclosure B. A total of eighty-five groups and individuals commented on the proposed rule. These eighty-five letters contained nearly 700 individual comments. These individual comments addressed a wide range of issues, including those for which specific comment was requested by the Commission, and all parts of the rule.

The staff has completed its preliminary analysis of the public comments received and has formulated, consistent with this analysis, its recommendations with respect to the final technical criteria. These are provided to the Commission in the form of a draft Federal Register Notice (Enclosure A), which contains the draft final regulation and a Statement of Considerations which identifies and discusses the major issues, particularly those of a policy nature, raised in the public comment and indicates how the staff recommends they be resolved. Additionally, the staff has provided its rationale for the final performance objectives related to the geologic repository after permanent closure and to the retrievability option; the draft Final Environmental Impact Assessment, and the draft Final Value/Impact Assessment. The staff will be providing within a month a complete rulemaking package which will also contain the detailed analysis of public comments received as well as the draft Congressional letters, public announcement and final rule in comparative text. Staff will ask the Commission to approve for publication as a final rule that part of 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," dealing with the technical criteria and conforming amendments.

William J. Dircks
Executive Director for Operations

Enclosures: — IN BP
A. Draft Federal Register Notice
B. Copy of Federal Register Notice for proposed 10 CFR Part 60 (46 FR 35280)
C. Draft Final Rationale Document for the Performance Objectives in 10 CFR Part 60
D. Draft Final Environmental Impact Assessment in support of 10 CFR Part 60
E. Draft Final Value/Impact Analysis Statement

DISTRIBUTION:
Commissioners
OGC
OPE
OCA
SECY
ACRS

Pat. of Secy
82-288,
7/7/82

ENCLOSURE A

NUCLEAR REGULATORY COMMISSION

10 CFR Part 60

DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES: TECHNICAL CRITERIA

AGENCY: Nuclear Regulatory Commission.

ACTION: Final Rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is publishing final amendments which specify technical criteria for disposal of high-level radioactive wastes (HLW) in geologic repositories. The criteria address siting, design, and performance of a geologic repository, and the design and performance of the package which contains the waste within the geologic repository. Also included are criteria for monitoring and testing programs, performance confirmation, quality assurance, and personnel training and certification.

EFFECTIVE DATE:

FOR FURTHER INFORMATION CONTACT: Patricia A. Comella, Deputy Director of the Division of Health, Siting and Waste Management, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Telephone (301) 427-4616.

SUPPLEMENTARY INFORMATION:

Background

On February 25, 1981, the Nuclear Regulatory Commission published rules which establish procedures for the licensing of geologic disposal, by the U.S. Department of Energy (DOE), of high-level radioactive wastes (HLW). 46 FR 13971. On July 8, 1981, NRC proposed technical criteria which would be used in the evaluation of license applications under those procedural rules. 46 FR 35280. NRC received 85 comment letters on these proposed technical criteria. The Commission has considered all these comments in preparing the final technical criteria that are published here. The principal comments, and the Commission's responses, are reviewed in the discussion below. A more detailed analysis of the comments is contained in an NRC staff report (NUREG-0806) which is being distributed to all the commenters and which is available without charge on request. This staff report includes a rationale for the performance objectives in 10 CFR Part 60 as well as a comment analysis. The final rules contain a number of changes, explained in this statement, that reflect concerns addressed in the public comments.

The licensing procedures referenced above provide for DOE to submit Site Characterization Reports to NRC prior to characterizing sites that may be suitable for disposal of HLW. NRC will analyze these reports, taking into account public comments, and will make appropriate comments to DOE. Site characterization will include testing at alternative sites.

The licensing process will begin with the submission of a license application with respect to a site that has been characterized. Following hearing, DOE may be issued a construction authorization. Prior to emplacement of HLW, DOE would be required to obtain a license from NRC; an opportunity for hearings is provided prior to issuance of such a license. Permanent closure of the repository and termination of the license would also require licensing action.

The purpose of the technical criteria is to define more clearly the bases upon which licensing determinations will be made and to provide guidance to DOE and information for the public with respect to the Commission's policies in this regard. The criteria also indicate the approach we are taking to implementation of an Environmental Protection Agency standard, particularly with respect to the classification of processes and events as "anticipated" or "unanticipated" and the definition of the "accessible environment" from which radionuclides must be isolated.[1]

The Commission anticipates that licensing decisions will be complicated by the uncertainties that are associated with predicting the behavior of a geologic repository over the thousands of years during which HLW may present hazards to public health and safety. It has chosen to address this difficulty by requiring that a DOE proposal be based upon a multiple barrier approach. An engineered barrier system is required to compensate for uncertainties in predicting the performance of the geologic setting, especially during the period of high radioactivity. Similarly, because the performance of the engineered barrier system is also subject to considerable uncertainty, the geologic setting must be able to contribute significantly to isolation.

The multibarrier approach is implemented in these rules by a number of performance objectives and by more detailed siting and design requirements. In addition to the objective of assuring that licensed facilities

[1]Reorganization Plan No. 3 of 1970 authorizes EPA to establish generally applicable environmental standards for radioactivity. A draft standard developed by EPA would allow higher levels of radioactivity for "unanticipated processes and events" than would be permitted if "anticipated processes and events" were to occur. The draft standard also relates these levels to places within the "accessible environment." We have assumed that these concepts will be reflected in final standards that may be established by EPA.

will adequately isolate HLW over the long term, these provisions also address considerations related to health and safety during the operational period prior to permanent closure of the repository.

In this statement of considerations the Commission will first discuss six issues on which it had specifically requested public comment. It will then review other principal changes to the rule which have been adopted in the light of comments received. The discussion will then take up suggestions of a policy nature which the Commission has declined to adopt. Finally, a section-by-section analysis reviews all changes made other than those of a strictly editorial nature.

Issues Raised by the Commission

As noted above, the Commission specifically requested public comment on six issues, each of which will be reviewed here before turning to other considerations. These issues dealt with: (1) a single overall performance standard vs. minimum performance standards for each of the major elements of the geologic repository; (2) the need for, and appropriate duration of, a waste retrievability period; (3) the level of detail to be used in the criteria, particularly with respect to design and construction requirements; (4) the desirability of population-related siting criteria; (5) the application of an ALARA (as low as reasonably achievable) principle to the performance requirements dealing with containment and control of releases; and (6) alternative approaches on dealing with possibilities of human intrusion into the repository.

Single vs. Multiple Performance Standards

The Commission identified two potentially viable approaches to assuring achievement of the desired isolation goal of keeping releases so as to assure that radioactivity in the general environment is kept to sufficiently low levels. We suggested that a course that would be "reasonable and practical" would be to prescribe minimum performance standards for each of the major elements of the geologic repository, in addition to prescribing the EPA standard as a single overall performance standard. However, as an alternative, we invited comment on an approach that would specify the EPA standard as the sole measure of isolation performance.

There was general acceptance of the Commission's multiple barrier approach, with its identification of two major engineered barriers (waste packages and underground facility), in addition to the natural barrier provided by the geologic setting.

While the usefulness of multiple barriers was recognized, the establishment of fixed numerical values for performance was extensively criticized. The criticism took two forms. First, numerous commenters argued that until such time as an EPA standard is established, no logical connection can be demonstrated between the performance of the particular barriers and the overall system performance objective. The values specified by NRC, it was argued, had not been shown to be either necessary or sufficient to meet any particular standard. The second criticism was that the performance appropriate to a particular barrier is greatly dependent upon design features and site characteristics and that values such as those proposed by the Commission could unduly restrict the applicant's flexibility - possibly imposing great additional expense without compensating protection of public health and safety.

The Commission recognizes the force of both these arguments. Nevertheless, if we were simply to adopt the EPA standard as the sole measure of performance, we would have failed to convey in any meaningful way the degree of confidence which we expect must be achieved in order for us to able to make the required licensing decisions. We should do more. To that end, we consider it appropriate to include reasonable generic requirements that, if satisfied, will ordinarily contribute to meeting the standards even though exceptions may need to be made for some designs and locations.

Our response has been to apply, for illustrative purposes, an assumed EPA standard and to examine the values for particular barriers that would assist in arriving at the conclusion that the EPA standard has been satisfied. (We have used, for this purpose, a draft EPA standard which was referred to in some of the comments. A copy of this draft standard has been placed in the PDR. The analysis is contained in NUREG-0806.) In this way, we have been able to demonstrate the logical connection which we make between the overall system performance objective for anticipated processes and events and the performance of specific barriers. One of the considerations that affects our judgment in this regard is the need to take proper account of uncertainties in the performance of any of the barriers. Our task is not only a mathematical one of modeling a system and fitting values for particular barriers into the model in order to arrive at a "bottom line" of overall system performance. We are also concerned that our final judgments be made with a high degree of confidence. Where it is practical to do so, we can and will expect barrier performance to be enhanced so as to provide us with greater confidence in our licensing judgments. Accordingly, a variance between actual and assumed EPA standards will not necessarily require a change of corresponding magnitude in the individual barrier performance requirements.

While use of an assumed EPA standard provides a basis for specifying anticipated performance requirements for individual barriers, it does not deal with the concern about undue restriction upon the applicant's flexibility. Our response to this has not been to abandon the values altogether, but rather to allow them to be modified as the particular case warrants. We thus require the applicant to comply with the specified values or such other values as the Commission "may approve or specify." Among the factors that the Commission might take into account in exercising this discretion are the radiation and heat generation rate of the waste, the characteristics of the host rock, and particular sources of uncertainty in predicting the performance of the geologic repository. Any variance between an actual EPA standard and that assumed could also be a basis for approving or specifying other values for radionuclide release rate, designed containment period, or pre-waste-emplacement ground water travel time.

The numerical criteria for the individual barriers included in the rule are appropriate, insofar as anticipated processes and events are concerned, in assisting us to determine with reasonable assurance that the EPA standard has been satisfied. It should be noted, however, that considerations related to unanticipated processes and events could form the basis for requiring even higher levels of individual barrier performance than would otherwise be the case.

Retrievability

The purpose of this requirement was to implement in a practical manner the licensing procedures which provided for temporal separation of the emplacement decision from the permanent closure decision. Since the period of emplacement would be lengthy and since the knowledge of expected repository performance could be substantially increased through a carefully planned program of testing, the Commission wished to base its decision to permanently close on such information. The only way it could envision this was to insist that ability to retrieve - retrievability - be incorporated into the design of the repository.

The proposed rule would have required in effect that the repository design be such as to permit retrieval of waste packages for a period of up to 110 years (30 years for emplacement, 50 years to confirm performance, 30 years to retrieve). The Commission solicited comment, noting that we would not want to approve construction of a design that would unnecessarily foreclose options for future decisionmakers, but that we were concerned that retrievability requirements not unnecessarily complicate or dominate repository design.

While the benefits of retaining the option of retrieval were recognized, the length of the proposed requirement, in the opinion of several commenters, was excessive. In their view, the Commission had given inadequate consideration to the additional costs of design, construction, and operations implied in the original proposal; however, no new cost or design information was presented.

The Commission adheres to its former position that retrievability is an important design consideration. However, in response to the concerns expressed, we have decided to rephrase the requirement in functional terms, rather than in the inflexible way it was originally presented. The final rule thus specifies that the design shall keep open the option of waste retrieval throughout the period during which the wastes are being emplaced and, thereafter, until the completion of a performance confirmation program and Commission review of the information obtained from such a program. While we have provisionally specified that the design should allow retrieval to be undertaken at any time within 50 years after commencement of emplacement operations, this feature is explicitly subject to modification in the light of the planned emplacement schedule and confirmation program for the particular repository.

We have also included a specific provision clarifying our prior intention that the retrievability design feature do not preclude decisions allowing earlier backfilling or permanent closure. A related clarifying change has been the incorporation of a definition of "retrieval." This definition indicates that the requirement of retrievability does not imply ready access to emplaced wastes at all times prior to permanent closure.

We have thus retained the essential elements of the retrievability design feature, but have provided greater flexibility in its application.

Level of Detail

The proposed rule contained general and detailed prescriptive requirements, derived from Commission experience and practice in licensing other facilities, with respect to the design and construction of a repository. We noted, however, that we were continuing to examine other possibilities for promulgating the more detailed of these requirements and we invited comments on the topic.

The public response included arguments addressed both to the level of detail generally and to specific criteria which were deemed to be unduly restrictive.

We have concluded that there is merit in describing, in functional terms, the principal features which should be incorporated into repository design - such as protection against dynamic effects of equipment failure, protection against fire and explosions, emergency capability, etc. Certain of these proposed criteria, however, such as those dealing with subsurface ventilation and shaft and borehole seals, were excessively detailed and, in some cases, inappropriate. At this stage of development, we believe we should place emphasis upon the objectives that must be met and not become unduly concerned about the detailed ways that may be used in doing so. We address the changes that have been made in some detail in the section-by-section analysis of the rule.

Population-Related Siting Criteria

The proposed rule did not include any siting requirements which dealt directly with population density or proximity of population centers to a geologic repository operations area. We indicated our belief that a more realistic approach, given the long period of time involved, would be to address the issue indirectly through consideration of resources in the geologic setting.

The numerous comments submitted in response to our specific question on this issue fell generally into two categories - those who endorsed the proposed approach and those who believed that population factors were important. The latter group addressed not only the repository's long-term isolation capability, but also the relevance of population considerations in connection with the period when wastes are being received and emplaced. We are persuaded that population factors may need to be considered in connection with the period when wastes are being received and emplaced through evaluation of the adequacy of DOE's emergency plans. That section of the Safety Analysis Report dealing with emergency planning (see 60.21(c)(9) will be reviewed on a case-by-case basis in the licensing process according to criteria that will be set forth in the future in Subpart I. The Commission invites comments on the appropriate content of this subpart. Attention is called to the analogous provisions of 10 CFR Part 50, Appendix E and 10 CFR Part 72.

Population distribution over the long term is immaterial if the geologic repository operates as anticipated. Demographic factors could nevertheless be of concern to the extent that they could increase the probability or the consequences of releases associated with unanticipated processes or events. As to probability, it is difficult to relate the likelihood of releases to population factors; we think it is more realistic, as we originally stated, to reduce the probability by avoiding sites with significant resource potential and by using records and monuments to caution future generations. Consequences of unanticipated releases would be greater if they should occur in densely populated areas. Nevertheless, we think that it makes little sense to attempt to limit such consequences by means of a population-related siting criterion, since long-range demographic forecasts are so inherently speculative and unreliable; instead, we are taking the approach that releases that result from the occurrence of unanticipated processes and events must be evaluated and must satisfy the EPA standard which we expect will be very conservative.

Although demographic factors thus play a very limited role in the final rule, we nevertheless anticipate that the selection of a densely populated area is unlikely. DOE will need to acquire interests in land within the controlled area and may have to have additional powers beyond the boundaries of the controlled area. These requirements may be difficult to satisfy unless a remote location is selected for the repository.

ALARA

The notice of proposed rulemaking requested comment on "whether an ALARA (as low as reasonably achievable) principle should be applied to the performance requirements dealing with containment and control of releases." Some commenters felt that ALARA should be applied to all licensed activities, and that no exception should be made for geologic repositories. Other commenters argued against incorporating ALARA, since the allowable releases under the EPA standard would already be so low as to eliminate any significant risk to public health and safety.

Although we cannot predict with certainty the form that an EPA standard may take, we do anticipate that the permissible amounts of radioactivity in the general environment will be established at such a low level that efforts to reduce releases further would have little, if any, demonstrable value. Accordingly, the ability of a repository to perform at levels superior to the EPA standard should not be the issue in licensing proceedings. The central issue with respect to the EPA standard is whether DOE's proposal, and the data presented in its support, will enable the Commission to determine with reasonable assurance that the established EPA standard will be met. We may insist upon the adoption of a variety of design features, tests, or other measures in order to be able to conclude with confidence that the EPA standard is met. The result may be the same as if we were to impose similar requirements in the name of keeping releases as low as reasonably achievable. But when we find that certain measures are needed to improve our confidence in dealing with uncertainties, we are making a substantial safety judgment.

The same kinds of balancing that are undertaken in ALARA determinations may be appropriate. That is, if conference in the performance of the repository is sensitive to a particular source of uncertainty, it will be in order for the Commission to take into account both the significance of the factor involved and the costs of reducing or eliminating it.

In short, we have concluded that the long-term performance requirements should not be tied to an ALARA principle, and the rule remains as it was when proposed. We believe the concerns of the commenters in support of the ALARA approach will be largely accommodated in connection with our treatment of uncertainties in the course of the licensing process.

Human Intrusion

The Commission observed, in the preamble of the proposed rule, that everything that is reasonable should be done to discourage people from intruding into the repository. Those measures which we felt to be reasonable included directing site selection toward sites having little resource value and marking and documentation of the site. Beyond that, we felt there would be no value in speculating on the "virtual infinity of human intrusion scenarios and whether they will or will not result in violation of the EPA standard." We explained that inadvertent intrusion was highly improbable, at least for the first several hundred years during which time the wastes are most hazardous; and even if it should occur, it is logical to assume that the intruding society would have capability to assess the situation and mitigate consequences. We recognized that deliberate intrusion to recover the resource potential of the wastes could result in elevated releases of radioactivity, but concluded that the acceptability of such releases was properly left to those making the decision to undertake resource recovery operations. We noted that comment on our proposal and alternative approaches would be welcome.

Commenters generally accepted the approach outlined. A number of commenters did emphasize the importance of intrusion scenarios as having the potential to lead to releases of radionuclides to the environment, but they suggested no alternative means for dealing with the prospect. One commenter correctly calls attention to the possibility of a third category of intrusion - that which is "intentional yet indifferent" - which was not covered in our discussion of "inadvertent" or "deliberate" intrusion. This behavior presupposes knowledge (albeit imperfect) of the existence and nature of the repository and a level of technology that could be applied to remedial action as well as to the intrusion itself. We have addressed this and other concerns in the revised language that is being adopted.

Although our discussion accompanying the proposed rule indicated that intrusion scenarios need not be considered, the rule itself was not explicit on this point. We consider it necessary to clarify our position and, in doing so, we do allow for examination of intrusion under appropriate bounding conditions. Our objective is to provide a means for evaluating events that are reasonably of concern, while at the same time excluding speculative scenarios that are inherently implausible. We will not require this generation to design for fanciful events which we have an abiding conviction will never occur; on the contrary, we will grant a license if we are satisfied that the risk to the health and safety of future generations is not unreasonable.

The rule now incorporates a definition of "unanticipated processes and events" which are reviewable in a licensing proceeding; such processes and events expressly include intrusion scenarios that have a sufficiently high likelihood and potential adverse consequence to exceed the threshold for review. The scenarios must be "sufficiently credible to warrant consideration." We are requiring that certain assumptions be made in assessing this likelihood. First, the monuments required by the rule are assumed to be sufficiently permanent to serve their intended purpose. We take this position because of our confidence that monuments can be built to survive. While we assume that the monuments will last, we do not automatically assume that their significance will continue to be understood, although we expect that monuments can be designed to be readily decipherable. Second, we require an assumption that the value to future generations of potential resources can be assessed adequately at this time. Consistent with our previously-stated views, we think that the selection of a site with no foreseeably valuable resources could so reduce the likelihood of intrusion as to reduce, or eliminate, any further need for it to be considered. Third, we require the assumption that some functioning institutions - though not necessarily those undertaking the intrusion - understand the nature of radioactivity and appreciate its hazards. The extent of intergenerational transfer of knowledge is, of course, debatable; it is conservative, in the light of human history to date, to predict this minimal level of information and to take it into account in assessing the likelihood that intrusion will occur.

Fourth, we provide that relevant records are preserved, and remain accessible, for several hundred years after permanent closure. While perhaps this period could not be justified on the basis of historic precedents alone, we consider the required deposit in land records and archives, together with current data handling technology, to provide a sufficient basis for assuming that information about the repository will continue to be available for several hundred years.

The definition of "unanticipated processes and events" also implicitly bounds the consequences of intrusion scenarios. This is accomplished not only by the assumption of continued understanding of radioactivity and survival of records, but also by the further assumptions that if there are institutions that can cause intrusion at depth in the first place, there will also be institutions able to assess the risk and take remedial action. It need not be assumed that today's technology would be used - merely that a level of social organization and technological competence equivalent to that applied in initiating the processes or events concerned would be available to deal with the situation.

In summary, we have retained the principle that highly speculative intrusion scenarios should not be allowed to become the driving force in license reviews, but we have introduced some flexibility to permit consideration of intrusion on a case-by-case basis where circumstances warrant.

Other Principal Changes

Anticipated/Unanticipated Processes and Events

The proposed rule defined anticipated processes and events as "those natural processes and events that are reasonably likely to occur during the period the intended performance objective must be achieved and from which the design bases for the engineered system are derived." At the same time, we were requiring that the facility be designed so as to assure that long-term releases conform to standards established by EPA. The statement of considerations pointed out that if the process or event is unlikely, the overall system must still limit the release consistent with the EPA standard as applied to such events. This created a contradiction because on the one hand it was stated that the design bases should be derived from anticipated processes and events while, on the other hand, the design was to meet an EPA standard as applied to what was unanticipated.

We have resolved this conflict by eliminating the reference to design bases from the definition of "anticipated processes and events." We have also included a definition of "unanticipated processes and events."

It should be noted that the distinction between anticipated and unanticipated processes and events relates solely to processes and events affecting the geologic setting. We intend that a judgment whether a natural process or event is anticipated or unanticipated be based upon a careful review of the geologic record. Such processes or events would not be anticipated unless they were reasonably likely, assuming that processes operating in the geologic setting during the Quaternary Period were to continue to operate but with the perturbations caused by the presence of emplaced waste superimposed thereon. Unanticipated processes and events would include those that are judged not to be reasonably likely to occur during the period the intended performance objective must be achieved, but which nevertheless are sufficiently credible to warrant consideration. These include processes and events which are not evidenced during the Quaternary Period or which, though evidenced during the Quaternary, are not likely to occur during the relevant time frame. Identification of unanticipated processes and events for a particular site will require considerable judgment and may not be subject to quantification of probabilities of such events.

Because the design basis for the engineered barrier system will be derived from the identification of anticipated and unanticipated processes and events, such identification will have a pervasive effect on the basic structure of the licensing proceedings. We therefore contemplate directing that rulings made in the course of construction authorization hearings on the scope of anticipated and unanticipated processes and events be certified to the Commission for interlocutory review, pursuant to 10 CFR 2.718(i).

The license review will thus need to include a determination whether the proposed activities will meet the EPA standard as applied to anticipated processes and events and as applied to such unanticipated processes and events, if any, as have been found to warrant consideration. Each determination will be made in the light of assessments which will involve interpretation of the geologic record and consideration of credible human-induced events as bounded by the assumptions set forth above. Complex quantitative models will need to be employed, these to be of sufficient sophistication to take into consideration a wide range of factors that may be event or process oriented. One result of the performance assessment, in simplified terms, will be the development of probability density functions for the consequences of the proposed activities that will be considered in arriving at a determination of whether there is reasonable assurance, making allowance for the time period and hazards involved, that the outcome will be in conformance with the EPA standard. There are two principal elements that will go into our application of this "reasonable assurance" concept. First, the performance assessment which has been performed must indicate that the likelihood of exceeding the EPA standard is low. Second, we must be satisfied that the performance assessment is sufficiently conservative, and its limitations are sufficiently well understood, that the actual performance of the geological repository will be within predicted limits.

Transuranic waste (TRU). The proposed rule included a definition of transuranic waste and performance objectives that would apply to the disposal of TRU in a licensed geologic repository. This was widely misconstrued as a requirement that radioactive material conforming to the definition must be disposed of in this manner. This was not the intention, nor in fact did the rule so specify. Rather, the Commission was merely indicating what performances objectives would apply *if* TRU were disposed of in a licensed geologic repository. Some commenters also took exception to the definition of TRU in the rule.

Whether or not a geologic repository is subject to licensing depends upon the applicability of Sections 202(3) and 202(4) of the Energy Reorganization Act of 1974. (See definition of "HLW facility.") If a facility is licensed, then the Commission must consider the radiological hazards associated with whatever wastes may be emplaced. We attempted, in the proposed rule, to address the requirements for one such kind of waste - TRU. But we were too restrictive, in that our definition of TRU was too limited for present purposes and in that wastes other than HLW and TRU were not covered at all. For the time being, we have concluded that the matter is best handled by eliminating all references to TRU. The remaining performance objectives provide adequate guidance to deal with TRU-related issues that may arise.

We have also reviewed the waste package requirements, which as originally written would have applied to all emplaced radioactive waste. It is appropriate to include such requirements for HLW, which must necessarily be disposed of in a licensed facility. Since we do not know what other radioactive wastes, if any, will also be emplaced, and what their chemical, radiological, thermal, and other characteristics may be, we have decided to leave pertinent requirements to be determined on a case-by-case basis as the need arises.

Unsaturated zone. The Commission had explained that the proposed criteria were developed for disposal in saturated media, and that additional or alternative criteria might need to be developed for regulating disposal in the unsaturated zone. Accordingly, the performance objective for containment of HLW was written so as to require the assumption of full or partial saturation of the underground facility and the favorable and potentially adverse conditions concerned only siting in the saturated zone.

This approach was criticized on the basis that disposal in the unsaturated zone was a viable alternative, and that since the criteria were generally applicable without regard to the possibility of saturation, their scope and applicability should not be unduly restricted. We have reviewed the criteria in the light of the comments and find this criticism to be well-founded. The criteria as written are generally appropriate to disposal in both the saturated zone and the unsaturated zone. For disposal in the saturated zone, however, we will continue to require that performance of the geologic setting be evaluated on the assumptions of both the partial and complete filling with ground water of available void spaces in the underground facility. We have also identified conditions operating in the geologic setting so as to differentiate appropriately between saturated and unsaturated zone environments.

Terminology - Several commenters criticized, as vague or confusing, the terms used by the Commission to describe the various geographical locations that are addressed by the rule. There are many such locations --and there must be, because we must deal with different concerns during site characterization, during operations, and after permanent closure. We have nevertheless attempted to clarify the terms. In addition to the significant changes reviewed here, minor revisions are addressed in the section-by-section analysis.

Accessible Environment/Controlled Area. The isolation capability of a geologic repository is evaluated at a boundary which we have referred to as the "accessible environment." Under the proposed rule, this was defined as "portions of the environment directly in contact with or readily available for use by human beings." Several commenters criticized this definition as being excessively vague; further, the definition failed to assure that the isolation capability of the rock surrounding the underground facility would be given appropriate weight in licensing reviews.

We agree with the criticism and have revised the definition in several respects -- but most importantly, by excluding from the accessible environment that portion of the lithosphere that is inside what we are calling, in the final rule, a "controlled area." This is an area marked with monuments designed to caution future generations against subsurface penetrations. The size and shape of the controlled area will depend upon the characteristics of the particular facility, but it must be small enough to justify confidence that the monuments will effectively discourage subsurface disturbances. We have therefore limited the size of the controlled area so that it extends no more than 10 kilometers from the emplaced waste. This is consistent with a draft standard that is under consideration by EPA. That draft standard is also the source of the language specifying the surface locations that are part of the accessible environment.

Geologic Setting. The proposed rule limited this term to systems that provide isolation of the waste. This is too restrictive a definition to cover the wider region of interest which we seek to encompass by "geologic setting." The definition has accordingly been extended to include the geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located.

Site. "Site" had been defined in the proposed rule as being equivalent to "geologic setting." This was appropriate where geologic setting referred to an area having isolation capability. In the final rule, isolation is to be provided within a controlled area rather than within the geologic setting and accordingly "site" now refers to the location of this controlled area.

<u>Decommissioning</u> - As used in the proposed technical criteria, the term "decommissioning" was intended to apply to that stage at which the underground facility was closed and shafts and boreholes were sealed. It was these activities that were addressed in § 60.51, "License amendment to decommission." This intention is better expressed by employing the term "permanent closure." Several commenters on the proposed rule expressed the opinion that including the requirement for dismantlement of all surface facilities in the definition of the term decommissioning may be unnecessary and overly restrictive. Upon consideration of these comments the Commission believes that where there is a need to refer to decontamination or dismantlement of surface facilities, this can readily be done without referring to "decommissioning."

Accordingly, all references to "decommissioning" have been deleted from the rule, and the language now refers to "permanent closure" or to "decontamination or dismantlement of surface facilities," as appropriate.

<u>Important to Safety</u>: The term "important to safety" has traditionally been linked to structures, systems, and components which must operate under accide conditions in a manner that will prevent serious offsite consequences. The proposed rule inappropriately referred to structures, systems, and components which must operate to meet the performance objectives--including those pertaining to long-term isolation under anticipated conditions--as being "important to safety." The effect of this was to extend accident-related design criteria to elements not subject

to relevant kinds of accidents. Design criteria related to isolation are important, and are included, but not because the structures, systems, and components in question are "important to safety" in the traditional sense.

In order to provide further clarificaton, we have included a specific value (an offsite dose of 0.5 rem) to be used in considering whether a structure, system, or component is important to safety. The choice of this value should not be construed as implying that it would be appropriate as applied to any other types of activities subject to regulation by the Commission. (Compare 10 CFR § 72.68, which provides for establishment of a controlled area for each independent spent fuel storage installation such that no "individual beyond the boundary would receive a dose greater than 5 rem from any design basis accident.)

"Important to safety"is also important in defining the actions that are necessary elements of a quality assurance program. For a geologic repository, however, quality assurance must be extended to structures, systems, and components important to radionuclide containment and isolation. Since, for the reasons discussed above, these concerns are no longer encompassed by the term "important to safety," the quality assurance provisions have been amended to apply to structures, systems, and components "important to radionuclide containment and isolation" as well.

<u>Other Principal Comments</u>

These issues raised by commenters merit discussion here even though they have resulted in no change to the rule.

Comparative Safety Analyses

Several commenters took exception to the proposed requirement that the Safety Analysis Report include a comparative evaluation of alternatives to the major design features that are important to radionuclide containment and isolation, on the ground that a safety analysis should be directed at the specific design being proposed. As a general principle, the commenters are correct. In the context of licensing activities at a geologic repository operations area, however, we think it is well within our discretion to seek the requested information. If we find, on the basis of our review, that the adoption of some alternative design feature would significantly increase our confidence that the performance objectives would be satisfied, and that the costs of such an approach are commensurate with the benefits, we should not hesitate to insist that the alternative be so adopted. This is consistent with the views expressed above in the discussion of the ALARA principle and, also, with the provisions of the revised performance objectives which contemplate that the performance objectives for particular barriers are subject to modification, on a case-by-case basis, as needed to satisfy applicable EPA standards.

Geological Siting Criteria

One commenter recommended that the rule should require that the slate of sites characterized by DOE be among the best that can be found on the basis of geological factors alone. We did indicate, when we adopted licensing procedures, that the site characterization requirements will assure that DOE's preferred site will be chosen from a slate of sites that are among the best that reasonably could be found. The two standards are quite different. We intended that DOE should be able to take into account a variety of non-geological considerations in its screening process. It could properly exclude such locations as (1) areas, such as national parks and wilderness, devoted to other paramount uses, (2) locations which would be subject to unusually severe environmental and socioeconomic impacts, and (3) locations where necessary surface, mineral, and water rights may be obtainable only at great expense and with severe dislocating effects on residents. We consider the rule, as written, properly conveys our meaning on this score.

The same commenter urged us to require a demonstration that the geologic characteristics of the chosen site provide the highest reasonably achievable degree of enhancement of the waste isolation capabilities of the repository. Again, we decline to accept the suggestion. In the first place, we anticipate that DOE would on its own initiative strive to maximize isolation capabilities in order to demonstrate more conclusively the facility's compliance with the performance objectives and other technical criteria. Beyond this, however, we believe the proposal could have undesirable and unintended consequences. Maximizing isolation capabilities could dictate development at one particular location instead of at another a few miles away; this could result in the same kind of adverse environmental or other effects as were described above. Furthermore, adherence to the proposed standard could unduly interfere with, or increase the cost of, achievement of other goals, such as maintenance of retrievability, providing for worker safety, etc.

The Commission is in full agreement with the underlying appraisal of the commenter that the isolation capabilities of the geologic repository play a key role in assuring that the performance objectives will be met. However, we do not believe that it is necessary or appropriate to place the degree of emphasis upon them which has been suggested.

Reasonable Assurance:

The proposed rule stated that with respect to the long-term objectives and criteria under consideration, "what is required is reasonable assurance, making allowable for the time period and hazards involved, that the outcome will be in conformance with those objectives and criteria." A number of commenters took exception to this formulation on the ground that it provides inadequate guidance as to the required level of proof. Others were concerned that "reasonable assurance" was too weak a test and that the Commission should not license DOE activities without a "high degree of confidence" that releases would be very small. Some commenters suggested that a statistical definition of acceptability should be employed.

We have not modified the language, but we have explained elsewhere (see Anticipated/Unanticipated Processes and Events, above) how the concept will be applied. We do expect that the information considered in a licensing proceeding will include probability distribution functions for the consequences from anticipated and unanticipated processes and events. Even if the calculated probability of meeting our standards is very high according to accepted statistical tests, that would not be sufficient for the Commission to have "reasonable assurance;" we would still have to assess uncertainties associated with the models and data that had been considered. This involves qualitative as well as quantitative assessments. We would not issue a license unless we were to conclude, after such assessments, that there is reasonable assurance that the outcome will in fact conform to the relevant standards and criteria.

The term "reasonable assurance" implies no lack of conservatism. On the contrary, it parallels language which we have applied in other contexts, such as the licensing of nuclear reactors. See 10 CFR 50.40(a). Should we select a different expression, we would need to explain the distinction between the adopted term (such as "high degree of confidence") and "reasonable assurance." Since we intend no such distinction, we prefer to retain the term "reasonable assurance."

Section-by-Section Analysis

[reserved]

PAPERWORK REDUCTION ACT

The applicantion/reporting/recordkeeping requirements contained in this Regulation affect fewer than 10 persons, and therefore, are not subject to Office of Management and Budget clearance as required by the Paperwork Reduction Act (P.L. 96-511).

REGULATORY FLEXIBILITY ACT CERTIFICATION

The Commission certifies that the final rule will not have a significant economic impaction a substantial number of small entities. The final rule does not apply to any small entities, and although units of local government could be affected by application of the rule in a specific regulatory licensing decision. The number of local governments affected would not be substantial due to the limited number of repositories scheduled for development.

10 CFR PART 60 - DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES

1. The authority citation for Part 60 is revised to read as follows: Authority: Secs. 51, 53, 62, 63, 65, 81, 161, 182, 183, 68 Stat. 929, 930, 932, 933, 935, 948, 953, 954, as amended (42 U.S.C. 2071, 2073, 2092, 2093, 2095, 2111, 2201, 2232, 2233); secs. 202, 206, 88 Stat. 1244, 1246 (42 U.S.C. 5842, 5846); sec. 14, Pub. L. 95-601, 92 Stat. 2591 (42 U.S.C. 2021a); sec. 102, Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332).

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273), §§ 60.71-60.75 are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

2. Section 60.2 is revised to read as follows:

§ 60.2 Definitions.

As used in this part--

a. "Accessible environment" means (1) the atmosphere, (2) the land surface, (3) surface water, (4) oceans, and (5) the portion of the lithosphere that is outside the controlled area.

"Anticipated processes and events" means those natural processes and events that are reasonably likely to occur during the period the intended performance objective must be achieved. To the extent reasonable in the light of the geologic record, it shall be assumed that those processes operating in the geologic setting during the Quaternary Period continue to operate but with the perturbations caused by the presence of emplaced radioactive waste superimposed thereon.

"Barrier" means any material or structure that prevents or substantially delays movement of water or radionuclides.

"Candidate area" means a geologic and hydrologic system within which one or more sites may be considered for site characterization.

"Capillary fringe" means the zone immediately above the water table in which all or some of the interstices are filled with water that is under less than atmospheric pressure and that is continuous with water below the water table.

"Commencement of construction" means clearing of land, surface or subsurface excavation, or other substantial action that would adversely affect the environment of a site, but does not include changes desirable for the temporary use of the land for public recreational uses, site characterization activities, other preconstruction monitoring and investigation necessary to establish background information related to the suitability of a site or to the protection of environmental values, or procurement or manufacture of components of the geologic repository operations area.

"Commission" means the Nuclear Regulatory Commission or its duly authorized representatives.

"Containment" means the confinement of radioactive waste within a designated boundary.

"Controlled area" means a surface location, to be marked by suitable monuments extending horizontally no more than 10 kilometers in any direction from the underground facility, and the underlying subsurface, which area has been committed to use as a geologic repository and from which incompatible activities would be restricted following permanent closure.

"Director" means the Director of the Nuclear Regulatory Commission's Office of Nuclear Material Safety and Safeguards.

"Disposal" means the isolation of radioactive wastes from the accessible environment.

"Disturbed zone" means that portion of the controlled area whose physical or chemical properties have changed as a result of underground facility construction or from heat generated by the emplaced radioactive wastes such that the resultant change of properties may have a significant effect on the performance of the geologic repository.

"DOE" mear the U.S. Department of Energy or its duly authorized representatives.

"Engineered barrier system" means the waste packages and the underground facility.

"Floodplain" means the lowland and relatively flat areas adjoining inland and coastal waters including flood prone areas of offshore islands and including at a minimum that area subject to a one percent or greater chance of flooding in any given year.

"Geologic repository" means a system for the disposal of radioactive wastes in excavated geologic media. A geologic repository includes (1) the geologic repository operations area, and (2) the portion of the geologic setting that provides isolation of the radioactive waste.

"Geologic repository operations area" means a high-level radioactive waste facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted.

"Geologic setting" means the geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located.

"High-level radioactive waste" or "HLW" means (1) irradiated reactor fuel, (2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted.

"HLW facility" means a facility subject to the licensing and related regulatory authority of the Commission pursuant to Sections 202(3) and 202(4) of the Energy Reorganization Act of 1974 (88 Stat 1244).[1]

"Host rock" means the geologic medium in which the waste is emplaced.

"Important to safety," with reference to structures, systems, and components means those engineered structures, systems, and components essential to the prevention or mitigation of an accident that could result in a radiation dose to the whole body, or any organ, of 0.5 rem or greater at or beyond the nearest boundary of the controlled area at any time until the completion of permanent closure.

"Indian tribe" means an Indian tribe as defined in the Indian Self-Determination and Education Assistance Act (Public Law 93-638).

"Isolation" means inhibiting the transport of radioactive material so that amounts and concentrations of this material entering the accessible environment will be kept within prescribed limits.

[1]These are DOE "facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under such Act [the Atomic Energy Act]" and "Retrievable Surface Storage Facilities and other facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive wastes generated by [DOE], which are not used for, or are part of, research and development activities."

"Permanent closure" means final backfilling of the underground facility and the sealing of shafts and boreholes.

"Performance Confirmation" means the program of tests, experiments, and analyses which is conducted to evaluate the accuracy and adequacy of the information used to determine reasonable assurance that the performance objectives for the period after permanent closure can be met.

"Public Document Room" means the place at 1717 H Street N.W., Washington, D.C., at which records of the Commission will ordinarily be made available for public inspection and any other place, the location of which has been published in the Federal Register, at which public records of the Commission pertaining to a particular geologic repository are made available for public inspection.

"Radioactive waste" or "waste" means HLW and any other radioactive materials other than HLW that are received for emplacement in a geologic repository.

"Retrieval" means the act of intentionally removing radioactive waste from the underground location at which the waste had been previously emplaced for disposal.

"Saturated zone" means that part of the earth's crust beneath the deepest water table in which all voids, large and small, are already filled with water under pressure greater than atmospheric.

"Site" means the location of the controlled area.

"Site characterization" means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a particular site relevant to the procedures under this part. Site characterization includes borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings, and in situ testing at depth needed to determine the suitability of the site for a geologic repository, but does not include preliminary borings and geophysical testing needed to decide whether site characterization should be undertaken.

"Tribal organization" means a tribal organization as defined in the Indian Self-Determination and Education Assistance Act (Public Law 93-638).

"Unanticipated processes and events" means those processes and events affecting the geologic setting that are judged not to be reasonably likely to occur during the period the intended performance objective must be achieved, but which are never the less sufficiently credible to warrant consideration. Unanticipated processes and events may be either natural processes or events or processes and events initiated by human activities other than those activities licensed under this part. Processes and events initiated by human activities may only be found to be sufficiently credible to warrant consideration if it is assumed that: (1) the monuments provided for by this part are sufficiently permanent to serve their intended purpose; (2) the value to future generations of potential resources within the site can be assessed adequately under the applicable provisions of this part; (3) an understanding of the nature of radioactivity, and an appreciation of its hazards, has been retained in some functioning institutions; (4) institutions are able to assess risk and to take remedial action at a level of social organization and technological competence equivalent to, or superior to, that which was applied in initiating the processes or events concerned; and (5) relevant records are preserved, and remain accessible, for several hundred years after permanent closure.

"Underground facility" means the underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals.

"Unrestricted area" means any area, access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

"Unsaturated zone" means the zone between the land surface and the deepest water table. It includes the capillary fringe. Generally, water in this zone is under less than atmospheric pressure, and some of the voids may contain air or other gases at atmospheric pressure. Beneath flooded areas or in perched water bodies the water pressure locally may be greater than atmospheric.

"Waste form" means the radioactive waste materials and any encapsulating or stabilizing matrix.

"Waste package" means the waste form and any containers, shielding, packing and other components surrounding the waste form.

"Water table" means that surface in a groundwater body at which the water pressure is atmospheric.

3. Section 60.10 is amended by adding paragraph (d) to read as follows:

§ 60.10 Site characterization.

(a) Prior to submittal of an application for a license to be issued under this part the DOE shall conduct a program of site characterization with respect to the site to be described in such application.

(b) Unless the Commission determines with respect to the site described in the application that it is not necessary, site characterization shall include a program of in situ exploration and testing at the depths that wastes would be emplaced.

(c) As provided in § 51.40 of this chapter, DOE is also required to conduct a program of site characterization, including in situ testing a depth, with respect to alternative sites.

(d) The program of site characterization shall be conducted in accordance with the following:

(1) Investigations to obtain the required information shall be conducted in such a manner as to limit adverse effects on the long-term performance of the geologic repository to the extent practical.

(2) As a minimum, the location of exploratory boreholes and shafts shall be selected so as to limit the total number of subsurface penetrations above and around the underground facility consistent with the information needed for site characterization.

(3) To the extent practical, exploratory boreholes and shafts in the geologic repository operations area shall be located where shafts are planned for underground facility construction and operation or where large unexcavated pillars are planned.

(4) Subsurface exploratory drilling, excavation, and in situ testing before and during construction shall be planned and coordinated with geologic repository operations area design and construction.

4. Section 60.11 is amended by revising paragraphs (a) and (b) to read as follows:

§ 60.11 Site characterization report.

(a) As early as possible after commencement of planning for a particular geologic repository operations area, and prior to site characterization, the DOE shall submit to the Director a Site Characterization Report. The report shall include[2] (1) a description of the site to be characterized; (2) the criteria used to arrive at the candidate area; (3) the method by which the site was selected for site characterization; (4) identification and location of alternative media and sites at which DOE intends to conduct site characterization and for which DOE anticipates submitting subsequent Site Characterization Reports; (5) a description of the decision process by which the site was selected for characterization, including the means used to obtain public, Indian tribal and State views during selection; (6) a description of the site characterization program including (i) the extent of planned excavation and plans for in situ testing, (ii) a conceptual design of a geologic repository operations area appropriate to the named site in sufficient detail to allow assessment of the site characterization program, with respect to investigation activities which address the ability of the site to host a geologic repository and isolate radioactive waste, or which may affect such ability, and (iii) provisions to control any adverse, safety-related effects from site characterization, including appropriate quality assurance programs; (7) a description of the quality assurance program to be applied to data collection; and (8) any issues related to

[2]To the extent that the information indicated in items 2 through 5 appears in an Environmental Impact Statement prepared by DOE for site characterization at the named site, it may be incorporated into DOE's Site Characterization Report by reference.

site selection, alternative candidate areas, or other sites, or design of the geologic repository operations area which the DOE wishes the Commission to review. Also included shall be a description of the research and development activities being conducted by DOE which deal with the waste form and packaging which may be considered appropriate for the site to be characterized, including research planned or underway to evaluate the performance of such waste forms and packaging.

(b) The Director shall cause to be published in the Federal Register a notice that the information submitted under paragraph (a) of this section has been received and that a staff review of that information has begun. The notice shall identify the site selected for site characterization, and alternative candidate areas being considered by DOE and shall advise that consultation may be requested by State and local governments and Tribal organizations in accordance with Subpart C of this part.

*　　　*　　　*　　　*　　　*

5. Section 60.21 is amended by revising paragraphs (c)(1), (c)(3), (c)(4), (c)(7), (c)(8), (c)(9), (c)(11), (c)(12), (c)(13), (c)(14), and (c)(15) to read as follows:

§ 60.21 Content of application.

*　　　*　　　*　　　*　　　*

(c) The Safety Analysis Report shall include:

(1) A description and assessment of the site at which the proposed geologic repository operations area is to be located with appropriate attention to those features of the site that might affect geologic repository operations area design and performance. The description of the site shall identify the location of the geologic repository operations area with respect to the boundary of the accessible environment.

(i) The description of the site shall also include the following information regarding subsurface conditions. This description shall, in all cases, include such information with respect to the controlled area. In addition, where subsurface conditions outside the controlled area may affect isolation within the controlled area, the description shall include such information with respect to subsurface conditions outside the controlled area to the extent such information is relevant and material. The detailed information referred to in this paragraph shall include--

(A) The orientation, distribution, aperture in-filling and origin of fractures, discontinuities, and heterogeneities;

(B) The presence and characteristics of other potential pathways such as solution features, breccia pipes, or other permeable anomalies;

(C) The geomechanical properties and conditions, including pore pressure and ambient stress conditions;

(D) The hydrogeologic properties and conditions;

(E) The geochemical properties; and

(F) The anticipated response of the geomechanical, hydrogeologic, and geochemical systems to the maximum design thermal loading, given the pattern of fractures and other discontinuities and the heat transfer properties of the rock mass and groundwater.

(ii) The assessment shall contain--

(A) An analysis of the geology, geophysics, hydrogeology, geochemistry, climatology, and meteorology of the site,

(B) Analyses to determine the degree to which each of the favorable and potentially adverse conditions, if present, has been characterized, and the extent to which it contributes to or detracts from isolation. For the purpose of determining the presence of the potentially adverse conditions, investigations should extend from the surface to a depth sufficient to determine critical pathways for radionuclide migration from the underground facility to the accessible environment. Potentially adverse conditions should be investigated outside of the controlled area if they affect isolation within the controlled area.

(C) An evaluation of the performance of the proposed geologic repository for the period after permanent closure, assuming anticipated processes and events, giving the rates and quantities of releases of radionuclides to the accessible environment as a function of time; and a similar evaluation which assumes the occurrence of unanticipated processes and events.

(D) The effectiveness of engineered and natural barriers, including barriers that may not be themselves a part of the geologic repository operations area, against the release of radioactive material to the environment. The analysis shall also include a comparative evaluation of alternatives to the major design features that are important to radionuclide containment and isolation, with particular attention to the alternatives that would provide longer radionuclide containment and isolation.

(E) An analysis of the expected performance of the major design structures, systems, and components, both surface and subsurface, to identify those that are important to safety. For the purposes of this analysis, it shall be assumed that operations at the geologic repository operations area will be carried out at the maximum capacity and rate of receipt of radioactive waste stated in the application.

(F) An explanation of measures used to confirm the models used to perform the assessments required in paragraphs (A) through (D). Analyses and models that will be used to predict future conditions and changes in the geologic setting shall be supported by using such methods as field tests, in situ tests, laboratory tests which are representative of field conditions, monitoring data and natural analog studies.

* * * * *

(3) A description and analysis of the design and performance requirements for structures, systems, and components of the geologic repository which are important to safety. This analysis shall consider-(i) the margins of safety under normal conditions and under conditions that may result from anticipated operational occurrences, including those of natural origin; (ii) the adequacy of structures, systems, and components provided for the prevention of accidents and mitigation of the consequences of accidents, including those caused by natural phenomena.

(4) A description of the quality assurance program to be applied to the structures, systems, and components important to safety and to the engineered and natural barriers important to waste isolation.

* * * * *

(7) A description of the program for control and monitoring of radioactive effluents and occupational radiation exposures to maintain such effluents and exposures in accordance with the performance objectives through permanent closure.

(8) A description of the controls that the applicant will apply to restrict access and to regulate land use at the site and adjacent areas,

including a conceptual design of monuments which would be used to identify the controlled area after permanent closure.

(9) Plans for coping with radiological emergencies at any time prior to permanent closure and decontamination or dismantlement of surface facilities.

*　　　　*　　　　*　　　　*　　　　*

(11) A description of design considerations that are intended to facilitate permanent closure and decontamination or dismantlement of surface facilities.

(12) A description of the design for retrievability.

(13) An identification and evaluation of the natural resources of the geologic setting, including estimates as to undiscovered deposits, the exploitation of which could affect the ability of the geologic repository to isolate radioactive wastes. Undiscovered deposits of resources characteristic of the area shall be estimated by reasonable inference based on geological and geophysical evidence. This evaluation of resources, including undiscovered deposits, shall be conducted for the site and for areas of similar size that are representative of and are within the geologic setting. For natural resources with current markets the resources shall be assessed, with estimates provided of both gross and net value. The estimate of net value shall take into account current development, extraction and marketing costs. For natural resources without current markets, but which would be marketable given credible projected changes in economic or technological factors, the resources shall be described by physical factors such as tonnage or other amount, grade, and quality.

(14) An identification of those structures, systems, and components of the geologic repository, both surface and subsurface, which require research and development to confirm the adequacy of design. For structures, systems, and components important to safety and to the engineered and natural barriers important to waste isolation, DOE shall provide a detailed description of the programs designed to resolve safety questions, including a schedule indicating when these questions would be resolved.

(15) The following information concerning activities at the geologic repository operations area:

(i) The organizational structure of DOE as it pertains to construction and operation of the geologic repository operations area including a description of any delegations of authority and assignments of responsibilities, whether in the form of regulations, administrative directives, contract provisions, or otherwise.

(ii) The quality assurance organization to be used to ensure safety.

(iii)***

(vii) Plans for permanent closure and plans for the decontamination or dismantlement of surface facilities.

(viii) Plans for any uses of the geologic repository operations area for purposes other than disposal of radioactive wastes, with an analysis of the effects, if any, that such uses may have upon the operation of the structures, systems, and components important to safety and the engineered and natural barriers important to waste isolation.

6. Section 60.22 is amended by revising paragraphs (a) and (d) to read as follows:

§ 60.22 Filing and distribution of application.

(a) An application for a license to receive and possess source, special nuclear, or byproduct material at a geologic repository operations area at a site which has been characterized, and an accompanying environmental report, and any amendments thereto, shall be filed in triplicate with the Director and shall be signed by the Secretary of Energy or the Secretary's authorized representative.

* * * * *

(d) At the time of filing of an application and environmental report, and any amendments thereto, one copy shall be made available in an appropriate location near the proposed geologic repository operations area (which shall be a public document room, if one has been established) for inspection by the public and updated as amendments to the application or environmental report are made. An updated copy shall be produced at any public hearing on the application for use by any parties to the proceedings.

* * * * *

7. Section 60.31 is amended by revising paragraphs (a) (1) and (a) (2) to read as follows:

§ 60.31 Construction authorization.

* * * * *

(a) Safety. That there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a geologic repository operations area of the design proposed without unreasonable risk to the health and safety of the public. In arriving at this determination, the Commission shall consider whether:

(1) The DOE has described the proposed geologic repository including but not limited to (i) the geologic, geophysical, geochemical and hydrologic characteristics of the site; (ii) the kinds and quantities of radioactive waste to be received, possessed, stored, and disposed of in the geologic repository operations area; (iii) the principal architectural and engineering criteria for the design of the geologic repository operations area; (iv) construction procedures which may affect the capability of the geologic repository to serve its intended function; and (v) features or components incorporated in the design for the protection of the health and safety of the public.

(2) The site and design comply with the criteria contained in Subpart E.

* * * * *

8. Section 60.32 is amended by revising paragraphs (b) and (c) to read as follows:

§ 60.32 Conditions of construction authorization.

(a) * * * *

(b) The Commission will incorporate in the construction authorization provisions requiring the DOE to furnish periodic or special reports regarding: (1) progress of construction, (2) any data about the site obtained during construction which are not within the predicted limits upon which the facility design was based, (3) any deficiencies in design and construction which, if uncorrected, could adversely affect safety at any future time, and (4) results of research and development programs being conducted to resolve safety questions.

(c) The construction authorization will include restrictions on subsequent changes to the features of the geologic repository operations area and the procedures authorized. These restrictions will fall into three categories of descending importance to public health and safety as follows: (1) those features and procedures which may not be changed without (i) 60 days prior notice to the Commission, (ii) 30 days notice of opportunity for a prior hearing, and (iii) prior Commission approval; (2) those features and procedures which may not be changed without (i) 60 days prior notice to the Commission, (ii) prior Commission approval; and (3) those features and procedures which may not be changed without 60 days prior notice to the Commission. Features and procedures failing in paragraph (c)(3) of this section may not be changed without prior Commission approval if the Commission, after having received the required notice, so orders.

* * * * *

9. Section 60.43 is amended by revising paragraph (b)(3) to read as follows:

§ 60.43 License specifications.

(a) * * * *

(b) License conditions shall include items in the following categories--

(1) * * *

(3) Restrictions as to the amount of waste permitted per unit volume of storage space considering the physical characteristics of both the waste and the host rock.

* * * * *

10. Section 60.46 is amended by revising paragraphs (a)(3) and (a)(6) to read as follows:

§ 60.46 Particular activities requiring license amendment.

(a) ıless expressly authorized in the license, an amendment of the license shall be required with respect to any of the following activities--

(1) * * *

(3) Removal or reduction of controls applied to restrict access to or avoid disturbance of the controlled area.

(4) * * *

(6) Permanent closure.

11. Section 60.51 is amended by changing the undesignated center heading immediately preceding the section from DECOMMISSIONING to PERMANENT CLOSURE and by revising paragraphs (a)(1)(2)(4)(5) and (6), and paragraph (b).

§ 60.51 License amendment for permanent closure.

(a) DOE shall submit an application to amend the license prior to permanent closure. The applicatión shall consist of an update of the license application and environmental report submitted under §§60.21 and 60.22, including:

(1) A description of the program for post-permanent closure monitoring of the geologic repository.

(2) A detailed description of the measures to be employed--such as land use controls, construction of monuments, and preservation of records--to regulate or prevent activities that could impair the long-term isolation of emplaced waste within the geologic repository and to assure that relevant information will be preserved for the use of future generations. As a minimum, such measures shall include--

(i) Identification of the controlled area and geologic repository operations area by monuments that have been designed, fabricated, and emplaced to be as permanent as is practicable; and

(ii) Placement of records in the archives and land record systems of local and Federal government agencies, and archives elsewhere in the world, that would be likely to be consulted by potential human intruders; such records shall identify the location of the geologic repository operations area and the controlled area and the nature and hazard of the waste.

(3) * * *

(4) The results of tests, experiments, and any other analyses relating to backfill of excavated areas, shaft sealing, waste interaction with the host rock, and any other tests, experiments, or analyses pertinent to the long-term isolation of emplaced wastes within the geologic repository.

(5) Any substantial revision of plans for permanent closure.

(6) Other information bearing upon permanent closure that was not available at the time a license was issued.

(b) DOE shall update its environmental report in a timely manner so as to permit the Commission to review, prior to issuance of an amendment, substantial changes in the permanent closure activities proposed to be carried out or significant new information regarding the environmental impacts of such permanent closure.

12. Section 60.52 is amended by revising paragraphs (a), and (c)(2) to read as follows:

§ 60.52 Termination of license.

(a) Following permanent closure and the decontamination or dismantlement of surface facilities, DOE may apply for an amendment to terminate the license.

* * * * *

(c) A license shall be terminated only when the Commission finds with respect to the geologic repository--

(1) * * *

(2) That the final state of the geologic repository operations area conforms to DOE's plans for permanent closure and DOE's plans for the decontamination or dismantlement of surface facilities, as amended and approved as part of the license.

* * * * *

13. The title of Section 60.61 is revised to read as follows:

§ 60.61 Site characterization review.

* * * * *

14. Section 60.62 is amended by revising paragraph (b) to read as follows:

§ 60.62 Filing of proposals for State participation.

* * * * *

(b) States potentially affected by locating a geologic repository operations area at a site that has been selected for characterization may submit to the Director a proposal for State participation in the review of the Site Characterization Report and/or license application. A State's proposal to participate may be submitted at any time prior to docketing of an application or up to 120 days thereafter.

* * * * *

15. Section 60.64 is amended by revising paragraph (a) to read as follows:

§ 60.64 Participation by Indian tribes.

(a) Any Indian tribe which is potentially affected by locating a geologic repository operations area at a site that has been selected for characterization may:

* * * * *

16. Subpart D is revised to read as follows:

SUBPART D--RECORDS, REPORTS, TESTS, AND INSPECTIONS

§ 60.71 General recordkeeping and reporting requirement.

(a) DOE shall maintain such records and make such reports in connection with the licensed activity as may be required by the conditions of the license or by rules, regulations, and orders of the Commission as authorized by the Atomic Energy Act and the Energy Reorganization Act.

(b) Records of the receipt, handling, and disposition of radioactive waste at a geologic repository operations area shall contain sufficient information to provide a complete history of the movement of the waste from the shipper through all phases of storage and disposal.

§ 60.72 Construction records.

(a) DOE shall maintain records of construction of the geologic repository operations area.

(b) The records required under paragraph (a) shall include at least the following --

(1) Surveys of the underground facility excavations, shafts, and boreholes referenced to readily identifiable surface features or monuments;

(2) A description of the materials encountered;

(3) Geologic maps and geologic cross sections;

(4) Locations and amount of seepage;

(5) Details of equipment, methods, progress, and sequence of work;

(6) Construction problems;

(7) Anomalous conditions encountered;

(8) Instrument locations, readings, and analysis;

(9) Location and description of structural support systems;

(10) Location and description of dewatering systems; and

(11) Details, methods of emplacement, and location of seals used.

§ 60.73 Reports of deficiencies.

DOE shall promptly notify the Commission of each deficiency found in the characteristics of the site, and design and construction of the geologic repository operations area which, were it to remain uncorrected, could (a) be a substantial safety hazard, (b) represent a significant deviation from the design criteria and design bases stated in the application, or (c) represent a deviation from the conditions stated in the terms of a construction authorization or the license, including license specifications. The notification shall be in the form of a written report, copies of which shall be sent to the Director and to the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix D of Part 20 of this chapter.

§ 60.74 Tests.

(a) DOE shall perform, or permit the Commission to perform, such tests as the Commission deems appropriate or necessary for the administration of the regulations in this part. These may include tests of (a) radioactive waste, (b) the geologic repository including its structures, systems, and components, (c) radiation detection and monitoring instruments, and (d) other equipment and devices used in connection with the receipt, handling, or storage of radioactive waste.

(b) The tests required under this section shall include a performance confirmation program carried out in accordance with Subpart F of this part.

§ 60.75 Inspections.

(a) DOE shall allow the Commission to inspect the premises of the geologic repository operations area and adjacent areas to which the DOE has rights of access.

(b) DOE shall make available to the Commission for inspection, upon reasonable notice, records kept by the DOE pertaining to activities under this part.

(c)(1) DOE shall upon request by the Director, Office of Inspection and Enforcement, provide rent-free office space for the exclusive use of the Commission inspection personnel. Heat, air-conditioning, light, electrical outlets and janitorial services shall be furnished by DOE. The office shall be convenient to and have full access to the facility and shall provide the inspector both visual and acoustic privacy.

(2) The space provided shall be adequate to accommodate a full-time inspector, a part-time secretary and transient NRC personnel and will be generally commensurate with other office facilities at the geologic repository operations area. A space of 250 square feet either within the geologic repository operations area's office complex or in an office trailer or other onsite space at the geologic repository operations area is suggested as a guide. For sites at which activities are carried out under licenses issued under other parts of this chapter, additional space may be requested to accomodate additional full-time inspectors. The office space that is provided shall be subject to the approval of the Director, Office of Inspection and Enforcement. All furniture, supplies and communication equipment will be furnished by the commission.

(3) DOE shall afford any NRC resident inspector assigned to that site, or other NRC inspectors identified by the Regional Director as likely to inspect the facility, immediate unfettered access, equivalent to access provided regular employees, following proper identification and compliance with applicable access control measures for security, radiological protection and personal safety.

* * * * *

17. Subparts E, F, G, H, and I are added to read as follows.

SUBPART E--TECHNICAL CRITERIA

SUBPART E - TECHNICAL CRITERIA

§60.101 Purpose and nature of findings.

(a)(1) Subpart B of this part prescribes the standards for issuance of a license to receive and possess source, special nuclear, or byproduct material at a geologic repository operations area. In particular,

§ 60.41(c) requires a finding that the issuance of a license will not constitute an unreasonable risk to the health and safety of the public. The purpose of this subpart is to set out performance objectives and site and design criteria which, if satisfied, will support such a finding of no unreasonable risk.

(2) While these performance objectives and criteria are generally stated in unqualified terms, it is not expected that complete assurance that they will be met can be presented. A reasonable assurance, on the basis of the record before the Commission, that the objectives and criteria will be met is the general standard that is required. For § 60.112, and other portions of this subpart that impose objectives and criteria for repository performance over long times into the future, there will inevitably be greater uncertainties. Proof of the future performance of engineered barrier systems and the geologic setting over time periods of many thousands of years is not to be had in the ordinary sense of the word. For such long-term objectives and criteria, what is required is reasonable assurance, making allowance for the time period, hazards, and uncertainties involved, that the outcome will be in conformance with those objectives and criteria.

(b) Subpart B of this part also lists findings that must be made in support of an authorization to construct a geologic repository operations area. In particular, § 60.31(a) requires a finding that there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a geologic repository operations area of the design proposed without unreasonable risk to the health and safety of the public.

As stated in that paragraph, in arriving at this determination, the Commission will consider whether the site and design comply with the criteria contained in this subpart. Once again, while the criteria may be written in unqualified terms, the demonstration of compliance may take uncertainties and gaps in knowledge into account, provided that the Commission can make the specified finding of reasonable assurance as specified in paragraph (a) of this section.

§ 60.102 Concepts.

This section provides a functional overview of Subpart E. In the event of any inconsistency with definitions found in § 60.2 those definitions shall prevail.

(a) The HLW facility.

NRC exercises licensing and related regulatory authority over those facilities described in section 202(3) and (4) of the Energy Reorganization Act of 1974. Any of these facilities is designated an HLW facility.

(b) The geologic repository operations area.

(1) This part deals with the exercise of authority with respect to a particular class of HLW facility--namely a geologic repository operations area.

(2) A geologic repository operations area consists of those surface and subsurface areas that are part of a geologic repository where radioactive waste handling activities are conducted. The underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals, is designated the underground facility.

(3) The exercise of Commission authority requires that the geologic repository operations area be used for storage (which includes disposal) of high-level radioactive wastes (HLW).

(4) HLW includes irradiated reactor fuel as well as reprocessing wastes. However, if DOE proposes to use the geologic repository operations area for storage of radioactive waste other than HLW, the storage of this radioactive waste is subject to the requirements of this part.

(c) Areas related to isolation.

Although the activities subject to regulation under this part are those to be carried out at the geologic repository operations area, the licensing process also considers characteristics of areas that are defined in other ways. There is to be an area surrounding the underground facility referred to above, which is designated the controlled area, within which DOE is to exercise specified controls to prevent adverse human actions following permanent closure. The location of the controlled area is the site. The portion of the lithosphere that is outside the controlled area (and, also, the atmosphere, the land surface, surface water, and oceans) constitutes the accessible environment. There is an area, designated the geologic setting, which includes the geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located. The geologic repository operations area plus the portion of the geologic setting that provides isolation of the radioactive waste make up the geologic repository.

(d) Stages in the licensing process.

There are several stages in the licensing process. The site characterization stage, though begun before submission of a license application, may result in consequences requiring evaluation in the license review. The construction stage would follow, after issuance of a construction authorization. A period of operations follows the issuance of a license by the Commission. The period of operations includes the time during which emplacement of wastes occurs; and any subsequent period before permanent closure during which the emplaced wastes are retrievable; and permanent closure, which includes sealing of shafts. Permanent closure represents the end of active human intervention with respect to the engineered barrier system.

(e) Isolation of Waste.

Early during the life of a geologic repository, when radiation and thermal levels are high and the uncertainties in assessing repository performance are large, special emphasis is placed upon the ability to contain the wastes by waste packages within an engineered barrier system. This is known as the containment period. The engineered barrier system includes the waste packages and the underground facility. A waste package is composed of the waste form and any containers, shielding, packing, and other components surrounding the waste form. The underground facility means the underground structure, including openings and backfill materials, but excluding, shafts, boreholes, and their seals.

Following the containment period special emphasis is placed upon the ability to achieve isolation of the wastes by virtue of the characteristics of the geologic repository. The engineered barrier system works to control the release of radioactive material to the geologic setting and the geologic setting works to control the release of radioactive material to the accessible environment. Isolation means the act of inhibiting the transport of radioactive material to the accessible environment in amounts and concentrations within limits.

PERFORMANCE OBJECTIVES

§ 60.111 Performance of the geologic repository operations area through permanent closure.

(a) Protection against radiation exposures and releases of radioactive material. The geologic repository operations area shall be designed so that until permanent closure has been completed, radiation exposures and radiation levels, and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in Part 20 of this chapter and such generally applicable environmental standards as may have been established by the Environmental Protection Agency.

(b) Retrievability of waste.

(1) The geologic repository operations area shall be designed to preserve the option of waste retrieval throughout the period during which wastes are being emplaced and, thereafter, until the completion of a performance confirmation program and Commission review of the information obtained from such a program. To satisfy this objective, the geologic repository operations area shall be designed so that any or all of the emplaced waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste emplacement operations are initiated, unless a different time period is approved or specified by the Commission. This different time period may be established on a case-by-case basis consistent with the emplacement schedule and the planned performance confirmation program.

(2) This requirement shall not preclude decisions by the Commission to allow backfilling part or all of, or permanent closure of, the geologic

repository operations area prior to the end of the period of design for retrievability.

(3) For purposes of this paragraph, a reasonable schedule for retrieval is one that would permit retrieval in about the same time as that devoted to construction of the geologic repository operations area and the emplacement of wastes.

§ 60.112 Overall system performance objective for the geologic repository after permanent closure.

The geologic setting shall be selected and the engineered barrier system and the shafts, boreholes and their seals shall be designed to assure that releases of radioactive materials to the accessible environment following permanent closure conform to such generally applicable environmental standards as may have been established by the Environmental Protection Agency with respect to either anticipated processes and events or unanticipated processes and events. For disposal in the saturated zone, both the partial and complete filling with ground water of available void spaces in the underground facility shall be included among the anticipated processes and events.

§ 60.113 Performance of particular barriers after permanent closure.

(a) General provisions.

(1) Engineered barrier system

(i) The engineered barrier system shall be designed so that assuming anticipated processes and events, (a) Containment of HLW will be substantially complete during the period when radiation and thermal conditions in the underground facility are dominated by fission product decay; (b) any release of radionuclides from the engineered barrier system shall be a gradual process which results in small fractional releases to the geologic setting over long times.

(ii) In satisfying the preceding requirement, the engineered barrier system shall be designed, assuming anticipated processes and events, so that:

(A) Containment of HLW within the HLW waste package will be substantially complete for a period of 1,000 years after permanent closure of the geologic repository, or such other period as may be approved or specified by the Commission.

(B) The release rate of any radionuclide following the containment period shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 years following permanent closure, or such other fraction of the inventory as may be approved or specified by the Commission; provided, that this requirement does not apply to any radionuclide which is released at a rate less than 0.1% of the calculated total annual release at 1,000 years following permanent closure.

(2) <u>Geologic setting</u>. The geologic repository shall be located so that pre-waste emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall be at least 1,000 years or such other travel time as may be approved or specified by the Commission.

(b) On a case-by-case basis, the Commission may approve or specify some other radionuclide release rate, designed containment period, or pre-waste-emplacement groundwater travel time as needed for the Commission to find that the overall system performance objective, as it relates to anticipated processes and events, is satisfied. Among the factors that the Commission may take into account are:

(1) Any generally applicable environmental radiation standard established by the Environmental Protection Agency;

(2) The age and nature of the waste, and the design of the underground facility, particularly as these factors bear upon the time during which the thermal pulse is dominated by the decay heat from the the fission products:

(3) The geochemical characteristics of the host rock; and

(4) Particular sources of uncertainty in predicting the performance of the geologic repository.

(c) Additional requirements may be found to be necessary to satisfy the overall system performance objective as it relates to unanticipated processes and events.

LAND OWNERSHIP AND CONTROL

§ 60.121 Requirements for ownership and control of interests in land.

(a) Ownership of land.

(1) Both the geologic repository operations area and the controlled area shall be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use.

(2) These lands shall be held free and clear of all encumbrances, if significant, such as: (i) rights arising under the general mining laws; (ii) easements for right-of-way; and (iii) all other rights arising under lease, rights of entry, deed, patent, mortgage, appropriation, prescription, or otherwise.

(b) Additional controls.

Appropriate controls shall be established outside of the controlled area. DOE shall exercise any jurisdiction and control over surface and subsurface estates necessary to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation. The rights of DOE may take the form of appropriate possessory interests, servitudes, or withdrawals from location or patent under the general mining laws.

(c) Water rights.

(1) DOE shall also have obtained such water rights as may be needed to accomplish the purpose of the geologic repository operations area.

(2) Water rights are included in the additional controls to be established under paragraph (b) of this section.

SITING REQUIREMENTS

§ 60.122 Siting Requirements.

(a) If any of the favorable conditions specified in paragraph (b) of this section are operating in the geologic setting, they may contribute to the ability of the geologic setting to meet the performance objectives relating to isolation of the waste. If any of the potentially adverse conditions specified in paragraph (c) of this section are present, they may render the site unsuitable for hosting a geologic repository. In order to show that a potentially adverse condition does not compromise the ability of the site to host a geologic repository the following must be demonstrated:

(1) The potentially adverse human activity or natural condition has been adequately investigated, including the extent to which the condition may be present and still be undetected taking into account the degree of resolution achieved by the investigations; and

(2) The effect of the potentially adverse human activity or natural condition on the site has been adequately evaluated using analyses which are sensitive to the adverse human activity or natural condition and assumptions which are not likely to underestimate its effect; and

(3)(i) The potentially adverse human activity or natural condition is shown by analysis pursuant to paragraph (a)(2) of this section not to affect significantly the ability of the geologic repository to isolate waste, or

(ii) The effect of the potentially adverse human activity or natural condition is compensated by the presence of a combination of the favorable characteristics so that the performance objectives for the geologic setting are met, or

(iii) The potentially adverse human activity or natural condition can be remedied.

(b) Favorable conditions.

(1) The nature and rates of tectonic, hydrogeologic, geochemical, and geomorphic processes operating within the geologic setting during the Quaternary Period would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(2) For disposal of HLW in the saturated zone, hydrogeologic conditions that provide--

(i) A host rock with low horizontal and vertical permeability;

(ii) Downward or dominantly horizontal hydraulic gradient in the host rock and;

(iii) Low vertical permeability and low hydraulic potential between the host rock and surrounding hydrogeologic units; and

(iv) Groundwater travel times between the disturbed zone and the accessible environment that substantially exceed 1,000 years.

(3) For disposal of HLW in the unsaturated zone, hydraulic conditions that provide --

(i) Low and nearly constant moisture content in the host rock and surrounding hydrogeologic units;

(ii) A water table sufficiently below the underground facility such that the capillary fringe does not encounter the host rock;

(iii) A laterally extensive low-permeability hydrogeologic unit above the host rock that would divert the downward infiltration of water beyond the limits of the underground facility;

(iv) A host rock with high saturated permeability and effective porosity that provides for a freely draining condition; and

(v) A climatic regime with precipitation as a small percentage of potential evapotranspiration.

(4) Geochemical conditions that--(i) Promote precipitation or sorption of radionuclides; (ii) Inhibit the formation of particulates, colloids, and inorganic and organic complexes that increase the mobility of radionuclides; or (iii) Inhibit the transport of radionuclides by particulates, colloids, and complexes.

(5) Mineral assemblages that, when subjected to anticipated thermal loading, will remain unaltered or alter to mineral assemblages having equal or increased capacity to inhibit radionuclide migration.

(6) Conditions that permit the emplacement of waste at a minimum depth of 300 meters from the ground surface. (The ground surface shall be deemed to be the elevation of the lowest point on the surface above the disturbed zone.)

(c) Potentially adverse conditions.

(1) Potential for failure of existing or planned man-made surface water impoundments that could cause flooding of the geologic repository operations area.

(2) Potential for adverse impacts on the geologic repository operations area resulting from the occupancy and modification of floodplains.

(3) Potential for forseeable human activity to adversely affect the groundwater flow system, such as groundwater withdrawal, extensive irrigation, subsurface injection of fluids, underground pumped storage, military activity or construction of large scale surface water impoundments.

(4) Potential for natural phenomena such as landslides, subsidence, or volcanic activity of such a magnitude that large-scale surface water impoundments could be created that could change the regional groundwater flow system and thereby adversely affect the performance of the geologic repository.

(5) Potential for the water table to rise sufficiently so as to cause saturation of an underground facility located in the unsaturated zone.

(6) Structural deformation, such as uplift, subsidence, folding, or faulting that may adversely affect the regional groundwater flow system.

(7) Potential for changes in hydrologic conditions that would significantly affect the migration of radionuclides to the accessible environment, such as changes in hydraulic gradient, average interstitial velocity, storage coefficient, hydraulic conductivity, natural recharge, potentiometric levels, and discharge points.

(8) Potential for climatic changes that would have an adverse effect on the hydrologic conditions.

(9) Groundwater conditions in the host rock, including chemical composition, high ionic strength or ranges of Eh-pH, that could affect the solubility of the waste form or chemical reactivity of the engineered barrier system so as to increase the difficulty of designing the engineered barrier system to meet the performance objectives of §§ 60.112 and 60.113.

(10) Geochemical processes that would reduce sorption, result in degradation of the rock strength, or adversely affect the performance of the engineered barrier system.

(11) For disposal in the saturated zone, groundwater conditions in the host rock that are not reducing.

(12) Evidence of dissolutioning such as breccia pipes, dissolution cavities, or brine pockets.

(13) Structural deformation such as uplift, subsidence, folding, and faulting during the Quaternary Period.

(14) Earthquakes which have occurred historically that if they were to be repeated could affect the site significantly.

(15) Indications, based on correlations of earthquakes with tectonic processes and features, that either the frequency of occurrence or magnitude of earthquakes may increase.

(16) Evidence of igneous activity since the start of the Quaternary Period.

(17) Evidence of extreme erosion during the Quaternary Period.

(18) Potential resources within the site that have greater gross value, net value, or commercial potential than the average for other areas of similar size that are representative of and located in the geologic setting.

(19) Evidence of subsurface mining for resources within the site.

(20) Evidence of drilling for any purpose within the site.

(21) Geologic, geotechnical, or groundwater conditions that would require complex engineering measures in the design and construction of the underground facility or in the sealing of boreholes and shafts.

(22) Geomechanical properties that do not permit design of underground openings that will remain stable through permanent closure.

DESIGN REQUIREMENTS FOR THE GEOLOGIC REPOSITORY OPERATIONS AREA

§60.130 Scope of design requirements for the geologic repository operations area.

Sections 60.131 through 60.134 specify minimum requirements for the design of the geologic repository operations area. These design requirements are not intended to be exhaustive, however. Omissions in §§60.131 through 60.134 do not relieve DOE from any obligation to provide such safety features in a specific facility needed to achieve the performance objectives contained in §§60.111 and 60.112. All design criteria must be consistent with the results of site characterization activities.

§60.131 General design requirements for the geologic repository operations area.

(a) Radiological protection.

The geologic repository operations area shall be designed to maintain radiation doses, levels, and concentrations of radioactive material in air in restricted areas within the limits specified in Part 20 of this chapter. Design shall include--

(1) Means to limit concentrations of radioactive material in air;

(2) Means to limit the time required to perform work in the vicinity of radioactive materials, including, as appropriate, designing equipment for ease of repair and replacement and providing adequate space for ease of operation;

(3) Suitable shielding;

(4) Means to monitor and control the dispersal of radioactive contamination;

(5) Means to control access to high radiation areas or airborne radioactivity areas; and

(6) A radiation alarm system to warn of significant increases in radiation levels, concentrations of radioactive material in air, and of increased radioactivity released in effluents. The alarm system shall be designed with provisions for calibration and for testing its operability.

(b) Structure, systems, and components important to safety.

(1) Protection against natural phenomena and environmental conditions.

The structures, systems, and components important to safety shall be designed so that natural phenomena and environmental conditions anticipated at the geologic repository operations area will not result in failure to achieve the performance objectives for the period through permanent closure.

(2) Protection against dynamic effects of equipment failure and similar events.

The structures, systems and components important to safety shall be designed to withstand dynamic effects such as missile impacts, that could result from equipment failure, and similar events and conditions that could lead to loss of their safety functions.

(3) Protection against fires and explosions.

(i) The structures, systems, and components important to safety shall be designed to perform their safety functions during and after credible fires or explosions in the geologic repository operations area.

(ii) To the extent practicable, the geologic repository operations area shall be designe o incorporate the use of noncombustible and heat resistant materials, and explosives shall be excluded from areas containing radioactive materials.

(iii) The geologic repository operations area shall be designed to include explosion and fire detection alarm systems and appropriate suppression systems with sufficient capacity and capability to reduce the adverse effects of fires and explosions on structures, systems, and components important to safety.

(iv) The geologic repository operations area shall be designed to include means to protect systems, structures, and components important to safety against the adverse effects of either the operation or failure of the fire suppression systems.

(4) Emergency capability.

(i) The structures, systems, and components important to safety shall be designed to maintain control of radioactive waste, and permit prompt termination of operations and evacuation of personnel during an emergency.

(ii) The geologic repository operations area shall be designed to include onsite facilities and services that ensure a safe and timely response to emergency conditions and that facilitate the use of available offsite services (such as fire, police, medical and ambulance service) that may aid in recovery from emergencies.

(5) Utility services.

(i) Each utility service system that is important to safety shall be designed so that essential safety functions can be performed under both normal and emergency conditions.

(ii) The utility services important to safety shall include redundant systems to the extent necessary to maintain, with adequate capacity, the ability to perform their safety functions.

(iii) Provisions shall be made so that, if there is a loss of the primary electric power source or circuit, reliable and timely emergency power can be provided to instruments, utility service systems, and operating systems, including alarm systems. This emergency power shall be sufficient to maintain structures, systems, and components important to safety in a functional mode.

(6) Inspection, testing, and maintenance. The structures, systems, and components important to safety shall be designed to permit periodic inspection, testing, and maintenance, as necessary, to ensure their continued functioning and readiness.

(7) Criticality control. All systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste shall be designed to ensure that a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. Each system shall be designed for criticality safety under normal and accident conditions. The calculated effective multiplication factor (k_{eff}) must be sufficiently below unity to show at least a 5% margin, after allowance for the bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation.

(8) Instrumentation and control systems. Instrumentation and control systems shall be designed to monitor and control the behavior of systems important to safety over anticipated ranges for normal operation and for accident conditions.

(9) Compliance with mining regulations. To the extent that DOE is not subject to the Federal Mine Safety and Health Act of 1977, as to the construction and operation of the geologic repository operations area, the design of the geologic repository operations area shall nevertheless include such provisions for worker protection as may be necessary to provide reasonable assurance that all structures, systems, and components important to safety can perform their intended functions. Any deviation from relevant design requirements in 30 CFR, Chapter I, Subchapters D, E, and N will give rise to a rebuttable presumption that this requirement has not been met.

(10) Shaft conveyances used in radioactive waste handling.

(i) Hoists important to safety shall be designed to preclude cage free fall.

(ii) Hoists important to safety shall be designed with a reliable cage location system.

(iii) Hoist loading and unloading systems shall be designed with a reliable system of interlocks that will fail safely upon malfunction.

(iv) Hoists important to safety shall be designed to include two independent indicators to indicate when waste packages are in place, grappled, and ready for transfer.

§ 60.132 Additional design requirements for surface facilities in the geologic repository operations area.

(a) Facilities for receipt and retrieval of waste. Surface facilities in the geologic repository operations area shall be designed to allow safe handling and storage of wastes at the geologic repository operations area, whether these wastes are on the surface before emplacement or as a result of retrieval from the underground facility.

(b) Surface Facility Ventilation. Surface facility ventilation systems supporting waste transfer, inspection, decontamination, processing, or packaging shall be designed to provide protection against radiation exposures and offsite releases as provided in §60.111(a).

(c) Radiation control and monitoring.

(1) Effluent control. The surface facilities shall be designed to control the release of radioactive materials in effluents during normal

operations and accident conditions so as to meet the performance objectives of § 60.111(a).

(2) Effluent monitoring. The effluent monitoring systems shall be designed to measure the amount and concentration of radionuclides in any effluent with sufficient precision to determine whether releases conform to the design requirement for effluent control. The monitoring systems shall be designed to include alarms that can be periodically tested.

(d) Waste treatment. Radioactive waste treatment facilities shall be designed to process any radioactive wastes generated at the geologic repository operations area into a form suitable to permit safe disposal at the geologic repository operations area or to permit safe transportation and conversion to a form suitable for disposal at an alternative site in accordance with any regulations that are applicable.

(e) Consideration of permanent closure. The surface facility shall be designed to facilitate decontamination or dismantlement.

§ 60.133 Additional design requirements for the underground facility.

(a) General criteria for the underground facility.

(1) The underground facility shall be designed to provide for structural stability, control of groundwater movement and control of radionuclide releases, as necessary to comply with the performance objectives of §§60.111, 60.112, 60.113.

(2) The orientation, geometry, layout, and depth of the underground facility, and the design of any engineered barriers that are part of the underground facility shall contribute to the containment and isolation of radionuclides.

(3) The underground facility shall be designed so that the effects of disruptive events such as intrusions of gas, or water, or explosions, will not spread through the facility.

(b) Flexibility of design. The underground facility shall be designed with sufficient flexibility to allow adjustments, where necessary, to accommodate specific site conditions identified through in situ monitoring, testing, or excavation.

(c) Design for retrieval of waste. The underground facility shall be designed to permit retrieval of waste in accordance with the performance objectives of §60.111.

(d) Control of water and gas. Water and gas control systems shall be designed to be of sufficient capability and capacity to reduce the potentially adverse effects of water and gas intrusion into the underground facility.

(e) Design of subsurface openings.

(1) Subsurface openings shall be designed so that operations can be carried out safely and the retrievability option maintained.

(2) Subsurface openings shall be designed to reduce the potential for deleterious rock movement or fracturing of overlying or surrounding rock.

(f) Rock excavation. The design of the underground facility shall incorporate excavation methods that will reduce the potential for creating a preferential pathway for groundwater or radioactive waste migration to the accessible environment.

(g) Subsurface ventilation.

The ventilation system shall be designed to--

(1) Control the transport of radioactive particulates and gases within and releases from the geologic repository operations areas in accordance with the performance objectives of §60.111.

(2) Assure continued function under normal operation and accident conditions; and

(3) Separate the venti ation of excavation and waste emplacement areas.

(h) Engineered barriers.

Engineered barriers shall be designed to assist the geologic setting in meeting the performance objectives of §§ 60.112 and 60.113.

(i) Design for thermal loads. The underground facility shall be designed so that the predicted thermal and thermomechanical response of the host rock and groundwater system will not degrade significantly the performance of the geologic repository.

§ 60.134 Design of seals for shafts and boreholes.

(a) General design requirement. Seals for shafts and boreholes shall be designed so that following permanent closure they do not become pathways that will compromise the geologic repository's ability to meet the performance objectives of §§ 60.112 and 60.113.

(b) Selection of materials and placement methods. Materials and placement methods for seals shall be selected to reduce, to the extent practicable, (1) the potential for creating a preferential pathway for groundwater; or (2) radioactive waste migration through existing pathways.

DESIGN REQUIREMENTS FOR THE WASTE PACKAGE

§ 60.135 Requirements for the waste package and its components.

(a) Waste package design requirements for high-level waste.

(1) Packages for HLW shall be designed so that the in situ chemical, physical, and nuclear properties of the waste package and its interactions with the emplacement environment do not compromise the function of the waste packages or the performance of the underground facility or the geologic setting.

(2) The design shall include but not be limited to consideration of the following factors: solubility, oxidation/reduction reactions, corrosion, hydriding, gas generation, thermal effects, mechanical strength, mechanical stress, radiolysis, radiation damage, radionuclide retardation, leaching, fire and explosion hazards, thermal loads, and synergistic interactions.

(b) Design requirements for non HLW.

Design requirements for waste types other than HLW will be addressed on an individual basis if and when they are disposed of in a geologic repository.

(c) Waste form requirements for HLW.

High-level radioactive waste that is emplaced in the underground facility shall be designed to meet the following requirements:

(1) Solidification. All such radioactive wastes shall be in solid form and placed in sealed containers.

(2) Consolidation. Particulate waste forms shall be consolidated (for example, by incorporation into an encapsulating matrix) to limit the availability and generation of particulates.

(3) Combustibles. All combustible radioactive wastes shall be reduced to a noncombustible form unless it can be demonstrated that a fire involving a single package will not compromise the integrity of other packages, adversely affect any safety-related structures, systems, or components important to safety, or adversely affect the performance of the underground facility.

(d) Waste package requirements for HLW.

HLW package design shall meet the following specific requirements:

(1) Explosive, pyrophoric, and chemically reactive materials. The waste package shall not contain explosive or pyrophoric materials or chemically reactive materials in an amount that could interfere with operations in the underground facility or compromise the ability of the geologic repository to satisfy the performance objectives of §§ 60.111, 60.112, and 60.113.

(2) Free liquids. The waste package shall not contain free liquids in an amount that could adversely affect the performance of waste packages under § 60.112(b) (because of chemical interactions or formation of pressurized vapor) or result in spillage and spread of contamination in the event of package perforation during the period through permanent closure.

(3) Handling. Waste packages shall be designed to maintain waste containment during transportation, emplacement, and retrieval.

(4) Unique identification. A label or other means of identification shall be provided for each package. The identification shall not impair the integrity of the package and shall be applied in such a way that the information shall be legible at least to the end of

the period of retrievability. Each package identification shall be consistent with the package's permanent written records.

PERFORMANCE COMFIRMATION REQUIREMENTS

§ 60.137 General requirements for performance confirmation.

The geologic repository operations area shall be designed so as to permit implementation of a performance confirmation program that meets the requirements of Subpart F of this part.

SUBPART F - PERFORMANCE CONFIRMATION PROGRAM

§ 60.140 General requirements.

(a) The performance confirmation program shall provide data which indicates, where possible, whether--

(1) Actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the licensing review; and

(2) Natural and engineered systems and components required for repository operation, or which are designed or assumed to operate as barriers after permanent closure, are functioning as intended and anticipated.

(b) The program shall be started during site characterization and it will continue until permanent closure.

(c) The program shall include in situ monitoring, laboratory and field testing, and in situ experiments, as may be appropriate to accomplish the objective as stated above.

(d) The program shall be implemented so that:

(1) It does not adversely affect the natural and engineered elements of the geologic repository to a significant degree.

(2) It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities.

(3) It monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a geologic repository.

(4) It provides an established plan for feedback and analysis of data, and implementation of appropriate action.

§ 60.141 Assessment of geotechnical and design parameters.

(a) During repository construction and operation, a continuing program of surveillance, measurement, testing, and geologic mapping shall be conducted to ensure that geotechnical and design parameters are confirmed and to ensure that appropriate action is taken to inform the Commission of changes needed in design to accommodate actual field conditions encountered.

(b) Subsurface conditions shall be monitored and evaluated against design assumptions.

(c) As a minimum, measurements shall be made of rock deformations and displacement, changes in rock stress and strain, rate and location of water inflow into subsurface areas, changes in groundwater conditions, rock pore water pressures including those along fractures and joints, and the thermal and thermomechanical response of the rock mass as a result of development and operations of the geologic repository.

(d) These measurements and observations shall be compared with the original design bases and assumptions. If significant differences exist between the measurements and observations and the original design bases and assumptions, the need for modifications to the design or in construction methods shall be determined and these differences and the recommended changes reported to the Commission.

(e) In situ monitoring of the thermomechanical response of the underground facility shall be conducted until permanent closure to ensure that the performance of the natural and engineering features are within design limits.

§ 60.142 Design testing.

(a) During the early or developmental stages of construction, a program for in situ testing of such features as borehole and shaft seals, backfill, and the thermal interaction effects of the waste packages, backfill, rock, and groundwater shall be conducted.

(b) The testing shall be initiated as early as is practicable.

(c) A backfill test section shall be constructed to test the effectiveness of backfill placement and compaction procedures against design requirements before permanent backfill placement is begun.

(d) Test sections shall be established to test the effectiveness of borehole and shaft seals before full-scale operation proceeds to seal boreholes and shafts.

§ 60.143 Monitoring and testing waste packages.

(a) A program shall be established at the repository for monitoring the condition of the waste packages. Packages chosen for the program shall be representative of those to be emplaced in the repository.

(b) Consistent with safe operation of the repository, the environment of the waste packages selected for the waste package monitoring program shall be representative of the emplaced wastes.

(c) The waste package monitoring program shall include laboratory experiments which focus on the internal condition of the waste packages. To the extent practical, the environment experienced by the emplaced waste packages within the repository during the waste package monitoring program shall be duplicated in the laboratory experiments.

(d) The waste package monitoring program shall continue as long as practical up to the time of permanent closure.

SUBPART G - QUALITY ASSURANCE

§ 60.150 Scope.

As used in this part, "quality assurance" comprises all those planned and systematic actions necessary to provide reasonable assurance that the repository and its subsystems or components will perform satisfactorily in service. Quality assurance includes quality control, which comprises those quality assurance actions related to the physical characteristics of a material, structure, component, or system which provide a means to control the quality of the material, structure, component, or system to predetermined requirements.

§ 60.151 Applicability.

The quality assurance program applies to all systems, structures and components important to safety, to design and characterization of barriers required to satisfy the performance objectives for the period after permanent closure, and to activities which would prevent or mitigate events that could cause an undue risk to the health and safety of the public and to the performance confirmation program. These activities include: site characterization, facility and equipment construction, facility operation, permanent closure, and decontamination and dismantling of surface facilities. Construction comprises all those activities that are required to build a repository.

§ 60.152 Implementation.

DOE shall implement a quality assurance program based on the criteria of Appendix B of 10 CFR Part 50 as applicable, and appropriately supplemented by additional criteria as required by § 60.151.

SUBPART H - TRAINING AND CERTIFICATION OF PERSONNEL

§ 60.160 General requirements.

Operations that have been identified as important to safety in the Safety Analysis Report and in the license shall be performed only by trained and certified personnel or by personnel under the direct visual supervision of an individual with training and certification in such operation. Supervisory personnel who direct operations that are important to safety must also be certified in such operations.

§ 60.161 Training and certification program.

The DOE shall establish a program for training, proficiency testing, certification and requalification of operating and supervisory personnel.

§ 60.162 Physical requirements.

The physical condition and the general health of personnel certified for operations that are important to safety shall not be such as might cause operational errors that could endanger the public health and safety. Any condition which might cause impaired judgment or motor coordination must be considered in the selection of personnel for activities that are important to safety. These conditions need not categorically disqualify a person, so long as appropriate provisions are made to accommodate the defect.

SUBPART I - EMERGENCY PLANNING CRITERIA

[RESERVED]

Dated at Washington, D.C., this __________day ____ of ____, 1982.

For the Nuclear Regulatory Commission.

Samuel J. Chilk
Secretary of the Commission

ENCLOSURE B

NUCLEAR REGULATORY COMMISSION

10 CFR Part 60

Disposal of High-Level Radioactive Wastes in Geologic Repositories

AGENCY: Nuclear Regulatory Commission.

ACTION: Proposed rule.

SUMMARY: The NRC is publishing proposed amendments which specify technical criteria for disposal of high-level radioactive wastes (HLW) in geologic respositories. The proposed criteria address siting, design, and performance of a geologic repository, and the design and performance of the package which contains the waste within the geologic repository. Also included are criteria for montoring and testing programs, performance confirmation, quality assurance, and personnel training and certification. The proposed criteria are necessary for the NRC to fulfill its statutory obligations concerning the licensing and regulating of facilities used for the receipt and storage of high-level radioactive waste.

DATE: Comments received after November 5, 1981 will be considered if it is practical to do so, but assurance of consideration cannot be given except for comments received on or before this date.

ADDRESS: Written comments or suggestions on the proposed amendments should be sent to the Secretary of the Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch. Copies of comments may be examined in the U.S. Nuclear Regulatory Commission Public Document Room, 1717 H Street NW, Washington, D.C. Comments may also be delivered to Room 1121, 1717 H Street NW, Washington, D.C., between 8.15 a.m. and 5:00 p.m.

FOR FURTHER INFORMATION CONTACT: Frank J. Arsenault, Director of the Division of Health, Siting and Waste Management, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Telephone (301) 427-4350.

SUPPLEMENTARY INFORMATION:

Background

On December 6, 1979 the Nuclear Regulatory Commission (Commission or NRC) published for comment proposed procedures for licensing geologic disposal of high-level radioactive wastes. The licensing procedures were published in final form on February 25, 1981 (46 FR 13971). On May 13, 1980 (45 FR 31393) the Commission published for comment an Advance Notice of Proposed Rulemaking (ANPR) concerning technical criteria for regulating disposal of high-level radioactive wastes (HLW) in geologic respositories. Included with the advance notice was a draft of the technical criteria under development by the staff. The public was asked to provide comment on several issues discussed in the advance notice and to reflect on the draft technical criteria in light of that discussion. The comments received were numerous and covered the full range of issues related to the technical criteria. The technical criteria being proposed here are the culumination of a number of drafts, and were developed in light of the comments received on the ANPR. It is the Commissions's belief that the regulation proposed here is one which is both practical for licensing and this notice provides a flexible vehicle for accommodating comments in that it points out alternatives and calls for comment in a number of critical plans. The Commission has prepared an analysis of the comments which explains the changes made from the ANPR, and intends to publish soon the comments and the analysis as a NUREG document. A draft of this NUREG has been placed in the Commission's Public Document Room for review. In addition, the staff has begun a program to develop guidance as to the methods that it regards as satisfactory for demonstrating compliance with the requirements of the proposed rule.

ENCLOSURE B

The technical criteria being set forth here as proposed rulemaking are a result of the Commission's further effort in regulating geologic disposal of HLW by the Department of Energy (DOE). The rationale for the performance objectives and the Environmental Impact Assessment supporting this rulemaking are also being published separately and are available free of charge upon written request to Frank Arsenault at the above address. In developing these criteria we have not reexaminated DOE's programmatic choice of disposal technology resulting from its Generic Environmental Impact Statement, inasmuch as the Commission has expressly reserved until a later time possible consideration of matters within the scope of that generic statement (44 FR 70408). Accordingly, the technical criteria apply only to disposal in geologic respositories and do not address other possible or potential disposal methods. Similarly, in that DOE's current plans call for dispoal at sufficient depth to be in the area termed the saturated zone, these criteria were developed for disposal in saturated media. Additional or alternative criteria may need to be developed for regulating disposal in the unsaturated or vadose zone.

Authority

Sections 202 (3) and (4) of the Energy Reorganization Act of 1974, as amended, provide the Commission with licensing and regulatory authority regarding DOE facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under the Atomic Energy Act and certain other long-term HLW storage facilities of DOE. Pursuant to that authority, the Commission is developing criteria appropriate to regulating geologic disposal of HLW by DOE. The requirements and criteria contained in this proposed rule are a result of that effort.

Relation to Generally Applicable Standards for Radiation in the Environment Established by the Environmental Protection Agency

The Environmental Protection Agency (EPA) has the authority and responsibility for setting generally applicable standards for radiation in the environment. It is the responsibility of the NRC to implement those standards in its licensing actions and assure that public health and safety are protected. Although no EPA standard for disposal of HLW yet exists, these proposed technical criteria for regulating geologic disposal of HLW have been developed to be compatible with a generally applicable environmental standard. Specifically, the performance objectives and criteria speak to the functional elements of geologic disposal of HLW and the analyses required to give confidence that these functional elements will perform as intended.

Disruptive Processes and Events

The NRC's implementing regulations assume that licensing decisions will be based, in part, on the results of analysis of the consequences of processes and events which potentially could disrupt a repository. Thus, throughout the criteria are requirements that the design basis take into account processes and events with the potential to disrupt a geologic repository. If the process or event is anticipated, i.e., likely, then the design basis requires barriers which would not fail in a way that would result in the repository not meeting the performance objectives. Anticipated processes and events would include such items as waste/rock interactions that result from emplacement of the wastes or the gradual deterioration of borehole seals. If the process or event is unlikely, then the overall system must still limit the release of radionuclides consistent with the EPA standard as applied to such events. An example of an unlikely event would be reactivation of a fault within the geologic setting which had not exhibited movement since the start of the Quaternary Period. In general, both likely and unlikely processes and events are expected to be site and design specific and would be identified by DOE in its license application.

Multiple Barriers

The proposed technical criteria were developed not only with the understanding that EPA's generally applicable environmental standard would need to be implemented, at least in part, by performing calculations to predict performance, but also with the knowledge that some of those calculations would be complex and uncertain. Natural systems are difficult to characterize and any understanding of the site will have significant limitations and uncertainties. Those properties which pertain to isolation of HLW are difficult to measure and the measurements which are made will be subject to several sources of error and uncertainty. The physical and chemical processes which isolate the wastes are themselves varied and complex. Further, those processes are especially difficult to understand in the area close to the emplaced wastes because that area is physically and chemically disturbed by the heat generated by those wastes.

However, a geologic repository consists of engineered features as well as the natural geologic environment. Any evaluation of repository performance, therefore, will consider the waste form and other engineering factors which are elemental to the performance of the repository as a system. By partitioning the engineered system into two major barriers, the waste package and the underground facility, and establishing performance objectives for each, the Commission has sought to exploit the ability to design the engineered features to meet specific performance objectives as a means of reducing some of the uncertainties in the calculations of overall repository performance.

In addition, the requirements for containment, controlled release rate, and 1,000-year groundwater transit time are three criteria which act independently of the overall repository performance to provide confidence that the wastes will be isolated at least for as long as they are most hazardous.

Containment and Isolation

During the first several hundred years following emplacement of the wastes, both the radiation from and the heat generated by the wastes are attributable mainly to the decay of the shorter-lived nuclides, primarily fission products. At about 1,000 years after emplacement both the radiation from and heat generated by decay of the wastes have diminished by about 3 orders of magnitude. As the decay of the longer-lived nuclides, primarily actinides, begins to dominate, both the radiation from and thermal output of the wastes continue to fall until almost 100,000 to 1,000,000 years after emplacement. By that time both have diminished by about 5 orders of magnitude and both heat and radiation become roughly constant due to the ingrowth of daughter nuclides, primarily Ra-225, Ra-226 and their decay products.

The technical criteria would require the engineered system to be designed so that the wastes are contained within the waste package for the first thousand years following emplacement. Following this period, containment is no longer assumed and the function of the waste package and underground facility is to control the release of radionuclides from the underground facility. By requiring containment during the period when the thermal conditions around the waste packages are most severe, evaluation of repository performance is greatly simplified to considerations of the degree of conservatism in the containment design relative to events and processes that might affect the performance during the containment period.

Although both the radiation from and heat generated by the decay of the wastes have diminished about 3 orders of magnitude during the containment period, the area surrounding the emplaced wastes will not return to temperatures near those before the wastes were emplaced until after about 10,000 years. As mentioned earlier, the thermal disturbance of the area near the emplaced wastes adds significantly to the uncertainties in the calculation of the transport of the radionuclides through the geologic environment. The technical criteria are intended to compensate for uncertainties by imposing further design requirements on the waste package and underground facility, thereby limiting the source term by controlling the release rate.

Role of the Site

The Commission neither intends nor expects either containment to be lost completely at 1,000 years following emplacement or the engineered system's contribution to the control of the release of wastes to cease abruptly at some later time. However, the Commission recognizes that at some point the design capabilities of the engineered system will be lost and that the geologic setting—the site—must provide the isolation of the wastes from the environment, and has translated this requirement into a performance objective for the geologic setting. The Commission also recognizes that isolation is, in fact, a controlled release to the environment which could span many thousands of years, and that the release of radionuclides and the potential exposures to individuals which could result, should be addressed in the evaluation of a repository. A complement to the evaluation of the effects of design basis processes and events which might disrupt the repository is a projection of how the repository, unperturbed by discrete external events, will evolve through the centuries as a result of the geologic processes operating at the site. Hence, an amendment is being proposed to that portion of Subpart B of 10 CFR Part 60 which describes the contents of the Safety Analysis Report of DOE's application for geologic disposal of HLW which would require DOE to project the expected performance of the proposed geologic repository noting the rates and quantities of expected releases of radionuclides to the accessible environment as a function of time.

Retrievability

The licensing procedures of 10 CFR Part 60 were written assuming that there would be a program of testing and measurement of the thermal, mechanical, and chemical properties of the major engineered barriers to confirm their expected performance. The Commission would like to tie the requirement for retievability of the wastes to the expected time needed to execute the performance confirmation program. However, at present it appears to the Commission that neither the specific nature nor the period needed for execution of the performance confirmation program will be certain until construction of the repository is substantially complete: that is, until the actual licensing to receive wastes at a geologic repository. Hence it is difficult at this time to use the performance confirmation program as a basis for establishing a period of retrievability. Nonetheless, DOE is now making critical decisions regarding the design of geologic repositories which will have a direct effect upon how long the optio to retrieve wastes can be maintained, and upon the difficulty which will be encounted in exercising that option, should that be necessary for protection of public health and safety. Therefore, to provide a suitable objective in this regard, the proposed rule sets forth a requirement that the engineered system be designed so that the option to retrieve the waste can be preserved for up to fifty years following completion of emplacement. Thus, the waste package and the underground facility would be designed so that the period of retrievability would not be the determinant of when the Commission would decide to permit closure of the repository. Rather, the Commission would be assured of the option to let the conduct of the performance confirmation program indicate when it is appropriate to make such a decision. In particular, the Commission is concerned that the thermo-mechanical design of the underground facility be such that access can be maintained until the Commission either decides to permit permanent closure of the repository or to take corrective action, which may include retrieval.

As it is now structured, the rule would require in effect that the repository design be such as to permit retrieval of waste packages for a period of up to 110 years. The components of this total period are as follows: the first waste packages to go in the repository are likely to be in place about thirty years before all wastes are in place; thereafter, a 50-year period is required by the rule; finally, a retrieval schedule is suggested of about the same time as the original construction plus emplacement operations—another 30-odd years. Since it is probably not practical to adjust the retrievability design aspects of the repository according to the order of emplacement of the waste packages, the 110-year requirement will apply to all of the waste. The Commission is particularly interested in comments on the degree to which this requirement will govern the thermal and mechanical design of the repository and on whether some shorter period would be adequate or whether there are other ways than an overall retrievability requirement to preserve options before permanent closure. The Commission does not want to approve construction of a design that will foreclose unnecessarily options for future decisionmakers, but it is also concerend that retrievability requirements not unnecessarily complicate or dominate repository design.

The retrievability requirement does not specify the form in which the wastes are to be retrievable or that wastes are "readily retrievable." The requirement is simply that all the wastes be retrievable during a period equal to the period of construction and emplacement. DOE's plans for retrieval are specifically requested as part of its license application and the practicability of its proposal will be considered by the Commission. Waste may be retrieved upon NRC approval of a DOE application or upon order by NRC, or otherwise, where authorized by DOE's license.

Human Intrusion

Some concern has been raised on the issue of human intrusion into a geologic repository. Human intrusion could conceivably occur either inadvertently or deliberately. Inadvertent intrusion is the accidental breaching of the repository in the course of some activity unrelated to the existence of the repository, e.g., exploration for or development of resources. For inadvertent intrusion to occur, the institutional controls, site markers, public records, and societal memory of the repository's existence must have been ineffective or have ceased to exist. Deliberate or intentional intrusion, on the other hand, assumes a conscious decision to breach the repository; for example, in order to recover the high-level waste itself, or exploit a mineral associated with the site.

Historical evidence indicates that there is substantial continuity of information transfer over time. There are numerous examples of knowledge, including complex information, being preserved for thousands of years. This has occurred even in the absence of printing and modern information transfer and storage systems. Furthermore, this information transfer has survived disruptive events, such as wars, natural disasters, and dramatic changes in the social and political fabric of societies. The combination of the historical record of information transfer, provisions for a well-marked and extensively documented site location, and the scale and technology of the operation needed to drill deeply enough to penetrate a geologic repository argue strongly that inadvertent intrusion as described above is highly improbable, at least for the first several hundred years during which time the wastes are most hazardous. Selecting a site for a repository which is unattractive with respect to both resource value and scientific interest further adds to the improbability of inadvertent human intrusion. It is also logical to assume that any future generation possessing the technical capability to locate and explore for resources at the depth of a repository would also possess the capability to assess the nature of the material discovered, to mitigate consequences of the breach and to reestablish administrative control over the area if needed. Finally, it is inconsistent to assume the scientific and technical capability to identify and explore an anomalous heat source several hundred meters beneath the Earth's surface and not assume that those exploring would have some idea of either what might be the cause of the anomaly or what steps to take to mitigate any untoward consequence of that exploration.

The above arguments do not apply to the case of deliberate intrusion. The repository itself could be attractive and invite intrusion simply because of the resource potential of the wastes themselves. Intrusion to recover the wastes demands (1) knowledge of the existance and nature of the repository, and (2) effort of the same magnitude as that undertaken to emplace the wastes. Hence intrusion of this sort can only be the result of a conscious, collective societal decision to recover the wastes.

Intrusion for the purpose of sabotage or terrorism has also been mentioned as a possibility. However, due to the nature of geologic disposal, there seems to be very little possibility that terrorists or saboteurs could breach a repository. Breach of the repository would require extensive use of machinery for drilling and excavating over a considerable period of time. It is highly improbable that a terrorist group could accomplish this covertly.

In light of the above, the Commission adopted the position that commonsense dictates that everything that is reasonable be done to discourage people from intruding into the repository. Thus, the proposed technical criteria are written to direct site selection towards selection of sites of little resource value and for which there does not appear to be any attraction for future societies. Further, the proposed criteria would require reliable documentation of the existence and location of the repository and the nature of the wastes emplaced therein, including marking the site with the most permanent markers practical. However, once the site is selected, marked, and documented, it does no use to argue over whether these measures will be adequate in the future, or to speculate on the virtual infinity of human intrusion scenarios and whether they will or will not result in violation of the EPA standard. Of course, the Commission recognizes that there are alternative approaches to the Human Intrusion question. Accordingly, comment on this and alternative approaches is welcome.

Relation to Other Parts of NRC Regulations

The proposed rule contemplates that DOE activities at a geologic repository operations area may in appropriate cases be licensed under other parts of NRC regulations and would then not be governed by these technical criteria. We note, in this connection, that the scope section of the procedural rule specifically provides that Part 60 shall not apply to any activity licensed under another part. This allows an independent spent fuel storage installation to be licensed under Part 72, even though located at a geologic repository operations area (provided, of course, it is sufficiently separate to be classified as "independent"). Other DOE activities of the geologic repository operations area could be licensed under Parts 30 or 70 if an exemption from Part 60 is determined to be appropriate.

Alternative Approach

In the course of the Commission's deliberation, it becomes evident that in order to have confidence in the ability of a geological repository to contain and isolate the wastes for an extended period of time, the repository must consist of multiple barriers. In view of the uncertainties that attach to reliance on the geologic setting alone, the Commission believes that a repository should consist of two major engineered barriers (waste packages and underground facility) in addition to the natural barrier provided by the geological setting. The Commission is emphasizing these elements to take advantage of the opportunity to attain greater confidence in the isolation of the waste. Having reached these conclusions, the Commission considers next whether or not and to what level of detail the performance criteria for a geological repository should be prescribed. In this regard the Commission considers the following 3 alternatives:[1]

1. Prescribe a single overall performance standard that must be met. The standard in this case would be the EPA standard;

2. Prescribe minimum performance standards for each of the major elements, in addition to requiring the overall system to meet the EPA standards; and

3. Prescribe detailed numerical criteria on critical engineering attributes of the repository system.

Alternative 3 is considered overly restrictive on the design flexibility and judged to be inappropriate at this stage of technological development. Therefore, this alternative is quickly eliminated as a viable regulatory approach.

Alternative 1 has as its principal advantage the fact that it provides maximum flexibility in apportioning credit for containment and isolation to the several elements of the repository. It also allows the designer to incorporate and apply new technological developments and knowledge from the site characterization phase to the repository design. Notwithstanding some concern over its practicality in the regulatory framework, the Commission cannot at this time eliminate it from further consideration. The Commission is, therefore, specifically requesting the general public, particularly those from the technical communities, to comment on this point. In addition, the Commission requests commentors espousing this alternative to address specifically ways in which the Commission might find reasonable assurance that the ultimate standards

[1] Detailed discussions on the advantages and disadvantages of each of these alternatives are given in Appendix J to Commission Paper SECY-81-287, April 27, 1981, "Rationale for Performance Objectives and Required Characteristics of the Geologic Setting." This appendix is being published separately and is available without charge on request to the Commission's Public Document Room, 1717 H St. NW, Washington, D.C. 20555.

are met without prescribing standards for the major elements of a repository.

In relation to the first and the third alternatives that are briefly discussed above, Alternative 2 appears to offer a reasonable and practical compromise. In addition to retaining the single overall performance standard in Alternative 1 as the final performance objective, this approach establishes the minimum performance objectives for each of the 3 major barriers of the repository. While this approach limits the repository designer's flexibility, it is clear that meeting these minimum design goals would substantially enhance the Commission's confidence that the final EPA standard will be met. Therefore, the Commission prefers a technical rule established upon this approach.

It should be noted that, in the event that the Commission decides to adopt the Alternate 1 approach in the final rulemaking, portions of the proposed rule (e.g., the section on requirements for the geological setting) would have to be further studied and possibly revised. In addition, it is possible that further public comments would have to be sought.

Major Features of the Proposed Rule

1. *Overall Description.* The proposed technical criteria have been written to address the following: performance objectives and requirements for siting, design and construction of the repository, the waste package, confirmation of repository performance, quality assurance, and the training and certification of personnel. As appropriate, these topics are divided in turn to address separately requirements which apply during construction, waste emplacement, and after permanent closure (decommissioning) of the repository. Although the licensing procedures indicate that there would be separate subparts for siting and design requirements, viz. Subparts E and F, respectively (cf. § 60.31(a)(2)), the NRC now believes that the site and design are so interdependent that such a distinction is artificial and misleading. For example, although the requirement to place the underground facility at a minimum depth of 300 meters is clearly a design requirement, it is manifested as a siting requirement since unless the site has a host rock of sufficient thickness at sufficient depth, the above design requirement cannot be met. Hence the proposed Subpart E to 10 CFR Part 60 contains both site and design requirements.

To enable the Commission to reach a finding as to whether the generally applicable environmental standard for disposal of HLW is met and that public health and safety will be protected, a careful and exhaustive analysis of all the features of the repository will be needed. That analysis necessarily must be both qualitative and quantitative although the analysis can and will be largely quantitative during the period that greatest reliance can be placed upon the engineered system. Thereafter, although the issues of concern, and certainly the physics of a repository itself, do not change, the numerical uncertainties begin to become so large that calulations become a weak indicator of expected repository performance.

In sum, the technical criteria perform two tasks. First they serve to guide DOE in siting, designing, constructing, and operating a repository in such a manner that there can be reasonable confidence that public health and safety will be protected. Second, they serve to guide DOE in those same areas in such a manner that there can be reasonable confidence that the analyses, needed to determine whether public health and safety is protected, can be performed.

2. *Performance Objectives.* The design and operation of the repository are prescribed to be such that during the period that wastes are being emplaced and performance assessed, exposure to workers and releases of radioactivity to the environment must be within limits set by the Commission and the EPA. Further, the repository is to be designed so that the option can be preserved to retrieve the emplaced wastes beginning at anytime up to 50 years following completion of emplacement. Following permanent closure, the repository must perform so that releases are within the limits prescribed by the generally applicable environmental standard which will be set by the EPA. Further, the design of the repository must include a waste package and an underground facility, as well as the site, as barriers to radionuclide migration.

The performance of the engineered system (waste package and underground facility) following permanent closure is specified to require containment of the wastes within the waste package for at least 1000 years following closure, when temperatures in the repository are substantially elevated, and control of the release of nuclides to the geologic environment thereafter.

Transuranic waste (TRU) may be disposed of in a geologic repository. Since transuranic waste does not generate significant amounts of heat, there is no advantage to containment for any specified period. Hence, the requirement for TRU waste is simply a controlled release equivalent to that for HLW, provided they are physically separted from the HLW so that they will not experience a significant increase in temperature.

Although a minimum 1,000-year containment and a maximum one part in 100,000 release rate will satisfy these criteria, the Commission considers it highly desirable that wastes be contained as long thereafter as is reasonably achievable, and that release rates be as far below one part in 100,000 as is reasonably achievable.

3. *Siting Requirements.* Although no specific site suitability or exclusion requirements are given in the criteria, stability and minimum groundwater travel times are specified as required site characteristics. ALARA (as low as reasonably achievable) principles have not been applied to the natural features of a site because they are not amenable to modification once a site is chosen. However, the technical criteria do identify site characteristics considered favorable for a repository as well as characteristics which, if present at the site, may compromise site suitability and which will require careful analysis and such measures as may be necessary to compensate for them adequately. The impact of these characteristics on overall performance would be site specific. Thus, the Commission has judged that these should not be made absolute requirements. Presence of all the favorable characteristics does not lead to the conclusion that the site is suitable to host a repository. Neither is the presumption of unsuitability because of the presence of an unfavorable characteristic incontrovertible. Rather, the Commission's approach requires a sufficient combination of conditions at the selected site to provide reasonable assurance that the performance objectives will be achieved. If adverse conditions are identified as being present, they must be thoroughly charaterized and analyzed and it must be demonstrated that the conditions are compensated for by repository design or by favorable conditions in the geologic setting.

The Commission has not included any siting requirements which directly deal with population density or proximity to population centers. Rather, the issue has been addressed indirectly through consideration of resources in the geologic setting. The Commission believes this to be a more realistic approach given the long period of time involved with geologic disposal. Nonetheless, the Commission invites comment on whether population related siting requirements should be included in the final rule and how they might be implemented.

4. *Design and Construction.* In addition to the requirements on designing for natural phenomena, criticality control, radiation protection, and effluent control, the proposed technical criteria require the design of the repository to accommodate potential interaction of the waste, the underground facility, and the site. Requirements are also placed upon the design of the equipment to be used for handling the wastes, the performance and purpose of the backfill material, and design and performance of borehole and shaft seals. Further, there are requirements related to the methods of construction. The Commission believes such requirements are necessary to assure that the ability of the repository to contain and isolate the wastes will not be compromised by the construction of the repository.

The proposed technical criteria would require that the subsurface facility be designed so that it could be constructed and operated in accordance with relevant Federal mining regulations, which specify design requirements for certain items of electrical and mechanical equipment and govern the use of explosives.

These criteria are a blend of general and detailed prescriptive requirements. They have been developed from Commission experience and practice in the licensing of other nuclear facilities such as power plants and fuel cycle facilities. While there are differences in the systems and components addressed by these criteria from those of power plants or fuel cycle facilities, and the criteria have been written to be appropriate for a geologic repository, the proposed criteria represent a common practice based on experience which has shown that the above items need to be regulated. The level of detail of these criteria reflects the Commission's current thinking on how to regulate effectively geologic disposal of HLW. However, the Commission continues to examine other possibilities for promulgating the more detailed of these requirements. Comments are invited on formulations for the design and construction criteria in the rule, perhaps in a more concise form; these may be supplemented, of course, with more details in staff guidance documents such as Regulatory Guides.

5. *Waste Package.* The proposed requirements for the design of the waste package emphasize its role as a key component of the overall engineered system. Besides being required to contribute to the engineered system's meeting containment and controlled release performance objectives, both compatibility with the underground facility and the site and a method of unique identification are required of the waste package. Included in the section of the proposed technical criteria which deals with the waste package are requirements that the waste form itself contained within the package be consolidated and non-pyrophoric.

6. *Performance Confirmation.* The proposed technical criteria include requirements for a program of testing and measurement (Subpart F). The main purpose of this program is to confirm the assumptions, data, and analyses which led to the findings that permitted construction of the repository and subsequent emplacement of the wastes. Further, the performance confirmation program includes requirements for monitoring of key geologic and hydrologic parameters throughout site characterization, construction, and emplacement to detect any significant changes in the conditions which supported the above findings during, or due to operations at the site. Also included in the program would be tests of the effectiveness of borehole and shaft seals and of backfill placement procedures.

Regulatory Flexibility Certification

In accordance with the Regulatory Flexibility Act of 1980, 5 U.S.C. 605(b), the Commission hereby certifies that this rule will not, if promulgated, have a significant economic impact on a substantial number of small entities. This proposed rule affects only the Department of Energy, and does not fall within the purview of the Act.

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, the National Environmental Policy Act of 1969, as amended, and sections 552 and 553 of title 5 of the United States Code, notice is hereby given that adoption of the following amendments to Title 10, Chapter I, Code of Federal Regulations is contemplated.

PART 60—DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES

1. The authority citation for Part 60 reads as follows:

Authority: Secs. 51, 53, 62, 63, 65, 81, 161b., i., o., p., 182, 183, Pub. L. 83-703, as amended, 68 Stat. 929, 930, 932, 933, 935, 948, 953, 954, as amended (42 U.S.C. 2071, 2073, 2092, 2093, 2095, 2111, 2201, 2232, 2233); Secs. 202, 206, Pub. L. 93-438, 88 Stat. 1244, 1246 (42 U.S.C. 5842, 5846); Sec. 14, Pub. L. 95-601 (42 U.S.C. 2021a); Sec. 102(2)(c), Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332)

2. Section 60.2 is revised to read as follows:

§ 60.2 Definitions.

For the purposes of this Part—

"Accessible Environment" means those portions of the environment directly in contact with or readily available for use by human beings.

"Anticipated Processes and Events" means those natural processes and events that are reasonably likely to occur during the period the intended performance objective must be achieved and from which the design bases for the engineered system are derived.

"Barrier" means any material or structure that prevents or substantially delays movement of water or radionuclides.

"Candidate area" means a geologic and hydrologic system within which a geologic repository may be located.

"Commencement of construction" means clearing of land, surface or subsurface excavation, or other substantial action that would adversely affect the environment of a site, but does not include changes desirable for the temporary use of the land for public recreational uses, site characterization activities, other preconstruction monitoring and investigation necessary to establish background information related to the suitability of a site or to the protection of environmental values, or procurement or manufacture of components of the geologic repository operations area.

"Commission" means the Nuclear Regulatory Commission or its duly authorized representatives.

"Containment" means the confinement of radioactive waste within a designated boundary.

"Decommissioning," or "permanent closure," means final backfilling of subsurface facilities, sealing of shafts, and decontamination and dismantlement of surface facilities.

"Director" means the Director of the Nuclear Regulatory Commission's Office of Nuclear Material Safety and Safeguards.

"Disposal" means the isolation of radioactive wastes from the biosphere.

"Disturbed zone" means that portion of the geologic setting that is significantly affected by construction of the subsurface facility or by the heat generated by the emplacement of radioactive waste.

"DOE" means the U.S. Department of Energy or its duly authorized representatives.

"Engineered system" means the waste packages and the underground facility.

"Far field" means the portion of the geologic setting that lies beyond the disturbed zone.

"Floodplain" means the lowland and relatively flat areas adjoining inland and coastal waters including flood prone areas of offshore islands and including at a minimum that area subject to a one percent or greater chance of flooding in any given year.

"Geologic repository" means a system for the disposal of radioactive wastes in excavated geoligic media. A geologic repository includes (1) the geologic repository operations area, and (2) the geologic setting.

"Geologic repository operations area" means an HLW facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted.

"Geologic setting" or "site" is the spatially distributed geologic, hydrologic, and geochemical systems that provide isolation of the radioactive waste.

"High-level radioactive waste" or "HLW" means (1) irradiated reactor fuel, (2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted.

"HWL facility" means a facility subject to the licensing and related regulatory authority of the Commission pursuant to Sections 202(3) and 202(4) of the Energy Reorganization Act of 1974 (88 Stat. 1244).[2]

"Host rock" means the geologic medium in which the waste is emplaced.

"Important to safety," with reference to structures, systems, and components, means those structures, systems, and components that provide reasonable assurance that radioactive waste can be received, handled, and stored without undue risk to the health and safety of the public.

"Indian Tribe" means an Indian tribe as defined in the Indian Self-Determination and Education Assistance Act (Public Law 93–638).

"Isolation" means inhibiting the transport of radioactive material so that amounts and concentrations of this material entering the accessible environment will be kept within prescribed limits.

[2]These are DOE "facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under such act (the Atomic Energy Act)" and "Retrievable Surface Storage Facilities and other facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive wastes generated by (DOE), which are not used for, or are part of, research and development activities."

"Medium" or "geologic medium" is a body of rock characterized by lithologic homogeneity.

"Overpack" means any buffer material, receptacle, wrapper, box or other structure, that is both within and an integral part of a waste package. It encloses and protects the waste form so as to meet the performance objectives.

"Public Document Room" means the place at 1717 H Street NW., Washington, D.C., at which records of the Commission will ordinarily be made available for public inspection and any other place, the location of which has been published in the Federal Register, at which public records of the Commission pertaining to a particular geologic repository are made available for public inspection.

"Radioactive waste" or "waste" means HLW and any other radioactive materials other than HLW that are received for emplacement in a geologic repository.

"Site" means the geologic setting.

"Site characterization" means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a particular site relevant to the procedures under this part. Site characterization includes borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings, and in situ testing at depth needed to determine the suitability of the site for a geologic respository, but does not include preliminary borings and geophysical testing needed to decide whether site characterization should be undertaken.

"Stability" means that the nature and rates of natural processes such as erosion and faulting have been and are projected to be such that their effects will not jeopardize isolation of the radioactive waste.

"Subsurface facility" means the undergound portions of the geologic repository operations area including openings, backfill materials, shafts and boreholes as well as shaft and borehole seals.

"Transuranic wastes" or "TRU wastes" means radioactive waste containing alpha emitting transuranic elements, with radioactive half-lives greater than five years, in excess of 10 nanocuries per gram.

"Tribal organization" means a Tribal organization as defined in the Indian Self-Determination and Education Assistance Act (Public Law 93–638).

"Underground facility" means the undergound structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals.

"Unrestricted area" means any area, access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

"Waste form" means the radioactive waste materials and any encapsulating or stabilizing materials, exclusive of containers.

"Waste package" means the airtight, watertight, sealed container which includes the waste form and any ancillary enclosures, including shielding, discrete backfill and overpacks.

3. Section 60.10 is revised to read as follows:

§ 60.10 Site characterization.

(a) Prior to submittal of an application for a license to be issued under this part the DOE shall conduct a program of site characterization with respect to the site to be described in such application.

(b) Unless the Commission determines with respect to the site described in the application that it is not necessary, site characterization shall include a program of in situ exploration and testing at the depths that wastes would be emplaced.

(c) As provided in § 51.40 of this chapter, DOE is also required to conduct a program of site characterization, including in situ testing at depth, with respect to alternative sites.

(d) The program of site characterization shall be conducted in accordance with the following:

(1) Investigations to obtain the required information shall be conducted to limit adverse effects on the long-term performance of the geologic repository to the extent practical.

(2) As a minimum the location of exploratory boreholes and shafts shall be selected so as to limit the total number of subsurface penetrations above and around the underground facility.

(3) To the extent practical, exploratory boreholes and shafts in the geologic repository operations area shall be located where shafts are planned for repository construction and operation or where large unexcavated pillars are planned.

(4) Subsurface exploratory drilling, excavation, and in situ testing before and during construction shall be planned and coordinated with repository design and construction.

4. Paragraphs (c)(1), (c)(3), and (c)(13) of § 60.21 are revised to read as follows:

§ 60.21 Content of application.

* * * * *

(c) The Safety Analysis Report shall include:

(1) A description and assessment of the site at which the proposed geologic repository operations area is to be located with appropriate attention to those features of the site that might affect facility design and performance. The description of the site shall identify the limits of the accessible environment with respect to the location of the geologic repository operations area.

(i) The description of the site shall also include the following information regarding subsurface conditions in the vicinity of the proposed underground facility—

(A) The orientation, distribution, aperture in-filling and origin of fractures, discontinuities, and heterogeneities;

(B) The presence and characteristics of other potential pathways such as solution features, breccia pipes, or other permeable anomalies;

(C) The bulk geomechanical properties and conditions, including pore pressure and ambient stress conditions;

(D) The bulk hydrogeologic properties and conditions;

(E) The bulk geochemical properties; and

(F) The anticipated response of the bulk geomechanical, hydrogeologic, and geochemical systems to the maximum design thermal loading, given the pattern of fractures and other discontinuities and the heat transfer properties of the rock mass and groundwater.

(ii) The assessment shall contain—

(A) An analysis of the geology, geophysics, hydrogeology, geochemistry, and meteorology of the site;

(B) Analyses to determine the degree to which each of the favorable and adverse conditions, if present, has been characterized, and the extent to which it contributes to or detracts from isolation.

(C) An evaluation of the expected performance of the proposed geologic repository noting the rates and quantities of expected releases of radionuclides to the accessible environment as a function of time. In executing this evaluation DOE shall assume that those processes operating on the site are those which have been operating on it during the Quaternary Period and superpose the perturbations caused by the presence of emplaced radioactive waste on the natural processes.

(D) An analysis of the expected performance of the major design structures, systems, and components, both surface and subsurface, that bear significantly on the suitability of the geologic repository for disposal of radioactive waste assuming the anticipated processes and events and natural phenomena from which the design bases are derived. For the purposes of this analysis, it shall be assumed that operations at the geologic repository operations area will be carried out at the maximum capacity and rate of receipt of radioactive waste stated in the application.

(E) An explanation of measures used to confirm the models used to perform the assessments required in paragraphs (A) through (D). Analyses and models that will be used to predict future conditions and changes in the geologic setting shall be confirmed by using field tests, in situ tests, field-verified laboratory tests, monitoring data, or natural analog studies.

* * * * *

(3) A description and analysis of the design and performance requirements for structures, systems, and components of the geologic repository which are important to safety. This analysis shall consider—(i) the margins of safety under normal and conditions that may result from anticipated operational occurrences, including those or natural origin; (ii) the adequacy of structures, systems, and components provided for the prevention of accidents and mitigation of the consequences of accidents, including those caused by natural phenomena; and (iii) the effectiveness of engineered and natural barriers, including barriers that may not be themselves a part of the geologic repository operations area, against the release of radioactive material to the environment. The analysis shall also include a comparative evaluation of alternatives to the major design features that are important to radionuclide containment and isolation, with particular attention to the alternatives that would provide longer radionuclide containment and isolation.

* * * * *

(13) An identification and evaluation of the natural resources at the site, including estimates as to undiscovered deposits, the exploitation of which could affect the ability of the site to isolate radioactive wastes. Undiscovered deposits of resources characteristic of the area shall be estimated by reasonable inference based on geological and geophysical evidence. This evaluation of resources, including undiscovered deposits, shall be conducted for the disturbed zone and for areas of similar size that are representative of and are within the geologic setting. For natural resources with current markets the resources shall be assessed, with estimates provided of both gross and net value. The estimate of net value shall take into account current development, extraction and marketing costs. For natural resources without current markets, but which would be marketable given credible projected changes in economic or technological factors, the resources shall be described by physical factors such as tonnage or other amount, grade, and quality.

* * * * *

5. Paragraph (a)(2) of § 60.31 is revised to read as follows:

§ 60.31 Construction authorization.

* * * * *

(a) * * *

(2) The site and design comply with the criteria contained in Supart E.

* * * * *

6. Paragraph (a)(2) of § 60.51 is revised to read as follows:

§ 60.51 License amendment to decommission.

(a) * * *

(2) a detailed description of the measures to be employed—such as land use controls, construction of monuments, and preservation of record—to regulate or prevent activities that could impair the long-term isolation of emplaced waste within the geologic repository and to assure that relevant information will be preserved for the use of future generations. As a minimum, such measures shall include—

(i) Identification of the geologic repository operations area by monuments that have been designated, fabricated, and emplaced to be as permanent as is practicable; and

(ii) Placement of records of the location of the geologic repository operations area and the nature and hazard of the waste in the archives of local and Federal government agencies, and archives elsewhere in the world, that would be likely to be consulted by potentional human intruders.

* * * * *

7. New Subpart E "Technical Criteria," Subpart F "Performance Confirmation," Subpart G, "Quality Assurance" and Subpart H, "Training and Certification of Personnel" are added to 10 CFR Part 60.

Subpart E—Technical Criteria

Subpart E—Technical Criteria

§ 60.101 Purpose and nature of findings.

(a)(1) Subpart B of this part prescribes the standards for issuance of a license to receive and possess source, special nuclear, or byproduct material at a geologic repository operations area. In particular, § 60.41(c) requires a finding that the issuance of a license will not constitute an unreasonable risk to the health and safety of the public. The purpose of this subpart is to set out performance objectives and site and design criteria which, if satisfied, will support such a finding of no unreasonable risk.

(2) While these performance objectives and criteria are generally stated in unqualified terms, it is not expected that complete assurance that they will be met can be presented. A reasonable assurance, on the basis of the record before the Commission, that the objectives and criteria will be met is the general standard that is required. For § 60.111, and other portions of this subpart that impose objectives and criteria for repository performance over long times into the future, there will inevitably be greater uncertainties. Proof of the future performance of engineered systems and geologic media over time periods of a thousand or many thousands of years is not to be had in the ordinary sense of the word. For such long-term objectives and criteria, what is required is reasonable assurance, making allowance for the time period and hazards involved, that the outcome will be in conformance with those objectives and criteria.

(b) Subpart B of this part also lists findings that must be made in support of an authorization to construct a geologic repository operations area. In particular, § 60.31(a) requires a finding that there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a repository of the design proposed without unreasonable risk to the health and safety of the public. As stated in that paragraph, in arriving at this determination, the Commission will consider whether the site and design comply with the criteria contained in this subpart. Once again, while the criteria may be written in unqualified terms, the demonstration of compliance may take uncertainties and gaps in knowledge into account, provided that the Commission can make the specified finding of reasonable assurance as specified in paragraph (a) of this section.

§ 60.102 Concepts.

(a) *The HLW facility.* NRC exercises licensing and related regulatory authority over those facilities described in section 203 (3) and (4) of the Energy Reorganization Act of 1974. Any of these facilities is designated an *HLW facility.*

(b) *The geologic repository operations area.*

(1) This part deals with the exercise of authority with respect to a particular class of HLW facility—namely a *geologic repository operations area.*

(2) A *geologic repository operations area* consists of those surface and subsurface areas that are part of a geologic repository where radioactive waste handling activities are conducted. The underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals, is designated the *underground facility.*

(3) The exercise of Commission authority requires that the geologic repository operations area be used for *storage* (which includes *disposal*) of *high-level radioactive wastes (HLW).*

(4) HLW includes irradiated reactor fuel as well as reprocessing wastes. However, if DOE proposes to use the geologic repository operations area for storage of *radioactive waste* other than HLW, the storage of this radioactive waste is subject to the requirements of this part. Thus, the storage of *transuranic-contaminated waste (TRU),* though not itself a form of HLW, must conform to the requirements of this part if it is stored in a geologic repository operations area.

(c) *Areas adjacent to the geologic repository operations area.* Although the activities subject to regulation under this part are those to be carried out at the geologic repository operations area, the licensing process also considers characteristics of adjacent areas. First, there is to be an area within which DOE is to exercise specified controls to prevent adverse human actions. Second, there is a larger area, designated the *geologic setting or site* which includes the spatially distributed geologic, hydrologic, and geochemical systems that provide isolation of the radioactive waste from the accessible environment. The geologic repository operations area plus the geologic setting make up the *geologic repository.* Within the geologic setting, particular attention must be given to the characteristics of the host rock as well as any rock units surrounding the host rock.

(d) *Stages in the licensing process.* There are several stages in the licensing process. The *site characterization* stage, though begun before submission of a license application, may result in consequences requiring evaluation in the license review. The *construction stage* would follow, after issuance of a construction authorization. A *period of operations* follows the issuance of a license by the Commission. The period of operations includes the time during which *emplacement* of wastes occurs; and any subsequent period before permanent closure during which the emplaced wastes are *retrievable;* and *permanent closure,* which includes final backfilling of subsurface facilities, sealing of shafts, decontaminating and dismantling of surface facilities. Permanent closure represents the end of active human activities with the geologic repository operations area and engineered systems.

(e) *Containment.* Early during the repository life, when radiation and thermal levels are high and the consequences of events are especially difficult to predict rigorously, special emphasis is placed upon the ability to contain the wastes by waste packages within an engineered system. This is known as the *containment period.* The *engineered system* includes the waste packages as well as the underground facility. A *waste package* includes:

(1) The *waste form* which consists of the radioactive waste materials and any associated encapsulating or stabilizing materials.

(2) The *container* which is the first major sealed enclosure that holds the waste form.

(3) *Overpacks* which consist of any buffer material, receptable, wrapper, box or other structure, that is both within and an integral part of a waste package. It encloses and protects the waste form so as to meet the performance objectives.

(f) *Isolation.* Following the containment period special emphasis is placed upon the ability to achieve isolation of the wastes by virtue of the characteristics of the geologic repository. *Isolation* means the act of inhibiting the transport of radioactive material to the accessible environment in amounts and concentrations within limits. The *accessible environment* means those portions of the environment directly in contact with or readily available for use by human beings.

Performance Objectives

§ 60.111 Performance objectives.

(a) *Performance of the geologic repository operations area through permanent closure.*—(1) *Protection against radiation exposures and releases of radioactive material.* The geologic repository operations area shall be designed so that until permanent closure has been completed, radiation exposures and radiation levels, and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in Part 20 of this chapter and any generally applicable environmental standards established by the Environmental Protection Agency.

(2) *Retrievability of waste.* The geologic repository operations area shall be designed so that the entire inventory of waste could be retrieved on a reasonable schedule, starting at any time up to 50 years after waste emplacement operations are complete. A reasonable schedule for retrieval is one that requires no longer than about the same overall period of time than was devoted to the construction of the geologic repository operations area and the emplacement of wastes.

(b) *Performance of the geologic repository after permanent closure.*—(1) *Overall system performance.* The geologic setting shall be selected and the subsurface facility designed so as to assure that releases of radioactive materials from the geologic repository following permanent closure conform to such generally applicable environmental radiation protection standards as may have been established by the Environmental Protection Agency.

(2) *Performance of the engineered system.*—(i) *Containment of wastes.*[*] The engineered system shall be designed so that even if full or partial saturation of the underground facility were to occur, and assuming anticipated processes and events, the waste packages will contain all radionuclides for at least the first 1,000 years after permanent closure. This requirement does not apply to TRU waste unless TRU waste is emplaced close enough to HLW that the TRU release rate can be significantly affected by the heat generated by the HLW.

(ii) *Control of releases.*[*]

(A) For HLW, the engineered system shall be designed so that, after the first 1,000 years following permanent closure, the annual release rate of any radionuclide from the engineered system into the geologic setting, assuming anticipated processes and events, is at most one part in 100,000 of the maximum amount of that radionuclide calculated to be present in the underground facility (assuming no release from the underground facility) at any time after 1,000 years following permanent closure. This requirement does not apply to radionuclides whose contribution is less than 0.1% of the total annual curie release as prescribed by this paragraph.

(B) For TRU waste, the engineered system shall be designed so that following permanent closure the annual release rate of any radionuclide from the underground facility into the geologic setting, assuming anticipated processes and events, is at most one part in 100,000 of the maximum amount calculated to be present in the underground facility (assuming no release from the underground facility) at any time following permanent closure. This requirement does not apply to radionuclides whose contribution is less than 0.1% of the annual curie release as prescribed by this paragraph.

(3) *Performance of the geologic setting.*—(i) *Containment period.* During the containment period, the geologic setting shall mitigate the impacts of premature failure of the engineered system. The ability of the geologic setting to isolate wastes during the isolation period, in accordance with paragraph (b)(3)(ii) of this section, shall be deemed to satisfy this requirement.

(ii) *Isolation period.* Following the containment period, the geologic setting, in conjunction with the engineered system as long as that system is expected to function, and alone thereafter, shall be capable of isolating radioactive waste so that transport of radionuclides to the accessible environment shall be in amounts and concentrations that conform to such generally applicable environmental standards as may have been established by the Environmental Protection Agency. For the purpose of this paragraph, the evaluation of the site shall be based upon the assumption that those processes operating on the site are those which have been operating on it during the Quaternary Period, with perturbations caused by the presence of emplaced radioactive wastes superimposed thereon.

§ 60.112 Required characteristics of the geologic setting.

(a) The geologic setting shall have exhibited structural and tectonic stability since the start of the Quaternary Period.

(b) The geologic setting shall have exhibited hydrogeologic, geo-chemical, and geomorphic stability since the start of the Quaternary Period.

(c) The geologic repository shall be located so that pre-waste emplacement groundwater travel times through the far field to the accessible environment are at least 1,000 years.

Ownership and Control of the Geolocghic Repository Operations Area

§ 60.121 Requirements for ownership and control of the geologic repository operations area.

(a) *Ownership of the geologic repository operations area.* The geologic repository operations area shall be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use. These lands shall be held free and clear of all encumbrances, if

[*] The Commission specifically seeks comment on whether an ALARA principle should be applied to the performance requirements dealing with containment and control of releases. In particular, the Commission has considered whether the technical criteria should explicitly require containment to be for "as long as is reasonably achievable" and the release rate to be "as low as is reasonably achievable." Comments should address the merits of such a requirement, how to best frame it, and the practicality of its implementation.

significant, such as: (1) rights arising under the general mining laws; (2) easements for right-of-way; and (3) all other rights arising under lease, rights of entry, deed, patent, mortgage, appropriation, prescription, or otherwise.

(b) *Establishment of controls.* Appropriate controls shall be established outside of the geologic repository operations area. DOE shall exercise any jurisdiction and control over surface and subsurface estates necessary to prevent adverse human actions that could significantly reduce the site or engineered system's ability to achieve isolation. The rights of DOE may take the form of appropriate possessory interests, servitudes, or withdrawals from location or patent under the general mining laws.

Additional Requirements for the Geologic Setting

§ 60.122 Favorable conditions.

Each of the following conditions may contribute to the ability of the geologic setting to meet the performance objectives relating to isolation of the waste. In addition to meeting the mandatory requirements of § 60.112, a geologic setting shall exhibit an appropriate combination of these conditions so that, together with the engieered system, the favorable conditions present are sufficient to provide reasonable assurance that such performance objectives will be met.

(a) The nature and rates of tectonic processes that have occurred since the start of the Quaternary Period are such that, when projected, they would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(b) The nature and rates of structural processes that have occurred since the start of the Quaternary Period are such that, when projected, they would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(c) The nature and rates of hydrogeological processes that have occurred since the start of the Quaternary Period are such that, when projected, they would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(d) The nature and rates of geochemical processes that have occurred since the start of the Quaternary Period are such that when projected, they would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(e) The nature and rates of geomorphic processes that have occurred since the start of the Quarternary period are such that, when projected they would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(f) A host rock that provides the following groundwater characteristics—(1) low groundwater content; (2) inhibition of groundwater circulation in the host rock; (3) inhibition of groundwater flow between hydrogeologic units or along shafts, drifts, and boreholes; and (4) groundwater travel times, under pre-waste emplacement conditions, between the underground facility and the accessible environment that substantially exceed 1,000 years.

(g) Geochemical conditions that (1) promote precipitation or sorption or radionuclides; (2) inhibit the formation of particulates, colloids, and inorganic and organic complexes that increase the mobility of radionuclides; and (3) inhibit the transport of radionuclides by particulates, colloids, and complexes.

(h) Mineral assemblages that, when subjected to anticipated thermal loading, will remain unaltered or alter to mineral assemblages having increased capacity to inhibit radionuclide migration.

(i) Conditions that permit the emplacement of waste at a minimum depth of 300 meters from the ground surface. (The ground surface shall be deemed to be the elevation of the lowest point on the surface above the disturbed zone.)

(j) Any local condition of the disturbed zone that contributes to isolation.

§ 60.123 Potentially adverse conditions.

The following are potentially adverse conditions. The presence of any such conditions may compromise site suitability and will require careful analysis and such measures as are necessary to compensate for them adequately pursuant to § 60.124.

(a) *Adverse conditions in the geologic setting.*

(1) Potential for failure of existing or planned man-made surface water impoundments that could cause flooding of the geologic repository operations area.

(2) Potential, based on existing geologic and hydrologic conditions, that planned custruction of large-scale surface water impoundments may significantly affect the geologic repository through changes in the regional groundwater flow system.

(3) Potential for human activity to affect significantly the geologic repository through changes in the hydrogeology. This activity includes, but is not limited to planned groundwater withdrawal, extensive irrigation, subsurface injection of fluids, underground pumped storage facilities, or underground military activity.

(4) Earthquakes which have occurred historically that if they were to be repeated could affect the geologic repository significantly.

(5) A fault in the geologic setting that has been active since the start of the Quaternary Period and which is within a distance of the disturbed zone that is less than the smallest dimension of the fault rupture surface.

(6) Potential for adverse impacts on the geologic repositroy resulting from the occupancy and modification of floodplains.

(7) Potential for natural phenomena such as landslides, subsidence, or volcanic activity of such a magnitude that large-scale surface water impoundments could be created that could affect the performance of the geologic repository through changes in the regional groundwater flow.

(8) Expected climatic changes that would have an adverse effect on the geologic, geochemical, or hydrologic characteristics.

(b) *Adverse conditions in the disturbed zone.* For the purpose of determining the presence of the following conditions within the distrubed zone, investigations should extend to the greater of either its calculated extent or a horizontal distance of 2 km from the limits of the underground facility, and from the surface to a depth of 500 meters below the limits of the repository excavation.

(1) Evidence of subsurface mining for resources.

(2) Evidence of drilling for any purpose.

(3) Resources that have either greater gross value, net value, or commercial potential than the average for other representative areas of similar size that are representative of and located in the geologic setting.

(4) Evidence of extreme erosion during the Quaternary Period.

(5) Evidence of dissolutioning of soluble rocks.

(6) The existence of a fault that has been active during the Quaternary Period.

(7) Potential for creating new pathways for radionuclide migration due to presence of a fault or fracture zone irrespective of the age of last movement.

(8) Structural deformation such as uplift, subsidence, folding, and fracturing during the Quaternary Period.

(9) More frequent occurrence of earthquakes or earthquakes of higher

magnitude than is typical of the area in which the geologic setting is located.

(10) Indications, based on correlations of earthquakes with tectonic processes and features, that either the frequency of occurrence or magnitude of earthquakes may increase.

(11) Evidence of igneous activity since the start of the Quaternary Period.

(12) Potential for changes in hydrologic conditions that would significantly affect the migration of radionuclides to the accessible environment including but not limited to changes in hydraulic gradient, average interstitial velocity, storage coefficient, hydraulic conductivity, natural recharge, potentiometric levels, and discharge points.

(13) Conditions in the host rock that are not reducing conditions.

(14) Groundwater conditions in the host rock, including but not limited to high ionic strength or ranges of Eh-pH, that could affect the solubility and chemical reactivity of the engineered systems.

(15) Processes that would reduce sorption, result in degradation of the rock strength, or adversely affect the performance of the engineered system.

(16) Rock or groundwater conditions that would require complex engineering measures in the design and construction of the underground facility or in the sealing of boreholes and shafts.

(17) Geomechanical properties that do not permit deisign of stable underground openings during construction, waste emplacement, or retrieval operations.

§ 60.124 Assessment of potentially adverse conditions.

In order to show that a potentially adverse condition or combination of conditions cited in § 60.123 does not impair significantly the ability of the geologic repository to isolate the radioactive waste, the following must be demonstrated:

(a) The potentially adverse human activity or natural condition has been adequately characterized, including the extent to which the condition may be present and still be undetected taking into account the degree of resolution achieved by the investigations; and

(b) The effect of the potentially adverse human activity or natural condition on the geologic setting has been adequately evaluated using conservative analyses and assumptions, and the evaluation used is sensitive to the adverse human activity or natural condition; and

(c)(1) The potentially adverse human activity or natural condition is shown by analysis in paragraph (b) of this section not to affect significantly the ability of the geologic setting to isolate waste, or

(2) The effect of the potentially adverse human activity or natural condition is compensated by the presence of a combination of the favorable characteristics cited in § 60.122, or

(3) The potentially adverse human activity or natural condition can be remedied.

Design and Construction Requirements

§ 60.130 General design requirements for the geologic repository operations area.

(a) Sections 60.130 through 60.134 specify minimum requirements for the design of, and construction specifications for, the geologic repository operations area. Requirements for design contained in §§ 60.131 through 60.133 must be considered in conjunction with the requirements for construction in § 60.134. Sections 60.130 through 60.134 are not intended to contain an exhaustive list of design and construction requirements. Omissions in §§ 60.130 through 60.134 do not relieve DOE from providing safety features in a specific facility needed to achieve the performance objectives contained in § 60.111. All design and construction criteria must be consistent with the results of site characterization activities.

(b) Systems, structures, and components of the geologic repository operations area shall satisfy the following:

(1) *Radiological protection.* The structures, systems, and components located within restricted areas shall be designed to maintain radiation doses, levels, and concentrations of radioactive material in air in those restricted areas within the limits specified in Part 20 of this chapter. These structures, systems, and components shall be designed to include—

(i) Means to limit concentrations of radioactive material in air;

(ii) Means to limit the time required to perform work in the vicinity of radioactive materials, including, as appropriate, designing equipment for ease of repair and replacement and providing adequate space for ease of operation;

(iii) Suitable shielding;

(iv) Means to monitor and control the dispersal of radioactive contamination;

(v) Means to control access to high radiation areas or airborne radioactivity areas; and

(vi) A radiation alarm system to warn of increases in radiation levels, concentrations of radioactive material in air, and of increased radioactivity released in effluents. The alarm system shall be designed with redundancy and in situ testing capability.

(2) *Protection against natural phenomena and environmental conditions.*

(i) The structures, systems, and components important to safety shall be designed to be compatible with anticipated site characteristics and to accommodate the effects of environmental conditions, so as to prevent interference with normal operation, maintainence and testing during the entire period of construction and operations.

(ii) The structures, systems, and components important to safety shall be designed so that natural phenomena and environmental conditions anticipated at the site will not result, in any relevant time period, in failure to achieve the performance objectives.

(3) *Protection against dynamic effects of equipment failure and similar events.* The structures, systems and components important to safety shall be designed to withstand dynamic effects that could result from equipment failure, such as missle impacts, and similar events and conditions that could lead to loss of their safety functions.

(4) *Protection against fires and explosions.*

(i) The structures, systems, and components important to safety shall be designed to perform their safety functions during and after fires or explosions in the geologic repository operations area.

(ii) To the extent practicable, the geologic repository operations area shall be designed to incorporate the use of noncombustible and heat resistant materials.

(iii) The geologic repository operations area shall be designed to include explosion and fire detection alarm systems and appropriate suppression systems with sufficient capacity and capability to reduce the adverse effects of fires and explosions on structures, systems, and components important to safety.

(iv) The geologic repository operations area shall be designed to include means to protect systems, structures, and components important to safety against the adverse effects of either the operation or failure of the fire suppression systems.

(5) *Emergency capability.*

(i) The structures, systems, and components important to safety shall be designed to maintain control of radioactive waste, and permit prompt termination of operations and evacuation of personnel during an emergency.

(ii) The geologic repository operations area shall be designed to include onsite facilities and services that ensure a safe and timely response to emergency conditions and that facilitate the use of available offsite services (such as fire, police, medical and ambulance service) that may aid in recovery from emergencies.

(6) *Utility services.*

(i) Each utility service system shall be designed so that essential safety functions can be performed under both normal and emergency conditions.

(ii) The utility services important to safety shall include redundant systems to the extent necessary to maintain, with adequate capacity, the ability to perform their safety functions.

(iii) The emergency utility services shall be designed to permit testing of their functional operability and capacity. This will include the full operational sequence of each system when transferring between normal and emergency supply sources, as well as the operation of associated safety systems.

(iv) Provisions shall be made so that, if there is a loss of the primary electric power source or circuit, reliable and continued emergency power is provided to instruments, utility service systems, and operating systems, including alarm systems. This emergency power shall be sufficient to allow safe conditions to be maintained. All systems important to safety shall be designed to permit them to be maintained at all times in a functional mode.

(7) *Inspection, testing, and maintenance.* The structures, systems, and components important to safety shall be designed to permit periodic inspection, testing, and maintenance, as necessary, to ensure their continued functioning and readiness.

(8) *Criticality control.* All systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste shall be designed to ensure that a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. Each system shall be designed for criticality safety under normal and accident conditions. The calculated effective multiplication factor (k_{eff}) must be sufficiently below unity to show at least a 5% margin, after allowance for the bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation.

(9) *Instrumentation and control systems.* Instrumentation and control systems shall be designed to monitor and control the behavior of engineered systems important to safety over anticipated ranges for normal operation and for accident conditions. The systems shall be designed with sufficient redundancy to ensure that adequate margins of safety are maintained.

(10) *Compliance with mining regulations.* To the extent that DOE is not subject to the Federal Mine Safety and Health Act of 1977, as to the construction and operation of the geologic repository operations area, the design of the geologic repository operations area shall nevertheless include such provisions for worker protection as may be necessary to provide reasonable assurance that all structures, systems, and components important to safety can perform their intended functions. Any deviation from relevant design requirements in 30 CFR, Chapter I, Subchapters D, E, and N will give rise to a rebuttable presumption that this requirement has not been met.

§ 60.131 Additional design requirements for surface facilities in the geologic repository operations area.

(a) *Facilities for receipt and retrieval of waste.* Surface facilities in the geologic repository operations area shall be designed to allow safe handling and storage of wastes at the site, whether these wastes are on the surface before emplacement or as a result of retrieval from the underground facility. The surface facilities shall be designed so as to permit inspection, repair, and decontamination of such wastes and their containers. Surface storage capacity is not required for all emplaced waste.

(b) *Surface facility ventilation.* Surface facility ventilation systems supporting waste transfer, inspection, decontamination, processing, or packaging shall be designed to provide protection against radiation exposures and offsite releases as provided in § 60.111.

(c) *Radiation control and monitoring.*—(1) *Effluent control.* The surface facilities shall be designed to control the release of radioactive materials in effluents during normal and emergency operations. The facilities shall be designed to provide protection against radiation exposures and offsite releases as provided in § 60.111.

(2) *Effluent monitoring.* The effluent monitoring systems shall be designed to measure the amount and concentration of radionuclides in any effluent with sufficient precision to determine whether releases conform to the design requirement for effluent control. The monitoring systems shall be designed to include alarms that can be periodically tested.

(d) *Waste treatment.* Radioactive waste treatment facilities shall be designed to process any radioactive wastes generated at the geologic repository operations area into a form suitable to permit safe disposal at the geologic repository operations area or to permit safe transportation and conversion to a form suitable for disposal at an alternative site in accordance with any regulations that are applicable.

(e) *Consideration of decommissioning.* The surface facility shall be designed to facilitate decommissioning.

§ 60.132 Additional design requirements for the underground facility.

(a) General criteria for the underground facility.

(1) The underground facility shall be designed so as to perform its safety functions assuming interactions among the geologic setting, the underground facility, and the waste package.

(2) The underground facility shall be designed to provide for structural stability, control of groundwater movement and control of radionuclide releases, as necessary to comply with the performance objectives of § 60.111.

(3) The orientation, geometry, layout, and depth of the underground facility, and the design of any engineered barriers that are part of the underground facility shall enhance containment and isolation of radionuclides to the extent practicable at the site.

(4) The underground facility shall be designed so that the effects of disruptive events such as intrusions of gas, or water, or explosions, will not spread through the facility.

(b) *Flexibility of design.* The underground facility shall be designed with sufficient flexibility to allow adjustments, where necessary to accommodate specific site conditions identified through in situ monitoring, testing, or excavation.

(c) *Separation of excavation and waste emplacement (modular concept).* If concurrent excavation and emplacement of wastes are planned, then:

(1) The design shall provide for such separation of activities into discrete areas (modules) as may be necessary to assure that excavation does not impair waste emplacement or retrieval operations.

(2) Each module shall be designed to permit insulation from other modules if an accident occurs.

(d) *Design for retrieval of waste.* The underground facility shall be designed to—

(1) Permit retrieval of waste in accordance with the performance objectives (§ 60.111);

(2) Ensure sufficient structural stability of openings and control of groundwater to permit the safe conduct of waste retrieval operations; and

(3) Allow removal of any waste packages that may be damaged or require inspection without compromising the ability of the geologic repository to meet the performance objectives (§ 60.111).

(e) *Design of subsurface openings.*

(1) Subsurface openings shall be designed to maintain stability throughout the construction and operation periods. If structural support is required for stability, it shall be designed to be compatible with long-term deformation, hydrologic, geochemical, and thermomechanical characteristics of the rock and to allow subsequent placement of backfill.

(2) Structures required for temporary support of zones of weak or highly fractured rock shall be designed so as not to impair the placement of permanent structures or the capability to seal excavated areas used for the containment of wastes.

(3) Subsurface openings shall be designed to reduce the potential for deleterious rock movement or fracturing of overlying or surrounding rock over the long term. The size, shape, orientation, and spacing of openings and the design of engineered support systems shall take the following conditions into considerations—

(i) natural stress conditions;

(ii) deformation characteristics of the host rock under normal conditions and thermal loading;

(iii) The kinds of weaknesses or structural discontinuities found at various locations in the geologic repository;

(iv) Equipment requirements; and

(v) The ability to construct the underground facility as designed so that stability of the rock is enhanced.

(f) *Rock excavation.* The design of the underground facility shall incorporate excavation methods that will limit damage to and fracturing of rock.

(g) *Control of water and gas.*

(1) Water and gas control systems shall be designed to be of sufficient capability and capacity to reduce the potentially adverse effects of groundwater intrusion, service water intrusion, or gas inflow into the underground facility.

(2) Water and gas control systems shall be designed to control the quantity of water or gas flowing into or from the underground facility, monitor the composition of gases, and permit sampling of liquids.

(3) Systems shall be designed to provide control of water and gas in both waste emplacement areas and excavation areas.

(4) Water control systems shall be designed to include storage capability and modular layouts that ensure that unexpected inrush or flooding can be controlled and contained.

(5) If the intersection of aquifers or water-bearing geologic structures is anticipated during construction, the design of the underground facility shall include plans for cutoff or control of water in advance of the excavation.

(6) If linings are required, the contact between the lining and the rock surrounding subsurface excavations shall be designed so as to avoid the creation of any preferential pathway for groundwater or radionuclide migration.

(h) *Subsurface ventilation.* The ventilation system shall be designed to—

(1) Control the transport of radioactive particulates and gases within and releases from the subsurface facility in accordance with the performance objectives (§ 60.111);

(2) Permit continuous occupancy of all excavated areas during normal operations through the time of permanent closure;

(3) Accommodate changes in operating conditions such as variations in temperature and humidity in the underground facility;

(4) Include redundant equipment and fail safe control systems as may be needed to assure continued function under normal and emergency conditions; and

(5) Separate the ventilation of excavation and waste emplacement areas.

(i) *Engineered barriers.*

(1) Barriers shall be located where shafts could allow access for groundwater to enter or leave the underground facility.

(2) Barriers shall create a waste package environment which favorably controls chemical reactions affecting the performance of the waste package.

(3) Backfill placed in the underground facility shall be designed as a barrier.

(i) Backfill placed in the underground facility shall perform its functions assuming anticipated changes in the geologic setting.

(ii) Backfill placed in the underground facility shall serve the following functions:

(A) It shall provide a barrier to groundwater movement into and from the underground facility.

(B) It shall reduce creep deformation of the host rock that may adversely affect (*1*) waste package performance or (*2*) the local hydrological system.

(C) It shall reduce and control groundwater movement within the underground facility.

(D) It shall retard radionuclide migration.

(iii) Backfill placed in the underground facility shall be selected to allow for adequate placement and compaction in underground openings.

(j) *Waste handling and emplacement.*

(1) The systems used for handling, transporting, and emplacing radioactive wastes shall be designed to have positive, fail-safe designs to protect workers and to prevent damage to waste packages.

(2) The handling systems for emplacement and retrieval operations shall be designed to minimize the potential for operator error.

(k) *Design for thermal loads.*

(1) The underground facility shall be designed so that the predicted thermal and thermomechanical response of the rock will not degrade significantly the performance of the repository or the ability of the natural or engineered barriers to retard radionuclide migration.

(2) The design of waste loading and waste spacings shall take into consideration—

(i) Effects of the design of the underground facility on the thermal and thermomechanical response of the host rock and the groundwater system;

(ii) Features of the host rock and geologic setting that affect the thermomechanical response of the underground facility and barriers, including but not limited to, behavior and deformational characteristics of the host rock, the presence of insulating layers, aquifers, faults, orientation of bedding planes, and the presence of discontinuities in the host rock; and

(iii) The extent to which fracturing of the host rock is influenced by cycles of temperature increase and decrease.

§ 60.133 Design of shafts and seals for shafts and boreholes.

(a) *Shaft design.* Shafts shall be designed so as not to create a preferential pathway for migration of groundwater and so as not to increase the potential for migration through existing pathways.

(b) *Shaft and borehole seals.* Shaft and borehole seals shall be designed so that:

(1) Shafts and boreholes will be sealed as soon as possible after they have served their operational purpose.

(2) At the time of permanent closure sealed shafts and boreholes will inhibit transport of radionclides to at least the same degree as the undisturbed units of rock through which the shafts or boreholes pass. In the case of soluble rocks, the borehole and shaft seals shall also be designed to prevent groundwater circulation that would result in dissolution.

(3) Contact between shaft and borehole seals and the adjacent rock does not become a preferential pathway for water.

(4) Shaft and borehole seals can accommodate potential variations of stress, temperature, and moisture.

(5) The materials used to construct the seals are appropriate in view of the geochemistry of the rock and groundwater system, anticipated deformations of the rock, and other in situ conditions.

(c) *Shaft conveyances used in radioactive waste handling.*

(1) Shaft conveyances used to transport radioactive materials shall be designed to satisfy the requirements as set forth in § 60.130 for systems, structures, and components important to safety.

(2) Hoists important to safety shall be designed to preclude cage free fall.

(3) Hoists important to safety shall be designed with a reliable cage location system.

(4) Hoist loading and unloading systems shall be designed with a reliable system of interlocks that will fail safely upon malfunction.

(5) Hoists important to safety shall be designed to include two independent indicators to indicate when waste packages are in place, grappled, and ready for transfer.

§ 60.134 Construction specifications for surface and subsurface facilities.

(a) *General requirement.* Specifications for construction shall conform to the objectives and technical requirements of §§ 60.130 through 60.133.

(b) *Construction management program.* The construction specifications shall facilitate the conduct of a construction management program that will ensure that construction activities do not adversely affect the suitability of the site to isolate the waste or jeopardize the isolation capabilities of the underground facility, boreholes, shaft, and seals, and that the underground facility is constructed as designed.

(c) *Construction records.* The construction specifications shall include requirements for the development of a complete documented history of repository construction. This documented history shall include at least the following—

(1) Surveys of underground excavations and shafts located via readily identifiable surface features or monuments;

(2) Materials encountered;

(3) Geologic maps and geologic cross sections;

(4) Locations and amount of seepage;

(5) Details of equipment, methods, progress, and sequence of work;

(6) Construction problems;

(7) Anomalous conditions encountered;

(8) Instrument locations, readings, and analysis;

(9) Location and description of structural support systems;

(10) Location and description of dewatering systems; and

(11) Details, methods of emplacement, and location of seals used.

(d) *Rock excavation.* The methods used for excavation shall be selected to reduce to the extent practicable the potential to create a preferential pathway for groundwater or radioactive waste migration or increase migration through existing pathways.

(e) *Control of explosives.* If explosives are used, the provisions of 30 CFR 57.6 (Explosives) issued by the Mine Safety and Health Administration, Department of Labor, shall be met, as minimum safety requirements for storage, use and transport at the geologic repository operations area.

(f) *Water control.* The construction specifications shall provide that water encountered in excavations shall be removed to the surface and controlled in accordance with design requirements for radiation control and monitoring (§ 60.131(c)).

(g) *Waste handling and emplacement.* The construction specifications shall provide for demonstration of the effectiveness of handling equipment and systems for emplacement and retrieval operations, under operating conditions.

Waste Package Requirements

§ 60.135 Requirements for the waste package and its components.

(a) *General requirements of design.* The design of the waste package shall include the following elements:

(1) *Effect of the site on the waste package.* The waste package shall be designed so that the in situ chemical, physical, and nuclear properties of the waste package and its interactions with the emplacement environment do not compromise the function of the waste packages. The design shall include but not be limited to consideration of the following factors: solubility, oxidation/reduction reactions, corrosion, hydriding, gas generation, thermal effects, mechanical strength, mechanical stress, radiolysis, radiation damage, radionuclide retardation, leaching, fire and explosion hazards, thermal loads, and synergistic interactions.

(2) *Effect of the waste package on the underground facility and the natural barriers of the geologic setting.* The waste package shall be designed so that the in situ chemical, physical, and nuclear properties of the waste package and its interactions with the emplacement environment do not compromise the performance of the underground facility or the geologic setting. The design shall include but not be limited to consideration of the following factors: solubility, oxidation/reduction reactions, corrosion, hydriding, gas generation, thermal effects, mechanical strength, mechanica stress, radiolysis, radiation damage, radionuclide retardation, leaching, fire and explosion hazards, thermal loads, and synergistic interactions.

(b) *Waste form requirements.* Radioactive waste that is emplaced in the underground facility shall meet the following requirements:

(1) *Solidification.* All such radioactiv wastes shall be in solid form and place in sealed containers.

(2) *Consolidation.* Particulate waste forms shall have been consolidated (fo example, by incorporation into an encapsulating matrix) to limit the availability and generation of particulates.

(3) *Combustibles.* All combustible radioactive wastes must have been reduced to a noncombustible form unless it can be demonstrated that a f involving a single package will neithe compromise the integrity of other packages, nor adversely affect any safety-related structures, systems, or components.

(c) *Waste package requirements.* T waste package design shall meet the following requirements:

(1) *Explosive, pyrophoric, and chemically reactive materials.* The waste package shall not contain explosive or pyrophoric materials or chemically reactive materials that co interfere with operations in the underground facility or compromise t ability of the geologic repository to satisfy the performance objectives.

(2) *Free liquids.* The waste package shall not contain free liquids in an amount that could impair the structural integrity of waste package components (because of chemical interactions or formation of pressurized vapor) or result in spillage and spread of contamination in the event of package perforation.

(3) *Handling.* Waste packages shall be designed to maintain waste containment during transportation, emplacement, and retrieval.

(4) *Unique identification.* A label or other means of identification shall be provided for each package. The identification shall not impair the integrity of the package and shall be applied in such a way that the information shall be legible at least to the end of the retrievable storage period. Each package identification shall be consistent with the package's permanent written records.

Performance Confirmation Requirements

§ 60.137 General requirements for performance confirmation.

The geologic repository operations area shall be designed so as to permit implementation of a performance confirmation program that meets the requirements of Subpart F of this part.

Subpart F—Performance Confirmation

§ 60.140 General requirements.

(a) The performance confirmation program shall ascertain whether—

(1) Actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the licensing review; and

(2) Natural and engineered systems and components required for repository operation, or which are designed or assumed to operate as barriers after permanent closure are functioning as intended and anticipated.

(b) The program shall have been started during site characterization and it will continue until permanent closure.

(c) The program will include in situ monitoring, laboratory and field testing, and in situ experiments, as may be appropriate to accomplish the objective as stated above.

(d) The confirmation program shall be implemented so that:

(1) It does not adversely affect the natural and engineered elements of the geologic repository.

(2) It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities.

(3) It monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a geologic repository.

(4) It provides an established plan for feedback and analysis of data, and implementation of appropriate action.

§ 60.141 Confirmation of geotechnical and design parameters.

(a) During repository construction and operation, a continuing program of surveillance, measurement, testing, and geologic mapping shall be conducted to ensure that geotechnical and design parameters are confirmed and to ensure that appropriate action is taken to inform the Commission of changes needed in design to accommodate actual field conditions encountered.

(b) Subsurface conditions shall be monitored and evaluated against design assumptions.

(c) As a minimum, measurements shall be made of rock deformations and displacement, changes in rock stress and strain, rate and location of water inflow into subsurface areas, changes in groundwater conditions, rock pore water pressures including those along fractures and joints, and the thermal and thermomechanical response of the rock mass as a result of development and operations of the geologic repository.

(d) These measurements and observations shall be compared with the original design bases and assumptions. If significant differences exist between the measurements and observations and the original design bases and assumptions, the need for modifications to the design or in construction methods shall be determined and these differences and the recommended changes reported to the Commission.

(e) In situ monitoring of the thermomechanical response of the underground facility shall be conducted until permanent closure to ensure that the performance of the natural and engineering features are within design limits.

§ 60.142 Design testing.

(a) During the early or developmental stages of construction, a program for in situ testing of such features as borehole and shaft seals, backfill, and the thermal interaction effects of the waste packages, backfill, rock, and groundwater shall be conducted.

(b) The testing shall be initiated as early as is practicable.

(c) A backfill test section shall be constructed to test the effectiveness of backfill placement and compaction procedures against design requirements before permanent backfill placement is begun.

(d) Test sections shall be established to test the effectiveness of borehole and shaft seals before full-scale operation proceeds to seal boreholes and shafts.

§ 60.143 Monitoring and testing waste packages.

(a) A program shall be established at the repository for monitoring the condition of the waste packages. Packages chosen for the program shall be representative of those to be emplaced in the repository.

(b) Consistent with safe operation of the repository, the environment of the waste packages selected for the waste package monitoring program shall be representative of the emplaced wastes.

(c) The waste package monitoring program shall include laboratory experiments which focus on the internal condition of the waste packages. To the extent practical, the environment experienced by the emplaced waste packages within the repository during the waste package monitoring program shall be duplicated in the laboratory experiments.

(d) The waste package monitoring program shall continue as long as practical up to the time of permanent closure.

Subpart G—Quality Assurance

§ 60.150 Scope.

(a) As used in this part, "quality assurance" comprises all those planned and systematic actions necessary to provide adequate confidence that the repository and its subsystems or components will perform satisfactorily in service.

(b) Quality assurance is a multidisciplinary system of management controls which address safety, reliability, maintainability, performance, and other technical disciplines.

§ 60.151 Applicability.

The quality assurance program applies to all systems, structures and components important to safety and to activities which would prevent or mitigate events that could cause an undue risk to the health and safety of the public. These activities include: exploring, site selecting, designing, fabricating, purchasing, handling, shipping, storing, cleaning, erecting, installing, emplacing, inspecting, testing, operating, maintaining, monitoring, repairing, modifying, and decommissioning.

§ 60.152 Implementation.

DOE shall implement a quality assurance program based on the criteria of Appendix B of 10 CFR Part 50 as applicable, and appropriately supplemented by additional criteria as required by § 60.151.

§ 60.153 Quality assurance for performance confirmation.

The quality assurance program shall include the program of tests, experiments and analyses essential to achieving adequate confidence that the emplaced wastes will remain isolated from the accessible environment.

Subpart H—Training and Certification of Personnel

§ 60.160 General requirements.

Operations that have been identified as important to safety in the Safety Analysis Report and in the license shall be performed only by trained and certified personnel or by personnel under the direct visual supervision of an individual with training and certification in such operation. Supervisory personnel who direct operations that are important to safety must also be certified in such operations.

§ 60.161 Training and certification program.

The DOE shall establish a program for training, proficiency testing, certification and requalification of operating and supervisory personnel.

§ 60.162 Physical requirements.

The physical condition and the general health of personnel certified for operations that are important to safety shall not be such as might cause operational errors that could endanger the public health and safety. Any condition which might cause impaired judgement or motor coordination must be considered in the selection of personnel for activities that are important to safety. These conditions need not categorically disqualify a person, so long as appropriate provisions are made to accomodate such defect.

Dated at Washington, D.C. this 2nd day of July, 1981.

Samuel J. Chilk,

Secretary of the Commission.

[FR Doc. 81-20233 Filed 7-7-81; 8:45 am]

BILLING CODE 7590-01-M

ENCLOSURE C

RATIONALE FOR PERFORMANCE OBJECTIVES IN 10 CFR PART 60

DISPOSAL OF HIGH LEVEL RADIOACTIVE
WASTE IN GEOLOGIC REPOSITORIES

TABLE OF CONTENTS

I. INTRODUCTION

In this discussion the staff will address a number of the major issues raised by the commenters on the proposed technical criteria, although for ease of presentation individual commenters are not identified in this document. In particular, the report will address concerns about the basis for numerical performance objectives (including requirements for multiple barriers with both natural and engineered components) and for a requirement to design for a retrievability option. Revised performance objectives, including a requirement to provide a retrievability option, as recommended by the staff, appear in Appendix I.

This chapter briefly delineates the authority of three federal agencies in disposal of high-level radioactive wastes (HLW) -- the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), and the Environmental Protection Agency (EPA). Chapters II through V deal with the nature of the high level waste problem, the function and description of a deep geologic repository, and the sources of uncertainty in predicting the performance of such a repository. Chapter VI discusses the alternatives considered in selecting a regulatory approach and the rationale for the approach selected. Chapter VII describes the anticipated routine long term performance of the repository, and its relationship to numerical criteria for major barriers of the repository. Chapter VIII describes two failure scenarios for long term repository performance, and their relationship to the numerical criteria associated with the major barriers. Chapter IX describes the rationale for requiring the repository to be designed for retrievability; that is, so that the option to retrieve the wastes is preserved. Chapter IX also contains the basis for the numerical value selected for the design period during which the retrieval option is to be preserved.

Three Federal agencies have major roles in the national program for disposal of high-level radioactive wastes. The EPA is responsible for developing a generally applicable environmental standard which will serve as the overall performance objective for releases from normal operations involved in high-level waste disposal. The NRC will develop and issue regulations which cover all aspects of high-level waste disposal, and which will implement the EPA standard. The NRC will then consider license applications for HLW disposal to determine whether the proposal will conform to the regulation. The DOE has lead responsibility for formulating national policy for disposal of HLW, and has determined that national policy should focus on disposal of HLW in mined geologic repositories (Ref. 1-1). Further, DOE is responsible for constructing and operating a waste disposal facility in accordance with NRC regulations.

Disposal of radioactive waste in a manner that will assure safety for many thousands of years represents a unique problem not previously dealt with in other NRC or EPA standards. The NRC staff has considered several approaches that might be applied to this unusual regulatory problem. The remainder of this report provides the bases for the approach selected for siting and design of the repository to assure effective long-term isolation of the wastes.

II. NATURE OF THE HIGH-LEVEL WASTE PROBLEM

In this chapter we describe the types and quantities of high-level wastes, and their properties, such as radioactivity and heat generation rates, that could affect the design and performance of a HLW facility. For perspective, we compare the hazard of the HLW, as a function of time, with the hazard of the natural uranium ore that was mined to make the fuel that produced the wastes. From these considerations we attempt to draw some inferences about the relevant time periods for isolation of HLW.

Types and Quantities of Wastes

HLW may be disposed of in two basic forms: spent fuel discharged from nuclear power plants (if it is disposed of as a waste), and the residue resulting from reprocessing spent fuel for recovery of uranium and/or plutonium.

Substantial quantities of HLW currently exist in the United States as a result of both U.S. defense programs and commercial nuclear power operations, and additional quantities of wastes are projected to be generated in the future by both programs. The amount of radioactivity in defense wastes is less than 10% of that in the commercial wastes which are expected to be generated by the time a repository is constructed and in operation; the following discussion is therefore limited to commercial waste inventories. It should be recognized that defense wastes will add a small but significant increment to the total HLW inventory, and that commercial wastes represent an upper bound with respect to heat generation rates and concentrations of radioactivity.

Commercial light-water reactors of the type currently in use in the U.S. generate spent fuel at a rate of about 35 metric tons of heavy metal (MTHM) per GWe-yr* of electrical energy production. Currently operating

* GWe-yr means the amount of electrical energy, in billions of watts, produced in a year of continuous operation.

nuclear power plants have a generating capacity of about 55 GWe, and additional plants which are planned or under construction could increase the total generating capacity to about 130-150 GWe.

Depending on the rate at which new plants are placed in service, the cumulative year 2000 inventory of spent fuel is likely to lie in the range from about 45,000 to 72,000 MTHM* (Ref. 2-1), or about the capacity of a single repository (Ref. 2-2). By the year 2040, 1 to 3 additional repositories would be required depending on the growth rate of nuclear power generation, whether or not the waste is reprocessed, and the geologic media selected for disposal.

Waste Characteristics

As nuclear fuel is irradiated in a nuclear reactor, three types of radioactive products are formed. Fission products are generated by fissioning uranium and plutonium isotopes and, with a few exceptions, are characterized by relatively short half-lives and low radiotoxicity. Actinides are radionuclides with atomic numbers greater than 88, and result from non-fission neutron absorptions in uranium. The actinides typically have longer half-lives and higher radiotoxicities than the fission products. Small quantities of additional radionuclides, called activation products, are produced by neutron absorption in the structural materials which support and contain the fuel in a reactor. The activation products make only a minor contribution to the overall radiotoxicity of HLW, and will not be discussed further.

* The small current inventories of commercially generated reprocessing wastes are insignificant.

Figure 1 presents the radioactivity of pressurized water reactor (PWR) spent fuel as a function of time after removal from a reactor, while Figures 2 and 3 present the same information for the wastes which would result from reprocessing the spent fuel from the uranium recycle and mixed oxide fuel cycles, respectively.* (Figures 1-3 as well as subsequent figures and tables in this chapter are all normalized on the basis of one metric tonne of heavy metal (MTHM) initially charged to a reactor.)

For each of the three waste types, 99.9% or more of the initial radioactivity decays away within the first 1000 years, primarily because of decay of Sr-90, Cs-137 and other short-lived fission products. In all three fuel cycles, the fission product radioactivity decreases by 5 orders of magnitude during the first thousand years and then stays relatively constant until about 100,000 years after disposal. Some of the shorter-lived actinides such as Pu-238 also decay significantly during the first 1000 years.

Figures 4, 5 and 6 display the decay heat generation for spent fuel and reprocessing wastes from these same fuel cycles. The rate at which heat is generated by the waste decreases less rapidly than the total radioactivity, but at least a 99% reduction in heat generation rate is achieved within the first 1000 years for each of the waste types. Also, in all three fuel cycles, the fission product decay heat generation rate decreases by almost 6 orders of magnitude during the first 1000 years

*In the uranium recycle fuel cycle, it has been assumed that 99.5% of the plutonium in spent fuel is recovered and placed in storage, while the recovered uranium is returned to the fuel cycle. In the mixed oxide fuel cycle, both plutonium and uranium are returned to the fuel cycle. Reference 2-3 discusses additional assumptions.

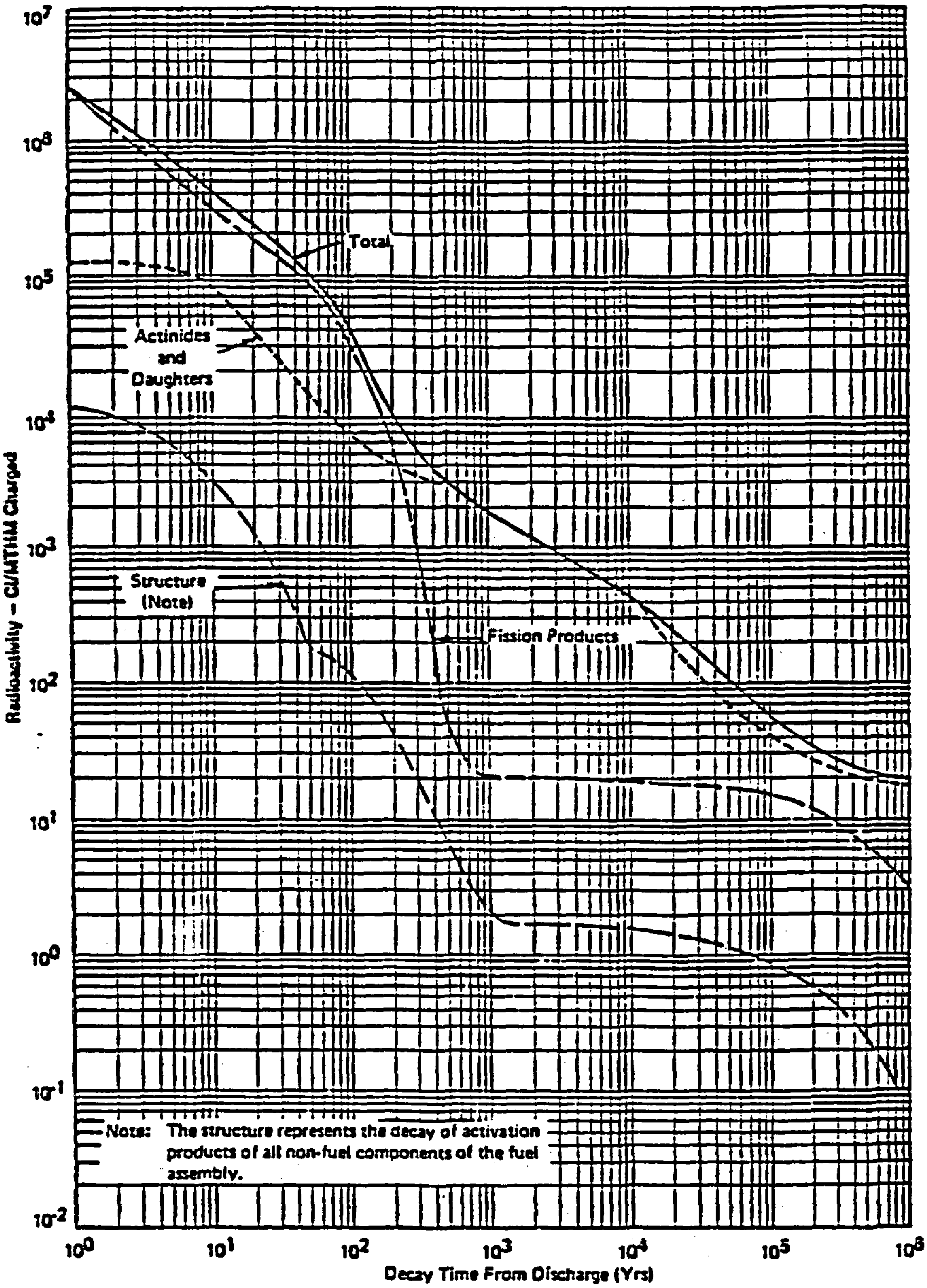


FIGURE 1. PWR SPENT FUEL -- RADIOACTIVITY
(Ref. 2-3)

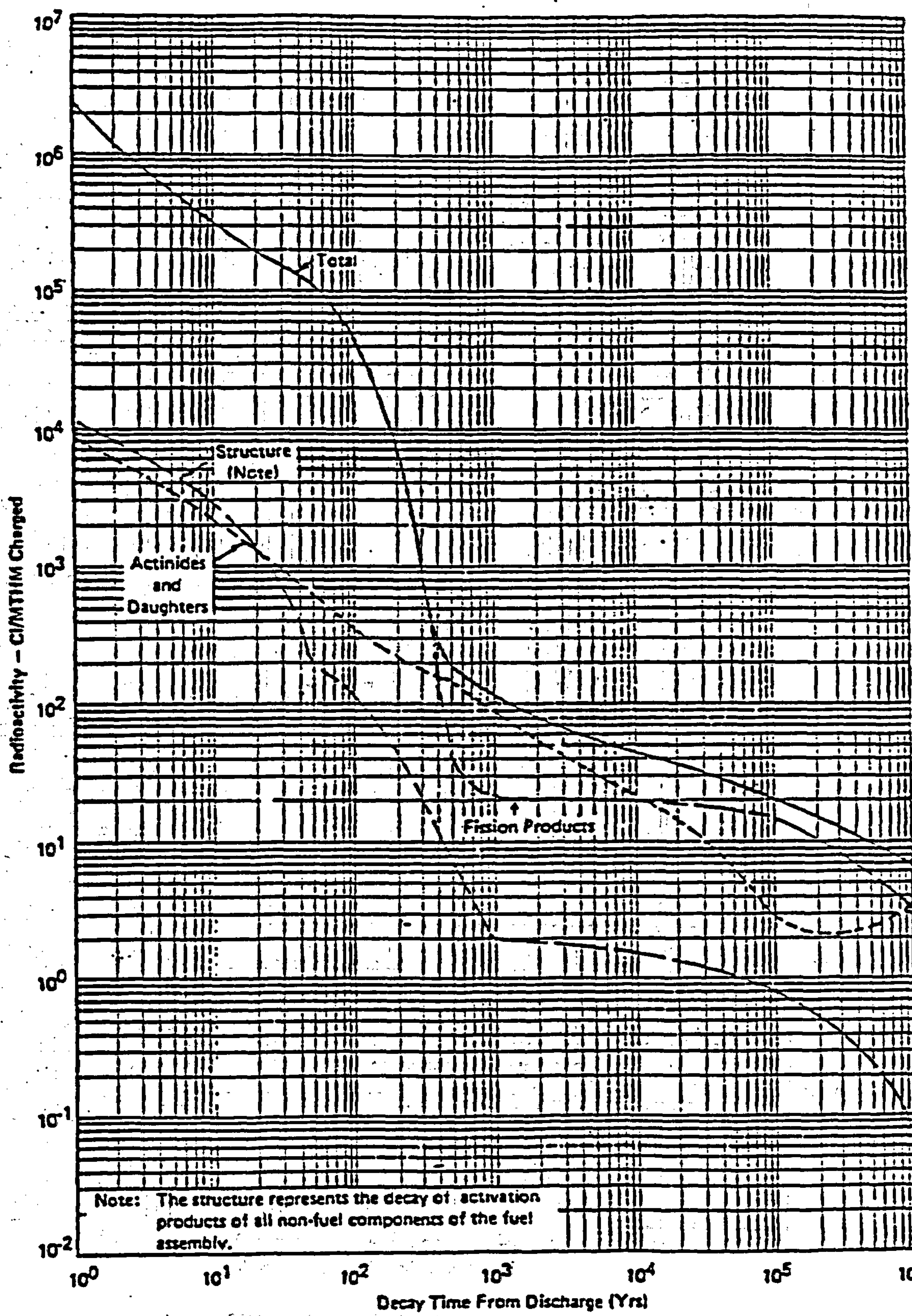


FIGURE 2. URANIUM RECYCLE REPROCESSING WASTE -- RADIOACTIVITY (Ref. 2-3)

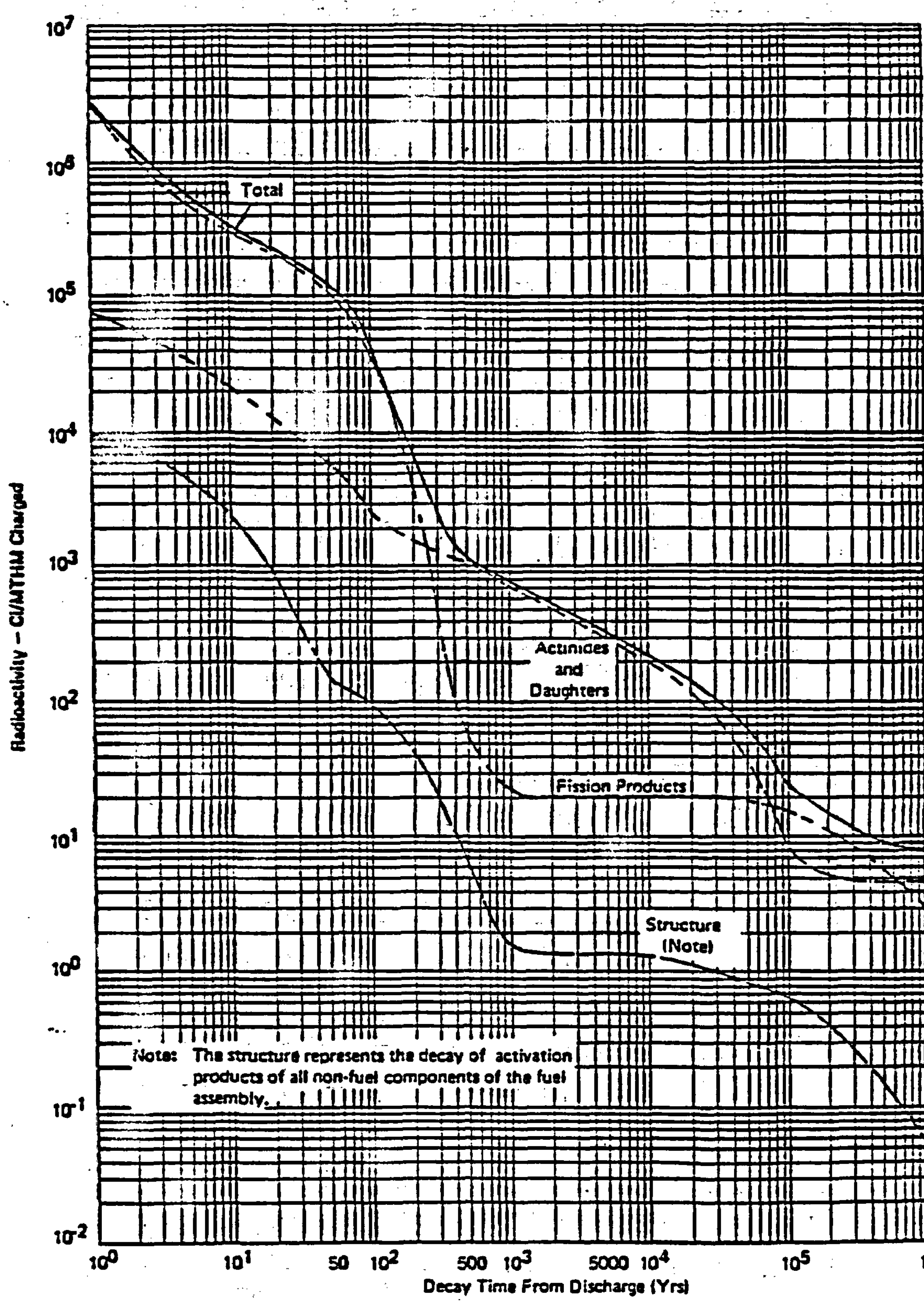


FIGURE 3. MIXED OXIDE REPROCESSING WASTE -- RADIOACTIVITY (Ref. 2-3)

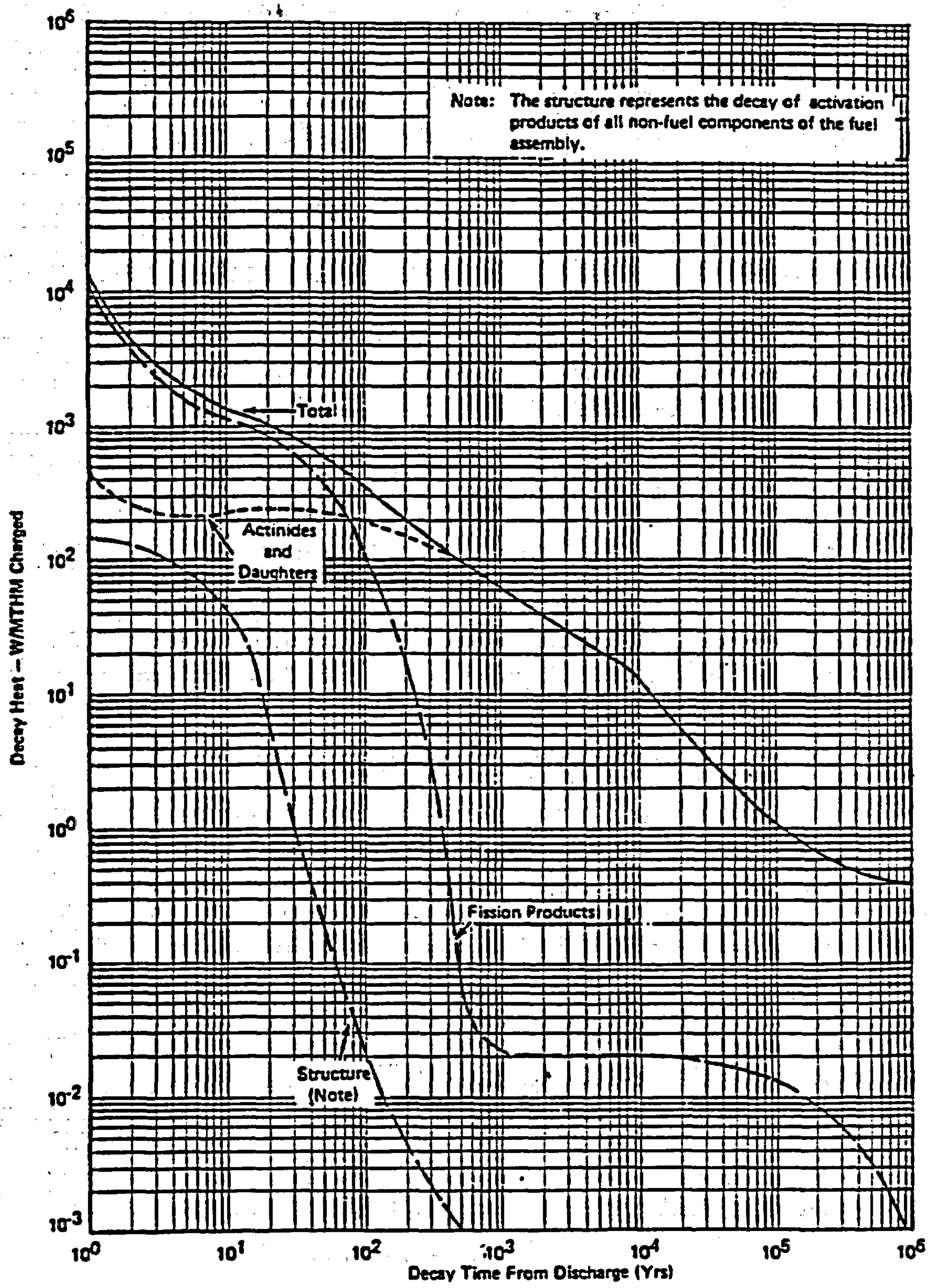


FIGURE 4. PWR SPENT FUEL -- DECAY HEAT GENERATION (Ref. 2-3)

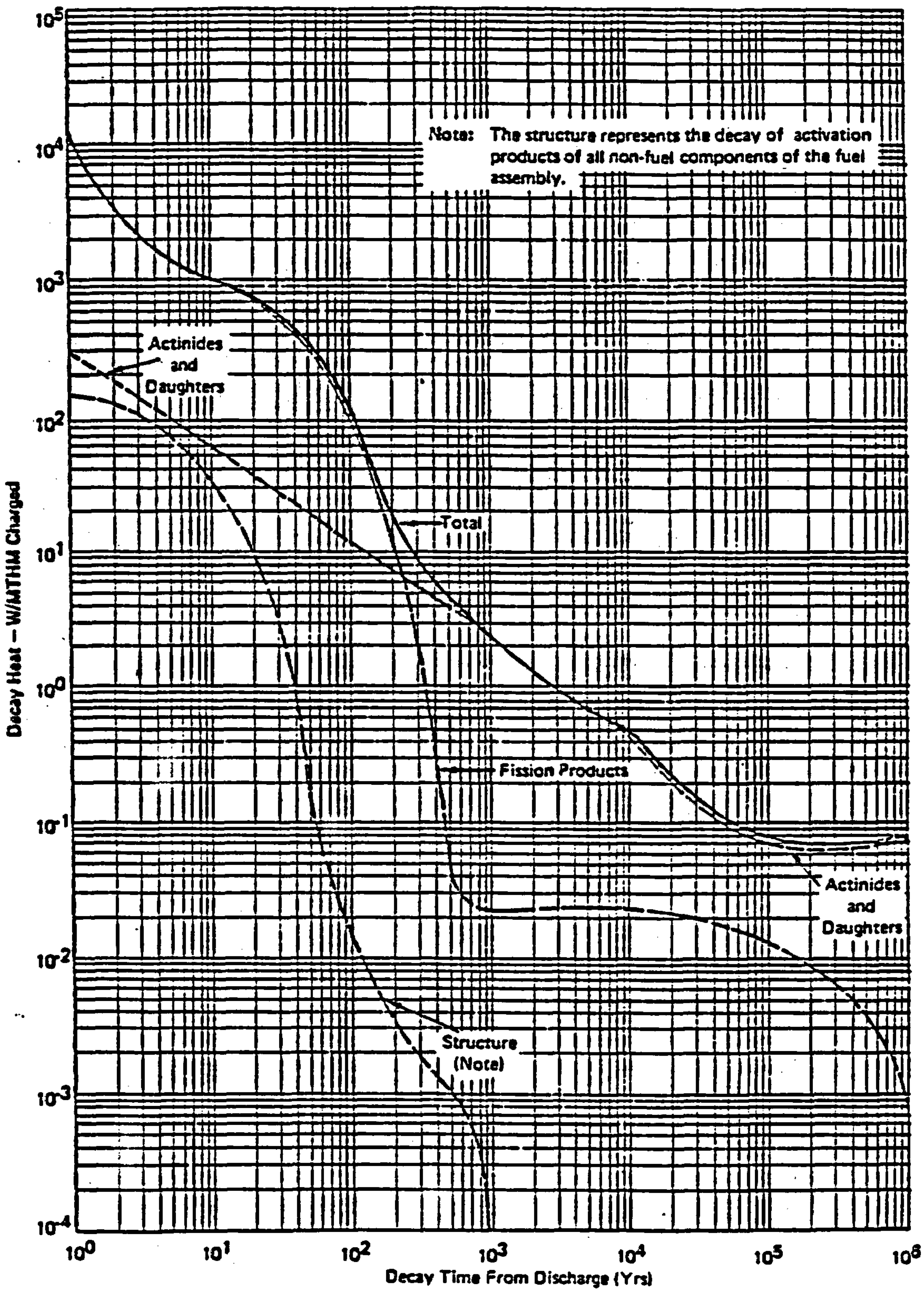


FIGURE 5. URANIUM RECYCLE REPROCESSING WASTE -- DECAY HEAT GENERATION (Ref. 2-3)

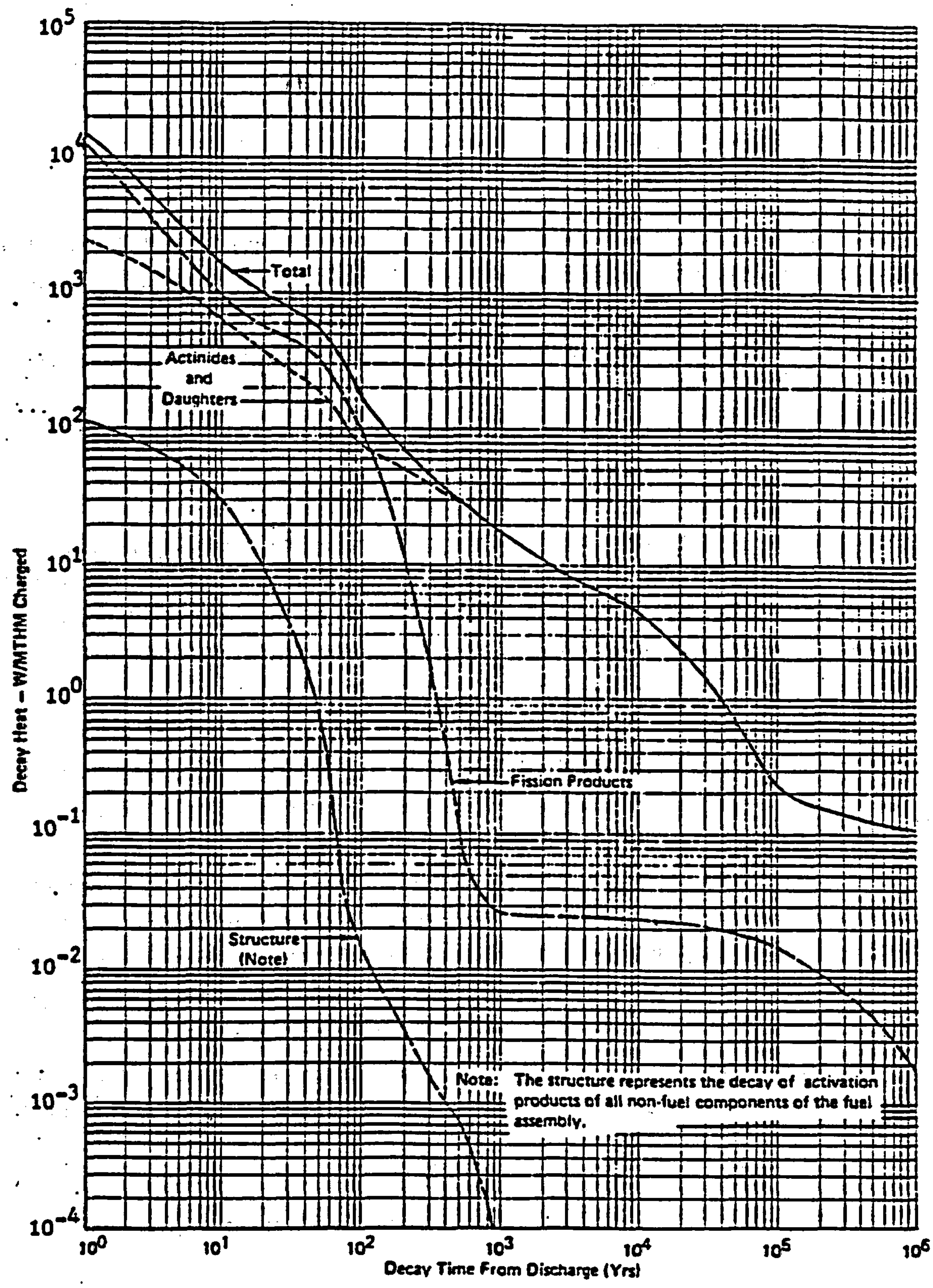


FIGURE 6. MIXED OXIDE REPROCESSING WASTE -- DECAY HEAT GENERATION (Ref. 2-3)

and stays relatively constant for the next 100,000 years.

The preceding discussion does not address the differing radiotoxicities of the nuclides present in HLW. A rough estimate of the intrinsic hazard of a radioactive waste material can be obtained by calculating the "hazard index" or "untreated dilution index" (UDI) defined by:

$$UDI = \sum_{i} \frac{Qi}{MPC_i}$$

where Qi is the activity of nuclide i in the waste and MPC_i is the concentration limit for the nuclide in effluents as presented in 10 CFR 20. This "untreated dilution index" then represents the quantity of water (in cubic meters) which would be required to dilute the waste to meet the effluent concentration limits of Part 20. Figures 7, 8 and 9 present this index as a function of time for spent fuel and reprocessing wastes. These figures also include, for perspective, the "untreated dilution index" for an equivalent amount of unmined uranium ore.

Recent revisions in the ICRP's recommendations for dosimetry calculations (ref. 2-4) cause some significant changes in this measurement of the relative hazard of HLW as a function of time. This effect has been noted recently in the scientific literature by a number of authors (ref. 2-5, 2-6 and 2-7). Revised curves, based on the more recent ICRP recommendations (ICRP-30), are displayed in Figures 10, 11 and 12 for spent fuel and reprocessing wastes. The most significant results of the ICRP revisions are:

1) the hazard of some of the fission products (primarily Sr-90) is reduced,

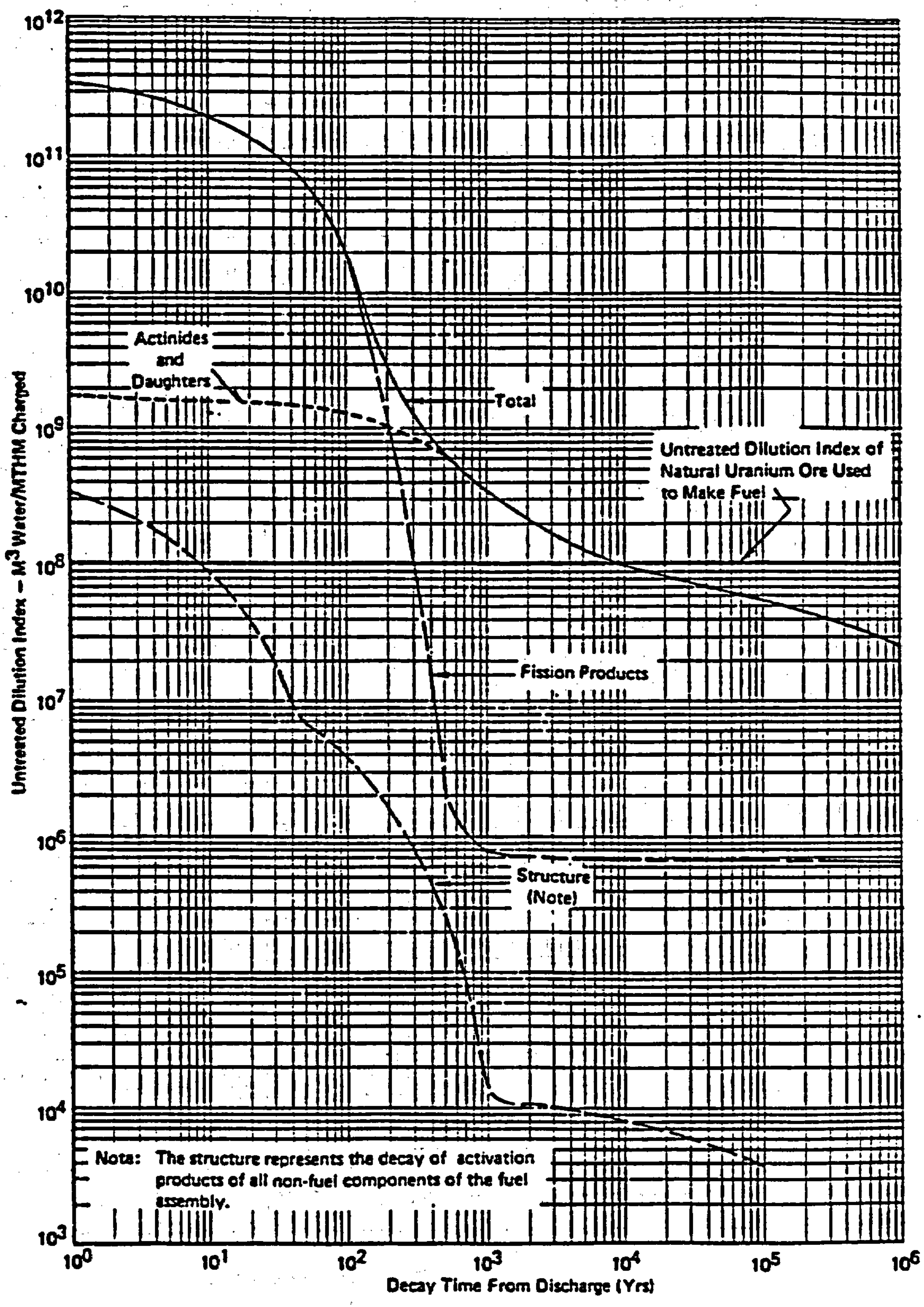


FIGURE 7. PWR SPENT FUEL -- UNTREATED DILUTION INDEX (Ref. 2-3)

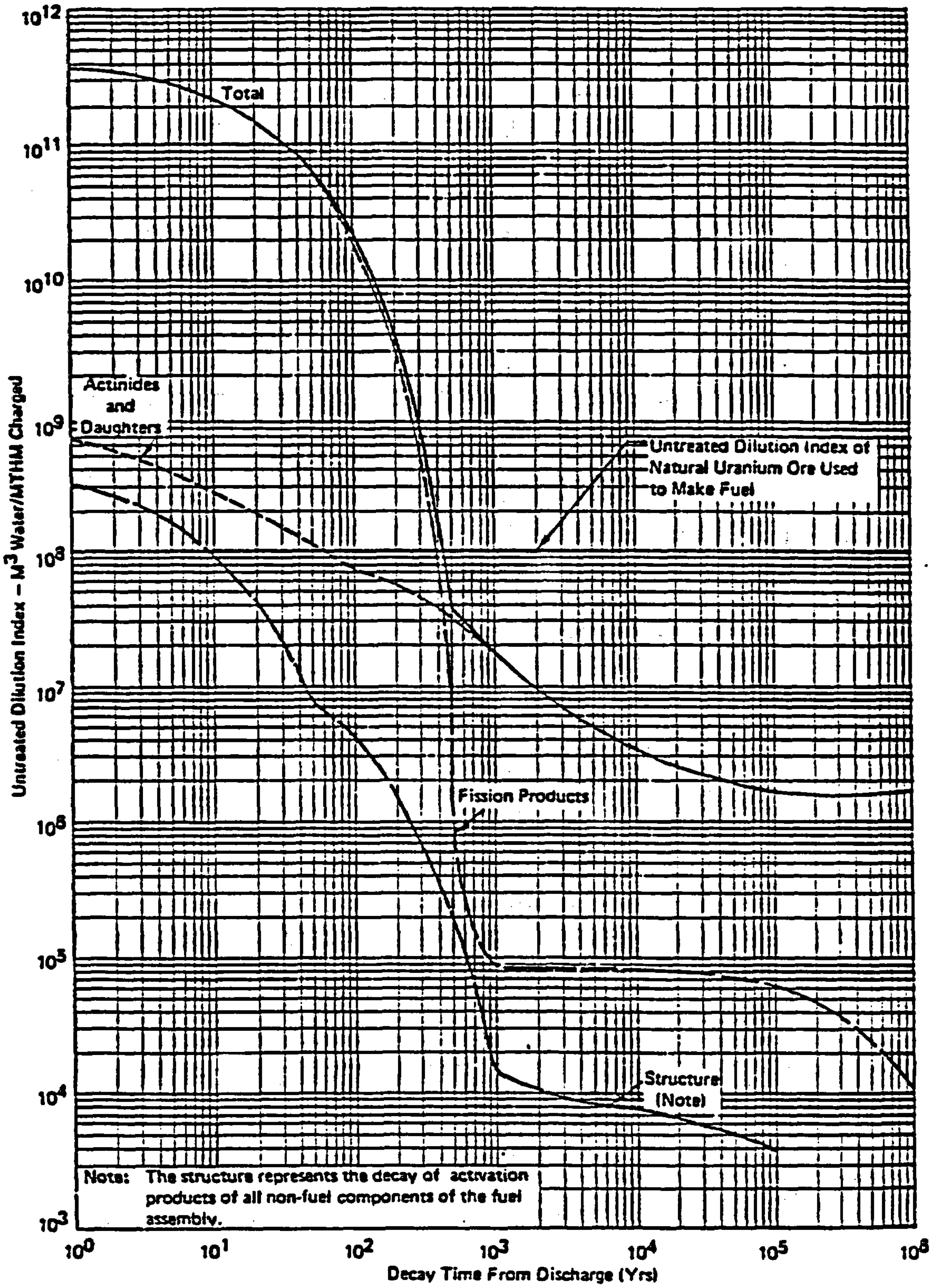


FIGURE 8. URANIUM RECYCLE REPROCESSING WASTE -- UNTREATED DILUTION INDEX (Ref. 2-3)

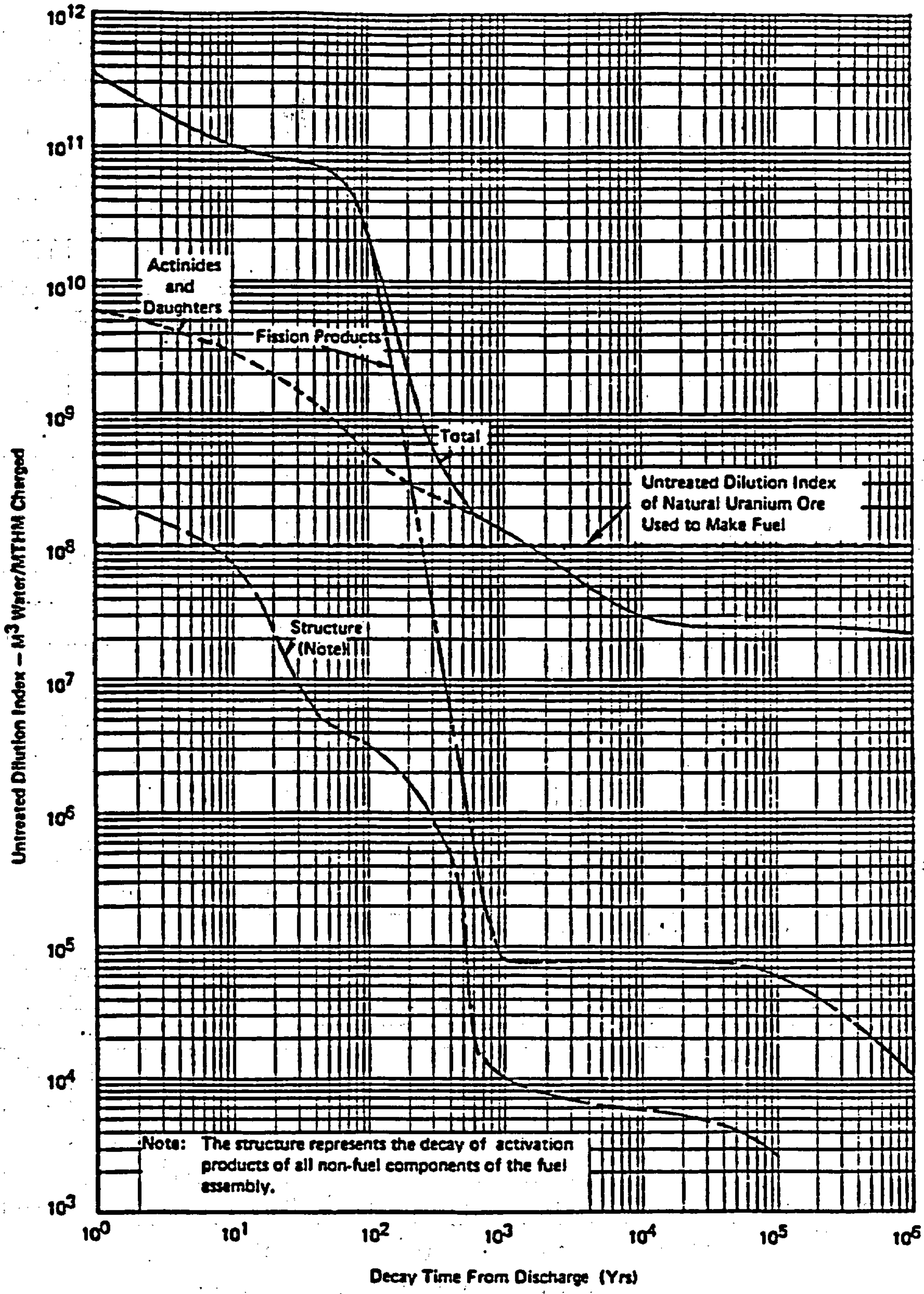


FIGURE 9. MIXED OXIDE REPROCESSING WASTE -- UNTREATED DILUTION INDEX (Ref. 2-3)

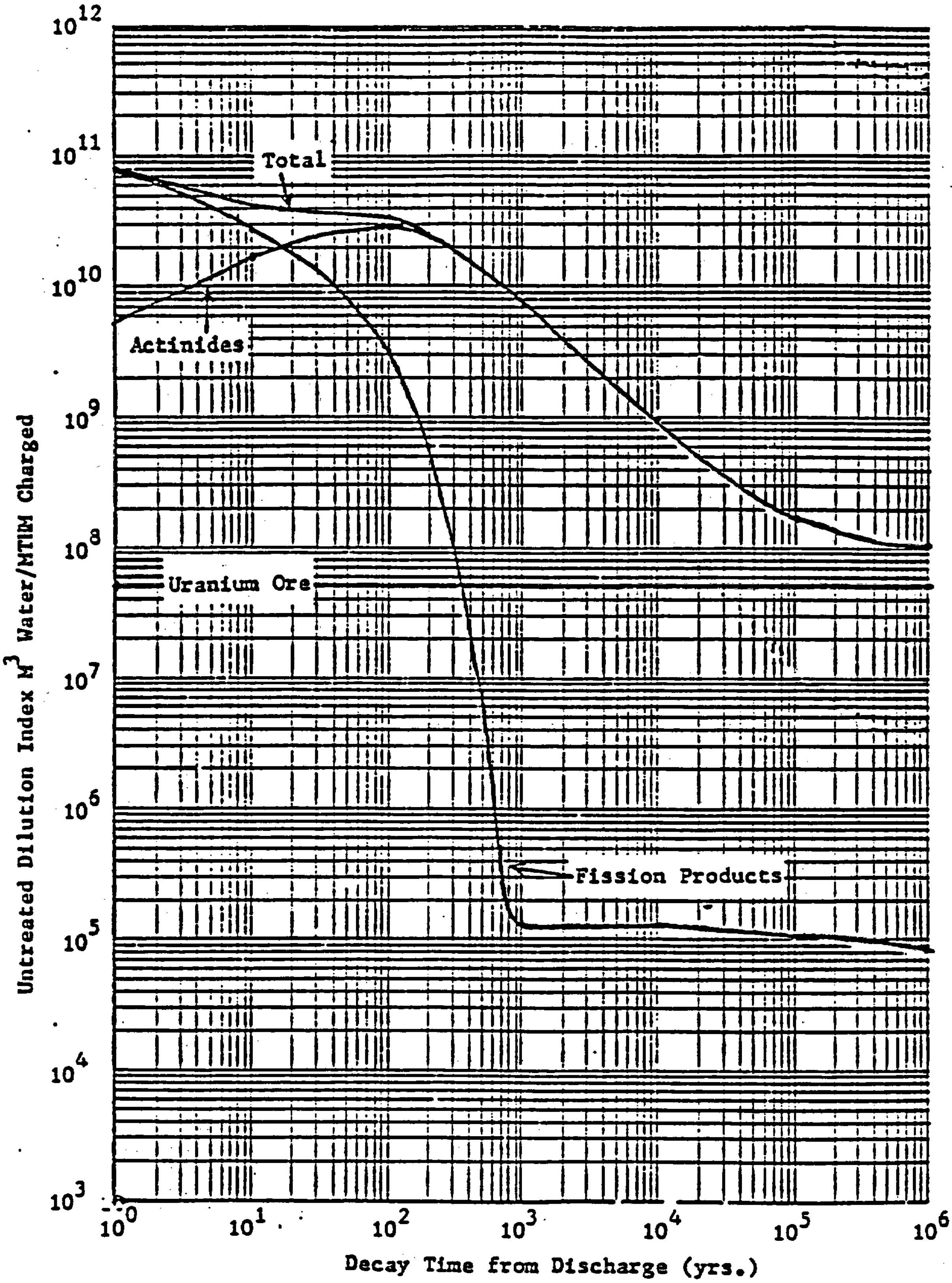


Figure 10. PWR Throwaway Cycle - Untreated Dilution Index Based on ICRP-30 Dosimetry.

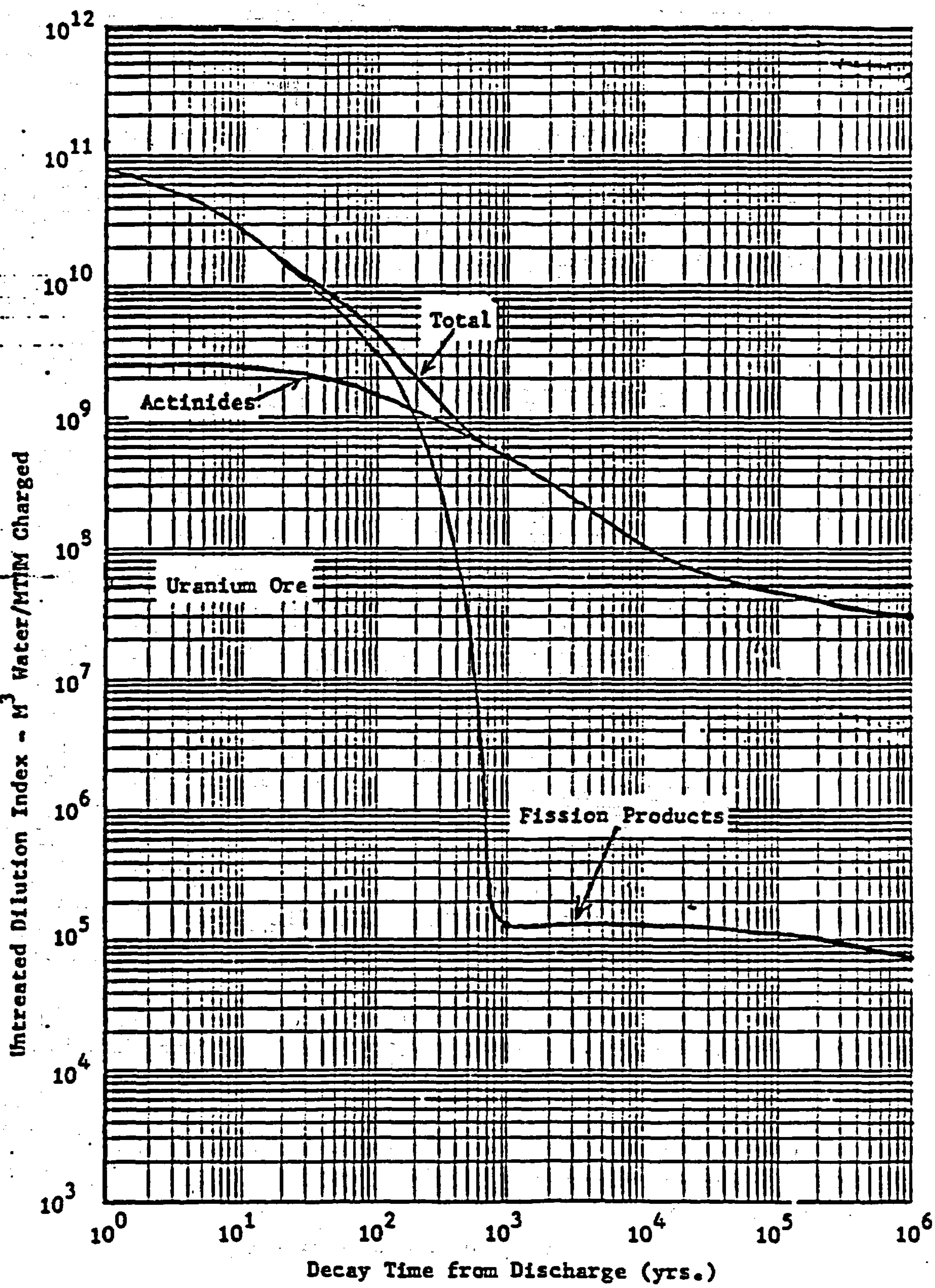


Figure 11. Reprocessed Waste - Untreated Dilution Index
Based on ICRP-30 Dosimetry.

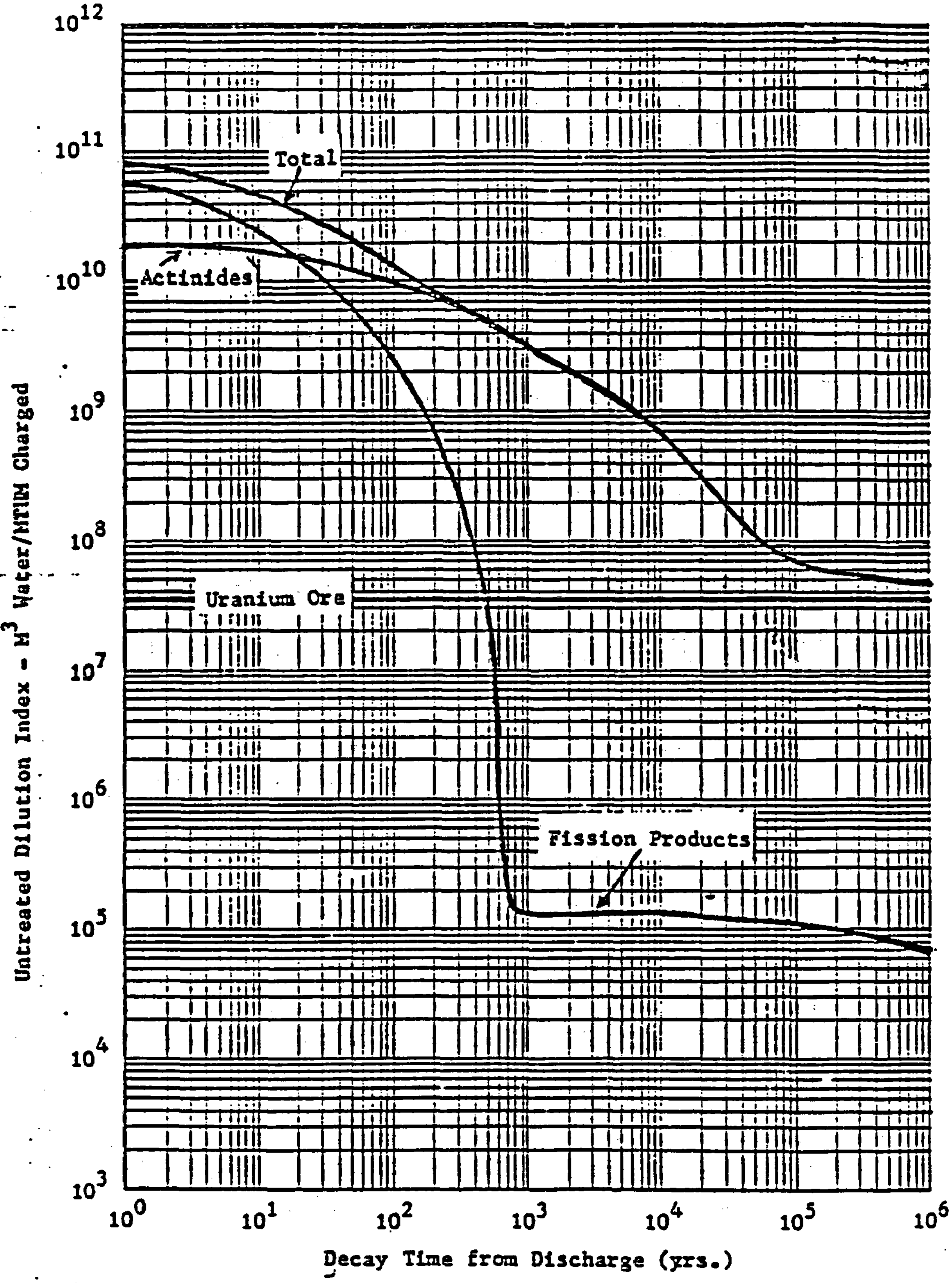


Figure 12. Mixed Oxide Reprocessing Waste - Untreated Dilution Index Based on ICRP-30 Dosimetry.

2) the hazard of several of the long-lived actinides is increased (especially Am-241, Am-243 and Np-237), and

3) the hazard of Ra-226 is reduced and, as a result, the hazard of the original uranium ore is reduced.

The UDI curves of Figures 7-12 indicate that the toxicity decreases substantially (90% - 99.9%) during the first 1000 years for all three waste types and for both dosimetry approaches considered. Table 1 lists the nuclides and their inventories which dominate the UDI curves using the revised ICRP-30 calculational procedure.

The "untreated dilution index" can provide some perspective regarding the intrinsic toxicity of a radioactive material, but is subject to the following limitations:

o The UDI does not consider the physical or chemical form of the radioactive material. Properties such as solubility or leachability may significantly affect the true hazard to human health.

o The location of the material and the pathways through which it could reach humans are not considered.

o There is considerable uncertainty inherent in the dosimetry parameters upon which the UDI is based, leading to considerable uncertainty in the index itself.

Despite these limitations, the UDI and the comparison with uranium ore are useful in understanding the magnitude of the hazard associated with HLW and how this hazard changes with time. In order to gain further

TABLE 1 - Dominant Nuclides* in Spent Fuel

Nuclide	Curies/ MTHM	UDI (m^3/ MTHM)	Percent of Total UDI
10 Years			
Sr-90	6.0E4	2.0E10	43
Am-241	1.7E3	1.1E10	24
Cs-137	8.6E4	7.2E9	16
Pu-241	8.0E4	2.7E9	6
Pu-238	2.2E3	2.5E9	5
Cm-244	1.4E3	5.2E[illegible]	1
1000 Years			
Am-241	9.2E2	6.1E9	80
Pu-240	4.4E2	7.5E8	10
Pu-239	3.2E2	5.4E8	7
Np-237	1.0E0	1.1E8	1
Am-243	1.6E1	1.1E8	1
I-129	3.8E-2	6.4E4	—
Tc-99	1.4E1	4.[illegible]E4	—
100,000 Years			
Np-237	1.2E0	1.4E8	78
Pu-239	2.0E1	3.4E7	19
Ra-226	9.8E-1	4.7E6	3
I-129	3.8E-2	6.4E4	—
Tc-99	1.0E1	3.3E4	—

*Tc-99 and I-129 are included because of their mobility in geohydrologic systems.

understanding of the potential impacts of disposal of high level wastes, it is necessary to consider the rate of releases of the radioactive materials from the location where the wastes are emplaced and the physical and chemical processes that transport the radioactivity back to parts of the environment where it can be contacted by humans. These rates and processes are addressed in detail in the following chapters.

III FUNCTION OF A GEOLOGIC REPOSITORY

At present, national policy is focusing on disposal of HLW in mined geologic repositories (ref. 3-1). The primary function of a mined geologic repository is to isolate the waste so that only small quantities of the wastes would return to the environment over such long times that disposal would not constitute an unreasonable risk to public health and safety. The principal mechanism by which radioactive material is anticipated to be released to the environment from a geologic repository is by contamination of groundwater (ref. 3-2) that contacts the emplaced waste and transports the radioactive materials from the repository to locations in the environment where they can be ingested or contacted by humans. Thus, the assessment of how well a repository performs its isolation function involves consideration of the time when groundwater initially contacts the waste, the rates at which groundwater can contact the waste, the quantities and concentrations of radioactive materials which may be transported away from the disposal facility, and the rates of transport of the radionuclides through the geologic, hydrologic and geochemical systems to the accessible environment.

In order to emplace the wastes, the repository must be open for a period of years during which wastes would be received and handled in surface facilities, transported to the underground facility and placed in disposal locations. After this period of operation, the repository would be sealed and permanently closed. Until the time of permanent closure, handling of the radioactive materials would be carried out so that the public and workers would be protected from excessive exposure to radiation. The measures taken to protect the public and workers during the pre-closure period would be similar to those taken for radiation protection at other nuclear facilities and are not discussed further.

In light of the hazards of the radioactive materials in the HLW and the time periods involved, the measures required to achieve successful isolation of HLW are unique. As discussed in Chapter II, there are substantial uncertainties involved in estimating the toxicity of the waste material itself, and these uncertainties are compounded by uncertainties in such factors as the release rate of wastes from a repository and the pathways by which the wastes might reach the environment. These uncertainties will be discussed in more detail in the following chapters.

IV DESCRIPTION OF A GEOLOGIC REPOSITORY

A mined geologic repository is a facility which achieves isolation (limiting the rate of waste release to the accessible environment to acceptable levels) by means of two major subsystems. These are the geologic setting itself, which is selected for geologic, hydrologic and geochemical attributes which can contribute to isolation; and the engineered system consisting principally of waste packages and materials used to backfill and seal the underground facility, boreholes and shafts. The geologic setting and the engineered system differ both in their contributions to isolation and in the degree of confidence which can be placed on predictions of their long-term performance. Any mined geologic repository will contain some combination of these engineered and natural barriers which together must provide isolation. This is commonly called the multiple-barrier or the defense-in-depth approach. A major issue the Commission has had to deal with in promulgating technical criteria for geologic disposal of HLW is "how do the components of these two subsystems contribute to isolation and what confidence can be placed on their relative contributions to overall system performance?" To answer this question, the staff considered what the respective contributions of the geologic setting and the engineered system to overall performance should be so that the Commission can determine that there is reasonable assurance that a particular repository can isolate wastes.

ENGINEERED BARRIER SYSTEM

As currently envisioned by DOE in its GEIS on Commercial Waste Management (Ref. 4-1), wastes placed in a geologic repository will be in solid form and will be in a container or canister which, as a minimum, is needed to facilitate shipping and handling. Packages can be made of long-lived corrosion resistant materials, and special low permeability and absorbent materials can be placed around the canisters and in the underground facility to contribute to isolation. In fact DOE, in its GEIS, states that one of the functions of the waste package is to contain the waste for periods sufficient to allow most of the fission products to decay to very low levels. This action protects the waste from groundwater contact until the temperature and radiation levels have decreased to the point where technically supportable predictions of radionuclide release rates to the host rock can be made. It is expected that, at the end of repository decommissioning, the underground facility will have been backfilled and the boreholes and shafts which connect the underground facility with the ground surface will have been sealed with low permeability materials. The combination of waste packages and the underground facility we have called the engineered barrier system. The engineered barrier system can contribute to isolation first by controlling the release rate of radioactive materials to the geologic setting, thereby reducing the contribution which the geologic setting must make, and second, by providing a source of isolation which is relatively independent of the geologic setting and which can therefore mitigate the consequences of unforeseen failure of that setting.

This control of the source term can be achieved in several ways. First, the engineered barrier system can be designed of materials that limit the rate at which groundwater can contact the wastes. Second, the waste form itself can be comprised of, or encapsulated in, leach resistant materials. Third, materials which can retard migration once leaching has occurred can be placed in the underground facility and around the canisters to further control release of radioactive materials to the geologic setting.

One means by which waste-groundwater contact can be limited is by containment. In this context, containment means confining the wastes within a sealed boundary, such as a metal or ceramic container or canister, to protect the waste form from groundwater and to delay the onset of leaching and migration until the containment boundary is breached. Such a container can protect the waste form from water during the period when radiation and temperatures are high and release rate predictions are difficult. Even after an initial breach of a canister, which may only be a small pinhole or crack, the waste package may continue to contribute substantially to control of release for decades or centuries by limiting the amount of water which may contact the waste form.

Use of a long lived package to achieve containment is a means, therefore, to compensate for, and to an extent avoid, uncertainties in the prediction of rates of release and migration of the individual radionuclides, particularly during the critical period when the hazard of the wastes is greatest and the heat generation rates are the highest. This is important, because, as explained in Chapter V, temperature is one of the principal factors in calculating what the source term to the geologic setting is. During this critical period the uncertainties in predicting release rates for long times are very great. Even if we did understand the mechanisms completely, the data scatter increases with temperature so that test programs to gather the data to narrow the uncertainties to reasonable bounds are very cumbersome (Ref.4-2).

THE GEOLOGIC SETTING

Following release of the radioactive materials from the engineered barrier system, the geologic setting alone must provide whatever additional isolation is needed to keep radioactive materials entering the accessible environment to acceptable levels. The geologic setting can provide the needed isolation by two principal means. First, the geologic setting can exhibit hydrologic conditions and be comprised of materials whose properties result in low groundwater velocities and long groundwater travel times to the accessible environment. Second, the geologic setting can be comprised of materials that chemically inhibit transport of radionuclides by groundwater by, for example, ion-exchange or precipitation reactions. The objective is for the geologic setting, through long groundwater travel times and geochemical retardation, to delay the arrival time of radionuclides at the accessible environment for many thousands of years. During this time additional radioactive decay will take place, so that only a small fraction of the material released from the engineered barrier system will enter the accessible environment, and then only very far in the future.

V. UNCERTAINTIES ASSOCIATED WITH GEOLOGIC DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES

In the two previous chapters we discussed the function of geologic disposal of HLW (Chapter III) and gave a brief description of current concepts for a geologic repository (Chapter IV). Assessments of the long-term performance of such a HLW repository require the use of quantitative models, and substantial uncertainties are associated with both the models themselves and with the input data necessary for their use. In this chapter we discuss the uncertainties associated with long-term performance assessments, the effects of those uncertainties on the confidence that can be placed in such assessments, and the means by which these uncertainties may be reduced or compensated for.

In section 1 of this chapter, we begin by reviewing the functions of engineered barriers for isolating HLW, noting specific processes which control or determine these functions. For each process, we cite 1) the properties important in the process, 2) the methods available to measure those properties, 3) ways to determine whether the function is achieved, and 4) the uncertainties associated with those determinations. In section 2, we treat the key elements of the geologic setting in a similar manner. Finally, we discuss the implications of the uncertainties with respect to confidence that the wastes will continue to remain isolated long into the future.

The specific processes discussed are chosen to follow current concepts of a geologic repository. A canister containing a leach-resistant waste form is emplaced within a backfilled underground facility. Hence, in section 1 we discuss the engineering by focusing upon the containment properties of a canister, leach properties of waste forms, and sorption/chemical/mechanical properties of backfill. The processes discussed (corrosion, leaching, etc.) would be relevant to any engineering scheme which might be proposed to control release of radionuclides to the geologic setting. Similarly, groundwater flow, geochemical retardation, and the general suitability of a location to host a geologic repository are discussed in section 2.

1. Uncertainties in the control of radionuclide release to the geologic setting through engineering.

If an engineered barrier system is used to control the release of radionuclides to the geologic setting by methods such as containing the wastes for some period or controlling the rate at which the nuclides are released, then there must be some level of confidence that the materials will perform as planned. This section discusses those processes which determine how engineered materials will behave and affect containment or release of radionuclides, methods for determining and projecting the performance of engineered materials and the uncertainties associated with projecting barrier performance.

To assess the performance of barrier materials it is necessary to understand the environment which they experience, as altered by the effects of these materials on that environment. The central feature of the environment will be groundwater, whose naturally occurring properties such as chemistry and temperature will be altered by thermal and radiation effects of the waste, as well as by chemical interactions with the barrier materials. The complexity of these interactions will result in an uncertainty in the understanding of the environment experienced by the barrier materials which will contribute to the uncertainties in the prediction of their performance.

a) Leach-resistant waste forms

(i) Properties

Leach-resistant waste forms can control releases of radionuclides to the geologic setting in two ways. First, the rate at which nuclides are released can be reduced, reducing nuclide concentrations in groundwater. Second, retention of radionuclides in the waste form allows time for decay, reducing the total quantity of radioactivity ultimately released to the geologic setting.

Leaching will depend on parameters associated with the ground (or repository) water contacting the waste form, such as composition, pH and Eh; parameters pertinent to the waste form itself, such as surface area and structure; and parameters which affect properties of both the water and the waste form, such as temperature and radiation. (Ref. 5-1, 5-2 and 5-3).

(ii) Determination of leach rate

Leaching of a waste form by groundwater is a very complex process. There is as yet no rigorous, well determined rate expression available to describe the leaching of a waste form and its dependence on all the physical, chemical and geometric properties that are known to affect it. Moreover, much of the data available indicate a complex interplay between leach rates and parameters such as pH, Eh, flow rates, leachant chemistry and how these parameters may change with temperature. As a result the models presently available to estimate the rate of leaching generally reflect empirical correlations rather than theoretical principles. Experimental measurements can be conducted under conditions intended to represent the expected leaching environment (Ref. 5-4 and 5-5).

Controlled perturbations of leach rate experiments may lead to a broader understanding of fundamental leach rate phenomena (e.g., the influence of temperature and pH on leaching) and, in principle, can aid in the development of and improve the validity of the models. However, in all cases, predictions of long term performance will be based on the results of tests and analyses of those results. From such analyses, it is known that certain parameters such as temperature and radiation alter the measured leach rates significantly (Ref. 5-6 and 5-7). As the temperature increases the mechanism of leaching may change, the nature of the leaching medium may change, and the ability to precisely and reproducibly determine the leach rate may be hampered. Radiation will alter characteristics of the leaching medium, such as, its pH (Ref. 5-8), and thus will alter measured leach rates. The combined effects of increased temperature and radiation can potentially increase the uncertainties in the leach performance of the waste form to a point where they may not easily be quantifiable.

Further, there will always remain the question as to whether the conditions by which leach rates are determined in the laboratory are the same as those which will be encountered by the waste form in the repository. Uncertainties in measurements of current geologic characteristics (e.g., flow rates) and, particularly, in predictions of future geologic conditions, place limits on the reliability of long-term leaching extrapolations.

(iii) Implications

Several conditions must be met if a leach resistant waste form is to serve as a major barrier to waste release:

1) The influence of significant parameters (e.g., temperature, groundwater chemistry) must be thoroughly investigated. An understanding of the influence of these parameters may require that the waste form be contained to prevent the initiation of leaching until temperature and radiation levels are low enough that a greater degree of confidence can be placed on the long term leach behavior.

2) Predictions of the repository environment far into the future must be bounded, including changes in the environment between closure and resaturation of the underground facility. Such predictions need not be precise, but the bounds must lie within the range of conditions for which the waste form has been experimentally tested.

3) Manufacturing quality control must be adequate to assure that the properties of "production line" waste forms do not deviate significantly from the properties of the waste forms evaluated in the laboratory.

If these conditions are met, leach rates may be extrapolated with less uncertainty. Furthermore, long-term leach rates can probably be predicted with more confidence than can near-term leach rates because of the elevated temperature conditions shortly after waste emplacement. A low leach rate waste form can therefore serve as a high performance engineered barrier over the long-term after thermal and radiation effects have decreased. The level of confidence would probably be lower in the short-term (hundreds of years) when elevated temperatures and radiation may cause extreme repository conditions.

The waste form testing, groundwater measurement and manufacturing quality control conditions discussed above seem reasonable in light of the degree of confidence which could be placed on a low-leach rate waste form as an engineered barrier. A numerical limit for the leach rate to be achieved by such a waste form will be discussed in a later chapter.

(b) Canister

(i) Properties

The use of a canister to contain the wastes is a means which can overcome some of the difficulties with predicting leach rate and radionuclide sorption (to be discussed in section (c)) at the elevated temperatures and radiation levels likely to be present during the first few centuries following closure. Containment can delay the onset of the leaching process until temperatures have fallen to a level where the leach rate is predictable with a higher degree of confidence.

The mechanism of containment functions not so much to keep wastes within a specified volume, (e.g., the canister) but to keep the groundwater from contacting the waste-form until temperature and radiation levels are within the range where laboratory data can be relied on to predict long term performance with reasonable assurance. Hence, the process of concern is deterioration of the canister. Some of the physical and chemical parameters which determine corrosion rates are the same as those which determine leach rates. Principal among these are groundwater chemistries (Eh, pH chemical composition), temperature and radiation (Ref. 5-9).

(ii) Determination of expected containment time

Actual containment time can not be observed directly because of the long periods involved. Rather, the expected containment time must be inferred from extrapolation of experiments, noting both the modes and rates of deterioration and failure. Typically, specimens of the material to be used, including weldments, will be subjected to conditions simulating the groundwater and, possibly, the radiation environment expected to be present.

(iii) Implications

The principal advantage of containment is that it permits the system to be simplified by separating the waste from the groundwater until such time as temperature and radiation effects decrease to where laboratory tests can better simulate repository conditions.

Container degradation or failure can be experimentally measured over a wide range of anticipated repository conditions (e.g., typical repository water chemistries, temperatures and radiation fields). As with leaching from a waste form, corrosion of a metallic barrier is a complex kinetic process and may be difficult to predict. At higher temperatures, new mechanisms may arise and the uncertainties in the data may increase. However, failure rates for some processes, or the conditions under which a specific process can cause failure, may be investigated. Failure rates under the range of conditions expected in the repository can be estimated and their accompanying uncertainties bounded. These can then be used to assess the performance of canister materials and to bound the confidence in that assessment.

The conditions previously discussed for leach rate predictions (predictions of groundwater conditions, testing that bounds these conditions, and manufacturing quality control) also apply to containment time predictions. If these conditions are met, containment times may be extrapolated with confidence. A numerical limit for the containment time to be achieved will be discussed in a later chapter.

(c) Backfill

(i) Properties

Backfill materials can serve a number of purposes. They can retard migration from the underground facility of radionuclides leached from the waste form, can condition groundwater within the underground facility both to slow corrosion of canisters and to lower leach rates, and can physically limit the rate of groundwater contact with a canister or waste form (Ref. 5-10). The chemical, thermal, and mechanical (physical) properties of the backfill and its interaction with the groundwater determine its performance. When groundwater interacts with a canister or a waste form, the chemical composition of the resultant solutions must be considered if backfill is used to retard radionuclide migration, limit leach rates or reduce solubility limits. Further, for backfill to be a useful agent for conditioning groundwater or retarding radionuclide movement it must contact the groundwater effectively. That is, the backfill must be emplaced in such a way that there are no extensive voids or channels that would permit the groundwater to bypass the backfill materials. In addition, the backfill must be able to perform its function in the changing thermal, chemical, and radiation environment of the repository.

(ii) Determination of backfill performance

Standard engineering tests for compaction, permeability, homogeneity, and gradation can be performed on backfill emplaced within an underground facility to assure the proper mechanical properties for its intended function. Groundwater conditioning and radionuclide retardation properties can be determined by laboratory tests which focus on the chemical properties of the backfill. Backfill materials can be tested in the laboratory and in-situ to determine their behavior in the repository environment (Ref. 5-11 and 5-12).

(iii) Implications

The functions of a backfill material can be considered to be of two basic types:

(1) An adjunct to other barriers. A backfill can condition groundwater to help control containment times and leach rates, and can limit the rate of groundwater contact with a canister or waste form.

(2) A barrier in its own right. A backfill can retard movement of nuclides away from their location of emplacement.

The uncertainty in the performance of a backfill material probably cannot be quantified very precisely. Rather, the backfill serves largely to reduce the uncertainty in the performance of the other barriers. (For example, by controlling the pH of the groundwater, uncertainty in the corrosion rate of a canister may be reduced.) The backfill can, nevertheless, serve an important function in overall repository performance, and can be instrumental in predicting the performance of the other engineered barriers.

2. Uncertainties with respect to transport of radionuclides through the geologic setting.

Regardless of the extent to which engineering is used to contain wastes or control the release of radionuclides, the geologic setting determines the environment in which the engineering must perform its intended function. Hence, the geologic setting must be characterized, measured, and understood at least with respect to the design parameters of the engineering. Moreover, to the extent that the geologic setting is used to isolate the wastes from the accessible environment, or that it is relied upon to mitigate the consequences of premature or unanticipated failure of the engineering, it must be characterized, measured, and understood with respect to its ability to control the movement of radionuclides to the accessible environment. In this section we discuss the parameters which describe the processes and characteristics of the geologic setting relevant to the functions described above.

(a) Groundwater Hydrology

(i) Properties

The groundwater is the likely means by which radionuclides would be transported from a geologic repository to the accessible environment. Hence a long groundwater flow time between the underground facility and the accessible environment is a highly favorable condition for waste isolation. Further, our confidence in the ability of a geologic repository to isolate wastes is directly dependent upon an understanding of the groundwater at the location of the repository. The characteristics by which we describe the groundwater flow through porous media typically are those by which any fluid system is described: gradient, porosity, permeability, temperature, density, viscosity, and the geometry of the system. For flow in fractured media, an effective porosity and an effective permeability can be developed based on average fracture size and length and the porosity and permeability of the unfractured rock. (The chemical properties of the groundwater also are important to the design of the engineering used to contribute to the isolation of the wastes. The measurements of the chemical properties relevant to engineering, and their associated uncertainties were discussed in the previous section.)

(ii) Determination of groundwater flow

The hydraulic properties of the groundwater system particularly important to isolation of radioactive wastes are related to groundwater flow (rate, quantity, direction, and, in the saturated zone, time for resaturation of the underground facility). Groundwater flow can be measured directly for simple, fast-moving aquifers. However, the underground facility is likely to be constructed in an aquitard or aquiclude, and nearby aquifers are likely to be very slow flowing, and may be complex and fractured. Such slow flow or complex heterogeneous conditions make direct measurement of groundwater flow difficult. Fluid systems models that incorporate the properties described in the preceding section can be used in place of direct measurement to estimate groundwater flow. Such models have been developed, but have not been validated, for estimating groundwater flow in the slow-flow conditions expected in the stratum in which an underground facility would be constructed. Moreover fracture-flow will likely be of importance in many host rocks, but the development of fracture-flow models is in its infancy and the utility of these models for predictive purposes has not yet been demonstrated (Ref. 5-13 through 5-16).

Groundwater dating is an alternative to direct measurement for estimating groundwater flow, and does not require measurement of all the properties which determine groundwater flow. Hence, groundwater dating can provide a semi-independent check on groundwater flow estimates (Ref. 5-17). Groundwater dating involves uncertainties which are potentially important, however. Among these are uncertainties in initial isotope ratios, chemical or physical processes which could alter isotope ratios or concentrations along the flow-path, and mixing with groundwaters from other sources between measurement locations. At present, groundwater dating techniques applicable to waste repositories are mostly in the early stages of development, except for methods using C-14 (Ref. 5-18).

(iii) Implications

Some of the uncertainties associated with estimates of groundwater flow for repository performance can be assessed quantitatively by means of parameter sensitivity analyses and statistical sampling techniques (Ref. 5-19, 5-20 and 5-21). However, the utility of uncertainties estimated in this way is limited with regard to actual flow at a repository site for several reasons. Validation is lacking for flow estimates under slow-flow and fracture-flow conditions. Also, the models used to make the estimates may not properly account for (1) the diverse and heterogeneous geologic environments which are likely to be encountered over the distance of groundwater travel from where the wastes are emplaced to the accessible environment, and (2) the effects of natural geologic processes, as well as the thermomechanical perturbations caused by the wastes themselves, which may significantly alter groundwater flow patterns over the time period required for waste isolation.

(b) Geochemistry

(i) Properties

Favorable geochemistry would tend to retard the movement of radionuclides with the groundwater. The movement of radionuclides typically is described by the groundwater flow rate and the empirical retardation factor. The latter is a shorthand for the complex geochemical processes which affect radionuclide transport in groundwater. The retardation factor is described in terms of characteristics of the geologic medium (e.g., bulk density and porosity for porous-medium flow) and the equilibrium distribution coefficient, Kd, which accounts for the chemical interactions among a radionuclide, the constituents of the groundwater, and the host rock/aquifer of concern.

Solubility limits may also be important, particularly for the actinide elements. If the rate of groundwater contact with a waste form is very low (e.g., because of favorable backfill material properties), or if the solubility limit of an element is very low, the apparent "leach rate" of a waste form will be reduced independent of the inherent leaching characteristics of that material. Solubility limits are dependent primarily on the groundwater chemistry (for a given element). Thus, a combination of a favorable groundwater chemistry and a low rate of groundwater contact with a waste form (e.g., good backfill properties) could substantially reduce nuclide dissolution rates from a waste form.

(ii) Determination of geochemistry conditions

The relevant processes and considerations which must be measured or inferred to understand and predict geochemical retardation of radionuclides include, among others, precipitation/dissolution (controlled by solubility), the chemical forms of nuclides in solution, sorption/desorption interactions, and colloid transport and ultrafiltration. Generally, the limiting geochemical processes are chemical complexing (which determines species present in the groundwater), and precipitation and sorption/desorption (which affect the amounts of radionuclides dissolved in groundwater).

Laboratory tests can be used to estimate maximum solubilities, and field measurements can be made to verify laboratory measurements. Similarly, laboratory measurements can be used to determine sorption/desorption properties. However, the relevance of laboratory measurements to actual field conditions is only beginning to be investigated. This area must be considered to be very speculative.

Theoretical geochemical models have recently been developed to investigate element speciation in realistic geochemical environments. (Ref. 5-22 and 5-23). However, the requisite field data and thermodynamic data, particularly for transuranic elements, are difficult to obtain. Most of the available thermodynamic data are at a temperature of 25°C and standard atmospheric pressure, and need to be adjusted to expected repository conditions (Ref. 5-24). Experiments at elevated temperatures are being conducted (Ref. 5-25). In addition, the models involve important assumptions, such as that of chemical equilibrium, which may be unrealistic if the spatial variation in geochemical properties of the geologic setting is severe. Finally, theoretical models do not yet incoporate kinetic effects in the predictions of element speciation, nor do they relate speciation to predictions of retardation in groundwater transport. At present, theoretical geochemical modeling probably cannot provide an adequate substitute for empirical data approximating projected anticipated repository conditions, especially for elements such as Pu, Np, U, and Tc, whose mobility characteristics depend strongly on geochemistry (Ref. 5-26).

(iii) Implications

A large body of experimental data on solubilities and Kd's has been obtained for many of the important radionuclides in HLW (Ref. 5-27 and 5-28). However, serious questions have been raised about the relevance of Kd's to observed retardation effects, and about the ability to measure and to predict the in situ conditions which must be known to reduce the uncertainties associated with both solubilities and kd's to tractable levels (Ref. 5-29). Estimates of solubilities and Kd's and the uncertainties associated with them have been made for the geologic media of interest to the national program (Ref. 5-30) and are used in the calculations appearing in Chapters VII and VIII of this document.

(c) Geologic Environment

(i) Properties

The characteristics customarily used to describe the geologic environment relate to its mechanical and thermal properties, its mineralogy, and its geologic structure. The processes which affect these characteristics include climatic changes, surface erosion/deposition, diagenesis, and tectonic processes such as uplift, subsidence, folding, and faulting.

(ii) Characterization of the geologic environment

Geologic characteristics, i.e., both the present thermal, mechanical, chemical, etc., properties of a given location and the geologic processes anticipated to be operating there now and in the future, are essential not only for understanding factors relevant to transport of wastes by groundwater, but also for confidence in the performance of any engineering over the long term. Not only must the present conditions be favorable for those functions, but also there must be some assurance that the processes expected in the future at the location will have no significant adverse effect. That is, the processes and events which occur at this location either 1) leave the relevant characteristics unchanged, or 2) change them in a way that allows confident predictions of no adverse consequence to the isolation of the wastes. Measurements can be made of the mechanical and thermal properties, mineralogy, and structure of a particular location, although complexity of a location and spatial inhomogeneity add to the difficulty of interpreting the results of such measurements. The existence of past geologic processes are evidenced by the geologic record. Inferences are made from that evidence as to the likelihood of continued or renewed activity of those processes.

(iii) Implications

Uncertainties in our understanding of the present state of a geologic environment result from the potentially complex spatial variations in pressure, structure, and mineralogy. In order to reduce uncertainties, field data can be collected employing sample sizes and spacings of sampling locations which match the scale of important inhomogeneities in the location. Some uncertainties are quantifiable, e.g., those associated with the extrapolations and interpolations based on field data which are numerical and, thus, are subject to statistical analyses (Ref. 5-31). The magnitude and significance of these uncertainties are site specific.

The predictions as to which geologic processes are likely to be active into the future and which events are likely to occur are based primarily on interpretations and temporal extrapolations of the geologic record. Significant uncertainties may result from the incompleteness or possible misinterpretation of the geologic record. Predictions based on the geologic record are inherently judgmental, particularly for discrete events at specific locations. Nonetheless, the geologic record can be used to estimate bounds for the future effects of anticipated geologic processes and events. At locations which have exhibited little change since the beginning of the Quaternary, the numerical uncertainties in quantitatively predicting the effect of geologic processes on repository performance are likely to be unimportant for time periods of about 10^4

years or less, but may become significant for longer times (Ref. 5-32). However, there is always a residual uncertainty as to whether a process or event might occur which is not expected or considered likely on the basis of the geologic record and which will cause the engineering to fail.

Thermal and mechanical perturbations of the natural geologic environment caused by development and operation of a repository and emplacement of wastes also need to be taken into account in determining the suitability of a location for waste disposal (Ref. 5-33). For about the first 10^3 years, when the decay heat generated in the waste is most important, and decreasingly thereafter,it is likely that the thermal perturbations will have important effects in the rock in close proximity to where the wastes are emplaced. In principle, uncertainties associated with predicting the post-closure effects of thermal field and mechanical perturbations (e.g., in salt) are quantifiable on the basis of field tests. Testing is difficult, however, both because of the long time period over which the decay heat is significant and because the physical size and layout of a test facility should simulate expected repository conditions.

3. Assessment of performance over long periods of time

In the previous sections we discussed the properties by which engineered and geologic systems could contribute to isolation of radioactive wastes. We also discussed the kinds of measurements and experiments needed to conclude that those systems would perform the various functions that might be attributed to them. Finally, we discussed the uncertainties associated with those measurements and experiments and touched upon the implications of those uncertainties with respect to confidence in the isolation of high-level radioactive wastes.

From the preceding discussions of this chapter it is seen that, of the uncertainties which affect confidence in geologic disposal of HLW, the most common and most easily accommodated is measurement uncertainty. There are, of course, practical limitations to the accuracy and precision of measurements of the relevant properties, especially field measurements of the geologic setting in which a repository might be located. Yet, measurement uncertainty is quantifiable and amenable to statistical analyses. Not only the values of properties deemed relevant can be known, but also some quantitative statement can be made as to how well those values are known.

Mathematical models must figure prominently in any assessment of the long-term performance of a HLW repository since there will be no opportunity to observe actual repository performance prior to licensing. The reliability of the predictions of these models is limited by the reliability of the input data to these models and by the reliability of the models themselves. The geologic sciences are far from being precisely predictive and, as a result, the models and most of the geological data upon which they rely are subject to sizeable uncertainties. These uncertainties could make repository licensing problematical for the Commission unless adequate compensating measures are employed. Engineered barriers can, as the preceeding paragraphs indicate, substantially reduce and compensate for these uncertainties. Some engineered barriers, e.g., waste forms, can reduce uncertainties by reducing the source term which the geologic environment must control. Other engineered barriers, such as canisters, can reduce uncertainties by preventing contact between the waste form and the groundwater until the temperature and radiation levels are low enough that the mechanisms controlling radionuclide releases to the geologic setting are understood and the data scatter in measuring and predicting these releases is reduced to tractable levels. Additional engineered barriers, such as backfill materials, can compensate for uncertainties in ways which may be largely qualitative, but which will nevertheless lend confidence to a decision on overall repository performance.

In a complementary manner, the geologic setting will compensate for uncertainties in the performance of the engineered barrier system. A minimum groundwater travel time can provide quantifiable compensation for premature failure of or excessive early releases from the waste package and underground facility. Siting criteria addressing resources can reduce the liklihood of inadvertant intrusion into the engineered barriers system. Overall, this element of redundancy of barriers is expected to play a significant role in any Commission decision to license a HLW repository.

The specific contributions which individual barriers can make to overall repository performance and to reductions in uncertainty, are discussed in more detail in subsequent chapters.

VI. IMPACT OF UNCERTAINTIES ON REGULATIONS FOR GEOLOGIC DISPOSAL OF HLW

1. Regulatory policy

If we examine again the implications of uncertainties (discussed in Chapter V) associated with determining whether the engineered and natural barrier systems will function as desired as components of a geologic repository, we see that none is free from the uncertainties discussed above. Further, no matter how good the design or how excellent the site, and no matter how precise and accurate the measurements and observations of the components of the repository, the best that can be known is the state of the repository at the time the Commission must decide whether to allow closure. The state of the repository beyond that decision point is an inference. While it is conceivable that the DOE could develop a design that does not require anything of the geology other than to provide a location, or could choose a site so good that no engineered barriers would be needed, there will be no opportunity to see the engineering or the site work under all the anticipated conditions, or to observe whether the actual conditions are those for which the engineering is designed or the site selected. Further, there is always the uncertainty as to whether processes and events not anticipated in the design or not expected to occur at the site will indeed occur, and fail the repository.

Faced with this same type of uncertainty for other licensing decisions in the past, although not to the same degree, the Commission has applied a policy of multiple protective systems. This is commonly known as the defense-in-depth approach. In the case of geologic disposal of HLW, this policy would be realized as a requirement that the site and the engineering share in the task of isolating the wastes. Moreover, no one who has been involved in the formulation of national policy for the disposal of HLW, including the DOE, the USGS, the EPA, and the Interagency Review Group on the management of radioactive wastes has suggested exclusive reliance on either geology or engineering for isolation of HLW. The reasoning behind the implementation of the Commission's policy and its advantages for licensing geologic disposal of HLW are discussed below.

First, requiring both engineering and geology to contribute to isolation can be used to limit the consequences of an unanticipated process or event, which could cause failure of one barrier to properly perform its isolation function. Since the Commission will need to make a judgement as to whether it has reasonable assurance that the public health and safety suffers no unreasonable risk from permitting disposal of HLW within a repository in the absence of any experience and proof-testing, the knowledge that mechanisms are in place which limit the consequences of partial failure will add to confidence in that judgement, despite the knowledge that unanticipated processes and events could occur. Further, since some of the functions of the engineering and the site operate by different mechanisms (e.g., groundwater flow and canister corrosion), requiring DOE to use both in a repository provides multiplicity in the methods by which safety is provided. Although one can never be sure that all eventualities have been addressed, viewing possible failure modes/mechanisms from more than one perspective adds confidence that nothing major has been overlooked.

Finally, although isolation of wastes through engineering or geology involves many of the same properties, and indeed in some instances involves similar processes (e.g., both containment of wastes by a waste package and retardation of radionuclides by the geochemistry of the geologic setting could rely on sorption of radionuclides suspended in groundwater), the major contributors to uncertainty for each arise from different considerations. For example, poor correspondence between laboratory and field measurements has resulted in considerable uncertainty associated with retardation factors for the geologic setting. In the case of material incorporated in the waste package to retard radionuclides, the retardation factors can be measured to relatively small amounts of statistical uncertainty. Hence, to the extent, and over the times, that we can rely on waste packages to contain radionuclides, the uncertainties associated with retardation by the geology are less important. On the other hand, as time progresses our confidence in the waste package's continued performance diminishes. However, the long history of geologic conditions provided by the geologic record permits more confident evaluation of the ability of the location to maintain some level of retardation of radionuclides into the future. Hence confidence in the geologic record compensates for the uncertainty in the survivability of engineering, while confidence in containment for an initial period compensates for uncertainty in geochemical retardation.

2. Numerical requirements

Numerical specification of the contribution to isolation to be made by the site and by the engineering should be consistent with both the standard to be met (the generally applicable standard for radiation in the environment from the disposal of HLW), and whatever the Commission regards as an appropriate level of risk from unanticipated processes and events.

Although no HLW standard exists at present, the Commission can proceed to specify numerical performance objectives by assuming a standard based upon a reasonable expectation of what an HLW standard might be. Several comments on the proposed rule referred to Draft 19 of the EPA standard, which has been under development for some time. We have therefore chosen this draft as the basis for an assumed standard, and in Chapter VIII we consider numerical requirements for containment, controlled release, and groundwater flow time which, if met, will contribute to meeting it.

3. Additional considerations

Use of an assumed HLW standard provides a basis for specifying numerically, at this time, performance of individual barriers (e.g., containment) under anticipated processes and events. However, when a HLW standard is promulgated, the Commission should have the discretion to review and change as needed the numerical values specified for those barriers in light of that standard. Among the factors the Commission might take into account in exercising this discretion are the age and nature of the wastes, characteristics of the geologic setting, and particular sources of uncertainty in predicting the performance of the engineered barrier system or the geologic setting. Finally, in specifying performance numerically at this time, we have not foreclosed the possibility that considerations related to unanticipated processes and events could form a basis for changing the specification, for requiring additional specifications, or both.

VII IMPACT OF NUMERICAL REQUIREMENTS ON ROUTINE RELEASES

As stated in Chapter VI, Draft 19 of the EPA standard, referenced by a number of comments on the proposed rule, has been employed to show the relationship between overall system performance and the numerical requirements on the engineered barrier system and the geologic setting. We expect EPA to publish soon a proposed standard for public comment similar to this draft. This chapter contains an assessment of the contributions to overall performance under anticipated processes and events. An assessment of the mitigation of unanticipated processes and events appears in Chapter VIII. The working draft of the assumed standard fixes a number of parameters against which the overall performance of a repository will be evaluated, including a location at which performance is to be measured (the boundary of the accessible environment), a measure of performance (cumulative releases of specific radionuclides measured in curies), and an interval during which performance is to be measured (10,000 years). In the draft Supplementary Information accompanying the working draft, the EPA also notes its judgment that regulation of releases for a 10,000 year interval will protect public health and safety beyond 10,000 years. Specific limits for releases for reasonably foreseeable (anticipated) processes and events appear in Table 2.

Table 2

Limits of Cumulative Releases to the Accessible Environment for 10,000 Years After Disposal According to the Assumed Standard

Radionuclide	Release Limit Curies Per 1000 MT
Americium-241	10
Americium-243	4
Carbon-14	200
Cesium-135	2000
Cesium-137	500
Neptunium-237	20
Plutonium-238	400
Plutonium-239	100
Plutonium-240	100
Plutonium-242	100
Radium-226	3
Strontium-90	80
Technetium-99	2000
Tin-126	80
Any other alpha-emitting radionuclide	10
Any other radionuclide which does not emit alpha particles	500

For purposes of our assessment, consistent with the assumed standard, the accessible environment is assumed to be all areas on the land surface regardless of distance from the repository and to include all subsurface locations beyond a vertical surface one mile away from the location of the emplaced wastes. These boundaries appear in Figure 13. (A more recent working draft of the standard allows a distance of up to 10 km rather than 1 mile. This change does not significantly affect the results of the present study, however, since only the groundwater travel time explicitly appears). For an actual repository the distance from the wastes to the vertical boundary of the accessible environment is expected to be site specific but not to exceed 10 km.

Routine Release Scenario: The Undisturbed Repository

The NRC staff identified a scenario for the purpose of showing the effect of numerical requirements for the engineered barrier system and the geologic setting on the performance of a geologic repository which is operating normally. A diagram of this scenario appears in Figure 13.

It is anticipated that if radionuclides are released from an undisturbed repository to the accessible environment, this release will take place by failure of the container surrounding the wastes, dissolution of the wastes by groundwater, and migration of the radioactive material dissolved from the wastes with the groundwater to the accessible environment. For this reason, location of the underground facility in the saturated zone is considered a realistic bounding case for routine release. In this scenario, groundwater is presumed to resaturate the repository within a few centuries after closure and to initiate deterioration of the waste packages, causing eventual breaching of the waste packages and start of radionuclide release to the underground facility. In time, the radionuclides are released to the geologic

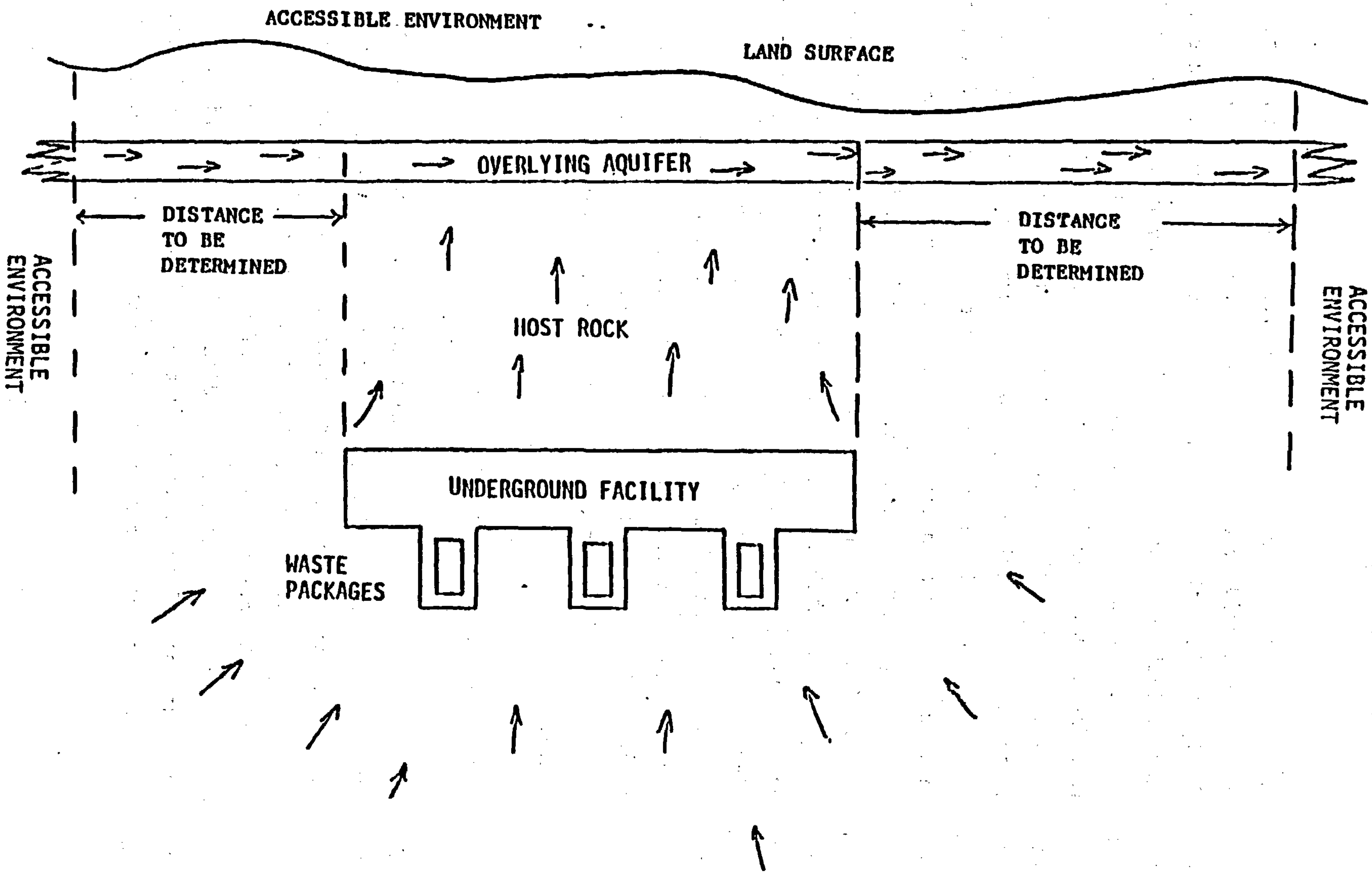


FIGURE 13 - DIAGRAM OF ENGINEERED BARRIER SYSTEM AND GEOLOGIC SETTING FOR THE ROUTINE RELEASE SCENARIO FOR ALL MEDIA.

setting. The assumption of prompt resaturation is conservative but realistic because void spaces in the backfilled repository will result in a hydraulic gradient that will tend to promote flow inward, and because some natural leakage is anticipated. An upward hydraulic gradient in the geologic setting is assumed, causing groundwater carrying the radionuclides to move vertically through the host rock from the repository to an overlying aquifer. The radionuclides then follow the groundwater flowpath horizontally along the aquifer away from the repository and eventually reach the accessible environment. Transport of some radionuclides through both the host rock and the aquifer is assumed to be impeded by chemical retardation and by limitations on radionuclide solubility. Alternative release paths might be selected, such as a downward gradient which could move radionuclides to an underlying aquifer. However, thermal effects will tend to enhance transport to an overlying aquifer, so this upward case is considered realistic. This scenario will be considered for the three media currently of greatest interest for HLW disposal: basalt, welded tuff, and salt. Evaluation of this scenario involves prediction of the behavior of an undisturbed repository taking into account uncertainties associated with significant parameters.

Numerical Assessment: The Model Chosen

To quantify the effects of numerical requirements for the engineered barrier system and the geologic setting in the routine release scenario, it is necessary to specify a quantitative model which corresponds to the qualitative description above. That model may then be used to determine how each of the barriers affects the performance of the overall geologic repository. The model selected for describing this scenario is a quasi-two dimensional model in which the radionuclides travel vertically upward, both through the repository and from it to the aquifer, after which they travel horizontally along the aquifer. This model approximates the groundwater flow shown in Figure 13 by a series of legs, shown in Figure 14. Legs A and B correspond to the upper aquifer, leg C corresponds to flow through the underground facility itself, and leg D corresponds to flow from the underground facility through the host rock to the upper aquifer.

A number of simplifying assumptions have been made in order to implement this model. These assumptions are consistent with generally accepted practice in transport modeling and are not intended to introduce either conservatism or non-conservatism into the analysis. First, one-dimensional Darcy flow is assumed, implying that flow in the legs is proceeding slowly through porous media, and that all significant flow is unidirectional. Slow flow is certainly reasonable in view of the small conductivities and hydraulic gradients involved in geologic disposal systems. Porous flow is reasonable for sandstone aquifers assumed to overlie bedded salt, but for basalt and welded tuff flow through fractures is likely. Therefore, the hydraulic conductivity has been adjusted for basalt and welded tuff to roughly approximate fracture flow. Presumption of unidirectional flow in the legs has been shown to lead to good agreement with complex multidimensional models such as SWIFT (Ref. 7-1) for applications similar to this one (Ref. 7-2 and 7-3).

The model also presumes that rock properties are invariant for the length of an individual leg, so that properties such as permeability and chemical retardation are constants. A radionuclide passing through an actual unit is likely to encounter a spatially varying environment that may affect its velocity. The constant properties of the leg specified in the model therefore are spatial averages of estimates of the aquifer properties, so that a radionuclide is modeled to traverse the leg in the same length of time it would take to traverse the aquifer unit the leg

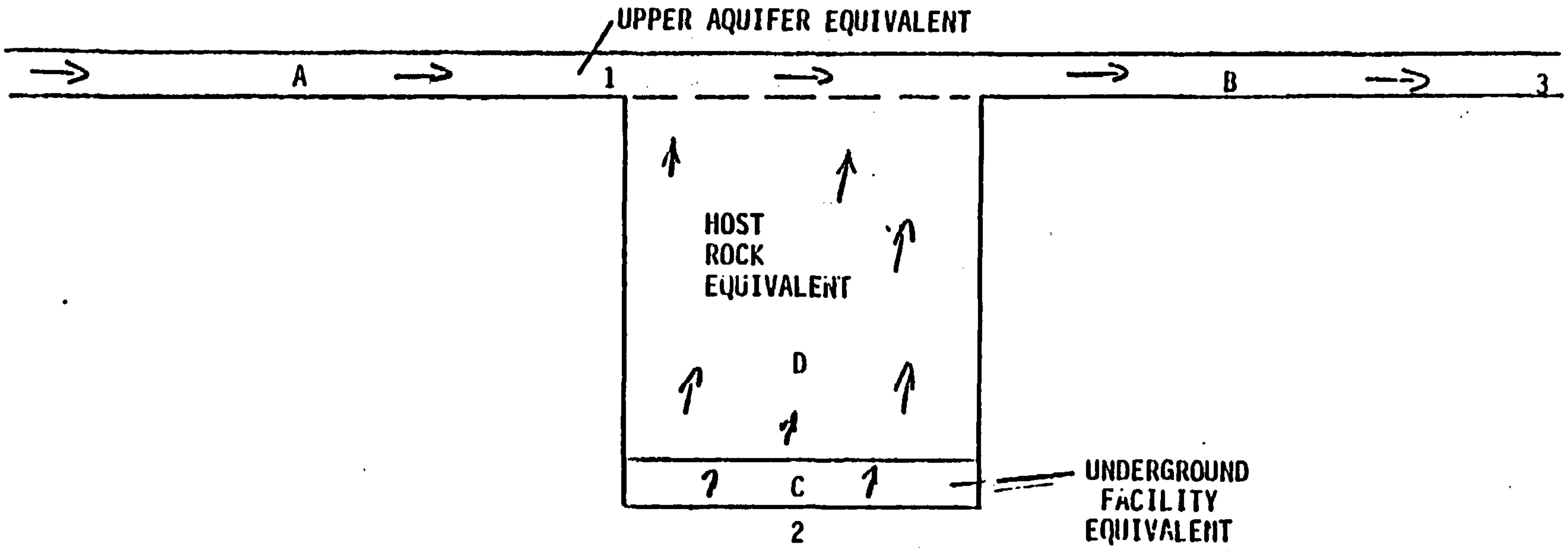


FIGURE 14 - UNIDIRECTIONAL FLOW MODEL CORRESPONDING TO FIGURE 1,
ROUTINE RELEASE SCENARIO

represents. Further, the ranges of the properties considered below are considered to encompass the changes in these properties that are anticipated to occur along actual aquifer units.
Another simplification made by this model is that it does not account for all of the effects of the heat released by the waste. The model does account for thermal buoyancy effects on flow in leg D, by adjusting the pressure at point 2, the point where flow enters the underground facility.

The model does not account, however, for possible permeability changes in the overlying host rock which might result from thermomechanical effects. Finally, as applied here, the model does not deal with the specific processes which cause canister failure or which affect radionuclide release rates from the engineered barrier system. It therefore does not deal with the uncertainties associated with early failure of containment such as hydrothermal dissolution of waste forms or failure of the backfill to retard radionuclides due to elevated temperatures or radiation fluxes. While these limitations of the model are noted, it is the staff's view that the model can provide significant, realistic insight into the relationship between numerical criteria and repository performance.

To implement this model, the NWFT/DVM code was used (Ref. 7-4 and 7-5), which requires an extensive set of parameters as input data. These parameters, whose selection reflects the assumptions mentioned above, have been divided into two groups; the first is subject to relatively little uncertainty, the second reflects many of the sources of uncertainty discussed in Chapter V. The first, to be called fixed parameters, are those quantities which define the system and which are specified as point values. In an actual case these parameters would be fixed by the geometry of the site and the properties of the fluid and waste which are relatively well known. These include the distances along the legs shown in Figure 14, the cross-sectional area of the legs, fluid properties such as density and viscosity, and waste properties such as initial inventory and half-lives. The second group, to be called variables, consists of parameters whose values are subject to uncertainties which may span several orders of magnitude. These parameters are not taken as point values in the calculation, but are approximated by distributions. These variables include solubility and retardation factors for individual radionuclides, and factors affecting groundwater travel time, such as permeability and hydraulic gradients. In addition, this group includes parameters for which numerical criteria were established in the Proposed Technical Rule, such as containment time by the waste packages and radionuclide release rates from the underground facility, so that repository performance can be assessed as these parameters vary over the given ranges.

Table 3 identifies the fixed parameters used by the model and the values used in the analyses. Table 4 identifies the variables whose values are approximated by distributions in the calculations, and gives the ranges of those values used in these analyses.

Input Data for Routine Release Scenario

The point values for the fixed parameters shown in Table 3 reflect the media and underground facility designs currently being given the most emphasis by DOE. The dimensions of the underground facility which lead to the areas of legs C and D and the length of leg C are taken from EPA's granite reference repository (Ref. 7-6). The areas of legs A and B and the length of leg B are consistent with overlying aquifers for repositories located in basalt, welded tuff, and salt (Ref. 7-7) and the length of leg D corresponds to the one mile distance to the accessible

TABLE 3. FIXED PARAMETERS FOR ROUTINE RELEASES IN BASALT, WELDED TUFF, AND SALT

Description	Value	Units
Area of leg A	1×10^6	ft^2
" " " B	1×10^6	"
" " " C	8×10^6	"
" " " D	8×10^6	"
Length of leg A	Not needed	ft
" " " B	5250	"
" " " C	16	"
" " " D (Basalt)	1530	"
" " " " (Welded Tuff)	2725	"
" " " " (Salt)	1850	"
Conductivity of leg C	infinite	
Porosity of leg C	Not needed	
Pressure at point 1	0	psi
Initial radionuclide inventory	*	Curies
Radionuclide half lives	*	years
Water Density	62.3	$\#/ft^3$
Water Viscosity	1.02	Centipoise

*From Ref. 7-8.

TABLE 4. Variables and their ranges. (For normal and lognormal distributions, ranges are for .001 and .999 quantiles.)

Variable	Distribution	Range in basalt	Range in welded tuff	Range in bedded salt	Units
Kd for Am in host rock	Lognormal	(2.5E1, 2.0E6)	(8.5E1, 9.5E3)	(5.0E1, 1.0E4)	ml/g
Kd for Pu in host rock	Lognormal	(4.5E1, 5.2E3)	(7.0E1, 2.0E3)	(3.0E1, 1.0E4)	ml/g
Kd for U in host rock	Lognormal	(4.0E0, 1.3E3)	(1.0E-2, 1.5E1)	(1.0E-2, 2.7E2)	ml/g
Kd for Np in host rock	Lognormal	(1.5E0, 2.8E4)	(4.5E0, 3.1E1)	(2.0E0, 4.0E2)	ml/g
Kd for fission products in host rock	Lognormal	(1.7E1, 5.8E3)	(5.0E1, 2.1E5)	(1.0E-2, 3.0E3)	ml/g
Kd for Am in aquifer	Lognormal	(1.0E-2, 1.0E5)	(8.5E1, 3.6E2)	(5.0E1, 1.0E4)	ml/g
Kd for Pu in aquifer	Lognormal	(1.0E-2, 1.0E4)	(7.0E1, 4.5E2)	(3.0E1, 1.0E4)	ml/g
Kd for U in aquifer	Lognormal	(1.0E-2, 1.0E4)	(1.0E-2, 1.1E1)	(1.0E-2, 2.7E2)	ml/g
Kd for Np in aquifer	Lognormal	(1.0E-2, 5.0E1)	(5.0E0, 7.0E0)	(2.0E0, 4.0E2)	ml/g
Kd for fission products in aquifer	Lognormal	(1.0E-2, 5.0E2)	(1.2E2, 8.6E3)	(1.0E-2, 3.0E3)	ml/g
Solubility limit for Am		leach-limited	leach-limited	leach-limited	g/g
Solubility limit for Pu	Lognormal	(2.5E-12, 2.5E-8)	leach-limited	(6.0E-17, 4.0E-4)	g/g
Solubility limit for U	Lognormal	(2.0E-6, 2.0E-4)	leach-limited	(1.6E-8, 3.0E-2)	g/g
Solubility limit for Np	Lognormal	(2.5E-19, 2.5E-13)	leach-limited	(1.3E-25, 5.0E-7)	g/g
Solubility limit for Tc	Lognormal	(1.0E-9, 1.0E-7)	leach-limited	(1.9E-9, 9.5E-5)	g/g
Solubility limit for fission products		leach-limited	leach-limited	(6.3E-17, 1.6E-4)	g/g
Dispersivity	Uniform	(5.0E1, 5.0E2)	(5.0E1, 5.0E2)	(5.0E1, 5.0E3)	ft
Radionuclide release time	Loguniform	(1.0E3, 1.0E7)	(1.0E3, 1.0E7)	(1.0E3, 1.0E7)	yr
Conductivity in aquifer (legs A & B)	Lognormal	(1.0E0, 1.0E4)	(1.0E-5, 2.0E0)	(1.5E-1, 6.8E2)	ft/da
Porosity in aquifer (legs A & B)	Normal	(1.0E-1, 3.0E-1)	(2.0E-1, 4.8E-1)	(1.0E-1, 2.0E-1)	--
Conductivity in host rock (legs C & E)	Loguniform	(1.0E-7, 1.0E0)	(3.1E-5, 9.1E0)	(3.6E-12, 2.8E0)	ft/da
Pososity in host rock (legs C & E)	Lognormal	(1.1E-3, 1.0E-2)	(1.8E-5, 1.3E-2)	(3.3E-4, 2.2E-1)	--
Gradient in host rock	Uniform	(5.0E-3, 3.0E-2)	(1.0E-2, 4.0E-2)	(5.0E-3, 3.0E-2)	ft/ft
Gradient in aquifer		Uniform (1.0E-4, 1.0E-2)	Loguniform (1.0E-3, 1.0E-1)	Uniform (2.0E-3, 1.0E-2)	ft/ft
Canister life	Loguniform	(1.0E2, 1.0E4)	(1.0E2, 1.0E4)	(1.0E2, 1.0E4)	yr

environment. The initial radionuclide inventory is taken from DOE's projections for spent fuel (Ref. 7-8).

The variables which appear in Table 4 reflect many of the uncertainties discussed at length in Chapter V. Uncertainties in geohydrology include predictions of conductivities, porosities, hydraulic gradients and dispersivities. These sources of uncertainty are accounted for in the model by expressing these variables as distributions of values which span the range of available data. Similarly, distributions of solubilities and distribution coefficients (Kd's) are generally used in recognition of the uncertainties involved in predicting these properties. Three radionuclides, ^{129}I, ^{14}C, and ^{99}Tc, do not appear to be retarded chemically, and are therefore presumed to move at the same speed as the groundwater. This information was developed by Sandia National Laboratory under contract to NRC through a review of the available data for pertinent sites and rock formations (Ref. 7-7). These data are consistent with conditions to be found in the media being investigated by DOE and are considered appropriate for this modelling exercise. However, it is recognized that a thorough analysis of a specific site might well make use of additional or different data which would be more pertinent to that particular site. The ranges and distributions for waste package life and radionuclide release rate were selected to uniformly bound the numerical values in the proposed rule.

Output From Routine Release Scenario

The effects of the variables whose uncertainties are modeled by the distributions in Table 4 on repository performance were investigated by repeatedly running NWFT/DVM using a standard statistical sampling technique (Ref. 7-9, 7-10). In this statistical technique, a "case" composed of 26 values, one for each of the variables in Table 4, was selected from within the ranges shown in the table. By selecting the values at random and by running enough cases to investigate the entire data range, the effects of each of the variables on repository performance can be determined.

The effect of radionuclide release rate from the repository to the host rock on the fraction of cases tested which meet the assumed standard can be seen in Figure 15 for routine releases from basalt. In this figure, release rates are varied along the horizontal axis and groundwater travel times are varied along the vertical axis. It should be noted that the release rates shown are <u>limits</u> which apply to all radionuclides for a particular case; if the solubility for a particular nuclide for that case was sufficiently low, that radionuclide might be released more slowly than the release limit associated with that case. The lines plotted on the figure are for constant fractions of cases tested which <u>fail</u> <u>to</u> meet the assumed standard. For example, for a groundwater travel time of 1000 years and a release rate from the underground facility slightly slower than 1 part in 50,000 per year, the fraction of cases failing to meet the assumed standard is 0.10 or 10%. Similarly, at a groundwater travel time of 100 years, the release rate from the underground facility at which the fraction of cases failing to meet the standard is 0.10 is very nearly 1 part in 300,000 per year.

<u>Engineered Barrier System Release Rate Requirement</u>

Impact of Release Rate on Performance

Figure 16 is like Figure 15, but for bedded salt rather than basalt. Because of the generally low permeability of salt, it should be emphasized that travel time is an independent variable in Figure 16, and the likelihood of actually having any particular travel time is not

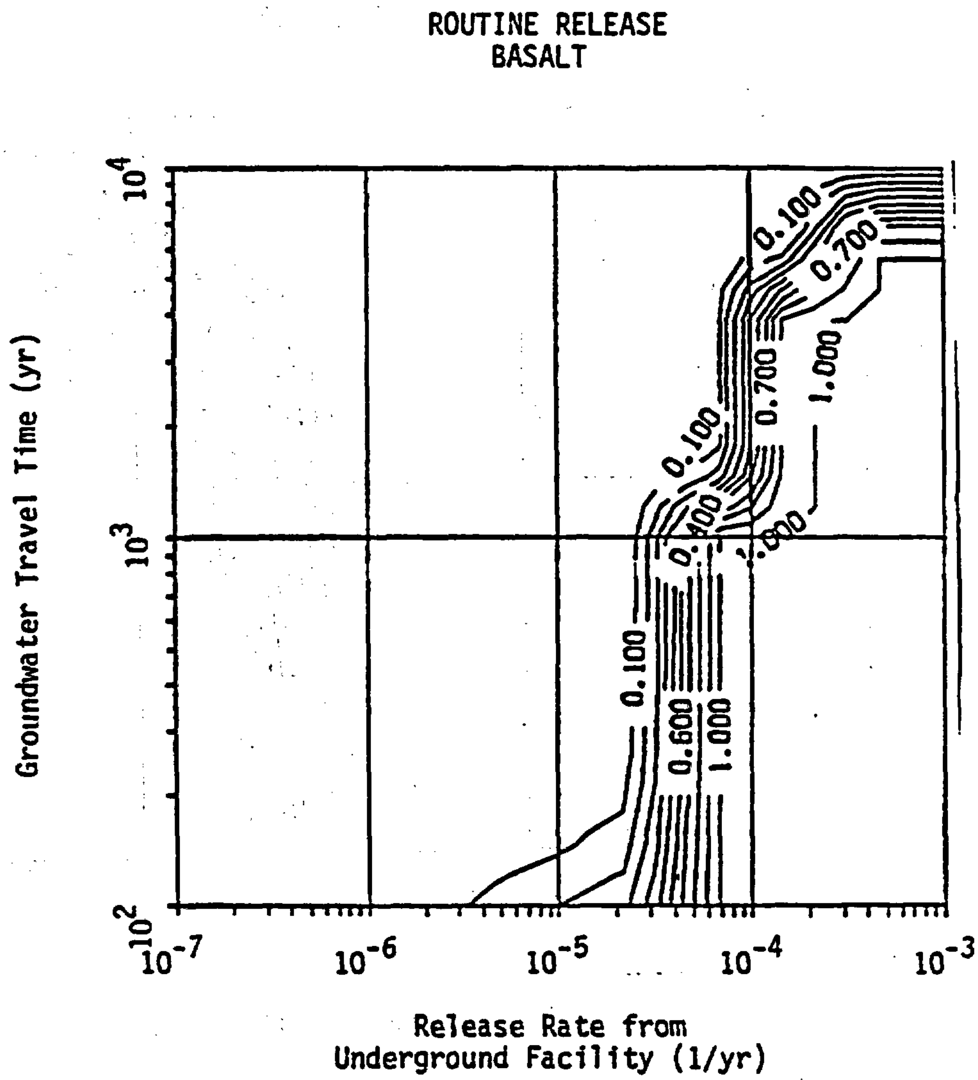


Figure 15. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is basalt.

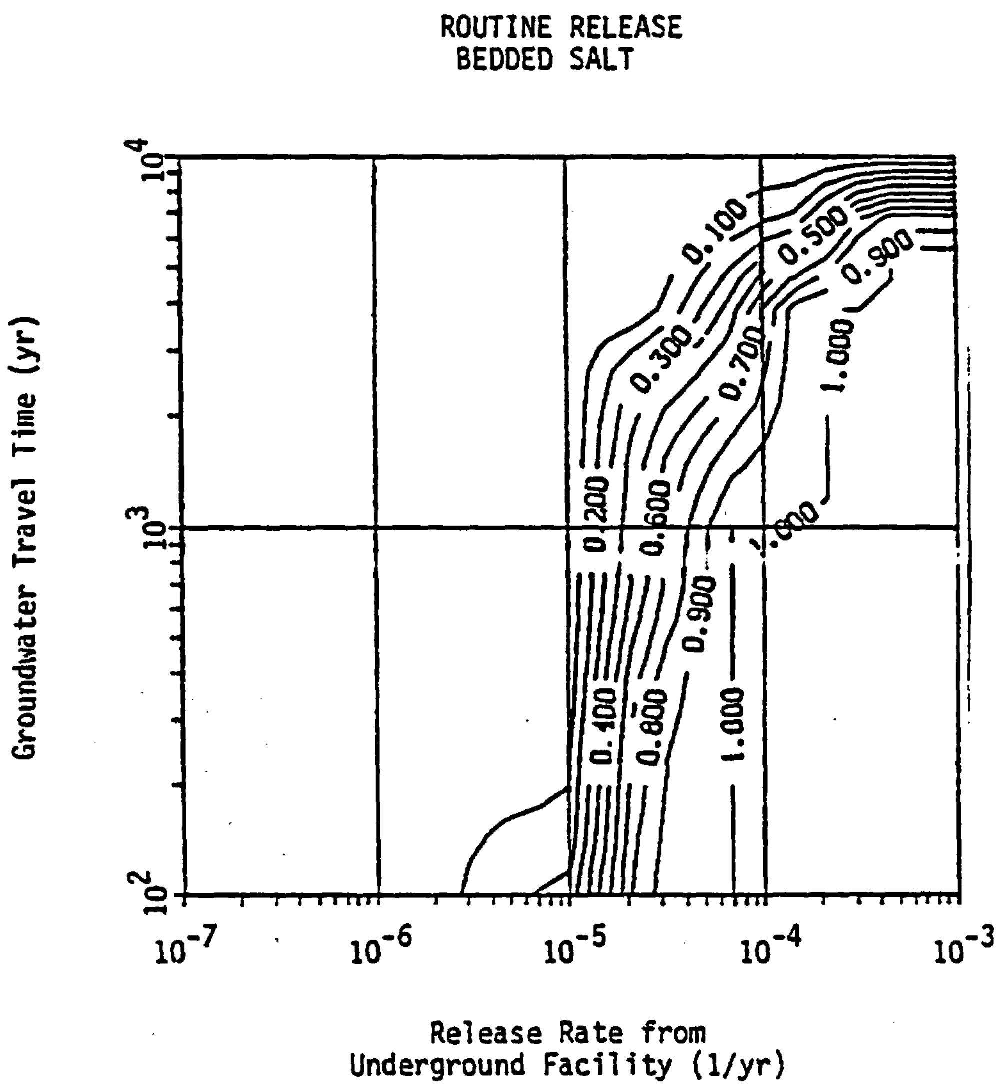


Figure 16. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is bedded salt.

considered. Nevertheless, in spite of the generally low permeability, a routine release scenario in salt is considered because of the uncertainties discussed previously.

In Figures 15 and 16, it is seen that as release rate from the repository decreases, the probability of failing to meet the assumed standard decreases significantly for both welded tuff and bedded salt. It may also be seen that there is a region in each figure in which the lines of constant fractions of cases lie relatively close to each other. In these regions, relatively small changes in release rate from the underground facility or in groundwater travel time are observed to make relatively large changes in the fraction of cases whose releases fail to comply with the assumed standard. Outside these regions, changes in release rate from the underground facility and in the groundwater travel time has less impact, since they do not cause the lines of constant failure rate to be crossed. (Although no fractions less than 0.10 are shown in the figure, it is apparent that the largest gradients are near the lines shown.)

For basalt (Figure 15), decreasing release rates from the underground facility from about 1 part in 5,000 per year to about 1 part in 50,000 per year reduces the fraction of cases failing to meet the assumed standard from about 1.00 to 0.10, while for bedded salt (Figure 16) reducing release rates from the underground facility to about 1 part in 100,000 per year is needed to achieve a fraction of failures below 0.10. For these media, it is therefore quite advantageous to have a release rate from the underground facility as low as about 1 part in 100,000 per year, but there is little further improvement to be gained from a substantially slower release rate, since this release rate results in compliance with the assumed standard for most travel times.

On the other hand, inspection of Figure 17 reveals that for a repository in the saturated zone in welded tuff, the greatest improvement is gained by having releases less than about 1 part in 1,000,000 per year. This result is due to inferior geochemical retardation of uranium in welded tuff compared to basalt or bedded salt, consistent with the lower range of Kd's for uranium in welded tuff which appears in Table 4. Figure 18 is identical to Figure 17, except that the effects of uranium are neglected, and for that case, the behavior of a welded tuff repository is very much like those in basalt and bedded salt. This result demonstrates that the impact of the rate of release of radionuclides from the engineered barrier system is media specific.

Alternatively, the influence of the engineered barrier release rate can be evaluated by directly comparing releases from the engineered barriers with the release limits of Table 2. Table 5 presents such a comparison for a release rate of 10^{-5} per year following an initial 1000 year containment period. The quantities released do not greatly exceed the limits for any of the nuclides except Am and Pu. This table demonstrates that a low release rate from the engineered barriers is able to contribute substantially to overall repository performance, and may provide a very desirable degree of redundancy for nuclides such as ^{99}Tc which are unlikely to be controlled very effectively by the geologic barriers.

Achievability

As stated in the proposed rule, "Proof of the future performance of engineered systems and geologic media over time periods of a thousand or many thousands of years is not to be had in the ordinary sense of the word." Demonstration of compliance with any of the performance objectives will be accomplished through extrapolations and data using

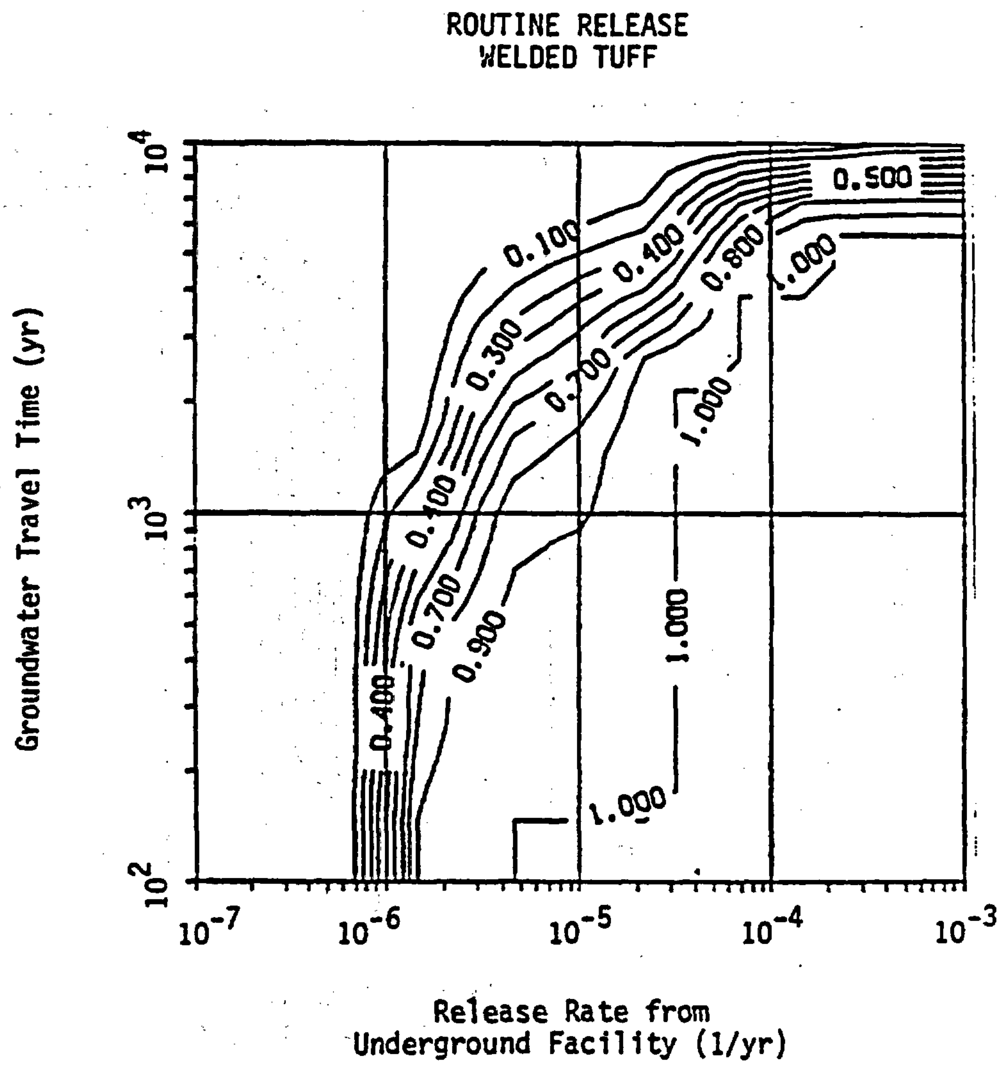


Figure 17. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is welded tuff.

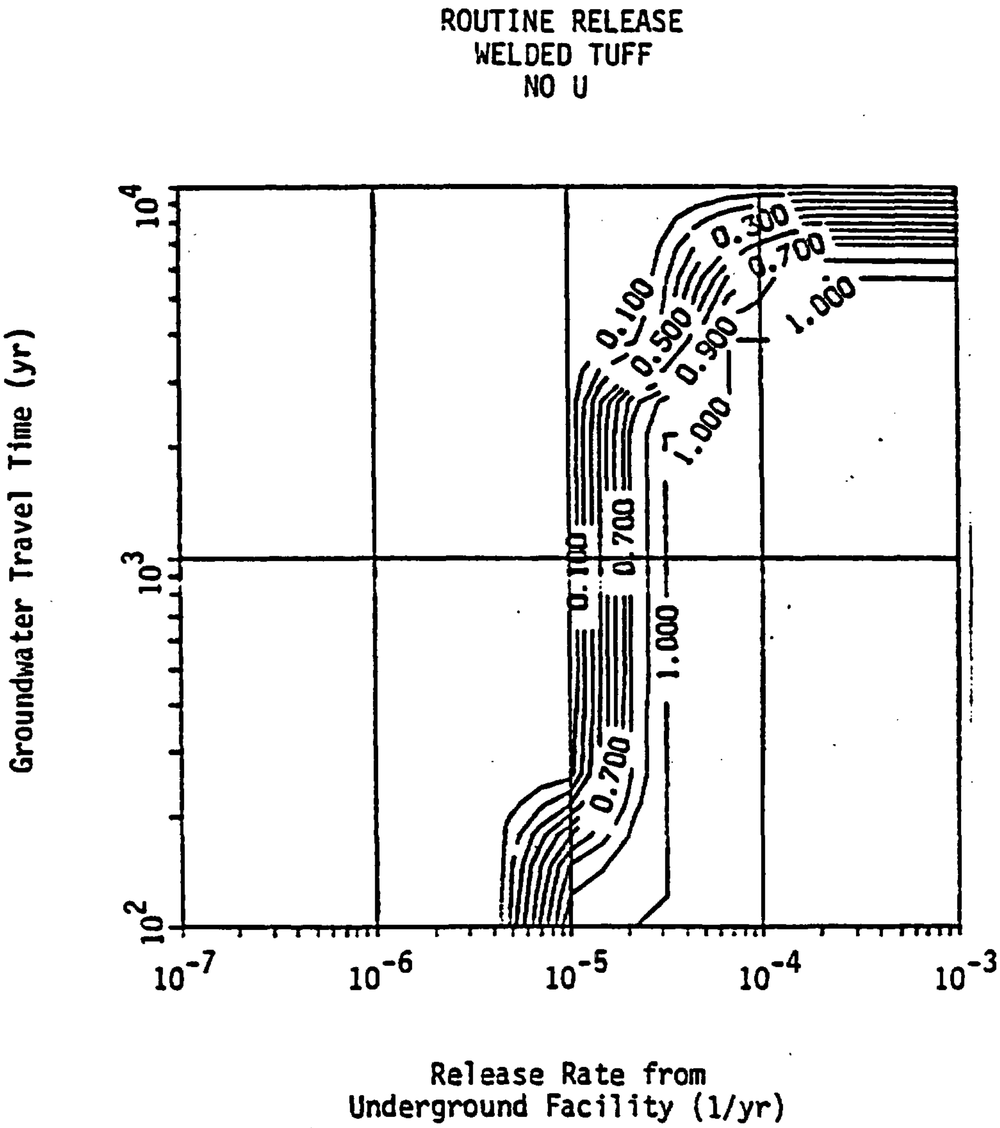


Figure 18. Contours of constant fraction of cases failing to comply with the assumed standard <u>neglecting uranium</u> as a function of limiting release rate and travel time. Medium is welded tuff.

Table 5. Effectiveness of 10^{-5} per year release rate in complying with the EPA standard.

NUCLIDE	REPOSITORY INVENTORY @ 1000 yr (Curies)	NRC RELEASE RATE* (Ci/yr)	TOTAL RELEASES (YEARS 1000 to 10,000) (Ci)	EPA LIMIT (Ci/100,000 MTHM)	RATIO OF TOTAL RELEASE TO EPA LIMIT
Am-241	9.24E7	9.2E2	3.0E6	1000	3,000
Am-243	1.57E6	1.6E1	1.4E5	400	350
C-14	1.35E3	1.4E-2	1.2E2	20,000	0.006
Cs-135	2.23E4	2.2E-1	2.0E3	200,000	0.01
Cs-137	1.00	1.0E-5	3.4E-3	50,000	0
I-129	3.8E3	3.8E-2	3.4E2	90,000	0.004
Np-237	1.0E5	1.0E0	9.0E3	2,000	4.5
Pu-238	9.8E4	9.8E-1	8.2E2	40,000	0.02
Pu-239	3.2E7	3.2E2	2.9E6	10,000	290
Pu-240	4.4E7	4.4E2	4.0E6	10,000	400
Pu-242	1.7E5	1.7E0	1.5E4	10,000	1.5
Ra-226	2.84E2**	2.84E-3	2.6E1	300	0.09
Sr-90	1.5E-1	1.5E-6	4.8E-4	8,000	0
Tc-99	1.4E6	1.4E1	1.3E5	200,000	0.65
Sn-126	5.6E4	5.6E-1	5.0E3	8,000	0.62
Total	1.7×10^{8}	1.7E3			

*Equal to 10^{-5} x values in column 1. Note that release rates at or below 1.7 Ci/yr (0.1% of total rate) meet the rule.

**Release calculations based on inventory at 1000 years. In the absence of leaching, the quantity of Ra-226 would increase to 1.22E4 Ci per 100,000 MTHM at 10,000 years.

physical models based on accelerated tests and natural analogs which are subject to uncertainties. These uncertainties can only be expressed as a statement of reliability or probability that the criterion will be achieved. To require absolute assurance of exact numerical compliance is neither reasonable nor intended. Rather the quantity and quality of the data and the methods will be carefully reviewed as part of the licensing process.

While DOE has not proposed a particular design to control releases from the engineered barrier system, considerable research and development has been devoted to the subject. The NRC staff has been following DOE's technology development program closely, and has been assessing the uncertainties associated with achieving a release rate of 1 part in 100,000 per year.

Brookhaven National Laboratory (Ref. 7-11) has concluded that the criterion is readily achievable, and in some cases exceeded, using borosilicate glass encased in non-radioactive glass.

Savannah River Laboratories consider that this requirement can be met by either of their waste forms currently receiving most attention, borosilicate glass or SYNROC (Ref. 7-12). The Department of the Interior in its comments on the proposed rule supported the achievability of this criterion by means of a succession of barriers at low temperature conditions (Ref. 7-13).

Nowak considers that a one-foot-thick backfill barrier around the waste can delay breakthrough of most fission products for 1000 to 10,000 years, and the breakthrough of transuranics for substantially longer (Ref. 7-14). Smith, Salter and Jacobs suggest that, for the case of Hanford basalts, low solubility alone may limit releases from the underground facility to very low levels (Ref. 7-15). Therefore, having reconsidered the matter, the staff continues to conclude that the requirement to limit the release rate from the engineered system to 1 part in 100,000 per year at 1000 years is reasonably achievable, particularly in view of the Commission's statement that absolute proof of compliance is not required.

Geologic Setting Groundwater Travel Time Requirement

Impact of Travel Time Requirement on Performance

Figures 15 and 16 also show the effect of groundwater travel time on the fraction of vectors whose results fail to comply with the assumed standard for basalt and bedded salt. In each figure, groundwater travel times of several hundred years are required to reduce the fraction of vectors which fail to 0.10 or less, without simultaneously requiring excessively low release rates from the underground facility. It is also seen that groundwater travel times approaching 10,000 years are needed to reach the region where rapid release rates from the engineered barrier system such as 1 part in 5,000 per year and faster can be tolerated. (This is intuitively reasonable since the model assesses repository performance over a 10,000 year interval and a 10,000 year groundwater travel time would prevent radionuclides from reaching the accessible environment during that time.)

It has already been demonstrated that a release rate from the underground facility of 1 part in 100,000 per year is appropriate, and a nominal groundwater travel time requirement should be consistent with it. Such a value could lie between several hundred and several thousand years for basalt and bedded salt, and a value of 1,000 years is certainly helpful in conjunction with reasonably achievable leach rates.

Figure 17 shows that a groundwater travel time of more than 5,000 years is needed to achieve reasonably low failure rates for welded tuff. As noted in the discussion of the release rate criterion, this result is due to lowered geochemical retardation of uranium in welded tuff, compared to basalt and bedded salt.

Achievability

The NRC staff has estimated the time necessary for groundwater to travel one mile from the underground facility. Using data from Table 4, the staff evaluated the fraction of these travel times which exceeded 1,000 years. Those fractions are 0.61 for basalt, 0.93 for bedded salt, and 0.98 for welded tuff. While the permeability and hydraulic gradient data (from Table 4) used in these analyses are not intended to represent a particular site, it is considered that these data are representative of conditions likely to be found in these media.

Further, Battelle has modeled the Hanford site, and reports (Ref. 7-16) that the average distance which groundwater travels from the underground facility in 10,000 years is 5,800 feet, (less than 1.1 miles). Rockwell has also modelled the Hanford site, and shows how far groundwater travels in 100,000 year increments (Ref. 7-17). According to this report, after 800,000 years, the groundwater has moved less than 5 kilometers (about 3 miles) from the underground facility.

The staff considers that these results provide significant support for the achievability of a minimum groundwater travel time requirement of 1,000 years between the disturbed zone and an accessible environment which is located up to 10 kilometers away.

Conclusion

A 1000 year groundwater travel time can be of significant value in providing reasonable assurance that the assumed standard can be met without placing an undue reliance on the ability of the underground facility to minimize release rates, and is readily achievable.

Further, the 1000 year groundwater travel time requirement is an essential component of the defense-in-depth concept as applied to waste disposal. This requirement constitutes a quantifiable criterion for the geologic setting to meet, in contrast to the remainder of the siting criteria for which compliance will be determined by expert judgement. The 1000 year groundwater travel requirement thus constitutes an invaluable measure of the quality of the geologic setting.

Engineered Barrier System Containment Time Requirement

Impact of Containment Time on Performance

The impact of a containment interval on repository performance is discussed from a different perspective than criteria on release rates from the engineered barrier system or groundwater travel time. Use of a long lived package to achieve containment is a means to compensate for, and to an extent avoid, uncertainties in the prediction of rates of release and migration of the individual radionuclides, particularly during the critical period when the hazard of the wastes is greatest and the heat generation rates are the highest. These uncertainties have been discussed in Chapter V, but for convenience, they are briefly reviewed below.

Temperature is one of the principal factors in calculating what the source term to the geologic setting is. During the initial period the uncertainties in predicting release rates for long times are very great. Even if we did understand the mechanisms completely, the data scatter increases with temperature so that test programs to gather the data to narrow the uncertainties to reasonable bounds are very cumbersome (Ref.7-18).

Additional uncertainties due to thermal effects influence radionuclide transport following release. Thermally induced convection near the underground facility may occur and may transport radionuclides in unanticipated ways. Thermomechanical effects may create pathways for groundwater to travel through the host rock in the disturbed zone. By containing the wastes until the repository temperatures have peaked and are spatially relatively uniform, much of the uncertainty associated with these effects can be avoided.

A further source of uncertainty arises from the large number of different fission product radionuclides, each of which has a variety of solubilities and retardation factors. The latter uncertainties recall Chapter II and the Untreated Dilution Indices appearing in Figures 10, 11, and 12. By containing the wastes until the fission products are nearly depleted, these uncertainties can be greatly reduced.

In order to determine a nominal containment time requirement which can be expected to reduce these sources of uncertainty, it is necessary to consider how fission product inventories and near-field temperatures change as a function of time. Fission product inventories and their changes appear in Figures 1 through 12, and have the same general characteristic in each figure. At about 1000 years, the fission product contribution either becomes extremely small or, having decreased dramatically up to that time, becomes relatively constant. Thus, on the basis of the fission product contributions to either radionuclide inventory in curies, to heat generation rate, or to hazard, containment for about 1,000 years appears to be appropriate. Therefore, from the perspective of impact on repository performance, a containment time of 1,000 years, with provision for flexibility, is most appropriate for dealing with uncertainties involved in assessing routine releases.

Achievability of Containment Requirement

As expressed more generally in the discussion of the achievability of release rates, the staff does not intend that the containment time requirement be achieved absolutely for all of the waste (i.e., absolute proof of zero release for 1000 years is not required). It is expected that containment of the waste will be substantially complete, with releases during the containment time limited to a small fraction of the inventory present. What is intended is that the waste package design have a high reliability, taking into account anticipated processes and events that could affect package performance. It is realized that a small fraction of the approximately 100,000 packages will be breached before 1000 years due to variations in materials, manufacturing processes, etc. that can only be estimated using statistical procedures. Similarly, a signficant fraction of the packages may remain intact for much longer than 1000 years.

There has been considerable emphasis in the DOE program over the last several years on the research and development needed to design a long lived waste package. NRC has, in its own program, been reviewing DOE's R&D and has been performing assessments of the uncertainties involved in designing a waste package that could reasonably be expected to contain waste for 1000 years.

Brookhaven National Laboratory (Ref. 7-11) states that a multilayered metal container can provide containment for 1,000 years, as can carbon coated particles and high silica glass coated waste forms. Westinghouse has developed for DOE conceptual designs for titanium clad and self-shielded cast steel and cast iron containers which they consider will contain wastes for 1,000 years in basalt (Ref. 7-19). In a report for the Electric Power Research Institute, SAI describes a container capable of retaining its integrity for 13,000 years (Ref. 7-20). While DOE has not yet proposed a waste package design, the NRC staff considers that the concepts being considered have promise and that a design objective for the waste package lifetime of 1000 years is reasonable.

Combined Performance Objectives For The Routine Release Scenario

Impact of the Proposed NRC Requirements

The combined impact of all three performance objectives for the case of the routine release scenario in basalt is shown in Figure 19. Like earlier figures, Figure 19 results from repeatedly running NWFT/DVM using a standard statistical sampling technique (Ref. 7-11). In this figure, the horizontal axis displays the sum of the ratios of releases of individual radionuclides to those permitted by the assumed EPA standard. The vertical axis displays the fraction of cases in the sample which exceed the value appearing on the horizontal axis. It may be seen from the figure that for the unrestricted case, which includes all sample points regardless of whether or not they satisfy the 10 CFR 60 criteria, there is about a 0.10 or 10% probability of exceeding the assumed standard by a factor of 10. However, for the case of a repository which complies with 10 CFR 60, the probability of about 0.10 or 10% is associated with releases of 1/100 of the assumed standard. Alternatively, the unrestricted case has a 0.20 or 20% probability of releases exceeding to the assumed standard, but compliance with 10 CFR 60 reduces that probability to near zero.

Figures 20 and 21 contain similar results for bedded salt and welded tuff, respectively. The probability of releases exceeding the assumed standard is reduced from about 6% to nearly zero for bedded salt, and from about 10% to near zero for welded tuff.

A comparison of Figures 17 and 21 raises the point that in Figure 17, compliance with the release rate and groundwater travel time values still permits about a 90% probability of repository failure to meet the assumed standard, but Figure 21 indicates that similar compliance will result in

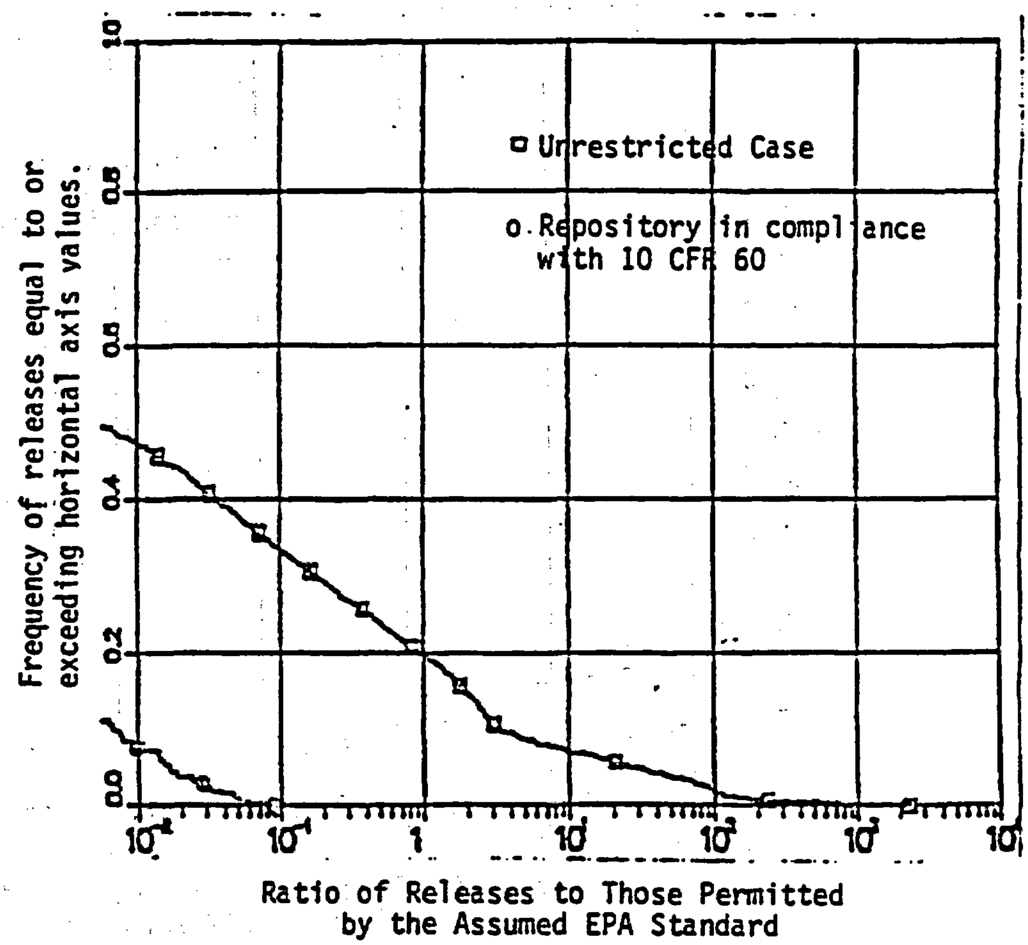


Figure 19. Relationship Between Releases From a Geologic Repository and the Probability of Those Releases for the Routine Release Scenario for Basalt.

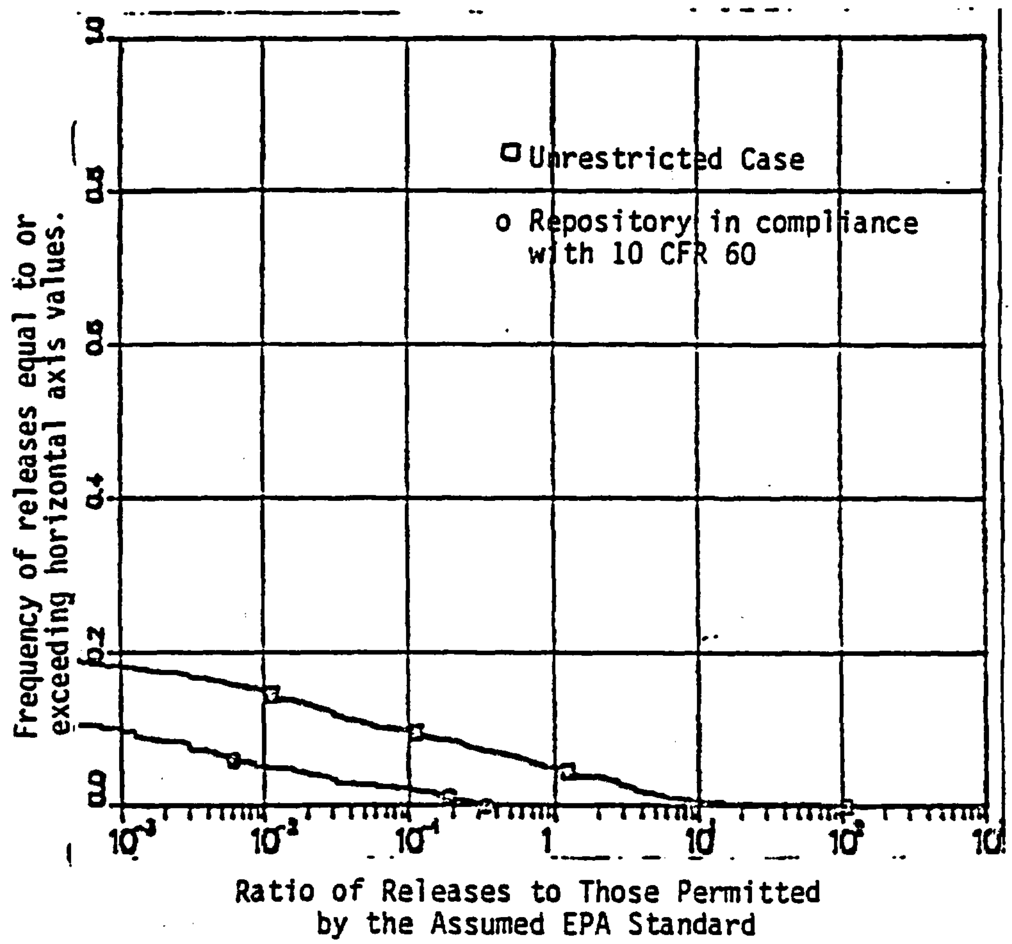


Figure 20. Relationship Between Releases From a Geologic Repository and the Probability of Those Releases for the Routine Release Scenario for Bedded Salt.

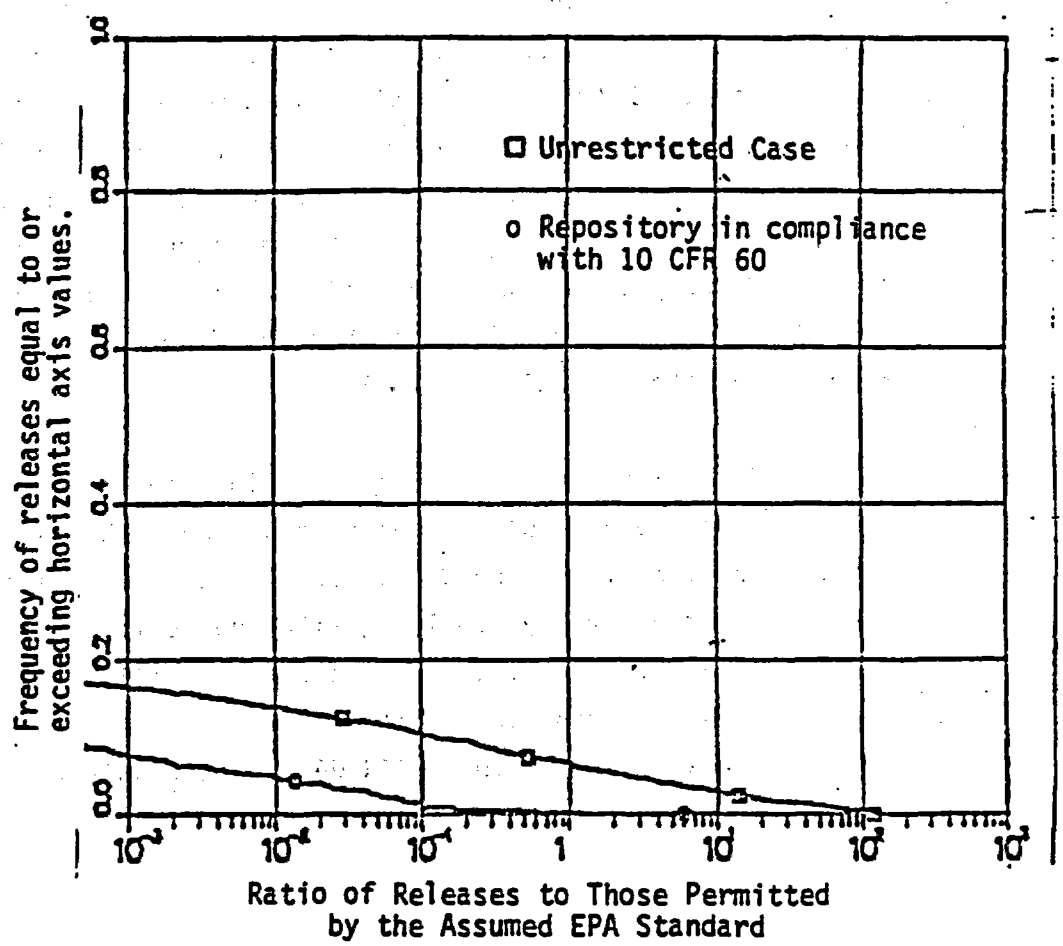


Figure 21. Relationship Between Releases From a Geologic Repository and the Probability of Those Releases for the Routine Release Scenario for Welded Tuff.

a near-zero probability of failure. These figures are consistent, because the permeability and hydraulic gradient data for welded tuff which appear in Table 4 generally result in long groundwater travel times, and the entire range of these data was used to arrive at Figure 21. Thus, for welded tuff, the relatively low geochemical retardation of uranium compared to other media, which was discussed in connection with Figure 18, is compensated for by relatively long groundwater travel times. Therefore, in Figure 21, both the unrestricted case and the case in compliance with 10 CFR 60 have sample points with groundwater travel times which generally exceed thousands of years, and therefore result in releases to the accessible environment below the assumed standard. By contrast, Figure 17 takes travel time as an independent variable, taking no account of the probability of actually having a certain travel time. Figures 19, 20, and 21 are alike in that the figures show results for the entire range of the variables in Table 4.

In summary, for a routine release scenario in basalt, bedded salt, and welded tuff, for the variable ranges tested, the probability of exactly meeting or exceeding the assumed standard is reduced from a range of from 6% to 20% to nearly zero by complying with the performance objectives in 10 CFR 60. By associating these predicted probabilities with uncertainties in achieving the standard, it is concluded that compliance with the numerical criteria in 10 CFR 60 significantly reduces such uncertainties.

VIII IMPACT OF NUMERICAL REQUIREMENTS ON UNANTICIPATED EVENTS

In the previous chapter we showed how meeting the controlled release rate of 1 part in 100,000 per year and minimum groundwater travel time of 1000 years to the accessible environment contributed to meeting the assumed

HLW standard. We also discussed how requiring containment of the wastes within the waste package substantially contributed to confidence that the assumed standard would be met. In this chapter we show how the numerical requirements, if met, would limit the consequences of a failure of a portion of the repository system (the natural barriers). We present this chapter by way of illustration only. We have made no estimate of the probability of such events actually occuring. Estimates of the likelihood of a low probability geologic event that could disrupt the repository can only be made on the basis of the geologic record for a particular site, and even then will involve considerable uncertainty. However, we illustrate how the numerical requirements for the individual barriers mitigate the consequences of failure of the natural barriers with respect to the assumed EPA standard as it applies to unanticipated processes and events.

1. FAULTING SCENARIO

There are plausible scenarios in which the geologic barrier is breached. One such scenario assumes a fault through the underground facility, extending through an overlying aquifer. We assume that the fault offers no hydrologic resistance to vertical flow to the overlying aquifer, which carries the contaminant to the accessible environment. However, we assume that the fault does not breach any waste packages and does not influence the release rate from the engineered barrier system.

The code used to evaluate this scenario is the same NWFT/DVM code that was used in the routine release scenario. In this case leg D has been modified to simulate the result of the fault described above by assuming infinite permeability and a zero retardation factor. The variable ranges for the fluid parameters are those for basalt shown in Table 4 of Chapter

VII. Figure 22 shows the flow model for this scenario, and Table 3 shows the fixed parameters selected. The time of the occurrence of the fault was a random variable distributed uniformly over the 10,000 years.

Conclusions

Figure . shows the fraction of outcomes of the faulting scenario exceeding various multiples of the assumed EPA standard. Results are displayed both for repositories which meet the numerical criteria associated with the engineered barrier system and for repositories whose containment interval and release rates span the ranges for these variables shown in Table 4. The staff has not attempted to establish a standard for releases for this scenario. However, for comparison purposes, it may be seen from the Figure that that compliance with 10 CFR 60 reduces the frequency of releases greater than or equal to the assumed standard from about 0.85 to about 0.70. Similarly, the frequency of releases 10 times the assumed standard or greater decreases from about 0.60 to less than 0.40, and the frequency of releases 100 time the assumed standard decreases from 0.40 to less than 0.10. Clearly, for this scenario, controlling the rate of release of radionuclides to the geologic setting does have the effect of limiting consequences.

2. Borehole Scenario

We have re-examined the human intrusion question in light of the public comment on the proposed technical criteria. We make no assumption with respect to the question of whether small-scale unintentional intrusion may warrant examination at the time of licensing, and, therefore, may be appropriate for inclusion in the safety analysis report to be prepared by DOE as part of a license application. Nevertheless, in this section we

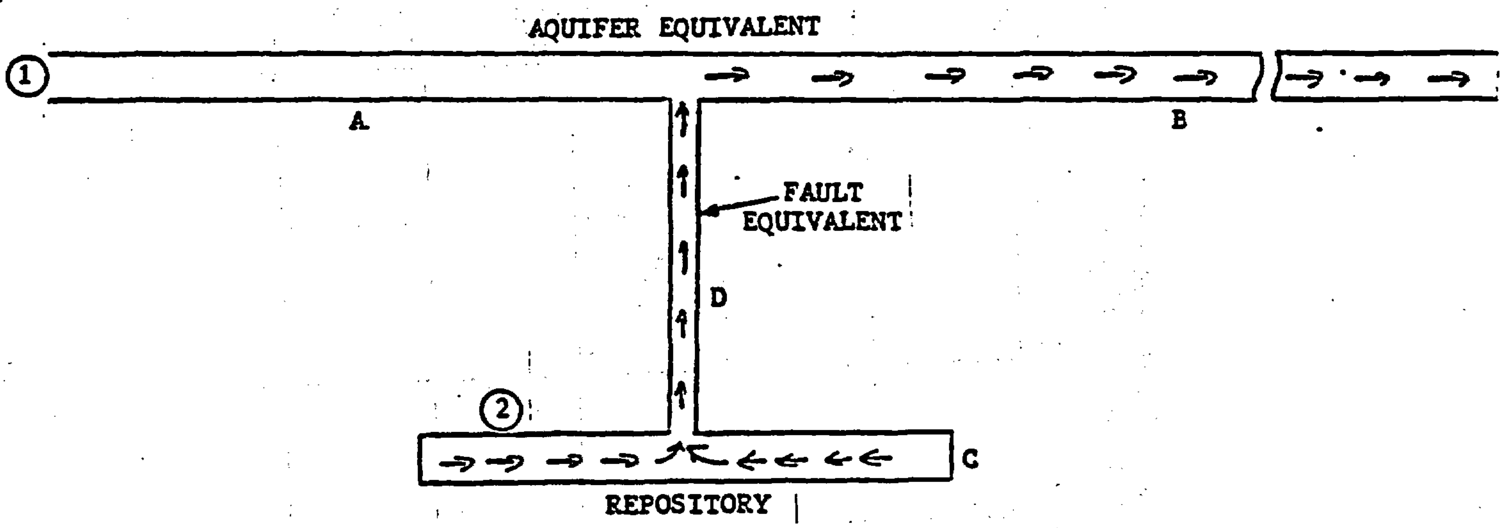


FIGURE 22. FLOW MODEL FOR FAULT SCENARIO

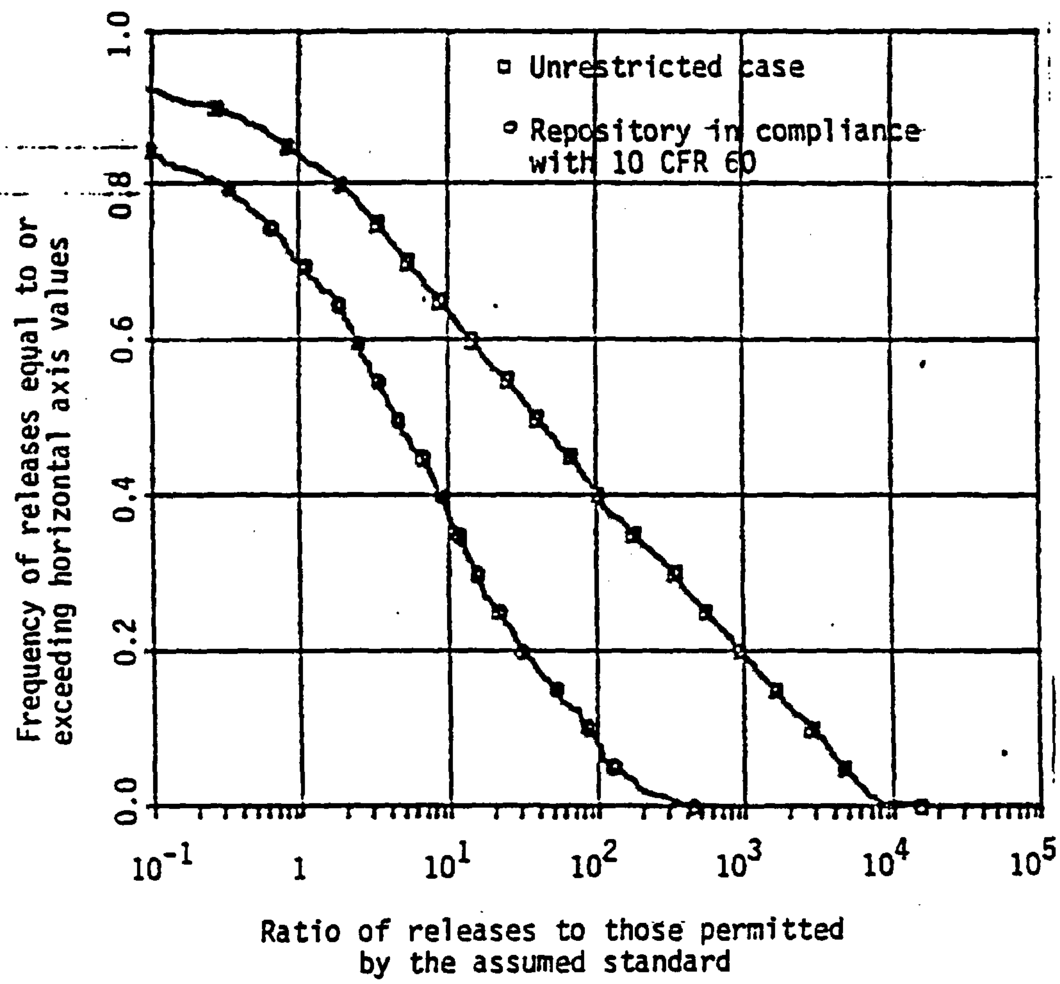


Figure 23. Relationship between releases in the fault scenario and probability of those releases.

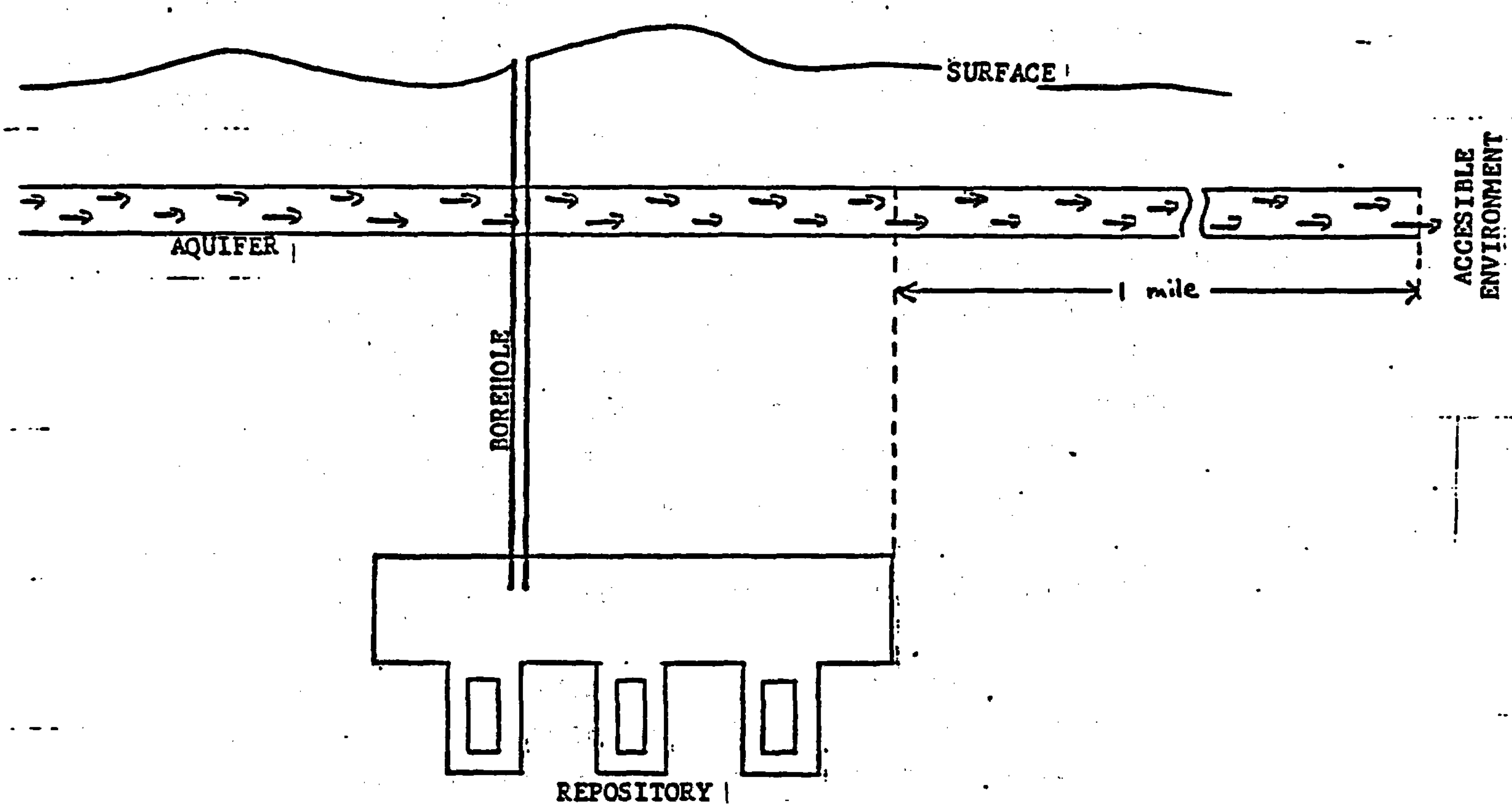


FIGURE 24. MODEL FOR BOREHOLE SCENARIO

examine the consequences of a small scale intrusion scenario which assumes a borehole penetration into the underground facility as an example of such small-scale intrusion, and examine the consequences. The model for this scenario appears in Figure 24. As in the preceeding scenarios, groundwater is presumed to resaturate the repository shortly after closure and to initiate deterioration of the waste packages. The eventual breach of the packages releases radionuclides to the underground facility, and in time, to the geologic setting. The time when the borehole is drilled is distributed uniformly between 100 and 10,000 years after repository closure. Release occurs by the bulk removal of contaminated water during the drilling process. A volume of 200 m^3 (7058 ft^3) of water from the underground facility is assumed to mix with the drilling fluid and to be brought to the surface. (Ref 8-1). The concentrations of radionuclides in the groundwater in the repository determine the quantity of each nuclide brought to the surface (the accessible environment). If a larger quantity of contaminated water were brought to the surface, or if more frequent small-scale intrusions were considered credible, the consequences would be proportionately greater.

Figure 25 illustrates the effect this small-scale intrusion in terms of consequence relative to the assumed standard of Chapter VII. We note that under the assumptions of this scenario, small-scale intrusion of this type is mitigated by the engineered barriers already required to meet the assumed EPA standard as it applies to routine releases.

IX RETRIEVABILITY

In its licensing procedures for disposal of high-level radioactive waste in geologic repositories, the NRC has adopted a step-by-step approach that consists of four principal stages:

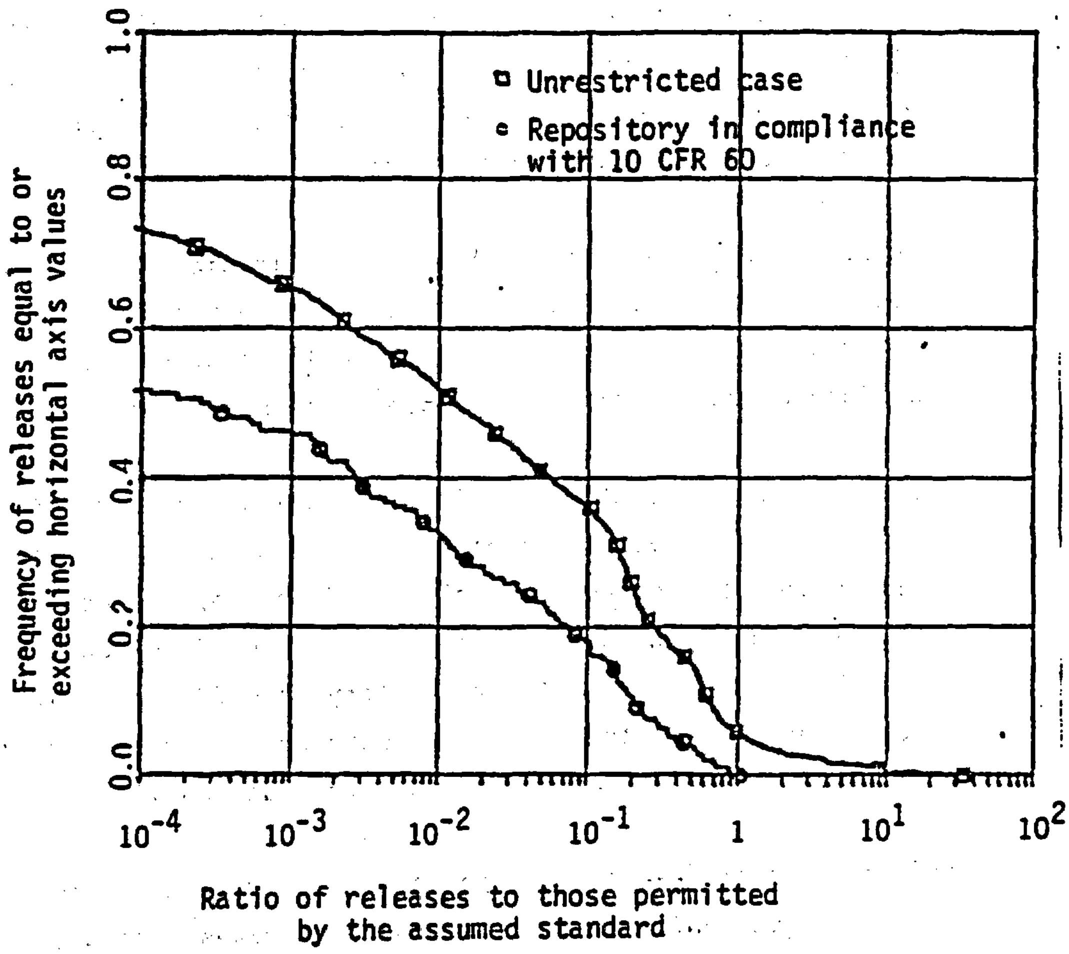


Figure 25. Relationship between releases in the borehole scenario and probability of those releases.

(1) Site characterization, during which detailed studies of alternative candidate sites are conducted before selection of one of the sites for development as a repository.

(2) Construction authorization, during which NRC reviews a license application that contains a detailed design and an analysis of the performance of the repository based on the site specific information obtained during a site characterization.

(3) License to receive wastes, when the application is reviewed again prior to operation. At this time, the repository design and performance assessment are updated in light of new information obtained about the site during construction of the repository.

(4) Permanent closure, at which time an application to terminate operations and seal the repository is submitted. The application will again contain updated analyses of the performance of the repository in light of: (1) information obtained about the site during the operation of the repository; and (2) data collected about the performance of the engineered barrier system to verify that performance can be expected to be within design limits.

At the permanent closure stage, the Commission will determine whether the DOE's performance confirmation program demonstrates that the repository can be expected to work as planned. Here performance confirmation means the program of tests, experiments, and analyses which is conducted to evaluate the accuracy and adequacy of the information used to determine reasonable assurance that the performance objectives for the period after permanent closure can be met. Commission's intent in separating the license application and permanent closure decisions was to be able, following emplacement of the waste, to obtain further information concerning the workability of the repository and to use this information in making its final decision on the acceptability of permanent closure. The retrievability option provides the capability to implement this regulatory approach.

The NRC staff therefore considers that the option to retrieve the wastes must be preserved long enough to complete a program of monitoring and verification of repository performance. The design must also ensure that the option is preserved long enough to permit a decision to permanently close the repository or take any corrective actions shown to be necessary by the verification and monitoring program. Since some of the assumptions and issues that will need to be verified and resolved by the monitoring program may not be identified until the underground facility is excavated, it is not possible to specify prior to construction the complete content of the verification program or how long it will take. We expect the verification program to evolve throughout the operating lifetime of the repository.

On the other hand, important design decisions will need to be made before submitting an application. Some of these design decisions will affect the length of time available to take corrective action or conduct retrieval, if found to be necessary. For example, the thermal loading of the waste in the emplacement areas will affect the temperature of the host rock and the stability of the underground structure. These factors will have a large effect on the ability to retrieve the wastes, since the structure could become too unstable or the rocks too hot to safely recover the wastes. Therefore the staff concluded that a retrievability period must be chosen early in the design process to permit the design to go forward, and a retrievability requirement was included in the proposed technical criteria.

For the licensing procedures to be workable, the staff considers that the option to retrieve should be preserved for the time necessary to emplace all of the wastes, complete a performance confirmation program, arrive at a decision as to whether retrieval must be undertaken, and execute retrieval, if found to be necessary. The design for retrievability should encompass all of these considerations.

Present estimates of the time to be devoted to the operation of the repository are 25 to 30 years (Ref. 9-1, 9-2). Performance confirmation programs have been suggested which require a variety of periods to complete. For example, some proposed hydro-thermomechanical studies (Ref. 9-3) will require 8 years to complete. Alternatively, performance confirmation may require approaching maximum temperatures in the host rock near the waste package. Reaching these temperatures will require up to 10 years for reprocessed high level waste and 20 to 25 years for spent fuel depending on the geologic medium, according to the DOE Final GEIS (Ref. 9-4). For some media and conceptual repository designs more than 25 years may be required according to TM-36 (reference 5). While the appropriate length of such a program will be site and design specific, the above estimates suggest that a program extending through the period waste is being emplaced is not unreasonable.

Clearly, such a program should be initiated as early in the operational phase as practicable, both to provide guidance during operations and to ensure that completion of the program does not delay closure. However, common sense dictates that the option to modify or to initiate a new phase of a performance confirmation program late in the operational phase should be maintained to be able to respond to variability in the host rock or to technological developments which lead to engineering changes. The capacity to keep the repository open for 10 to 15 years after the operational phase if needed is therefore advisable.

Adding the time needed for the operational phase to the time needed to provide the options discussed above results in a total interval of around 35 to 45 years.

Therefore, we have concluded that the repository should be designed so that the waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste emplacement is initiated. We consider a reasonable schedule to be one in which the waste could be retrieved in the same overall time that the repository was constructed and wastes were emplaced. We do not intend to preclude a decision to permanently close the repository before 50 years has elapsed, if sufficient data are available to support an earlier decision, and if the people charged with the decision to seal the repository are satisfied. However, we do not want the underground facility design to be such that retrieval would be so expensive or difficult or entail such high occupational exposures that the option is foreclosed and needed corrective actions could not be taken.

As discussed earlier, the staff recognizes that site and design specific factors will strongly influence selection of the design for retrievability. The performance objective has therefore been expressed to permit flexibility to take these factors into account during licensing.

Maintaining the option to retrieve the wastes does not entail keeping the mined areas open, although DOE may choose to do so in some geologic media. A design in which the emplacement rooms are backfilled and sealed, but corridors and shafts are kept open and surface handling facilities are maintained could be acceptable, provided that the rooms could be remined and the wastes removed, if necessary. Remining of the backfill should not be precluded because of high temperatures or because it was needed for structural stability. Trade-offs between keeping rooms open and ventilated, backfilling, and areal heat densities are design options that DOE must consider in meeting this requirement. Both the proposed and final rules do not require that retrieval be essentially the reverse of emplacement. We can foresee no situation where protection of the public health and safety would require the waste to be removed very rapidly.

Rather, we envision that if, as the result of years of data collection and analysis, a decision is made that the site or design is not adequate to isolate the wastes for the long term, corrective actions could be taken. These actions could be performed over a period of years or decades without an imminent health and safety hazard. Therefore, the final rule requires that if a decision to retrieve is made, the design should be such that the inventory of wastes could be removed in about the same number of years in which it was emplaced. We intend for DOE to have considerable flexibility in the design of the repository in meeting these requirements.

A repository designed to permit retrieval of the waste has advantages in addition to the limiting case of preserving a Commission option to order abandonment of the site at as late a stage as permanent closure. From the time waste emplacement starts until permanent closure any of a variety of eventualities may require corrective action. Examples might include repair or replacement of canisters that prove to have manufacturing defects, changes to more effective backfill, or perhaps installation of additional barriers in the exits. Design of the repository for retrievability of the waste assures that it will remain practical to take corrective actions should they become necessary.

REFERENCES

1-1. U. S. Department of Energy, "Record of Decision, Program of Research and Development for Management and Disposal of Commercially-Generated Radioactive Wastes," Federal Register 46, 26677, May 14, 1981.

2-1. U. S. Department of Energy, "Spent Fuel and Radioactive Waste Inventories and Projections as of December 31, 1980," DOE/NE-0017, 1981.

2-2. U. S. Department of Energy, "Management of Commercially Generated Radioactive Waste," DOE/EIS-0046-F, 1980.

2-3. A. D. Little, "Technical Support of Standards for High-Level Radioactive Waste Management", EPA 520/4-79-007A, Arthur D. Little, Inc., for U.S. EPA, 1977.

2-4. ICRP-79, International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30, (New York: Pergamon Press), Referred to as ICRP 30, 1979.

2-5. A. G. Croff, "Potential Impact of ICRP-30 on the Calculated Risk from Waste Repositories." (To be published in Transactions of the American Nuclear Society).

2-6. B. L. Cohen, "Effects of ICRP Publication 30 and the 1980 BEIR Report on Hazard Assessments of High-Level Wastes," Health Physics 42, 133, (1982).

2-7. G. E. Runkle, "Comparison of ICRP-2 and ICRP-30 for

Estimating the Dose and Adverse Health Effects from Potential Radionuclide Releases from a Geologic Waste Repository," SAND 81-2163C, Sandia National Laboratories. (To be published in Proceedings of Waste Management 82, University of Arizona.)

3-1. U. S. Department of Energy, "Record of Decision: Program of Research and Development for Management and Disposal of Commercially Generated Radioactive Wastes," Federal Register 46, 26677, May 14, 1981.

3-2. Report to the President by the Interagency Review Group on Nuclear Waste Management," TID-29442, March 1979. Available for purchase from National Technical Information Service, Springfield, Virginia, 22161.

4-1. U. S. Department of Energy, "Final Environmental Impact Statement, Management of Commercially Generated Radioactive Waste," DOE/EIS-0046 F, October, 1980.

4-2. D.G. Schweitzer and M.S. Davis, Brookhaven National Laboratory, letter to J.B. Martin, May 13, 1982. A copy of this letter has been placed in the public document room.

5-1. C. Klingsberg, J. Duguid, "Status of Technology for Isolating High-Level Radioactive Waste in Geologic Repositories. DOE/TIC 11207, October, 1980.

5-2. C. M. Koplic, M. F. Koplan, and B. Ross, "The Safety of Repositories for Highly Radioactive Wastes, Rev. Mod. Phys. 54, 269 (1982).

5-3. J. B. Moody, "Radionuclide Migration/Retardation: Research and Development Technology Status Report, ONWI-321, March, 1982.

5-4. L. L. Hench, D. E. Clark, "Surface Properties and Performance Prediction of Alternative Waste Forms." (To be published through NRC contract NRC-04-78-252).

5-5. D. G. Coles, "A Continue-Flow Leach Testing Method for Various Nuclear Waste Forms," Nuc. and Chem. Waste Mgmt., 2, 245 (1981).

5-6. J. E. Mendel and others, "Physical Properties of Glass for Immobilization of High Level Radioactive Waste," Nuc. and Chem. Waste Mgmt. 1, 17 (1980).

5-7. K. D. Reeve and others, "The Development and Testing of SYNROC for High Level Waste Fixation," Australian Atomic Energy Commission Research Establishment, New South Wales, Australia, (1981).

5-8. W. H. McCorkle, "Heavy Water in Nuclear Reactors," Nucleonics 11, 24, (1953).

5-9. D. Isherwood, "Geoscience Data Base Handbook for Modeling a Nuclear Waste Repository," Vol. 1 and 2, NUREG/CR-0912, UCRL-52719, Lawrence Livermore Laboratory, 1981.

5-10. J. M. West, Electrodeposition and Corrosion Processes, D. von Nostrand, 1975.

5-11. L. V. Benson, P. C. Lichthner, and N. A. Pope, "Engineered Barriers: Rationale and Assessment." (To be published as LBL 12446.)

5-12. E. J. Wheelwright, and others, "Development of Backfill Materials as an Engineered Barrier in the Waste Package System." (To be published as an ONWI interim report under DOE contract OE-AC06-7CRLO 1830).

5-13. C. R. Faust, and J. W. Mercer, "Ground-Water Modeling: Recent Developments," Groundwater 18, 569 (1980).

5-14. J. O. Duguid, and P. C. Y. Lee, "Flow in Fractured Porous Media," Water Resour. Res. 13, 558, (1977).

5-15. G. E. Grisak, and J. F. Pickens, "Solute Transport Through Fractured Media, 1. The Effect of Matrix Diffusion," Water Resour. Res. 16, 719 (1980).

5-16. C. E. Neuzil, and J. V. Tracy, "Flow Through Fractures," Water Resour. Res. 17, 191 (1981).

5-17. A. B. Muller, "Isotopic Techniques in Radioactive Waste Disposal Site Evaluation: A Method for Reducing Uncertainties, I. T, T/^{3}He, ^{4}He, ^{14}C, ^{36}Cl," Proceedings of the Symposium on Uncertainties Associated with the Regulation of the Geologic Disposal of High-Level Radioactive Waste, p. 161, NUREG/CP-0022, CONF-810372, U.S. Nuclear Regulatory Commission and Oak Ridge National Laboratory (in press).

5-18. J. C. Fontes, and J. M. Garnier, "Determination of the Initial ^{14}C Activity of the Total Dissolved Carbon: A Review of the Existing Models and a New Approach," Water Resour. Res. 15, 399 (1979)

5-19. J. P. Delhomme, "Spatial Variability and Uncertainty in Groundwater Flow Parameters: A Geostatistical Approach," Water Resour. Res. 15, 269 (1979).

5-20. D. H. Tang, and G. F. Pinder, "Analysis of Mass Transport with Uncertain Physical Parameters," Water Resour. Res. 15, 1147 (1979).

5-21. L. Smith, and F. W. Schwartz, "Mass Transport, 3. Role of Hydraulic Conductivity Data in Prediction," Water Resour. Res. 17, 1463 (1981).

5-22. J. W. Ball, E. A. Jenne, and D. K. Nordstrom, "WATEQ2 - A Computerized Chemical Model for Trace and Major Element Speciation and Mineral Equilibria of Natural Waters," p. 815 in Chemical Modeling in Aqueous Systems, ed. by E.A. Jenne, American Chemical Society Symposium Series No. 93, Washington, D. C., 1979.

5-23. G. Sposito, and S. V. Mattigod, "GEOCHEM: A Computer Program for the Calculation of Chemical Equilibria in Soil Solutions and Other Natural Water Systems," University of California - Riverside, 1980.

5-24. M. Pourbaix, Atlas of Electrochemical Equilibria in Aqueous Solutions, Pergamon Press, Oxford, 1966.

5-25. J. Paquette, and R. J. Lemire, "A Description of the Chemistry of Aqueous Solutions of Uranium and Plutonium to 200°C Using Potential-pH Diagrams," Nucl. Sci. Eng. 79, 26 (1981).

5-26. E. A. Bondietti, "The Influence of Geochemical Variables on Long-Lived Radionuclide Migration and Risk Assessment," Proceedings of the Symposium on Uncertainties Associated with the Regulation of the Geologic Disposal of High-Level Radioactive Waste, p. 337, NUREG/CP-0022, CONF-810372, U.S. Nuclear Regulatory Commission and Oak Ridge National Laboratory, March, 1982.

5-27. L. L. Ames, and D. Rai, "Radionuclide Interactions with Soil and Rock Media, Vol. 1. Processes Influencing Radionuclide Mobility and Retention, Element Chemistry and Geochemistry, Conclusions and Evaluation," EPA/520/6-78-007, Battelle Pacific Northwest Laboatories for U. S. Environmental Protection Agency, 1978.

5-28. Y. Onishi, R. J. Serne, E. M. Arnold, C. E. Cowan, and F. L. Thompson, "Critical Review: Radionuclide Transport, Sediment Transport, and Water Quality Mathematical Modeling; and Radionuclide Adsorption/Desorption Mechanisms," NUREG/CR-1322, PNL-2901, Pacific Northwest Laboratory, 1981.

5-29. D. G. Coles and L. D. Ramspott, "^{106}Ru Migration in a Deep Tuffaceous Alluvium Aquifer, Nevada Test Site," Lawrence Livermore Laboratory, UCRL-85320, 1981.

5-30. R. E. Pepping, M. S. Y. Chu, M. D. Siegel, "Calculations of Radionuclide Releases from Hypothetical Nuclear Waste Repositories in Basalt, Bedded Salt, and Tuff: An Evaluation of Compliance with Draft EPA Standard 40 CFR 191 and Draft Regulation 10 CFR 60," SAND 82-1557, Sandia National Laboratories for U. S. NRC, 1982.

5-31. P. G. Doctor, "The Use of Geostatistics in High Level Radioactive Waste Repository Site Characterization," Rad. Waste Mgmt. 1, 193 (1980).

5-32. J. L. Smith, and M. A. Balderman, "Natural Geologic Processes as Sources of Uncertainty in Repository Modeling," Proceedings of the Symposium on Uncertainties Associated with the Regulation of the Geologic Disposal of High-Level Radioactive Waste, p. 247, NUREG/CP-0022, CONF-810372, U.S. Nuclear Regulatory Commission and Oak Ridge National Laboratory, March, 1982.

5-33. F. A. Donath, "Postclosure Environmental Conditions and Waste Form Stability in a Geologic Repository for High-Level Nuclear Waste," Nucl. and Chem. Waste Mgmt. 1, 103 (1980).

7-1. M. Reeves and R. M. Cranwell, "User's Manual for the Sandia Waste-Isolation Flow and Transport Model (SWIFT) Release 4.81," NUREG/CR-2324, 1981.

7-2. J. E. Campbell, R. L. Iman, and M. Reeves, "Risk Methodology for Geologic Disposal of Radioactive Waste: Transport Model Sensitivity Analysis," NUREG/CR-1377, 1980.

7-3. J. E. Campbell, P. C. Kaestner, B. S. Langkopf, and R. B. Lautz, "Risk Methodology for Geologic Disposal of Radioactive Waste: The Network Flow and Transport (NWFT) Model," NUREG/CR-1190, 1980.

7-4. J. E. Campbell, D. E. Longsine and R. M. Cranwell, "Risk Methodology for Geologic Disposal of Radioactive Waste: The NWFT/DVM Computer Code Users Manual," NUREG/CR-2081, 1981.

7-5. D. H. Lester, G. Jansen, and H. C. Burkholder, "Migration of Radionuclide Chains Through an Adsorbing Medium", AIChE Symposium Series No. 152 - Adsorption and Ion Exchange, 71, 202 (1975).

7-6. A. D. Little, "Technical Support of Standards for High-Level Radioactive Waste Management," Vol. D - Release Mechanisms, EPA 520/4-79-007D, Arthur D. Little, Inc. for U. S. EPA, 1980.

7-7. R. E. Pepping, M. S. Y. Chu, M. D. Siegel, "Calculations of Radionuclide Releases from Hypothetical Nuclear Waste Repositories in Basalt, Bedded Salt, and Tuff: An Evaluation of Compliance with Draft EPA Standard 40 CFR 191 and Draft Regulation 10 CFR 60," SAND 82-1557, Sandia National Laboratories for U. S. NRC, 1982.

7-8. U. S. Department of Energy, "Draft Environmental Impact Statement: Management of Commercially-Generated Radioactiave Waste," Vol. 2, Tables A.14 and A.15, DOE/EIS-0046-D 1979.

7-9. R. L. Iman, W. J. Conover, and J. E. Campbell, "Risk Methodology for Geologic Disposal of Radioactive Waste: Small Sample Sensitivity Analysis Techniques for Computer Models, With an Application to Risk Assessment," NUREG/CR-1397 1980.

7-10. S. A. Silling, "Comparison of the Proposed Part 60 Technical Criteria and the EPA Standard," (an NRC staff analysis available in the NRC Public Document Room).

7-11. R. Dayal and others "Nuclear Waste Management Technical Support in the Development of Nuclear Waste Form Criteria for the NRC," Vol. 1, p. 321, NUREG/CR-2333 1982.

7-12. E. J. Hennelly, Memorandum to R. T. Huntoon, "DWPF Waste Form Decoupling and the 10 CFR 60 Technical Criteria for Geologic Repositories," Savannah River Laboratory, Memorandum no. DPST-81-786, dated October 14, 1981. Available in NRC PDR.

7-13. U. S. Department of the Interior, Comment on Proposed Rule 10 CFR 60, NRC Public Document Room, 1981.

7-14. E. J. Nowak, "The Backfill as an Engineered Barrier for Nuclear Waste Management," in Scientific Basis for Nuclear Waste Management, Volume 2, C. J. M. Northrup, Jr., Ed. (Plenum Press, New York, 1980), p. 403.

7-15. M. J. Smith, P. F. Salter, and G. K. Jacobs, "Waste-Package Performance Requirements for Repository in Basalt," Proceedings of the 1981 National Waste Terminal Storage Program Information Meeting, p. 298, DOE/NWTS-15, U.S. Department of Energy, November, 1981.

7-16. F. H. Dove, and others, "Assessment of Effectiveness of Geologic Systems -- AEGIS Technology Demonstration for a Nuclear Waste Repository in Basalt," pp. 8.18-8.22, PNL-3632 (Draft), Battelle Pacific Northwest Laboratories, 1981.

7-17. R. C. Arnett and others, "Pasco Basin Hydrologic Modeling and Far-Field Radionuclide Migration Potential," p. 55, RHO-BWI-LD-44, Rockwell Hanford Operations, 1981.

7-18. D. G. Schweitzer and M. S. Davis, Brookhaven National Laboratory, letter to J.B. Martin, May 13, 1982. A copy of this letter has been placed in the public document room

7-19. D. Newby, "Engineered Waste Package Conceptual Design, DEFENSE HIGH-LEVEL WASTE (Form 1), COMMERCIAL HIGH-LEVEL WASTE (Form 1), and SPENT FUEL (Form 2) DISPOSAL IN BASALT," AESD-TME-3133 (Draft), Westinghouse Electric Corporation, Advanced Energy Systems Division.

7-20. W. A. Rodger and others, "Status Report on Integrated Design and R&D Assessment of Nuclear Waste Disposal," EPRI-NP-1655, Analytic Sciences Corporation for Electric Power Research Institute, December, 1980.

8-1. A. D. Little, "Technical Support of Standards for High-Level Radioactive Waste Management," Vol. D - Release Mechanisms, EPA 520/4-79-007D, Arthur D. Little, Inc. for U. S. EPA, 1980.

9-1. Kaiser Engineers, Inc. and others, "Nuclear Waste Repository in Basalt, Project B-301, Functional Design Criteria," RHO-BWI-CD-38 REV. 3, Rockwell Hanford Operations, 1980.

9-2. Bechtel Group, Inc., "NWTS Conceptual Reference Repository Description (CRRD), Volume II, Facility and Systems Description," ONWI-258 for the Office of Nuclear Waste Isolation, 1981.

9-3 G. Korbin, and others, "Experiments, Conceptual Design, Preliminary Cost Estimates and Schedules for an Underground Research Facility," LBL-13190, Lawrence Berkeley Laboratory, 1981.

9-4 U. S. Department of Energy, "Management of Commercially Generated Radioactive Waste, Vol. 2," Final Environmental Impact Statement, DOE/EIS-0046F, 1980.

ENCLOSURE D

FINAL ENVIRONMENTAL IMPACT ASSESSMENT
IN SUPPORT OF 10 CFR PART 60,
"DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTE IN
GEOLOGIC REPOSITORIES"; TECHNICAL CRITERIA

Summary and Conclusion

No comment was received on the "Environmental Impact Assessment In Support of Proposed Rulemaking: Disposal of High-Level Radioactive Waste in Geologic Repositories; Technical Criteria, 10 CFR Part 60," NUREG-0806, July 1981 (EIA), which was published in support of the proposed technical criteria. However, since there have been some changes to the rule as proposed, the staff has reviewed the EIA to determine whether it should be modified.

The principal change to the rule relevant to the EIA is the increased flexibility provided with the numerical performance requirements for the two major components of the engineered barrier system and for the geologic setting. The staff examined the assumptions, analyses, and findings of the EIA in light of this change. After examining the EIA, the staff concluded that the analysis and conclusions of the EIA remained sound and that no amending or modifying was warranted. The reasoning which lead the staff to this conclusion is discussed below.

Logic of The EIA

The EIA published in support of the proposed technical criteria contained an assessment of non-radiological environmental impacts which could be expected from two different geologic repository concepts. The first was a concept which relied exclusively on the properties of the geologic setting in which the repository was located to isolate the emplaced wastes from the accessible environment. The second relied exclusively on engineering to contain the wastes, the geologic setting only being host to the engineering. It was reasoned in the EIA that these two concepts represented extremes in a spectrum of possible repository designs which rely to one degree or another on a combination of natural and engineered barriers to isolate the wastes. Further, it was concluded that a design conforming to the technical criteria as proposed, particularly the performance objectives, clearly would be bounded by the two extremes. If the incremental impact of going from a minimal engineering repository to an all-engineering repository were insignificant, then so too would be the impact of meeting the proposed technical criteria. The analysis of the EIA indeed did indicate no significant differences in non-radiological environmental impact between the two repository concepts. Hence, the staff concluded that the proposed technical criteria were not likely to impose any substantial environmental impact over and above that which would be expected to result from geologic disposal of HLW. Radiological impacts were not addressed in the EIA because consideration such impacts are part of the process for setting the radiological standard for HLW disposal.

Effect of Changes to the Technical Criteria

The numerical requirements on the performance of the engineered barrier system and the geologic setting have not been changed substantially from those proposed. There is, however, flexibility for other values to be proposed by DOE or imposed by the Commission. Nonetheless, the explicit requirement in the final rule that both the engineered barrier system and the geologic setting contribute to the isolation of the wastes assures that any licensed repository would be within the extremes considered in the EIA. Hence the expected non-radiological impacts remain bounded by those extremes, and the conclusions of the EIA remain valid.

An additional change is that the retrievability period has become more flexible in the final criteria and does not necessarily extend for as long a time as would have been required under the proposed technical criteria. Retrievability was one of the design considerations with potential environmental impacts addressed in the EIA. The incremental impact of 100 year post operation retrievability over the five year retrievability of the minimal engineering concept was not found to be significant. The final technical criteria nominally requires retrievability for 50 years past beginning with the start of operations rather than 50 years past the end of operations. Hence with respect to retrievability, the final technical criteria still would not be expected to have any significant environmental impact.

For these reasons the staff does not believe that the environmental impacts due to the technical criteria of the final rule are likely to be significantly different for any actual repository which the DOE might propose from those assessed in the EIA for meeting the proposed technical criteria. Thus the staff expects no significant incremental non-radiological environmental impact to result from meeting the requirements of the final rule. Therefore, no changes are necessary in the EIA.

ENCLOSURE E

VALUE IMPACT STATEMENT ON
10 CFR 60--DISPOSAL OF HIGH-LEVEL
RADIOACTIVE WASTES IN GEOLOGIC
REPOSITORIES: TECHNICAL CRITERIA

On July 18, 1981 the proposed rule, 10 CFR Part 60 was published for public comment in the Federal Register accompanied by notification that the Preliminary Value/Impact Analysis for the proposed rule was also available and open for public comment.

In summary, the preliminary analysis concluded that "in regard to the disposal of high-level radioactive waste in subsurface excavated areas, the NRC should provide guidance to DOE through regulations which establish performance objectives and associated technical criteria. The method of meeting the performance objectives and criteria should be contained in regulatory guides and staff position papers. The development of guidance should be done by NRC with external technical assistance as needed. The guidance should contain both performance objectives to clearly state what is expected of a geologic repository, and to the extent needed, prescriptive requirements to constrain and direct design and siting such that the health and safety findings necessary for licensing can be made with confidence."

The public comment period resulted in a total of 85 comments on the proposed rule. No comments were received on the Preliminary Value/Impact Analysis. As a result, the basic findings of the Preliminary Value/Impact Analysis have not changed and are applicable, as written, to the final version of 10 CFR Part 60.

Department of Energy
Washington, D.C. 20585

OCT 29 1982

MEMORANDUM FOR Honorable Nunzio J. Palladino
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

On July 29, 1982, the Department of Energy met with the NRC staff in an open meeting to discuss the proposed final draft of 10 CFR Part 60. Others who had participated in the rulemaking proceeding were also invited to this meeting.

Draft copies of the final Rule and "Rationale for Performance Objectives in 10 CFR Part 60" were distributed. Based upon those documents and discussions at that meeting, it is clear that a number of basic Department concerns are not being adequately addressed by the NRC staff as it proceeds with the development of the Rule. Accordingly, I am writing to advise the Commission directly that the Department has serious difficulties with certain aspects of the Rule as now written, despite extensive discussions with NRC staff management and the apparent accommodations of our concerns.

The Department's major concern with the proposed Rule, which has been noted in our comments and in those of other reputable reviewers, is the inclusion of ad hoc numerical design requirements for subsystems (individual barriers). Because the degree to which a repository contains radionuclides over time is the ultimate test of its adequacy, we believe the Rule should be based on and derived from an overall system performance objective, as were the curie release limits which have been proposed by EPA in their draft Standard. Instead, the Rule centers on the imposition of performance requirements for individual components that are neither derived from nor related to an overall system performance objective.

Further, inclusion in the Rule of numerical performance requirements for individual barriers will, because of the difficulties in demonstrating compliance, significantly complicate the licensing process and add needless expense of the disposal of high-level waste. The NRC has issued drafts for public review and comment twice, first on May 13, 1980, and again on July 8, 1981. In response, the Department and other concerned parties have expressed reservations about the NRC's approach. These comments, however, have not been fully addressed by the NRC staff, perhaps partially because of a failure to appreciate the potential licensing pitfalls involved.

In its current form the Rule still contains rigid, numerical requirements for individual components that are not justified. For example, the Rule states in section 60.113(a)(1)(ii)(A):

> "Containment of HLW within the HLW waste package will be substantially complete for a period of 1,000 years after permanent closure of the geologic repository, or such other period as may be approved or specified by the Commission."

The NRC staff position is that the phrase "or such other period as may be approved or specified by the Commission" sufficiently addresses the Department's concern that the 1,000-year period constitutes a firm requirement. We, however, cannot agree. As a practical matter, case-by-case approvals of deviations from specific numerical requirements are almost never granted, require extensive litigation, and, accordingly, are not a realistic alternative to compliance with specific numerical criteria.

We are seriously concerned over the numerical requirements prescribed in 60 113 for components in the Rule for three reasons. First, we believe that the need to demonstrate compliance will unnecessarily complicate and prolong the licensing process. Simply determining the requirements necessary for demonstrating a 1,000-year waste package, for example, is likely to consume considerable time. Secondly, the requirements in the Rule are not technically justifiable. For example, as discussed in our previous comments on the proposed Rule, a long lived (1,000-year) waste package makes no measurable contribution toward protecting the health and safety of the public. The third reason for concern is that of unnecessary cost. The cost of a very long-lived waste package--and exotic, very low release rate waste forms, which also appear to be required by the Rule--would needlessly add to the expense of the disposal of the Nation's waste.

In addition, we have found that the NRC staff's "Rationale" document, which accompanies the draft Rule and sets forth the staff's bases for the requirements it contains, does not, in fact, support the specific requirements in the Rule. During their presentation to the Commission on the proposed Rule, the NRC staff acknowledged that the imposition of the numerical values will not in and of themselves ensure that the proposed EPA Standards will be met. The geologic conditions in the repository must provide a measure of protection from premature radionuclide release. In assessing the effectiveness of the geology, however, minimal credit was allowed because of assumed conditions which were seriously flawed compared to geologic options the Department is investigating.

Enclosed are excerpts from the comments of others on the NRC Rule. You can see that the Department is not alone in taking a position against the specific design requirements included in the proposed Rule. Even one of the NRC staff's principal contractors, Sandia National Laboratories, has stated "If a constant release rate and a groundwater travel time greater than approximately 500 years is assumed, then the presence of (a) canister has little effect on releases."

We understand that on November 2, 1982, the NRC staff is scheduled to brief the Commission on alternative procedures to finalize the technical criteria. portion of 10 CFR 60. Given our concerns with the requirements of the Rule as presently drafted, we urgently request an opportunity to present to the Commission our concerns and to suggest alternatives which we believe will significantly improve the Rule. Unfortunately, senior members of DOE management will be out of the country on November 2. Consequently, we request that the Commission reschedule the NRC's staff presentation to a mutually convenient time. Additionally, we request that the Commission defer any action on this matter until we have had an opportunity to present our concerns to the Commission.

Thank you for your consideration of our request. I am sure that we can work together to develop a useful, technically sound rule.

Sincerely,

Shelby T Brewer
Assistant Secretary
for Nuclear Energy

Enclosure

cc:
John F. Ahearne, Commissioner
James Asselstine, Commissioner
Victor Gilinsky, Commissioner
Thomas Morgan Roberts, Commissioner

Enclosure

SUMMARY OF OTHER PARTICIPANTS' COMMENTS

I. SYSTEMS APPROACH

Many commentors supported the systems approach to performance assessment and suggested elimnation of subsystem performance requirements. A few of these comments are quoted below.

NRC Advisory Committee on Reactor Safeguards

". . . we believe that the licensee should be given a greater degree of flexibility for compliance with the overall safety goal. One approach would be to emphasize the fact that the NRC will be evaluating the anticipated performance of the total waste repository as a system, in contrast to the performance of its individual components. Since we foresee only one or two repositories being built within the next several decades, we believe that each should be evaluated in relation to overall performance on a case-by-case basis."

American Nuclear Society

". . . ANS strongly recommends that all subsystem numerical performance requirements be deleted in favor of more general statements permitting system trade-offs to achieve the desired overall system or repository performance. Specifically, the following values should be deleted:

1000-Year Waste Package Life (Section 60.111(b)(2))
10 Long-Term Release Rate (Section 60.111(b)(2)(ii)(A))
1000-Year Undistrubed Water Travel Time (Section 60.112(c))
50-Year Retrieval Time (Section 60.111(a)(2))"

"It is our concerted view that overly restrictive and specific performance standards are not necessary, and that such standards in regulation form are likely to add to the overall cost of waste disposal without achieving any degree of benefit to the public health and safety. Instead, using current engineering practices, a carefully sited, engineered, and designed repository coupled with effective confirmation and design validation can assure compliance with a single, overall performance criterion for the repository as a whole system. The application of such a single performance standard would not only coincide with the Environmental Protection Agency's recommended approach of the systems concept, but would permit repository designers to optimize the repository as a system of both natural and engineered barriers for differing site and geologic medium characteristics."

Utility Nuclear Waste Management Group

". . . the NRC barrier performance objectives approach, as embodied in the current proposed regulations, can only be viewed as the arbitrary imposition, on individual system components, of special-value standards that are without scientific or other technical support."

". . . we cannot agree that the inclusion of such component requirements will increase the ability to show compliance with an overall system performance requirement (e.g., EPA protection standards), since such a showing will necessarily involve the use of mathematical models independent of specific component performance requirements."

"UNMWG is firmly of the view that overall repository performance should be addressed directly by means of the systems approach. Utilization of an overall performance standard would correctly serve to focus attention on total repository performance. In addition, it would provide for appropriate design flexibility; something which is important in order to both be able to take advantage of new developments, as this new undertaking proceeds, and to accommodate and effectively utilize the specific characteristic of individual sites."

National Research Council/National Academy of Sciences

"The BRWM (Board on Radioactive Waste Management) questions the adequacy of the proposed numerical criteria to accomplish these (their) purposes." . . . "Specifically, our conclusions regarding the proposed numbers are as follows:

1. NRC has not presented adequate evidence that these numerical criteria can "support a finding of no unreasonable risk to the health and safety of the public" . . .

2. NRC has not shown that these numerical criteria are either necessary or sufficient to meet the "EPA Standard." . . .

3. It has not been shown that adoption of the numerical criteria will simplify the licensing process . . .

4. No attempt has been made to demonstrate the technical validity of the proposed criteria. . .

5. NRC has not shown how the proposed numerical criteria for the waste package can be verified . . ."

". . . we recommend that precise numerical criteria for major elements of the repository system be eliminated."

II. 1000-YEAR WASTE PACKAGE

The NRC received many technical comments questioning the validity of the 1000-year waste package containment requirement. A few of the comments are quoted below.

Lawrence Livermore Laboratory

"The zero-released containment limit as proposed by the Commission is not necessary because more reliance can and should be placed on the other barriers . . ." "In addition, it should be recognized that small releases are not intolerable, in view of the vast inventory of naturally-occuring radionuclides in the earth's crust . . ." "The containment time proposed by the Commission is not reasonable because the function of the waste package should be to provide containment primarily during handling and shipping, including possible retrieval, not long-term containment."

American Nuclear Society

"The requirement for a 1,000-year containment period by engineered barriers is grossly excessive and unsupported by scientific fact." "NRC claims that the basis for the choice of 1,000 years is mainly that the heat induced by the waste in the geologic medium will increase the waste package leachability and reduce the near-field transport time, with the net result that the radiological source term from the "distrubed zone" increases. NRC does not argue that the 1,000-year containment period is necessary to reduce the overall radiological releae to man's environment to an acceptable level."

It is agreed that the postulated release from the underground facility would be accelerated due to resulting higher temperatures in the geologic medium but, generally, the calculational models used do not take credit for any holdup or delay of radionuclides in the region of relatively higher temperatures. Rather, the radiological source term for the far-field transport models are derived directly from the waste package release rate as if the heated geologic medium region or "distrubed zone" did not exist. Thus, any acceleration of release from the underground facility due to temperature effects has already been discounted and, therefore, should not be used to penalize the waste package design."

Dr. T. H. Pigford, University of California at Berkeley

Dr. Pigford has prepared a detailed analysis of the NRC's proposed 1,000-year waste package containment period. Seven areas were analyzed: (1) the NRC's purpose; (2) the importance of 1,000-year containment to overall performance; (3) temperatures assumed by the NRC; (4) temperature effects; (5) extrapolation from current knowledge; (6) compliance verification; and (7) cost estimate.

Dr. Pigford summarizes:

"The above analysis shows that NRC's proposed criterion that the radionuclides be confined within the waste package for 1,000 yr is without adequate or valid technical foundation, is based upon questionable assumptions, and may not be important to long term public health and safety. There is no showing by NRC that the proposed criterion is necessary or sufficient for NRC's stated purposes."

Environmental Protection Agency

"Although we strongly support the multiple barrier approach, we think that the 1000 year waste package requirement may be excessive. Studies published by the Electric Power Research Institute (EPRI) and confirmed by EPA indicate that in almost all situations improvements in canister life are less important for reducing long-term risks than improvements in waste form or careful selection of site characteristics. If the waste package lasted only a few hundred years, it would guard against uncertainties during the period of greatest heat generation; however, the 1000-year life requirement for the waste package could necessitate the use of very expensive or exotic materials (such as titanium) for waste canisters. The supporting documentation for the rule does not consider the potential cost of this requirement. In light of the relatively small benefits and possible high cost, we believe the Commission should reexamine this requirement."

Institute of Electrical and Electronics Engineers

"The 1000-year requirement for Waste Package integrity would probably be unduly restrictive in cases where engineered barriers are available and/or groundwater travel times are longer than 1000 years. In addition, it may be prohibitively difficult and expensive to fabricate waste packages that will remain intact for 1000 years, and impossible to provide assurance that the requirement will be met."

III. RELEASE RATE REQUIREMENT

The NRC proposed release limit of one part in 100,000 per year was also disputed by most of the technically qualified commentors.

Dr. T. H. Pigford, University of California at Berkeley

"The numerical specification of a fractional release rate of 10^{-5}/yr is of questionable importance to long-term safety and is proposed without a technically valid basis and with invalid assumptions of existing technology and cost if such a numerical criterion were adopted, compliance could probably not be verified. It would be more appropriate for NRC to state the considerations which may help guide DOE in its development and proof of the waste package as one of the possible barriers that may aid in meeting whatever safety standards that emerge."

Dr. H. P. Ross, Geophysical Consultant

"The one part in 100,000 release requirement for the engineered system again will be impossible to verify and ignores the positive features of a good geologic site to contain or delay transport of radionuclides. The requirement as stated requires engineering overkill for a single component of the system which will be unnecessarily costly and still impossible to verify. Sorption, long travel paths, and dilution all tend to offset the effects of release from the engineered system."

IV. 1,000-Year Groundwater Travel Time

Several commentors disagreed with the 1,000-year groundwater travel time requirement.

Dr. T. H. Pigford, University of California at Berkeley

"NRC has not shown need or adequate technical basis for its proposed numerical criterion for water travel time. It would be more appropriate for NRC to state its considerations of water travel time as a contributor to overall safety performance. It would be appropriate for DOE to have the flexibility to select sites with water travel times sufficient so that, in combination with the other properties of the site and of the engineering design, there will be reasonable assurance that a regulatory specified overall performance standard will be achieved."

Institute of Electrical and Electronics Engineers

"Placing the requirement on water travel time, rather than on radionuclide travel time, may, in effect, result in focusing on an implicit assumption that no retardation occurs. This is another compounding conservatism."

V. INTERNATIONAL COMMENTS

Agencies from two countries, the Netherlands and the United Kingdom, were concerned about the performance criteria proposed by the NRC.

Netherland Energy Research Foundation

" / . . there should be only one approach for setting performance criteria for a high-level waste repository. That approach should be the prescription of a single performance standard for the overall disposal system." . . . "It is only by means of an iterative process of safety assessment and repository system improvement that the relative importance of the different components to the overall system can be evaluated."

"At least for a carefully designed HLW-repository in salt the waste package is therefore not a key component of the overall engineered system . . ."

"The restrictive containment or confinement of the radioactive waste to its waste package is an irrational requirement. The boundary of confinement can easily be shifted more outward without any consequences from the point of view of radiological hazard to man and his environment."

Department of the Environment, United Kingdom

"Document 10 CFR 61 illustrates the setting of overall performance objectives whilst allowing some flexibility in designing and operating each individual repository, whereas document 10 CFR 60 appears to set acceptance criteria not always justified by technical evidence."

"The rule has been developed in the absence of raidological protection criteria (environmental standards), for disposal of high-level wastes; the proposed technical criteria are, therefore, arbitrary. This approach to setting technical criteria is incorrect in principle. It leads to criteria which are inflexible because, since they have no clear basis, there can be no basis for changing them. In addition the approach is very likely to lead to criteria which are too restrictive, thus causing more expenditure on high-level waste disposal than is warranted by radiological protection consideration."

"The rule does not define in any detail the means by which compliance with performance objectives is to be demonstrated. As a consequence the proposed performance objectives have little meaning and it is very difficult to decide whether they are appropriate or achievable."

". . . the proposed rule is unsatisfactory and should not be adopted in its present form. It would be preferable to leave the rule in "proposed" form until the EPA standards have been published and until there is sufficient information available to derive technical criteria from these standards. The rule should then be revised."

"We feel that too many firm numbers are being laid down without sufficient experimental and theoretical justification. Particularly if disposal will not take place for many years it is better to set overall dose limits to define the required performance of the multiple barrier. It is then up to designers to optimize the individual elements in the system as models and experimental data are improved over the years. The proposed rule would freeze options too soon."

ORIGINAL

OFFICIAL TRANSCRIPT
PROCEEDINGS BEFORE

NUCLEAR REGULATORY COMMISSION

COMMISSION MEETING

PUBLIC MEETING

DKT/CASE NO.

TITLE: OPTIONS REGARDING HIGH-LEVEL WASTE [illegible] TECHNICAL CRITERIA (PART 60)

PLACE: WASHINGTON, D.C.

DATE: OCTOBER 18, 1982

PAGES: [illegible]

ALDERSON REPORTING
(202) 628-9300
440 FIRST STREET, N.W.
WASHINGTON, D.C. 20001

8211240218 158pp

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

OPTIONS REGARDING HIGH-LEVEL WASTE RULE
TECHNICAL CRITERIA (PART 60)

PUBLIC MEETING

Nuclear Regulatory Commission
Room 1130
1717 H Street, N. W.
Washington, D. C.

Thursday, November 18, 1982

The Commission convened, pursuant to notice, at 2:05 p.m.

COMMISSIONERS PRESENT:

NUNZIO PALLADINO, Chairman of the Commission
VICTOR GILINSKY, Commissioner
JOHN AHEARNE, Commissioner
THOMAS ROBERTS, Commissioner
JAMES ASSELSTINE, Commissioner

STAFF AND PRESENTERS SEATED AT COMMISSION TABLE:

S. CHILK
M. MALSCH
G. CUNNINGHAM
P. COMELLA
W. DIRCKS
J. DAVIS
M. BELL
B. HEWETT
F. COFFMAN
S. BREWER
R. DeJu
D. EGAN
P. MEYERS
K. KRAUSKOPF

* * *

DISCLAIMER

This is an unofficial transcript of a meeting of the United States Nuclear Regulatory Commission held on November 18, 1982 in the Commission's offices at 1717 H Street, N. W., Washington, D. C. The meeting was open to public attendance and observation. This transcript has not been reviewed, corrected, or edited, and it may contain inaccuracies

The transcript is intended solely for general informational purposes. As provided by 10 CFR 9.103, it is not part of the formal or informal record of decision of the matters discussed. Expressions of opinion in this transcript do not necessarily reflect final determinations or beliefs. No pleading or other paper may be filed with the Commission in any proceeding as the result of or addressed to any statement or argument contained herein, except as the Commission may authorize.

P R O C E E D I N G S

CHAIRMAN PALLADINO: Good afternoon, ladies and gentlemen.

Today's meeting addresses the Commission's proposed technical rule for disposal of high-level radioactive waste in geologic repositories.

Proposed technical criteria were published for public comment in July 1981. Today's speakers will touch on several questions concerning the timing and content of a final technical rule.

Our first presentation will be made by the NRC staff under the EDO, Bill Dircks. The staff has recently highlighted for the Commission the potential problems in finalizing the technical rule before the Environmental Protection Agency issued an effective standard for high-level waste disposal.

In particular the staff noted that the NRC's performance objectives for waste package containment time and the release rate from the engineered barrier system are closely linked to the EPA standard. The staff argues that the two performance objectives ought not be finalized until the EPA standard is published.

Following the NRC staff will be the Department of Energy represented by Shelby Brewer, Assistant Secretary for Nuclear Energy and by Dr. Frank Coffman, Deputy Assistant Secretary for Nuclear Energy.

In a letter dated October 29th, 1982 DOE expressed a fundamental objection to the NRC's numerical performance objectives for the individual barriers of the geologic repository. DOE requested the opportunity to address the Commission before the Commissioners act on the staff's approach to finalizing the NRC technical criteria, including the individual performance objectives.

Following DOE we have allotted time for the EPA represented by Dan Egan of the Waste Management Branch and the National Academy of Sciences represented by Dr. Konrad Krauskopf who is the Chairman of the Board on Radioactive Waste Management. The representatives may wish to comment on the presentations of the NRC and DOE and the Commissioners will probably also wish to ask some questions.

We have allotted roughly 30 minutes apiece for the NRC staff and DOE speakers and five minutes apiece for the remaining two speakers. That doesn't mean though that we won't interrupt with questions.

(Laughter.)

CHAIRMAN PALLADINO: If there aren't any other Commissioner remarks at this time ---

COMMISSIONER GILINSKY: I have a question I would like to ask. I guess I would like to understand what it is we are letting ourselves in for. Are we starting another round of comments or are we going to entertain comments from others who participated in this rulemaking? I guess I would like to ask the General Counsel what happens if we modify our views as a result of today's meeting? Would we then have to put a rule out for comment again?

MR. MALSCH: It would depend on what the change was. If the data is already basically in the record and what you are hearing are sort of elaborations or arguments based upon data already submitted in comments, I would say there is no need to go out again for comment.

If we get, you know, laid before the Commission at a late date an entirely new rationale for an entirely different rule, then, yes, there is a possibility you would have to go out again for comment. It would depend on the nature of the comments.

MR. CUNNINGHAM: I would agree with that, but I would add specifically if the changes go to the systems approach rather than the engineering barriers approach and eliminate those subcriteria, that would be a major change which I think would require renoticing.

COMMISSIONER GILINSKY: And are we going to entertain comment from others?

CHAIRMAN PALLADINO: What is that?

COMMISSIONER GILINSKY: Are we going to entertain comment from others who are not here today?

CHAIRMAN PALLADINO: I think that would depend a little bit on what we hear.

COMMISSIONER AHEARNE: Or on whether it makes any modification to the rule proposed.

COMMISSIONER GILINSKY: Whether we change our views.

COMMISSIONER AHEARNE: That is right.

CHAIRMAN PALLADINO: Any other comments or questions?

(No response.)

CHAIRMAN PALLADINO: Okay. Then I will turn the meeting over to Mr. Dircks.

MR. DIRCKS: We had one primary objective when the meeting was scheduled, and that was to discuss the five alternatives that we presented to the Commission in SECY-82-427, and John Davis will go through those alternatives.

I have to emphasize that all those alternatives are based on the multiple-barrier quantitative criteria approach. So we didn't intend to get into an argument over whether or not you should have multiple-barriers and numerical criteria. That we thought was established by the Commissioner in its guidance to the staff and when we issued the proposed rule. If that were changed, we would have to go back and have further discussions on that subject.

I thought before we got to the alternative questions, I do think it is necessary though to address some of the points raised in the DOE October 29th ? memorandum. Again, I don't want to get into a debate on the technical issues they raised, but I do think it is important to address I think the allegations that were made that we didn't follow a rulemaking process that had integrity.

I think in our rulemaking process in the addressing of comments, I do think we have followed a legitimate and correct path. There were comments made in the DOE memo that gave examples of how we were unresponsive or did not adequately address comments and I do think we want to get into that issue because that did question the integrity of the whole rulemaking process.

COMMISSIONER GILINSKY: You say you do or you don't?

MR. DIRCKS: We do. Now in some cases it is going to be difficult because the memo goes back and forth between the comments that were made in the context of the rulemaking process and some comments that were quoted I think out of context. So we are going to try to match the two and I am going to ask Pat Comella to try very briefly to address that issue.

After she is finished, I would like to then go back to John Davis to go over the options that we presented in our memorandum to the Commission.

MR. CUNNINGHAM: All right. To just recap a few facts connected with the public comments that we received, to date we have received and documented 91 comment letters of which the most recent was the October 29th memorandum from DOE. Those letters were distributed. We had about nine from other federal agencies, 11 from state and local governments, two from foreign countries who were very interested in the question of waste disposal, and, oh, about 20 from the industry professional societies, consulting firms and the remainder from private individuals. There were two letters from Congressional either committees or Congressmen.

The summary of the public comments received, it is going to be difficult to avoid getting into content, but I will do my best.

(Laughter.)

MR. CUNNINGHAM: There was general support for the multi-barrier approach, and let me characterize that as general acceptance that both engineering and geology should contribute to waste isolation in the geologic repository.

Concern, however, was expressed over the numerical performance requirements. There was concern about specifying numerical requirements for subsystems, and the comments generally fell into two categories. One would be no numerical criteria for subsystems at all specified in the rule, or, if you do, have some provision for flexibility.

The lack of an EPA standard was noted. It was noted in two respects. How can you finalize criteria if yo don't have a standard and how can you show a relationship between the subsystem performance requirements and an overall system requirement without the standard in place?

The question of the meaning of reasonable assurance, that evoked quite a lot of concern. What is the nature of the proof required during the licensing process in order to arrive at a licensing decision given the very long periods of time involved and the uncertainty associated with this particular enterprise?

There was comment on the retrievability, specific detailed requirements, the TRU requirements that were in the proposed rule and there was discussion of disposal in the unsaturated zone. If you will recall, the proposed rule was limited to disposal in the saturated zone, a fact that a number of commenters offered very helpful comment upon.

COMMISSIONER AHEARNE: Pat, just one question. On those that raised questions about the level of detail, did they suggest elimination of the detail from the rule and placing it in something else or just the elimination of the detail?

MR. CUNNINGHAM: It was varied, if I recall correctly. Some suggested elimination of very specific requirements. Generally I think that there was not difficulty with putting into another form of guidance. It was just the question of whether or not that was appropriate for a regulation.

COMMISSIONER AHEARNE: So that it was not necessarily then complete disagreement with the approach that the detail represented?

MR. CUNNINGHAM: I wouldn't say that. Yes, I would say that there was not difficulty with it. It was where it was.

COMMISSIONER AHEARNE: So that something like a reg. guide might be an appropriate route.

MR. CUNNINGHAM: Yes.

In the next few viewgraphs I am going to just quickly step through how we went about analyzing public comments. I don't think that there was anything different from the approach that we took in analyzing these comments for this rulemaking versus other rulemakings.

I would say, however, that the staff was particularly sensitive to the great importance and visibility attached to this rulemaking and the fact that that recent rulemakings of the Commission have come under scrutiny by the courts and have come in for criticism, and I think that that provided additional incentive to do a very fine job in terms of providing systematic and documented identification and consideration of all of the issues addressed by the commenters of showing how they were considered, what changes resulted from the proposed rule and why those changes were made.

We went through a very detailed process then to identify all of the topics, to collect the individual comments of which there were several hundred and to place them into proper context. We were quite concerned about that I know and went through a number of iterations before we felt that we had them properly contexted.

We then categorized them by topic, and then we did topical analyses. The results of those analyses occur in three different documents. Each comment is responded to individually. It may be a cross-reference to the policy overview in the section-by-section analysis which shows where the changes were made and there may be some discussion in the individual response.

The third document that is provided is the treatment of the technical issues and those are treated in the rationale document which you received in July.

In order to provide some idea of what we did, what the comments were and how the staff responded to them, I have used the DOE letter of November 5th, 1981 for three examples and I have selected the most recently arrived letter from DOE for the fourth example. I did that because they are the ones who have expressed the most concern about how we have handled the comment analysis. So it seemed to me to be most appropriate to use their letter.

I have quoted hopefully not out of context or misrepresented what they said. "We have long recognized the need for a multi-barrier approach and the objectives which the Commission is seeking to achieve." The staff response to that in terms of reference to the draft final rule would be that the multi-barrier approach is retained. The individual repository subsystems are identified, containment within the waste packages, controlled release from the underground facility and a minimum groundwater travel time to the accessible environment, those are treated qualitatively as well as then numerical requirements specified quantitatively.

Also in comment letter No. 48 "The Department considers that a more appropriate way of accomplishing the objectives expressed by the Commission would be to provide specific subsystem performance goals by providing the flexibilty to salect numerical subsystem criteria on a case-by-case basis." Language was also provided as part of the DOE submittal at that time. The staff considered the language as well as the comments.

I would note, too, that similar comments were received. These are in other letters and these are merely illustrative. The numerical performance objectives for individual subsystems are retained. However, there is provision for flexibility to propose alternative numbers.

The third example DOE expressed concern, "It is not clear how the individual performance objectives are related to the EPA release limits using the techniques of performance analysis and an understanding of the geologic and hydrologic environments." I would make reference here to the rationale document in which the staff has shown the relationship between the assumed EPA standard which is Draft 19 referenced by a number of commenters in their letters and the numerical performance objectives that are in the draft final rule.

The Sandia performance assessment models were used to perform this analysis and there was a detailed discussion in the document of the uncertainties associated with the geologic and hydrologic environments now that have been typical for a repository system.

For my last example I have gone to the most recent DOE letter which has been assigned Docket No. 91. We are seriously concerned over the numerical requirements for components. We believe that the need to demonstrate compliance will unnecessarily complicate and prolong the licensing process.

While I have provided a preliminary staff response that points out the fact that in licensing the individual subsystems would have to be identified wherever DOE wants credit for the performance of a particular subsystem or component of the geological repository, be it an engineer component or a geologic barrier, it would have to be able to demonstrate why such credit should be given.

Ultimately a criterion is specified numerically and performance is measured against that particular criterion. So there is potential for litigation involving compliance demonstration in the licensing process regardless of whether you specify the performance criterion now in advance in the rule or whether you await the licensing case.

The question then is whether or not you bound the litigative risks more readily by specifying the criteria in advance or whether you do so by waiting until you get to licensing. On that point I would like Guy to address the advantages as the staff sees it of specifying the requirements now.

MR. CUNNINGHAM: The point was made in DOE's most recent letter that in their view licensing would be much more difficult if these performance criteria were specified in the rule. Our experience in licensing would suggest that the case is probably just the opposite.

You have two features here, identifying the criterion and measuring performance against the criterion. If the criterion is identied in the rule, that cannot be litigated. If you don't have the criterion, you will litigate it.

The classic example, of course, was ECCS.

Back in the early 70's the only criterion was abundant emergency core cooling and we litigated months and months what is abundant. Then after you define what is abundant, then you have to say do you have that much. This rule would prescribe what is abundant and that would not be litigated.

I might add that when we went to rulemaking the ECCS we eliminated that issue and we don't litigate ECCS any more.

COMMISSIONER GILINSKY: What you say is I think right, but reading what DOE has sent to us my impression is that what concerns them is having to come in and ask for an exemption will be an awkward thing.

MR. CUNNINGHAM: Well I think that is a separate issue.

COMMISSIONER AHEARNE: Well, you see, your description was quite right, if the criteria could be met.

MR. CUNNINGHAM: That is right.

COMMISSIONER AHEARNE: And if it is a different assumption, you get a different answer.

MR. CUNNINGHAM: That is right. If they choose to avail themselves of the flexibility which we have in this proposed rule, then they are back to the situation where there were no criteria and you have to litigate both issues.

COMMISSIONER GILINSKY: Right.

MR. CUNNINGHAM: What are the criteria and do you meet it.

MR. DIRCKS: That is the other issue, are the criteria reasonable criteria and can they be met. Of course, that is the other issue that I think we would be prepared to discuss, but I didn't know whether you wanted to get into that issue.

COMMISSIONER AHEARNE: I was just commenting on Guy's description, and he started with an unspoken something.

MR. CUNNINGHAM: You are correct. If you meet the criteria, then you eliminate a major issue. If you don't eliminate and meet the criteria and just to justify some other approach, then you litigate both issues.

CHAIRMAN PALLADINO: I gather they felt they might be, as Commissioner Gilinsky said, in an awkward position if they have to come back and ask for less stringent criteria.

COMMISSIONER GILINSKY: Well, it is something that ought to get very careful scrutiny.

CHAIRMAN PALLADINO: Sure. I am just saying what their argument was.

MR. CUNNINGHAM: Well, I think that is true. Part of their argument was that there is a regulatory mind stand against ever granting exemptions.

COMMISSIONER ROBERTS: And they say that pretty emphatically.

COMMISSIONER AHEARNE: I think it is certainly true that for the first repository it will be very difficulty to get away with many explicitly stated exemptions.

MR. DIRCKS: Of course, that is why we put the Alternative B in there. We didn't want them looking at that as an exemption but as an alternative path than the one they are taking.

You are finished?

MS. COMELLA: Yes.

MR. DAVIS: Now if I can focus on why the staff felt we were originally coming down here, and that is to get some guidance.

COMMISSIONER GILINSKY: The original purpose of the meeting.

COMMISSIONER AHEARNE: No, those are two different things.

(Laughter.)

MR. DAVIS: Why we thought we were coming down.

COMMISSIONER AHEARNE: There were two meetings that turned out to be combined into one.

MR. DAVIS: This is the part that the staff was asking for, and that is basically to receive from the Commission some guidance on how to proceed to go to a final on Part 60 in the absence of the EPA standard.

As you all know, the EPA standard is used as the overall performance goal for Part 60. We in developing this rule, which has been in the works for some years, never anticipated that we would be at this point without the EPA standard. We were well mindful of some recent experiences which we have had with regard to, and I think the term is getting ahead of EPA in our rulemaking.

COMMISSIONER GILINSKY: Which isn't hard to do.

(Laughter.)

MR. DAVIS: So consequently we thought it was time to pause and come back to the Commission and say we would like to have some guidance on how should we now proceed.

Now of course the major issue that has arisen is this performance objectives appearing in the rule. As Mr. Dircks has already mentioned of course, this was a Commission position previously taken and the staff has gone through and followed through on what we considered to be the Commission direction and we have ended up with the rule which does have the numerical performance criteria within it.

Now the criteria that we are suggesting as in the options, we are not suggesting that we remove the numerical performance criteria for the geological setting.

COMMISSIONER AHEARNE: You mean the ground water travel time.

MR. DAVIS: I am sorry, the ground water travel time. The concept of geologic disposal suggests isolation over a long period of time and we believe that the time of the criteria within the rule is a prudent number. I also might comment that this is not a matter in issue. This has not been brought to us as a matter in issue.

COMMISSIONER AHEARNE: Let me see if I understand that last comment, John. There are three numerical criteria in the proposed rule.

MR. DAVIS: Right.

COMMISSIONER AHEARNE: You are saying that two of them are the ones that you are going to talk about. The third one, the ground water travel time, is not going to be one of items that is listed either in or out of these options because it is not an item at issue.

MR. DIRCKS: No. That was a side statement. The real reason is because we think the concept of geologic disposal calls for a long time and that that number which we have is a prudent time. Parenthetically it has not been raised as an issue.

COMMISSIONER AHEARNE: What I am puzzled by is that I thought that all three numbers were in there because deep geologic disposal and prudent planning requires the barrier concept and the numbers are in there to try to get confidence that the overall limit can be met. I am having difficulty seeing why one of them is treated so differently than the other two.

MR. DAVIS: Well, the geologic number is of course a matter of geology. The other two numbers are matters which can be influenced by engineering. So consequently what has been focused upon are those numbers which are subject to some degree of influence by man and engineer.

COMMISSIONER AHEARNE: The geological one is subject to selection.

MR. DAVIS: That is right.

COMMISSIONER AHEARNE: In other words, where you choose the site ---

MR. DAVIS: --- will determine the degree of the geologic barrier, right.

Now the next slide shows why we need the standard and I think we are all aware why we need the standard. It does specify the quantities of radioactive material that can be released to accessible environment. It does set the time period over which performance must be assessed, in other words, 10,000 years. It does provide the definition for the accessible environment. Then we are relying on the EPA EIS, on its standard to address the radiological impacts of a high-level waste disposal.

As I have mentioned, we did fully anticipate that the EPA standard would be in place before we got to this point.

COMMISSIONER AHEARNE: Now when the comments were out or when our rule was out, and it was Draft 19 I think was the EPA standard that you were talking about, is that still the latest draft or are there any major changes since that time?

MR. BELL: The draft that was available at the time the proposed rule went out and the one that we used in our analysis was Draft 19. The current working draft of the EPA is Draft 21. There have been some changes to the definitions and to the guidelines, but the numerical quantities in the standard itself haven't changed at all.

COMMISSIONER AHEARNE: So the 10,000 year, for example as the period of assessment is still the same?

MR. BELL: It is still the same and the quantities that could be released over that period would be the same.

MR. DAVIS: Now if we can turn to the five options that are called out in the staff paper ---

COMMISSIONER GILINSKY: Did you say Draft 21?

MR. BELL: Yes.

MR. DAVIS: Under Option 1 what the staff is proposing is that you finalize the rule except for the numerical substance then of the two numbers associated with the performance objectives of the engineered barrier system, that is the waste package containment time and the EPA barrier system, and move forward with the rule.

These two numbers would be reserved until after the EPA publishes an effective standard at which time the staff would look at that which it has done and see if it needs to be modification to the rule and proceed to insert the numbers.

COMMISSIONER GILINSKY: If there were any major departure from numbers that have been put out for comment, wouldn't you go out for comment again?

MR. DAVIS: It would have to back out for comment. Now of course what this would do ---

COMMISSIONER GILINSKY: Do you have any sense for how long that process would take?

MR. DAVIS: It would depend on when the EPA standard comes out of course.

COMMISSIONER GILINSKY: For going out for comment again.

MR. DAVIS: For going out for comment?

COMMISSIONER GILINSKY: Yes.

MR. DAVIS: What would you think?

MR. BELL: On a narrow issue like this, fixing the couple of numbers, given an EPA standard, we think that could be done fairly quickly in a fairly narrow scope of the rule.

MR. DAVIS: Now the major points in item 1 are it does get ahead of the EPA standard and it would get the major portion of the rule into place and remove whatever uncertainty there is in those portions.

Option 2 is the same as option 1 with the exception that the staff proposes to go out on limited public comment on the removal of the two numbers; that is, comments would be asked on should we reserve the numerical objectives until the standard is publicized, or should we finalize numerical objectives in the absence of the standard and rely on flexibility provisions which are in the current version of the rule.

CHAIRMAN PALLADINO: The rule you are talking about does have additional information about saturated versus unsaturated?

MR. DAVIS: Yes, sir, it does, and we would have to go out for comment on that. In anything we do we will have to go out for comment.

CHAIRMAN PALLADINO: Well, the first one, okay, you are not asking for comments.

MR. DAVIS: Right, but in the first one, sir, when we publish the final rule we would have to ask for comments on the saturated and unsaturated also.

COMMISSIONER GILINSKY: Let me ask you, if there any suggestion in these various reiterations of the EPA that their basic numbers are going to be changed or is it a matter of additional criteria or guidelines?

MR. DAVIS: There is an EPA person here to address that. I don't believe we have such an indication.

COMMISSIONER GILINSKY: Aren't the EPA numbers the only thing that would affect the numbers in our rule, and if those aren't changing what prospect is there for our changing our numbers?

MR. BELL: EPA will be in the process of publishing these for comment for the very first time and we expect that it may be a very controversial standard on some of the issues being dealt with, the time periods involved and how you treat issues such as intrusion and other potential disruptive events.

COMMISSIONER GILINSKY: Well, let's see, are we talking about waiting till EPA has a final rule or until EPA has a proposed rule?

MR. BELL: A final rule.

COMMISSIONER GILINSKY: Oh, that is a long time, isn't it?

MR. DAVIS: It can be a considerable period of time.

COMMISSIONER GILINSKY: Because they are not even proposing yet.

MR. DAVIS: That is right, the proposed rule is not yet packaged.

COMMISSIONER GILINSKY: So we might be taking about years.

COMMISSIONER AHEARNE: Yes.

MR. DAVIS: Based on the issue, we are talking about years.

COMMISSIONER ASSELSTINE: What is the impact of that kind of a delay given all of the ongoing work that is planned over the next several years?

COMMISSIONER GILINSKY: The impact I take it on the waste program.

COMMISSIONER ASSELSTINE: Yes. Doesn't it really call into question the whole foundation of the program over the next several years?

(Simultaneous conversations -- Inaudible)

(Laughter.)

MR. DAVIS: I think what the benefit of what we are proposing to do is that it makes clear if we publish the rule either under one or two in the final form it is merely subtracting out these two numbers. Now if the Commission has firmly decided on the comparative approach, then all it is waiting for is what should these numbers be. If you don't publish the rule, in other words, if you don't do anything at the present time or sit back and wait, then that decision is not yet ---

MR. DIRCKS: And I think it allows the site selection and site characterization process to go forward.

COMMISSIONER GILINSKY: Well, but if you don't gave numbers, what the public knows or DOE knows is that there is a box and something is going to go in there between zero and infinity.

COMMISSIONER AHEARNE: But, Vic, we can't choose the final numbers no matter what we do. The final number, Congress at the moment says that final number is EPA's.

COMMISSIONER GILINSKY: We can put out a number which is subject to change or subject to modification upon receiving EPA's final number.

CHAIRMAN PALLADINO: What is the force of doing that, Vic?

COMMISSIONER GILINSKY: Well, it keeps things moving and it gives people guidance and the chances are on the basis of what we are hearing that it is probably going to be about right.

COMMISSIONER AHEARNE: John, let me ask you what would happen if we had something slightly different, if we put out our final rule as final and we took those two numbers and put them in a regulatory guide?

MR. DAVIS: Well, of course, that I am sure is an approach that certainly could be taken. It would of course, if the decision is made at a later point to change those numbers, make it procedurally less difficult to change. I think the downside of that would be again a question of Commission resolve as much as anything else.

COMMISSIONER AHEARNE: Except that these are the two numbers that you have pointed out in your proposal, at least several of them. Several of your options are ones that we are supposed to be saying that they aren't final.

MR. DAVIS: That is what we are saying now, right.

COMMISSIONER AHEARNE: So that it would appear to me that if you put them into a regulatory guide then that is I thought a clear statement that these are the numbers the staff believes are the right numbers to be used and in the absence of an EPA final number it would also seem to avoid the court challenge or the type of a challenge that we have recently been going through of how can we firm up a final answer in the absence EPA because we would not have firmed up the final answer, but if the final rule went out it would still have the multi-barrier concept, wouldn't it?

MR. DAVIS: Are you suggesting removing the numbers at any time from the final rule?

COMMISSIONER GILINSKY: When we have final numbers, I assume we could put them in the rule if we wanted to, but in the meantime to publish them but in a less formal manner.

COMMISSIONER AHEARNE: Yes.

CHAIRMAN PALLADINO: But I understand under your route you wouldn't even have to put them in a final rule.

MR. DIRCKS: Then you would lose the advantage on the litigation.

COMMISSIONER ASSELSTINE: That is right.

COMMISSIONER GILINSKY: It sounds like if they do not do everything you are suggesting plus publish a regulatory guide with a number.

MR. DIRCKS: John is saying keep them there temporarily until you firm them up and then put them back in the rule.

MR. DAVIS: That is not what I understood him to say.

COMMISSIONER AHEARNE: Once they are finally firmed up, but it looks like years if that is going to happen. This just cleans up to my mind that you have got a final rule and you have got a regulatory guide that says here is the way we traditionally treat regulatory guides.

CHAIRMAN PALLADINO: Then what would you do, have another final rule when you get the numbers?

COMMISSIONER AHEARNE: If we ever get the numbers.

CHAIRMAN PALLADINO: But I am assuming we will.

MR. DAVIS: Let me ask so I clearly understand this, Commissioner. Are you suggesting that we would go with option 1 or 2 and then have a regulatory guide?

COMMISSIONER AHEARNE: I would say option 1 except rather than saying they are reserved until the EPA standard, you could say up in the beginning, and depending upon your belief, you could say if or when an EPA standard final rule is published then final performance criteria can be put into this rule. You would publish a regulatory guide, however, that would say here are the ---

MR. DAVIS: Concurrent with this final rule.

COMMISSIONER AHEARNE: Yes.

COMMISSIONER GILINSKY: It seems to me you could achieve the same result by just putting in the numbers and labeling them as provisional and subject to change upon receipt of EPA's final ---

CHAIRMAN PALLADINO: But there is still this point though that if you wanted to go final and you wanted to include some of the material on unsaturated soils you would still have to get comments, would you not?

MR. DAVIS: On that particular aspect.

CHAIRMAN PALLADINO: So we wouldn't be final, at least for that exception ---

MR. DAVIS: Except for that particular aspect, it would be.

CHAIRMAN PALLADINO: It would be final except for that ---

MR. DAVIS: Except for that particular aspect.

CHAIRMAN PALLADINO: But could you call that a final rule?

COMMISSIONER ASSELSTINE: Except for that particular aspect.

(Laughter.)

CHAIRMAN PALLADINO: Would you say that in the rule then, that this is final except ---

MR. DAVIS: You would say it when you publish the final rule.

(Laughter.)

CHAIRMAN PALLADINO: No, I am following John's approach where you say this is the final rule right now and you would have identified except for this part and which you are asking comments for this part.

MR. DAVIS: Right. That is what we would do with regard to that saturated zone.

CHAIRMAN PALLADINO: So that portion would not be final.

MR. DAVIS: Right.

CHAIRMAN PALLADINO: The reason I was asking is if we are going out for comments on that we wouldn't be lengthening the period if we went out on option 2.

MR. DAVIS: If you went on option 2 we would answer to that regardless of what option we took.

CHAIRMAN PALLADINO: What would option 2 do for you?

MR. DAVIS: Option 2 would give us some advice and comment from the public on how this thing should proceed. Now it may be well if the Commission at this point wanted to go with Commissioner Ahearne's approach, that would be an another option.

CHAIRMAN PALLADINO: You are recommending option 2 if I recall.

MR. DAVIS: Right.

CHAIRMAN PALLADINO: And I think it is important for us to know why you recommend it and what you hope to get out of it as opposed to any other option.

MR. DAVIS: If they would put the rest of the rule in place as a final rule and remove whatever uncertainties may exist in that part of the rule, that would be firm.

COMMISSIONER AHEARNE: That is the same as option 1.

MR. DIRCKS: It has all the advantages in our eyes of option 1, plus it covers the extra base of making sure we have gotten public input into this decision. I think that is the only added advantage.

Now I think when you talk about, as the

discussion went here, of moving ahead with a final rule, which I think is essantially option 3 in a variation, although we discussed in our memorandum to the Commission the issue of the environmental impact statement, it was not discussed here today and you might want to hear from Guy Cunningham on that issue. If we move ahead with a final rule we do have some environmental impact statement considerations that should be kept in mind.

CHAIRMAN PALLADINO: I didn't follow that, Bill.

MR. CUNNINGHAM: The consideration is that the Commission did not prepare an environmental impact statement on this rule. That decision was made at the time of the proposed rule and the rationale was that there would be both an EIS done by the Department of Energy, its programmatic environmental impact statement, and there would be one from the EPA dealing with its standard and that those two would cover the entire area and that we could essentially adopt those conclusions.

The problem we have now of course is that one of those assumptions is false, that there is not presently an EPA EIS. I think its absence poses some litigative risk if we were to go ahead with a final rule now.

COMMISSIONER GILINSKY: Who is going to litigate it?

MR. CUNNINGHAM: It could be an environmentalist type group, NRDC or Sierra Club. If your answer is it is likely to be the Department of Energy, I doubt it.

MR. DIRCKS: Well, anyhow, we wanted to mention that in case you got on that track of ---

COMMISSIONER GILINSKY: I am on that track.

(Laughter.)

MR. DIRCKS: You are on that track.

CHAIRMAN PALLADINO: Which track?

MR. DIRCKS: I think publish the rule. On 3.

CHAIRMAN PALLADINO: Which you haven't gotten to yet.

MR. DIRCKS: No.

MR. DAVIS: Option 3 is to publish the rule as it now exists, and it does have existing numerical performance objectives in it.

COMMISSIONER GILINSKY: We would have to say that those are provisional and subject to change upon obtaining the EPA's final numbers.

MR. DIRCKS: Yes, and we would condition it on that it would be revised in case the EPA came out with numbers substantially different from their standard.

MR. DAVIS: Then options 4 and 5 is to go into limbo and wait until the EPA standard comes out.

(Laughter.)

MR. DAVIS: Then option 5 is to renotice the whole rule as it is now and perhaps get additional public comment. I think the primary point against that is most of the rule is not a matter of contention at all and we would urge that you move forward with at least finalizing those parts of the rule which are not in contention.

COMMISSIONER AHEARNE: John, could you explain to me why the following description of the difference between 1 and 2 is not correct. No. 2 is the same as No. 1 except it says for years we have been frustrated with trying to get EPA to act. The Congress has been frustrated with trying to get EPA to act. Option 2 says we are asking the public can you tell us how to get the EPA to act.

(Laughter.)

COMMISSIONER AHEARNE: This is a semi-facetious way of saying I didn't see what option was buying for you.

MR. DAVIS: It would highlight certain aspects of our current situation.

MR. DIRCKS: It is asking for a little help.

That completes our portion of the program.

MR. DAVIS: Again, what we came down for is some guidance so we can move along with putting it into final form.

CHAIRMAN PALLADINO: Let's see, under No. 1 you would issue the final rule highlighting that one little part of it that is not final and has to have some comment.

MR. DAVIS: Right, and we would subtract out the two numbers.

CHAIRMAN PALLADINO: Then you would also subtract the two numbers.

MR. DIRCKS: Yes.

MR. DAVIS: Right.

CHAIRMAN PALLADINO: But you would have to get some input on this unsaturated material.

MR. DAVIS: That is true in all options.

CHAIRMAN PALLADINO: Now I can understand that, but I am having trouble with understanding why you think No. 2 is an improvement over No. 1.

MR. DAVIS: Because we would get public input.

COMMISSIONER AHEARNE: I just described it.

(Laughter.)

CHAIRMAN PALLADINO: I understand your version. I want to hear his version.

(Laughter.)

MR. DAVIS: Because we would get public input into the Commission decision and hopefully develop a stronger position for their decision, whatever it may be.

MR. DIRCKS: I think it is just another signal and we talked about it. 1 and 2 are about equal and 2 says we just get a little more public input into whether this is the right course or not to take.

CHAIRMAN PALLADINO: But it wouldn't get public input on the substance of the rule.

MR. DIRCKS: That is right.

MR. DAVIS: Just on how to handle the EPA.

(Laughter.)

MR. DIRCKS: Comments may come back to go ahead with Option 3 and move ahead and finalize the thing and revise it later on.

COMMISSIONER ASSELSTINE: The public could well provide a rationale for what is the best approach to take.

MR. DIRCKS: Yes.

CHAIRMAN PALLADINO: Okay. Any further questions?

(No response.)

CHAIRMAN PALLADINO: Well, both 1 and 2 would permit DOE to proceed, except insofar as those numbers might apply.

MR. DAVIS: That is right.

COMMISSIONER AHEARNE: All of them would. The absence of a rule also allows DOE to proceed. The question is what kind of constraints are placed on that procedure.

COMMISSIONER ASSELSTINE: But 1 or 2 would principally affect the question of packaging and the design of the facility.

MR. DIRCKS: I think the ground water movement, I think that part would enable them to move along with a little more security in their site selection.

COMMISSIONER ASSELSTINE: That is right, but to the extent that exploration or investigative work on packaging form and the engineered aspects of the facility were intended to go along at the same time that site characterization work was going along, then that would be new uncertainty or continuing uncertainty in those areas.

CHAIRMAN PALLADINO: Do you have any reaction to Commissioner Ahearne's suggestion using, what is it, a NUREG?

COMMISSIONER AHEARNE: A reg. guide.

MR. DAVIS: Was the suggestion to combine that with No. 2 or No. 1 or No. 3?

COMMISSIONER AHEARNE: No. 1.

MR. DAVIS: No. 1?

COMMISSIONER AHEARNE: Yes.

MR. DAVIS: Well, the only thing you would give up in it is of course the Commission would give up the opportunity to have public comment on proposals. Now let me make certain I understand it, Commissioner Ahearne. You are saying No. 1 as it is written with subtraction of the two numbers, the placement of those two numbers in a reg. guide which would be published simultaneously with the rule?

COMMISSIONER AHEARNE: Yes.

MR. DAVIS: I don't see anything wrong with that. I can think of nothing right now to argue against that.

MR. DIRCKS: I think it is consistent with 1, but it gives a little more guidance.

CHAIRMAN PALLADINO: Any other questions of the Commissioners?

(No response.)

CHAIRMAN PALLADINO: Okay, thank you.

(At this point in the proceedings Ms. Comella and Messrs. Cunningham, Dircks, Davis and Bell left the Commissioners' table and Messrs. Hewett, Coffman, Brewer and DeJu joined the Commissioners at the table.)

COMMISSIONER ASSELSTINE: John, it does strike me that that is a somewhat unusual use of a reg. guide because it is not the normal situation where you are saying this is one approach to satisfying the requirements of the regulation that the staff finds acceptable. This would be an area where we are taking the requirements out of the regulation altogether.

COMMISSIONER AHEARNE: Except that we would be having barriers. The regulation talks about barriers.

COMMISSIONER ASSELSTINE: Yes, that is true.

COMMISSIONER AHEARNE: And of course what it is an attempt to get at is EPA eventually in theory will have some limit and this is now how. At that stage our regulations have to be constructed in such a way to make sure that limit is met.

COMMISSIONER ASSELSTINE: That is right.

CHAIRMAN PALLADINO: We are prepared to listen to DOE's comments.

MR. BREWER: Thank you, Mr. Chairman.

We are very grateful for the opportunity to appear before you this afternoon. I think you understand the urgency the President has propelled us with toward a swift, careful solution to the high-level waste management system.

I have with me Frank Coffman, who is the Deputy Assistant Secretary for Waste, Raul DeJu from Rockwell and Mr. Hewett from Battelle.

In general we strongly support the current version of 10 CFR 60. As you know, we do have some reservations about the quantitative guides placed on individual subsystems and it is about that central concern that we will brief you this afternoon on a very technical basis. I would like to have Mr. Coffman proceed with that at this time.

MR. COFFMAN: Thank you also for the opportunity to comment.

Before I get into the presentation let me say that the rule has gone through three rounds of comment and the specific area, Section 113, was called out specifically for comment the last time around.

Secondly, we fully agree with the combination of multi-barrier approaches, including engineered barriers and natural geologic barriers. The question is one of course of applying a general and ad hoc barrier and the impacts of that which I want to describe today.

Your staff today presented to the Commission options with respect to finalization of the technical criteria. The Department of Energy, which is the future applicant, does not believe that any of these options properly addresses the Department's concerns.

To do that we recommend that the Commission modify Sections 112 and 113 before publication perhaps using the results of a searching peer review if the Commission needs additional technical evaluation beyond that already available to them in our and other participants' comments.

Before elaborating on this recommendation let me affirm the Department of Energy's support for the Nuclear Regulatory Commission in the matter of 10 CFR 60. As the Department testified in the oversight hearing on nuclear waste programs before the House Interior Subcommittee, we saw the need for Commission involvement early in the Department's site exploration and characterization activities. I should note the effective ongoing interactions between the Department and the Commission's staff as evidenced by our last eight workshops at Hanford. The same might also be said for TMI.

(Slide presentation.)

MR. COFFMAN: If I could have the first viewgraph.

In addition, we do feel that the draft final rule as presented in the public meeting at Germantown on July 29th has many positive features which deserve publication. Without enumerating them in detail, the draft rule provides for public health and safety, it also supports an overall system performance objective upon which we have taken a strong supportive position and provides guidance in many key areas. Resolution of these key areas are a result of NRC staff work in response to the comments provided by the Department and other participants.

However, the Department continues to disagree with portions of 10 CFR 60 technical criteria as we discussed in our letters to the Commission of November 5th, 1981 and October 29th, 1982. The concerns center on the lack of technical justification for numerical subsystem requirements, the probable complications and delays in the licensing process that would occur in demonstrating compliance and the probable cost of developing components that would be required.

COMMISSIONER GILINSKY: You are not, I take it, objecting to a particular number, but to having the numbers there at all?

MR. COFFMAN: That is correct. We believe, if I can get ahead of myself, that we need a broad, flexible rule on which we can build a comprehensive set of standards and NUREGs. We do not believe that an ad hoc generic standard in the rule is the proper approach. If there was a NUREG guide on basalt issued in the future based on this rule, I would understand that and we would support that. The answer is we are not objecting to numeric engineered numbers. We are objecting to an ad hoc number which calls into fundamental question the licensability on a site specific basis.

CHAIRMAN PALLADINO: You used the word "ad hoc." Would not the future ones be ad hoc also? I don't know what you imply by ad hoc. Do you mean arbitrary?

MR. COFFMAN: By that I mean that when you license a repository there will be a series of systems, ground water travel time, absorption, solubility and engineered requirements as you have here which in consort must show that you are a small fraction of the EPA standard.

If you are in a media such as salt where we believe it might be impossible to demonstrate a waste package that we could ever afford to pay for, we might rely on other parameters or we might disavow that site.

COMMISSIONER GILINSKY: Well, I will tell you, you really want total flexibility in meeting the EPA standard. Is that a mischaracterization?

MR. COFFMAN: It is in that we would be

receptive to site specific reg. guides. In other words, if there was a reg. guide that talked to waste package life and engineering system performance, if you want to specify a subcomponent we would be receptive to that.

COMMISSIONER GILINSKY: But that could only after a site has been picked and you know the characteristics and then you started developing a reg. guide, but that is likely to come too late, don't you think?

COMMISSIONER ASSELSTINE: And even then it is not a requirement.

COMMISSIONER GILINSKY: Yes, and even then it is not a requirement. But in any case ---

MR. COFFMAN: We will come back to that. It is a valid point, but I would hope we could come back to it in future viewgraphs.

If I can skip forward, I am going to go to viewgraph No. 2.

The second viewgraph, please.

Our comments center on the content, as I said, of Section 112 and 113, that is specifically we feel that the requirement to meet generic levels of performance on site specific subsystems is inappropriate. We also believe that there is a significant degree of uncertainty and inconsistency in the two sections.

If I can have the next viewgraph.

In summary what we are recommending is that Section 113 be eliminated and that Section 112 be redrafted to emphasize systems analysis procedures and that consultation between the NRC and DOE staffs and other appropriate participants take place to resolve other concerns such as definitions, proofs of compliance and proposed reg. guides.

On the other hand, the Commission may feel that it is preferable to turn to a technically competent peer group for analysis of NRC staff's and our positions on these two issues. In that case we suggest that the Commission may wish to consider requesting the ACRS Subcommittee on Waste Management or the National Academy of Sciences to comment or appoint a Hearing Board. Either of these actions should be followed by specific recommendations, including a draft of the final rule to the Commission by the peer group or Hearing Board.

COMMISSIONER GILINSKY: Isn't this all going to set the program back I would think at least a year and perhaps more?

MR. COFFMAN: Our understanding until a week ago was that neither of those paragraphs were in the final version and we had deeply hoped that this rule would be going to final without further comment in two weeks.

COMMISSIONER AHEARNE: And neither with 60.113 or 60.112?

MR. COFFMAN: The new paragraphs in Section 113.

COMMISSIONER ROBERTS: Say that again, as of two weeks ago you what?

MR. COFFMAN: Our understanding was as of two weeks ago that these two paragraphs were being considered for deletion in response to the comments from the National Academy of Sciences and the ACRS, the EPA and other commentars, including ourselves. Then we learned of this option meeting and found that, indeed, that was not the case which is why we requested the opportunity to brief you directly.

COMMISSIONER GILINSKY: Let me ask you, does this material you are presenting contain new data or new arguments or is this sort of a reformulation of arguments and data you have presented before?

MR. COFFMAN: It is a reformulation of the arguments in the November letter and again as late as our October letter.

COMMISSIONER GILINSKY: But both letters come after the comment period. Did those letters, do you feel, contain new material?

MR. COFFMAN: I don't believe they do. We have material here by example which shows what the positions taken mean, but in terms of the position they are essentially identical.

COMMISSIONER AHEARNE: Specifically, Frank, you mentioned the two paragraphs. These were the two with respect to the numerical criteria for the barrier package?

MR. COFFMAN: The package and the ten to the minus five ---

COMMISSIONER AHEARNE: Now you also say there is an inconsistency between 112 and 113.

MR. COFFMAN: Section 112 basically supports the need to perform a systems approach to licensing the repository where you identify all of the barriers in sequence and assign to them what you think is licensable and defensible barrier characteristics and those would be assembled and provided as a package for licensing.

What Section 113 does is it says independent of whether it is Hanford basalt where you have ground water or whether it basalt where there is no ground water flow and where you probably don't need a thousand year package at all. Independent of all those you have to meet these criteria and if you don't meet them then both the Department and the Commission must entertain an exception to a design objective in the rule. That is where the fundamental difficulty arises.

MR. BREWER: Section 113, Commissioner, effectively eliminates the degrees of freedom that the Department would have. For example, to give a very simple, crude example, a thousand year package should be compared, for example, to the ground water transport time in basalt, which I believe is some 30,000 years. So the 1,000 year package would just make it 31,000 rather than 30,000.

COMMISSIONER GILINSKY: If you have complete confidence in both of them.

MR. COFFMAN: Yes.

MR. BREWER: Yes.

CHAIRMAN PALLADINO: What does 112 have that you want to modify?

MR. COFFMAN: Do you want to comment on that?

MR. HEWETT: The basic disagreement we have with 112 is the last sentence which stipulates that we have to assume the repository would be saturated with water. In the case of a salt repository, one chooses a salt repository because of an absence of water and the staff has preassumed without basis that the repository would fill with water, which is contrary to what our studies show.

MR. COFFMAN: Likewise with tuff.

COMMISSIONER GILINSKY: Could I ask you where you got the impression that these were going to be dropped?

MR. COFFMAN: Well we, as a result of the July 29th meeting where we were briefed on that, we had a series of discussions ---

COMMISSIONER GILINSKY: This was what meeting?

MR. COFFMAN: This was a public meeting that Jack Martin had to describe the rationale document which is the new document. In those series of discussions we came to the understanding that those paragraphs were probably going to be deleted.

COMMISSIONER GILINSKY: From Jack Martin?

MR. COFFMAN: Yes.

CHAIRMAN PALLADINO: What is that last sentence? Do you have the version of the sentence that you want to get rid of?

MR. HEWETT: I don't have the draft with me.

CHAIRMAN PALLADINO: I have a draft here that is a comparative draft.

MR. HEWETT: Is this the one with lines through it?

CHAIRMAN PALLADINO: Yes.

MR. HEWETT: In that particular draft they moved the sentence to 113. If we had that draft we could narrow our comments to 113.

MR. COFFMAN: In two viewgraphs down the road I would like to show some examples of how engineered and natural barriers interact to show compliance with the EPA standard.

If I could summarize briefly, the two fundamental differences between NRC and DOE is summarized in these two points. Our interpretation of the staff position is that they believe that man can build a respository with less uncertainty in its performance by depending on engineered systems rather than relying on the performance of natural barriers.

COMMISSIONER ASSELSTINE: Let me stop you right there, Frank. Is it rather than or in addition to?

MR. COFFMAN: Well, it provides a rule and standard which has its focus on engineered system. Whereas the bulk of the retardation, the factor of ten to the eighth that you need in retardation comes basically from natural barriers that you get from picking the site.

COMMISSIONER GILINSKY: Well, it is fair to say it weights things in the direction of engineered systems.

MR. COFFMAN: Yes, that is correct.

COMMISSIONER ASSELSTINE: But it has an additional degree of providing assurance.

MR. COFFMAN: And that is the point I hope to show in the next viewgraph.

CHAIRMAN PALLADINO: I don't follow that. I thought part of the issue in packaging was to keep it intact during a period when the heating and therefore the temperature reached a peak and get it over that peak so then you can rely on the natural geologic situation. The reason they picked a thousand years was because it peaked somewhere maybe as late as 500 years and you just added some for assurance.

So I am not sure that is a true statement that they think they can build something. Well, it depends on how you want to describe it. I was trying to follow it as you were paraphrasing it and I see it is stated differently here. It says "The dependence upon engineered systems rather than a natural barrier system will result in a repository with less uncertainty in its overall performance." Now the way you say it here I would say that is true. Now tell me why it isn't.

MR. COFFMAN: The point of fact is that the issue at heart is the presence of radioactivity in the accessible environment. That is the slant of the EPA standard and the systems approach is what they use to derive it.

As I will show on future viewgraphs, the presence or absence of either the waste form requirement or the package requirement makes a negligible impact on that standard and that result which is what you are there to meet.

Now, indeed, you can focus on a sort of generic argument that there will be a thermal plume there for the first 200 years and would it not be nice to have it canned during that time.

CHAIRMAN PALLADINO: I understood from the staff it was necessary to keep the leaching rate down.

MR. COFFMAN: Maybe then I should skip this viewgrah and go to the next one.

CHAIRMAN PALLADINO: No, I am just trying to understand. I am not unwilling to accept your point of view.

MR. HEWETT: I think the point should be made that it may be necessary, but that is highly site specific. In certain sites, in hard rock sites where you have water that goes through the rock at a low rate, leaching could occur there fairly soon. In a salt site there isn't any ground water flowing through and you have excellent containment provided by the salt itself.

COMMISSIONER GILINSKY: Does this pose problems for sites other than salt? I mean you keep returning to salt and I wonder whether that is the problem?

MR. HEWETT: That is because there is a great difference between a salt site and a hard rock site because the salt is plastic and flows and it is free from ground water.

COMMISSIONER GILINSKY: Is that where the principal problems lie with the application of this rule?

MR. HEWETT: That is why we would prefer to see a guide issued for a particular medium. If you are going to have a guide with numbers, there should be a guide for salt and a guide for basalt.

COMMISSIONER ASSELSTINE: Are you saying basically that you recognize that there is a need for these kinds of requirements for sites other than salt, but you are not prepared to recognize that there is a need for these kinds of requirements for salt since you don't expect them?

MR. COFFMAN: I think that what we are trying to say is that we acknowledge that we would want to take some credit for waste form and package life depending upon the site. If you have a site where the water is flowing fast through it and you are up against a thousand year ground water travel time, you are probably going to want an elaborate package.

On the other hand, if you have got a site where the ground water travel time is zero, then there is no mechanism to mobilize that waste for the first thousand years. So why do you have a can to mobilize a waste that is not moving. It is that kind of systems tradeoff that we would like to have.

COMMISSIONER GILINSKY: Well, isn't there in here implicit the notion that you may have made a mistake about the geologic setting and you may have taken a number of measurements and concluded something about the water travel time but you may have missed something else?

CHAIRMAN PALLADINO: Or something happens that changes it.

COMMISSIONER GILINSKY: It is really that drives one in the direction of something that you can design and test.

MR. HEWETT: But it can't change that much. There are too many natural barriers in there.

COMMISSIONER GILINSKY: I guess it is a matter of opinion.

MR. COFFMAN: Of all of the models that we have put together we have been unable to model a situation with zero package and in zero waste form we would exceed the EPA standard. The next viewgraph starts getting at the reasons why. If we could take just ten more minutes and then come back. Your points are important, but I also want to make a couple of technical points.

If I could have the next viewgraph.

The EPA standard is a 10,000 year standard. The first point I want to make is the predominant importance of ground water travel time. We are going to pick sites that have ground water travel times of tens of thousands of years. The net result of that will be that by the time any radioactivity which is leached gets to the site boundary or to the accessible environment it will have decayed for 35 to 100 thousand years and the only residual nuclide will be Iodine 129 which a half life of 16 million years.

COMMISSIONER AHEARNE: Frank, your assumption here is that everything starts when you first ---

MR. HEWETT: Immediately.

MR. COFFMAN: Immediately, and that is exactly the point. A thousand year waste package will change that 35,000 year number by 1,000 years.

COMMISSIONER GILINSKY: Assuming you have got those numbers right and you haven't made any mistakes.

MR. COFFMAN: We have a viewgraph for that one as well.

(Laughter.)

COMMISSIONER AHEARNE: These are generic materials? The general site, for example, the tuff site would have this range of characteristics?

MR. COFFMAN: Yes.

MR. HEWETT: These are actual sites. These aren't generic.

MR. COFFMAN: These are our three sites.

MR. DeJU: There are actual data to support each of these measurements.

COMMISSIONER AHEARNE: The basalt is Hanford?

MR. COFFMAN: Yes.

MR. DeJU: The basalt is Hanford and that is a composite of over 200 measurements.

COMMISSIONER ASSELSTINE: Which are the two salt sites?

MR. DeJU: The Paradox Basin in Utah and the Permian Basin in Texas and there are on the order of a hundred measurements for each of them.

COMMISSIONER AHEARNE: And the tuff is the bottom?

MR. DeJU: Right.

MR. COFFMAN: May I have the next viewgraph, please.

Now hopefully this will give you a feeling of the importance of engineered systems relative to natural geologic systems. On the left you see the draft EPA limit. If you assume a site with a thousand year ground water travel time, a thousand year waste package and a ten to the minus five leach rate and ignore the natural absorption and the natural solubility, which is an absorptive assumption, but if you only rely on your engineered systems, within about 3,000 years you will exceed the EPA standard by a factor of three or four thousand and it will for thousands of years into the future.

CHAIRMAN PALLADINO: Where do I see that?

MR. COFFMAN: This red curve going up right here.

CHAIRMAN PALLADINO: Now what is it that this curve is telling me?

COMMISSIONER ASSELSTINE: That is only if you rely on engineered barriers, right?

MR. COFFMAN: Right.

MR. HEWETT: What we did was use exactly what the staff asked for, you know, 60.113. We said if we meet those requirements this will be the result and we assumed a hypothetical site exactly as the staff did in their rationale.

MR. COFFMAN: This is a rationale document assumption.

MR. DeJU: That ignores absorption and solubility.

MR. COFFMAN: Right.

If I can go to the extreme right-hand side, I took as an example and it is even better for salt, but if I take the Hanford site and I take the ground water travel time, absorption, solubility and natural decay with zero waste package and zero waste form, I will be at 11 percent of the EPA standard after 35,000 years.

Now if I put in addition to that, and this is your question, Jim, if I put a thousand year waste package and ten to the minus five leach rate, I would reduce at Hanford for this conservative, realistic case my exposure to man from about 11 percent of the standard to about 7 percent of the standard.

Now that would occur 1,000 years later because it had a waste package. This is for all time. This is not for 10,000 years. This is exposure to mankind for all time and it would be 11 percent of the standard. That incremental that I would buy with the waste package represents 40 health effects in basalt for all mankind for all time.

COMMISSIONER ROBERTS: Have you made this presentation to the NRC staff?

MR. COFFMAN: This one I have not. We have made the arguments in more detail but not this briefing.

COMMISSIONER AHEARNE: Frank, on your left-hand side the difference between that and the right-hand side, and you have the natural barriers on the right-hand side ---

MR. COFFMAN: That is correct.

COMMISSIONER AHEARNE: ---you did include absorption ---

MR. DeJU: Absorption and there is some solubility constraints for basalt.

COMMISSIONER AHEARNE: And decay?

MR. DeJU: That is right, and that is 99 percent of Iodine 129.

MR. COFFMAN: That is another point, that after 35,000 years for any of these sites the isotope which gives you dose is 99 percent Iodine 129. It has a 16 million year half life. Unless you have a waste form that can do ten to the minus six or ten to the minus seven, the ultimate dose to mankind is identical. I don't know of any engineered system that can hold it back 16 million years nor do I think I care.

If I could have the next viewgraph.

CHAIRMAN PALLADINO: No, don't go too fast. You haven't brought me along yet.

MR. COFFMAN: Sorry.

CHAIRMAN PALLADINO: Is this only for Hanford basalt, this 11 to 7 percent?

MR. COFFMAN: Yes.

CHAIRMAN PALLADINO: What is for other situations?

MR. COFFMAN: It is better.

Can I have the viewgraph after this one.

COMMISSIONER GILINSKY: May I ask you why have you not take this up with our staff?

MR. COFFMAN: We have. This discussion has been going on for three years.

COMMISSIONER GILINSKY: But I thought your response to ---

MR. HEWETT: We haven't shown them this presentation.

MR. COFFMAN: I haven't shown them this set of viewgraphs.

MR. DeJU: Commissioner Gilinsky, at the workshops that we had at Hanford with the staff we discussed in much more detail the subject that we are talking about here in terms of waste package life and what it represents and performance for a repository in basalt.

MR. COFFMAN: Mr. Chairman, you asked the question what about salt.

CHAIRMAN PALLADINO: And what about the others, the tuff and what-not, are they better than this 11 to 7?

MR. COFFMAN: Yes. This is salt. If you read the middle headline, for embedded salt we predict for all models zero release of the radioactivity from that embedded salt for all time.

COMMISSIONER AHEARNE: That is because there is no ground water.

MR. COFFMAN: That is because there is no ground water. So the number is zero for salt.

CHAIRMAN PALLADINO: This assumes that what has been will stay and you will have no ground water and it will be stable.

MR. COFFMAN: Yes. Then the question comes of intrusion. Here we have modeled an eight-inch bore hole drilling within 20 feet of a waste package going through the above aquifer, through the repository and into the bottom adquifar, which is the direction that water would move because of hydrologic head.

What would happen there is we assumed the worst case that the salt would not extrude the thing off within a thousand years, the models show about 200, and that there would be some leaching out. The net result of that would be that some 50,000 years after that hole was bored, which would be the year after you close the repository, that 50,000 years later there would be a blip in the accessible environment 10 miles away which could represent 5/10,000ths of the EPA standard under an intrusion with a drill hole.

MR. DeJU: That is about a half a health effect.

MR. COFFMAN: And it is one-half of one health effect.

MR. BREWER: Over all time.

MR. COFFMAN: We cannot see any impact of waste form or waste package on that number. It is all Iodine 129.

COMMISSIONER AHEARNE: Correct me if I am wrong, but I doubt whether the staff would have said we agree that there is no water flowthrough and never any chance but we still believe there could be a significant health effect. That is not their position I would imagine. It is a good argument, but it is not clear to me it is addressing their argument. I recognize this is the DOE argument and we have to judge which side ---

MR. COFFMAN: If I can back up one viewgraph.

CHAIRMAN PALLADINO: Why is it that you didn't convince the staff or what is it that they are holding on to that you are not recognizing?

MR. HEWETT: The dialogue with the staff was always directed at us asking them the basis for the numbers and for a very long time no basis ever appeared. Then we started to hear about what some of the bases were. As a matter of fact, in the case of the waste package even the staff's contractors didn't agree with it. There was a paper given this year by the Sandia contractor that showed that you didn't need a waste package as long as you had 500 years ground water travel. We never really tried to provide a technical basis for the staff. We came to the staff to find out what their basis was and we finally saw what they were using in the rationale document and on that basis they don't look at anything beyond 10,000 years.

Well, you can use that argument and show that we need nothing because all of the ground water travel time is far in excess of 10,000 years. So if we use their basis that would knock down all those numbers.

COMMISSIONER AHEARNE: Would it be correct just for argument purposes that then you would be satisfied with a licensing criteria that would say that it can only be located in a location where the ground water travel time can be proven to be at least 35,000 years?

MR. HEWETT: I don't believe it is necessary to be that strict.

CHAIRMAN PALLADINO: How strict would you feel it necessary to be?

MR. COFFMAN: I think that is the whole point of the EPA's standard making and the systems approach to it. The objective is not to pick a number which is close to the best that anybody can meet. The objective is to pick a series of subcomponents, engineered and natural, at a specific site which guarantees that the public health and safety is protected, and it is that systems approach that is getting lost in a discussion about an ad hoc package lifetime.

COMMISSIONER GILINSKY: But suppose we follow up this point about the travel time, would you then propose to put the waste away without any package or any facility, and then why not if it meets the ---

MR. COFFMAN: As a matter of fact, and I understand that question, the package discussions and the waste form discussions came up when we talked about shipping the waste from a reprocessing plant to the repository and everyone agreed that you cannot ship liquid high-level waste. So we got into discussions of calcines and then we got into borasilica glass and the Department is selecting borasilica glass as a waste form for shipping and it has to be put into a can and put in the repository. I think it is important that during the repository operation and during shipment that it is safe from the environment.

COMMISSIONER GILINSKY: So this is a transportation casket.

MR. COFFMAN: I think technically in terms of the public health and safety the concerns are during transportation and during the period when the repository is open.

COMMISSIONER GILINSKY: Do you see any need to put standards on the repository itself given that the water travel time would meet the EPA 10,000 year requirement?

MR. HEWETT: Well, we think that you should look on a site specific basis to see if there are engineering enhancements that can help.

COMMISSIONER GILINSKY: But if you have a site where the water travel time is well over 10,000 years ---

MR. COFFMAN: Independent of that, the place where you can have potential water in leakage and you may want to recover or whatever, I think you have to have a package in a stable waste form during the 50 to

100 years that the facility is operational and that provides I think the kind of assurance ---

COMMISSIONER GILINSKY: So those are the kinds of times you are thinking about?

MR. COFFMAN: Yes.

COMMISSIONER GILINSKY: Let me ask you one more question. You mentioned the output of a reprocessing plant. What is it that you see going to a repository and ---

CHAIRMAN PALLADINO: In what form? Are you thinking of just pouring water down there?

MR. COFFMAN: The defense waste treatment facility is selecting borasilica glass in a steel can which has a lifetime probably of two to three hundred years in borasilica glass. We at West Valley are proceeding with a waste form which we are staffing to be borasilica glass in a steel can which is a two or three hundred year waste package.

COMMISSIONER GILINSKY: When are those going to be available?

MR. COFFMAN: You mean the waste?

COMMISSIONER GILINSKY: Yes.

MR. COFFMAN: In about 1990 for DWPF and in about 1992, '91 or '92 for West Valley.

COMMISSIONER GILINSKY: DWPF is what?

MR. BREWER: The DWTF if the proposed Defense Waste Solidification Plant at Savannah River to work off the tanked waste, liquid waste.

COMMISSIONER GILINSKY: And what do you see happening with the commercial fuel?

MR. COFFMAN: I would hope that there is some institutional mechanism found by which a commercial venture at Barnwell will proceed by 1990. If not, then other ---

MR. BREWER: We are making our repository designs in planning to be satisfactory for either spent fuel or solidified high-level reprocessed waste.

COMMISSIONER GILINSKY: It wouldn't then be sensitive to that choice?

MR. BREWER: No, sir.

CHAIRMAN PALLADINO: Frank, you are talking about borasilica glass in a steel liner and you say it is 200 years. Why do you say 200 years, because you made the liner thin and it is going to corrode or there is going to be interaction between it and something else? What more do you have to do to go to a thousand years, for example? To me now you just admitted that we are not talking about whether we should package it or not, but we are talking about the price of the packing, so to speak. So it isn't whether you package or not.

It is that you want to package and do you want it to last for 200 years or 1,000. That is the where you have led me to right now.

MR. COFFMAN: I am talking about the site specific aspects of it. I am thinking about getting a license is what I am really thinking about. If I have to come to you and get a license and I have got a stainless steel package in salt and the standard says that you have to assume that it is saturated with ground water, then the corrosivity of salt makes it extremely difficult for me to show you based on 10 years of engineering data that this thing will last with "reasonable assurance" for a thousand years.

CHAIRMAN PALLADINO: So you are saying that the price or the degree of difficulty should be related to the site?

MR. COFFMAN: I think it will be, yes.

CHAIRMAN PALLADINO: Those are the major points I am getting out of the discussion so far.

MR. BREWER: Mr. Chairman, if I could explain it another way. There are sort of four degrees of freedom that the waste form, be it borasilica glass or whatever, the liner and its design and thickness and material, and the geology, that is the water transport time, et cetera, and the fourth is economics. The way the rule now reads that we are oppossed to is that three of those four degrees of freedom are nailed down. We are overconstrained. So that we cannot optimize the repository, the entire system.

CHAIRMAN PALLADINO: There is one other argument that I think has to be addressed. One might say well here is a packaging form I am going to use for this particular material salt. You say great and we package it and all of the sudden for some reason you can't put it there and you have to go put it in another place where the characteristics are different. I thought part of the staff philosophy was let's make it good enough so you don't have to worry about whether it is site specific.

MR. HEWETT: But you probably would change the package in going from a site of salt.

CHAIRMAN PALLADINO: If you make it so it meets the requirements for any of your sites, then you don't into that problem that you package it for one and now it is no good for the other.

MR. DeJU: Mr. Chairman, the problem that you have with that option, and the Department looked at that option earlier, is that when you have a generic waste package you have a very expensive waste package. You have overdesigned the waste package in order to be generic.

CHAIRMAN PALLADINO: Oh, sure, if you are going to make it adaptable to every site.

MR. DeJU: In terms of optimizing the waste package design, it is more important to go to a site specific ---

COMMISSIONER GILINSKY: What sort of differences are you talking about?

MR. DeJU: Well, you are talking some sizeable, in the millions of dollars or hundreds of millions of dollars to billions of dollars difference.

COMMISSIONER GILINSKY: Well, per package what is the difference that you are talking about?

MR. DeJU: The various waste package costs range from $10,000-plus a package to hundreds of thousands of dollars a package. It depends upon whether you put a titanium overpack or whether you don't have an overpack or what how much metal you are going to bury in a repository.

COMMISSIONER AHEARNE: You are saying that you already have a fairly good sense of what type of design would be required to the level of detail to enable you to do a cost estimate?

MR. DeJU: There are conceptual designs and preliminary designs for the various sites that have incorporated some cost estimating.

MR. COFFMAN: Ralph, can I back up one viewgraph.

COMMISSIONER ASSELSTINE: Let me go back to one quick point you made, Frank, earlier just a few minutes ago. Were you saying that for salt it may not only be an economic problem, but it may be a technical feasibility problem?

MR. COFFMAN: I am sorry.

COMMISSIONER ASSELSTINE: Were you saying that for salt it may not only be an economic problem, but that it also may be a technical feasibility problem in being able because of the corrosiveness to design a cask that would satisfy the numerical requirement for the container?

MR. COFFMAN: That is right.

CHAIRMAN PALLADINO: I don't follow that one because then if you are going to put anything in salt, then you are going to have corrosion problems and you have got to make it thicker.

COMMISSIONER ASSELSTINE: That is the assumption that it is full of water, right?

MR. COFFMAN: That is part of it, yes.

CHAIRMAN PALLADINO: Well, you are going on the basis that things are as they have been, and I am not sure that is what we ---

MR. COFFMAN: And that there are intrusions.

COMMISSIONER AHEARNE: I think as you put it there, Joe, I would guess that is one of the fundamental differences between the staff approach and the DOE's position.

COMMISSIONER GILINSKY: Let me ask you something as a general question, you are troubled by having to come back on a case-by-case basis for an exemption for some particular either package requirement or repository requirement, but yet you are asking for an approach that would have us treat the whole question on a case-by-case basis and somehow you feel it is going to be easier for you that way. It would be harder to do it on one little piece of the license.

MR. BREWER: In the first case, Commissioner, it would be of the nature of applying for an exemption of an existing quantitative rule, and that has less appetite ---

COMMISSIONER GILINSKY: You just got an exemption from the rule.

MR. BREWER: We have less appetite for that than asking for ad hoc repository-by-repository rulemaking.

COMMISSIONER GILINSKY: Well, I think it may be unfamiliarity with our system that leads you to think that one is simpler than the other.

(Laughter.)

MR. BREWER: Well, one has public optics which are not there in the other.

MR. COFFMAN: Here is an example of another approach at this. If we apply for a license the first thing that we are going to go for and make an argument to you on is the ground water travel time. This is Hanford basalt. You see that by getting credit for the ground water travel time and the natural decay of radioactivity before it leaves the site we drop this by a factor of ten to the third.

CHAIRMAN PALLADINO: Could you explain what is on here. I am sorry, that is where I lose you.

MR. COFFMAN: The first hatched bar is the repository inventory in curies, and if that were released over a 10,000 year period you would be at about a million times the EPA curie limit.

CHAIRMAN PALLADINO: If released over what period of time?

MR. COFFMAN: About 10,000 years, which is the period the standard applies. If you take all the curies of the repository and release them over 10,000 years you would exceed the EPA standard by a million.

COMMISSIONER AHEARNE: By released you mean ---

MR. HEWETT: Without any credit for decay.

MR. COFFMAN: You release it to the accessible environment.

Then if you on the other hand take the entire inventory and release it, and a complete solubility, no absorption and let it transport through ground water, it will naturally decay down to about a thousand times. So 35,000 years from now you would exceed the EPA standard by about a factor of a thousand.

CHAIRMAN PALLADINO: And that is because of the 35,000 year ground water travel time?

MR. COFFMAN: Exactly, the ground water travel time and the natural decay.

CHAIRMAN PALLADINO: You seem to have as an assumption all the way along the 35,000 year travel time.

MR. DeJU: 35,000 is a very conservative number for Hanford and it is a result of a lot of work that has gone on there and it is the same number that is reported in the site characterization report that has gone to the Commission.

MR. COFFMAN: Then if you assume that while it is being transported along that there are realistic solubility limits on nuclides, you get down and meet the EPA standard. Then if you assume the absorptivity limits that are in Hanford basalt, you drop down to about 11 percent of the EPA limit. Then if you put on a thousand year waste package there is no change. This is for Hanford basalt.

CHAIRMAN PALLADINO: Wait a minute, why is there no change?

MR. COFFMAN: Because, one, it takes it 35,000 years to get there, it is delayed for 1,000 years, but the curies are of Iodine 129, which is so long half lifed that the dose to man over all time is identical.

COMMISSIONER AHEARNE: What you really mean is that there is no visible change in this scale.

CHAIRMAN PALLADINO: What did you do with the red there, you just put it in the package?

MR. COFFMAN: Then I assumed that the package was added in.

CHAIRMAN PALLADINO: And then what did you assume?

MR. COFFMAN: In the last one I assumed that I had to meet a ten to the minus five ---

CHAIRMAN PALLADINO: You added the package into what?

MR. HEWETT: These accumulative effects of barriers.

MR. COFFMAN: To being with I assume the waste was in there and it was completely soluble and completely liquid and it could immediately go to ground water. Then I assumed that some of it had solubility limits as a liquid like cesium has a solubility limit. Then I assumed that Hanford basalt has K-effective absorption rates. Then lastly I assumed that it was bottled up in a thousand year can. That is the first red block which has no impact. Last of all I assumed not only that, but I had a ten to the minus five waste form.

COMMISSIONER AHEARNE: I assume what you mean is that you had someone go back and redo the calculations.

MR. COFFMAN: Exactly.

CHAIRMAN PALLADINO: I was going to ask you in the can, while it is spending a thousand years in the can you are not getting the absorption or you not getting the solubility.

MR. HEWETT: That is correct.

CHAIRMAN PALLADINO: So that is where I am having trouble understanding what you are talking about.

MR. HEWETT: We are just trying to find a way to show you the effect of adding barrier after barrier. The blue barrier is an natural and we showed those first because they are a part of the site and we really don't nave much choice there once we have chosen the site.

MR. COFFMAN: The red ones you have to buy and pay for and select. That is fine if they add in terms of health effects or dose to man.

CHAIRMAN PALLADINO: But you are going to put it in a package for some reason anyhow.

MR. COFFMAN: Right.

CHAIRMAN PALLADINO: And you are saying those reasons are? Why do you put it in a package at all?

MR. COFFMAN: To transport it to the repository and to keep it stable and retrievable for the first hundred years.

CHAIRMAN PALLADINO: And this applies to any particular site?

MR. COFFMAN: Any of them, yes.

COMMISSIONER AHEARNE: This particular chart is Hanford?

MR. COFFMAN: This one is Hanford.

MR. DeJU: By the way, that particular chart is very, very conservative in that it doesn't take credit for a lot of barriers and it assumes a very large flow rate through the repository. So a lot of those conservative assumptions have been taken into account.

MR. COFFMAN: Ralph, if I can proceed through two viewgraphs.

CHAIRMAN PALLADINO: Just one more question and then I won't bother you any more for a while. In all these processes you must be making some assumption about temperatures and how those temperatures influence interaction. If you don't have it packaged as opposed to having it packaged, don't you change these rates considerably?

MR. HEWETT: It is all lost in the ground water travel. We assumed in the case of this Hanford example that the waste was released immediately over a one-year period. We looked at it over a ten year period and over a hundred year period and over a thousand year period and it didn't make any difference at all in the release.

MR. COFFMAN: The real reason is because if it is sitting here and you dump it in, the ground water travel time is about an inch a year. Now, you know, during the first five inches or five years all the cobalt decays. During the next 30 inches all the cesium and strontium is decaying. The point is that by the time you get to any accessible environment everything has decayed except Iodine 129. Iodine 129 has a 16 million half life and the waste form is not going to have any impact on that.

CHAIRMAN PALLADINO: See, but I picture things having cracks and not everything goes exactly the way you say.

MR. HEWETT: These numbers are very conservative, as Raul indicated in our estimation.

CHAIRMAN PALLADINO: Well, okay. Why don't you go on.

MR. COFFMAN: This is another approach just to show what we are talking about when we say there are natural defense in depth barriers. You have the vertical separation from aquifers, you have low host rock permeability, you have the question of solubility, you have the question of gound water travel times, you can pick media which are absorptive and of course if you have an acquifer which is penetrated you have the dilution potential there in that situation.

So not only are we supportive of engineered barriers which are specified on a site specific basis, but there is defense in depth through these systems which have been stable for geologic time.

If I can have the next view graph.

This is the time to get at Jim's question. We will have about five or ten years of data base when you give us our construction authorization and we have to make a reassonable extrapolation for a thousand year waste package as a result of this rule.

At the time we seal it up, which is 40 or 50 years after we have our construction authorization, we will have 50 years of data assuming we have run an aggressive R&D program. Even then there are questions about whether you can make reasonable assurance arguments under the current licensing environment that this number can be met. In lieu of making that argument we have to come back on an exception basis so that both the Commission and the Department has to make the arguments about why this thousand year number is accepted.

If I can have the next viewgraph.

This shows you the kind of time extrapolation arguments that we have to make for natural barriers. We are trying to pick sites which have been completely stable over the quaternary period which is the last million years approximately.

We are trying to extrapolate that data for the EPA standard of 10,000. We believe that convincing arguments can be made that ground water travel times, basic rock solubilities, basic rock absorptivities, those quantities and those arguments can be made convincingly before a licensing committee.

I don't think that the same is true in a near-field environment where you have a three or four hundred year waste package which is varying with time, where you have ground water intrusion at temperatures comparable to the heat exchanger environments and where you have a changing environment.

To make that argument and to model that in the near field is much more difficult than making a licensing argument in the far field where you are saying that ground water has traveled at this speed for the last hundred thousand years and we are reasonably convinced it will continue along at that speed for another 10,000 years.

COMMISSIONER AHEARNE: Frank, is it correct that your argument, and let me characterize it and see if you disagree. I had thought originally when you first started speaking that you were talking about the systems approach which the IRG had talked a lot about. My sense is that that is really not what you are advocating. What you are really advocating is site protection rather than the system, but it is really the specific chacteristics of the specific site because as far as I can tell your argument really is being based upon the properties of that site, either the absence of water such as salt or the very slow water travel time. Is that correct?

MR. COFFMAN: That is partially correct, yes.

All the way back to the 1957 National Academy of Sciences there was a basic push that man cannot design an engineered system to store his waste into the indefinite future. The only thing that is stable for geologic time is stable geology. So the whole purpose of a national screening and siting program is to find a site which has a set of natural features and characteristics that will protect mankind for all time.

Now we want to get a license for that and we want to protect during the operational phases. That is where the package and waste form question creeped in. Now we agree that there should be site specific waste package lifetime requirements and waste form requirements. That is not the problem. The problem is that they should be tailored to the specific sites ---

COMMISSIONER GILINSKY: But aren't you going to come in here and argue when you have got a site that you estimate to have a water travel time of say 35,000 years that you don't need a waste package and you don't need an engineered facility because you have made it?

MR. COFFMAN: The waste form and waste package will be required in part because of the retrievability requirement in the standard and because of the transportation laws. I can't ship liquid high-level waste on the highway.

COMMISSIONER GILINSKY: I understand and we talked about that.

CHAIRMAN PALLADINO: But that wouldn't be site specific. The transportation requirement wouldn't be different for one site from another.

COMMISSIONER GILINSKY: But as far as the site goes you are really laying it all on geology and the purpose of having requirements on the package and the facility and so on is to compensate for mistakes in analyzing the geology.

CHAIRMAN PALLADINO: At least in the first thousand years.

MR. COFFMAN: Let me say it one other way. What we are saying is that all the comments by competent others and ourselves have suggested that you should put in place a broad flexible rule and that as we gather physical data during the next two or three years that that should be supplemented with NUREGS or licensing guides as with the case with reactors which are tailored to the specific reality that we are going to be operating in and a thousand year waste package for salt poses a real technical and logical difficulty.

COMMISSIONER AHEARNE: As you may have gathered from my earlier comments in the previous section of the meeting, I am not in favor of putting that into the rule. So putting it in some separate document is tha way I was pushing. I am just trying to understand though. It really seems to me that at least your current thinking would, however, end up putting all of that protection on the geologic setting and the only thing I have to mull over, and I recognize your argument that we have all this past historical data, it nevertheless still is the argument that the uncertainly is sufficiently small that therefore one doesn't have to be concerned about the reliability of that estimate.

MR. HEWETT: Let me just bring out one point on that. All of the studies that have been done to date indicate that it isn't a matter of choice that we are saying put the reliance on the natural system. It is a matter of fact that with any reasonable natural system you simply can't design anything good enough to have much effect, and an example is this ten to the minus fifth.

COMMISSIONER AHEARNE: Of course and I wouldn't argue that. The reason that one looks at uncertainty and then says in tha regulatory world let me look at, say, a worst case is you ask yourself what if the predictions you are making fail. If your geological estimates are correct, they aren't going to argue with your case, well then this wasta form engineered barried just doesn't make any difference. That is absolutely true. The issue is what if because of some element of uncertainty you may be sufficiently far out on the fringe and you haven't looked at that. What if the estimate was completely wrong and it doesn't work that way?

MR. HEWETT: And that is why we chose numbers for this analysis that were way down on the conservative end of the range we have.

MR. COFFMAN: Let me give an example of the difficulty. Can I go four viewgraphs forward.

CHAIRMAN PALLADINO: You are ignoring this temperature problem during the early period of life. That is one of the major reasons I believe you have this engineered package so that you can cope with that and not somehow invalidate what is going to take place later on. That is one of the arguments I remember hearing.

MR. COFFMAN: Would you move forward four viewgraphs.

These are the kinds of problems we see coming into play. What is substantial containment and how do you prove it for a thousand years? Do all of the packages have to survive and, if not, how many are you talking about here? Can statistically significant thousand year accelerated tests be performed, radiation on the waste package, brine on package components, radiation on brine and package component interactions with each other which was raised as an issue with the DWPF waste form decision? Do the standards apply to worst case or to the average package? Where is the compliance boundaries for then to the minus five? How can licensing credit be determined for engineered system components, by long-term proof testing, long-term materials properties, the basis for intra-repository flow calculations, the basis for engineered component long-term radionuclide retention? For soluble host rocks like salt how can flow be shown to be affected by the engineered barriers? These are the kinds of ---

COMMISSIONER GILINSKY: But you can ask questions like that for your approach, too, which seems to me to be much mushier and more difficult to justify in a legal proceeding.

MR. COFFMAN: These arguments are made in the near field to meet a standard which is some cases is against the edge of what we think we might be able to meet in a dynamic thermal environment in the presence of high heat load and high radioactivity loads to meet an ad hoc number as opposed to meeting something in the ground water at the ambient temperature.

COMMISSIONER GILINSKY: Well, you are going to have to convince someone that the standard is met. This is a way of doing it. You raise these questions and they are good questions, but that is why the law has words like "reasonable assurance" and so on.

CHAIRMAN PALLADINO: I think we could sit down and agree to answer many of them.

Excuse me, I am sorry. Go ahead.

MR. COFFMAN: I have one viewgraph which summarizes I guess the issues all in one.

If I can have the slide A-1.

(Laughter.)

MR. COFFMAN: What we are saying here is that if those numbers go in, those two paragraphs go into this rule, then we have to do two things. To avoid a delay from not meeting the ad hoc number we have to run about a $40 or $50 million a year R&D program as an insurance that we are going to deliver this repository regardless.

Secondly, we have to come in with rather elaborate documentation of proof of compliance with an exception to that and both the Commission and the Department are going to have to deal with that as an exception and the public perception of requesting this exception is going to be that we requested something more relaxed and something less restrictive and it is going to create a lot of extra licensing issues.

COMMISSIONER GILINSKY: But what is the public perception of us relaxing entirely right now if you are going to talk about public perception?

MR. COFFMAN: The last time that this rule went out for comment the Commission explicitly requested that this section be commented on and the ACRS and the National Academy of Sciences, DOE and EPA recommended that you proceed toward a broad, flexible rule. That has been the comment for the last three years.

COMMISSIONER GILINSKY: I am not deciding this on the basis of public perception but on the basis of what I think is a reasonable rule. What I am suggesting to you is that the public perceptions may not be favorable to the approach that you are suggesting.

MR. HEWETT: I see one big difference and the big difference is that right now we are saying that the numbers in that regulation really don't buy you anything as far as the public health and safety is concerned. Now presumably if the Commission puts out the regulation with those numbers, the Commission has made a finding that those numbers do indeed buy you something for public health and safety and we would be coming in for an exemption against something which the Commission has found to be necessary. But right now that is still an open question we believe.

COMMISSIONER ASSELSTINE: On that point you have mentioned the comments from a number of other commenters. I looked at the comments from the Department of Interior and the Department of Interior seems to take just the opposite view from just your past statement, and that is that there is a significant advantage to redundancy among barriers during that initial period when short-lived fission products dominate the hazard and heat generation is greatest. I guess the Chairman raised that a little while ago and I would like you all to address that specifically because it does seem to me that one of the advantages to the staff's approach is that you get redundancy during that earlier period. It is not just a thousand years tacked on the end. It is a thousand years up front.

COMMISSIONER GILINSKY: You didn't include EPA in that group, did you?

MR. HEWETT: Yes, we did.

MR. COFFMAN: Yes.

COMMISSIONER GILINSKY: Their comment to us here seems to say the opposite and I suppose we will have an opportunity to find out.

MR. HEWETT: The comment to the regulation and what is in this presentation appear to be a bit different. But getting to the Department of the Interior, we met with them two weeks ago Wednesday to ask them about their comment. The reason for the comment was they were under the impression from talking with the staff that it was a very easy matter to have a thousand year package and to have a one in ten to the minus fifth release rate and that this was something you could buy off the shelf, and if you could do that, well then why not?

When we tried to explain some of the difficulties we saw, their reply was well, would you like us to send a letter in and clarify our comment.

COMMISSIONER GILINSKY: And?

MR. HEWETT: We suggested they wait until after this meeting.

(Laughter.)

COMMISSIONER ASSELSTINE: Well, I guess what you are saying is they see a substantial advantage in a redundancy of barriers, but if it is impossible to have a redundancy in barriers, then all right, they are willing to live with the situation without them.

MR. HEWETT: They weren't aware that we thought that that would muddy the waters. They thought it would clear them up.

CHAIRMAN PALLADINO: If there is no water there you can't muddy it.

(Laughter.)

COMMISSIONER ASSELSTINE: I guess the other thing I saw in their comments in particular was a considerably greater degree of uncertainty in their minds about the performance of a geologic environment over substantial periods of time.

MR. HEWETT: And if you look at our ground water travel time for the permian basin, it could vary from a hundred thousand years to a million years and that is a lot, but it is still ten times more than you need for the EPA standard.

MR. DeJU: That is why you would use very conservative numbers in doing these calculations. There is of course some uncertainty in all those numbers, but the more experimentation we do the more reliability we are getting into that. But you have to remember that in order to ascertain the value of the engineered barriers you also have to get some side data and you have to get some side geochemistry which a lot of times is more difficult to get than the overall far-field data that you need for the overall side assessment.

MR. COFFMAN: Again, I think it is important to recognize when you talked about disagreements, I think it is important to recognize, one, that we support the promulgation of the rule and that it has many features to it from land ownership to QA, et cetera, and that we consider those desirable features and we consider that the staff activities on that have been very constructive and will be very helpful.

On this particular one we also agree on a multi-barrier approach using a combination of engineered and natural barriers. The disconnect comes from how that is done and we believe that specific inflexible numbers at this time could create licensing difficulties and time delays for both the Commission and the Department in seeking a license.

We do not object to subsequent regulatory guides as we get some at-depth data. To date nobody bigger than eight inches in diameter have been at depth at any of these sites. Regulatory guides which contain numerical or more specific guidance on the issue of engineered systems and definitions associated with them to avoid this other morass of things associated with broad definitions we would support and I think that is the option we would like to suggest to you.

COMMISSIONER GILINSKY: But what we are talking about are the guts of the rule. These numbers really are, whether you agree with them or not or whether they are right or not, that is really the core of the rule.

MR. COFFMAN: If that is the case, why does the rule not have a minimum absorption number or a minimum solubility number? Why does the rule not have specific numbers for all of the barriers in the natural system? In other words, two numbers were picked out that came from a history of shipping waste and got put into place and the comments have gone around those things for three years, but basically it has been ignored on the technical merits and that is our fundamental problem.

CHAIRMAN PALLADINO: Let me make proposal. We have been here two hours. I am going to suggest, if our guests can spare the time, I am going to suggest a ten-minute break and then we will have EPA and the A&S representatives speak, and I might want the staff to comment on some of the points you have made. I think it is worth our spending some time on it. I don't see us taking any vote today. I think we are still in the learning process.

COMMISSIONER ROBERTS: Mr. Chairman, I will not be here when you reconvene. I am going out of that. That does not indicate any lack of interest at all and I will familiarize myself of what the remaining speakers say.

CHAIRMAN PALLADINO: Okay, thank you.

COMMISSIONER ASSELSTINE: Just before we let the DOE people go let me ask just one question, if I could, on the EPA standard. Based upon your whole presentation it really comes through to me how critical the EPS standard is as an element. Virtually all the assumptions you have made so far are based upon having an EPA standard and having one along the lines of the draft that has been bottled up for so long.

Would you agree that it is just absolutely critical that we get that standard out as just as soon as possible?

MR. COFFMAN: Yes.

COMMISSIONER GILINSKY: Do you have any difficulty with the EPA standard?

CHAIRMAN PALLADINO: I don't know what they are.

COMMISSIONER GILINSKY: Assuming that it ends up being 10,000 years.

COMMISSIONER ASSELSTINE: Draft 21.

MR. COFFMAN: There are some technical definitions which both NRC and we have commented on. There is one issue regarding definition of accessible environment, but that to us is a technicality. I think both to NRC staff and to DOE there are a couple of other examples and we have recommended that the rule be promulgated for comment and that these minor things could be worked out in the public comment period. We have sent a letter to the OMB recommeding that it be sent out for public comment.

CHAIRMAN PALLADINO: Well, thank you very much. Do you have more?

COMMISSIONER ASSELSTINE: No.

CHAIRMAN PALLADINO: Will you be able to remain in case we want to get back to you.

MR. BREWER: Dr. Coffman can remain.

Thank you, Mr. Chairman.

CHAIRMAN PALLADINO: Thank you for coming.

We will recess for 10 minutes.

(Whereupon a short recess was taken.)

CHAIRMAN PALLADINO: Would you please take you seats so that we can get started.

The next speaker will be Mr. Dan Egan of the Waste Management Branch of EPA.

Dan.

MR. EGAN: Thank you.

Glen Sjoblom sends his regrets that he couldn't be here this afternoon. He has been called away on business. I am the Project Leader for the oft-mentioned EPA standards and he felt there is some

OPTIONS FOR PROCEEDING WITH PART 60

- FINALIZE ENTIRE RULE EXCEPT FOR NUMERICAL PERFORMANCE OBJECTIVES FOR CONTAINMENT AND CONTROLLED RELEASE RATE, WHICH WOULD BE RESERVED UNTIL AFTER THE EPA STANDARD IS ISSUED

- FINALIZE ENTIRE RULE EXCEPT FOR NUMERICAL PERFORMANCE OBJECTIVES FOR CONTAINMENT AND CONTROLLED RELEASE RATE, BUT REQUEST PUBLIC COMMENT ON WHETHER OR HOW TO PROCEED IN THE ABSENCE OF THE EPA STANDARD

- FINALIZE THE ENTIRE RULE AND SAY WE WILL GO BACK AND REVISE IT IF NECESSARY WHEN THE EPA STANDARD IS ISSUED

- LEAVE THE ENTIRE RULE IN PROPOSED FORM UNTIL THE EPA STANDARD IS ISSUED

- REPROPOSE THE ENTIRE RULE AND ASK FOR THE PUBLIC COMMENT ON HOW WE SHOULD PROCEED justice in my coming to speak to you this afternoon about our program.

COMMISSIONER AHEARNE: I thought it was to convince us there really was someone.

(Laughter.)

MR. EGAN: Yes, he has allowed you to stick pinpricks in my hand to see if I really do bleed.

(Laughter.)

COMMISSIONER ASSELSTINE: The problem may not be with you.

COMMISSIONER AHEARNE: We recognize that.

(Laughter.)

MR. EGAN: I was hoping somebody else but me might make that point.

COMMISSIONER AHEARNE: I was, too.

(Laughter.)

MR. EGAN: What I have brought with me is a couple minutes of comments that really address perhaps your second meeting today, the question of whether it is appropriate to assess specific numerical requirements for the individual barriers.

Then perhaps after I read that what I would like to do is turn it over to questions both about those comments and about anything you might want to ask about the status of our standards.

Our environmental standards, part of that package would establish overall performance requirements for high-level waste disposal systems in terms of limits on releases of radioactivity to the environment for 10,000 years after disposal.

We believe that these limits should provide very good long-term protection for disposal of high-level waste and they should keep risk to future generations to a level no greater than the risk from the equivalent amounts of unmined uranium ore.

COMMISSIONER AHEARNE: That is the comparison criteria.

MR. EGAN: It is a comparison we use. It is not that we are saying that that is the basis for the standards. However, we picked a level that we think is reasonably achievable for an overall system performance, indeed reasonably achievable with a considerable margin, and we picked a level that both captures that and also captures a level we think should be low enough to be acceptable to the community and hopefully the public at large.

COMMISSIONER AHEARNE: The acceptabity is based on ---

MR. EGAN: It is one of the comparisons we made. There is certainly no way that we or anybody else has come up with a single valued approach to say this is an acceptable risk for an activity independent of circumstances. There is always a balancing of achievability and the acceptability involved.

COMMISSIONER GILINSKY: I am sorry I missed your first remarks and if you covered it I apologize, but in your prepared remarks you do say you expect to be able to propose them for public review in the near future.

COMMISSIONER AHEARNE: I think you skipped that initially.

(Laughter.)

MR. EGAN: I was expecting that we would probably get to questions on that topic after I finished my comments on the question of individual barriers. I had no doubt that that would escape your attention.

(Laughter.)

MR. EGAN: The comment I made in response to Commissioner Ahearne's question is certainly those are judgment calls we had to make in balancing those two. In fact, the comments we get in our public proceeding will certainly be a test of whether we have done that correctly.

However, in talking about the overall performance standards, we very clearly do not believe that these release limits provide an adequate regulatory framework by themselves. Disposal systems that meet our overall performance requirements will need to isolate high-level waste for many thousands of years in spite of unplanned events and in spite of unplanned potential failures of parts of the disposal system.

Compliance with these requirements will have to be judged through analytic projections of disposal system performance over a period far longer than any that has previously been considered in government regulations.

Because of the uncertainties inherent in applying these overall requirements, our package also contains seven criteria that should be met to assure the needed confidence that our long term release limits will be complied with.

COMMISSIONER AHEARNE: Is that for certain?

MR. EGAN: That is currently our position and we have not at the agency changed from that. As I am sure you are probably aware, we have represented that very strongly in various diaglogues with other agencies.

COMMISSIONER AHEARNE: Yes.

COMMISSIONER GILINSKY: Are those public, those criteria?

MR. EGAN: We haven't made them public.

However, certainly they are part of Draft 19, and as I understand it, Draft 19 is now understandably in your Public Document Room such that in that sense you have done that for us.

(Laughter.)

COMMISSIONER GILINSKY: We do that sometimes.

(Laughter.)

MR. EGAN: These criteria call for a cautious and common-sense approach to disposal that encourages use of disposal systems that are tolerant of potential mistakes and unknowns.

One of these criteria calls for use of multiple barriers in disposal systems with each barrier separately designed to provide substantial protection. This criterion is intended to compensate for unexpected failures of one or more of the barriers of a disposal system. Thus, the performance goals for each barrier should not merely be optimized within the context of a properly functioning system to meet our overall performance requirements. Instead, each barrier should be designed to provide as much protection as reasonably achievable for that barrier taking into account economic and social and other considerations and also allowing for possible failures of other barriers.

COMMISSIONER GILINSKY: Now does this

represent the change from previous ---

MR. EGAN: No, this criterion has not changed in its wording for some time.

COMMISSIONER GILINSKY: I mean, DOE represented ---

MR. EGAN: Let me touch upon that a little bit as we go through the letter. We did not use the words "as reasonably achievable" for each barrier in the criterion because we are not sure how you judge that, but the idea is that you do indeed design each barrier to a large extent independently and not counting on each and every other barrier to back up that particular barrier. It is a concept we are all familiar with here, one of redundancy and defense in depth and there is nothing particularly conceptually new to any of us.

We reiterate, and this gets to your question, that we strongly support the approach taken in proposed Part 60 to select specific performance requirements for the individual barriers of a geologic repository. We believe this is the best way to achieve the cautious strategy for disposal that we believe is essential and it should prevent shortsighted designs for barriers that do not appear critical in the context of an analytical overall system analysis. In fact, we have consistently urged the Commission to extend the approach to include specific performance requirements for site, geochemistry and hydrology.

At the same time, selection of the performance requirements for individual barriers must include judgments about cost and feasibility. For instance, our comments on your proposed technical criteria questions the appropriateness of the specific number of a thousand year requirement for containment within the waste package.

Our assessments and the data that we have available to us indicate that a thousand year waste package might cost a great deal without offering the extra long-term protection that enhanced performance of other barriers could provide even when it is assumed that some of the repository's components do not perform as expected.

Perhaps most importantly we are concerned that the apparent severity, again from our perspective, of that particular requirement may encourage not merely attack of that requirement, but attack of the whole approach, essentially throwing the baby out with the bath water, as it were.

COMMISSIONER GILINSKY: Did you suggest any other time for that ---

MR. EGAN: No. In our rule and our comments we did not make any specific suggestions.

CHAIRMAN PALLADINO: Are you saying that the number here is not long enough?

MR. EGAN: Let me get to my second question. We are seeing again our data and cost and the like. We certainly don't believe they are by any means the final word. In fact, when we discussed this with DOE, because we had to prepare a regulatory impact assessment for our standards, the data was clearly quite uncertain at that time and I suspect it still is. In fact, cost data is something that will come along fairly slowly as it typically does in a process such as this.

It is our judgment, just based on what we have seen, that the thousand year requirement may in fact have significant cost implications. On the other hand, it is also our judgment that the ten to the minus five waste form does not seem to have the same severity of cost implications as we understand it, but we certainly don't claim to be the ultimate experts on that, but that is the information we have.

To reiterate this, we support a specific numerical requirement for waste package lifetime, but a value other than a thousand years a thousand years may be appropriate.

COMMISSIONER AHEARNE: Since you have reached the conclusion that a thousand may be inappropriate, would you have a number which you feel might be appropriate?

MR. EGAN: Yes. From my own personal judgment, I will be glad to give you what I have seen, numbers like two or three or four hundred years, in that range, a few hundreds of years to get you past the very intense heat problem with the 30 year half life fission products. That seems to be perhaps more defensible and perhaps more achievable with the technologies we have seen, but again I hesitate, you know, to pass that on as the findings of an expert.

CHAIRMAN PALLADINO: Are there uncertainties in the length of time over this heat has to be handled, in other words, two or three hundred years might be a calculation? Is there something that you might say would be longer or shorter or different?

MR. EGAN: Well, when you get into the heat generation of the waste of course, the waste itself, you know pretty well that heat removal of course is a much more site specific thing and we have not studied that extensively. My picking of two or three hundred years is more based on the argument than the facts staff made to you that it was the decay of the radioisotopes that was perhaps the most important. Again, we have seen numbers that stretch into a thousand and it may drive you into materials that you might not have to go to if you cut that by a factor of three or four.

I am struck by the argument, particularly in a very high heat period that in fact you may have things going on that you can't model very well and there is some reason to have a redundant, or an extra redundant barrier in the system at that time.

COMMISSIONER ASSELSTINE: But your comment is based more upon the difficulty in meeting the thousand year requirement and the incremental protection that you see might be gained from that rather than anything, for example, in your standards that would drive it one way or the other?

MR. EGAN: That is correct. Let me finish this and comment on that in a minute.

To reiterate our position, we do support a specific numerical requirement and a value other than a thousand may be appropriate. We are encouraged that the revisions that we have seen in the proposed Part 60 would allow the Commission to pick a different requirement when more information, particularly information such as cost data, becomes available. We also wish to point out that the other specific requirements in the proposed Part 60, particularly the requirement on waste form release rate, appear to be both appropriate and we believe are also more important than the waste package requirement.

The approach of setting such specific numerical requirements on individual barriers, which is clearly not within our authority, is an appropriate way for the Commission to implement our environmental standards. Furthermore, we believe this approach is essential for developing the confidance that will be needed in disposal systems that must work for so long, and we believe the Commission should continue on this course.

I will get back to the question Commissioner Asselstine raised. In the comment letter we sent you all and which DOE has correctly quoted in their submission to you we did of course question the thousand year requirement and we are also fairly careful both in that paragraph and elsewhere in the letter to say we did support the approach you were taking.

We did not, as I go back and remember the letter, say exactly the words we said here such as you might consider this to be a clarification of our previous comments. But we have consistently felt you should set not only the requirements, specific numeric requirements that you have set, but we have also argued quite often that you could extend that to the geology as well and the geochemistry because it is clear.

COMMISSIONER AHEARNE: You said "We urge the Commission to extend the multiple barrier approach to the geology and geochemistry at the disposal site."

MR. EGAN: The analyses the DOE showed do reflect the fact that the geology does provide substantial protection and we are concerned that that should be focused on as well.

That completes I guess my formal comments or comments on your second part of the meeting and I guess I will go back to Commissioner Gilinsky's question as to where we stand on the package.

Of course I don't have a particularly firm answer as always.

(Laughter.)

MR. EGAN: The Administrator has been pushing, as Chairman Palladino well knows, very hard in the last several weeks to get the package out. We are not preparing internally a package so that everything is ready to go for her signature, and I am hoping that that road block can be cleared up and I think a feasible date would be by the end of the year, by mid or late December. My predictions here have not been terribly reliable before so I offer that with some salt, but I do get indications that there may be some resolutions of that coming along.

As you know, we have been over at OMB now since Christmas Eve of last year in the formal 12291 review.

CHAIRMAN PALLADINO: Do you think you are making progress?

MR. EGAN: Yes, I do in fact, but then I have thought that for a while.

(Laughter.)

COMMISSIONER GILINSKY: But the reports we have gotten back from meetings that I gather were held with you were that things seemed to be pretty much at an impasse.

MR. EGAN: Yes. Certainly the meeting the Chairman was at did not end with any agreement in sight, but it did end with the Administrator being very firmly committed to solve that particular problem at whatever level is appropriate.

COMMISSIONER ASSELSTINE: Is it fair to say that as far as you all are concerned and our staff is concerned and the DOE people are concerned that there is agreement there?

MR. EGAN: Yes.

CHAIRMAN PALLADINO: That there is agreement where?

COMMISSIONER ASSELSTINE: That there is agreement between our staff and the EPA and the DOE people.

MR. EGAN: We have letters on the record since June this summer from both DOE and NRC saying, you know, we agree that the standards are fine for public comment.

COMMISSIONER ASSELSTINE: So the hold is coming from OMB.

MR. EGAN: Oh, there is no question about that, and there has been that particular point for some time.

COMMISSIONER GILINSKY: Can I ask you what we are talking about here is putting the EPA standard out for comment. How long a period do you envisage for a standard to become effective?

MR. EGAN: I anticipated you might ask that, too. We do envision certainly initially allowing 180-day comment period, which is perhaps somewhat longer than the minimum required, but again because of the tremendous interest in this issue and also the complexity of the issue I feel it would be wrong to try to cut short a comment period any more quickly than that. We will hold public hearings at the end of that comment period.

We are forecasting that one year after the day of proposal we plan to promulgate the standard.

COMMISSIONER GILINSKY: Do you think you can do that even with public hearings at the end of the 180-day period because after that you have to prepare for those hearings?

MR. EGAN: Well, we will hold the hearings within the comment period, within the 180 days, and probably near the end of that period and then close the comment record both from written comments and from public hearing in approximately six months after we propose. That will give us about six months to organize the comments and deal with whatever we have to deal with as far as revising the rule if that is appropriate. My personal judgment is that it will come out, you know, on schedule within one year afterwards, you know, Murphy's Law being I think very valuable here, because I expect we will get a very wide range of comments. There are a lot of social issues besides techical issues that are involved here.

We do have a technical review panel that we are setting up through our Science Advisory Board to conduct a technical peer review at the same time as the public comment period. Essentially we have a number of things going on during that period of time.

COMMISSIONER GILINSKY: So really the earliest that one could have a final EPA standard is early 1984.

MR. EGAN: I think that is certainly a fair assessment. That would be my personal call from the way this has proceeded to date.

COMMISSIONER GILINSKY: That assumes that you in fact resolve your problems by the end of the year.

MR. EGAN: Not knowing what they are, that assumes that we do, yes. You know, your judgment, I would say at this point, is as good as mine on how much that is going to take you down through a similar type of rulemaking on yours.

CHAIRMAN PALLADINO: Any other questions?

COMMISSIONER AHEARNE: No. I thank Mr. Egan for his presentation.

COMMISSIONER GILINSKY: Thank you very much.

CHAIRMAN PALLADINO: Thank you both for your presentation and for your forthright answers to questions.

Now we have Dr. Krauskopf.

(At this point in the proceedings Mr. Egan left the Commissioners' table and Messrs. Krauskopf and Meyers joined the Commissioners at the table.)

CHAIRMAN PALLADINO: It is nice to have you with us.

MR. KRAUSKOPF: I am very glad of the opportunity to be with you.

I am the Chairman of the Board on Radioactive Waste Management of the National Academy, and I have with me Dr. Peter Meyers who is the Executive Office of that Board.

About a year ago the National Academy sent to you some comments that had been prepared by the Board on Radioactive Waste Management regarding an earlier issue of 10 CFR 60. Much of what I have to say will be a little dated because the Board has not considered 10 CFR 60 since that time. So some of the comments that were made in that letter would undoubtedly have to be revised today.

I will try to distinguish between what the Board said in that letter and what my guesses would be about what its opinions would be today.

COMMISSIONER GILINSKY: I wonder if you could say a word about the Board, the composition of the Board.

MR. KRAUSKOPF: The Board is made up of people from a number of different disciplines, from nuclear energy through chemistry, geology, hydrology to economics, materials science and even political science. It has been functioning for oh in one form or another for the last couple of decades, and it has tried to provide the answers to questions posed to it by government agencies, the Department of Energy, NRC and EPA. This report that I am speaking of was in answer to a request for comments by the NRC.

The Board was complimentary about the proposed rule in general. We were much impressed with the work that had gone into it and the care with which its recommendations had been prepared.

The letter was rather critical in some respects. We thought for one thing that the rule should not be issued until EPA had set its standards, that the rule should be left in a proposed form at present or otherwise the rule should carefully justify why it was being promulgated before the EPA standard had been set.

Regarding the numbers that have been talked about so much this afternoon, the general feel of the Board was that the numbers for subsystems did not belong in the rule, that if numbers were to be used they should appear in regulatory guides rather than in the rule.

We felt that the evidence supporting the numbers was not really very convincing, that no evidence was given, that the numbers would really support a finding of no unreasonable risk to the health and safety of the public. We thought that it had not been shown adequately that the numbers were either necessary or sufficient to meet the standard that EPA had apparently adopted, that is we did find a tentative standard at that time in I believe it was EPA's 19th version of their standard and we didn't feel that the numbers were demonstrated to be either necessary or sufficient to meet that standard.

We did not think that it had been adequately shown that the numbers would aid the licensing process, that the numbers were technically valid or that the numbers could be verified. We felt also that there was no real proof that the numbers were actually achievable at any reasonable cost.

We thought that concentration on these numbers would deflect the Department of Energy from work on an overall performance standard which we thought should be the object of the rule. A single overall performance standard was one of the alternatives in the rule at that time and we thought that that was a preferable approach rather than trying to set numbers for some systems.

We thought that the rule should contain a qualitative analysis of the factors which the numbers were attached to, that is, there should certainly be discussion of the lifetime of a canister, of the amount of radioactive material that could be permissible after the first few hundred or thousand years and there should be a discussion of geological factors like the motion of ground water.

But there should not be fixed numbers because each repository site is going to be different from others in many respects and that it is more important that each site be evaluated on its own and that the repository system should be investigated as a system and that there should be an opportunity for balancing say deficiency in one respect against advantages in another respect.

Also, we thought that the numbers, if they were set, will undoubtedly be changed in the future as we learn more about respository sites and as we learn more about the effects of radioactivity on organisms, and if the numbers are frozen in the rule they will be difficult to change in the future.

As Dr. Coffman has so eloquently explained, the numbers will be different from one site to another, that is for example, if you contrast a repository in salt with a repository in silicate rock the requirement for the life of the canister would necessarily be quite different and it would be awkward to have a specific number in the rule itself.

Well, these are some of the statements in that letter of last year. It seems to me that if the Board were to consider the latest version that probably some of those statements would be modified. Now I am speaking now as an individual and I am really making guesses as to what the Board would say.

It seems to me that the rationale that is attached to the final rule or document answers a number of our objections, that is, it does provide considerable evidence that the numbers suggested in the rule might be sufficient to satisfy the requirements of EPA.

Now I make that statement with some trepidation because I have not gone through the analysis and I do not know. It just seems to me that a real effort has been made in that direction and it looks to me as if there is much more evidence that there was originally. I am not sure that the evidence is so good that these numbers are necessary. In fact, I would think myself as an individual that some of them are more restrictive than necessary as a general rule.

Also it seems to me, and again this is an individual opinion, that part of this discussion ought to keep in the background that there will be only one or two repositories commissioned in the next say 40 years. So it seems to me that there isn't very much gained by making generic rules that would apply to many repositories. There simply won't be many repositories. So I should think each one would be better handled on a case-by-case basis considering the peculiarities of the particular sites.

It seems to me that flexibility is particularly important so that DOE can carry out its function of building a repository that will have minimum risk to health and safety.

I think that is about all I have to say.

CHAIRMAN PALLADINO: Okay. Thank you very much.

Any questions?

(No response.)

CHAIRMAN PALLADINO: I wonder if I might ask you a question. You said that you don't anticipate many repositories will be established and yet I have heard discussions of having established one can we keep up with the rates at which spent fuel or waste would be generated. From that I get the impression there might be several and they might be four purposes of experimentation or mainly for diversity, and it may be that we have different sites in different geologic formation.

If you have everything being site specific you are faced with having to predict which site it is going into. Do you have any thoughts on overcoming that problem?

MR. KRAUSKOPF: Possibly my guess about the number of repositories was pessimistic. I am afraid tht I have been conditioned by say 12 years or so in this game when originally a repository was supposed to be built in the middle 1980's and now it has been pushed up toward the end of the century.

CHAIRMAN PALLADINO: I wasn't thinking when these repositories ---

(Laughter.)

CHAIRMAN PALLADINO: Go ahead. I am sorry.

MR. KRAUSKOPF: Well, it simply seems to me that the rule should have an analysis of the important factors to consider in a repository, the geologic factors and the engineering factors. There is no argument on our side about the necessity for a multi-barrier approach, and this should be spelled out in qualitative terms in the rule and then for each repository there should be guidelines established for that particular kind of a geologic environment.

CHAIRMAN PALLADINO: If you found something wrong in the one and you wanted to transfer material over to the other ---

MR. KRAUSKOPF: That could well be a

difficulty, but to fashion a waste package that would be suitable both for putting in salt and for putting in a rock like basalt or granite or tuff, that would be pretty difficult and I think would be needlessly expensive.

COMMISSIONER GILINSKY: Let's see, you would see a process in which DOE would pick a site, inform us and we would then develop standards for that site before they designed a repository?

MR. KRAUSKOPF: You would develop regulations for that site, yes.

COMMISSIONER GILINSKY: Before they designed the repository presumably.

MR. KRAUSKOPF: I don't know about the sequence of events here. They would certainly have at least rough plans for the design of the repository.

COMMISSIONER GILINSKY: The way we were trying to work it was to, or our staff was at any rate, was to develop rules now that would be turned over to DOE and DOE would then pick a site on the basis of this and design a repository, packages and so on and submit an application. But if one goes with the site specific approach, then what we need to have is for DOE to pick a repository, come back and tell us about it and for us then to develop standards for that particular geology.

You are shaking your head. So how do you see it differently?

MR. MEYERS: Isn't it for DOE to make its proposal for that specific site as to the particular tradeoffs which it would feel adequately protected health and safety in line with the EPA's ---

COMMISSIONER GILINSKY: So there would simply be no standards. We would simply see what they have done and see if it meets the EPA standard? You talked to us earlier about regulatory guides.

MR. KRAUSKOPF: Yes.

COMMISSIONER GILINSKY: When will these come in the process? That is what I was trying to get at. If you are talking about a regulatory guide, which is site specific, that can only come after we know which site we are talking about. So there would be a period of time during we are preparing regulatory guides after a site has been picked and before one can design a repository.

MR. MEYERS: There is no reason you could not start a generic set of guides for salt and another generic set of guides for basalt. Much of the work can be done while the site selection and qualification is going on because it is medium specific rather than ---

COMMISSIONER GILINSKY: Well, but the way DOE was approaching it there is more to it than that. It is really knowing all the various other barriers and their performances that allows you to pick, say, the package standard.

MR. KRAUSKOPF: Of course I don't know the procedure of establishing these regulatory guides. I should think, as Peter has just pointed out, that it would be possible to develop a series of guides for the different possible geologic media and then those could be rather quickly modified for particular sites. I would not want to introduce long delays in the process.

COMMISSIONER GILINSKY: It seemed to me that we were taking a simpler approach which does involve possibly an increase in cost in the package over what you might arrive at if you had a very site specific approach, but it is one that applies to all sites and doesn't then require us to develop a regulatory framework for each one of those sites.

MR. KRAUSKOPF: Well, the difficulty is of course that it is impossible to set actual numbers that will be suitable for all sites.

COMMISSIONER GILINSKY: Well, you pay a penalty at some sites certainly. The alternative though is it seems to me a rather lengthier process. In other words, if one wants to optimize further I think we would be getting into a rather longer process which is going to have to take a look at individual sites and set up a framework for those.

MR. KRAUSKOPF: Well, I wish I knew more about the process of establishing regulations and guidelines.

CHAIRMAN PALLADINO: I think Commissioner Ahearne has a question.

COMMISSIONER AHEARNE: A couple of questions, if I could. Reading your letter is it fair for me to assume that underlying it was the report that was prepared by Tom Pickford?

MR. KRAUSKOPF: Oh, yes, very much so.

COMMISSIONER AHEARNE: He sent that into us and he said that your Board have given him permission to send that in as his individual comments.

MR. KRAUSKOPF: That is correct.

COMMISSIONER AHEARNE: Based on that then let me see if I understand correctly. It seems that you were raising in your letter two types of concerns. The first was there was no technical justification developed for the criteria, and I believe that to some extent the staff has attempted to address, as you had mentioned.

MR. KRAUSKOPF: That is correct, yes.

COMMISSIONER AHEARNE: The second, and now I refer more to Pickford's paper, is a question that the numbers themselves weren't correct, not so much that there was no justification, but then going through his own analysis he was reaching the conclusion that those were wrong numbers. I wondered whether that second piece in your sense would still be the flavor of your Board's position if they were to review it again?

MR. KRAUSKOPF: I would only be guessing as to what Dr. Pickford would say to a question like that. I would think that we would still object to the particular numbers. We would think I believe that the numbers are too restrictive.

COMMISSIONER AHEARNE: That is the site specific issue that is being debated.

MR. KRAUSKOPF: Yes.

COMMISSIONER AHEARNE: A final question speaking specifically to one of the comments in your letter. You say, and then I want to ask the implication of what DOE's position is, "The criterion of water transport time may not be verifiable and is probably not verifiable in some geologic media. Because the flow of water in some media is complex and poorly understood, the transport time may be verifiable only within broad limits."

DOE is making a great part of their argument, at least it seemed to be this afternoon, based upon very large travel times. How should I interpret your comments? Should I interpret them as saying that we ought to be cautious on accepting the complete reliance upon estimated large travel time?

MR. KRAUSKOPF: This is a technical matter of how you determine how fast ground water is moving. I suppose the question really hinges on what is meant by the broad limits.

COMMISSIONER AHEARNE: Yes.

MR. KRAUSKOPF: When ground water moves through rock it doesn't just move as a body but there will be stringers that will move faster than the rest of it and of course it will disperse in all directions and that sort of thing.

In the presentation by DOE this afternoon they were careful to point out repeatedly that they were using conservative numbers. They were using small numbers which would be on the low side of this broad limitation. So I don't think there is anything necessarily inconsistent there with their position.

COMMISSIONER AHEARNE: Thank you.

CHAIRMAN PALLADINO: All right. Thank you very much, Dr. Krauskopf and Dr. Meyers.

I was going to ask Mr. Dircks if he had any comment that he would feel appropriate to make based on what he has heard here and the staff.

MR. DIRCKS: Well, as we mentioned earlier, we didn't want to get into a point-by-point technical rebuttal of what DOE had to say. I think though you picked up where we do have a basic fundamental variance. It is that they are putting much more weight on the certainty of geology than the staff did and still does, and we are particularly concerned I think about the first several hundred to a thousand year limit when we believe that the material is at its most hazardous state.

I think the arguments were the temperature and particularly the fission product decay were two elements that we were particularly concerned about in our discussion of the thousand year period.

There are in addition to the DOE comments of course and the other comments you have heard today, there are many other commenters on this subject, and rather than for us to deal only with DOE today, you do I think owe it to yourself, if you want to get into this more deeply, to hear the comments of the Department of Interior, the Geologic Survey and of course the outside groups such as the Natural Resources Defense Council which has been quite active in commenting on the rule.

I do think that is the basic underlying

difference. It is that thousand year period, up to the thousand year period where we are a little bit less sure of the geology than DOE seems to be.

COMMISSIONER GILINSKY: Where does the rule stand geographically? Is it in Bethesda or is it here?

(Laughter.)

COMMISSIONER GILINSKY: I mean have you sent it to us to deal with?

MR. DIRCKS: No, not the full package.

COMMISSIONER GILINSKY: That is what I meant.

MR. DIRCKS: We sent you the rule itself, but I have the rule and if you ask me where it is ---

COMMISSIONER GILINSKY: No, no, no, I meant the package from you.

MR. DAVIS: Once we get the guidance we have requested today we can finalize the rule and bring it down fairly promptly and then go through all the technical briefings that the staff would be prepared to do. We were holding it back.

COMMISSIONER GILINSKY: I would very much like for you to send us the package. I don't know that we have to decide on the precise option for you to do that.

CHAIRMAN PALLADINO: I have something here that maybe is not the latest but it is dated November 5th. It says a proposed Part 60 criteria per your request at the agenda planning session.

MR. DAVIS: That is not the whole package.

MR. DIRCKS: That is not including all the comments.

CHAIRMAN PALLADINO: The rule but not the entire package.

COMMISSIONER GILINSKY: When I said rule I meant package.

COMMISSIONER ASSELSTINE: We have the rule but not the package.

MR. DIRCKS: We can send that down.

COMMISSIONER GILINSKY: I think it would be useful for you to send that forward and then we can deliberate on just exactly how we want to deal with it.

MR. DIRCKS: Fine.

CHAIRMAN PALLADINO: Okay. Any other comments?

(No response.)

CHAIRMAN PALLADINO: Well, thank you very much.

Now before we adjourn I would like to make a request of the whole audience. This may take an investment of two minutes of your time, but it could save us considerable more. I am going to adjourn this meeting and I am going to reconvene in affirmation session which is a ritual whereby we affirm notation votes and it takes a very short period of time unless somebody has a question on them and I don't anticipate any today. So if you would bear with us, I will ask you to stay seated and I will adjourn this meeting and start the other.

This meeting will stand adjourned.

(Whereupon, at 5:00 p.m., the meeting adjourned.)

* * *

NUCLEAR REGULATORY COMMISSION

This is to certify that the attached proceedings before the

COMMISSION MEETING

in the matter of: PUBLIC MEETING - Opetions Regarding High-Level Waste Rule Technical Criteria (Part 60)

Date of Proceeding: November 18, 1982

Docket Number:

Place of Proceeding: Washington, D. C.

were held as herein appears, and that this is the original transc thereof for the file of the Commission.

Mary C. Simons

Official Reporter (Typed)

Mary C Simons

Official Reporter (Signature)

United States Department of Energy

Presentation Before the United States Nuclear Regulatory Commission on the Matter of Draft 10 CFR Part 60

November 18, 1982

F. D. Coffman
Acting Director
Office of Terminal Waste Disposal
and Remedial Action
Office of Nuclear Energy
U.S. Department of Energy

VIEWGRAPHS

DRAFT 10 CFR 60 HAS MANY POSITIVE FEATURES WHICH SHOULD BE INCLUDED IN THE FINAL RULE.

- PROVIDES FOR THE PROTECTION OF THE PUBLIC HEALTH AND SAFETY WHILE PERMITTING DESIGN AND SITING FLEXIBILITY
- PROVIDES OVERALL SYSTEM PERFORMANCE OBJECTIVE (60.112)
- PROVIDES GUIDANCE IN KEY AREAS:
  - LAND OWNERSHIP AND CONTROL (60.121)
  - SITING REQUIREMENTS (60.121)
  - DESIGN REQUIREMENTS (60.130)
  - PERFORMANCE CONFIRMATION (SUBPART F)
  - QUALITY ASSURANCE (SUBPART G)
  - PERSONNEL TRAINING AND CERTIFICATION (SUBPART H)

DOE CONCERNS WITH 10 CFR 60 CENTERS ON 60.112 AND 60.113

1. REQUIREMENTS TO MEET GENERIC LEVELS OF PERFORMANCE ON A SITE-SPECIFIC BASIS

2. INCONSISTENCY BETWEEN 60.112 AND 60.113

3. IMPOSITION OF GENERIC ASSUMPTIONS ON SPECIFIC ROCK TYPES

DOE RECOMMENDS:

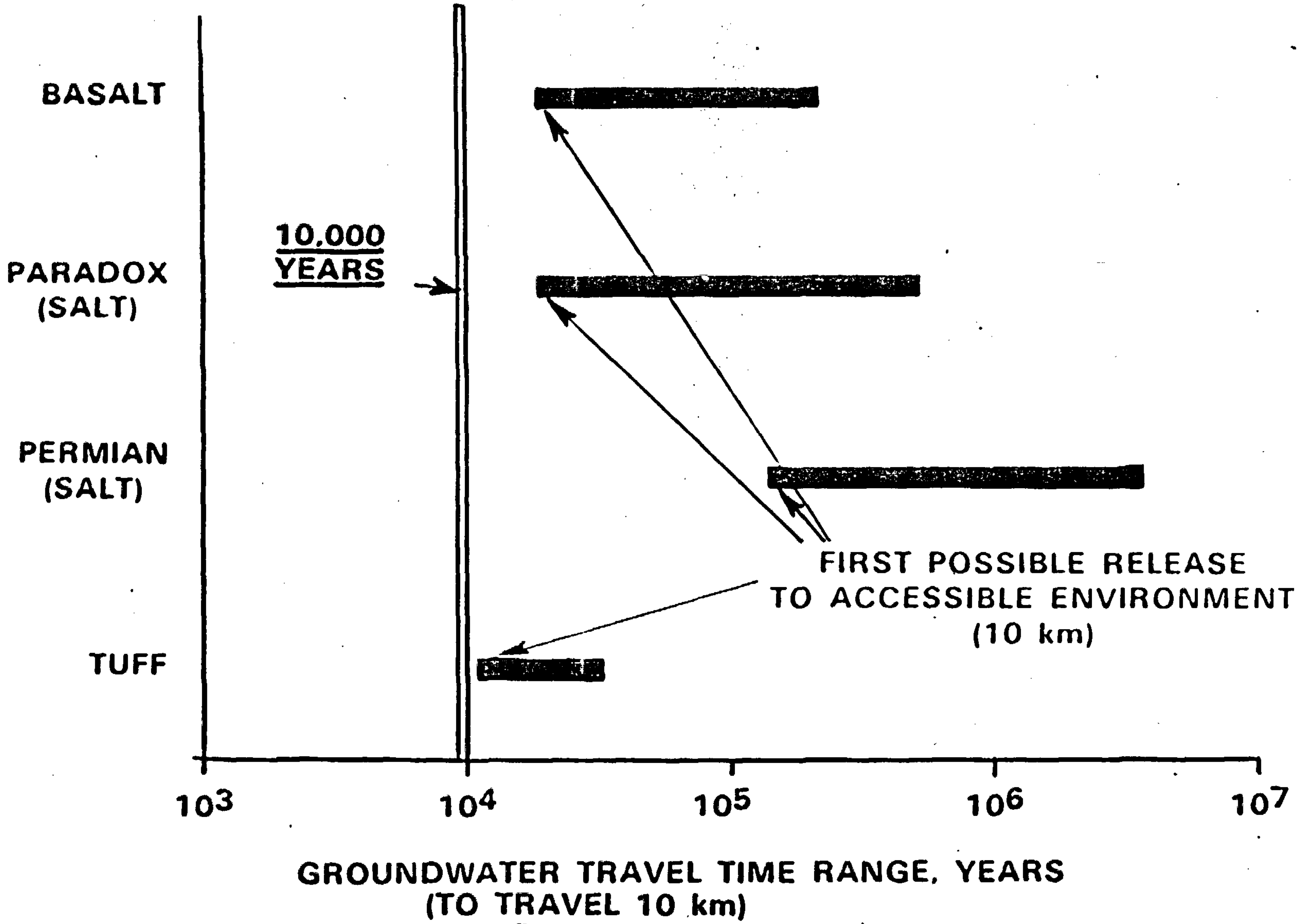
1. ELIMINATION OF 60.113
2. REDRAFTING OF 60.112
3. CONSULTATION BETWEEN NRC/DOE STAFFS TO RESOLVE OTHER CONCERNS
4. PUBLISH FINAL RULE

FUNDAMENTAL DIFFERENCES BETWEEN NRC STAFF AND DOE ARE:

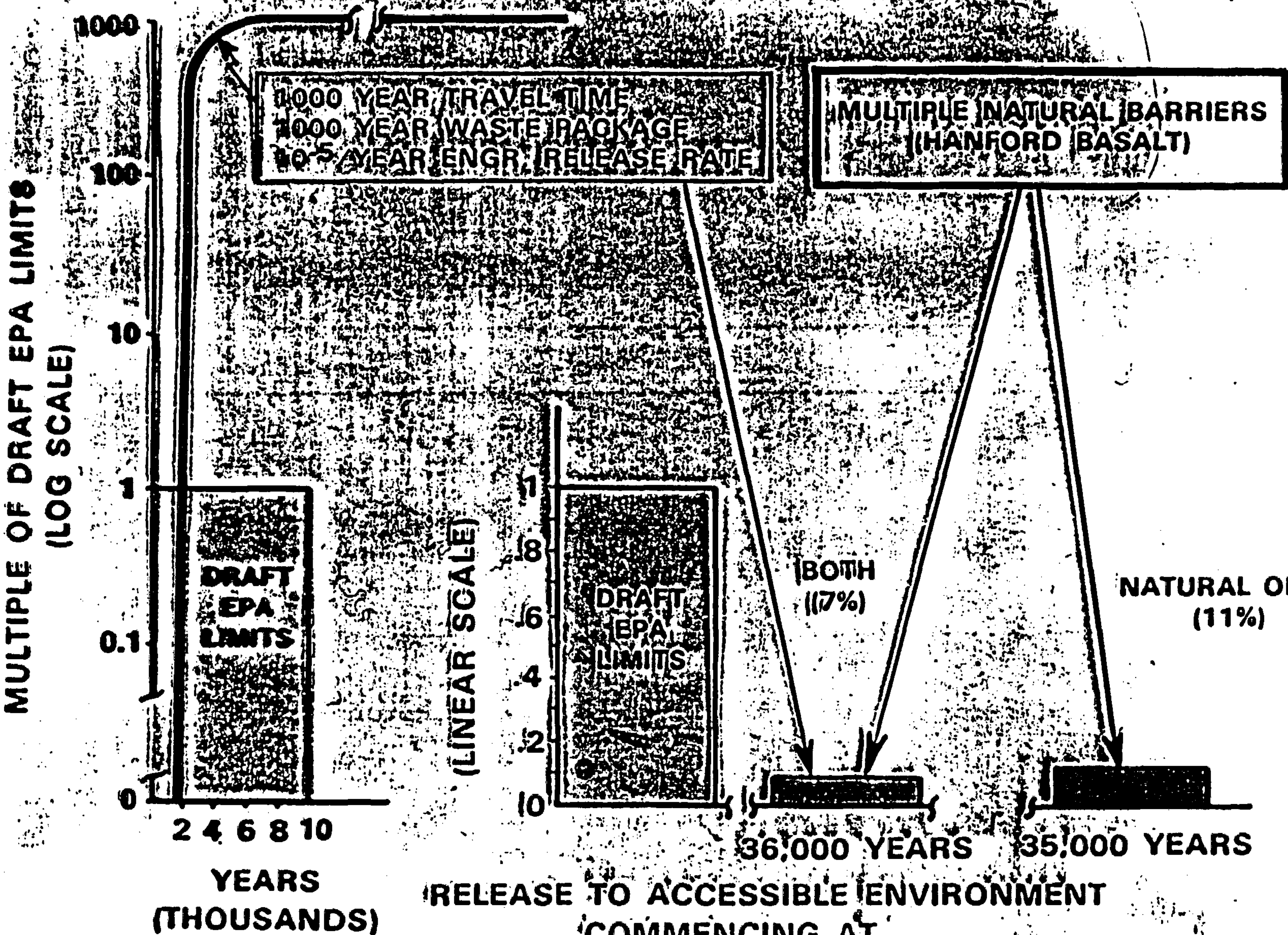
1. NRC STAFF STATES THAT DEPENDENCE UPON ENGINEERED SYSTEMS RATHER THAN NATURAL BARRIER SYSTEMS WILL RESULT IN A REPOSITORY WITH LESS UNCERTAINTY IN ITS OVERALL PERFORMANCE.

2. NRC STAFF STATES THAT BY SPECIFYING ENGINEERED PERFORMANCE YOU CAN REDUCE THE UNCERTAINTY IN TOTAL SYSTEM PERFORMANCE. [EVEN WHEN THE SUM OF THE SUBSYSTEMS PERFORMANCES DOES NOT ENSURE OVERALL (EPA STANDARD) COMPLIANCE.]

THE PROPOSED 10,000 YEAR EPA LIMIT WOULD BE MET ON THE BASIS OF GROUND-WATER TRAVEL TIME ALONE



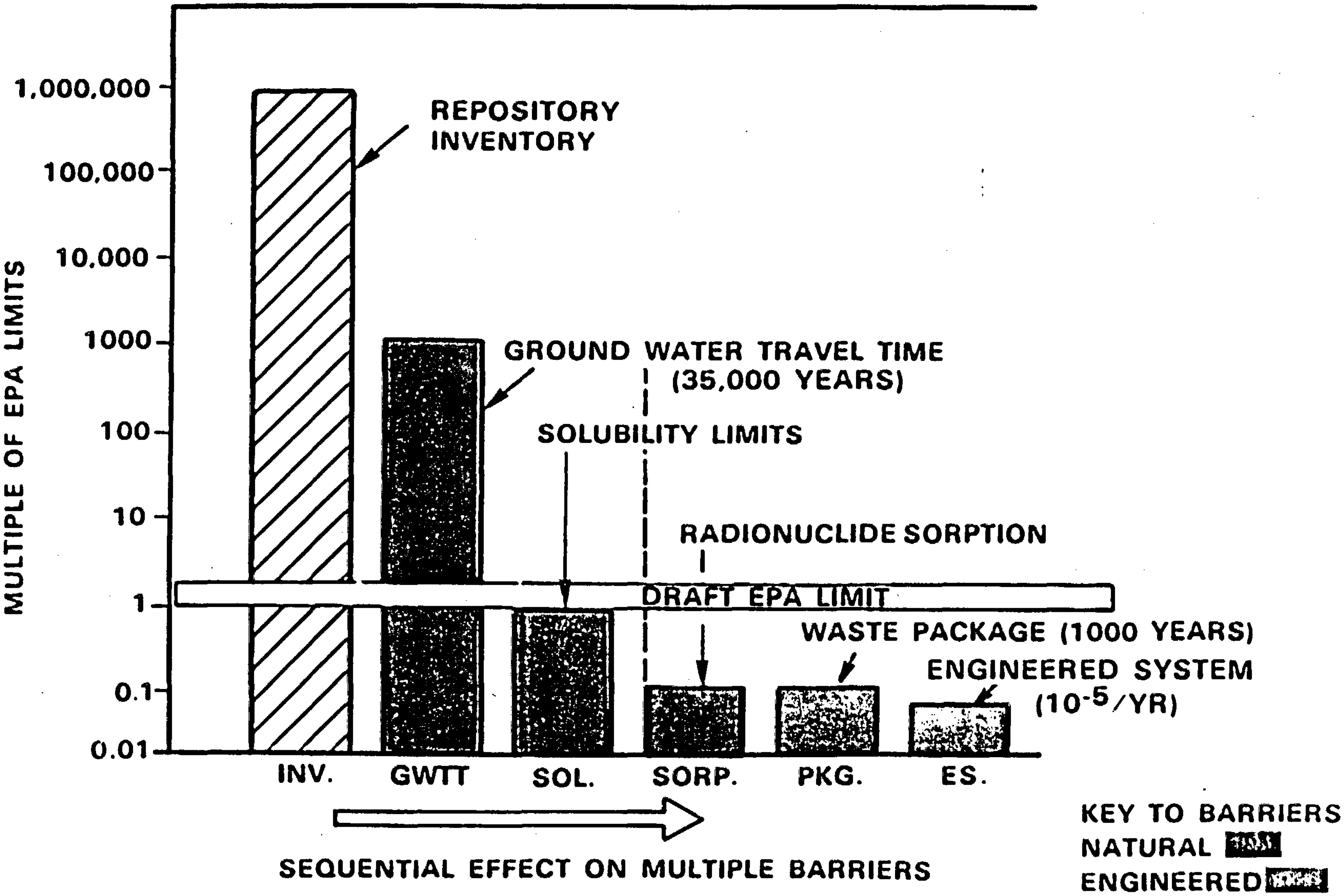
ALTHOUGH THE 60.113 REQUIREMENTS ARE INTENDED TO PROVIDE CONFIDENCE IN COMPLIANCE WITH THE EPA SYSTEM STANDARD, NATURAL BARRIERS DOMINATE SYSTEM PERFORMANCE



VG 6

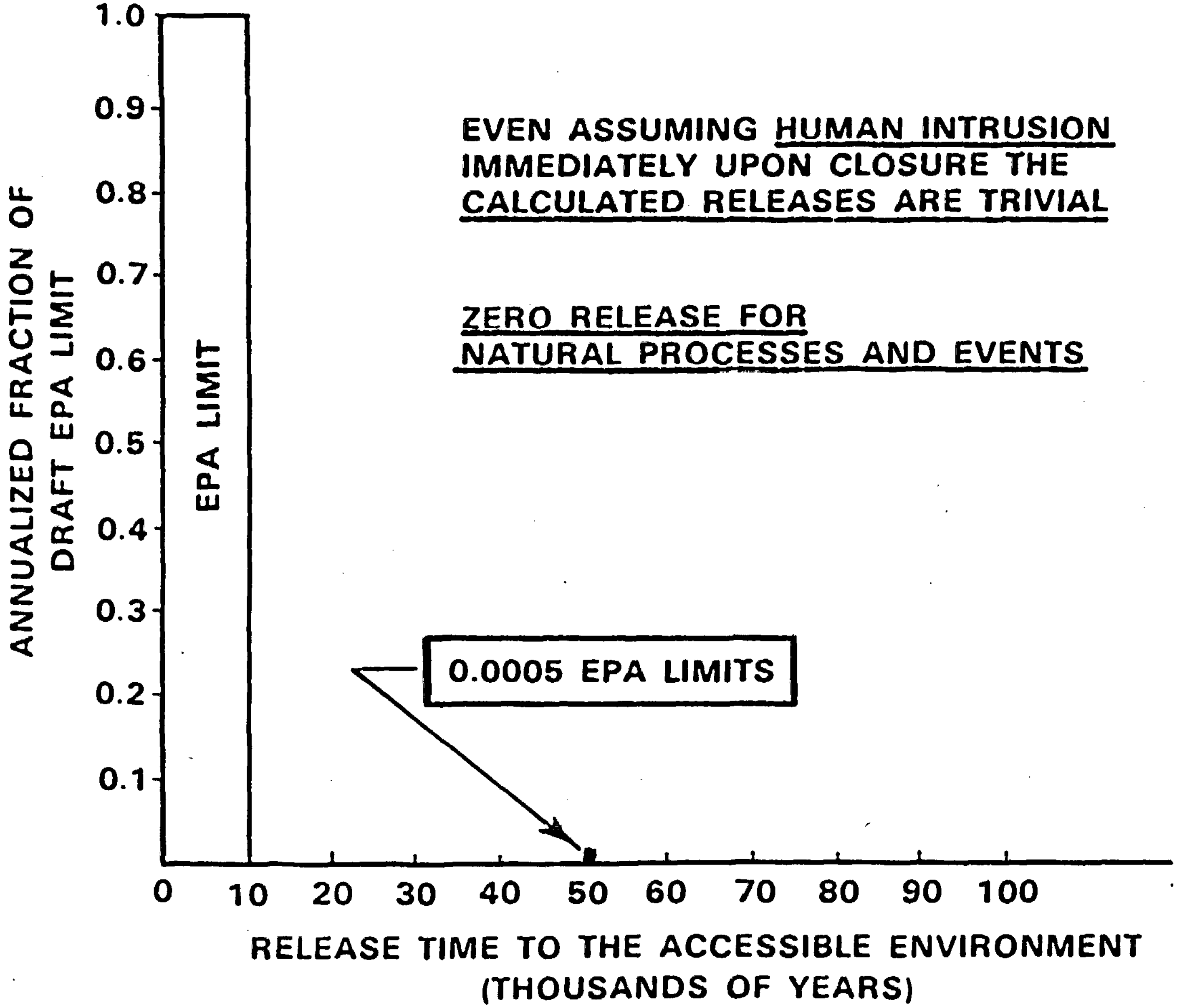
(HANFORD BASALT: RELEASE INTEGRATED OVER ALL TIME)

LOW INTEGRATED RELEASE DUE TO MULTIPLE NATURAL BARRIERS (SHOWN IN BLUE). ENGINEERED BARRIERS HAVE LITTLE OR NO EFFECT ON MAGNITUDE OF RELEASE



(REACHES ACCESSIBLE ENVIRONMENT 36,000 YEARS)

PARADOX BEDDED SALT



DEFENSE-IN-DEPTH IS PROVIDED BY THE MULTIPLE NATURAL BARRIERS

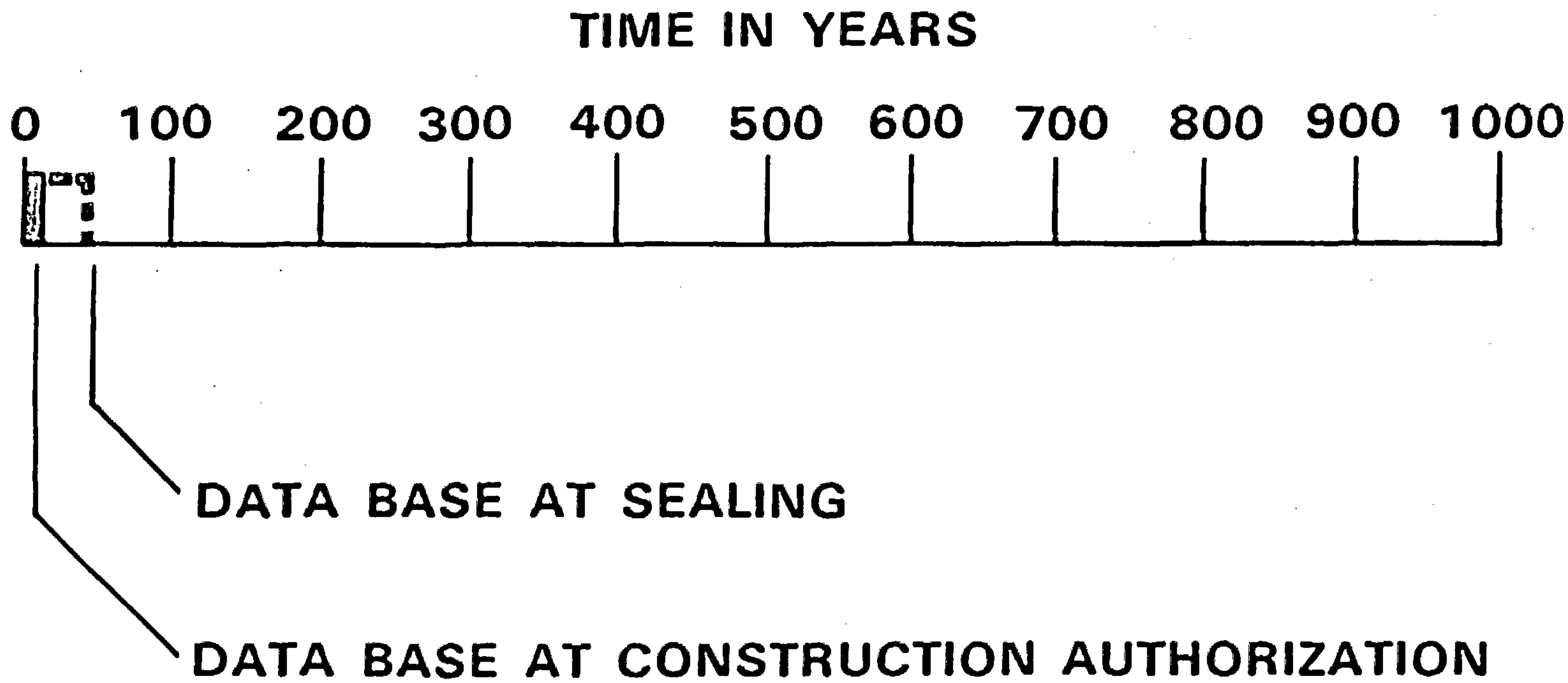
BASALT

- VERTICAL SEPARATION FROM AQUIFERS
- LOW HOST ROCK PERMEABILITY
- FAVORABLE GEOCHEMICAL CONDITIONS
- GROUNDWATER TRAVEL TIMES
- RADIONUCLIDE SORPTION
- DILUTION POTENTIAL IF AQUIFERS ARE CONTACTED

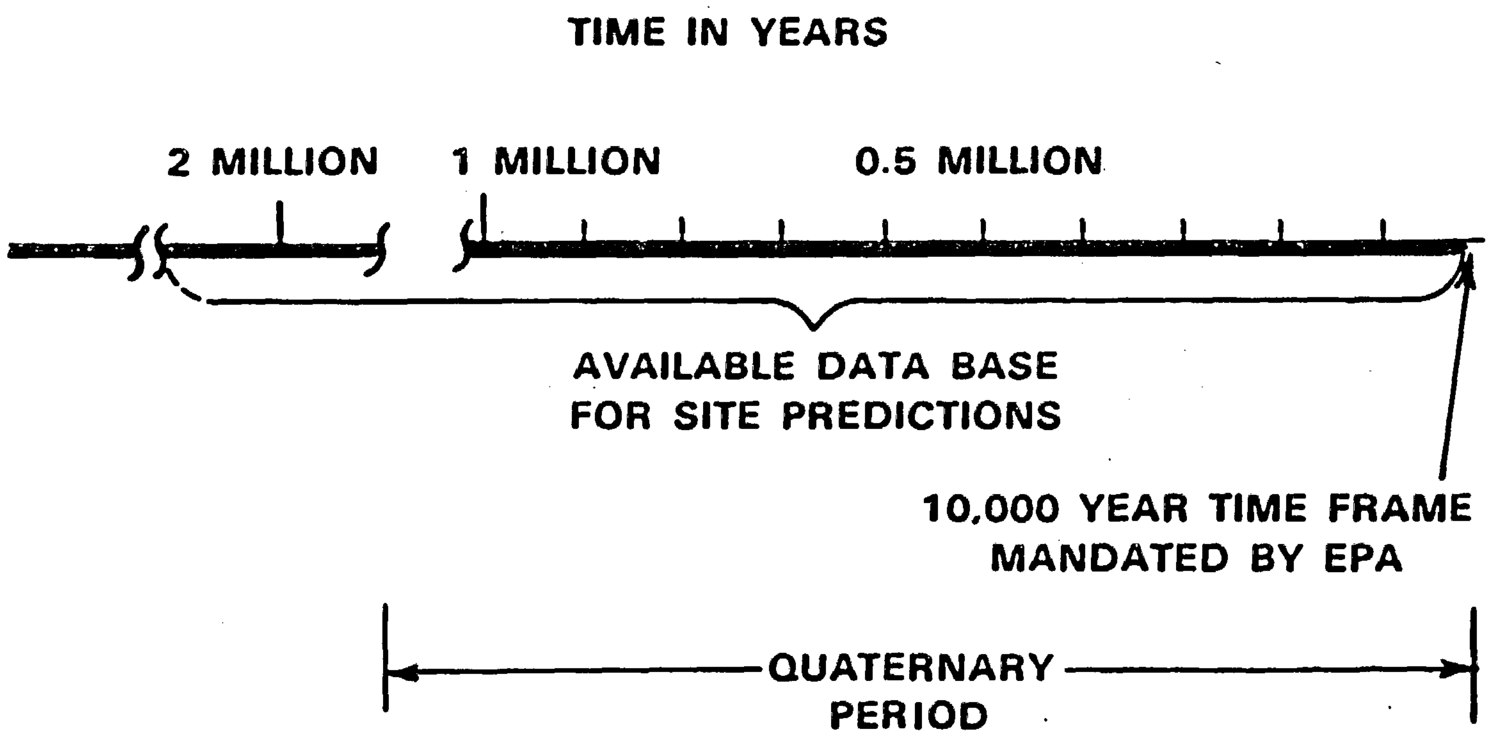
BEDDED SALT

- VERTICAL SEPARATION FROM GROUNDWATER
- NEGLIGIBLE HOST ROCK PERMEABILITY
- SELF-SEALING HOST ROCK
- DOWNWARD HYDROLOGIC GRADIENT (AWAY FROM HUMANS)
- GROUNDWATER TRAVEL TIMES
- RADIONUCLIDE SORPTION
- NEGLIGIBLE POTENTIAL OF ENTERING POTABLE WATER SYSTEMS

PROVING COMPLIANCE WITH 60.113 REQUIREMENTS (E.G., 1000 YEAR WASTE PACKAGE) REQUIRES EXTRAPOLATIONS THAT ARE VERY LARGE RELATIVE TO THE ENGINEERING DATA BASE



CONVERSELY, THE DATA BASE FOR SITE PREDICTIONS EXTENDS MILLIONS OF YEARS BACK IN TIME MAKING THE FORWARD EXTRAPOLATION VERY MINOR.



ALTHOUGH TECHNICALLY FEASIBLE, PROOF OF COMPLIANCE WILL BE EXTREMELY DIFFICULT DUE TO:

- VERY LARGE ENGINEERED DATA EXTRAPOLATIONS REQUIRED
- UNCERTAINTY REGARDING NATURE AND EXTENT OF PROOF REQUIRED BY NRC

191.14 IMPLEMENTATION

COMPLIANCE WITH 191.13 SHALL BE DETERMINED THROUGH ANALYTICAL PROJECTIONS OF POTENTIAL RELEASES OF WASTE TO THE ACCESSIBLE ENVIRONMENT. THESE PROJECTIONS SHOULD BE MADE IN ACCORDANCE WITH THE FOLLOWING PROVISIONS:

(A) PERFORMANCE ASSESSMENTS USED TO DETERMINE COMPLIANCE WITH THE PROJECTED PERFORMANCE REQUIREMENTS SHOULD CONSIDER *REALISTIC PROJECTIONS* OF THE PROTECTION PROVIDED BY ALL OF THE ENGINEERED AND NATURAL BARRIERS OF A DISPOSAL SYSTEM.

THE ADOPTION OF 60.113 WILL RESULT IN SIGNIFICANT R&D AND SYSTEM DESIGN CONTINGENCY COSTS DUE TO:

- TIMING AND UNCERTAINTY IN OBTAINING A 60.113(B) COMMISSION APPROVAL
- UNCERTAINTY REGARDING REQUIREMENTS FOR COMPLIANCE WITH 60.113

THE CASE-BY-CASE COMMISSION APPROVAL PROVISIONS IN 60.113(B) REQUIRE LARGE AND TIME CONSUMING EFFORTS BY DOE & NRC.

- DETAILED TECHNICAL ANALYSIS AND PETITION BY DOE (ACCOMPANIES PSAR)
- STAFF ANALYSIS AND RECOMMENDATION
- BOARD* REVIEW AND RECOMMENDATION TO COMMISSION
- COMMISSION FINDING

THE PROCESS COULD TAKE SEVERAL YEARS CONSIDERING FIRST-OF-A-KIND PROBLEMS, TYPICAL STAFF/APPLICANT QUESTION-RESPONSE-ANALYSIS CYCLES, POTENTIAL FOR PUBLIC INTERVENTION, AND THE COMPLEXITY OF SITE SPECIFIC TECHNICAL ISSUES.

*ASLB, ACRS SUBCOMMITTEE, AD HOC PANEL

THE PROPOSED 60.113 REQUIREMENTS ADD NUMEROUS COMPLEX ISSUES TO THE LICENSING PROCESS BY FOCUSING ATTENTION ON NEAR-FIELD AND VERY-NEAR-FIELD PHENOMENA THAT DO NOT STRONGLY AFFECT SYSTEM PERFORMANCE.

- HOW CAN SUBSTANTIAL CONTAINMENT FOR 1000 YEARS BE PROVEN?
- MUST ALL PACKAGES SURVIVE? IF NOT, HOW MANY?
- CAN STATISTICALLY SIGNIFICANT 1000 YEAR ACCELERATED TESTS BE PERFORMED?
  - RADIATION ON PACKAGE COMPONENTS?
  - BRINE ON PACKAGE COMPONENTS?
  - RADIATION ON BRINE?
  - PACKAGE COMPONENT INTERACTIONS WITH EACH OTHER?
- DO STANDARDS APPLY TO WORST-CASE OR AVERAGE PACKAGE?
- WHERE IS THE COMPLIANCE BOUNDARY FOR THE 10^{-5} CRITERION?
- HOW CAN LICENSING CREDIT BE DETERMINED FOR ENGINEERED SYSTEM COMPONENTS?
  - LONG-TERM PROOF TESTING?
  - LONG-TERM MATERIALS PROPERTIES
  - BASIS FOR DETAILED INTRA-REPOSITORY FLOW CALCULATIONS
  - BASIS FOR ENGINEERED COMPONENT LONG-TERM RADIONUCLIDE RETENTION
- FOR SOLUBLE HOST ROCKS (E.G., SALT) HOW CAN FLOW BE SHOWN TO BE AFFECTED BY THE ENGINEERED BARRIERS?

DOE CONCERNS WITH 10 CFR 60 CENTERS ON 60.112 AND 60.113

1. REQUIREMENTS TO MEET GENERIC LEVELS OF PERFORMANCE ON A SITE-SPECIFIC BASIS

2. INCONSISTENCY BETWEEN 60.112 AND 60.113

3. IMPOSITION OF GENERIC ASSUMPTIONS ON SPECIFIC ROCK TYPES

DOE RECOMMENDS:

1. ELIMINATION OF 60.113

2. REDRAFTING OF 60.112

3. CONSULTATION BETWEEN NRC/DOE STAFFS TO RESOLVE OTHER CONCERNS

4. PUBLISH FINAL RULE

BRIEFING ON OPTIONS FOR FINAL 10 CFR PART 60 TECHNICAL CRITERIA

W. J. DIRCKS, ET. AL.

NOVEMBER 18, 1982

TECHNICAL CRITERIA: BACKGROUND ON PUBLIC COMMENTS

- PROPOSED TECHNICAL CRITERIA PUBLISHED FOR COMMENT JULY 8, 1981
- PUBLIC COMMENT PERIOD CLOSED NOVEMBER 5, 1981
- SEVERAL HUNDRED INDIVIDUAL COMMENTS IN 91 LETTERS
- EVERY ISSUE ON WHICH COMMISSION SOUGHT COMMENT/EVERY ASPECT OF RULE ADDRESSED

BACKGROUND ON PUBLIC COMMENTS CONT'D

- SUMMARY OF PUBLIC COMMENTS RECEIVED
  - GENERAL SUPPORT FOR MULTI-BARRIER APPROACH
  - CONCERN EXPRESSED OVER:
    - NUMERICAL PERFORMANCE REQUIREMENTS
    - LACK OF EPA STANDARD
    - MEANING OF REASONABLE ASSURANCE
    - LENGTH OF RETRIEVABILITY REQUIREMENT
    - LEVEL OF DETAIL
    - TRU REQUIREMENTS
    - DISPOSAL IN UNSATURATED ZONE

STAFF ANALYSIS OF PUBLIC COMMENTS

OBJECTIVE: SYSTEMATIC AND DOCUMENTED IDENTIFICATION AND CONSIDERATION OF ALL ISSUES AND TOPICS RAISED IN THE PUBLIC COMMENTS TO SHOW WHAT WAS DONE IN THE FINAL RULE IN LIGHT OF COMMENTS RECEIVED AND WHY

STAFF ANALYSIS CONT'D.

- LETTERS EXAMINED TO IDENTIFY TOPICS ADDRESSED IN PUBLIC COMMENT
- LETTERS SECTIONED INTO INDIVIDUAL VERBATIM CONTEXTED COMMENTS ACCORDING TO TOPIC
- INDIVIDUAL COMMENTS COMPILED BY TOPIC
- PROPOSED RULEMAKING PACKAGE ANALYZED TOPICALLY BY TEAMS OF COGNIZANT TECHNICAL STAFF IN LIGHT OF COMPILED COMMENTS
- ONGOING MANAGEMENT REVIEW OF DRAFT RESPONSES AND RECOMMENDED CHANGES FOR ADEQUACY OF ANALYSIS, COHERENCY, INTERNAL CONSISTENCY, ETC.
- INDIVIDUAL COMMENTS AND RESPONSES PRESENTED IN 500-PAGE STAFF ANALYSIS
- SYNTHESIS OF INDIVIDUAL COMMENTS AND RESPONSES PRESENTED IN 70 PAGE POLICY OVERVIEW AND SECTION-BY-SECTION ANALYSIS OF CHANGES FROM PROPOSED RULE
- CRITICAL TECHNICAL ISSUES TREATED IN RATIONALE DOCUMENT

ILLUSTRATIVE EXAMPLE-1

DOE LETTER OF NOVEMBER 5, 1981

DOCKET NO. 48

"WE HAVE LONG RECOGNIZED THE NEED FOR A MULTIBARRIER APPROACH AND THE OBJECTIVES WHICH THE COMMISSION IS SEEKING TO ACHIEVE."

STAFF RESPONSE:

MULTIBARRIER APPROACH RETAINED (§60.112 & §60.113(A)(1)(I))

INDIVIDUAL REPOSITORY SUBSYSTEMS IDENTIFIED:

- CONTAINMENT WITHIN WASTE PACKAGES
- CONTROLLED RELEASE FROM UNDERGROUND FACILITY
- MINIMUM GROUNDWATER TRAVEL TIME TO ACCESSIBLE ENVIRONMENT

ILLUSTRATIVE EXAMPLE-2

DOE LETTER OF NOVEMBER 5, 1981:

DOCKET NO. 48

". . . THE DEPARTMENT CONSIDERS THAT A MORE APPROPRIATE WAY OF ACCOMPLISHING THE OBJECTIVES EXPRESSED BY THE COMMISSION WOULD BE TO PROVIDE SPECIFIC SUBSYSTEM PERFORMANCE GOALS . . . BY PROVIDING THE FLEXIBILITY TO SELECT NUMERICAL SUBSYSTEM CRITERIA ON A CASE-BY-CASE BASIS."

STAFF RESPONSE:

NUMERICAL PERFORMANCE OBJECTIVES FOR INDIVIDUAL SUBSYSTEMS (§60.113(A)(1)(II) & (2)) WITH FLEXIBILITY TO PROPOSE ALTERNATIVE NUMBERS (§60.113(B))

ILLUSTRATIVE EXAMPLE-3

DOE LETTER OF NOVEMBER 5, 1981

DOCKET NO. 48

". . . IT IS NOT CLEAR HOW THE INDIVIDUAL PERFORMANCE OBJECTIVES ARE RELATED TO THE EPA RELEASE LIMITS USING THE TECHNIQUES OF PERFORMANCE ANALYSIS AND AN UNDERSTANDING OF THE GEOLOGIC AND HYDROLOGIC ENVIRONMENTS."

STAFF RESPONSE:

RELATIONSHIP BETWEEN ASSUMED EPA STANDARD (DRAFT NO. 19) AND NUMERICAL PERFORMANCE OBJECTIVES SHOWN IN RATIONALE DOCUMENT. SANDIA PERFORMANCE ASSESSMENT MODELS USED IN ANALYSIS. UNCERTAINTIES ASSOCIATED WITH GEOLOGIC AND HYDROLOGIC ENVIRONMENTS DISCUSSED EXTENSIVELY.

ILLUSTRATIVE EXAMPLE-4

DOE LETTER OF OCTOBER 29, 1982

DOCKET NO. 91

"WE ARE SERIOUSLY CONCERNED OVER THE NUMERICAL REQUIREMENTS. . . FOR COMPONENTS. . . WE BELIEVE THAT THE NEED TO DEMONSTRATE COMPLIANCE WILL UNNECESSARILY COMPLICATE AND PROLONG THE LICENSING PROCESS."

STAFF RESPONSE:

- LICENSING PROCESS REQUIRES IDENTIFICATION AND ASSESSMENT AGAINST NUMERICAL CRITERIA OF CONTRIBUTIONS TO OVERALL SYSTEM PERFORMANCE OF ALL INDIVIDUAL SUBSYSTEMS OF DOE DESIGN FOR WHICH DOE WANTS CREDIT.
- ABSENCE OF NUMERICAL CRITERIA IN RULE DOES NOT CHANGE NEED FOR DOE TO IDENTIFY AND DEMONSTRATE INDIVIDUAL SUBSYSTEM PERFORMANCE.
- POTENTIAL FOR LITIGATION INVOLVING COMPLIANCE DEMONSTRATION IN LICENSING PROCESS REGARDING PERFORMANCE OF INDIVIDUAL SUBSYSTEMS EXISTS REGARDLESS.
- COMMISSION JUDGMENT THAT IDENTIFICATION OF INDIVIDUAL SUBSYSTEM NUMERICAL CRITERIA IN RULE ADDS TO CONFIDENCE (LEADS TO REASONABLE ASSURANCE) AND MORE CLEARLY DEFINES HEARING ISSUES FOR INDIVIDUAL SUBSYSTEM ASSESSMENT.
- ABSENCE OF NUMERICAL CRITERIA IN RULE BROADENS SCOPE OF ISSUES TO BE LITIGATED.
- BROADENED SCOPE HAS POTENTIAL FOR NEEDLESS EXPENSE AND DELAY IN DISPOSAL OF NATION'S WASTE.

STATEMENT OF ISSUES

HOW TO PROCEED WITH 10 CFR PART 60 IN THE ABSENCE OF THE EPA STANDARD

- EPA STANDARD IS USED AS THE OVERALL PERFORMANCE GOAL FOR 10 CFR PART 60
- PUBLICATION OF THE EPA STANDARD HAS BEEN IMMINENT FOR AT LEAST 2 YEARS, BUT HAS STILL NOT BEEN PUBLISHED FOR COMMENT
- NUMERICAL PERFORMANCE OBJECTIVES NEEDED TO HAVE CONFIDENCE THAT THE EPA STANDARD IS MET
- MINIMUM GROUNDWATER TRAVEL TIME NEEDED TO HAVE CONFIDENCE THAT GEOLOGIC SETTING CAN PROVIDE ADEQUATE ISOLATION

WHY EPA STANDARD IS NEEDED

THE EPA STANDARD WILL SETTLE A NUMBER OF IMPORTANT ISSUES THAT PART 60 DOES NOT COVER

- IT SPECIFIES THE QUANTITIES OF RADIOACTIVE MATERIAL THAT CAN BE RELEASED TO THE ACCESSIBLE ENVIRONMENT FROM A REPOSITORY FOR ANTICIPATED AND UNANTICIPATED PROCESSES AND EVENTS

- IT SETS THE TIME PERIOD OVER WHICH PERFORMANCE MUST BE ASSESSED - 10,000 YEARS

- IT PROVIDES THE DEFINITION OF THE ACCESSIBLE ENVIRONMENT

- WE ARE RELYING ON THE EPA EIS ON ITS STANDARD TO ADDRESS WHAT ARE THE RADIOLOGICAL IMPACTS OF HLW DISPOSAL

OPTIONS FOR PROCEEDING WITH PART 60

- o FINALIZE ENTIRE RULE EXCEPT FOR NUMERICAL PERFORMANCE OBJECTIVES FOR CONTAINMENT AND CONTROLLED RELEASE RATE, WHICH WOULD BE RESERVED UNTIL AFTER THE EPA STANDARD IS ISSUED

- o FINALIZE ENTIRE RULE EXCEPT FOR NUMERICAL PERFORMANCE OBJECTIVES FOR CONTAINMENT AND CONTROLLED RELEASE RATE, BUT REQUEST PUBLIC COMMENT ON WHETHER OR HOW TO PROCEED IN THE ABSENCE OF THE EPA STANDARD

- o FINALIZE THE ENTIRE RULE AND SAY WE WILL GO BACK AND REVISE IT IF NECESSARY WHEN THE EPA STANDARD IS ISSUED

- o LEAVE THE ENTIRE RULE IN PROPOSED FORM UNTIL THE EPA STANDARD IS ISSUED

- o REPROPOSE THE ENTIRE RULE AND ASK FOR THE PUBLIC COMMENT ON HOW WE SHOULD PROCEED