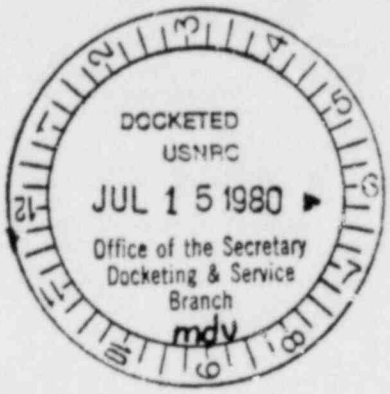
SD901-1

DOCKET NUMBER
PROPOSED RULE PR-60 (18)
(45 FR 31393)

Department of Energy
Washington, D.C. 20545

JUL 15 1980



MEMORANDUM FOR Mr. Samuel Chilk
Secretary, Nuclear Regulatory Commission
Attention: Docketing and Service Branch
Washington, D.C. 20555

The Department of Energy (DOE) is pleased to submit comments on the 10 CFR 60 "Technical Criteria for Regulating Geologic Disposal (of) High-Level Radioactive Waste" which were published as an Advance Notice of Proposed Rulemaking in the Federal Register on May 13, 1980, 45FR94, pages 31393 through 31408. Our comments are provided as three enclosures as follow:

1. Enclosure 1 provides the Departments' response to the four specific questions raised on page 31398 of the Federal Register Notice.

2. Enclosure 2 addresses major concerns identified in the course of our review and which we feel merit detailed consideration by the staff.

3. Enclosure 3 is a listing of specific comments and recommended revisions, many of which are editorial in nature or would improve the clarity of the regulation.

The enclosed comments represent the consensus of technical opinion available to the Department. In addition to the consolidated comments noted above, we are transmitting, verbatim, input we have received from a number of recognized experts which we recommend for your consideration. These experts are R. Ellison of D'Appolonia, I. Remson of Stanford University, H. Ross of the University of Utah Research Institute, G. Pinder of Princeton University, F. Parker of Vanderbilt University, N. Cook of the University of California and J. Bird of Cornell University.

During our review of the draft technical criteria it became apparent that the staff has expended significant effort in developing the proposed regulation. Consequently, our review has been chiefly directed towards identifying those areas where technical or interpretative ambiguities exist; where requirements appear excessive without an associated benefit to the public health and safety; where numerical criteria are suggested which have no supportive basis that we are aware of; or where implementation of the criteria would be difficult or impossible due to conflicting requirements or state-of-the-art limitations. Additionally, there are a number of instances in the draft technical criteria where we believed that design details and other limiting specifications (for example, hoist design) are being considered by the Commission when detailed design considerations are more appropriately within the purview of the Department for ultimate review by the Nuclear Regulatory Commission (NRC) staff.

Acknowledged by card. 7/16/80 mdv

The considerations addressed in the draft technical criteria are in general compatible with those currently being applied by the Department in its site evaluation and preliminary design activities although the application of the criteria causes some concern. The Department's approach has been extensively documented in its Statement of Position (DOE/NE-0007) submitted in support of the Waste Confidence Rulemaking. The licensing process to which the Department will be subject, including SAR/ER submittal and review, should provide an acceptable forum for evaluation of the Department's approach to overall repository safety. Consequently, we feel it necessary to take exception in those cases where the Department's responsibility to demonstrate safety would appear to be preempted by the NRC staff or where adequate flexibility is not allowed. These concerns are more specifically discussed in Enclosure 2.

We will be pleased to discuss the enclosed comments with the NRC staff at your convenience.

Sincerely,

Sheldon Meyers

Sheldon Meyers
Deputy Assistant Secretary
for Nuclear Waste Management

3 Enclosures

Enclosure 1

RESPONSES TO FOUR PARTICULAR QUESTIONS
(Page 31398)

Question 1:

Does the list of considerations above clearly, adequately, and fully identify the relevant issues involved in disposal on HLW?

Response:

The list of considerations does identify many key issues, but does not address them with sufficient clarity. There was an apparent emphasis on exhaustively listing items believed to be important by the staff. The actual importance of meeting the criteria, relative to safety, was not explained. For example 60.122(b) lists what the staff perceives to be "potentially adverse" conditions with no parallel attempt to explain why each item was stated.

Clarity suffers from both the organization and the writing style.

The "Nature of the Problem" is defined by listing five problem areas and six underlying principles. Seven considerations are then listed and comments requested on four questions. The draft technical criteria include eight active sections which do not appear to relate to the considerations introduced in the preamble.

The connection between the subtitles of the discussion of "Considerations" and the material discussed is difficult to understand. Subsection (1) "Systems Approach" is the basic "defense-in-depth" concept with which many are more familiar; Subsection (2) reads like design-basis events; Subsection (3) is an enlargement of (1) and might better be a part of it. Subsections (4) and (5) are ambiguous as written. We assume that under (4) Commission staff was trying to comment on whether one could identify "fatal flaws" that would exclude sites from consideration and, conversely, whether one could identify inclusionary attributes. It seems the issue of siting criteria remains open and is not yet to be specifically addressed. In fact, however, the technical criteria do include siting criteria. In (5), Codification of Models, the staff appears to be attempting to come to grips with how much weight is to be given to the use of predictive models and whether specific models should be specified. The treatment given this subject does not clarify the issue. The codification of specific models at this stage of development for both models and criteria is premature.

The supplementary Information section is not worded clearly. The following is quoted from discussion on "Codification of Models" (p. 31397) as an example:

> "If one views the realization of our understanding in geologic disposal from successively more nearly complete and accurate qualitative descriptions of the observed phenomena in question through more precise and semiquantitative and quantitative approximations where uncertainties are better understood and can be treated mathematically, to an elegant theory embodied in a mathematical description which represents a culmination of human thought, the present state of modeling for geologic repositories is closer to qualitative than quantitative."

The major problem with the Supplementary Information is the apparent inadequacy of the treatment relative to the criteria themselves. More importantly, the background section does not provide support for the criteria. For example, the numerical requirements in the Performance Objectives (60.111) are totally unsupported. Prior to issuing a proposed rule, it is imperative that the bases and rationale be fully illuminated. Also, as noted above, there is little or no correlation between the organization of this section and the criteria themselves.

Question 2:

Would a rule structured along the lines of the referenced draft rule reasonably deal with issues in an appropriate manner?

Response:

The basic structure of Subparts E-I is appropriate, however, many changes to the contents are needed. More importantly the bases and rationale should be structured in a manner consistent with the structure of the rule.

Question 3:

In light of the fact that EPA has the responsibility and authority to set the generally applicable environmental standard for radiation in the environment from the disposal of HLW, with what factors/issues should an NRC environmental impact statement on technical criteria deal?

Response:

The NRC EIS should address alternative approaches to regulating repositories (e.g., no requirements on individual elements of the system, qualitative requirements instead of quantitative requirements, etc.), environmental impacts of complying with the rule as presented compared to the alternatives, and cost benefit analyses of complying with the rule compared to the alternatives. It should also address the trade off between potential decreases in long term impacts versus the actual increases in present day impacts resulting from the extensive site characterization requirements.

Question 4:

What are the environmental impacts of criteria constructed in accordance with the above cited principles? What alternative criteria exist and what are their impacts?

Response:

Environmental and cost impacts will be associated with the requirement to characterize multiple sites at depth (44FR70410), the requirement to design to preserve the option to retrieve for 50 years after emplacement, and the requirement to utilize a 1000-year waste package. Alternative criteria are proposed in the ONWI 33(1) through 33(4) series and in the Department's Statement of Position for the NRC Waste Confidence Rulemaking.

MAJOR ISSUES

A. STANDARD OF PROOF

The staff apparently recognizes in 60.111, Performance Objectives, that it is impossible to prove with certainty that the performance objectives will be met in the far future. Thus the phrase "reasonable assurance" is used in conjunction with several of these criteria. It would be useful to provide, possibly in the statement of considerations, a discussion of the standard of proof implied by "reasonable assurance". The Commission should also provide guidance relative to the time over which reasonable assurance of isolation must be provided. The Department has proposed an objective of 10,000 years as indicated in its Statement of Position on the Confidence Rulemaking. We propose that a 10,000 year requirement be set by the Commission in this regulation as a performance objective for the repository.

B. TRANSURANIC WASTES

Although this document is titled "Technical Criteria for Regulating Geologic Disposal High-Level Radioactive Waste", there are references to TRU wastes. It is assumed that the references are included to address the disposal of TRU waste in a HLW repository. However, we believe this point should be addressed to eliminate the potential inference that these criteria would be applicable to a repository containing only TRU waste. In addition, with the exception of the footnote on page 31400, it is not clearly stated whether the criteria apply to HLW, to TRU waste, or to both.

It might be appropriate that all references to TRU waste requirements be deleted from 10 CFR 60 and made the subject of a separate regulation.

C. CONTAINMENT FOR 1000 YEARS

Paragraph 60.111(c) - Performance of Required Barriers and Engineered Systems requires that both the waste package and the underground facility be designed to provide reasonable assurance that radionuclides will be contained for at least 1,000 years after decommissioning. There is no basis given in the criteria or in the Supplementary Information to support the selection of 1,000 years. The discussion under "1. Lifetime of the Repository" discusses a period which "begins following closure of the repository, and will persist for the time that the relatively short-lived fission products dominate the hazard". The Department agrees with the concept of containment during this fission product period as reflected in the "Statement of Position of the United States Department of Energy, DOE/NE-0007, April 15, 1980, in the Proposed Rulemaking on the Storage and Disposal of Nuclear Waste. In that document, the Department identifies as Performance Objectives 1 (p.II-7):

> "Waste containment within the immediate vicinity of initial placement should be virtually complete during the period when radiation and thermal output are dominated by fission product decay. Any loss of containment should be a gradual process which results in very small fractional waste inventory release rates extending over very long release times, i.e., catastrophic losses of containment should not occur".

However, if 1,000 years is intended to represent this period where the hazard is dominated by the fission products, we believe that it is excessive. Several organizations have developed curves of the relative contributions of actinides and fission products to the radioactivity, decay heat or hazard index of radioactive waste. For example, EPA 520/4-79-007A, "Technical Support of Standards for High-Level Radioactive Waste Management, Volume A, Source Term Characterization" Figures A-4 through A-23 present curves of radioactivity, decay heat generation and untreated dilution index for the cases of a PWR throwaway cycle, PWR UO_2 cycle and mixed oxide cycle. The following table was derived from Figures A-4, A-5, and A-6 of that report.

Fraction of Total Contributed by Fission Products in PWR throwaway cycle

Decay Time in Years From Discharge	Relative Value of Radioactivity	Relative Value of Decay Heat	Untreated Dilution Index ("Hazard")
100	0.5	0.286	1.0
300	0.18	0.02	8.3×10^{-3}
500	1.5×10^{-3}	9.0×10^{-4}	3.8×10^{-3}
1000	1.0×10^{-3}	3.5×10^{-4}	1.4×10^{-3}

Based on this table it can be seen that whether the concern is radioactivity, decay heat, or hazard, the fission products no longer dominate at 300 years. It is recognized that other studies have produced varying results due to the input parameters assumed (burn up, etc.). We are not aware, however, of any calculations that indicate that the hazard is dominated by fission products beyond 300-500 years, let alone 1000 years. Even using the assumption that fission products have decayed to insignificant levels (less than 0.001 of original value) after 10 half-lives, and that cesium-137 and strontium-90 (both having half lives of about 30 years) are the dominant fission products, 300 years containment would appear to be more supportable than 1000 years.

The bases assumed by the staff for assigning the apparently arbitrary 1000-year containment period are not clear and we recommend that this question be reexamined in the light of the potential benefits that could accrue.

D. ONE PART IN ONE HUNDRED THOUSAND ANNUAL RELEASE RATE

Paragraph 60.111(c)(3)(i) specifies the annual release rate from the repository but does not provide any basis or justification for the value given. Since this release rate will be a direct contributor to the release to the biosphere, it should be related to the EPA criteria and to the state-of-the-art rather than stated as an a priori number. Also, it is not clear how long that release rate must be maintained (100,000 years?) or where the boundary of the "underground facility", at which the release is to be evaluated, is located. It must be noted that compliance with this criterion, as well as the other performance objectives, must be demonstrated by predictive calculations and cannot be "proven".

E. RETRIEVABILITY

Paragraphs 60.111(a)(3) and 60.135 require that the repository be designed so that the option remains open to retrieve the waste for up to 50 years after termination of waste emplacement. The basis for this period of time is not presented. In fact, the meaning of the word "retrievability" is not clear. We certainly agree that a specific time period, during which retrievability or recoverability will have to be maintained, should be specified. "Retrievability" implies that canisters can be retrieved as easily as they were emplaced, whereas "recoverability" implies that waste canisters may be recovered intact although requiring removal of backfilled material to do so. The exact period of time during which retrievability or recoverability should be maintained should not be specified now but should be established only after more information is available on the phenomena of concern. It may very well be that the required period of retrievability will depend upon and vary according to the geologic medium and environment in which a repository will be placed.

We are not sure what the present rule intends concerning backfilling of the rooms. We accept the premise that containers should be placed so that they are recoverable intact. However, the rule should not preclude early backfilling of the repository rooms. We believe that sufficient information is not yet available to specify the exact time at which backfilling of repository passages should take place. Backfilling would provide improved conditions for maintaining operational safety. Also, the lesser amount of waste rock that would need to be removed from the repository if backfilling were permitted during operation would reduce the environmental impact of any spoils pile on the surface. Maintaining the rooms in an open, ventilated condition for long periods would amount to storage and would, in effect, pass the responsibility for disposal to future generations. Several initial options exist in approching backfilling. For example, one option would be to backfill a representative number of rooms after loading them with waste. This would allow a productive monitoring program to begin. After the initial monitoring period, backfilling could be done for all of the rooms as they are filled with waste. Therefore we believe that specific time periods for maintaining retrievability or recoverability should not be specified at this time. Rather, the Commission should consider stating that such specific time periods will be established at the time of repository licensing depending upon the conditions at the proposed site.

The Supplementary Information states that "it might be desirable to postpone any irreversible (or not easily reversible) decisions until the maximum amount of reasonably obtainable information about how well the repository is functioning and can be expected to function and contain and isolate the waste for periods of time required [illegible] hand". However, there is no discussion of how this leads to 50 years after termination of waste emplacement nor is there any discussion of negative aspects of postponing this decision.

F. TREATMENT OF UNCERTAINTIES (P. 31395)

While we agree that there are many uncertainties associated with the geologic disposal of high-level radioactive waste, this section fails to put them into perspective. Too little recognition is given to the ability to bound the issues or problems. The end result is the impression of very little confidence in the conclusion that the geologic repository concept is viable. We believe the situation in regard to treatment of uncertainties is as noted in the following quotation from the Department's Statement of Position on in the Waste Confidence Rulemaking (p. II-299):

> "The conservative approach adopted by the Department is based upon a step-wise approach to system development and implementation, a multibarrier system for radionulcide containment and isolation, and appropriate design and operating margins to compensate for uncertainties.
>
> Proceeding in a cautious, step-wise manner in the development and implementation of waste disposal systems adds assurance that the best available information is considered in reaching decisions and irreversible impacts are minimized. The use of multiple independent natural and man-made barriers against waste release minimizes the impacts of potential disruptive forces by avoiding undue reliance on any given barrier. The use of appropriate design and operating margins provides assurance that residual uncertainties inherent in disposal systems are compensated for. Integration of scientific peer review into the program adds further assurance that the waste disposal objectives will be met. The Department's approach insures that the best available pertinent information will be considered in reaching decisions and that a high confidence in safety will be attained in spite of residual uncertainties in data, modeling, or future conditions."

G. HUMAN INTRUSION

This discussion of human intrusion (p. 31398) identifies many problems and their lack of resolution. The rule should provide incentives for developing measures to decrease the probability or consequences of future human intrusion. It should clearly differentiate between active (institutional) controls and passive measures (e.g., markers, tell-tales, etc.). It should also recognize that avoidance of resources is a weak argument against future intrusion. Resources are largely determined by technology, i.e., our ability to use the resources. We do not know what future technological needs may be. The emphasis should be on communicating knowledge of the repository's existence to future generations such that inadvertent intrusion is avoided. Merely avoiding present resources provides little or no assurance. We intend to develop a position paper on this subject to use to initiate a dialog with the Commission staff.

H. SITING REQUIREMENTS

The overall tone of the background material contained as "Supplementary Information" seems to indicate that geology, or the characterization of geology, will be insufficient to provide confidence that isolation can be achieved without additional engineered barriers. The extreme emphasis on "uncertainties" seems to indicate a negative approach to the problem of site selection and characterization.

The siting requirements themselves are structured in a negative way. There is an extensive list of adverse conditions, the presence of which means presumption of unacceptability. This is followed by a section saying that the presumption can be rebutted by demonstrating a number of things including the presence of favorable characteristics. A later section lists some of these favorable characteristics.

The regulation should be focused on repository performance. Each criterion should have a safety or environmental basis which is broadly applicable. Also, criteria must be compatible. These conditions seem to be lacking through the present draft. For example, literal interpretation of §60.122(g) would appear to require that the repository buffer zone be permeated by tunnels for in situ testing and to require shafts and a tunnel 1 km below the repository for the same purpose. Not only is such information of questionable value and very costly to obtain, but the act of obtaining the information could likely render the proposed formation unsuitable.

I. GEOLOGIC SIMPLICITY

The entire Supplemental Information section stresses geologic simplicity as a very important characteristic of a site without clearly explaining what is meant by the term. While we agree that geologic simplicity is a desirable characteristic, it is not the most important attribute of a site. The most important attribute of a natural barrier is that it works, not that it is mechanistically or descriptively simple. The prime purpose of the geologic setting is to contain the waste, and not to facilitate the licensing process. The geologic complexity of a site is based on two factors: (1) the real geologic system and (2) the apparent complexity created by our own inability to comprehend the system. As we learn about these systems the perceived complexity will change. In addressing this problem in the development of criteria, it is critical that the capability of the geologic setting to contain the waste be given a higher priority than the simplicity of the system.

The requirement in 60.122(a)(1) does put geologic simplicity in its proper perspective and that approach should be reflected in the supplemental information.

J. DESIGN SPECIFICATIONS VERSUS PERFORMANCE CRITERIA

In some sections of the document, specific design solutions to problems rather than technical criteria or performance objectives are stated. Specific examples of this are 60.132(c)(9)(v) which states "If aquifers or water-bearing structures

are encountered during construction then the Department must use pregrouting in advance of excavation", and 60.132(c)(6)(ii) which states "The Department shall design hoists with mechanically geared lowering devices that preclude cage free fall". While these may be appropriate designs in some cases, they are not the only solutions to the anticipated problem and may not be the best solutions. The regulation should state criteria not designs. The Department will design to meet the criteria and the NRC staff will have the opportunity to review the design and discuss, with the Department, alternative designs and their relative merits.

SPECIFIC RECOMMENDED CHANGES

A. 60.2 DEFINITIONS

1. NRC Proposed Wording:

"Aquifer" - means a distinct hydrogeologic unit that readily transmits water and yields significant quantities of waste to wells or springs.

Recommended Revision:

"Aquifer" - means a layer of rock or soil which is relatively more permeable than the nearby layers above or below and through which water flows. In an aquifer, the yield to wells is generally considered to be more than 1/3 gallon per minute.

Rationale:

Words like "significant" can lead to endless debate in the licensing process.

2. NRC Proposed Wording:

"Container" - means the first major sealed enclosure that holds the waste form.

Recommended Revision:

"Canister" - means the innermost sealed enclosure that holds the waste form.

Rationale:

Canister is the more commonly used term. The term "first" is unclear depending on whether one is counting from the outside or the inside.

3. NRC Proposed Wording:

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

Recommended Revision:

"Decommissioning" - means removal from active operational usage including decontamination and/or dismantlement.

Rationale:

Decommissioning should be differentiated from isolation.

4. NRC Proposed Wording:

"Disposal" - means permanent emplacement within a storage space with no intent to retrieve for resource values.

Recommended Revision:

Delete "for resource values".

Rationale:

The te · "permanent emplacement" earlier in the definition implies no intent to retrieve for any reason. If there is intent to retrieve, the term "storage" rather than "disposal" would apply, and emplacement would not necessarily be "permanent". Although the capability to retrieve will be maintained through the operational phase, there is no intent to retrieve unless required for safety.

5. NRC Proposed Wording:

"Expected processes and events" - means those natural processes or events that are likely to degrade the engineered elements of the geologic repository during a given period after decommissioning. As used in this part, expected processes and events do not include human intrusion.

Recommended Revision:

Change "degrade" to "occur and act upon".

Rationale:

The definition of "expected processes and events" is limited to these processes or events" that are likely to degrade the engineered elements..." Since this is a much narrower definition than would normally be ascribed to the term "expected processes and events", either the term should be made more specific and descriptive, or its definition should be more general for consistency with normal usage.

6. NRC Proposed Wording:

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

Recommended Revision:

Use a different word than floodplain.

Rationale:

This definition does not correspond with the standard meaning of "floodplain" as used by other government agencies (EPA). Suggest another term covering all areas susceptible to flooding, e.g., "floodprone".

7. NRC Proposed Wording:

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

Recommended Revision:

Redefine to address TRU disposal also, if appropriate.

Rationale:

See major comments.

8. NRC Proposed Wording:

"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.

Recommended Revision:

"Important..." means those structures, systems, and components that prevent or mitigate events that could cause unreasonable risk to the health and safety of the public due to release of radioactive material.

Rationale:

To be consistent with 60.171(b).

9. NRC Proposed Wording:

"Stability" - means the rate of natural processes affecting the site during the recent geologic past are relatively low and will not significantly change during the next 10,000 years.

Recommended Revision:

"Stability" is a relative term indicating that the rates of natural processes such as erosion and faulting are so low that their effect will not jeopardize isolation of the waste. This is determined by measuring the present rates of those processes and, by geologic evidence, deducing the rates in effect during the recent geologic past.

Rationale:

Specifying 10,000 years is useful and reasonable, but the terms above are somewhat subjective. It is also recommended that the regulation stipulate the first 10,000 years as the period over which reasonable assurance of isolation be provided (i.e., consistent with DOE's proposed objectives as set forth in its Statement of Position in the Confidence Rulemaking).

10. NRC Proposed Wording:

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

Recommended Revision:

a. Insert "other than HLW" after "radioactive waste".

b. Delete numerical definition of 10 nanocuries per gram.

Rationale:

a. Clarity

b. Numerical definitions for TRU wastes are being formulated by EPA and NRC regulations would more appropriately reflect the EPA definition. While DOE regulations use 10 nanocuries per gram to define the level above which TRU-contaminated wastes will not be emplaced in shallow land burial, a more precise evaluation of this limit is underway which may lead to a redefinition.

11. NRC Proposed Wording:

"Underground facility" - means the civil engineered structure, including backfill materials, but not including seals, in which waste is emplaced.

Recommended Revision:

Change "civil" to "subsurface".

Rationale:

Clarity.

12. Definitions should be added for the following terms which were used in the regulation:

a. "Institutional Control"

b. "Long Term"

c. "Module"

d. "Saturated Media"

e. "Site Suitability", (Contrast with "Site/Facility Acceptability")

f. "Quaternary" (provide specific length of time)

g. "Vadose Zone"

B. 60.101 PURPOSE

1. 60.101(e)

NRC Proposed Wording:

(e) The requirements and conditions in subsequent sections assume that disposal will be in saturated media. The Commission does not intend to exclude disposal in the vadose zone or any other method by promulgating these criteria; however, different criteria may need to be developed to license other disposal methods.

Recommended Revision:

Rewrite or delete.

Rationale:

This seems unduly restrictive and raises questions as to what actually constitutes a saturated medium and as to whether these criteria apply to salt deposits.

C. 60.111 PERFORMANCE OBJECTIVES

1. 60.111(c) Performance of Required Barriers and Engineered Systems

NRC Proposed Wording:

(1) Waste Package

The Department shall design waste packages so that there is reasonable assurance that radionuclides will be contained for at least the first 1,000 years after decommissioning and for as long thereafter as is reasonably achievable given expected processes and events as well as various water flow conditions including full or partial saturation of the underground facility.

(2) Underground Facility

The Department shall design the underground facility to provice reasonable assurance of the following:

(i) An environment for the waste packages that promotes the achievement of Paragraph 60.111(c)(1) above under conditions resulting from expected processes and events.

(ii) Containment of all radionuclides for the first 1,000 years after decommissioning of the geologic repository operations area and as long thereafter as is reasonably achievable, assuring expected events and processes and that some of the waste dissolves soon after decommissioning.

(3) Overall Performance of the Engineered System After Containment

The Department shall design the engineered system to provide reasonable assurance that:

(i) Starting 1,000 years after decommissioning of the geologic repository operations area, the radionuclides present in HLW will be released from the underground facility at an annual rate that is as low as reasonably achievable and is in no case greater than an annual rate of one part in one hundred thousand of the total activity present in HLW within the underground facility 1,000 years after decommissioning assuming expected processes and events.

(ii) Starting at decommissioning radionuclides present in TRU waste will be released at a rate that is as low as reasonably achievable and is in no case greater than one part in one hundred thousand of the total activity present in TRU waste within the underground facility at the time of decommissioning assuming expected processes and events.

Recommended Revision:

a. Throughout, change "1,000 years after emplacement" to a value which can be more readily supported by technical analysis. (As noted in general comments, 300 years seems to represent a more appropriate period.)

b. In (2)(ii) delete all after "processes".

c. In (3)(ii) add "annual" before "rate".

d. In (3)(i) and (ii) indicate the time frame over which the release rate should be maintained.

e. In (3)(i) and (ii) the "one part in one hundred thousand" should either be substantiated with a technical basis, replaced with a value which can be substantiated, or left qualitative. Clarification should be provided as to the boundary across which the release is measured (e.g., entry into aquifer) and how compliance can be proven.

Rationale:

a. (i) The rationale for a different value is dicsussed under Major Comments.

(ii) As noted in 60.111(a)(3) the option exists not to close the repository for 50 years after termination of waste emplacement operations. This makes the time of decommissioning very uncertain when the first waste is emplaced.

b. The last phrase is too vague to be useful in a regulation.

c. Consistency with (3)(i). The time frame is not stated. Such rates are likely to vary with time.

d. DOE knows of no basis for either promulgating that rate in terms of safety gained or for believing that compliance with that rate could be proven in a licensing proceeding.

2. 60.111(c)(4) Performance of the Geologic Environment

NRC Proposed Wording:

(i) The Department shall provide reasonable assurance that the degree of stability exhibited by the geologic environment at present will not significantly decrease over the long term.

(ii) The Department shall provide reasonable assurance that the site exhibits properties which promote isolation and that their capability to inhibit the migration of radionuclides will not significantly decrease over the long term.

(iii) The Department shall provide reasonable assurance that the hydrologic and geochemical properties of the host rock and surrounding confining units will provide radionuclide travel times to the accessible environment of at least 1,000 years assuming expected processes and events.

Recommended Revision:

a. In (c)(4)(i) change "decrease" to "degrade". Replace "over the long term" with "for the first 10,000 years".

b. Delete (c)(4)(iii).

Rationale:

a. Clarity. Additionally, references in this proposed 10CFR60 to changes in ambient conditions as "unfavorable" need to be considered in terms of some favorable, static ambient reference condition. That is, degradation per se is not relevant, performance degradation beyond some critical value is relevant. Clarity would be enhanced by using 10,000 years (consistent with §60.2 definition of "stability") in place of the more subjective "long term".

b. This item notes that the host rock will provide radionuclide travel time to the accessible environment of at least 1,000 years assuming expected events. Why a time restriction of 1,000 years? The principal point of waste isolation is missed here. The effectiveness of isolation must be related to risk criteria and dose to man predictions.

D. 60.121 SITE AND ENVIRONS OWNERSHIP AND CONTROL

General:

This section appears to recognize that permanent markers and records will last longer than the 100 year institutional control period. There needs to be a clear definition of what credit can be taken for markers and records, but we agree that it is not appropriate to do it at this time.

E. 60.122 SITING REQUIREMENTS

1. 60.122(a)(2)

NRC Proposed Wording:

The Department shall investigate and evaluate the natural conditions and human activities that can reasonably be expected to affect the design, construction, operation, and decommissioning of the geologic repository operations area. The natural conditions include geologic, tectonic, hydrologic, and climatic process. The Department shall evaluate the stability of the geologic repository and the isolation of radionuclides after decommissioning.

(i) The Department shall conduct investigations on the order of 100 kilometers horizontal radius from the geologic repository operations area,

(ii) The Department shall emphasize those natural conditions active anytime since the start of the Quaternary Period in their investigations.

(iii) The department shall emphasize the first 10,000 years following decommissioning in their prediction of changes in natural conditions and the performance of the geologic repository.

Recommended Revision:

a. Change (i) to: "The Department shall conduct investigations throughout the area and volume of the geologic and hydrologic environment which may affect or be affected by the geologic repository to assure that the local site conditions are compatible with the regional setting. The level of detail investigated at each distance from the geologic operations area shall be commensurate with the importance of data at that location."

b. Change (ii) to: "The Department shall document those natural processes active during the Quarternary Period in their investigations.

c. In (iii) insert "and extrapolation" after "prediction". Subsection (iii) is a very significant principle and should be elevated to a major performance objective.

Rationale:

a. The area to be investigated is site dependent. Clearly there is no need to do investigations beyond a defined connection to the accessible environment. Also the level of detail at the outer limits of the investigation does not necessarily have to be as intense as at the site itself.

b. Clarity. Conditions are not active.

c. Completeness. Also, the principle of 10,000 years being the most significant time of interest is very important and should be emphasized.

2. 60.122(a)(3)(ii) and (iii)

NRC Proposed Wording:

(ii) Demonstration of the stability of the geologic repository after decommissioning.

(iii) Demonstration of the isolation of radionuclides from the accessible environment after decommissioning.

Recommended Revision:

Replace the word "Demonstration" in each sentence with "Prediction," and add the phrase "based upon the state-of-the-art," to the end of each sentence.

Rationale:

One cannot demonstrate the future, but one can predict future processes to varying degrees based upon state-of-the-art techniques.

3. 60.122(a)(4)

NRC Proposed Wording:

The Department shall evaluate reasonably likely future variations in the site characteristics which may result from natural processes, human activities, construction of the repository, or waste/rock/water interactions.

Recommended Revision:

Insert "thermomechanical and physicochemical" before "waste/rock/water".

Rationale:

Clarity.

4. 60.122(a)(6)

NRC Proposed Wording:

The Department shall validate analyses and modeling of future conditions and changes in site characteristics using field tests, in situ tests, field-verified laboratory tests, monitoring data, or natural analog studies.

Recommended Revision:

a. Insert "to the extent practicable" after "characteristics".

b. Delete "field-verified"

Rationale:

a. The Supplementary Information section recognized the difficulties encountered in validation.

b. Meaningful field verifications of laboratory tests are not always possible within a "real-time" period.

5. 60.122(a)(7)

NRC Proposed Wording:

The Department shall continuously verify and assess any changes in site conditions which pertain to whether the performance objectives will be met.

Recommended Revision:

Change "continuously" to "continue to".

Rationale:

Continuously means without interruption.

6. 60.122(a)(8)

NRC Proposed Wording:

The Department shall perform a resource assessment for the region within 100 km of the site using available information. The Department shall include estimates of both known and undiscovered deposits of all resources that (1) have been or are being exploited or (2) have not been exploited but are exploitable under present technology and market conditions. The Department shall estimate undiscovered deposits by reasonable inference based on geologic and geophysical information. The Department shall estimate both gross and net value of resource deposits. The estimate of net value shall take into account development, extraction and marketing costs.

Recommended Revision:

a. Change "undiscovered deposits" to "potential reserves".

b. Delete "both gross and".

c. Change "net" to "fair market".

Rationale:

a. It is impossible to assess undiscovered deposits, but is common to estimate potential reserves.

b. Gross value is irrelevant if extraction or marketing costs make it impractical to develop.

c. Fair market is a more useful term than net value in this case.

7. 60.122(a)(9)

NRC Proposed Wording:

The Department shall determine by appropriate analyses the extent of the volume of rock within which the geologic framework, ground water flow, ground water chemistry, or geomechanical properties are anticipated to be significantly affected by construction of the geologic repository or by the presence of the emplaced wastes, with emphasis on the thermal loading of the latter. In order to do the analyses required in this paragraph, the Department shall at a minimum conduct investigations and tests to provide the following input data:

(i) The pattern, distribution, and origin of fractures, discontinuities, and heterogeneities in the host rock and surrounding confining units;

(ii) The presence of potential pathways such as fractures, discontinuities, solution features, unsealed faults, breccia pipes, and other permeable anomalies in the host rock and surrounding confining units;

(iii) The in situ determination of the bulk geomechanical properties, pore pressures and ambient stress conditions of the host rock and surrounding confining units;

(iv) The in situ determination of the bulk hydrogeologic properties of the host rock and surrounding confining units;

(v) The in situ determination of the bulk geochemical conditions, particularly the redox potential, of the host rock and surrounding confining units;

(vi) The in situ determination of the bulk response of the host rock and surrounding confining units to the anticipated thermal loading given the pattern of fractures and other discontinuities and the heat transfer properties of the rock mass.

As a minimum, the Department shall assume that the volume will extend a horizontal distance of 2 kilometers from the limits of the repository excavation and a vertical distance from the surface to a depth of 1 kilometer below the limits of the repository excavation.

Recommended Revision:

a. Delete the last paragraph.

b. In (i) add "statistical" in front of "distribution".

c. In (i), (ii), and (vi) change the discussion of fractures to permeability.

d. In (ii) delete "such as...anomalies".

e. In (iii), (iv), (v), and (vi) delete "in situ" and add at the end "by in situ, laboratory, and field tests and/or calculation as practicable".

f. In (v) change "redox potential" to "equilibrium solubility sorption data for the waste package and radionuclides".

Rationale:

a. If the volume of rock defined at the end of this section is the volume referred to in the first paragraph, it is impossible to assess all of these features throughout the volume (e.g., how can fracture patterns one km below the repository horizon be evaluated). Also, stating a minimum volume, without considering a site, is unrealistic. A detailed in situ determination of the properties discussed in (i) through (vi) of this subsection, to a depth of one km below the repository horizon could possibly compromise the integrity of the system by introducing potential pathways for fluid migration where none existed previously. What is pertinent to determine, by whatever means are available, is whether extensive confined aquifers occur below the repository level at depths which could be significantly affected by the waste repository. The depth of investigation should be determined by the regional geology.

b. Mapping the entire volume is impossible.

c. The term "fracture" tells nothing about the ability of the rock medium to affect waste transport, while permeability does.

d. Some of the features mentioned such as breccia pipes and solution features may be less permeable than the surrounding rock.

e. These items all specify in situ determination of properties. This is appropriate for many properties but some geomechanical (iii) and most geochemical (v) properties cannot practically be subject to "in situ determination". However, the "in situ properties" may be determined in the laboratory. The language needs to be clarified to allow this.

In addition, the type of testing and depth of data should be a function of parameter sensitivity (how much is warranted), uncertainty (is more data required), and ramifications (is data collection compatible with maintaining a sound structure).

By requiring in situ determinations in both host rock and surrounding confining units, NRC is requiring at least two, and perhaps many, test facilities to be constructed at each site. One facility will not be able to propagate thermal effects to surrounding rock units in a reasonable time frame. This appears to be an unreasonable requirement.

There should be some clarification here about ambient stress conditions. In situ determination is hard to do for the host rock, but impossible for the surrounding confining units. This should refer to calculational determination of ambient stress conditions.

Response of surrounding confining units to anticipated thermal loading cannot be measured, it can only be calculated. The time required for heat to reach surrounding confining units is very long and therefore it cannot be measured.

f. Redox potential is not a unique property of the rock but is dependent on the geochemistry, the volume of fluid and the behavior of the waste package.

F. 60.122(b) POTENTIALLY ADVERSE CONDITIONS

1. NRC Proposed Wording:

The following paragraphs describe human activities or natural conditions which can adversely affect the stability of the repository site, increase the migration of radionuclides from the repository, or provide pathways to the accessible environment. The Department shall demonstrate whether any of the potentially adverse human activities or natural conditions are present. The Department shall document all investigations.

The presence of any of the potentially adverse human activities or natural conditions will give rise to a presumption that the geologic repository will not meet the performance objectives. The conditions and activities in this section apply, unless otherwise stated, to the volume of rock determined by the Department in Paragraph 60.122(a)(8) above.

Recommended Revision:

Replace "can adversely" with "may have the potential to".
Delete second paragraph.

Rationale:

Whether or not the stated conditions are actually of importance is a matter of speculation. The statement as written is without basis.

These conditions should not give rise to the stated presumption. The last paragraph of the section identifies ways to show how they may be acceptable. Also, 60.122(a)(8) is an incorrect reference as it refers to the entire area with a 100 km radius. Presumably (a)(9) is meant.

2. 60.122(b)(1)

NRC Proposed Wording:

Potentially Adverse Human Activities

(i) There is or has been conventional or in situ subsurface mining for resources.

(ii) Except holes drilled for investigations of the geologic repository, there is or has been drilling for whatever purpose to depths below the lower limit of the accessible environment.

(iii) There are resources which are economically exploitable using existing technology under present market conditions.

(iv) Based on a resource assessment, there are resources that have either higher gross or net value than the average for other areas of similar size in the region in which the geologic repository is located.

(v) There is reasonable potential that failure of human-made impoundments could cause flooding of the geologic repository operations area prior to decommissioning.

(vi) There is reasonable potential based on existing geologic and hydrologic conditions and methods of construction for construction of large-scale impoundments which may affect the regional ground water flow system.

(vii) There is indication that present or reasonably anticipatable human activities can significantly affect the hydrogeologic framework. Human activities include ground water withdrawals, extensive irrigation, subsurface injection of fluids, underground pumped storage facilities or underground military activities.

Recommended Revisions:

a. In (ii) delete everything after "purpose" and add "at depths which would adversely affect the subsurface repository volume".

b. Delete (iv).

c. In (vii) change to read "...activities that would alter the hydrogeologic framework in an unacceptable manner".

Rationale:

a. Mines and boreholes which would not adversely affect the repository volume should not preclude the use of a site. Past drilling to above the repository horizon or outside

the horizontal extent of the subsurface workings does not impact the ability of the repository to isolate wastes. Known holes can be sealed and unknown holes are not known and therefore would not be considered.

b. This philosophy places too much importance on resources which, as indicated in the general comments, results in a weak argument for proving safety. The nature of future resource needs is not readily predictable and constantly changes.

c. Referring to 60.122(b)(1)(vii), it is conceivable that some future human activities can have little effect or actually improve the repository hydrologic framework. Ground water withdrawals from closed basins could eliminate a potential water transport capability. Of importance is the significance of the change to safety.

3. 60.122(b)(2)

NRC Proposed Wording:

(i) There is evidence of extreme bedrock incision since the state of the Quaternary Period.

(ii) There is evidence of dissolutioning, such as karst features, breccia pipes, or insoluble residues.

(iii) There is evidence of processes in the candidate area which could result in structural deformation in the volume of rock such as uplift, diapirism, subsidence, folding, faulting, or fracture zones.

(iv) The geologic repository operations area lies within the near field of a fault that has been active since the start of the Quaternary Period.

(v) There is an area characterized by higher seismicity than that of the surrounding region or there is an area in which there are indications, based on correlations of earthquakes with tectonic processes and features, that seismicity may increase in the future.

(vi) There is evidence of intrusive igneous activity since the start of the Quaternary Period.

(vii) There is a high and anomalous geothermal gradient relative to the regional geothermal gradient.

Recommended Revision:

a. General; these features mentioned are merely an inventory of natural processes going on almost everywhere. Whether or not they matter is part of the site selection procedure and the presumption that they do is a judgement made with bias. They should be deleted or a technical basis provided to support each.

b. Clarify the meaning of "extreme" in (i).

c. In (ii) replace "dissolutioning" with "dissolution". Insert "Quaternary" before "dissolution".

d. In (iii) insert "Quaternary tectonic" before processes.

e. In (iv) define "near field".

f. Delete (v) or put an absolute level on seismicity.

g. In (vi) delete "intrusive".

Rationale:

b. The meaning of "extreme" is subject to wide-ranging interpretations. Moreover, this requirement rules out investigation into the source of the entrenchment and its present and anticipated state of activity. The requirement ought to allow the Department to demonstrate by analysis whether groundsurface lowering could adversely affect the repository during the required containment period.

c. The presence of dissolution features does not necessarily discredit a candidate site. In the case of salt domes the cap rock is a by-product of dissolution that may have occurred much earlier in geologic history and may presently be acting as an effective impermeable seal.

Evidence of dissolution, collapse, or similar features which resulted from Pre-Quaternary geologic processes that have since been inactive, should not by itself disqualify a site. Reasonable proof of stability during the Quaternary should be required and adequate.

d. A time frame for these processes must be listed - otherwise all areas of the earth are "adverse".

e. "Near field", in contemporary usage, applies to earthquakes. It is not meaningful to refer to the "near field of a fault". This criterion is important, and it should be addressed more clearly and directly.

f. Increased seismicity is identified as a potentially adverse natural condition. Seismic activity can range from minor crustal adjustments to major disruptive events. Therefore, by simply noting that an increase in seismicity (with no qualification as to magnitude) is potentially a disruptive event involves faulty logic. In any case, seismicity effects on a repository must be considered in two time frames - during operation and after decommissioning. Effects on a repository vary greatly depending on the time frame. After decommissioning, seismicity may or may not be significant.

g. Any igneous activity since the start of the Quaternary Period is more disqualifying than many factors listed in this section.

4. 60.122(b)(3)

NRC Proposed Wording:

(i) There is potential for significant changes in hydrologic conditions including hydraulic gradient, average pore velocity, storativity, permeability, natural recharge, piezometric level, and discharge points. Evaluation techniques include paleohydrologic analysis.

(ii) The geologic repository operations area is located where there would be long term and short term adverse impacts associated with the occupancy and modification of floodplains. (executive Order 11988).

(iii) There is reasonable potential for natural phenomena such as landslides, subsidence, or volcanic activity to create large-scale impoundments that may affect the regional ground water flow system.

(iv) There is a fault or fracture zone, irrespective of age of last movement, which has a horizontal length of more than a few hundreds of meters.

Recommended Revision:

a. General:

The criteria listed are stated to be "technical" against which a license application can be reviewed. However, few criteria (and here hydrologic criteria are principally addressed) can possibly be called technical. The regulations heavily rely on qualified terms such as low hydraulic gradient, little hydraulic communication, long ground water residence time, long flow paths, or such phrases as "may effect the regional ground water flow system". Instead of (or perhaps in addition to) emphasizing these terms, the regulations should stress end products of waste isolation rather than a descriptive hydrogeologic narrative. For example, important products should be (a) estimates of acceptable risk afforded by specific radionuclide retention in a given geologic medium or comparisons between media, and (b) dose calculations under natural flow conditions and reasonable scenario variations. To understand these items, it is necessary to evaluate ground water flow paths and travel times plus radionuclide concentrations and distributions to the biosphere. The difference being the former is the end product while the latter are intermediate steps. Waste isolation is not assured by high or low gradients or long or short flow paths but rather by the response of the entire hydrogeologic and hydrochemical system of the host medium.

b. In part (i) delete "average pore velocity" or change it to "seepage velocity". Also insert "adverse" before "changes".

c. Delete part (iv) as written and replace with a criterion that addresses ground water conductivity.

Rationale:

a. Pore velocity is not a uniquely defined term. Potential for change to improve the isolation capability is not adverse.

b. No site is likely to be free of this sort of feature. If such "old" features exist, they should require detailed investigation to determine whether it functions as a ground water barrier or conductor, where in the ground water system it occurs, and how it may perturb the system.

c. It is the existing hydrologic environment that will be the prime factor in assessing transport. The scenarios for change should not be considered more important than the existing conditions.

5. 60.122(b)(4)

NRC Proposed Wording:

The rock units between the repository and the accessible environment exhibit low retardation for most of the radionuclides contained in the radioactive waste.

Recommended Revision:

Delete this paragraph.

Rationale:

Unspecific terms such as "low retardation" and "most" make this useless as an adverse characteristic.

6. Textual Material Following 60.122(b)(4)

NRC Proposed Wording:

A presumption that the geologic repository will not meet the performance objectives can be rebutted upon showing that the presence of the potentially adverse condition does not adversely affect the performance of the geologic repository. In order to make this showing, the Department shall first demonstrate that--

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

(2) The effect of the potentially adverse human activity or natural condition on the geologic framework, ground water flow, ground water chemistry and geomechanical integrity has been adequately evaluated using conservative analyses and assumptions, and the evaluation used is sensitive to the adverse human activity or natural condition;

(3) The effect of the potentially adverse human activity or natural condition is compensated by the presence of favorable characteristics in Paragraph 60.122(c) of this Section; and

(4) The potentially adverse human activity or natural condition can be remedied during construction, operation, or decommissioning of the repository.

Recommended Revision:

Change the first paragraph to:

In order to make a showing that any potentially adverse condition does not adversely affect the performance of the geologic repository, the Department shall first demonstrate that--; and put all of this material before 60.122(b)(1).

Rationale:

See Major Comments.

G. 60.122(c) FAVORABLE CHARACTERISTICS

1. General comment: This section should precede Potentially Adverse Characteristics and a basis for each characteristic should be provided.

2. NRC Proposed Wording:

Each of the following characteristics represents conditions which enhance the ability of the geologic repository to meet the performance objectives. Candidate areas and sites which exhibit as many favorable characteristics as practicable are preferred.

Recommended Revision:

Delete "Candidate areas and". Add "may" before "enhance".

Rationale:

The definition of candidate area (44FR60415) does not indicate the size of an area. DOE uses the term to describe an area on the order of 1000 square miles. It is not known whether or not the characteristics mentioned would enhance isolation in actual cases.

3. 60.122(c)(1)(i)

NRC Proposed Wording:

(i) Exhibits demonstrable surface and subsurface geologic, geochemical, tectonic, and hydrologic stability since the beginning of the Quaternary Period; and

Recommended Revision:

Provide more guidance on what is meant by this criterion.

Rationale:

These are extremely vague terms. As stated, all areas affected by Pleistocene glaciation (including the periglacial zone) would be unsuitable for siting. That is not reasonable, and its probably is not the intent. Also, tectonically stable, meaning zero, does not exist.

Surface "stability" and near-surface hydrologic "stability" according to the definition in 60.2 are certainly not demonstrable since the beginning of the Quaternary Period. What is a more reasonable approach to surface geology and near-surface hydrology is the concept of acceptable ranges and rates of change. The surface and near-surface is the zone where rapid changes in earth processes take place. The changes which have occurred during the Quaternary Period can be evaluated and future changes predicted within limiting values. If it can be shown that changes which occur within these limiting values have no effect on repository safety, then "stability" of the processes need not be demonstrated.

We believe a revision of this item (i) should separate surface geology and near-surface hydrology from subsurface characteristics. Stability of subsurface geologic characteristics should be demonstrated. Surface characteristics and processes need to have limits or limiting ranges defined and evaluated. Hydrologic attributes may need to be evaluated separately for the near-surface and for the deeper subsurface.

4. 60.122(c)(1)(ii)

NRC Proposed Wording:

(ii) contains a host rock and surrounding confining units that provide:

(a) long ground water residence times and long flow paths between the repository and the accessible environment;

(b) inactive ground water circulation within the host rock and surrounding confining units, and little hydraulic communication with adjacent hydrogeologic units due to ground water characteristics such as low intrinsic permeability and low fracture permeability of the rock mass; and

(c) geochemical properties, such as reducing conditions which result in low solubility of radionuclides, and near-normal pH, or a lack of complexing agents.

Recommended Revision:

a. In (b) change "inactive" to "negligible deep".

b. Change (c) to "favorable geochemical properties".

Rationale:

a. The term "inactive" requires an absolute lack of movement, and it implies that there must once have been movement. We are hopeful that candidate areas and sites will show evidence of there never having been significant ground water circulation in the vicinity of the host rock.

b. It would be preferable to state the characteristics in terms of net geochemical performance, rather than specifying which part of the redox, pH, and complexing spectra is desirable. This could also include such items as low leachability and mobility of radionuclides.

It is not clear what is meant by "near-normal pH". Whatever conditions exist at the site prior to disturbance are, by definition, normal. If the authors mean "neutral pH", that is neither possible nor beneficial in rocks whose usual environment is acidic or basic. Furthermore, "neutral" pH contradicts "reducing conditions".

5. 60.122(c)(2)(iii)

NRC Proposed Wording:

(iii) possesses ground water flow characteristics that--

(a) result in a host rock with very low water content;

(b) prevent ground water intrusion or circulation of ground water in the host rock;

(c) prevent significant upward ground water flow between hydrogeologic units or along shafts, drifts, and boreholes;

(d) result in low hydraulic gradients in the host rock and surrounding confining units;

(e) result in horizontal or downward hydraulic gradients in the host rock and surrounding confining units; and

(f) result in ground water residence times under ambient conditions, between the repository and the accessible environment, that exceed 1000 years.

Recommended Revision:

a. Delete (a).

b. In (b) delete "ground water intrusion or". Add "rapid" before "circulation".

Rationale:

a. Water content is not relevant, permeability and water movement are.

b. By definition ground water will be intruded into the rock. Also, some ground water movement, albeit slow, would be expected. Ground water movement at a rate which would result in insufficient isolation times are to be avoided.

6. 60.122(c)(2)(v)

Not Proposed Wording:

"possess a low population density";

Recommended Revision:

Specify and explain why a low population density is necessary.

Rationale:

Low population density means different things to different people. As written this could lead to endless debate in a hearing. Note that population density and meteorological characteristics (vi) are not properties of the volume of rock as stated.

H. 60.132(a) GENERAL DESIGN REQUIREMENTS

1. 60.132(a)(1) Compliance with Mining Regulations

NRC Proposed Wording:

The Department shall design, construct and operate the surface and subsurface facilities to comply with all applicable Federal and state mining regulations including Subchapters D, E, and N of 30 CFR Part 57 as applicable.

Revision:

Delete

Rationale:

This paragraph is not appropriate in an NRC regulation. There is some question whether an underground civil structure is a mine. This regulation refers to it as a "civil engineered structure". This question will be resolved by DOE and MSHA. If it is determined that MSHA rules are applicable, they will be enforced by MSHA and the NRC paragraph adds nothing. If MSHA determines that their rules are not applicable, the NRC would be in the position of enforcing another agency's rules which that agency says are not applicable.

It should also be noted that mine safety regulations may, in some cases, be incompatible with safe repository operation. For example, reversing air flow direction in the case of a fire would bypass the ventilation exhaust filters. These cases need to be worked out among the applicable regulatory agencies to avoid conflicting objectives.

2. 60.132(a)(1)(i)(a)

NRC Proposed Wording:

Prevent the accumulation of radioactive material in those systems to which access by personnel is required.

Recommended Revision:

Change "Prevent" to "minimize"

Rationale:

In general it is impossible to prevent slight accumulation of radioactive material, but proper design can minimize it.

I. 60.132(b) ADDITIONAL DESIGN REQUIREMENTS FOR SURFACE FACILITIES

1. 60.132(b)(2)

NRC Proposed Wording:

The Department shall design and construct surface facilities to facilitate safe and prompt retrieval of wastes including facilities to inspect, repair, decontaminate, and store retrieved wastes prior to their shipment off site. Surface storage capacity of all emplaced waste is not required, but must be sufficient to handle waste backlogs prior to shipment offsite.

Recommended Revision:

Delete "and construct"

Rationale:

We agree that designs should exist for facilities required to retrieve waste to assure that they are properly integrated into the overall design. However, the actual construction of facilities that will not be used for several years and in all probability may never be used.

J. 60.132(c) ADDITIONAL DESIGN REQUIREMENTS FOR SUBSURFACE FACILITIES

1. 60.132(c)(1)

NRC Proposed Wording:

The Department shall design the underground facility as an underground civil engineered structure that satisfies requirements for structural performance, control of ground-water movement and control of radionuclide transport. The Department shall design the facility to provide for safe operation during construction, emplacement, and retrieval of waste and to assure compliance with §60.111 (Performance Objectives).

Recommended Revision:

This paragraph should be revised to indicate what is meant by an underground civil engineered structure and reference the requirements for structural performance that are mentioned.

Rationale:

Clarity.

2. 60.132(c)(2)(iv)(a)

NRC Proposed Wording:

The shafts and boreholes are sealed along their entire length as soon after they have served their operational purpose as is practicable.

Recommended Revision:

Delete

Rationale:

This paragraph would seem to contradict 60.111(a)(3) which indicates that the option must exist to leave the shafts open for 50 years after they have served their operational purpose. The time at which boreholes and shafts are to be sealed should be determined as part of the licensing process between issuance of the License and Decommissioning.

3. 60.132(c)(2)(iv)(b)

NRC Proposed Wording:

The sealed shafts and boreholes provide a barrier to radionuclide migration which is at least equivalent to the barrier provided by the undisturbed rock.

Recommended Revision:

The sealed penetrations such as boreholes and shafts provide a barrier such that radionuclide migration from all penetrations is sufficiently low so that acceptable consequences are not exceeded when penetration migration potentials are added to all other repository release potentials. The margin of safety applied to determine acceptable seal performance shall be determined on a site-by-site basis.

Rationale:

The criteria should relate to repository performance, not the undisturbed rock properties. This criterion could, in the extreme, lead to rejection of rock with very low permeability because seals could not be developed to match the rock.

4. 60.132(c)(2)(vi)(c)

NRC Proposed Wording:

The Department shall design the underground facility to include engineered barriers which protect the waste package from (1) natural events and processes, (2) in situ stresses, (3) chemical attack, and (4) groundwater contact. The Department shall determine the location of the barriers by proper engineering analysis and in situ testing. The Department shall include in the design--

Recommended Revision:

Delete

Rationale:

This section calls for reduced creep deformation in the host rock and consequent reduced deformation in the waste package. This implies that reduced deformation would enhance long term isolation which probably is not true. Highly plastic materials, such as salt, possess excellent long term isolation capabilities precisely because they do creep at a high rate, thus closing the voids in the repository that would otherwise act as preferential pathways for the radionuclides to reach the accessible environment. Creep must be accommodated for in the design, not simply "reduced" as this section stipulates.

5. 60.132(c)(3)

NRC Proposed Wording:

The Department shall design the underground facility to facilitate retrieval of waste in accordance with §§60.111(a)(3). To accomplish this the Department shall design the underground facility to assure structural stability of openings and minimize ground water contact with the waste packages and design an emplacement environment that otherwise promotes waste recovery without compromising the ability of the geologic repository to meet the performance objectives.

Recommended Revision:

Delete second sentence.

Rationale:

This requirement to assure structural stability of openings appears to assume no backfill during the retrieval period. See major comment on retrievability. The regulation should state the requirement (first sentence). The Department will design to meet it and NRC should review the design for adequacy.

6. 60.132(c)(4)(i)

NRC Proposed Wording:

The Department shall design subsurface openings to assure stability throughout the construction, operation, and retrieval periods. If support systems and structures are required for stability, the Department shall design them to be compatible with long-term deformation characteristics of the rock and to allow for subsequent placement of backfill.

Recommended Revision:

Delete retrieval periods.

Rationale:

See previous comment.

7. 60.132(c)(5)

NRC Proposed Wording:

Lining of Subsurface Excavations

The Department shall line subsurface excavations in areas that require:

(i) A positive control of water or gas inflow from aquifers or other porous zones;

(ii) Support for zones of weak or fractured rock;

(iii) Anchorage for equipment or hardware.

Recommended Revision:

Delete

Rationale:

This paragraph would, presumably, eliminate alternate technologies to lining, even when alternatives may prove suitable and cost effective. In some cases, lining may be particularly undesirable. For example, adequate anchorage is possible in competent rock without lining. Further, this criterion should consider any consequences of lining or requirements for sealing. If the statement is required at all, it should simply state that: "Engineered control procedures should be used in any areas that require:..."

8. 60.132(c)(6)

NRC Proposed Wording:

Shaft conveyances used in waste handling

(i) The Department shall consider shaft conveyances as a system important to safety.

(ii) The Department shall design hoists with mechanical geared lowering devices that preclude cage free fall.

(iii) The Department shall design hoists with a reliable cage location system that provides direct signals from all levels in the shaft. The Department shall design and construct final unload points which are controlled and verified by local position detectors.

(iv) The Department shall design shaft loading and unloading systems with a reliable system of interlocks that will fail safely upon malfunction. The Department shall include in the design two independent indicators to indicate whether waste packages are in place, grappled, and ready for transfer.

Recommended Revision:

a. Insert "Radioactive" before "waste" in the title.

b. Insert "used to transport radioactive wastes" before "as" in (i).

c. Delete "with mechanically geared lowering devices" in (ii).

Rationale:

a&b. It should be clear that these requirements do not apply to the waste rock hoists.

c. Although the prevention of free fall is an important design goal, there is no reason at this time to restrict the technology method for achieving it.

9. 60.132(c)(7)(ii)

NRC Proposed Wording:

The Department shall insure that the contact between lining and the rock surrounding subsurface excavations does not jeopardize repository containment by providing a preferential pathway for ground water or radionuclide migration.

Recommended Revision:

Delete all after "containment".

Rationale:

A preferential pathway may or may not jeopardize repository containment.

10. 60.132(c)(9)

NRC Proposed Wording:

Compacted Backfill Test Section

To verify performance requirements intended in the design the Department shall establish, before any backfill placement is

initiated, a program for placement, sampling, and testing of the backfill section. If the result of testing and observations made at the test section are different from the original design intent then the Department must analyze the need for changes and report the recommended changes to the Commission.

Recommended Revision:

Delete "Compacted" from the title.

Rationale:

It presupposes that compaction is the best method. One might want to use material that would expand upon being wetted. Most backfill may not be compacted.

11. 60.132(c)(9)(v)

NRC Proposed Wording:

If aquifers or water-bearing structures are encountered during construction then the Department must use pregrouting in advance of excavation.

Recommended Revision:

Delete

Rationale:

Pregrouting in advance of excavation is only one of several engineering solutions to water inflow problems. Others include freezing and lining and temporary dewatering with short boreholes from within the excavation. In the case of repositories, pregrouting may be particularly unattractive because the grout may eventually reduce the effectiveness of backfilling and repository sealing. This paragraph should be removed from the regulations entirely. The method for handling water is a normal design consideration.

K. 60.132(d) GENERAL DESIGN REQUIREMENTS FOR CONSTRUCTION

1. 60.132(d)(1)(ii)

NRC Proposed Wording:

The Department shall coordinate the design of the geologic repository with site characterization activities to assure that

boreholes necessary for site characterization are located at future positions of shafts or large unexcavated pillars.

Recommended Revision:

Delete

Rationale:

Requiring boreholes for site characterization to be located at positions of future shafts or pillars is desirable but too restrictive for all cases. This restriction may cause important geologic information to be missed during investigation. For example, (1) it may be desirable to drill a boring away from the shaft area to further examine anomalous conditions in a geophysical survey or (2) inclined boreholes may provide significant geologic information but tunnels or shafts may not be constructed around these boreholes. Also a deep borehole cannot be controlled well enough to provide this assurance.

In any event, it should be made clear that this section deals only with deep boreholes that penetrate the host rock or other rocks important to isolation. It does not necessarily apply to shallow hydrologic boreholes.

2. 60.132(d)(1)(iii)

NRC Proposed Wording:

If critical host rock and other site specific design assumptions cannot be verified from boreholes, geophysical measurements, and/or an exploratory shaft and initial excavation, then the Department must establish a pilot program to further characterize the entire volume to be occupied by the underground facility and to verify critical host rock and site specific design assumptions prior to design finalization and waste emplacement.

Recommended Revision:

Clarify the timing of this pilot program.

Rationale:

We assume that this additional characterization is to be performed following the CA, concurrent with repository development.

3. 60.132(d)(3)

NRC Proposed Wording:

Excavation Techniques

The Department shall assure that methods used for excavation will neither create a preferential pathway for ground water or radioactive waste migration, nor increase the potential for migration through existing pathway. The Department shall use to the extent practicable mechanical excavators, boring machines and other non-blasting methods. If blasting is required for excavation, the Department must use methods specifically designed for each phase of the work that minimize fracturing of the surrounding rock. In this program the Department may include the use of pilot bores and tunnels and delay systems designed to minimize the amount of explosives detonated simultaneously. If blasting is utilized the Department must utilize controlled perimeter blasting such as the smooth blasting or preshearing techniques and cushion.

Recommended Revision:

Delete all after the first sentence.

Rationale:

The regulation should only state the criterion not the techniques used to meet it.

L. 60.132(e) RECORDS AND REPORTING REQUIREMENTS

1. 10 CFR 60.132(e)(3) Retention of Cores and Logs

NRC Proposed Wording:

The Department shall retain on site, until decommissioning, all cores from all exploratory borings drilled during site selection, site characterization, construction, and operation. The Department shall store the cores in durable boxes housed in weather-proof building. The Department shall arrange the cores to be readily available for inspection. The Department shall store in the same area logs of the borings, including geophysical logs.

Recommended Revision:

Change first sentence to: The Department shall retain until decommissioning, representative cores from exploratory

borings drilled at the site during site characterization, construction, and operation.

Rationale:

The requirement, as written, is unrealistic. During the course of the national site characterization and selection program, tens of miles of cores will be generated from all over the United States. There is no obvious utility in storing a core from a salt dome in Mississippi at a basalt repository in Washington, or vice versa. If a regional repository program were to be initiated, it would be impossible to store all cores at all repositories. In addition, it is common, and necessary, to send portions of cores to laboratories for testing. Such testing may be destructive and therefore that portion of the core cannot be stored in accordance with the requirement. The staff should review this paragraph to determine what is really required.

M. 60.133 WASTE PACKAGE AND EMPLACEMENT ENVIRONMENT

1. 60.133(a)

NRC Proposed Wording:

General Requirements. The Department shall insure...

Recommended Revision:

General Requirements. The requirements of this section are applicable only to H.W. The Department shall insure...

2. 60.133(a)(2)

NRC Proposed Wording:

Provide reasonable assurance that the in situ chemical, physical, and/or nuclear properties of the waste package and/or its interactions with the emplacement environment will not compromise the function of the waste packages. Supporting analyses shall include, but not be limited to, evaluation of the following factors: solubility, chemical reactions, corrosion, gas generation, thermal effects, mechanical strength, mechanical stresses, radiolysis, radiation damage, nuclide retardation, leaching, fire and explosion hazards, thermal loads, and synergistic interactions.

Recommended Revision:

Change "synergistic" to "adverse".

Rationale:

Synergistic interactions may not always be unfavorable.

3. 60.133(b)(3) Free Liquids

NRC Proposed Wording:

The waste package must contain no free liquids.

Recommended Revision:

Change "must not contain free liquids in amounts that could 1) impair the structural integrity of waste package components due to chemical interactions or formation of pressurized vapor, or 2) result in spillage and the spread of contamination in the event of package perforation".

Rationale:

In the case of spent fuel, it is not apparent how the presence of free liquids could be detected, how they could be removed, or what harm they could cause. In any case, an indication of what must be protected against should be provided.

4. 60.133(c)(1)

NRC Proposed Wording:

Physical Dimensions and Weight. Each container has been designed and fabricated to permit safe handling at the repository during operations and if necessary, during retrieval prior to repository decommissioning.

Recommended Revision:

Change "has been" to "shall be"

Rationale:

Editorial.

N. 60.137 MONITORING PROGRAMS

1. NRC Proposed Wording:

The Department shall initiate a system of monitors during site characterization. The Department shall maintain and supplement these monitors, as appropriate, throughout the period of institutional control. The Department shall design the monitoring systems to verify that the performance objectives of Section 60.111 are being achieved.

Recommended Revision:

Change "throughout the period of institutional control" to "until repository closure".

Rationale:

Most of the monitoring performed during repository operation is not appropriate after closure (e.g., 60.132(c)(2)(vii)(b)). Post closure monitoring is a different subject altogether and should be treated separately from preclosure monitoring. Perhaps it is too early to develop a regulatory requirement for post closure monitoring.

2. 60.137(b)

NRC Proposed Wording:

They provide baseline information on those parameters and natural processes pertaining to the safety of a candidate site that may be caused by site characterization activities.

Recommended Revision:

Clarify

Rationale:

The meaning of this item is not clear. Is it the intent to measure base line information on parameters and processes which may be disturbed by characterization activities?

Since NRC is requiring multiple sites be characterized, these monitoring requirements are excessive. At best, monitoring of key parameters should continue on a site selected for the repository and not on all "banked" sites.

D'APPOLONIA
CONSULTING ENGINEERS, INC.

Richard D. Ellison
EXECUTIVE VICE PRESIDENT

June 18, 1980

Mr. L. B. Myers
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, Ohio 43201

Dear Mr. Myers:

Enclosed are our Priority I comments (listed on Table I) to the draft NRC regulations for HLW repositories. Priority I means that we feel that the issue is very important and that it will be very important that changes be made.

Tomorrow, we will mail our Priority 2 comments. Those comments are also important and should be considered. However, if changes in Priority 2 items are not accomplished, the impact will not be nearly as severe.

We would be pleased to provide any clarifications to our comments that you may request.

Very truly yours,

Richard D. Ellison

RDE:se
Enclosures

10 DUFF ROAD, PITTSBURGH, PA 15235 TELEPHONE 412/243-0200

TABLE I

Priority I Comments

General

60.111(a)(2)

60.111(a)(3)

60.111(c)(2)(ii)

60.111(c)(3)(i)

60.111(c)(3)(ii)

60.111(c)(4)(iii)

60.122(b)

60.122(b)(1)(ii)

60.122(b)(1)(iii)

60.132(a)(3)(ii)

60.132(c)(2)(iv)(a)

60.132(c)(2)(iv)(b)

60.132(c)(3)

60.132(c)(7)(iii)

60.132(c)(9)(v)

60.135

PRIORITY I ISSUE
[GENERAL]

Subject of Comment:

General--The entire Draft of 10CFR60.

Comment:

The document represents a comprehensive effort with consideration of the multiple geoscience, health safety and engineering disciplines involved. It emphasizes the need of overall public safety concerns regarding radioactive waste disposal, while generally recognizing the realistic fact that absolute isolation may not be assured or necessary. The document attempts to address fairly comprehensively major criteria for siting, design and decommissioning of repositories. A few significant reservations on the overall document are expressed below, while comments on specific sections are discussed separately.

The statement of overall performance objectives is an essential first step in the development of any design criteria. However, the draft tends to intermix the overall objectives with delineation of specific methods on how to achieve these objectives. Such specifications are not necessary at this time and will inhibit the development of alternative design approaches based upon extensive R&D activities and site specific investigations. For instance, requirement of minimum 1,000 year migration period through a geologic media [60.111(c)(4)(iii)], probably would not affect most repository sites. However, there may be sites which have extremely low potential for any release to occur that would not completely meet the 1,000-year criterion. Each site should be judged on its total merits. Another example relates to the designation that the waste package contain radionuclides for at least the first 1,000 years. This could be stated as a general goal, but allowance should be made for consideration of a shorter period if the Department can show some repository sites to have geologic barrier conditions that can confidently be relied upon during the first 1,000 years. If the NRC feels that

example specifications must be included, there should be clear designations that alternatives will be acceptable if the Department demonstrates that overall performance objectives are met.

In summary, it is recommended that all quantitative specifications related to radionuclide release be eliminated or qualified as being goals only. The final acceptance or rejection should always be based on a comparison of predicted release rates with established EPA radiation standards.

Also, comment is appropriate for absolute or extreme terms such as "all," "optimum," "minimum," "maximum," "most severe," and "too complex" that are used in many locations in the draft. It is suggested that use of these terms be reexamined to make sure that an unnecessarily rigid position is not taken that will lead to future controversies in design development and licensing. For instance, the requirement to design against "most severe" geologic event [60.132(a)(3)(ii)] is impossible to meet, since literally the absolute most severe geologic event possible at any site would be eruption of a volcano or displacement due to faulting. In reality, however, the probability of occurrence of these events is so small as to make them unimportant to overall objectives.

PRIORITY I ISSUE
[60.111(a)(2)]

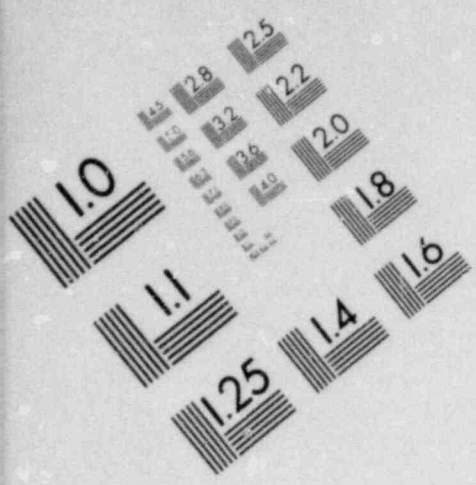
Subject of Comment:

60.111(a)(2) Releases after decommissioning. "The Department of Energy shall provide reasonable assurance that after decommissioning the geologic repository will isolate radioactive wastes to such a degree that quantities and concentrations of radioactive waste in the accessible environment will conform to such generally applicable environmental standards as may have been established by the Environmental Protection Agency."

Comment:

This statement is very reasonable and discussions at meetings with many scientific contributors indicate general concurrence that releases should conform to generally applicable environmental standards.

It is noted here, that this same approach should also be taken relative to determination of the adequacy of penetration seals [Section 60.132(c)(2)(iv)(b)]. At the recent International Meeting on Penetration Sealing (May 7-9, 1980 in Columbus, Ohio) it was a consensus that required performance of seals should be measured in terms of potential nuclide release rates vs allowable standards; as opposed to relating potential seal behavior to undisturbed rock behavior.



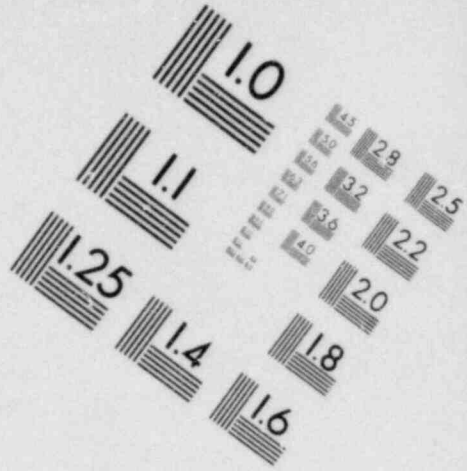
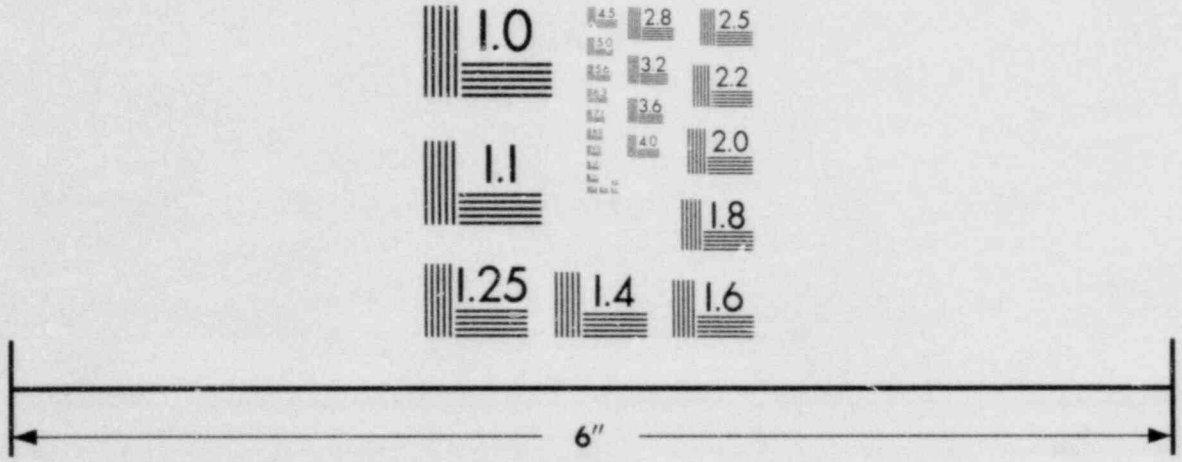
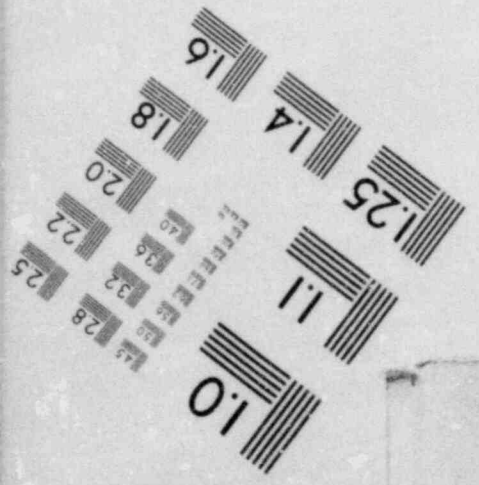


IMAGE EVALUATION
TEST TARGET (MT-3)



MICROCOPY RESOLUTION TEST CHART



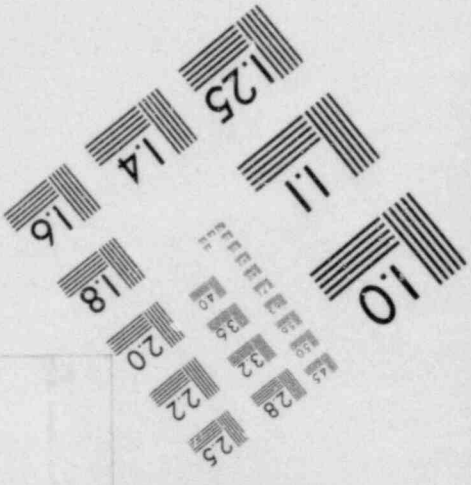


IMAGE EVALUATION
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MICROCOPY RESOLUTION TEST CHART

PRIORITY I ISSUE
[60.111(a)(3)]

Subject of Comment:

60.111(a)(3) Retrievability. "The Department of Energy shall design the geologic repository operations area so that the radioactive waste stored there can be retrieved for a period of 50 years after termination of waste emplacement operations, if the geologic repository operations area has not been decommissioned. If during this period a decision is made to retrieve the wastes the Department shall insure that wastes could be retrieved in compliance with Part 20 of this Chapter and in about the same period of time as that during which they were emplaced."

Comment:

As an initial comment, the above statement about retrievability can be confusing. It states fairly positively that the waste must be retrievable for 50 years after termination of operations if the area has not been decommissioned. However, the statement does not address retrievability if the area is decommissioned. Also, what are the conditions which can lead to decommissioning of an area? This confusion should be resolved in the final regulations.

Possibly of even greater importance, the period of 50 years after termination of operations appears to be very excessive. It is reasonable that the Department and the Commission have some time after waste placement to determine by monitoring that conditions are acceptable for decommissioning without providing special efforts to permit future retrieval. However, the major effort during backfilling and decommissioning should be to maximize long term adequacy of the repository. Trying to maintain a retrievable condition for the operating life plus 50 years could in-and-of-itself reduce the safety of the repository by causing undesirable rock stresses and movements. This will be important in salt because of natural creep closure. It also may be very important in other rocks which will crack, causing additional potential flow paths, if the voids are not backfilled in a reasonable period.

The actual time required for retrieval should be set on a site by site basis depending on conditions at that site and the overall repository design. It would be reasonable to request a minimum retrievable period for the first several years of operation when monitoring is being accomplished. A reasonable time frame would be 5 to 10 years for the first portion of a repository. Then at that time, the Department and Commission should develop a final decommissioning plan for all future areas of the repository.

It is worthy to note that the regulations are requiring engineered waste packages which will last for many more than 50 years. On that basis, retrievability would always be possible for at least 50 years if some extreme condition occurred. The cost would be very high, but that very small risk is justified by having a decommissioned system that tends to maximize long term storage safety.

In closing, the Commission is urged to not close on this issue with an extreme 50 year position until all of the ramifications of such a decision are understood.

PRIORITY I ISSUE
[60.111(c)(2)(ii)]

Subject of Comment:

60.111(c)(2)(ii) "Containment of all radionuclides for the first 1,000 years after decommissioning of the geologic repository operations area and as long thereafter as is reasonably achievable, assuming expected events and processes and that some of the waste dissolves soon after decommissioning."

Comment:

On the basis of Section 60.111(a)(2) the geologic system should not have to contain all radionuclides under all possible conditions. Instead, the level of escape should be within an acceptable standard. Also, it does not appear appropriate to consider "expected" geologic events in this connotation.* Instead, one should consider the probability of events occurring during this relatively short geologic period and the consequences of the events. The resulting risk (determined by considering the probability of the event, the probability of waste dissolutioning, and the probability of intersection of the event and dissolved waste) should be less than the acceptable standard.

*Note: If expected means the probability of event that could occur, or only those events with a high probability of occurrence for a given period, this definition should be incorporated into the Definitions section.

PRIORITY I ISSUE
[60.111(c)(3)(i)]

Subject of Comment:

60.111(c)(3)(i) "Starting 1,000 years after decommissioning of the geologic repository operations area, the radionuclides present in HLW will be released from the underground facility at an annual rate that is as low as reasonably achievable and is in no case greater than an annual rate of one part in one hundred thousand of the total activity present in HLW within the underground facility 1,000 years after decommissioning assuming expected processes and events."

Comment:

Relating the allowable release rates to the total activity in the repository is inappropriate. Using the arbitrary $\frac{1}{100,000}$ ratio could be either conservative or unconservative depending on the size of the site and repository conditions. Instead, the allowable release rate should be determined by the consequence or risk of the indicated release in relation to an acceptable standard. The consequence depends on the mode of potential release, concentration of contaminants, type of radioactive source, etc., in addition to the activity release rate. Risk will depend on the probability of potential events occurring. (Note: It is not appropriate to discuss "expected" geologic events in this situation.*)

*See footnote for Section 60.111(c)(2)(ii).

PRIORITY I ISSUE
[60.111(c)(3)(ii)]

Subject of Comment:

60.111(c)(3)(ii) "Starting at decommissioning radionuclides present in TRU waste will be released at a rate that is as low as reasonably achievable and is in no case greater than one part in one hundred thousand of the total activity present in TRU waste within the underground facility at the time of decommissioning assuming expected processes and events."

Comment:

[See the comments to Section 60.111(c)(3)(i).] The Commission should always limit releases so that consequences or risks are within acceptable standards. Arbitrary quantitative designations can not be appropriate for all repositories and all conditions. Also, geologic events are not "expected."* Instead, there is a probability of their occurrence during any designated time period.

*See footnote for Section 60.111(c)(2)(ii).

PRIORITY I ISSUE
[60.111(c)(4)(iii)]

Subject of Comment:

60.111(c)(4)(iii) "The Department shall provide reasonable assurance that the hydrologic and geochemical properties of the host rock and surrounding confining units will provide radionuclide travel times to the accessible environment of at least 1,000 years assuming expected processes and events."

Comment:

This objective is technically impractical. The travel time alone is only one consideration in determining the influence of nuclear waste release on public health. Other considerations include type, rate, concentration, total quantity of release, entry point to biosphere, mans use of biosphere, etc. As noted in comments on Sections 60.111(c)(3)(i) and (ii), the Commission should be consistent in limiting the consequence on risk of any release to accepted standards. Arbitrary quantitative designations without consideration of site specific conditions just do not make sense and can not be rationally defended. An appropriately designed repositiory will have varying requirements on engineered and geologic barriers, such that the net release to accessible environment is acceptable. Imposing an arbitrary travel time requirement could lead to discarding of some otherwise very attractive sites.

PRIORITY I ISSUE
[60.122(b)]

Subject of Comment:

60.122 (b) Potentially Adverse Conditions. "The following paragraphs describe human activities or natural conditions which can adversely affect the stability of the repository site, increase the migration of radionuclides from the repository, or provide pathways to the accessible environment. The Department shall demonstrate whether any of the potentially adverse human activities or natural conditions are present. The Department shall document all investigations. The presence of any of the potentially adverse human activities or natural conditions will give rise to a presumption that the geologic repository will not meet the performance objectives. The conditions and activities in this section apply, unless otherwise stated, to the volume of rock determined by the Department in Section 60.112(a)(8) above."

Comment:

The impact of potentially adverse conditions is very much overstated by the statement that "the presence of any of the potentially adverse .....conditions will give rise to a presumption that the geologic repository will not meet the performance objectives." That statement is qualified at the end of Section 60.122(b) by allowing a rebuttal if it can be shown that the potentially adverse conditions does not adversely affect performance of the geologic repository. It is strongly recommended that this latter position be taken at the beginning of this section to avoid the process of first "disqualifying" and the "requalifying" sites. This could be accomplished by changing the above wording to state "The presence of any of the potentially adverse human activities or natural conditions will require demonstration by the Department that the conditions do not adversely affect repository performance within acceptable standards if the site is to be considered as a viable option." Example methods of demonstrations are included at the end of this section. (Another way to accomplish this would be to leave the

adverse list out of the regulations entirely and state that it is the Department's obligation to show that the repository will perform adequately for all site conditions. This process will give better potential for selection of the best candidate sites in the United States.)

Finally, the volume considered for evaluation cannot possibly be the 100 km distance stated in Section 60.122(a)(8). It is assumed that this was a typographic error in the draft regulations. The correct reference for volume would appear to be Section 60.122(a)(9).

PRIORITY I ISSUE
[60.122(b)(1)(ii)]

Subject of Comment:

60.122(b)(1)(ii) "Except holes drilled for investigations of the geologic repository, there is or has been drilling for whatever purpose to depths below the lower limit of the accessible environment."

Comment:

The requirement to consider all drilled holes as an "adverse" condition as defined in the draft regulations is unnecessarily restrictive. Certainly, borings several km from the site do not necessarily pose extreme problems in all cases. A primary example would be a salt dome where the boring is completely away from the dome.

Further, borings nearer to the site may be separated from the repository by an adequate barrier or they may be sealed--and all open borings can be reentered for cleaning and sealing. This statement should be eliminated entirely or restated to include only borings at locations which could adversely affect containment and if the boring is not accessible for sealing.

PRIORITY I ISSUE
[60.122(b)(1)(iii)]

Subject of Comment:

60.122(b)(1)(iii) "There are resources which are economically exploitable using existing technology under present market conditions."

Comment:

This item should refer to resource demands and alternate supplies and not just to its exploitability. For example, salt is a resource which could be exploited economically from many salt domes and bedded salt areas. However, that resource will not be exploited because of the abundance of salt. Therefore, use of a particular dome for waste disposal is a preferable use of that resource.

PRIORITY I ISSUE
[60.132(a)(3)(ii)]

Subject of Comment:

60.132(a)(3)(ii) "The Department shall design and locate structures, systems and components important to safety to withstand the most severe of natural phenomena that are likely to occur at the site including seismic, meteorologic and hydrologic events without loss of capability to perform their safety function."

Comment:

It is assumed that this section deals with support facilities during the operations and not related to the repository after decommissioning. In that event, it is noted that the issue of designing nuclear facilities for natural events such as earthquakes has been debated for two decades. The proposed wording is sufficiently subjective to initiate a new series of debates to define "most severe," "likely to occur," and "safety function." It appears more logical for the Commission to adopt the "operating basis" and "safe shut down basis" events presently used for nuclear power plants as given in 10CFR100 Appendix A. The analyses procedures are understood and accepted. Also, they should not be highly controversial for repositories because they usually will not be sited in high risk areas and/or the number of safety related facilities are relatively limited.

PRIORITY I ISSUE
[60.132(c)(2)(iv)(a)]

Subject of Comment:

60.132(c)(2)(iv)(a) "The shafts and boreholes are sealed along their entire length as soon after they have served their operational purpose as is practicable;"

Comment:

Justification for not initially sealing the entire length could include:

- Only certain locations along penetrations are critical to seal performance. Sealing of one or several critical locations could be satisfactory for interim sealing if reentry at a later time to complete the seal is assured.
- Partial seals in boreholes for a temporary period would allow for some monitoring or testing of the seal before the entire penetration is filled.
- Possibly of greatest importance, by only partially sealing a penetration initially it will be possible to complete the seal at a later time (possibly at the time of decommissioning) using the best techniques available at that time. Improved techniques will be developed by ongoing R and D programs and/or by sealing activities of other repositories.
- In the case of shafts and tunnels, it may be desirable to temporarily leave a condition which permits reentry if desirable for future overall operational changes.

ONWI and the BWIP programs are both sponsoring major multiyear contracts to develop acceptable criteria for the materials, installation, and performance of penetration seals. Preliminary results (ONWI-55 and ONWI-90), show the potential benefits stated above for only partial sealing initially. The desirability and technical requirements for temporary partial sealing will be extended to firm, fully justified recommendations during the next several years of these ongoing investigations.

To account for the Commission's objective to assure that penetrations are sealed and yet leave room for improved procedures resulting from extensive generic and site-specific design efforts, the following wording is recommended for this section.

"Penetrations such as boreholes, shafts, and access tunnels shall be sealed along their entire length as soon as practicable after they have served their operational purpose, unless the Department provides procedures for only partially sealing any penetration initially, and has acceptable procedures for completing the seal prior to decommissioning. Justification for partial sealing will only be if there is a real potential for reentry into the penetration or if a substantial benefit from future advanced sealing technology is anticipated. In all cases where partial sealing is planned, the Department must demonstrate that the unsealed portion of the penetration will be preserved in an accessible condition and that all sealing will be completed at the time of decommissioning."

It is recommended that the extent and timing and extent of sealing be incorporated in repository and seal designs and that the NRC criteria reflect this recommendation.

PRIORITY I ISSUE
[60.132(c)(2)(iv)(b)]

Subject of Comment:

60.132(c)(2)(iv)(b) "The sealed shafts and boreholes provide a barrier to radionuclide migration which is at least equivalent to the barrier provided by the undisturbed rock."

Comment:

The report ONWI-55 (Office of Nuclear Waste Isolation, "Repository Sealing Design Approach - 1979") discussed the following alternative design goals for penetration seals.

1. Flow of permeant through the seal zone should be no greater than the flow through a similar area of undisturbed host material.

2. Flow of permeant through the seal zone is small compared with the total flow over the entire repository area.

3. The concentration of any radionuclide escape is within an acceptable limit.

4. The radionuclide migration rate through the seal zone is always less by a specified factor of safety than an acceptable level determined by a consequence analysis.

The proposed draft regulation is similar to the first of these alternatives except that the seal function is related to blockage of radionuclide migration as opposed to permeant flow. ONWI-55 also concludes that radionuclide flow is the appropriate measure for evaluation of seal adequacy.

Argument against either the proposed draft criterion as well as the first two ONWI-55 design goal alternatives are:

- They are not quantitatively related to the most fundamental objective of the repository, i.e., to mitigate the consequences of the stored waste to the biosphere.

- With them it will not be possible to conclusively prove that the objective of the goal is ever met, except perhaps after long-term monitoring of the performance of the seals.

- The goal does not recognize time variations of the repository conditions and of the seal materials.

To these, one could add that the goal could result in the best host rock not being acceptable because it's very low permeability condition makes it much more difficult to satisfy sealing requirements according to the draft. In the limit, a very good repository could be disqualified even if extremely tight seals could be placed--if one could not demonstrate that the seal was exactly equivalent to the host rock in terms of radionuclide blockage.

ONWI-55 recommends that the fourth design goal (see above) be accepted as a criterion for sealing. This goal is the most flexible and workable considering:

- The goal relates to acceptable release rates, thus requiring consideration of all site-specific conditions and institutional standards.

- It is expected that sealing investigations will show that sealing can be accomplished so that potential escape rates are very low. However, it may not be possible to positively conclude that escape rates at and near to a seal positively will be equal to or less than through a very good host material. Thus, the recommended goal does not unduly penalize (and possibly eliminate) the best host rock environments by requiring extreme sealing requirements, while much reduced sealing is required for less ideal host conditions.

- The use of a factor of safety (or some other similar reducing factor) permits the acceptable release level to be reduced as appropriate to account for the total number of penetrations, other potential release paths, any uncertainties in seal behavior or future events, and potential future reductions in institutional standards.

- The use of the factor of safety concept can permit consideration of time changes in repository and seal conditions, by assigning different factors for different time considerations.

Recognizing that the concepts of penetration sealing requirements will be greatly enhanced during the next several years, it is recommended that the draft regulations at this time be revised to permit the Commission and Department to agree upon the best solution when actual seal designs are being developed. The following wording is suggested.

"The sealed penetrations such as boreholes and shafts provide a barrier such that radionuclide migration from all penetrations is sufficiently low so that acceptable consequences are not exceeded when penetration migration potentials are added to all other repository release potentials. The margin of safety applied to determine acceptable seal performance shall be determined on a site-by-site basis."

PRIORITY I ISSUE
[60.132(c)(3)]

Subject of Comment:

60.132(c)(3) "Design to facilitate retrieval of waste. The Department shall design the underground facility to facilitate retrieval of waste in accordance with Section 60.111(a)(3). To accomplish this, the Department shall design the underground facility to assure structural stability of openings and minimize groundwater contact with the waste packages and design an emplacement environment that otherwise promotes waste recovery without compromising the ability of the geologic repository to meet the performance objectives."

Comment:

[See comments to Section 60.111(a)(3).] It is apparent that much additional discussion and evaluation is required before the Commission can give an absolute quantitative requirement for retrievability. It may be that there are several types of retrievability; i.e., "with direct access" before backfilling which would apply for a short period; and "technically feasible but with remining" for some longer period after backfilling. However, the backfilling would be accomplished using procedures aimed primarily at the long term isolation goal. It does not make sense to jeopardize long term isolation of an entire repository simply to achieve an excessive period for "direct access" retrievability.

PRIORITY I ISSUE
[60.132(c)(7)(iii)]

Subject of Comment:

60.132(c)(7)(iii) "During repository construction and operation the Department shall conduct a continued program of surveillance, testing, measurement, and geologic mapping to ensure that design parameters are verified and to provide additional data to confirm the isolation and containment characteristics of the seals and the underground facility. The Department shall measure and monitor changes in subsurface conditions on a regular basis."

Comment:

As with all underground construction activities, it must be anticipated that changed conditions will be encountered from time to time that may require that revisions be made to design parameters and construction techniques. It will be of major benefit to repository schedules and costs if the regulations include a mechanism for making the changes that will not change the overall intent of the repository without disrupting operations. Section 60.132(c)(7)(iii) appears to be an appropriate location to introduce this concept. A suggestion is to modify the wording as follows: ".....that design parameters are verified or appropriate changes made to suit actual field conditions, and to provide data....."

PRIORITY I ISSUE
[60.132(c)(9)(v)]

Subject of Comment:

60.132(c)(9)(v) "If aquifers or water bearing structures are encountered during construction then the Department must use pregrouting in advance of excavation."

Comment:

Pregrouting in advance of excavation is only one of several engineering solutions to water inflow problems. Others include freezing and lining and temporary dewatering with short boreholes from within the excavation. In the case of repositories, pregrouting may be particularly unattractive because the grout may eventually reduce the effectiveness of backfilling and repository sealing. This paragraph should be removed from the regulations entirely. The method for handling water is a normal design consideration.

PRIORITY I ISSUE
(60.135)

Subject of Comment:

60.135 "The Department shall design and construct the geologic repository operations area to permit retrieval of all waste packages, mechanically intact, if retrieval operations begin within 50 years after all of the waste has been emplaced and if the geologic repository has not been decommissioned. The design of the geologic repository operations area shall provide for retrievability of the waste within a period of time that is about the same as that in which it was emplaced."

Comment:

It is again noted that the retrieval/decommissioning situation in the draft regulations is confusing and probably not appropriate. [See comments to Sections 60.111(a)(3) and 60.132(c)(3).]

D'APPOLONIA
CONSULTING ENGINEERS, INC.

Richard D. Ellison
EXECUTIVE VICE PRESIDENT

June 19, 1980

Mr. L. B. Myers
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, Ohio 43201

Dear Mr. Myers:

Enclosed are our Priority II comments (listed on Table II) to the draft NRC regulations for HLW repositories. We do not want to diminish their value because we hope that these changes are made. However, the Priority I issues sent to you yesterday appear to be most critical.

Our review comments resulted from a variety of our personnel working for ONWI and for other repository activities. Accordingly, I am going to bind our comments so that each of our people will have a copy for review and their files. I will send you one of those bound copies so that you will have a complete record of D'Appolonia suggestions.

Very truly yours,

Richard D. Ellison

RDE:se
Enclosures

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TABLE II

Priority II Comments

Pg. 31396 Considerations

60.2 Definitions

60.101(e)

60.111(c)(1)

60.122(a)(2)(i)

60.122(a)(6)

60.122(a)(9)

60.122(a)(9)(v)

60.122(b)(1)(ii)

60.122(b)(2)(v)

60.122(b)(3)(i)

60.122(b)(3)(ii)

60.122(c)(1)(ii)(c)

60.132(c)(2)(i)

60.132(c)(2)(ii)

60.132(c)(2)(v)

60.132(c)(4)(ii)

60.132(c)(5)

60.132(c)(6)(ii)

60.132(d)(1)(ii)

PRIORITY II ISSUE
[CONSIDERATIONS (1)]

Subject of Comment:

Pg. 31396 Considerations (1) Systems Approach. "The term.....decision bases.

"It is evident that for a geologic repository, the geologic setting must be one barrier. In considering whether there should be other barriers, a key question which needs to be answered is whether it is prudent, in view of the nature of the problems and the uncertainties involved; to rely on the geologic setting alone to accomplish the functions stated above. The state-of-the-art in the earth sciences is such that all of the uncertainties associated with these functions cannot be resolved through consideration of the geologic setting.

"It is appropriate.....medium and site."

Comment:

This comment may not require any action by the NRC, but is made to possibly avoid future confusion. The thought presented in this paragraph indicates that the geologic setting can provide only one barrier. At the same time, however, ONWI is performing studies to see if sites can be located which have multiple natural barriers--i.e., where the geologic setting provides more than one barrier. It would appear to be potentially beneficial for the Department and Commission to concur on this concept. That concurrence should also have some effects on how the Commission treats undesirable quantitative specifications which presently cover all sites.

PRIORITY II ISSUE
(60.2)

Subject of Comment:

60.2 Definitions.

Comment:

Definitions of the terms "saturated media", "site", "institutional control", and "module" should be added.

Subject of Comment:

60.2 "Decommissioning--means final backfilling of subsurface facilities, sealing of shafts, and decontamination and dismantlement of surface facilities."

Comment:

Change of "..sealing of shafts..." to "...sealing of penetrations such as shafts..." is recommended.

PRIORITY II ISSUE
[60.101(e)]

Subject of Comment:

60.101(e) "The requirements and conditions in subsequent sections assume that disposal will be in saturated media. The Commission does not intend to exclude disposal in the vadose zone or any other method by promulgating these criteria; however, different criteria may need to be developed to license other disposal methods."

Comment:

Without a definition of saturated media, the statement is not very precise and will have different meanings to different persons. For example, does the term "saturated media" mean that the host is within a continuous water table condition or does it simply imply "below the water table."

PRIORITY II ISSUE
[60.111(c)(1)]

Subject of Comment:

60.111(c)(1) Waste Packages. "The Department shall design waste packages so that there is reasonable assurance that radionuclides will be contained for at least the first 1,000 years after decommissioning and for as long thereafter as is reasonably achievable given expected processes and events as well as various water flow conditions including full or partial saturation of the underground facility."

Comment:

The general purpose of the 1,000 year designation appears reasonable based upon radionuclide decay rates and desired redundancy with the isolation provided by the geologic system. However, it seems premature at this time to absolutely conclude that 1,000 years is the correct number for all repository sites. For example, if a site is determined to provide extremely good natural isolation, but waste packages can be assured for only 700 years because of a chemical condition or waste package costs, the site may still present a very attractive alternative. It is strongly recommended that this section be qualified to permit shorter periods, if the Department can demonstrate that the combined geologic barriers and engineered barriers satisfy the intent of a HLW repository.

PRIORITY II ISSUE
[60.122(a)(2)(i)]

Subject of Comment:

60.122(a)(2)(i) "The Department shall conduct investigations on the order of 100 kilometers horizontal radius from the geologic repository operations area."

Comment:

For some sites 100 km may be too small, while for others, such as salt domes, 100 km may be too large. It is recommended that this section eliminate the strict use of a "quantitative designation" and replace it with "the investigation of each geologic tectonic, hydrologic and climatic factor important to repository functioning should be conducted over that area required to fully describe and analyze that feature." At some sites and for some factors, the distance could be 100 km or more. The level of detail investigated at all distances from the repository site shall be determined to suit the type and importance of data at that location.

PRIORITY II ISSUE
[60.122(a)(6)]

Subject of Comment:

60.122(a)(6) "The Department shall validate analyses and modeling of future conditions and changes in site characteristics using field tests, in situ tests, field-verified laboratory tests, monitoring data, or natural analog studies."

Comment:

It is always difficult to envision every scientific procedure that may be used to verify and/or validate a finding, particularly in an area with major R&D efforts. It is recommended that the following statement be added to the end of this section: ". . .or other method demonstrated to be appropriate by the Department."

PRIORITY II ISSUE
[60.122(a)(9)]

Subject of Comment:

60.122(a)(9) "The Department shall determine by appropriate analyses the extent of the volume of rock within which the geologic framework, ground-water flow, ground-water chemistry, or geomechanical properties are anticipated to be significantly affected by construction of the geologic repository or by the presence of the emplaced wastes, with emphasis on the thermal loading of the latter. In order to do the analyses required in this paragraph, the Department shall at a minimum conduct investigations and tests to provide the following input data...

"As a minimum, the Department shall assume that the volume will extend a horizontal distance of 2 kilometers from the limits of the repository excavation and a vertical distance from the surface to a depth of 1 kilometer below the limits of the repository excavation."

Comment:

In some cases, such as a salt dome, a distance of 2 km from the repository may be excessive. This can be handled without excessive effort, if all parties recognize the level of detail actually needed as distance may vary from site-to-site. Possibly of greater importance, the 1 km depth below the repository as an unqualified requirement may not always be desirable. For example, if there are several aquifers within 1 km distance, it will be desirable that borings below the repository be limited to only the absolute minimum required--and their locations should be very carefully selected. It is recommended that this section be changed to say that the volume extends to 1 km, but that the extent of data required between 300 m and 1 km below the repository will be determined on a site-by-site basis.

PRIORITY II ISSUE
[60.122(a)(9)(v)]

Subject of Comment:

60.122(a)(9)(v) "The in situ determination of the bulk geochemical conditions, particularly the redox potential, of the host rock and surrounding confining units."

Comment:

This statement implies that the most important geochemical characterization is likely to be redox potential (or eH). First, it may not be; pH or trace element/mineral geochemistry may be far more important. Second, this is a very difficult measurement to make accurately under good in situ conditions. Finally, unless the location of in situ measurements is exceptionally clean of foreign matters (drilling mud, oxygen, etc.), the measurement may be meaningless. More important and practical than in situ measurement may be good laboratory work using simulated host rock and fluids.

PRIORITY II ISSUE
[60.122(b)(1)(ii)]

Subject of Comment:

60.122(b)(1)(ii) "Except holes drilled for investigations of the geologic repository, there is or has been drilling for whatever purpose to depths below the lower limit of the accessible environment."

Comment:

This requirement is unncessarily restrictive. Borings may be separated from the Repository by an adequate barrier or they may be sealed. The statement should include the qualifier, "if it is probable that the boring could adversely affect isolation and if complete sealing may not be accomplished."

PRIORITY II ISSUE
[60.122(b)(2)(v)]

Subject of Comment:

60.122(b)(2)(v) "There is an area characterized by higher seismicity than that of the surrounding region or there is an area in which there are indications based on correlations of earthquakes with tectonic processes and features that seismicity may increase in the future."

Comment:

This factor is not needed as special adverse condition. The seismicity of an area will always be one of the important site selection and design factors. The importance of seismicity will be decided on a site-by-site basis.

PRIORITY II ISSUE
[60.122(b)(3)(i)]

Subject of Comment:

60.122(b)(3)(i) "There is potential for significant changes in hydrologic conditions including hydraulic gradient, average pore velocity, storativity, permeability, natural recharge, piezometric level, and discharge joints. Evaluation techniques include paleohydrologic analysis."

Comment:

What is "average pore velocity?" Also, if required at all, this section should apply only if the change would reduce the isolating capability of the repository.

PRIORITY II ISSUE
[60.122(b)(3)(ii)]

Subject of Comment:

60.122(b)(3)(ii) "The geologic repository operations area is located where there would be long term and short term adverse impacts associated with the occupancy and modification of floodplains. (Executive Order 11988)."

Comment:

The intent of this condition is not clear. Apparently, it deals only with surface facilities. It is premature at this time to rule out underground spaces on the basis of surface hydrologic and hydraulic conditions. Future studies may show that surface facility designs can be changed at less cost than required to improve less suitable underground conditions.

PRIORITY II ISSUE
[60.122(c)(1)(ii)(c)]

Subject of Comment:

60.122(c)(1)(ii)(c) "Geochemical properties, such as reducing conditions which result in low solubility or radionuclides, and near-normal pH, or a lack of complexing agents."

Comment:

It would be preferable to state the characteristics in terms of net geochemical performance, rather than specifying which part of the redox, pH, and complexing spectra is desirable. This could also include such items as low leachability and mobility of radionuclides.

PRIORITY II ISSUE
[60.132(c)(2)(i)]

Subject of Comment:

60.132(c)(2)(i) "The Department shall demonstrate that the underground facility includes those engineered features that are needed to limit radioactive releases after decommissioning to levels that are as low as reasonably achievable. The Department shall include an identification and a comparative evaluation of alternatives to the major design features that are provided to enhance radionuclide retardation and containment."

Comment:

As low as reasonably achievable could be stated as a goal. However, the requirement should be related to the acceptable standard.

PRIORITY II ISSUE
[60.132(c)(2)(ii)]

Subject of Comment:

60.132(c)(2)(ii) "The Department shall design the underground facility such that the orientation, geometry, layout, and depth of the underground excavation in addition to any engineered barriers provided as part of the underground facility are optimized for that site. The Department shall use as optimization criteria the performance objectives in Section 60.111(c)(2), (c)(3)."

Comment:

This paragraph requires that the underground facility be optimized (presumably with respect to performance objectives, although this is not clear) for a given site. First, optimization is a normal design function and does not need to be stated in a regulation. More importantly, the section specifies the optimization criteria. It is impossible for anyone to state today all of the factors that should be considered in the design process. These factors and their relative importance for different site conditions will be finalized during the next few years as site investigations, designs and R&D programs are completed. The last sentence of this section should be eliminated as a minimum.

PRIO[illegible] II ISSUE
[60.132(c)(2)(v)]

Subject of Comment:

60.132(c)(2)(v) "The Department shall place emphasis on multicomponent borehole and shaft and seals and use materials that are compatible with the rock properties and other in situ conditions."

Comment:

Consideration should be given toward better qualification of the term "compatible." Compatibility incorporates a spectrum of material properties, including geochemical, thermal response, mechanical response, and must consider host conditions, under a range of physiochemical conditions. It is not necessary for the seal properties to be the same as the rock for compatibility requirements to be completely satisfied. For example, it often will be desirable for the seal material to be more ductile/flexible than the host rock so that the seal will not crack under thermally or mechanically induced movements.

PRIORITY II ISSUE
[60.132(c)(4)(ii)]

Subject of Comment:

60.132(c)(4)(ii) "The Department shall design openings to minimize the potential for deleterious rock movement or fracturing of overlying or surrounding rock. The Department shall optimize opening design, including shape, size orientation, spacing and support materials with respect to natural stress conditions, deformation characteristics of the host rock under thermal loading, and the nature of weaknesses or structural discontinuities present at the location of the opening."

Comment:

See comment to Section 60.132(c)(2)(ii).

PRIORITY II ISSUE
[60.132(c)(5)]

Subject of Comment:

60.132(c)(5) Lining of subsurface excavations. "The Department shall line subsurface excavations in areas that require:

(i) A positive control of water or gas inflow from aquifers or other porous zones;

(ii) Support for zones of weak or fractured rock;

(iii) Anchorage for equipment or hardware."

Comment:

This paragraph would, presumably, eliminate alternate technologies to lining, even when alternatives may prove suitable and cost effective. In some cases, lining may be particularly undesirable. For example, adequate anchorage is possible in competent rock without lining. Further, this criteria should consider any consequences of lining on sealing requirements. If the statement is required at all, it should simply state that: "Engineered control procedures should be in any areas that require:...."

PRIORITY II ISSUE
[60.132(c)(6)(ii)]

Subject of Comment:

60.132(c)(6)(ii) "The Department shall design hoists with mechanical geared lowering devices that preclude cage free fall."

Comment:

Although the prevention of free fall is an important design goal, there is no reason at this time to restrict the technology method for achieving it.

PRIORITY II ISSUE
[60.132(d)(1)(ii)]

Subject of Comment:

60.132(d)(1)(ii) "The Department shall coordinate the design of the geologic repository with site characterizaton activities to assure that boreholes necessary for site characterizaton are located at future positions of shafts or large unexcavated pillars."

Comment:

Requiring boreholes for site characterization to be located at positions of future shafts or pillars is desirable but too restrictive for all cases. This restriction may cause important geologic information to be missed during investigation. For example, (1) it may be desirable to drill a boring away from the shaft area to further examine anomalous conditions in a geophysical survey or (2) inclined boreholes may provide significant geologic information but tunnels or shafts may not be constructed around these boreholes. This section could state that boreholes for site investigation that will not be at a shaft and will require sealing should be minimized, and that they will be permitted only if the Department demonstrates their need and how the seal will be successfully placed.

In any event, it should be made clear that this section deals only with deep boreholes that penetrate the host rock or other rocks important to isolation. It does not necessarily apply to shallow hydrologic boreholes.

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June 18, 198[illegible]

Mr. L.B. Myers
ONWI
Battelle
505 King Avenue
Columbus, Ohio 43201

Dear Mr. Myers:

Some very serious hydrologic errors in the "Technical Support Documentation for the Siting Requirements in USNRC 10 CFR Part 60 - Disposal of High-Level Radioactive Wastes in Geologic Repositories" overshadow all other aspects of the document. These errors have resulted in the preparation of an "Advance Notice of Proposed Rulemaking" that sets up unnecessary requirements and misses the essential requirements.

It should be emphasized that this erroneous information did not come from the regular refereed hydrologic literature. Rather, it came from inexcusable verbage that has been allowed to creep into print in sources other than the regular refereed hydrologic literature as referenced on page 3-6.

First let me describe the erroneous information and erroneous thought trends in these documents:

Page 6-9 discusses "permeability" values as low as 10^{-10} cm/sec. I have seen even lower values in non-refereed literature. First of all, if the units are cm/sec, the correct terminology should be "hydraulic conductivity". When such numbers are substituted into the flow equations at normal groundwater gradients over very long periods of time, they can predict objectionable radionuclide transport to the biosphere. Therefore, it appears to the uninitiated that "Regardless of host rock permeability and depth, there is sufficient time for groundwater to penetrate the repository and return biologically significant radionuclides to the accessible environment." (Page 1-4). As a consequence, groundwater containment cannot be counted on and "Performance studies and sensitivity analyses indicate, over the long term under reasonable conditions, it is primarily the geochemical system that will determine the rate of release of radionuclides to the accessible environment. . . ." (Page 3-6). Because of uncertainties about the geochemical system, it is therefore essentially impossible to prove containment. The result has been the specification of unnecessary testing and requirements while the truly important ones are not mentioned. Fortunately, this is completely wrong!

[illegible]

When there is a linear relationship between groundwater discharge and gradient, the flow regime is said to be "Darcian". Hydraulic conductivity is the constant of proportionality, and the relationship is Darcy's Law. Darcy's Law and the commonly-used transport equations apply only when the flow is Darcian. In the case of a nuclear repository site, the fluid flow regime will be non-Darcian because of the low permeabilities of the host rocks. In fact, if Darcian flow can occur in a geologic material, that material is too permeable for use as a repository host rock.

As mentioned, "hydraulic conductivity" values of 10^{-10}cm/sec and smaller are reported from studies of potential repository host rocks. If very large time frames are used, solution of the transport equations may predict objectionable radionuclide transport to the biosphere even for these low values of "hydraulic conductivity." However, such low values of "hydraulic conductivity" indicate the presence of materials sufficiently impermeable to preclude Darcian flow. Therefore, these computations are completely without meaning. They are not even approximations. They are totally worthless.

I have read of laboratory experiments in which the ends of cores of dense unfractured granite or salt are subjected to pressure differences of 250,000 psi. After some time, water is driven through the core. Using Darcy's law, "hydraulic gradients" of 10^{-10}cm/sec or there about are computed and reported. Subsequently, people use such "hydraulic conductivities" under normal groundwater gradients of say 0.001 to predict significant groundwater transport over long periods of time. Again, this is completely wrong.

The water that passed through the core was not subject to Darcian flow. A value of 10^{-10}cm/sec is not hydraulic conductivity. Because Darcy's law does not apply, there is no linear relationship between flow and gradient. Therefore, that number can only be used at the experimental head gradient of 250,000 psi per core length. If it takes 250,000 psi differential to move water through the core, the water is not moving through capillary cores. It must be moving through spaces of subcapillary size and against tremendous adsorptive force fields. Almost certainly, a large threshold gradient is needed to move water molecules against such forces. In short, it is likely that a rock that tests at 10^{-10}cm/sec under such huge gradients will have a zero transport rate under a field gradient of 0.001.

The other problem with the laboratory core is that it is likely to miss joints and faults. Thus, for fractured impermeable rocks, the laboratory tests can seriously underestimate transport. Fortunately, the answer to this is simple. Before emplacement of canisters in repository cored holes, the cored holes can be pressure tested at non-destructive pressures. If a test results in a "hydraulic conductivity" of say 10^{-10}cm/sec, two things are apparent. First, there are no open fractures that are conducting significant amounts of fluid. Second, the transport to the biosphere under normal field gradients over the 1,000 year specified transport period is zero because the flow is "sub-Darcian".

In conclusion, the hydrology can do the containment job essentially for a period as short as 1,000 years. Second, with the geochemistry as a backup, the transport problem is tractable over the short design periods now specified.

Sincerely yours,

Irwin Remson
Professor

IR:rh

cc: Dr. R.B. Laughan
Mr. Thomas Nicholson
GRG Committee
Professor Krauskopf

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June 17, 1980

Mr. L. B. Myers
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, Ohio 43201

Dear Mr. Myers:

I am pleased to submit the following comments regarding the Nuclear Regulatory Commission document 10 CFR 60, Subparts E, F as published in the May 13 Federal Register. I understand these comments will be forwarded to NRC as an attachment to the ONWI developed review.

General Comments

The Supplementary Information developed as Background, Nature of the Problem, Underlying Principles, and Considerations would appear to adequately identify the key issues involved in the disposal of HLW. The underlying conservative evaluation of repository sites is appropriate to the importance of the problem, but should not be so rigidly applied that reasonably acceptable sites are eliminated without full consideration of offsetting favorable factors. Predictions of future site stability for the long term (i.e. 10,000 years or more) will be impossible to demonstrate. Thus well reasoned, competent judgement based on the geologic record of the last millions of years must be an acceptable substitute for demonstrated future stability. One point not adequately addressed is that the risk and economics of timely geologic storage must ultimately be compared with the risk and economics of no geologic storage -- the alternative which could result from the ultimate in conservative site evaluations.

Specific Comments

Subpart E - Technical Criteria

*60.2 Definitions. The definitions are adequate and sufficient.

*60.101 Purpose. No comment.

*60.111 Performance Objectives

(3) Retrievability - The requirement of 50 year retrievability should not exclude backfilling of the mined areas; to do so may place unnecessary thermal and mechanical stress on the repository site.
- Is the waste package requirement of radionuclide containment for 1,000 years feasible with current state-of-the-art? If there is some uncertainty in this, the specific (1,000 years) time requirement should be modified.

(4) Performance of the geologic stability - Reasonable assurance of geologic stability for 10,000 years seems reasonable and achievable.

*60.121 Site and Environs Ownership and Control - No comment.

*60.122 Siting Requirements

(a)(2)(i) Geologic investigations completed for a radius of 100 km from the repository area is a reasonable requirement, but the level of detail of these investigations is not specified. It is probably best this way, with the level of detail being a judgement rather than specified regulatory consideration.

(a)(2)(iii) A 10,000 year period for prediction of changes in natural conditions and the performance of the geologic repository is reasonable and appropriate.

(a)(5) A reasonable trade-off must be made between drill hole testing to reduce geologic uncertainty and the intent to minimize drilling to preserve the integrity of the reservoir.

(a)(9)+ Knowledge of the geologic and physical properties of the repository host for a distance of 2 km from the limits of excavation is reasonable and prudent. A similar knowledge for depths of 1 km below the repository excavation must either

a) admit and accept considerable uncertainty and rely largely upon geologic judgement and geophysical measurement, or
b) provide for several drill holes within and surrounding the repository, to depths 1 km below excavation levels.

A reasonable trade-off between the two possibilities must be accepted and acknowledged as a clarification of statements within this section.

(b)(1) Potentially adverse human activities.
Items (i) through (vii) provide an adequate and reasonable listing of potentially adverse human activities.

(b)(2) Potentially adverse natural conditions - geologic and tectonic.
Items (i), (iii), (iv), (v), (vi), (vii) are reasonable and prudent.

(b)(2)(ii) Evidence of dissolutioning, collapse, or similar features which resulted from Pre-Quaternary geologic processes that have since been inactive, should not by itself disqualify a site. Reasonable proof of stability during the Quaternary should be required and adequate.

(b)(3) Potentially adverse natural conditions - hydrologic.
(iv) Presence of a fault or fracture zone with a horizontal length of more than a few hundreds of meters should not by itself disqualify a site. Countless examples may be sited of fractures tightly sealed with quartz, calcite or clays which show no evidence of movement or fluid flow for 10's of millions of years. The requirement as stated may be unnecessarily restrictive.

(c) Favorable characteristics.
The intent of this section is clear and reasonable. However the degree to which many characteristics can be measured or demonstrated is questionable. The entire section should be qualified by "consistent with the state-of-the-art" and "in-so-far as possible with acceptable drilling limitations".

*60.132 Design Requirements - No comment.

*60.133 Waste package and Emplacement Environment - No comment.

*60.134, 60.136 Missing in Federal Register??

*60.135 No comment.

*60.137 No comment.

Subpart G - Quality Assurance

*60.171 Quality Assurance Program

The need for a quality assurance program to maintain quality control for studies and data gathering associated with siting a geologic repository is recognized. Nevertheless many geological, geophysical, geochemical and hydrologic studies are not readily amenable to tightly specified field procedures, measurement procedures, etc. The nature of geoscience exploration activities is that step 3 depends upon the results of steps 1 and 2, upon terrain and earth conditions, etc. The implementation of a quality control program for these activities implies substantial increases in cost, perhaps less data for the same budgeted expenditures, and increased delays in receiving data and survey results. Thus I urge recognition of the unique aspects of geoscience exploration in the detailed statement of the quality assurance program, and I encourage the use of reasoned judgement and flexibility instead of rigid specifications normally associated with quality assurance programs.

I hope these comments are useful in your evaluation of the current form of 10 CRF Part 60.

Sincerely,

Howard P. Ross

Howard P. Ross
Geophysicist; ONWI Geologic Review Group
Senior Geophysicist/Project Manager, ESL/UURI

DEPARTMENT OF CIVIL ENGINEERING

PROGRAMS OF STUDY

UNDERGRADUATE
Architecture/Engineering
Basic Engineering
Civil Engineering
Geological Engineering

GRADUATE
Structures/Mechanics
Transportation
Water Resources

Princeton University
SCHOOL OF ENGINEERING/APPLIED SCIENCE
PRINCETON, NEW JERSEY 08544 609-452-4600

June 17, 1980

Mr. L.B. Myers
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, Ohio 43201

Dear Mr. Myers:

Please find enclosed my comments on "Nuclear Regulatory Commission 10 CFR Part 60, Technical Criteria for Regulating Geologic Disposal (of) High Level Radioactive Waste" as requested.

Sincerely yours,

George F. Pinder

George F. Pinder
Director
Water Resources Program

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Enclosure

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COMMENTS ON "Nuclear Regulatory Commission 10 CFR Part 60
Technical Criteria for Regulating Geologic
Disposal (of) High Level Radioactive Waste"
by George F. Pinder

1.0 PREAMBLE

The technical aspects of the geologic disposal of high level radioactive waste (HLW) are cosmopolitan in scope. This attribute of the problem is reflected in the broad spectrum of related yet separate topics covered in this document. In the remarks to follow I have elected to focus only on those elements of the document that are within my primary area of expertise--the physical description and analysis of mass transport in the subsurface.

2.0 GENERAL COMMENTS

2.1 "Indelible concepts" and "golden numbers"

While the proposed document can, and indeed should, be viewed as a preliminary statement of the Commission's position regarding the technical criteria for regulating geologic disposal of HLW, it is very important to examine the most fundamental concepts presented therein so that the more general ideas as well as the technical details of the presentation are properly evaluated. In this spirit I feel one must beware of what I shall call "indelible concepts" and "golden numbers". Indelible concepts are those ideas introduced early in the formulation of a problem which become inviolate as the analysis of the problem proceeds. The inertia against change in these concepts often arises because the evolving document is inextricably tied to them. Thus a complete revision of the conceptual

model underlying the analysis would be required should they change.

Golden numbers are similar. These are numbers introduced into an analysis without careful deliberation or scientific justification. They are generally considered a working estimate, but often become cast in concrete as the analysis proceeds. I feel this document contains both "indelible concepts" and "golden numbers".

An example of an "indelible concept" is found on page 31394 of the Federal Register Vol. 45, No. 94. There the problem of the disposal of HLW is decomposed into five subproblems 1) lifetime of the repository,2) physical extent of the repository 3) waste/rock interaction, 4) treatment of uncertainties, and 5) problems of human intrusion. These subproblems are further subdivided into appropriate sub-subproblems. For example 1) lifetime of the repository is broken into a) site selection, b) construction and emplacement of wastes, c) post closure of the repository. The first of these, site selection, is further broken down into two sub-sub-subdivisions I) site suitability criteria, II) site acceptibility criteria. It is evident that this hierarchial structure, which essentially dictates the fundamental form of the final criteria, is built upon the original five subdivisions. These original subdivisions, however, are selected without documented consideration of alternatives. Because of the impact each step in this problem decomposition has on the final analysis, I feel it is imperative that each procedural step be properly justified.

Golden numbers are at least as insidious as "indelible concepts" in inadvertently dictating long range decisions. Consider, for example, page 31401. Permissible travel time to the environment is given a lower bound of 1000 years; the lower bound on waste package containment is also given to be 1000 years. The annual rate of release from the facility is required to be no greater than 1/100,000 of the total activity present in HLW. The siting investigations shall extend on the order of 100 kilometers. No justification or rationale is given for selecting these four numbers which, in my opinion, play an important role in the final selection of appropriate criteria. Because the reasons for choosing these figures are not presented, they are not subject to scrutiny commensurate with their importance.

2.2 The Role of Models

The proposed rules recognize the irreducible residual uncertainty inherent in forecasts of environmentally related processes. Radionuclide transport is, of course, such a process. However the concomitant deductions regarding modelling which appear to have arisen out of this recognition warrant additional consideration.

Models, whether they be mathematical, physical or electrical, assist the hydrologist in predicting the behavior of hydrologic systems under new or existing stresses. They play a particularly important role when a system is so complex that hydrologic insight and experience are inadequate to provide an accurate determination of system behavior. In systems which respond very slowly one cannot rely on observed behavior to predict the future and models are

essential in providing meaningful forecasts. The radionuclide transport problem certainly qualifies as a candidate for modelling when viewed from this perspective (this is consistent with the discussion of "fundamental difficulties" on page 31395).

While it is evident to most hydrologists that modelling is an important tool in forecasting the movement of contaminants in the subsurface, one may argue that our knowledge of the HLW disposal site is so inadequate that such models are fraught with fundamental irreducible uncertainty. Recall, however, that a model is simply the physical or mathematical realization of our conceptual understanding of the problem. In other words the accuracy of a model is a direct reflection of the accuracy of our conceptual model. All field investigations are designed to enhance our conceptual and, by inference, mathematical (or physical) model of the system. If the inherent uncertainty in our mathematical model is so great as to preclude its utility as a forecasting tool then, inasmuch as our conceptual model exhibits the same uncertainty, there is very little hope that "expert opinion" will provide additional insight. One must then conclude that one of two alternatives remain. 1) additional field experiments or alternative investigations must be performed to reduce the residual uncertainty or 2) the fundamental HLW problem is not amenable to analysis in a classical scientific or engineering sense.

It is the stated position of the Commission staff "not to require modelling to be the primary decision tool to determine the capability of the geologic repository to contain and isolate wastes from the biosphere". I am diametrically opposed to this point of view. I believe

that a model (probably but not necessarily mathematical) is an essential element of the decision making process. It provides the following advantages:

1) it presents, unambiguously, to the scientific community and public at large the state of knowledge regarding the behavior of the system

2) it provides a clearly defined focus for professional discussions, contributions and criticisms which gradually illuminate our understanding of the behavior of the proposed repository site

3) it allows us to evaluate the impact of our lack of knowledge on the acceptability of a particular site. The simplest type of analysis along these lines involves the use of ranges of parameter values in a series of simulations

4) it is the only methodology that will provide meaningful information on the time of travel of radionuclides from the disposal site to the biosphere under various breaching scenarios

5) carefully orchestrated, the model can be used to demonstrate to public officials and the general population the probable behavior of the repository under a reasonable range of conditions.

In summary, I feel that a representative model of any potential site is a necessary but not sufficient condition for licensing. To attempt anything less would surely jeopardize the credibility of the licensing program in the eyes of the scientific community.

3.0 SPECIFIC COMMENTS

Inasmuch as this document is now part of the public record, I will not point out those typographical errors which have doggedly escaped the editorial staff. They seldom compromise the message of the document.

Pg 31394, Col. 3, Line 23-31: The difference between the two requirements of technical criteria is too subtle for me to pick up on first reading. Could this be clarified?

Pg. 31394, Col. 3, Line 1b*: While I concur with the observation, I suggest some evidence to substantiate this statement is warranted.

Pg. 31395, Col. 2, Line 31: Considering geologic disposal is an entirely new enterprise and that there will be no opportunity to observe behavior over the long term it seems contradictory to rely on expert opinion which, in turn, relies on past experience.

Pg. 31395, Col. 2, Line 9b-1b: Although I concur with the concept of uncertainty as a major problem with HLW repository siting, I feel the concept of uncertainty described here misses the mark. Perhaps it could be re-examined?

Pg. 31395, Col. 3, Line 13: The meaning of the statement regarding the separation of temporal and spatial elements of geological disposal eludes me. I cannot see how such a separation is possible either physically or mathematically. Moreover, were it possible, I fail to see how it would influence uncertainty.

Pg. 31396, Col. 1, Line 7b: In looking at uncertainty, I feel one must keep in mind the final goal. Is it 1) to make the uncertainty amenable to analysis, 2) to reduce its magnitude, 3) to evaluate its impact? Each objective requires a different course of action. The comment "Such measures..." seems to confound 1) and 2) above.

Pg. 31397, Col. 2, Line 5b: The general discussion of modelling appears naive. The allusion to qualitative models is inaccurate and inappropriate. I strongly recommend reconsideration of this entire section (5). If I were to present all of my concerns about this section it would require another much longer report.

Pg. 31398, Col.1, Line 14b: "A satisfactory if imprecise margin of safety". I have more than a little difficulty accepting an imprecise margin of safety as satisfactory -- perhaps you could substitute another word for satisfactory.

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* b indicates lines counted from bottom

Pg. 31400, Col. 2, Line 14b: Calculation of transport travel times requires transport models -- have you de facto required models in your rules? The same argument can be made for items (iii) top of page 31401, Col. 1 and elsewhere beyond this point.

Pg. 31401, Col. 2, Line 14-Line 18b: I believe this list of (vi) requirements is not now, nor likely to be in the foreseeable future, within the capability of earth scientists or engineers. This strikes me as an unreasonable wish-list devoid of consideration for and of available technology.

Pg. 31402, Col. 1, Line 12: "Storativity" is irrelevant to problems within this time frame.

Pg. 31402, Col. 3, Items a)-f): Many of these items are irrelevant misleading, or misinterpretations of the literature. I think this section requires careful scrutiny by a qualified hydrologist.

Pg. 31405, Col. 2, Line 9b-5b: Why?

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Environmental and Water Resources Engineering • Direct phone 322-2697

June 18, 1980

Gentlemen:

As agreed, please find enclosed for your information a copy of my comments to ONWI on 10 CFR 60 Subparts E-I, as requested in Wayne Carbiener's letter of May 27.

Best personal wishes.

Sincerely yours,

Frank L. Parker

Frank L. Parker

FLP:bl

Enclosure

Nuclear Regulatory Commission Document on
"Technical Criteria for Regulating Geologic Disposal
of High-Level Radioactive Wastes"
10 CFR-Part 60 in the Federal Register of May 13, 1980
pp. 31393-31408

GENERAL COMMENTS

FRANK L. PARKER
Vanderbilt University

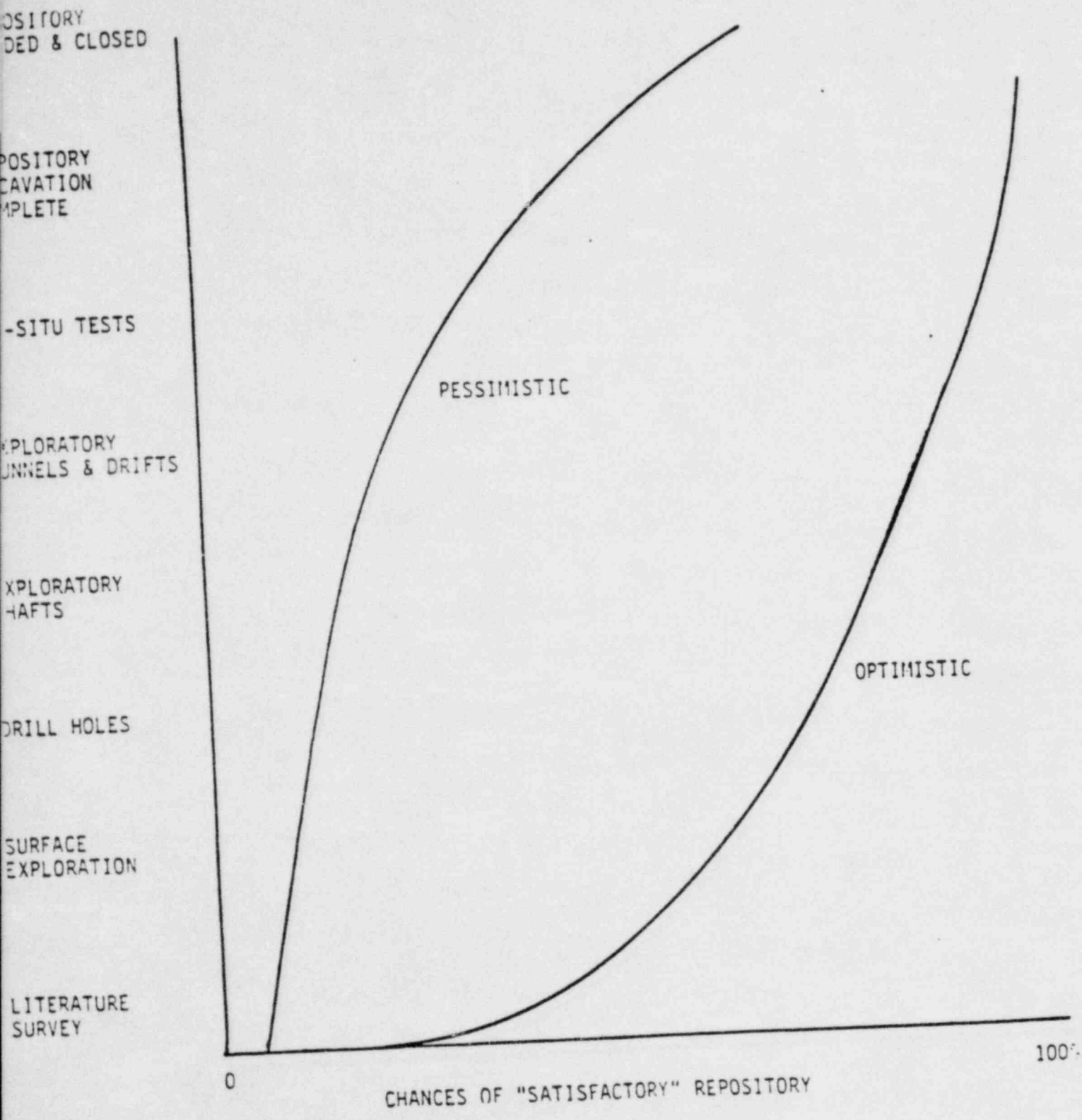
The document is, in many ways, admirable, in that it tries as best it can to state forthrightly what the present status of knowledge is in the field of geological disposal of radioactive wastes. However, though the proposed rule-making and the "Technical Support Documentation for the Siting Requirements in 10 CFR-Part 60" (4/7/80 draft) go on for hundreds of pages, the final result is the same generic conclusions as have been regurgitated many times by many other groups in many other forms. The proposed rule-making finally concludes that expert opinion will be required to determine whether or not the site is suitable. Consequently, there is no defense of the specific numbers mentioned in the proposed rules other than generalized comments such as until the end of the effective lives of the fission products and beyond times which it is impossible to even hope to determine what the human population and its characteristics are liable to be. Therefore, it places an enormous burden on the Department of Energy in trying to satisfy criteria which depend so much on expert testimony, when at no place in the document is there any discussion of how expertise will be determined and, possibly more important, who will evaluate the expert opinion and on what basis.

While it is almost impossible in administrative hearing to challenge the qualifications of the expert witness, it is impossible to challenge the qualifications of the hearing authority and the basis on which the hearing authority will be constituted. How can the public be assurred that the best interests of the country will be fostered if the quality of the hearing examiners and if the criteria which are of crucial importance are left strictly to the judgement of undefined experts? Consequently, this makes the problem of the proposing agency, The Department of Energy, exceedingly difficult.

Equally crucial in a determination of this sort is the degree of confidence that the hearing authority must have or the expert witnesses must have that the proposed solution will be successful. Will the Nuclear Regulatory Commission be satisfied with a 50% confidence, 90% confidence, 99% confidence, or will it demand 100% confidence that the site will work as planned and at what stage will this confidence be demanded? The attached figure shows the extent to which legitimate expert opinion can differ, depending on their degree of risk-adverseness.

For example, a risk-adverse person might follow only a curve that would be essentially only the abscissa, based on forthcoming Office of Technology Assessment Report on Radioactive Waste Management. That is, he would not have any confidence in the success of a repository until the repository had been in place for 10,000 years or more. At the opposite pole would be a person who, from a cursory glance at the literature, would have 100% belief in the success of a repository. His curve would lie along the ordinate.

These are extreme positions. However, the two positions shown are generalized as the envelope within which most competent geologists, geo-hydrologists and earth science people would find themselves. They would have


OSITORY
DED & CLOSED
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-SITU TESTS
XPLORATORY
UNNELS & DRIFTS
XPLORATORY
HAFTS
DRILL HOLES
SURFACE
EXPLORATION
LITERATURE
SURVEY
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OPTIMISTIC
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100%
CHANCES OF "SATISFACTORY" REPOSITORY

some confidence from a survey of the literature to eliminate spots that are unlikely to be successful and their confidence would increase as one made further investigations both at the surface and below ground. The pessimistic person (responsible pessimist) would still not have 100% confidence even after the repository itself was closed, whereas a responsible optimist would believe that, after a reasonable amount of underground exploration, he would have high confidence in the development of a 'successful' repository.

There is also insufficient discussion or acknowledgement that each of the individual barriers does not have to be totally satisfactory in itself, but it is the whole system that is of importance. While lip service is given to the systems approach, insufficient attention is paid to the fact that each component of the system can be the regulating step. While one does design the barriers in depth, one would not need to have each component in itself totally capable of attaining all the objectives of the siting requirements. This is certainly not clear in the document. One could think of the system as a series of coupled reservoirs with the final discharge leading to the biosphere. Consequently, a holdup in any one of the reservoirs could be sufficient to reduce the concentrations to the biosphere to acceptable limits. This is a crucial point. Consequently, this would make possible the siting of facilities in locations which may be so diverse that one would have better hydrologic characteristics, one would have better geological characteristics, one might have better man-made barrier characteristics, and these could be tailored and should be tailored to produce a system that gives satisfactory results.

I agree wholeheartedly with the major emphasis that is given to in-situ testing. What is not clear is at what stage in the licensing process this

would be required and what specific tests would have to be held and what would be the go-no go criteria of the tests.

There seems to be no advantage taken of the INFCE studies, where in the long run, it assumes that all the waste materials wind up in the world's oceans. The study, therefore, concludes that one should calculate the dosages both for the naturally-occurring radioactive elements and without the naturally-occurring radioactive elements, because these all would eventually wind up in the world's oceans.

Equally important in such criteria is the assumption that no mitigating measures are possible, though retreival is, of course, indicated. There are other mitigating measures which could be possible and which should be evaluated. There is no discussion about the projected slow rate of releases of contaminants from the repositories relative to the rate of release of contaminants from reactors if accidents should occur. The enormous differences in release rates are not documented and are not taken into account in the analysis of the requirements.

Finally, in the technical support documentation there are some outrageous statements tucked away in the long, drawn-out narrative. For example, page 5-32, the first full paragraph, first sentence, says "as a minimum, a site is presumed unsuitable if there is past evidence of dissolutioning within the repository/site interaction zone. . . . What is sought are indications of substantive dissolution as indicated by a layer of insoluble residues." As the writers must be well aware, many of the salt domes have layers of insoluble residues on top of the domes and, frequently, on the sides of the domes which most likely have been left behind by previous dissolutions. However, these layers of insoluble residues now protect the salt domes from further dissolution or reduce dissolution to a very slow rate. Yet by this definition, many of the salt domes would be considered

ineligible. I am sure this is not the intent of the document, but in a document as long as this, it is very possible that many more such outrageous statements are included.

It is also obvious that the process of site approval must be better designed than is given in this document. As is evident in the book edited by Lawrence Tribe, When Values Conflict, attempts to improve benefit/cost analyses finally result in having an open process that is well understood and that develops the trust of all responsible people on various sides of the issue. There is no indication here how the process would be structured so that it would be an open and acceptable process to the majority of the people involved in such a decision.

DETAILED COMMENTS

Federal Register

Page 31395, item 4, the whole sentence states "first, geologic disposal is an entirely new enterprise/no experience with geologic disposal." It may be true that no experience exists with purposeful geologic disposal, but, in fact, one can find in salt mines relics from the Celtic age and one can find in Pompeii and other areas items that have been disposed of in a geologic setting which have remained inviolate over long periods of time. One can certainly obtain some data from these instances. The data base is not quite so bleak as is indicated in the discussion.

Page 31396, item 3, dealing with the conservative analysis, "conservative analysis because of the many uncertainties associated with high-level radioactive waste and geological repositories," reinforces my original comments that unless one is prepared to state what level of confidence one is willing to settle for, then one cannot handle these uncertainties. In carrying out a conservative analysis, one has to be careful that so many conservative assumptions are not made that eventually a less-

conservative solution is found.

Page 31397, item 4, last sentence, "it will be necessary to determine the site-acceptability question on a case-by-case basis." Since there will be so few sites selected, picking them on a site-by-site basis is not such a bad idea, but more substance has to be given so that, in fact, the agency can have some indication whether or not it would be possible to obtain a license prior to going to the expense of developing a full-scale repository.

Further justification needs to be given for the basis upon which models are almost totally excluded except to compare sites and designs. It is not clear at all how the long-term (far future) dosages can be determined except by the use of mathematical models. While the absolute value of the numbers certainly cannot be taken to be very accurate, it is difficult to see other methods that will be superior. Expert opinion leaves the process so open ended that it is difficult to see how one can avoid using models to bound long-term futures. The major advantage of the models is that the assumptions must be documented, whereas expert opinion is based upon internalized models.

Page 31399, definition of expected processes - unfortunately agencies have frequently tried to redefine the English language. It is indicated here that human intrusion is not to be treated as an expected process and event. It should be so treated. Definition of high-level radioactive waste should indicate that spent reactor fuel will be treated as waste if so defined. Should follow the International Atomic Energy Agency's definition of high-level waste.

Page 31402 (C)(2)(iii)(a), normally "result in a host rock with very low water content." This would, in effect, eliminate clay, which I do not

think is the intent.

Page 31403 (4), should be some indication of the use of modular design which does show up later. (5) should also include non-propagation.

Page 31404 (2)(ii), would seem to indicate that if one wants the optimum solution one should extract maximum amount. In fact would like to err on the side of safety so that one would leave a larger amount of media to be sure of providing a margin of safety. The same point is made (iv)(2), optimizing opening design, etc.

Page 31405 (8), presupposes that compaction is the best method. One might want to use material that would expand upon being wetted.

(9)(v) The requirement of using pregrouting is not compatible with mandating performance rather than technique.

Technical Support Documentation

Page 1-4 - Some statements are very difficult to understand, since they are pronounced ex cathedra. For example, in (ii), third sentence, "regardless of the host rock permeability and depth, there is sufficient time for groundwater to penetrate the repository and return biologically significant radionuclides to the accessible environment." Where is the justification for this? One could certainly conceive of host rock permeability such as in salt where there is not time for the groundwater to come through and return any material in signficant quantities to the environment.

Page 1-6 - The 100 km distance certainly is an arbitrary value. It might be more useful to talk about the geologic and hydrologic regime that is of interest rather than an arbitrary 100 kilometers.

Page 1-8 - The second to last sentence in the second full paragraph is a very important comment, and yet it receives very little attention throughout the document.

Page 1-9, first sentence, how does one rationalize spent fuel disposal with the indication that "valuable subsurface resources that could encourage activities related to exploration and recovery" would eliminate sites?

(iv) would indicate that "the lack of substantive geochemical properties to significantly retard radionuclide migration to carry with it the presumption of site unsuitability," seems to be overdrawn, since it is only one of the retarding factors. One could easily install man-made barriers.

Page 3-3 - second paragraph, third sentence, the "waste packages provide a means to transport and shield the waste." This should indicate that waste packages are more than that and thus provide containment as well, at least for the short term.

Page 3-4 - third full paragraph - "in order to reasonably demonstrate the sufficient isolation of radioactive waste, each of the three components of the repository system must contribute to:" One can see that, as mentioned earlier, each of the components does not have to, in itself, make the site desirable. It is the sum total that is important, not the individual components.

Page 3-15 - 25 square kilometers and 10 cubic kilometers were previously used. That does not make them ideal for all circumstances.

Page 3-21 - section 3.4.1.3. - item 2 - "each of the site components to provide a margin of safety and it requires . . ." Again the same comments about each.

Page 3-23 - item 3.4.3. - fourth line from the bottom - no definition of "biologically significant."

Page 3-24 - fourth line - "very long travel times." No definition.

Page 3-25 - middle of the first paragraph - "as noted by Heckman and others, . . . radioactive decay has not substantially reduced the hazard." Since, at the end of the time period, the fission products are gone, the toxicity has been substantially reduced, as a matter of fact, by four or five orders of magnitude.

Page 3-26 - first full paragraph - it is very important item and yet it is relegated to the rear. It should be emphasized up front that "this objective through different combinations of site parameters."

Page 4-2 - second paragraph - item 3 - verification. Does not indicate over what period; how it should be done or whether one can do a retrospective type verification in trying to fit the models to natural phenomena that have already occurred.

Page 4-7 - item 3 - should indicate that hydraulic recharge and discharge areas are also critical areas.

Page 4-51 - last complete sentence - makes no sense whatsoever when it says "as such there may be too many factors to permit use of modeling." That is the reason why one does modeling because there are so many factors that one cannot do a simple hand calculation or determine the outcome intuitively.

Page 4-55 - last full sentence - indicates that the near field is far more important than the far field, because it might be possible to short circuit through the far field by changes in the near field. This is an area that needs further development by the Department of Energy. It should be noted that, in spite of any short circuiting in the near field, there may be sufficient latitude in the far field to absorb short circuiting in the near field. If that is so, it should be stated very explicitly.

Page 4-62 - item 4.5.2.4. - second and third sentences - ignores the work done in Sweden and elsewhere on near field tests to measure the flow of nuclides.

Page 5-3 - item 8 - the final sentence in the first paragraph is very important. Yet in no place does this report say what is the range of latitude in adverse conditions that is acceptable. It needs to be spelled out in very great detail, and yet it is not.

Page 5-6 - last full sentence in the first paragraph - the emphasis seems to be on this "little influence on all the performance objectives." Since it was previously indicated that if the process is rate-limited in a number of the performance objectives, then it is not necessary to show that all of them limit the dose.

Page 5-11 - first paragraph - it is not indicated who will resolve at an early time the definition of "acceptable risk." I agree that it is vitally important but there is nothing indicated here as to how it will be resolved.

Page 5-25 - section 5.2.1.3. - needs to indicate that site is unsuitable if the influences on groundwater are adverse.

Page 6-1 - end of page - needs to indicate volume of water flowing is important, as well as velocity.

Page 6-5 - first line - "required favorable . . ." seems incompatible.

Page 6-6 - last line - same comment.

Page 6-20 - first full sentence - not "dose significant" only accessible.

June 18, 1980

L. B Myers

RECEIVED

JUN 16 1980

LYNN B. MYERS

Neville G. W. Cook
3261 Rohrer Drive
Lafayette, California 94549
June 11, 1980

Mr. L. B. Myers
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, Ohio 43201

Dear Mr. Myers:

COMMENTS ON NUCLEAR REGULATORY COMMISSION
ADVANCE NOTICE OF PROPOSED RULEMAKING.
Technical Criteria for Regulating Geologic
Disposal High-Level Radioactive Waste
10CFR60 (Subparts E-1)

These comments concerning the technical criteria for regulating geologic disposal of high-level radioactive waste are made in response to a letter from Dr. W. A. Carbiener of ONWI dated May 27, with which were enclosed copies of the May 13 Federal Register and background information from the USNRC Public Document Room.

The latter information on "Technical Support Documentation for the Siting Requirements in USNRC 10CFR Part 60: Disposal of High-Level Radioactive Waste in Geologic Repositories", proved to be of particular assistance, and includes a commendably useful list of references.

The treatment of this question in the Federal Register both in the Supplementary Information and in Subpart E is very uneven, reflecting probably the current state of knowledge. However, a more systematic presentation would likely lead to a clearer identification of the problems, and specifications of the criteria.

For example, under the heading "Nature of the Problem" five distinct areas are identified, namely, (1) Lifetime of the Repository, (2) Physical Extent, (3) Waste/Rock Interaction, (4) Treatment of Uncertainties and (5) Human Intrusions. Although these problems are important, they do not seem to define any hierarchical system.

. . . continued . . .

It has seemed to me always that the foremost motivation for geologic disposal is that it makes radioactive wastes much less accessible to human action and less susceptable to meteorological and geologic changes in the long-term, than can be envisaged for any form of near surface storage. If this is so, the next most important question is: Do there exist rocks at convenient depths and of sufficient extent within which it is practicable to develop a repository of a useful size? Is this question not more pertinent than the discussion on page 31396 under (2) Physical Extent? If rocks within which a useful repository could be developed exist, is the next question not: Do such rocks exist within geologic and hydrologic settings likely to provide assurance of the safety and stability of a repository, in both the short- and the long-term, and of the isolation of radioactive wastes within it? Provided that these two questions can be answered in the affirmative, and to date there does not appear to be any evidence that they cannot, the next level of detail such as waste/rock interactions and the methods by which the performance of a repository can be predicted and assured, must be examined.

The discussion under Considerations, starting on page 31396, includes items which can be commended and others which can be criticized. As examples, a commendable statement is "The two most important attributes of the natural barrier are that the site should be geologically simple and stable so that the site can be easily understood ...". On the other hand, a statement which can be criticized is "... whether the geologic setting at a particular site can fulfill the stated purpose of the geologic barrier relies fundamentally on the predictive power of the particular transport model appropriate to that site". In fact, the transport model may be quite correct but the field data used in it could easily be totally inadequate.

Finally, the statement that "The lack of empirical data on the performance of engineered barriers or the inability to obtain credible data may preclude the development of use of credible quantitative models in the showing that either the uncertainties are addressed properly in the performance standards or the performance standards are met in a particular licensing action." is both clumsy and confusing. The facts are that engineered barriers can be based on geologic analogs, the behavior of which over long periods of time is known and the properties of which have been, or can be, understood well. Such engineered barriers have all the long-term advantages of geologic media but their properties can be understood, determined and controlled for use in achieving assured performance of a repository.

The discussion and examples above indicate that the answer to Question 1 on page 31398 is "No, the list of considerations does not clearly, adequately and fully identify the relevant issues involved in disposal of HLW.".

Turning now to Subpart E, itself, at least two of the definitions may lead to confusion. First, " 'Stability' - means the rate of natural processes affecting the site during the recent geologic past are relatively low and will not significantly change during the next 10,000 years". This is neither a

. . . continued . . .

rigorous nor precise statement. Second " 'Underground Facility' - means the civil engineered structure, including backfill materials, but not including seals (emphasis added) in which waste is emplaced"; in some rocks backfills and seals may have to be synonymous.

Under the headings of Performance objectives, Site and environs ownership and control and Siting requirements, the Department of Energy is directed to provide a number of assurances. An important omission seems to exist in that it is not always stated when the Department is to provide these assurances in relation to repository design, development and licensing, how they are to be provided nor how they are to be used. In fact, many of these assurances will have to be a function of the development of the repository, because the data needed to provide them will become available only as the repository is excavated and observations and tests are made underground.

In practice, the selection of a potentially suitable site, the characterization of such a site by surface exploration and, if favorable, further by underground exploration, followed by repository development and sealing is most likely to proceed by a process of elimination. Initially, a number of sites that seem to be potentially suitable as hosts for a repository will be selected, as directed in the Message from the President. Only those, or that, site which undergoes the whole sequence of site screening, characterization, testing and development without revealing any features which disqualify it from providing reasonable assurance that a repository constructed within it will provide isolation of radioactive wastes from the biopshere is likely to be used.

With a few reservations noted below, the discussion under the heading Design requirements is probably the best section of Subpart E. Possibly, the reason for this is that it is closest in character to questions for which precedents exist in licensing of reactors. The first reservation concerns Compliance with mining regulations; a repository is not a mine. To "design and construct" a repository "to comply" with "all applicable Federal and State mining regulations" may not result in the best repository. Certainly, they should be applied where beneficial and this is likely to be the case in the underground operations but not applied indiscriminately elsewhere. Items 7 and 8 under this heading are very important; sufficiently so to warrant a separate discussion.

Items [2] Construction and mapping records and [3] Retention of cores and logs on page 31406 and other vitally important data are identified but no mention is made of how this information should be adduced to confirm or reject the suitability of a site. Such information must be collected, analyzed and adduced on a continuing basis throughout the development of any repository.

Under General design requirements for subsurface operation a highly significant statement concerning the design of a repository in modules is made. This

. . . continued . . .

concept should not be limited to repositories where concurrent excavation and emplacement of wastes are planned; it is not unlikely that even a suitable repository site will not be uniformly satisfactory in its properties. Modular design ennances greatly the opportunity for using those parts of a site which are suitable, without jeopardizing them by including parts found to be less than completely suitable.

In conclusion it is suggested that a systematic, hierarchical approach to the establishment of geologic waste repositories is likely to facilitate the development of defensible regulatory criteria, including those of a specific nature, and that it is important to recognize that the establishment of a repository is likely to be a continuing process of selection based on the absence of any features which would disqualify a site or the repository within it, from providing reasonable assurance that radioactive wastes will be isolated from the biopshere adequately.

Yours sincerely,

Neville G. w. Cook

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Mr. L.B. Myers
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505 King Ave.
Columbus, Ohio 43201

26 June 1980

Dear Mr. Myers,

Enclosed are my comments on 10CFR60, sub-parts E-1. I apologize for being tardy with this. My schedule during the past six weeks has been so crowded that I simply have not had enough time to get everything completed in time. I have very carefully studied this document, and chose to be late rather than do a hasty job of it. I have sent copies of these comments to the other members of the Earth Science Review Panel, and to Dr. Carbienier.

Sincerely yours,

John M. Bird
Professor of Geology

COMMENTS ON THE NUCLEAR REGULATORY COMMISSION DOCUMENT 10CFR60, TECHNICAL CRITERIA FOR REGULATING GEOLOGIC DISPOSAL HIGH-LEVEL RADIOACTIVE WASTE, IN THE FEDERAL REGISTER OF 13 MAY 1980, PAGES 31393-31408.

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GENERAL COMMENTS

Concern about the safe disposal of radioactive waste has led to the general agreement that high-level wastes might best be buried within rocks of the Earth's crust. This consensus is founded on the knowledge that geologic features can be very old, and that a mined repository could be essentially permanent and isolated from the biosphere during the time required for isolation of the radioactive wastes. Essentially, two main barriers are provided by geologic disposal, containment of the waste in a waste-form and "package" that can be very resistant to leaching, and utilization of rocks, that because of their composition, geometry, and age, could prevent or retard possible migration, via ground water, of the radioactive elements to the biosphere. The various proposals for geologic waste-disposal utilize our knowledge of the behavior of rocks and geologic processes, and our ability to determine the amounts of time during which many various rocks and geologic features in the Earth's crust have persisted.

For many centuries mankind has extracted geological materials from the Earth. Today, we have a highly developed knowledge and technology of mining, and exploration for useful rocks and minerals. In fact, the

basis for industrial economics is mineral and fuel extraction from the crust of the Earth. Geologic disposal of radioactive waste involves mining practice, however, with a very significant difference. What is desired, the opposite of a mine, is to put radioactive waste to the Earth so as to completely isolate it from the biosphere for times sufficient to ensure complete safety. Unfortunately, the magnitude and difficulty of this task have been underestimated until a few years ago. Now the magnitude and difficulty are being overestimated, and confused, in the context of the geologic aspects of the task. It is known that many of the various ore bodies and other rock resources mined by humans are hundreds, even thousands of millions of years old. A very sophisticated technology exists for dating these rocks, and a great deal is known about how these rocks have formed and persisted during geologic time. We know a great deal about how to extract mineral resources. What we want to know now is how to return something into the Earth so that it stays there. Therefore, it is my view that, essentially, we must utilize all those aspects of rocks, minerals, and geologic processes that produce "permanent" geologic assemblages, for the design and construction of a geologic repository. Rather than "fight" the geologic environment by constructing an "unnatural" repository that would inexorably be altered by geologic processes, we must construct a repository of materials and within sites that can be demonstrated will remain in geologic "equilibrium" at depth, for a time sufficient to insure complete isolation and immobilization of the waste. Appropriate rocks, analogs of rocks and minerals, and geologic processes can be incorporated in the design and construction in ways that enhance our confidence in the safety and permanence of the repository. For example, the heat generated by the

radioactive waste can be used to drive mineralogic reactions that further seal the host-rocks and retard water-migration; waste cannisters can be made of analogs of natural rocks and minerals having properties that provide great inertness and strength. My view is that the underlying philosophy for geologic disposal of radioactive waste should be to utilize all the various geologic materials and processes that lead to chemical stability and permanence as can be demonstrated in natural geologic examples. In a sense, geologic disposal of radioactive waste is the reverse of mining. Certainly there is nothing "new" about mining. However, what we are attempting is to create a long-lasting geologic feature rather than consuming one. The difficulty and magnitude of the task can, I believe, be constrained and well-defined by existing geologic knowledge. Our confidence in our ability to do so, and our confidence in resulting repository designs, will be based on our understanding of geology and geologic time rather than "expert" opinions. It is not enough to satisfy a select group of experts that the design is viable and safe. Although the repository must be evaluated and demonstrated to be safe in the most rigorous ways by our most capable minds, it must also be understandable and acceptable to all concerned. We should be able to explain and predict the behavior of the geologic repository in terms similar to those used to explain a 150 million-year-old dinosaur skeleton to a museum visitor.

It is with these views that I have studied 10CFR60,E-1; I have concentrated on those parts that are within my expertise, geology. This is in many ways a very good document. It provides a great deal of information about various aspects of the endeavor, and tasks that must be completed. However, I find that appreciation of the geologic

aspects of the task is, in places confused or lacking. The document fairly states what the objectives are; however, it does not provide much evidence of a basic understanding of geologic materials and processes, and the opportunities for utilizing this knowledge to enhance the permanence and safety of a mined repository. Rather, the document reflects a lack of confidence and understanding in detail of the geologic aspects of Geologic Disposal.

SPECIFIC COMMENTS

P. 31394, Nature of the Problem, 1st paragraph. It is not clear how these "five distinct problem areas", lifetime of the repository, physical extent, waste/rock interaction, treatment of uncertainties, and human intrusions, supercede other, more fundamental questions pertinent to regulation of geologic disposal. Although they are important, there are other questions of equal or greater importance, eg. the validity of the basic premises of geologic disposal, the existence of appropriate sites, rocks, and limited hydrologic conditions. Also, it can be argued that one or two large repositories present problems that could be avoided by constructing many small repositories. As more waste is concentrated into a single site, the potential dangers increase significantly. A.E. Ringwood (pers. comm. and pre-print, April, 1980) has argued that deep-drill-hole burial in many sites has significant advantages. Has it been shown that large repositories at a few sites are preferable to many small and therefore dispersed, deep repositories?

P. 31395, no. 3, waste/rock interaction. "The chemical and thermal properties of the wastes undoubtedly will have a significant interaction with the rock unit into which they are emplaced". Although significant

heat would be generated by the waste, and would affect the surrounding rock, the statement implies that chemical reactions also would take place between the waste and the rock. One would certainly hope not! The technology exists to matrix the waste in extremely inert materials and to encapsulate the waste-matrix material in containers and overpacks that constitute a package that would prevent chemical reactions between the waste and host-rock. The matrix material and container can be constructed of analogs of minerals and rocks that are extremely inert, resistant to leaching, and of very high mechanical strength. Their behavior in repository conditions can be predicted from examples in the geologic record.

P. 31395, no. 4, Treatment of uncertainties. The statement, "First geologic disposal is an entirely new enterprise -- no experience exists with geologic disposal" is misleading. The endeavor of geologic disposal of radioactive waste is not comparable in difficulty, for example, to landing on the moon. A great deal of experience and technology already exist to facilitate the task. What we want to do is, in a sense, the reverse of mining. What we want to have is great confidence in the permanence and safety of the resulting construction. Also, in the next sentence, "based upon observations of the past" does not make sense. What is intended, I believe, is — based on observations and interpretations of the geologic record. The discussion of uncertainty is rather complex and confusing. I would argue that a large number of "geologic and hydrologic elements" in itself does not always lead to compounding uncertainty. Would one argue that a detailed map of the rivers of the U.S. is uncertain? We must specify scales when considering uncertainties

in geologic features or processes. Also, the last sentence is certainly wrong. How is it possible to argue that temporal and spatial relations are "separable aspects" of geologic disposal? This sentence supports my earlier view that the document is in places lacking in geologic understanding.

P. 31395, no. 5, Human intrusions. "The only logical recourse, since engineering against human intrusion is impossible practically, is to avoid targets, i.e. sites which may invite such intrusion". If significant amounts of spent fuel are put into a geologic repository, an ore body has been created.

P. 31396, considerations, (1) systems approach. The concept of "natural and engineered barriers" has led to considerable problems in assessing geologic disposal schemes. I consider this section to be one of the best examples in 10CFR part 60 of a lack of basic understanidng about the geologic aspects of geologic disposal. If one argues that all of the components of the repository must be made of geologic materials or analogs of geologic materials, including the waste package, then "engineered barriers" are not something comprised of an artificial material for which there is no analog to be studied in the geologic record. In other words, much of the discussion in this section is based on the view that the repository will contain parts made of artificial materials that will change or fail during the lifetime of the repository. It is stated that -- "The state-of-the-art in the Earth sciences is such that all of the uncertainties associated with these functions can not be resolved through consideration of the geologic setting". This is not so. The Earth sciences can explain in great detail how rocks billions of years old

formed and have existed to the present. Given a specific geologic site, many combinations of "engineered barriers" comprised of analogs of geologic materials can be compared and selected in designs to reduce or eliminate uncertainties about the performance of the repository. The statement -- "Engineering can be used to narrow the extent of geologic processes which need to be considered in the rule making and licensing processes; that is, engineering can be used to bound and/or diminish the importance of certain geologic processes" -- does not make much sense. Essentially, this is a philosophy that one "fights" the geologic features. I would argue that the repository must utilize the geology and be comprised of geologic materials of known properties and behavior under the conditions that would prevail in the geologic setting. Finally, the statement -- "Similarly, to the greatest extent possible, the performance of the engineered systems should be insensitive to changes in those characteristics and should provide a high degree of protection by themselves" reflects a lack of understanding about the possibility of introducing ingredients into the repository/waste package that in anticipation of changes such as inflow of water, would be sensitive to the change and react in such a way as to counter the adverse event. Many such analogs of rock/mineral systems could be "engineered" from our understanding of geologic environments and processes. These possible ingredients for specific sites and anticipated processes need to be studied in detail. They promise to greatly increase our confidence about the behavior of a repository during its lifetime.

P. 31397, no. 3, The nature of the major regulatory elements. "The two most important attributes of the natural barrier are that the site should

be geologically simple and stable so that the site can be easily understood and so that there can be confidence that the ability of the site to contain and isolate the wastes will remain viable for long times". I would ask what constitutes "simple and stable". For example, basalt is not a "simple" rock in terms of its composition. What constitutes stability, eg. tectonic stability, chemical stability, thermal stability, and to what limits? In the second paragraph, -- "their insensitivity to any changes in the site characteristics so that there can be confidence in the predictability of their performance over time"; this requirement is wrong. It can be argued that one can engineer a "barrier" that would be sensitive to a change, and would react so as to counter deleterious effects of the change. For example, an overpack containing MgO would react with entering water to produce brucite, $Mg(OH)_2$. The reaction has a significant volume increase and could tend to seal the water pathways and counter the further encroachment of water.

P. 31397, no. 5, Codification of models in licensing process. The first sentence of the second paragraph is too complex. Also, as stated in the next sentence, I am not sure that it is a fact. However, the point that we should not rely solely on quantitative calculations and assessments in developing technical criteria, or licensing, is very important. It is well known that geologic features and processes have many variables. Attempts at quantification can lead to a great deal of effort to solve what might be relatively unimportant or ancillary questions.

P. 31398, 1st column, 17 lines from bottom, -- a satisfactory if imprecise margin of safety for site characteristics and engineering design can be realized". What is an imprecise margin of safety? I do not think it would be satisfactory.

P. 31398, Questions (1). My view, from the preceding is no, the list of considerations does not clearly, adequately and fully identify the relevant issues involved in the disposal of high-level wastes.

P. 31399, Sub-part E, Technical Criteria, definitions. "'Expected processes or events' - means those natural processes or events that are likely to degrade the engineered elements of the geologic repository during a given period after decommissioning." How are these processes or events distinguished as being deleterious? Some might improve an "engineered" barrier, as discussed earlier.

P. 31399, 2nd column, overpack. -- "any additional receptable (sic), wrapper, box or other structure" -- I would suggest adding material to the list because a component of the overpack might not be only structural.

P. 31399, 3rd column, stability. The definition is too imprecise, and does not make clear the distinction between rate of natural processes versus events of short duration during the specified period of the next 10,000 years.

P. 31399, 3rd column, underground facility. Seals might be made of geologic materials and be part of the engineered structure.

P. 31400, Siting requirements, (a) general requirements. It is not clear what -- "not so complex" means. For example, the tectonics of salt domes can be very complex and the petrology of the rock salt relatively simple. The tectonics of plateau basalts is relatively simple whereas the petrology of the basalt is quite complex. This is an important requirement and its intentions must be made quite clear. Under (2) -- "The natural conditions

include geologic, tectonic, hydrologic and climatic process". "Tectonic" and "hydrologic" are part of the geology of a site and should not be distinguished as separate "natural conditions". In (i) following, on what basis was 100 kms selected. The list of objectives of understanding the geology and climate of a site preclude specifying such a distance before-hand. This distance would have to be evaluated on a site-by-site basis.

P. 31401, 1st column, (8). Under (ii) -- have not been exploited but are exploitable under present technology and market conditions". This is an important task. However, it is not clear why, in terms of the desire to understand the possibilities of human intrusion, why the resources would be estimated using present market conditions. For example, one hundred years ago, a large copper ore body became uneconomic if the grade of the ore went below approximately 14%. Today, such an ore body would be valuable.

P. 31401, 2nd column, (i)-(vi). At what level would all of these questions and tasks be resolved? I very much doubt that all of the fractures, for example, at a given site could be recorded; how would the "bulk geomechanical properties" be recorded, and at what level of detail, etc? These topics constitute a list of things that, from a geologic point of view, could never be "satisfied" beyond some level of accuracy and description. To present such a list in the way it is here again reflects a lack of judgement and understanding of geologic features, processes, and the ways. they are studied.

P. 31401, 3rd column, (1)-(iii). Present market conditions should not be used, as discussed previously.

P. 31401, 3rd column, (2)-(ii). "There is evidence of dissolutioning, such as karst features, breccia pipes, or insoluble residues". Many breccia pipes are not the result of "dissolutioning", such as diatremes. Many sedimentary rocks contain evidence of dissolutioning, such as styolites in limestone, and clay mineral segregations in rock salt. These features would not necessarily be potentially adverse natural conditions in a site. Also, under (iv) what amount of activity of the fault would be serious? It can be argued that all faults are active, even very ancient and "inactive" ones, because of tidal forces and plate movement. It is very important that (i) through (vii) be re-written and very carefully considered. These statements are based on the premise that any geologic "activity" would be detrimental to the site. One can argue that the converse might be true in the context of using geologic processes to enhance the repository design!

P. 31402, (4) Potentially adverse natural conditions -- geochemical, following to design requirements. This section is confusing and imprecise. It reflects a lack of understanding of potential benefits of ground water on sealing certain kinds of rock. Although it is true that waste-generated heat would tend to increase water flow, it is also possible that such an effect might be utilized to drive mineralogic reactions that would seal fractures and effectively prevent the water from reaching the waste package. This section reflects the general assumption that water in the repository site is always an adverse condition. We are not yet sure that this is so.

P. 31402, Design requirements. I do not have significant comments on this section. I found it to be clear and well thought-out, and the best part of the 10CFR60 document.