March 27, 1985

SECY-85-109

RULEMAKING ISSUE
(Affirmation)

For: The Commissioners

From: William J. Dircks
Executive Director for Operations

Subject: AMENDMENTS TO 10 CFR PART 60--DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES

Purpose: To obtain Commission approval of a notice of final rulemaking.

Category: This paper involves a minor policy question.

Issue: Should 10 CFR Part 60 contain specific criteria for geologic disposal of high-level radioactive wastes in the unsaturated zone.

Summary: This paper presents final amendments which will assure that NRC regulations address considerations relevant to all geologic repositories whether sited in the saturated or unsaturated zone. Staff recommends that the Commission approve for publication as final amendments to 10 CFR Part 60 specific technical criteria for geologic disposal of high-level radioactive wastes within the unsaturated zone. Since resource needs to implement 10 CFR Part 60 have been reflected in programmatic budget requests no significant new resource expenditures will be required by issuance of these amendments.

Background: The Commission published for public comment proposed amendments to 10 CFR Part 60 which contained specific technical criteria related to disposal of high-level radioactive wastes within the unsaturated zone on February 16, 1984 (49 FR 5934). The recommended final amendments were developed following consideration of the comments received from fourteen groups and individuals. The recommended final amendments were presented before the ACRS Waste Management Subcommittee on July 11, 1984, and were discussed during the 292nd ACRS meeting, August 9-11, 1984.

Discussion: Regulations which established procedures for licensing the disposal of high-level radioactive wastes (HLW) in geologic

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repositories were published on February 25, 1981 (46 FR 13971). Proposed technical criteria against which license applications would be reviewed under 10 CFR Part 60 were published for public comment on July 8, 1981 (46 FR 35280) and final technical criteria were promulgated on June 21, 1983 (48 FR 28194).

In the statement of considerations to the proposed technical criteria the Commission explained that the proposed criteria were developed for disposal in saturated media because the then current plans of the Department of Energy (DOE) called for disposal at sufficient depth to lie solely within the hydrogeologic region called the saturated zone (46 FR 35281). The Commission further noted that additional or alternative criteria may need to be developed for regulating disposal in the unsaturated zone.

The Commission approach was criticized by several commenters, including DOE and the U.S. Geological Survey. The bases for this criticism were that (1) disposal of HLW within the unsaturated zone was a viable alternative to HLW disposal within the saturated zone and (2) since the Part 60 technical criteria were generally applicable without regard to the possibility of saturation, their scope and applicability should not be unduly restricted. The NRC staff reviewed the technical criteria in light of the public comments and found this criticism to be well-founded. The staff drew the possibility of further rulemaking in this area to the Commission's attention in SECY-83-59.

In the statement of considerations to the final technical criteria the Commission recognized that although the final technical criteria were generally appropriate to disposal in both the saturated and unsaturated zones, some distinctions were needed (48 FR 28203). Rather than promulgating the specific criteria which would apply to the unsaturated zone at the time the final technical criteria were published in June 1983, the Commission stated that it preferred to issue such criteria in proposed form so as to afford further opportunity for public comment. Proposed amendments developed in response to this Commission decision were published for public comment on February 16, 1984 (SECY-83-444; 49 FR 5934). Enclosure C contains a copy of the proposed amendments as published in the Federal Register. The proposed amendments contained provisions for new definitions (§60.2) and favorable and potentially adverse siting criteria (§60.122) related to HLW disposal within the unsaturated zone. Additionally, in the statement of considerations which accompanied the proposed amendments, the Commission particularly sought public comment on questions related to groundwater travel time calculations in unsaturated geologic media (49 FR 5937).

In conjunction with the proposed amendments, NRC published draft NUREG-1046 -- Disposal of High-Level Radioactive Wastes in the Unsaturated Zone: Technical Considerations for public comment. The Commission received a total of fourteen comment letters in response to its solicitation of public input on both the proposed amendments and draft NUREG-1046. In general, these commenters supported the Commission's proposed action and raised no significant new issues with respect to this rulemaking action. The commenters primarily addressed the questions posed by the Commission on groundwater travel time calculations and suggested word changes to the proposed amendments for the sake of clarity and technical accuracy.

Current technical criteria governing the post-emplacement performance of the particular barriers (i.e. engineered barriers and geologic setting) of the geologic repository system are set forth at §60.113 (48 FR 28224). The post-closure performance criteria for the geologic setting (§60.113(a)(2)) require that the geologic repository be located so that pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment be at least 1,000 years or such other travel time as may be approved or specified by the Commission (48 FR 28224).

In the statement of considerations which accompanied the proposed amendments the Commission discussed several reasons why calculations of pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel through the unsaturated zone could have large associated uncertainties, and hence could be of questionable value in estimating the capability of the geologic setting to isolate HLW from the accessible environment (49 FR 5936). The Commission stated that if DOE could demonstrate with reasonable assurance that travel time for groundwater movement through the unsaturated zone can be quantified, then DOE should be allowed to include such travel time when demonstrating compliance with §60.113(a)(2). The Commission also recognized that it may be more appropriate to specify another parameter upon which performance may be evaluated for a geologic setting in the unsaturated zone, or to utilize the approach set forth in §60.113(b) which provides the Commission with the flexibility to specify variations in the performance objectives on a case-by-case basis, as long as the overall system performance objective is satisfied. Therefore, to solicit public input on groundwater travel time in the unsaturated zone the Commission posed two questions on this issue in the statement of considerations (49 FR 5937). These questions requested public comment on: 1) how groundwater travel time in the unsaturated zone could be determined with reasonable assurance, and whether or not the existing groundwater travel time performance objective in §60.113(a)(2) should be limited to groundwater movement within the saturated zone; and 2) whether ground-

water travel time is an appropriate measure of performance for a site within the unsaturated zone or whether an alternative performance objective would be more appropriate. The issues surrounding the groundwater travel time calculations were specifically addressed by seven of the fourteen commenters on the proposed amendments and draft NUREG-1046. A discussion of the views expressed by these commenters is contained in Enclosure A (pp.4-14) while the individual comments on groundwater travel time are categorized in Enclosure D (pp. 4-16).

Following consideration of the public comments on groundwater travel time calculations, the staff recommends that the Commission maintain its original position as set forth at 49 FR 5936 that if DOE can demonstrate with reasonable assurance that travel times for groundwater movement through the unsaturated zone can be quantified, then DOE should be allowed to include such travel times when demonstrating compliance with §60.113(a)(2). However, the staff recognizes that for the unsaturated zone it may be more appropriate in some cases for the Commission to utilize the approach set forth in §60.113(b) which, as mentioned above, provides the Commission with the flexibility to specify variations in performance objectives on a case-by-case basis as long as the overall system performance objective is satisfied.

Although no change was made explicitly to the groundwater travel time provisions of §60.113(a)(2), the proposed definition of the term "groundwater" set forth at §60.2 would clarify that §60.113(a)(2) is equally applicable to geologic repositories within either the saturated or unsaturated zone. Similarly, the recommended amendment to the Siting Criteria (§60.122(b)(7)) would have the effect of making pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment which substantially exceeds 1,000 years a favorable condition for HLW disposal within either hydrogeologic zone.

In response to the comments which addressed other provisions of the proposed amendments, several word changes have been made for the sake of clarity and technical accuracy. A detailed discussion of the changes recommended by the staff can be found in the draft Federal Register notice (Enclosure A). In addition to these changes, new amendments containing modifications to existing provisions of §§60.133 and 60.134 are also included in the recommended final amendments. The provisions of §§60.133(f) and 60.134(b) have been modified to more closely identify the concept of a potential for creating a preferential pathway for groundwater to contact the waste packages. This change was prompted by a commenter's observation that as originally worded, these provisions might not be internally consistent with proposed §60.122(b)(8)(iv)

which identified a host rock that provides for free drainage as a favorable hydrogeologic condition in the unsaturated zone. Further, minor word changes were made to these two provisions for the sake of technical accuracy.

A staff analysis of the public comments on the proposed amendments and draft NUREG-1046 is provided in Enclosure D. The staff considered all public comments in developing the recommended final amendments.

The staff has reviewed the provisions of the final DOE Siting Guidelines related to the unsaturated zone against the recommended final amendments to 10 CFR Part 60 and has determined that the DOE Siting Guidelines are not in conflict with the 10 CFR Part 60 amendments.

NRC resource needs to implement the provisions of 10 CFR Part 60 have been reflected in programmatic budget requests. Thus, no significant new resource expenditures will be required by issuance of these amendments.

Recommendations: That the Commission:

1. Approve for publication as final amendments to 10 CFR Part 60 specific technical criteria for geologic disposal of HLW in the unsaturated zone and the accompanying Statement of Considerations, as set forth in the draft Federal Register notice in Enclosure A.

2. Certify that this rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. This certification is necessary in order to satisfy the requirements of the Regulatory Flexibility Act, 5.U.S.C. 605(a).

3. Note:

   a. The changes made to the proposed 10 CFR Part 60 amendments as published in the Federal Register are provided in comparative text in Enclosure B.

   b. Enclosure C contains a copy of the proposed amendments as published in the Federal Register on February 16, 1984.

   c. The detailed staff analysis of public comments on the proposed amendments and draft NUREG-1046 is contained in Enclosure D. (Draft NUREG-1046 is currently under review by the staff and will be revised to reflect

changes made in the unsaturated zone amendments. When this draft report has been revised it will be published as a final NUREG report).

d. A regulatory analysis is presented as Enclosure E.

e. A review of a draft version of the recommended final amendments was presented before the ACRS on July 11, 1984. Enclosure F is a copy of the August 14, 1984 letter from J. C. Ebersole, Chairman, ACRS to Chairman Palladino.

f. As provided by Section 121(c) of the Nuclear Waste Policy Act of 1982, no environmental assessment is being prepared in connection with this action.

g. This rule contains no new or amended recordkeeping, reporting, or application requirement, or any other type of information collection requirement, subject to the Paperwork Reduction Act (Pub. L. 96-511).

h. The Chief Counsel for Advocacy of the Small Business Administration will be informed by the Division of Rules and Records of the certification regarding economic impact on small entities.

i. The Subcommittee on Energy and the Environment of the House Interior and Insular Affairs Committee, the Subcommittee on Nuclear Regulation and the Senate Committee on the Environment and Public Works, the Subcommittee on Energy, Nuclear Proliferation and Federal Services of the Senate Committee on Government Affairs, and the Subcommittee on Energy and Power of the House Interstate and Foreign Commerce Committee will be informed of this rulemaking action by a letter similar to Enclosure G.

j. The Office of Public Affairs has determined that it is not necessary to issue a public announcement on these amendments.

Scheduling: If scheduled on the Commission agenda, the staff recommends this paper be considered at an open meeting. While no specific circumstances require Commission action by a particular date, the

Commission should be aware that the Department of Energy is currently considering certain unsaturated geologic media as potential repository sites.

William J. Dircks
Executive Director for Operations

Enclosures:
A. Federal Register Notice Containing Final Amendments to 10 CFR 60
B. Comparative Text Version of Amendments
C. Federal Register Notice on Proposed Amendments
D. Staff Analysis of Public Comments
E. Regulatory Analysis
F. ACRS Comments on Amendments
G. Draft Congressional Letter

Commissioners' comments should be provided directly to the Office of the Secretary by c.o.b. Thursday, April 11, 1985.

Commission Staff Office comments, if any, should be submitted to the Commissioners NLT Thursday, April 4, 1985, with an information copy to the Office of the Secretary. If the paper is of such a nature that it requires additional time for analytical review and comment, the Commissioners and the Secretariat should be apprised of when comments may be expected.

This paper is tentatively scheduled for affirmation at an Open Meeting during the Week of April 15, 1985. Please refer to the appropriate Weekly Commission Schedule, when published, for a specific date and time.

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ENCLOSURE A

NUCLEAR REGULATORY COMMISSION

AMENDMENTS TO 10 CFR PART 60

Disposal of High-Level Radioactive Wastes
in Geologic Repositories

AGENCY: Nuclear Regulatory Commission.

ACTION: Final rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is amending its regulations for the disposal of high-level radioactive wastes in geologic repositories. These amendments will ensure that the rule contains specific criteria for the disposal of high-level radioactive wastes within the unsaturated zone. This action is necessary to assure that NRC regulations address considerations relevant to all geologic repositories, whether sited in the saturated or unsaturated zone.

EFFECTIVE DATE:

FOR FURTHER INFORMATION CONTACT: Dr. Frank A. Costanzi, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC 20555, telephone (301)427-4362.

SUPPLEMENTARY INFORMATION:

BACKGROUND

On February 25, 1981, the Nuclear Regulatory Commission (NRC) promulgated a rule that established procedures for licensing the disposal of high-level radioactive wastes (HLW) in geologic repositories (46 FR 13971). NRC promulgated technical criteria to be used in the evaluation of license applications under those procedures on June 21, 1983 (48 FR 28194). Although these technical criteria are generally appropriate to disposal in both the saturated and unsaturated hydrogeologic zones, some further distinctions need to be made for disposal in the unsaturated zone. Consequently, the Commission expressed its intent to issue specific technical criteria for the unsaturated zone after promulgating the final technical criteria so as to afford further opportunity for public comment on this issue. Proposed amendments to these technical criteria to include HLW disposal within either the saturated or unsaturated zone were published for comment on February 16, 1984. These proposed amendments contained provisions for new definitions and favorable and potentially adverse siting criteria. In addition to the proposed amendments, the Commission specifically requested public input on two questions related to groundwater travel time calculations within the unsaturated zone. In conjunction with the proposed

amendments, the Commission published for public comment draft NUREG-1046[1] which contained a discussion of the principal technical issues considered by the Commission during the development of the proposed amendments.

SUMMARY OF COMMENTS AND CHANGES

A total of fourteen groups and individuals commented on the proposed amendments and draft NUREG-1046. There was general acceptance of the Commission's view that disposal of HLW within the unsaturated zone is a viable alternative to disposal within the saturated zone. The commenters addressed the Commission's specific questions on groundwater travel time within the unsaturated zone and provided additional comments suggesting word changes to improve the technical accuracy and clarity of the proposed amendments. The principal comments received on the questions and proposed amendments, and the Commission's corresponding responses, are discussed below. Changes and clarifications made in the rule as a result of the Commission's consideration of these comments are also explained in this section. Copies of the individual comment letters and a detailed analysis of these letters by the NRC staff are available in the NRC Public Document Room, 1717 H Street NW., Washington, DC 20555.

[1]Draft NUREG-1046 -- Disposal of High-Level Radioactive Wastes in the Unsaturated Zone: Technical Considerations is currently being revised to reflect changes made in the amendments to 10 CFR Part 60 related to HLW disposal within the unsaturated zone. When this revision is completed, a copy of NUREG-1046 will be placed in the Commission's Public Document Room. Upon publication, copies of NUREG-1046 may be purchased by calling (301) 492-9530 or by writing to the Publication Services Section, Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, DC 20555, or purchased from the National Technical Information Service, Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

(a) Groundwater Travel Time Calculations.

Technical criteria governing the post-emplacement performance of the particular barriers of the geologic repository system (i.e. engineered barriers and geologic setting) are set forth at §60.113 (48 FR 28224; June 21, 1983). The post-closure performance criterion for the geologic setting set forth at §60.113(a)(2) requires that the geologic repository be located so that pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment be at least 1,000 years or such other travel time as may be approved or specified by the Commission. Although no change was made explicitly to the provisions of §60.113(a)(2) in the proposed amendments for the unsaturated zone, the proposed definition of the term "groundwater" set forth at §60.2 would clearly make the scope of §60.113(a)(2) applicable to geologic repositories within either the saturated or unsaturated zone. Similarly, the proposed amendment to the Siting Criteria (§60.122(b)(7)) would have the effect of making pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment which substantially exceeds 1,000 years a favorable condition for HLW disposal within either hydrogeologic zone.

In the statement of considerations which accompanied the proposed amendments, the Commission discussed possible limitations of the pre-waste-emplacement groundwater travel time performance objective of §60.113 when applied to the unsaturated zone. However, the Commission stated that if DOE could demonstrate with reasonable assurance that travel time for groundwater movement through the unsaturated zone can be quantified, then DOE should be allowed to include such travel time when

demonstrating compliance with §60.113(a)(2). The Commission also acknowledged that it may be more appropriate to specify another parameter upon which performance may be evaluated for a geologic setting in the unsaturated zone, or to use the approach set forth in §60.113(b) which provides the Commission with the flexibility to specify variations in performance objectives on a case-by-case basis, as long as the overall system performance objective is satisfied. Further, the Commission observed that calculations of pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel through the unsaturated zone could involve considerable uncertainty, and thus requested public comment on questions related to the applicability of the existing 10 CFR Part 60 performance objective for the geologic setting to sites located in unsaturated geologic media. In response to this solicitation of public comment, seven of the fourteen commenters specifically addressed the questions on groundwater travel time calculations. These questions and the views expressed by the seven commenters are reviewed below.

The notice of proposed rulemaking first requested comment on how groundwater travel time in the unsaturated zone could be determined with reasonable assurance. Comments received in response to this question were divided nearly equally into two categories. The first group of commenters argued that presently it would be difficult to calculate groundwater travel time in the unsaturated zone with reasonable assurance because of the lack of generally acceptable methodology and the limited scope of research efforts currently devoted to this question. A second group of commenters, comprised predominantly of representatives of other Federal agencies, endorsed the opinion that groundwater travel time could

be determined with reasonable assurance. One of these commenters indicated that groundwater travel time calculations could be made by measuring the amount of natural tritium in the groundwater samples from a vertical profile in unsaturated geologic formations. Two other commenters stated that groundwater travel time could be derived from groundwater flux using measurements of ambient water content, degree of saturation, matric potential and hydraulic conductivity to determine moisture-characteristic curves relating these parameters to one another. These curves can be developed so as to predict constitutive relationships over a wide range of conditions. From these relationships and flux determinations these commenters argued that groundwater velocities and subsequently groundwater travel times could then be estimated. One of these two commenters further stated that reasonable assurance may be gained in estimating groundwater travel time using results of laboratory testing, state-of-the-art direct determinations in the field or laboratory, and bounding estimates developed by indirect methods, while both commenters indicated that reasonable assurance may also be gained by incorporating uncertainty analyses into predictive models.

The Commission recognizes that prior to the commencement of HLW disposal studies most groundwater investigations in unsaturated geologic media were generally limited in scope to issues related to near-surface, highly porous soils and unconsolidated rock types. Efforts to predict groundwater movement through potentially suitable geologic repository sites within the unsaturated zone often entail the application of hydrogeologic theories, models and methodologies governing near-surface, porous media to much deeper hydrogeologic environments and different rock properties than they originally were designed for. The Commission

realizes that given the current state of groundwater investigations there may be difficulties associated with groundwater travel time calculations in both the saturated and unsaturated zones, as one commenter observed. However, the Commission concludes that groundwater travel time calculations can be determined in the unsaturated zone, though not necessarily with great precision, provided that the proper level of site characterization analysis is conducted. Following a detailed study of the comments received on this question, the Commission believes it is feasible for DOE to demonstrate compliance with the groundwater travel time provision, using existing field and laboratory experiments. Further, as several commenters indicated, a substantial effort is currently underway to develop new methodologies and to improve existing techniques for measuring the hydrogeologic parameters and flow properties that will provide the necessary input to groundwater travel time calculations. For example, it was noted that in-situ monitoring techniques, including tracer tests, are undergoing development and may broaden the range of rock types and conditions for which it is feasible to estimate groundwater velocity and, hence, groundwater travel time.

The second part of the first question on which the Commission sought comment centered on whether or not the existing groundwater travel time performance objective in §60.113(a)(2) should be limited to groundwater movement within the saturated zone. The general consensus among commenters on this issue was that there is no reason to strictly limit the groundwater travel time performance objective to water movement in the saturated zone. Following a review of the discussions presented in these comments the Commission has determined that the groundwater travel

time provision (§60.113(a)(2)) can be applied to a geologic setting located in either the saturated or unsaturated zone. The Commission could discern no obvious advantage for developing a parallel provision for the unsaturated zone as one commenter suggested. With respect to another commenter's concern that if the Commission decided to retain the groundwater travel time provision, travel time along any segment of the flow path, including the unsaturated zone, should be creditable, provided that reasonable assurance has been demonstrated. The Commission has concluded further that the definition of the term "groundwater" set forth at §60.2 will allow travel time along subsurface flowpaths to be considered regardless of the hydrogeologic regime through which the water is moving. As defined in §60.2, "groundwater" means all water which occurs below the land surface. The Commission believes that the concerns of one commenter that it would be inappropriate to limit groundwater travel time to the saturated zone because such an action would not accurately indicate the actual radionuclide transport time from the original location of the waste to the accessible environment will also be largely accommodated by the definition of the term "groundwater" in §60.2. With respect to the view expressed that the approach set forth in §60.113(b) may be particularly appropriate in the case of HLW disposal in the unsaturated zone, it should be noted that in those instances when groundwater travel time calculations cannot be demonstrated with reasonable assurance, the Commission may prefer to specify or approve alternative performance objectives pursuant to §60.113(b).

In its second question related to groundwater travel time the Commission sought public comment on whether groundwater travel time represented an appropriate measure of performance for a site within the

unsaturated zone, or whether an alternative performance objective for the geologic setting would be more appropriate. The views expressed by the commenters were nearly equally divided on this issue. Some of the commenters asserted that, although not ideal, the groundwater travel time provision may, under certain circumstances, represent an appropriate measure of performance for a geologic setting in the unsaturated zone. Other commenters argued that groundwater travel time was not an appropriate performance objective for HLW disposal within the unsaturated zone and suggested several alternative performance objectives, as discussed below.

With respect to alternative performance requirements, one commenter considered it unacceptable to establish an alternative performance measure for unsaturated geologic media while using a different measure for a saturated salt site. The Commission anticipates that the decision to apply the groundwater travel time provision to all geologic settings regardless of the hydrogeologic zone in which the site is located should alleviate this commenter's concern. Another commenter stated that although groundwater travel time substantially exceeding 1,000 years is a favorable condition, it is not appropriate as a totally definitive performance objective for disposal in either the saturated or unsaturated zone. However, in view of §60.113(b), the groundwater travel time performance objective is not such a "totally definitive" objective. The same commenter considered release criteria as the absolute measure of total performance and further argued that realistic estimates of release criteria for the unsaturated zone might not be possible until observations are actually made in shafts and drifts. In response, the Commission would note that the site characterization program would

include such observations. One commenter indicated that if NRC chose to retain the groundwater travel time performance objective that this provision should only be applied if the travel time calculations include combined travel times in the unsaturated and saturated zones so as to better approximate radionuclide transport. The Commission considers the concerns of this commenter to be accommodated by the definition of the term "groundwater" adopted in the final amendments.

Most commenters who argued against the application of the groundwater travel time performance objective to unsaturated geologic media generally suggested alternatives based either on the hydrogeologic concept of flux or upon the case-by-case approach of §60.113(b).

As derived from U.S. Geological Survey Water Supply Paper-1988 the term groundwater "flux" can be defined as the rate of discharge of groundwater per unit area of porous or fractured geologic media measured at right angles to the direction of flow. In comparison, the term "groundwater travel time" used in 10 CFR Part 60 can be interpreted as the length of time required for a unit volume of groundwater to travel between two locations. Alternatives suggested by the commenters which were based upon the concept of flux included a maximum groundwater flux requirement and a dual "either/or" criterion which would allow the applicant the option of demonstrating compliance with either a minimum groundwater travel time requirement or a maximum groundwater flux requirement. After considering the possibility of an alternative performance objective based upon the maximum groundwater flux, the Commission has decided to retain the groundwater travel time requirement for geologic settings regardless of the hydrogeologic zone in which they are located. This decision was based on the Commission's belief that the groundwater travel time

requirement represents an independent measure of the overall hydrogeologic system performance which may encompass a variety of hydrogeologic parameters including groundwater flux. However, the Commission expects that groundwater flux will be an important factor in the technical evaluation of radionuclide releases in the unsaturated zone, as well as in the saturated zone.

The Commission does not consider it necessary to specify a dual "either/or" groundwater criterion suggested by one commenter since under the provisions of §60.113(b), the Commission already has the flexibility to approve or specify some other radionuclide release rate, designed containment period, or pre-waste-emplacement groundwater travel time on a case-by-case basis. Further, the Commission anticipates that areally integrated or averaged groundwater flow velocity referred to by this same commenter will be addressed in the evaluation of uncertainties surrounding the groundwater travel time calculations.

In addition, to a performance criterion based upon groundwater flux, other alternative performance criteria were discussed by commenters. DOE, in its original comment letter on the proposed amendments expressed general support for a performance criterion based upon groundwater flux, but in an addendum to this letter concluded that it would be impractical to define a performance objective for the geologic setting based on flux through a geologic repository located in the unsaturated zone. Instead, DOE took the position that an alternative performance objective developed upon the concept of a minimum time for groundwater travel to the accessible environment based on four separate physical events would be more appropriate for the unsaturated zone. The four physical events contained in the suggested DOE alternative performance objective are:

(1) the creation of a drying zone around the emplaced wastes, (2) the subsequent return of moisture to the rock surrounding the waste canisters, (3) the travel time through the unsaturated zone and finally, (4) the travel time to the accessible environment by groundwater movement through the saturated zone.

The manner in which these or possibly other events may occur within the geologic repository system will depend upon the interactions of a number of site- and design-specific parameters such as the thermomechanical and hydrogeologic properties of the host rock, thermal loading of the underground facility and waste package design. However, as noted at 48 FR 28203, the Commission believes that it is important to consider both natural and engineered barriers individually and has structured the technical criteria of 10 CFR Part 60 in a way that requires that the natural and engineered barriers each make a definite contribution to the overall system performance objective for the geologic repository. To that end the Commission considers it important to maintain a standard of performance for the geologic setting that is a measure of the quality of the natural barriers and is independent of any interaction between these natural barriers and the engineered barriers.

The existing pre-waste-emplacement groundwater travel time provision (§60.113(a)(2)) is such a performance standard since it is characteristic of the area outside of the disturbed zone created by underground facility construction and waste emplacement operations. This parameter is not dependent upon the effects of waste emplacement and is intended to provide assurance of isolation beyond the first 1000 years. The Commission prefers the existing groundwater travel time provision, which

is part of its multiple barrier approach, to the alternative performance objective suggested by DOE since the latter does not offer a measure of performance for the geologic setting that can be evaluated independently of design and engineering factors. Further, the physical parameters needed to evaluate pre-waste-emplacement conditions of the geologic setting can be accurately measured with direct and indirect field methodology.

The DOE suggestion would necessitate that estimates of long-term performance of the geologic setting under post-waste-emplacement conditions be used in the Commission's deliberations on whether the groundwater travel time performance objective is met. The uncertainties associated with such estimates can be affected by a number of factors, including the age and nature of the waste and the design of the underground facility. Evaluations of the performance of the geologic setting under post-waste-emplacement conditions must also take into account predictions of future changes in the thermomechanical, geochemical and hydrogeologic properties of the geologic setting through time as a result of the creation of a non-isothermal environment due to waste emplacement. The Commission's view is that the present emphasis on pre-waste-emplacement conditions will provide a higher degree of confidence in the continued isolation capabilities of the natural barriers of the geologic setting over the long term.

The view was also expressed by other commenters that the development of a new alternative performance objective to existing §60.113 (a)(2) may not be necessary since the Commission's approach set forth at §60.113(b) might be a more appropriate means of specifying alternatives

to the groundwater travel time criterion. The Commission notes that it is essentially following this approach in its decision to retain the existing provisions of §60.113(a)(2) and §60.113(b).

Following a review of the various alternative performance objectives suggested by the commenters, the Commission considers groundwater travel time to represent a more appropriate parameter upon which the performance of the geologic setting can be evaluated than any of the suggested alternatives because a prescribed groundwater travel time can be generically applied and will provide a conservative estimate of a minimum radionuclide release time to the accessible environment. It should be noted, however, that the Commission still retains the option of applying the provisions of §60.113(b) instead of §60.113(a)(2) to a particular geologic setting when such an action is deemed appropriate.

(b) Definition of Groundwater.

Three commenters addressed the Commission's proposed definition of the term "groundwater" as meaning "all water below the Earth's surface". Two of these commenters, citing possible confusion among the public and scientific community stated that the Commission should not define "groundwater" in this manner, but rather should limit the use of the term to water within the saturated zone. In contrast, one commenter commended NRC on this definition, but noted that it may not be consistent with the definition of the term included in the proposed EPA environmental standards -- 40 CFR 191. In its proposed rule EPA defined "groundwater" as "water below the land surface in a zone of saturation" (47 FR 58205, December 29, 1982). While the Commission recognizes that limiting the use of the term "groundwater" to water within the saturated zone may

currently be a more widely accepted practice, the Commission also notes that numerous members of the scientific community routinely use the term groundwater in the same context as the Commission proposed.

The Commission has carefully reviewed the arguments presented by the commenters on this issue and has decided to retain the definition of groundwater with one minor change--the phrase "Earth's surface" has been replaced by "land surface". This change was made for the sake of clarity and internal consistency with wording in the definition of the term "unsaturated zone". The Commission's decision was based on the fact that, at present, no unique definition of the term "groundwater" appears to be universally accepted in the technical community. Therefore, the Commission has not actually redefined the term "groundwater" as one commenter suggested but rather has adopted one of the commonly used definitions of the term that is most consistent with the Commission's intent concerning the provisions related to groundwater throughout the Part 60 regulation. With respect to the differences between the definition of the term "groundwater" adopted by the Commission and that proposed by EPA, the Commission notes that it does not consider the two definitions to be inconsistent since the scope of the definition adopted in §60.2 will encompass water within the zone of saturation as well as water within the unsaturated zone. As noted above, the Commission considers it necessary to adopt a broader definition of the term "groundwater" in order to maintain consistency with previous Commission usage of this term and to effectively apply the provisions of 10 CFR Part 60 to the regulation of HLW disposal within unsaturated as well as saturated geologic media. Further, since EPA has not yet promulgated its final environmental standards, the Commission cannot

anticipate whether or how "groundwater" will actually be defined in the final EPA regulation.

(c) Definition of the "unsaturated zone."

The Commission's proposed definition was derived from U.S. Geological Survey (USGS) Water Supply Paper 1988. Two commenters noted that the phrase "deepest water table" introduced confusion into the definition of the term "unsaturated zone" (§60.2). The Commission had inferred that the phrase "deepest water table" as used by the USGS referred to the regional water table and hence adopted this same phraseology in the definition of the term "unsaturated zone" set forth in the proposed amendments to 10 CFR Part 60. However, in light of confusion expressed by commenters which may be due partially to the incorrect inference by some that the phrase "deepest water table" referred to local rather than regional water tables, the definition of term "unsaturated zone" has been modified. To clarify the Commission's original intent, the phrase "deepest water table" has been replaced by "regional water table" in the final amendments. (A conforming change has also been made to the definition of the term "saturated zone"). Additionally, the phrase "water in this zone is under less than atmospheric pressure" has been rewritten as "fluid pressure in this zone is less than atmospheric pressure" for the sake of technical clarity. The Commission has attempted to maintain internal consistency with the definitions of hydrogeologic terms presented in USGS Water Supply Paper 1988 wherever practicable and for this reason has not adopted any of the alternative definitions of the term "unsaturated zone" suggested by the commenters.

(d) Favorable Siting Conditions.

§60.122(b)(2). The term "low hydraulic potential" has been replaced with "low hydraulic gradient" in §60.122(b)(2)(iii) as suggested by one commenter for the sake of technical accuracy.

§60.122(b)(7). In addition to comments received in response to the Commission's specific request for input on its questions related to groundwater travel time calculations in the unsaturated zone, the subject of groundwater travel time was also addressed by two commenters on proposed §60.122(b)(7). The issues raised by these two commenters merit discussion here although they have resulted in no change to the rule.

The provisions of §60.122(b)(7) have the effect of identifying pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years as a favorable siting criteria for both the saturated and unsaturated zones. Previously these provisions (formerly designated as §60.122(b)(2)(iv)) applied only to sites within the saturated zone.

One commenter on proposed §60.122(b)(7) opposed the application of this provision to the unsaturated zone on the grounds that the determination of groundwater travel time in the unsaturated zone may not be necessary nor always be possible. Under such circumstances, this commenter argued, inability to demonstrate that groundwater travel time substantially exceeds 1,000 years should not amount to the absence of a favorable condition. The issue of groundwater travel time in the unsaturated zone has already been discussed in detail in the above section on Groundwater Travel Time Calculations and will not be repeated here. With respect to the second part of this comment the Commission

reiterates its position set forth in the Supplementary Information to the final 10 CFR Part 60 technical criteria (48 FR 28201) that a site is not disqualified as a result of the absence of a favorable siting condition.

A second commenter on §60.122(b)(7) expressed the view that for a HLW repository within the unsaturated zone, minimizing leachate flux would appear to be at least as important as maximizing groundwater travel time. To that end, this commenter felt that it might be more appropriate to specify as a favorable siting condition a dual "either/or" criterion such that groundwater travel time is greater than 1,000 years or groundwater flux through the host rock at a proposed site is less than some average rate. This rate, it was argued, could be based on nuclide solubility, leach rate criteria, and population exposure criteria. The commenter stated that whichever criterion was ultimately selected it should be based upon an areally integrated or averaged calculation, over an area on the order of the cross-sectional area of the repository normal to the direction of expected flux regardless of hydrogeologic zone to help reduce controversy concerning how the "fastest pathway" can be determined. For a discussion of the concept of applying a dual criterion of either groundwater travel time or groundwater flux see the above section entitled Groundwater Travel Time Calculations.

Minor corrections have been made to the provisions of §60.122(b)(8) for the sake of clarity and technical accuracy as a result of the comments received. The phrase "and nearly constant" has been deleted from §60.122(b)(8)(i) and a typographical error in the word "overlying" has been corrected.

(e) Potentially Adverse Conditions.

§60.122(c)(9). This provision of the final technical criteria identified groundwater conditions in the host rock that are not reducing as a potentially adverse condition for the saturated zone. One commenter on the proposed amendments stated that a parallel provision should be provided for the unsaturated zone. The Commission considers this argument to have merit and has modified the final amendments accordingly. Rather than create an additional provision, the Commission has deleted the qualifying phrase "for disposal in the saturated zone" from existing §60.122(c)(9) to ensure that this provision will be applicable equally to groundwater conditions in the saturated and unsaturated zones.

§60.122(c)(23). Minor editorial changes have been made as suggested by one commenter, for the sake of clarity.

§60.122(c)(24). During the development of the proposed amendments (47 FR 5935, February 16, 1984) the Commission's staff identified vapor transport of contaminants as a potential concern associated with HLW disposal in the unsaturated zone. The Commission noted that in unsaturated geologic media, water is transported in both liquid and vapor phases. The relative contribution of transport via both these phases and their direction of movement with respect to a geologic repository was deemed to directly influence the containment of contaminants. Vapor transport, particularly when a thermal gradient is imposed, may provide a possible mechanism for radionuclide migration from a geologic repository in unsaturated geologic media. This issue was discussed at length by the Commission in the proposed amendments and in draft NUREG-1046. The comments received on the discussion of vapor transport and on the wording of the proposed amendment §60.122(c)(24) indicated a need for the

Commission to clarify its intent with respect to vapor transport.

The issue of vapor transport of contaminants is a relatively new issue that has grown out of scientific investigations of the feasibility of HLW disposal in unsaturated geologic media. Since most scientific studies related to HLW disposal within the unsaturated zone have been initiated very recently, many of the associated issues have not as yet been examined in any great detail. The Commission recognized that vapor formation may not necessarily constitute an adverse condition for a particular geologic repository site, but, given the fact that vapor transport could provide a mechanism for radionuclide transport within the unsaturated zone, it wanted the opportunity to evaluate whether or not vapor transport could adversely affect a geologic repository system. To that end the Commission identified the potential for vapor transport of radionuclides from an underground facility located in the unsaturated zone to the accessible environment as a potentially adverse condition in the proposed amendments (§60.122(c)(24)). The Commission has not reached any conclusions on vapor transport, as one commenter incorrectly inferred, but rather is currently sponsoring research on vapor transport in unsaturated fractured rock in an effort to better understand this subject.

Some confusion was expressed by the commenters with respect to the Commission's use of the term "vapor transport". In particular, one commenter stated that §60.122(c)(24), as written, was ambiguous and meaningless. The term "vapor transport" as used in the proposed amendments referred to both water vapor and the gaseous state of some constituent contaminants. A second commenter on this issue suggested that the Commission add quantitative clarifications to this provision since the

proposed wording allowed no potential vapor transport of radionuclides by molecular diffusion (i.e., transport at a microscopic level due to concentration gradients) or convective transport (i.e., transport due to temperature or density gradients). The same commenter noted that while the flux values associated with these two transport processes might be miniscule, they would not be zero at any unsaturated site. The Commission does not consider it appropriate to add quantitative clarifications to §60.122(c)(24) because the movement of radionuclides in the gaseous state is, to a large extent, dependent on site- and design-specific parameters. The Commission considers the movement of radionuclides in the gaseous state may be a potentially important site- and design-related process and will retain the opportunity to evaluate whether or not such a process will adversely affect the geologic repository system. However, to alleviate the confusion surrounding proposed §60.122(c)(24), the wording of this provision has been extensively modified in the final amendments. Reference to "vapor transport" has been deleted, and this provision now solely addresses the potential for the movement of radionuclides in a gaseous state through air-filled pore spaces of an unsaturated geologic medium to the accessible environment as a potentially adverse condition. The Commission believes the revised wording will more accurately convey its original intent and should remove any ambiguity associated with the previous wording, such as one commenter's query of where the vapor transport is occurring and when it is important.

The Commission agrees with the commenter who indicated that vapor transport may also occur in geologic repositories sited in the saturated zone until resaturation occurs. A temporary, localized, unsaturated

region could form around an underground facility within the saturated zone as a result of activities related to construction and operation of a geologic repository (e.g. dewatering of shafts and drifts). To date, the issue of vapor transport has not been raised for a geologic repository within the saturated zone primarily because such a phenomenon would be expected to be encompassed within a much larger saturated region, that is, vapor transport might only be expected to occur in that portion of the host rock where the voids are not completely filled or refilled with groundwater. Further, it is anticipated that the time required for waste package integrity (300-1,000 yrs) will generally exceed the post-closure time required for resaturation of a geologic repository within the saturated zone (assumed by the NRC staff to occur within a few hundred years following permanent closure). Therefore, the Commission does not consider it necessary at this time to identify vapor transport as a potentially adverse condition for HLW disposal within the saturated zone. However, if future research in the area of vapor transport challenges these current assumptions, the Commission may decide to broaden the provisions of §60.122(c)(24) to include both the saturated and unsaturated zones.

(f) Design Criteria.

Changes were made to provisions of the final technical criteria related to design criteria. The provisions of §60.133(f) have been modified to more closely identify the concept of a potential for creating a preferential pathway for groundwater to contact the waste packages. This change was prompted by a commenter's observation that as originally worded, this provision might not be internally consistent with new

§60.122(b)(8)(iv) which identifies a host rock that provides for free drainage as a favorable hydrogeologic condition in the unsaturated zone. Similar word changes have been made to the provisions of §60.134(b) for consistency with §60.122(b)(8)(iv). Additionally, the phrase "radioactive waste migration" has been changed to "radionuclide migration" in both §60.133(f) and §60.134(b) for the sake of technical accuracy. The changes should ensure that these provisions will be equally applicable to geologic repositories within either the saturated or unsaturated zone, and will more accurately convey the Commission's original intent.

ENVIRONMENTAL IMPACT

Pursuant to Section 121(c) of the Nuclear Waste Policy Act of 1982, the promulgation of these criteria does not require the preparation of an environmental impact statement under Section 102(2)(C) of the National Environmental Policy Act of 1969 or any environmental review under subparagraph (E) or (F) of Section 102(2) of such Act.

PAPERWORK REDUCTION ACT STATEMENT

The final rule contains no new or amended recordkeeping, reporting or application requirement, or any other type of information collection requirement subject to the Paperwork Reduction Act (Pub. L. 96-511).

REGULATORY FLEXIBILITY CERTIFICATION

In accordance with the Regulatory Flexibility Act of 1980 (5 U.S.C. 605(b)), the Commission certifies that this rule will not have a significant economic impact on a substantial number of small entities. The only entity subject to regulation under this rule is the U.S. Department of Energy, which is not a small entity as defined in the Regulatory Flexibility Act.

LIST OF SUBJECTS IN 10 CFR PART 60

High-level waste, Nuclear power plants and reactors, Nuclear materials, Penalty, Reporting and recordkeeping requirements, Waste treatment and disposal.

ISSUANCE

For the reasons set out in the preamble and under the authority of the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, the Nuclear Waste Policy Act of 1982, and 5 U.S.C. 553, the Nuclear Regulatory Commission is adopting the following amendments to 10 CFR Part 60.

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

1. The authority citation for Part 60 continues to read as follows:

Authority: Secs. 51, 53, 62, 63, 65, 81, 161, 182, 183, 68 Stat. 929, 930, 932, 933, 935, 948, 953, 954, as amended (42 U.S.C. 2071, 2073, 2092, 2093, 2095, 2111, 2201, 2232, 2233); secs. 202, 206, 88 Stat. 1244, 1246, (42 U.S.C. 5842, 5846); secs. 10 and 14. Pub. L. 95-601, 92 Stat. 2951 (42 U.S.C. 2021a and 5851); sec. 102, Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332); sec. 121, Pub. L. 97-425, 96 Stat. 2228 (42 U.S.C. 10141).

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

2. Section 60.2 is amended by adding two new definitions in proper alphabetical sequence and revising an existing definition:

§ 60.2 Definitions.

* * * * *

"Groundwater" means all water which occurs below the land surface.

* * * * *

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

* * * * *

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

* * * * *

3. Section 60.122 is amended by revising paragraphs (b)(2)(iii) and (c)(9), redesignating paragraph (b)(2)(iv) as (b)(7), and adding new paragraphs (b)(8), (c)(22), (23) and (24) to read as follows:

§ 60.122 Siting criteria.

* * * * *

(b) ***

(2) ***

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

* * * * *

(7) Pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years.

(8) For disposal in the unsaturated zone, hydrogeologic conditions that provide--

(i) Low moisture flux in the host rock and in the overlying and underlying hydrogeologic units;

(ii) A water table sufficiently below the underground facility such that fully saturated voids contiguous with the water table do not encounter the underground facility;

(iii) A laterally extensive low-permeability hydrogeologic unit above the host rock that would inhibit the downward movement of water or divert downward moving water to a location beyond the limits of the underground facility;

(iv) A host rock that provides for free drainage; or

(v) A climatic regime in which the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration.

(c) ***

(9) Groundwater conditions in the host rock that are not reducing.

* * * * *

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

(23) Potential for existing or future perched water bodies that may saturate portions of the underground facility or provide a faster flow path from an underground facility located in the unsaturated zone to the accessible environment.

(24) Potential for the movement of radionuclides in a gaseous state through air-filled pore spaces of an unsaturated geologic medium to the accessible environment.

* * * * *

4. Section 60.133 is amended by revising paragraph (f) to read as follows:

§ 60.133 Additional design criteria for the underground facility.

* * * * *

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

* * * * *

5. Section 60.134 is amended by revising paragraph (b)(1) to read as follows:

§ 60.134 Design of seals for shafts and boreholes.

* * * * *

(b) ***

(1) The potential for creating a preferential pathway for groundwater to contact the waste packages or (2) for radionuclide migration through existing pathways.

Dated at Washington, DC, this _____ day of _____, 1985.

For the Nuclear Regulatory Commission.

_____

Samuel J. Chilk,
Secretary of the Commission.

ENCLOSURE B

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

1. The authority section for Part 60 continues to read as follows:

Authority: Secs. 51, 53, 62, 63, 65, 81, 161, 182, 183, 68 Stat. 929, 930, 932, 933, 935, 948, 953, 954, as amended (42 U.S.C. 2071, 2073, 2092, 2093, 2095, 2111, 2201, 2232, 2233): secs. 202, 206, 88 Stat. 1244, 1246, (42 U.S.C. 5842, 5846); secs. 10 and 14. Pub. L. 95-601, 92 Stat. 2951 (42 U.S.C. 2021a and 5851); sec. 102, Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332); sec. 121, Pub. L. 97-425, 96 Stat. 2228 (42 U.S.C. 10141).

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

[1.] 2. Section 60.2 is amended by adding two new definitions in proper alphabetical sequence and revising an existing definition:

§ 60.2 Definitions.

* * * * *

"Groundwater" means all water which occurs below the [Earth's] land surface.

* * * * *

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

* * * * *

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

* * * * *

[2.] 3. Section 60.122 is amended by revising paragraphs (b)(2)(iii) and (c)(9), redesignating paragraph (b)(2)(iv) as (b)(7), and adding new paragraphs (b)(8), (c)(22), (23) and (24) to read as follows:

§ 60.122 Siting criteria.

* * * * *

(b) ***

(2)***(iii) Low vertical permeability and low hydraulic [potential] gradient between the host rock and the surrounding hydrogeologic units.

* * * * *

(7) Pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years.

(8) For disposal in the unsaturated zone, hydrogeologic conditions that provide--

(i) Low [and-nearly-constant] moisture flux in the host rock and in the overlying and underlying hydrogeologic units;

(ii) A water table sufficiently below the underground facility such that fully saturated voids continuous with the water table do not encounter the underground facility;

(iii) A laterally extensive low-permeability hydrogeologic unit above the host rock that would inhibit the downward movement of water or divert downward moving water to a location beyond the limits of the underground facility;

(iv) A host rock that provides for free drainage; or

(v) A climatic regime in which the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration.

* * * * *

(c) ***

(9) [For-disposal-in-the-saturated-zone,] Groundwater conditions in the host rock that are not reducing.

* * * * *

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

(23) Potential for existing or future perched water bodies that may [~~have the effect of saturating~~] saturate portions of the underground facility or [~~providing~~] provide a faster flow path [~~for radionuclide movement~~] from an underground facility located in the unsaturated zone to the accessible environment.

(24) Potential for [~~vapor transport of radionuclides from the underground facility located in the unsaturated zone~~] the movement of radionuclides in a gaseous state through air-filled pore spaces of an unsaturated geologic medium to the accessible environment.

* * * * *

4. Section 60.133 is amended by revising paragraph (f) to read as follows:

§ 60.133 Additional design criteria for the underground facility.

* * * * *

(f) Rock excavation. The design of the underground facility shall incorporate excavation methods that will limit the potential for creating a preferential pathway for groundwater to contact the waste packages or [~~radioactive waste~~] for radionuclide migration to the accessible environment.

* * * * *

5. Section 60.134 is amended by revising paragraph (b)[-~~(1)~~-] to read as follows:

§ 60.134 Design of seals for shafts and boreholes.

* * * * *

(b) ***

(1) The potential for creating a preferential pathway for groundwater to contact the waste packages or [~~radioactive water~~] for radionuclide migration through existing pathways.

ENCLOSURE C

Proposed Rules

Federal Register
Vol. 49. No. 33
Thursday. February 16. 1984

This section of the FEDERAL REGISTER contains notices to the public of the proposed issuance of rules and regulations. The purpose of these notices is to give interested persons an opportunity to participate in the rule making prior to the adoption of the final rules.

NUCLEAR REGULATORY COMMISSION

10 CFR Part 60

Disposal of High-Level Radioactive Wastes in the Unsaturated Zone

AGENCY: Nuclear Regulatory Commission.

ACTION: Proposed rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is considering amending its rules on the disposal of high-level radioactive wastes (HLW) in geologic repositories so that the technical criteria for geologic disposal in the saturated zone may be equally applicable to disposal within the unsaturated zone. The amendments are being proposed in response to public comments on the proposed technical criteria for geologic disposal in the saturated zone. Final technical criteria adopted by the Commission for disposal of HLW in the saturated zone were published in the Federal Register on June 21, 1983.

DATES: Comment period expires April 16, 1984. Comments received after this date will be considered if it is practical to do so, but assurance of consideration cannot be given except as to comments received on or before this date.

ADDRESSES: Send comments or suggestions to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Docketing and Service Branch. Copies of comments received may be examined at the NRC Public Document Room, 1717 H Street NW., Washington, DC 20555.

FOR FURTHER INFORMATION CONTACT: Dr. Colleen Ostrowski, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC, 20555, telephone (301) 427-4343.

SUPPLEMENTARY INFORMATION:

Background

On February 25, 1981 the Nuclear Regulatory Commission (NRC) published a rule that established procedures for licensing the disposal of HLW in geologic repositories (46 FR 13971). NRC published proposed technical criteria to be used in the evaluation of license applications under those procedures on July 8, 1981 (46 FR 35280). In response to solicitation for public comments on the proposed technical criteria NRC received 93 comment letters. The Commission considered all public comments in developing the final technical criteria which were published on June 21, 1983 (48 FR 28194).

Several commenters on the proposed rule, including the U.S. Department of Energy (DOE), the U.S. Department of the Interior, and separately the U.S. Geological Survey (USGS), took issue with a statement made by the Commission at 46 FR 35281 which explained that the proposed technical criteria were developed specifically for disposal in saturated geologic media because DOE plans at that time called for HLW disposal at sufficient depth to be situated in the hydrogeologic region termed the saturated zone. The commenters considered disposal in the unsaturated zone [1] to be a viable alternative, and noted that since the technical criteria were generally applicable without regard to the possibility of saturation, their scope and applicability should not be unduly restricted. DOE, in its comments on this issue, suggested that since opportunities may arise for exploratory studies in unsaturated geologic media, the Commission should reexamine the rule and make whatever changes are necessary to ensure that the rule will apply to all geologic media. The U.S. Department of the Interior urged that the rule be modified because, under appropriate conditions, the unsaturated zone could provide one more natural barrier to the movement of radionuclides from the geologic repository to the water table.

The Commission has determined that disposal of HLW within the unsaturated zone is a realistic alternative to disposal within the saturated zone, provided that the site and the geologic repository design are carefully selected, and are capable of meeting the performance objectives of 10 CFR Part 60. In reaching this determination, the Commission has examined the arguments presented by the public commenters as well as the analysis of the principal issues associated with unsaturated zone disposal described in the NRC staff technical support document (draft NREG-1046) prepared in conjunction with the proposed amendments. This document identifies the positive aspects and possible concerns associated with disposal in the unsaturated zone and explains why the Commission has developed the following proposed amendments. Other issues which were discussed by public commenters but which did not result in proposed changes to the final rule are also addressed in the technical support document. Upon publication, a copy of draft NUREG-1046 entitled "Disposal of High-Level Radioactive Wastes in the Unsaturated Zone: Technical Considerations" will be placed in the Public Document Room, 1717 H Street NW., Washington, DC 20555. Since this document is available to the general public,[2] only a summary discussion of these issues is presented below.

Issues Examined by the Commission

The depth to the regional water table varies throughout the United States. Potential geologic repository sites within unsaturated geologic media may be identified in arid to semi-arid geographic regions of the country because such regions generally are characterized by a deep regional water table and hence, a relatively thick unsaturated zone. The unsaturated zone in certain arid regions of the United States has been documented as extending to depths of approximately 600 meters below the ground surface. In contrast, the unsaturated zone in humid regions is often only a few meters thick, or entirely non-existent.

Perhaps the most positive aspect associated with disposal of HLW within the unsaturated zone is that the HLW would be emplaced in a relatively dry (i.e., low moisture content) geologic

[1] The definition of the term "unsaturated zone" is derived from U.S. Geological Survey Water Supply Paper 1988 (Washington, DC, 1972).

[2] Free single copies of Draft NUREG-1046 may be requested for public comment by writing to the Publication Services Section, Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

medium. The Commission considers the relatively low moisture content of unsaturated sediment and rock as a positive aspect of HLW disposal in the unsaturated zone because the lack of available moisture could reduce leaching of the waste packages and thus, significantly reduce the likelihood of radionuclide transport by groundwater [3] migration. Further, it is generally recognized that vertical groundwater flux in the unsaturated zone is very small. A credible pathway for the migration of water soluble contaminants from a geologic repository located in the unsaturated zone to the accessible environment would probably be vertically downward to the underlying regional water table, and subsequently through the saturated groundwater units to the regional discharge points.

The Commission has reviewed several other issues that are of general concern to disposal of HLW in geologic repositories, regardless of the hydrogeologic zone involved. Such issues include the effects of climatic changes on the regional hydrologic systems, the potential for human intrusion into the geologic repository, and the effects of geologic processes (e.g., tectonism) on the structural stability of the geologic repository. The Commission does not believe that any of these issues would negate the generic concept of HLW disposal within the unsaturated zone. However, since the relative importance of these issues will depend upon natural conditions existing at a particular site, each must be evaluated on a site-by-site basis.

Vapor transport of contaminants has been identified by the Commission's staff as a potential concern associated with HLW disposal in the unsaturated zone. In unsaturated geologic media, water is transported in both liquid and vapor phases. The relative contribution of transport via liquid and vapor phases, and their direction of movement with respect to a geologic repository will have a direct influence on the containment of contaminants. Vapor transport, particularly when a thermal gradient is imposed may provide a possible mechanism for radionuclide migration from a geologic repository. However, positive aspects associated with vapor transport in the unsaturated zone may also be discerned since water vapor formed near the geologic repository may flow through air-filled openings and partially drained fractures, resulting in a drying of the surrounding host rock. This drying zone may extend hundreds of meters from the geologic repository, and thus may inhibit the movement of soluble contaminants. Therefore, the Commission views vapor transport as another issue which must be evaluated on a case-by-case basis to determine its effects (whether favorable or potentially adverse) on a particular site.

[3] The Commission recognizes that the term "groundwater" is generally applied by the technical community to water which occurs beneath the water table (i.e., phreatic water) while the term "vadose water" is more accurately applied to the soil water, gravitational water and capillary water which occur in the unsaturated zone (zone of aeration, vadose zone). However, for the sake of simplicity, groundwater is defined in the proposed amendments as all water which occurs below the Earth's surface.

Other Comments Considered by NRC

The Commission has reviewed the following six issues related to HLW disposal within the unsaturated zone which were addressed in the public comments on the proposed rule, as well as in a recent USGS publication,[4] and has determined that the final rule (48 FR 28194) accommodates these concerns. More detailed discussion of these issues is presented in draft NUREG–1046.

Minimum 300-Meters Depth for Waste Emplacement

One commenter on the proposed 10 CFR Part 60 technical criteria who advocated applying the rule equally to the saturated and unsaturated zones considered it necessary to change the siting criterion which sets a minimum depth of 300 meters for waste emplacement. However, the commenter incorrectly identified this provision (see § 60.122(b)) as a requirement, rather than as a favorable condition. The Commission notes that favorable conditions are those which may enhance waste isolation potential. Hence, a minimum depth of 300 meters for waste emplacement is considered a favorable condition because the deeper the HLW is emplaced, the less likely it is to be disturbed. Viewed in that light this depth is a favorable condition, irrespective of hydrogeologic zone. Since the unsaturated zone may extend to depths of up to 600 meters, the Commission considers this favorable condition to be a realistic one for both the saturated and unsaturated zones. Therefore, this provision of the rule has not been modified.

Requirements for Sealing Shafts and Boreholes

In USGS Circular 903 the view was expressed that, with respect to a geologic repository within the unsaturated zone, sealing shafts and boreholes tightly to inhibit water movement may be undesirable. The reasoning behind this view is that although shafts and boreholes need to be carefully sealed in the saturated zone so that they do not become future conduits for radionuclide migration, they may have an entirely different relation to an unsaturated zone repository. Shafts and boreholes would increase the amount of water moving through a geologic repository located within the unsaturated zone only if they diverted a significant amount of runoff to the subsurface.

The Commission has reviewed both the arguments of the USGS and the provisions of the final rule relating to the design of seals for shafts and boreholes (§ 60.134). The provisions of § 60.134 appear to be generally applicable to seals of shafts and boreholes in both hydrogeologic zones. Therefore, the Commission does not consider it necessary to modify § 60.134 at this time.

[4] Roseboom, E. H. Jr., 1983. Disposal of High-Level Nuclear Waste Above the Water Table in Arid Regions. U.S. Geological Survey Circular 903, Washington, DC. p. 21.

Backfill Requirements

Another issue which has been identified both in public comments on the proposed technical criteria and in USGS Circular 903 pertains to the necessity of backfill in a geologic repository located within the unsaturated zone. The USGS expressed the view that the role of backfill in the unsaturated zone would be the opposite of that in the saturated zone. Backfill material that would inhibit the flow of water to, and radionuclide migration from, the waste packages may be highly desirable in the saturated zone. In the unsaturated zone, however, the designers of a geologic repository may wish to promote drainage. The opinion has been expressed that within the unsaturated zone backfill should allow groundwater to drain readily, rather than serve as a barrier to drainage. It was suggested in USGS Circular 903 that if backfill is necessary to perserve structural or waste package integrity, a relatively permeable material (e.g., cobble-sized rock) could be used to permit continued drainage.

The final rule published by the Commission on June 21, 1983 contained only the general functional statement that the engineered barrier system (including backfill) be designed to assist the geologic setting in meeting the performance objectives for the period following permanent closure (§ 60.133(h), 48 FR 28227). This provision, as promulgated, should be

responsive to the concerns discussed above.

Waste Package Design Criteria

As defined at § 60.2, the term "waste package" means "the waste form and any containers, shielding, packing and other absorbent materials immediately surrounding an individual waste container" (48 FR 28219). The point has been raised that because of the different nature of the emplacement environment designs of waste package components for the saturated and unsaturated zones may be quite different. The Commission recognizes that several characteristics of the emplacement environment (e.g., oxidation conditions, lithostatic pressure, geochemistry, contact with groundwater, etc.) may vary significantly between the two hydrogeologic zones. This variation of emplacement environment may necessitate that DOE consider alternative designs for waste packages (including waste form, canisters, overpack, etc.) for geologic disposal in the unsaturated zone. The Commission has reviewed the performance objectives which pertain to the waste package (§ 60.111 and § 60.113), and believes that the provisions, as currently written, are equally applicable to waste packages emplaced within either the saturated or unsaturated zone. Similarly, the specific design criteria for the waste package and its components (§ 60.135, 48 FR 28227) have been determined to be generally applicable to both zones. Therefore, no changes have been made to the provisions of §§ 60.111, 60.113, or 60.135.

Ventilation

The issue of restricting the number of ventilation shafts associated with a geologic repository was addressed in USGS Circular 903. In the case of the saturated zone, the number of ventilation shafts may be kept at a minimum since the shafts could constitute potential pathways to the accessible environment. In USGS Circular 903 it is stated that in the case of the unsaturated zone additional shafts for ventilation would not compromise the geologic repository's performance because sealing shafts in the unsaturated zone is much simpler and of less consequence than in the saturated zone. Several potential benefits were cited by the USGS to support this view—e.g., reducing the problem of thermal load in the early phases of the geologic repository, removal of any water vapor during the operational period, drawing large amounts of desert air through the geologic repository to promote even drier conditions and increasing worker safety by providing alternative sources of ventilation and escape routes.

The number of ventilation shafts included in any geologic repository will be decided by the designer—DOE. No provision of 10 CFR Part 60 expressly limits the number of ventilation shafts that a geologic repository may contain. What is important is that the surface facility ventilation systems comply with the design critera in § 60.132(b) (48 FR 28226) and that the underground facility ventilation system be designed in accordance with § 60.133(g) (48 FR 28227). The Commission considers the design requirements for the ventilation systems set forth in §§ 60.132 and 60.133 to be applicable to both the saturated and unsaturated zones. As long as the ventilation system complies with provisions of §§ 60.111(a), 60.132, and 60.133 and does not compromise the integrity of the site to host a geologic repository, DOE will have broad flexibility in designing the system.

Exploratory Boreholes

Provisions relating to site characterization are set forth in the final rule at § 60.10 (48 FR 28219). Section 60.10(d)(2) requires that the number of exploratory boreholes and shafts be limited to the extent practical, consistent with obtaining the information needed for site characterization. The view was expressed in USGS Circular 903 that in the unsaturated zone, if the host rock already has a high vertical permeability, there is no reason to limit the number of drill holes. Thus, the USGS noted that if necessary, a proposed geologic repository could be explored like an ore body or coal bed, with drill holes every few hundred feet on a rectangular grid.

The Commission's view on the importance of not compromising the integrity of a site during the site characterization program of testing and exploration has been clearly stated at 44 FR 70409. However, if DOE should opt for a site exploration and characterization program which includes plans for drilling numerous boreholes then DOE would have the burden of showing the Commission that the ability of the site to isolate HLW has not been compromised during these activities.

Groundwater Travel Time in the Unsaturated Zone

The concept of groundwater travel time generally is applied in evaluations of saturated flow systems, where flow is continuous and temporal fluctuations in the potential of the systems are small. In contrast, water movement in the unsaturated zone is generally discontinuous and strongly dependent upon initial conditions (e.g., magnitude and spatial and temporal distribution recharge events) and the conductive properties of the partially saturated geologic media, which vary with moisture content. Reliable calculations and predictions of groundwater travel times and velocities require knowledge of these conditions and properties. Within the unsaturated zone the movement of a given volume of water over a given distance depends very strongly upon the nature of the recharge events. Additionally, the material properties (e.g., moisture characteristic curves, porosity, irreducible saturation, etc.) and the initial conditions (e.g., saturation, capillary pressure, matric potential) may be extremely difficult to measure on a representative scale for unsaturated porous and fractured geologic media.

For these reasons, calculations of pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel through the unsaturated zone may have large associated uncertainities, and may be of questionable value in estimating the capability of the geologic setting to isolate HLW from the accessible environment.

The new definition of the term "groundwater" which the Commission is proposing would have the effect of expanding the scope of the performance objectives set forth in § 60.113 to disposal in either the saturated or unsaturated zone. Similarly, the proposed amendment to the Siting Criteria (§ 60.122(b)(7)) would have the effect of making pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment which substantially exceeds 1,000 years a favorable condition for HLW disposal within either the saturated or unsaturated zone.

The Commission's current thinking on this issue is that if DOE can demonstrate with reasonable assurance that travel time for groundwater movement through the unsaturated zone can be quantified, then DOE should be allowed to include such travel time when demonstrating compliance with § 60.113(a)(2). However, such calculations of groundwater travel times through the unsaturated zone could involve considerable uncertainty. Further, long groundwater travel time possibly may be inconsistent with the proposed amendment which identifies a host rock that provides for free drainage as a

favorable hydrogeologic condition for disposal of HLW within the unsaturated zone. It may be more appropriate for the Commission to specify another parameter upon which performance may be evaluated for a geologic setting in the unsaturated zone, or to utilize the approach set forth in § 60.113(b) which provides the Commission with the flexibility to specify variations in performance objectives on a case-by-case basis, as long as the overall system performance objective is satisifed. Therefore, to solicit input in these matters the Commission is particularly seeking public comment on the following questions:

1. How can groundwater travel time in the unsaturated zone be determined with reasonable assurance? Should the groundwater travel time performance objective be limited to groundwater movement within the saturated zone?

2. Does groundwater travel time represent an appropriate measure of performance for a site within the unsaturated zone, or would an alternative performance objective for the geologic setting, (e.g., maximum likely volumetric flow rate of groundwater through the geologic repository) be more appropriate?

Environmental Impact: Negative Declaration

Pursuant to Section 121(c) of the Nuclear Waste Policy Act of 1982, the promulgation of these criteria shall not require the preparation of an environmental impact statement under Section 102(2)(C) of the National Environmental Policy Act of 1969 or any environmental review under subparagraph (E) or (F) of Section 102(2) of such Act.

Paperwork Reduction Review

The proposed rule contains no new or amended recordkeeping, reporting or application requirements, or any other type of information collection requirements subject to the Paperwork Reduction Act (Pub. L. 96-511).

Regulatory Flexibility Act Certification

In accordance with the Regulatory Flexibility Act of 1980 (5 U.S.C. 605(b)), the Commission certifies that this rule, if adopted, will not have a significant economic impact on a substantial number of small entities. The only entity subject to regulation under this rule is the U.S. Department of Energy.

List of Subjects in 10 CFR Part 60

High-level waste, Nuclear power plants and reactors, Nuclear materials, Penalty, Reporting and recordkeeping requirements, Waste treatment and disposal.

Issuance

For the reasons set out in the preamble and under the authority of the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, the Nuclear Waste Policy Act of 1982, and 5 U.S.C. 553, the Nuclear Regulatory Commission is proposing the following amendments to 10 CFR Part 60.

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

Authority: Secs. 51, 53, 62, 63, 65, 81, 161, 182, 183, 68 Stat. 929, 930, 932, 933, 935, 948, 953, 954, as amended (42 U.S.C. 2071, 2073, 2092, 2093, 2095, 2111, 2201, 2232, 2233); secs. 202, 206, 88 Stat. 1244, 1246, (42 U.S.C. 5842, 5846); secs. 10 and 14, Pub. L. 95-601, 92 Stat. 2951 (42 U.S.C. 2021a and 5851); sec. 102, Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332); sec. 121, Pub. L. 97-425, 96 Stat. 2228 (42 U.S.C. 1014).

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

1. Section 60.2 is amended by adding two new definitions in proper alphabetical sequence:

§ 60.2 Definitions.

* * * * *

"Groundwater" means all water which occurs below the Earth's surface.

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

* * * * *

2. Section 60.122 is amended by revising paragraph (b)(2)(iii), designating paragraph (b)(2)(iv) as (b)(7), and adding new paragraphs (b)(8), (c) (22), (23) and (24) to read as follows:

§ 60.122 Siting criteria.

* * * * *

(b) * * *

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

* * * * *

(7) Pre-waste-emplacement groundwater trave time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years.

(8) For disposal in the unsaturated zone, hydrogeologic conditions that provide—

(i) Low and nearly constant moisture flux in the host rock and in the overlaying and underlying hydrogeologic units;

(ii) A water table sufficiently below the underground facility such that fully saturated voids continuous with the water table do not encounter the underground facility;

(iii) A laterally extensive low-permeability hydrogeologic unit above the host rock that would inhibit the downward movement of water or divert downward moving water to a location beyond the limits of the underground facility;

(iv) A host rock that provides for free drainage; or

(v) A climatic regime in which the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration.

* * * * *

(c) * * *

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

(23) Potential for existing or future perched water bodies that may have the effect of saturating portions of the underground facility or providing a faster flow path for radionuclide movement from an underground facility located in the unsaturated zone to the accessible environment.

(24) Potential for vapor transport of radionuclides from the underground facility located in the unsaturated zone to the accessible environment.

Dated at Washington, D.C., this 13th day of February 1984.

For the Nuclear Regulatory Commission.

Samuel J. Chilk,

Secretary of the Commission.

[FR Doc. 84-4308 Filed 2-15-84; 8:45 am]

BILLING CODE 7590-01-M

ENCLOSURE D

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DRAFT

STAFF ANALYSIS OF PUBLIC COMMENTS ON THE PROPOSED AMENDMENTS TO 10 CFR PART 60 RELATED TO THE UNSATURATED ZONE AND DRAFT NUREG-1046

Prepared by
Waste Management Branch
DRPES
Office of Nuclear Regulatory Research

December, 1984

Enclosure D

COMMENT LETTERS

INTRODUCTION:

On February 16, 1984 the Nuclear Regulatory Commission (NRC) published proposed amendments to 10 CFR Part 60 to assure that its high-level radioactive wastes (HLW) regulations address considerations relevant to all geologic repositories, whether sited in the saturated or unsaturated zone (49 FR 5934). In addition to its request for comment on the proposed amendments, NRC particularly sought public input on several questions related to groundwater travel time calculations in the unsaturated zone (49 FR 5937). In conjunction with the proposed amendments NRC published draft NUREG-1046, which contained a discussion of the technical issues NRC considered during the development of the proposed amendments. NRC received a total of fourteen comment letters in response to its solicitation of public input on both the proposed amendments and draft NUREG-1046. These comments were considered with respect to revising and improving the text of the final amendments. This document presents the individual comments grouped according to subject and a detailed analysis of the comments by the NRC staff. Copies of the fourteen comment letters are included as Appendix A. A copy of the Federal Register notice containing the proposed amendments is included as Appendix B.

GENERAL COMMENTS:

Comment No. 1: B. Dover (1)

It is extremely important to be aware of the fact that "unsaturated" is NOT synonymous with a low moisture content. The last paragraph beginning on p. 5934 of the Federal Register notice referred to states that "Perhaps the most positive aspect associated with disposal of HLW within the unsaturated zone is that the HLW would be emplaced in a relatively dry (i.e., low moisture content) geologic medium." This implies that all unsaturated rocks are dry. This is patently untrue. Unsaturated merely means that the pore space in the rock is not filled with water. The actual water content depends on the amount of pore space. Thus a rock that has a porosity of 5% and which is saturated has exactly the same amount of contained water as a rock with a porosity of 10% which is 50% saturated. In fact, many of the rocks to which the USGS refers to as unsaturated have a very high porosity and a relatively high saturation, although less than 100%, and in fact contain much more water than saturated rocks with a lower porosity. Many volcanic tuffs in the Great Basin, in fact, contain considerably more water than granites in the more humid regions, even though the granites are saturated and the tuffs are not. Water content and the speed of the movement are the important factors; the percentage of "saturation" is really an insignificant factor.

Staff Response to Comment No. 1:

The staff generally agrees with the technical discussion of unsaturated geologic media presented by this commenter. However, the commenter has incorrectly inferred that NRC considers all unsaturated rocks to be dry. NRC used the term "relatively dry" to contrast conditions in saturated rocks. On the commenter's last point the staff notes that NRC has not used the concept of "percentage of saturation" in the amendments, and does not anticipate using the degree of saturation as a parameter against which sites will be evaluated.

Comment No. 2: E. Nemethy (2)

The discussion in this notice limits itself to waste burial in saturated and unsaturated zones.

Has the Commission given any consideration to above-ground repositories for HLW? Over the past few years, this approach has been written about, a number of times.

Should HLW be entombed in this manner, and if the containment were in the shape of a pyramid*, it might withstand earthquakes, tornadoes and concussion from bomb blasts.

*(tetrahedron)

Staff Response to Comment No. 2:

The Department of Energy (DOE) is responsible for developing the methods and technology for the permanent disposal of high-level radioactive wastes (HLW). Currently, DOE is considering disposal of HLW in mined geologic repositories, and hence, the provisions of 10 CFR Part 60 only address disposal in subsurface repositories. If DOE proposes disposal in above-ground repositories, different considerations would be involved in evaluating the safety and feasibility of such a method.

Comment No. 3: J. S. Kleinhans, State of Wisconsin Radioactive Waste Review Board (5)

The Wisconsin Radioactive Waste Review Board has reviewed the proposed revisions to 10 CFR 60 for disposal of high-level radioactive wastes in the unsaturated zone. This proposed rule appears to have considerable merit since it opens up another alternative for disposal. It also appears the Commission has identified the pertinent technical concerns with disposal in the unsaturated zone.

Staff Response to Comment No. 3:

No response necessary.

Comment No. 4: R. R. Loux and C. A. Johnson, State of Nevada Nuclear Waste Project Office (8)

The State of Nevada has reviewed the proposed rule and support documents identified in the subject notice. We are satisfied with the intent of the proposed rule and feel it is in line with the State's thinking on disposal in the unsaturated zone. However, we have some comments and suggested changes to improve the proposed rule.

Staff Response to Comment No. 4:

The comments and suggested changes identified by the State of Nevada are discussed in connection with the specific comments.

Comment No. 5: J. D. Patterson, Middle South Services (10)

Middle South Services, Inc. (MSS) is a technical support company for the Middle South Utilities (MSU) system which serves the electrical requirements of approximately 1,800,000 customers in portions of Arkansas, Louisiana,

Mississippi and Missouri. MSS has reviewed the proposed amendments and draft NUREG-1046, "Disposal of High-Level Radioactive Wastes in the Unsaturated Zone: Technical Considerations" and would like to express our support of the proposed amendment which allows the disposal of high-level radioactive waste (HLW) in the unsaturated geologic zone.

The Middle South System has four nuclear reactors in operation or nearing operational status, therefore Middle South Utilities has been closely following the progress being made toward the opening of the first high-level nuclear waste repository. The siting of these repositories must be limited to those geologic areas where the HLW can safely be disposed of without significant damage to the environment or harm to the public's health. A review of the proposed amendments and its associated NUREG shows that the unsaturated geologic zone is a viable alternative to disposal in the saturated zone. Each site, whether it is located in the saturated or the unsaturated zone, should be judged based on its overall ability to safely contain HLW. Currently, there is not sufficient technical justification to favor disposal in the saturated zone over the unsaturated zone. As mentioned in NUREG-1046, there are some factors which make disposal of HLW in the unsaturated zone preferable to disposal in the saturated zone. Two of these factors are: (1) wastes can be emplaced in a geologic medium with low moisture content which would minimize leaching of waste packages; and (2) enhanced retrievability-wastes would be more easily accessible in an unsaturated zone if this need should ever arise. There are factors which make the saturated zone a more desirable location, however, as stated previously, each site must be reviewed based on all relevant factors, not simply on whether the site is located in a saturated or unsaturated zone. A balancing of all factors will ensure that the most suitable sites are chosen for the disposal of HLW.

MSS regrets that we are unable to provide NRC with the technical comments which have been requested. However, we appreciate this opportunity to comment on and express our support of this proposed amendment. The siting and the eventual operation of HLW repositories are of vital importance to the electric utility industry. MSU encourages and supports NRC in their endeavor to accomplish this goal within the time-frame established in the Nuclear Waste Policy Act.

Staff Response to Comment No. 5:

No response necessary.

COMMENTS ON NRC QUESTIONS RELATING TO GROUNDWATER TRAVEL TIME IN THE UNSATURATED ZONE:

General Staff Response to Comment Nos. 6-14:

The following comments (6-14) were submitted in response to a specific NRC request for public comment on two questions related to groundwater travel time calculations in the unsaturated zone. The staff has considered the arguments presented by the commenters in developing its recommendations on these issues.

Based on the discussions presented in these comments, the staff recommends that the existing provisions of §60.113(a)(2) be applied to geologic settings located in either the saturated or unsaturated zone. However, the staff still recognizes that in some cases it may be more appropriate for the Commission to utilize the approach set forth in §60.113(b) which provides the Commission with the flexibility to specify variations in performance objectives on a case-by-case basis, as long as the overall system performance objective is satisfied. Since these comments were solicited by NRC, the staff does not believe it is necessary to provide individual responses in this document. A discussion of the concepts presented in these comments is contained in the Statement of Considerations which accompanies the final amendments.

Comment No. 6: B. Dover (1)

With regard to the question of whether or not groundwater travel time represents an appropriate measure of performance for a site within the unsaturated zone, I feel that it is absolutely essential that the same standard of measure be applied to all rock types and all sites, regardless of their setting with respect to the water table. I have no idea how groundwater travel time in the unsaturated zone can be determined; neither do I have any idea how groundwater travel time through salt can be measured. Maximum likely volumetric flow rate of groundwater through the repository might well be a more appropriate measure of performance, but if so, then this same measure should be applied to all rock types and all sites. It would be absolutely unacceptable to use the alternative performance measure for a rock situated in the unsaturated zone (even though containing a considerable amount of water and, in fact, possibly be "near" saturation) and apply a different measure for a site in a salt host rock, which in fact contains an amount of water almost defying measurement and with a "groundwater travel time" (if that term can even be applied) that is so slow as to be beyond comprehension.

Comment No. 7: B. Vild, State of Rhode Island and Providence Plantations (6)

Most ground water in Rhode Island is drawn from relatively shallow stratified-drift aquifers. Hydrologists in the Division of Land Resources have informed us that in many areas the water table is but a few meters below the surface. While some wells tap water which collects in rock fractures, such water also is found relatively close to the surface. According to our Water Resources Board, only a half-dozen or so water supply wells go below 500 feet (150 meters). This suggests a thin unsaturated zone. It is extremely unlikely, then, based on present evidence, that the Department of Energy could locate a nuclear waste repository in the unsaturated zone in Rhode Island and be able to satisfy its own minimum depth requirement of 200 meters (DOE siting guidelines, Sec. 960.4-2-5(d)). On the other hand, as indicated in the proposed rule, unsaturated zones in other areas, particularly those found in arid or semi-arid regions of the country, may be of sufficient thickness to allow the minimum depth requirement to be met.

Regardless of whether a site is chosen within the saturated zone or the unsaturated zone, our primary concern over the long term should be the isolation of nuclear waste from the accessible environment. Disposal in the unsaturated zone has the advantage of minimizing contact between the implanted waste and ground water. As ground water is the most likely pathway for radionuclides to the outside, Rhode Island would support considering such an option for disposal. We have stated on a number of occasions, particularly in regard to DOE's siting guidelines, that the repository should not contaminate ground water of potential use by present or future generations. The relative dryness of a thick unsaturated zone would help reduce the probability that contaminated ground water would reach Man.

However, ground water does flow in the unsaturated zone, and to demonstrate that its repository complies with stated performance objectives, the Department of Energy will have to assess ground water flow in both liquid and vapor phases. Ground water travel time in the unsaturated zone will be difficult to calculate, as the proposed rule indicates, because of "large associated uncertainties." Some quantification and generalization concerning ground water travel time will be necessary nonetheless to determine if proposed "potentially adverse conditions" (c)(22) and (c)(23) are present (49 FR 5937). Absent another parameter upon which to evaluate performance, DOE will have to attempt a "reasonable" estimate of ground water travel time to be corroborated to the extent possible when the Department characterizes the candidate site. As there may be much debate over which level of data is "reasonable" in the earlier stages of screening, Rhode Island would urge DOE and NRC to consult freely with the state geological contacts on this matter.

In its consideration of ground water flow (however that parameter is to be determined), we would recommend that NRC direct DOE to examine how the rate and direction of ground water flow is affected by withdrawal. Rhode Island's experience indicates that changes do occur in shallow aquifers and in some cases these changes are signficant. This would appear to be a matter of concern in any case where ground water flow is discontinuous and heavily dependent on spatial and temporal events, as in the unsaturated zone.

Comment No. 8: J. J. Kearney, Edison Electric Institute (7)

1. How can groundwater travel time in the unsaturated zone be determined with reasonable assurance? Should the groundwater travel time performance objective be limited to groundwater movement within the saturated zone?

EEI/UNWMG are not aware of any general, acceptable method for determining groundwater travel time in the unsaturated zone with reasonable assurance. However, there is no reason to strictly limit the groundwater travel time performance objective to groundwater movement within the saturated zone. We agree with the Commission's current thinking on this issue, as described in the rulemaking notice, that if DOE can demonstrate in a particular case with reasonable assurance that travel time for groundwater movement through the unsaturated zone can be quantified, then the Department should be allowed to include such travel time when demonstrating compliance with 10 CFR §60.113(a)(2).

2. Does groundwater travel time represent an appropriate measure of performance for a site within the unsaturated zone, or would an alternative performance objective for the geologic setting, (e.g., maximum likely volumetric flow rate of groundwater through the geologic repository) be more appropriate?

EEI/UNWMG believe that groundwater travel time can, in certain circumstances, represent an appropriate measure of performance for a site within the unsaturated zone. Where it does not, however, we do not believe that an alternative performance objective, such as maximum likely volumetric flow rate, would necessarily be more appropriate. Rather, consistent with one of the alternatives posed by the Commission in the rulemaking notice, we would favor utilization of the approach set forth in 10 CFR §60.113(b) providing the Commission with the basis to specify variations in performance objectives on a case-by-case basis, as long as the overall system performance objective is met. In this connection, the Commission should specifically note in the statement of considerations accompanying the adoption of a final rule that the approach in section 60.113(b) may be particularly appropriate in the case of disposal in the unsaturated zone.

Comment No. 9: R. R. Loux and C. A. Johnson, State of Nevada Nuclear Waste Project Office (8)

1. "How can groundwater travel time in the unsaturated zone be determined with reasonable assurance? Should the groundwater travel time performance objective be limited to groundwater movement within the saturated zone?"

In our opinion, it is premature to answer the first part of the question due to the limited research devoted to the question presently. Groundwater travel time in the unsaturated zone cannot now be determined with any assurance. With time, travel time in the unsaturated zone may prove to be as predictable (with similar levels of uncertainty) as travel times in saturated media. However, groundwater travel time is also subject to considerable uncertainty in the saturated zone, with the uncertainty generally increasing in fractured low permeability rocks. From our perspective, there is little confidence that determinations can be made with reasonable assurance in either media presently.

In response to the second question, there seems to be no demonstrated basis for establishing unsaturated zone travel time performance. It is acknowledged that ground water travel time is an acceptable performance measure in the saturated zone and may be appropriate for the unsaturated zone, however, presently there is no scientific basis to support a precise number for unsaturated zone travel time performance. The 1,000 year pre-emplacement ground water travel time performance objective now established for the saturated zone cannot be projected with reasonable certainty into the unsaturated zone. We believe this uncertainty does not preclude the use of a 1,000-year travel time, but that its use should be cautioned by the lack of scientific support to base the number. If the 1,000-year travel time is selected as a performance measure, the NRC should consider revisiting this performance standard later when a better understanding of moisture movement in the unsaturated zone is known.

2. "Does groundwater travel time represent an appropriate measure of performance for a site within the unsaturatd zone, or would an alternative performance objective for the geologic settihg, (e.g., maximum likely volumetric flow rate of groundwater through the geologic repository) be more appropriate?

Ground-water (unsaturated zone moisture) travel time may be appropriate in the unsaturated zone, and associated time credit to the accessible environment be considered as a measure of performance, however, the Commission should recognize several important factors believed to be involved in a travel time consideration of performance.

1. Travel time, and direction, may prove to be different for liquid and vapor phase moisture in the unsaturated zone.

2. Radionuclide transport may prove more complex in unsaturated flow than in saturated flow, and not closely related to moisture flux.

Performance based upon maximum likely volumetric flow rates may be even more speculative than groundwater travel time. Presently, recharge rates (a measure of volumetric flow rate) cannot be determined with precision, especially during variable climatic conditions. We believe that, although not ideal, ground water travel time in the unsaturated zone may be an acceptable performance measure at the present time, if the factors described previously are considered.

Alternative to a travel time performance standard, it is suggested the EPA standard be the performance measure by which the geologic setting is judged, or the Commission utilize the approach set forth in 60.113(b) of 10 CFR Part 60. This section provides the Commission with the flexiblity to specify variations in performance objectives on a case-by-case basis. The prime reason for suggesting this approach is the current absence of detailed understanding of moisture regimens in unsaturated zone environments, and the associated radionuclide transport by both liquids and gases in this type of environment. As more established relationships and techniques of analysis are developed for each site, an appropriate performance objective may be possible.

Comment No. 10: M. J. Lawrence, U.S. Department of Energy (9)

The Department believes the performance objective for a minimum 1,000-year groundwater travel time should only be applied to sites located in the saturated zone. The Department recommends an alternative performance objective, related to the geologic setting, for sites located in the unsaturated zone. The Department will provide a suggested alternative performance objective for NRC consideration by separate letter after the close of the public comment period. The Department will make every effort to provide this information by May 15, 1984.

Comment No. 11: M. J. Lawrence, U.S. Department of Energy (9)

Question 1. This question, as stated in the Supplementary Information Section, consisted of two questions which are addressed separately below.

A. "How can ground-water travel time in the unsaturated zone be determined with reasonable assurance?"

Ground-water flux can be determined, using measurements of ambient water content, degree of saturation, matric potential, and hydraulic conductivity to determine moisture-characteristic curves relating these parameters to one another. These curves can be developed so as to predict the constitutive relationships over a wide range of conditions (varying degrees of saturation and different matric potentials). From these relationships and flux determinations, velocity and subsequently ground-water travel time can be estimated.

In situ monitoring techniques, including tracer tests, are undergoing development and may broaden the range of rock types and conditions for which it is feasible to estimate velocity and ground-water travel time. NNWSI program investigations also presently include exploratory shaft tests on infiltration rates and sampling of intact fractured blocks for laboratory experiments. These techniques and investigations are state-of-the-art and should provide a direct determination, with reasonable assurance, of the ground-water flux used to estimate the ground-water travel time. In addition, DOE believes that reasonable bounds may be developed by less direct methods such as recharge rates determined from water budgets, perturbations of thermal gradients, or in situ monitoring of temporal changes in moisture profiles.

Reasonable assurance, therefore, may be gained in estimating ground-water travel time using results of laboratory testing, state-of-the-art direct determinations in the field or laboratory, and bounding estimates developed by indirect methods. In addition, reasonable assurance may also be gained by incorporating uncertainty analysis into predictive models. Although the uncertainty band for a given level of confidence in the calculations may be broad owing to the inability to measure ground-water velocities along all segments of the unsaturated zone travel paths or under all combinations of moisture conditions and matric potentials, the opportunity to invoke conservatism in the ground-water travel time calculations still exists.

B. "Should the ground-water travel time performance objective be limited to ground-water movement in the saturated zone?"

For a repository in the unsaturated zone, DOE does not believe the ground-water travel time objective should be limited to the saturated zone because this would not be an accurate indicator of actual radionuclide transport from the original waste location to the accessible environment (as discussed in the response to Question 2A). DOE has proposed, in discussions with the NRC on the siting guidelines (10 CFR Part 960), that this performance objective be limited to only sites located in the saturated zone, with a separate performance objective developed for the geologic setting for sites situated in the unsaturated zone. (See response to Question 2b)

Question 2. This question, as stated in the Supplementary Information Section, also consisted of two questions which are addressed separately below:

A. "Does ground-water travel time represent an appropriate measure of performance for a site within the unsaturated zone?"

DOE does not believe that ground-water travel time represents an appropriate measure of performance for a site within the unsaturated zone. The flux through the repository, both in the unsaturated and saturated zones, is a more appropriate and direct measure of potential cumulative releases to the accessible environment. The amount of water moving past the wastes is one of the primary factors which set a limit, independent of flow velocity, flow path, or travel time, on the maximum number of curies of a particular radionuclide that can be released from a repository and subsequently be transported by ground water to the accessible environment. DOE notes that Dames & Moore reach essentially the same conclusion in NUREG/CR-3130 when they concluded that flux and the frequency of wetting events were the primary factors in determining releases from wastes disposed in the unsaturated zone.

Should the NRC, however, choose to keep a minimum 1000-year ground-water travel time as the performance objective for the geologic setting, DOE believes it should logically be applied to sites situated in the unsaturated zone only if the travel time will include the combined travel times in the unsaturated zone and the saturated zone so as to better approximate radionuclide transport. This may necessitate a revision to the definition of the term "disturbed zone," since the current definition is so vague as to possibly permit defining the disturbed zone as extending downward through the unsaturated zone all the way to the water table or upward through the unsaturated zone all the way to the ground surface. DOE believes it would be inappropriate to apply the minimum ground-water travel time to only the saturated zone underlying a repository in the unsaturated zone, since such application would conflict with three highly favorable conditions resulting from a highly transmissive (and short travel time) water table aquifer underlying the repository. These are:

1. A highly transmissive aquifer can be expected to transmit any increased throughflow, resulting from increased precipitation during a glacial stage, with less rise in the water table and accordingly less likelihood of saturation of the respository from below.

2. A highly transmissive aquifer can be expected to significantly dilute any postulated releases from the repository since the characteristically low flux in the unsaturated zone would be a very small fraction of the throughflow in the aquifer.

3. A highly transmissive aquifer can be expected to significantly disperse any postulated releases from the repository since the dispersivity of the aquifer would be quite high.

Therefore, although a highly transmissive aquifer underlying a repository situated in the unsaturated zone may not provide a 1000-year ground water travel time to the accessible environment, it does not affect the flux through the unsaturated zone (hence it does not affect the cumulative release to the accessible environment over the 10,000 year period of interest). In addition, although the EPA standard is not based on dose, DOE notes a highly transmissive aquifer underlying a repository in the unsaturated zone provides a means of

assuring the reduction of the concentration of (and hence dose received from) any postulated releases due to dilution and dispersion (thereby being applicable to both reactive and non-reactive radioisotopes without consideration of sorption and other retardation processes).

B. "Would an alternative performance objective for the geologic setting (e.g., maximum likely volumetric flow rate of ground water through the geologic repository) be more appropriate?"

DOE believes an alternative performance objective for the geologic setting for a repository located in the unsaturated zone is more appropriate. DOE has initiated a concerted effort to develop such a performance objective for proposal to the NRC. This activity is still in progress, and DOE will provide an alternative performance objective by separate letter after the close of the public comment period. DOE will make every effort to provide the alternative performance objective by May 15, 1984.

DOE believes that the volumetric flow rate (flux) of ground water through a geologic repository located in the unsaturated zone is the most important factor in determinig the performance of the repository. However, DOE cannot at this time propose or endorse a numerical performance objective on maximum flux since the acceptable flux would be site-specific and design-specific.

DOE will continue, however, to consider flux and other factors in its attempt to develop an alternative performance objective for the geologic setting for a repository located in the unsaturated zone.

Comment No. 12: B. C. Rusche, U.S. Department of Energy (Addendum to Letter No.9)

As noted in the DOE comment letter to the NRC dated April 16, 1984, Dames & Moore concluded in NUREG/CR-3130 that the flux and the frequency of wetting events were the primary factors in determining releases from wastes disposed in the unsaturated zone. DOE stated that ground-water travel time does not represent an appropriate measure of performance for a site within the unsaturated zone and that the flux through the repository, both in the unsaturated and saturated zones, is a more appropriate and direct measure of potential cumulative releases to the accessible environment.

Accordingly, DOE has given considerable effort toward developing a proposed performance objective based on flux through a repository located in the unsaturated zone. Although this effort has reinforced the understanding that flux is the primary factor in determining releases from wastes disposed in the unsaturated zone, DOE has concluded that it is impractical to specify a minimum amount of flux or to otherwise define a performance objective for the geologic settings based on the flux through the repository. A determination of flux will be necessary, however, to demonstrate compliance with the EPA Standard.

As a result, DOE reviewed the NRC rationale for the performance objective specifying that the fastest likely path of radionuclide travel to the accessible environment shall be at least 1000 years or such other travel time as may be approved or specified by the Commission. This performance objective can be interpreted as specifying a minimum time before release of radionuclides to

the accessible environment. DOE concludes, based on this review and interactions between NNWSI Project staff and the NRC staff, that satisfying this performance objective is meant to provide an independent and redundant barrier to the engineered barrier system during that period of time when the wastes are most hazardous (46 FR 130, p. 35281). DOE notes that, for sites located in the unsaturated zone, this same effect may be derived, either in whole or to a large extent, from the creation of a drying zone around the underground facility during the period of the heat pulse. Therefore, the concept of a minimum time for release of radionuclides to the accessible environment forms a reasonable basis for a site performance objective for the unsaturated zone and is a more appropriate performance objective than ground-water travel time for the unsaturated zone.

The emplacement of radioactive waste canisters within an unsaturated zone repository leads to a situation wherein the heat generated by the wastes as they decay causes the moisture in the rock surrounding the waste canisters to migrate away from the waste canisters. Preliminary numerical modeling of this phenomenon[1] indicates that this migration creates a zone around the canisters, extending for a few tens of meters in which there is no water available to either corrode the canisters, dissolve the wastes, or transport any radioactive material. The drying phase for a saturated zone repository is expected to last several hundred years before resaturation is complete (NUREG-0804). In an unsaturated zone repository, the time required for moisture to return to the waste packages is expected to be even longer because the rock will return to initial conditions primarily through capillary effects.

A site performance objective for the unsaturated zone, based upon the minimum time for release of radionuclides to the accessible environment, must consider four separate physical events. The first event is the creation of the drying zone. The second event, which is closely related to the creation of the drying zone, is the subsequent return of moisture to the rock surrounding the waste canisters. These two events encompass a time during which no water is available to either corrode the waste canisters, dissolve the waste material, or transport radionuclides to the accessible environment. The third event important to the release of radionuclides to the accessible environment is the transport of radionuclides in the unsaturated zone. Finally, the radionuclides are transported to the accessible environment by ground water movement in the saturated zone.

The minimum time for release of radionuclides to the accessible environment is the sum of times required for each of the four events because they are temporally sequential. The minimum time for release of radionuclides to the accessible environment for an unsaturated zone repository is thus the sum of the time during which a drying zone exists around the waste canisters, the time it takes for the dry rock to return to initial moisture conditions, the time for ground water to travel through the unsaturated zone and the time for ground water to travel through the saturated zone to the accessible environment.

[1]B. Travis, H. Hudson, T. Nuttall, T. Cook, and R. Rundberg, 1984, "Preliminary Estimates of Water Flow and Radionuclide Transport in Yucca Mountain," LA-UR-84-40 (in Review), Los Alamos National Laboratory, Los Alamos, New Mexico.

It is not inconceivable that the time for drying added to the time for return to initial moisture conditions could encompass the total 1000 year period required for fission products to decay to insignificant levels. When all four time components are added together, significantly higher confidence in protection of public health and safety is obtained than if only the time when radionuclides are actually moving were considered.

The NNWSI Project site characterization activities include studies of the drying phenomenon. In addition to the previously mentioned study of radionuclide transport and the formation of the drying zone, other numerical studies which model the physical responses, in the unsaturated zone, to the emplacement of waste canisters and heat are underway. In situ tests to obtain information about moisture migration in response to thermal loads are planned for the exploratory shaft. These tests include bulk permeability tests, canister scale heater experiments and waste package tests. The waste package tests are reduced scale but are designed to specifically investigate moisture conditions, particularly moisture movement during thermal and post thermal periods of storage. High frequency electromagnetic, ultransonic and neutron methods are to be used to establish the moisture content in the area surrounding the simulated canister before and after thermal cycling and to monitor fluid movement during the experiments. These activities should provide the necessary and sufficient information to support demonstration of compliance with the proposed alternative performance objective.

Proposed Alternative Performance Objective

DOE proposes that Section 60.113(a)(2) be revised to Section 60.113(a)(2)(i) and a Section 60.113(a)(2)(ii) be added as follows:

> For a geologic repository located in the unsaturated zone, the minimum 1000 year travel time to the accessible environment shall include the time of existence of the drying zone around the emplaced wastes, the time required for rewetting to initial moisture conditions, the time of travel through the unsaturated zone, and the time of travel through the saturated zone.

Comment No. 13: A. Hirsch, Environmental Protection Agency (11)

With respect to the three questions on which the Commission particularly seeks comment:

Question: "How can ground water travel time in the unsaturated zone be determined with reasonable assurance?"

EPA Reply: EPA's Office of Solid Waste will soon publish Procedures for Modeling Flow Through Clay Liners to Determine Required Liner Thickness in its series of Technical Resource Documents. This manual presents a numerical simulation model to estimate travel time of water through unsaturated sediments. Once

copies are available from GPO, we will forward one to Dr. Colleen Ostrowski at the NRC.

Measuring natural tritium (^3H) concentrations in ground water samples from a vertical profile in unsaturated geologic formations may be another technique for estimating travel time. Since the atmospheric testing of nuclear weapons, ground water recharge (i.e., precipitation) has contained levels of this radioactive isotope above the naturally low levels existing before the testing began. Consequently, tritium may serve as an indicator or tracer of "new" water in a geologic profile, and thus may indicate approximate travel times from the recharge point.

Question: "Should the ground water travel time performance objective be limited to ground water movement within the saturated zone?"

EPA Reply: No. To allow DOE to take credit for the delay in water reaching the water table after passing an unsaturated zone repository (when considering NRC's existing 1,000 year "ground water" travel time requirement), NRC proposes to redefine the term "ground water" to include all water below the land surface, not just water below the water table, in the saturated zone. We do not think it is necessary to change the widely understood meaning of this term to accomplish NRC's objective. EPA agrees that DOE should be able to take credit for any such delays in the unsaturated zone. However, it would be more appropriate to make the existing section 60.113(a)(2) apply only to repositories in the saturated zone and to add a parallel section for unsaturated zone repositories that allows the Department to add the water travel times in the saturated and unsaturated zones to compare against the 1,000-year time period. Even if NRC redefines the term "ground water" for 10 CFR 60, EPA has no plans or need to make a corresponding change in 40 CFR 191.

Question: "Does ground water travel time represent an appropriate measure of performance for a site within the unsaturated zone, or would an alternative performance objective for the geologic setting be more appropriate?"

EPA Reply: No, it does not. An alternative option should be available. EPA does not believe that such a "water" travel time is appropriate as the only quantitative measure of performance for a site within the unsaturated zone. Instead, we believe that DOE should have the option of meeting a fairly stringent limit on the average annual flux of water through the repository to the accessible environment instead of the travel time requirement of section 60.113(a)(2). This limit should be chosen so that the corresponding total volume of water reaching the accessible environment within a thousand years would not be capable of transporting a significant amount of radioactivity, taking into account reasonable solubility limits. At a particular site, the Department should have the option of demonstrating compliance with either the minimum travel time requirement or the maximum water flux requirement.

Comment No. 14: B. Blanchard, U.S. Department of the Interior (13)

(1a) "How can ground-water travel time in the unsaturated zone be determined with reasonable assurance?" While it may not be possible to define ground-water velocities along all segments of unsaturated-zone travel paths with precision, particularly those segments through moderately to highly fractured media, the velocities and travel times in some segments are less elusive. In the case of a relatively uniform, porous medium with low-fracture density, the medium will be capable of transmitting a flux that is approximately equivalent to its saturated hydraulic conductivity without rejecting water to fracture flow paths. Further, it is within the state-of-the-art to determine ambient water content and degree of saturation as well as moisture-characteristic curves for such media so that effective conductivity can be predicted for a range of conditions. In-situ monitoring techniques are undergoing development and may broaden the range of rock types and conditions for which it is feasible to estimate velocity and, hence, travel time. On a site-specific basis, certain bounds may be placed by less direct considerations such as recharge rates based on water budgets, perturbations of thermal gradients, or in-situ monitoring of temporal changes in moisture profiles by neutron logging. Finally, repository investigations presently include exploratory-shaft tests on infiltration rates and sampling of intact fractured blocks for laboratory experiments.

"Reasonable assurance" may also be gained by incorporating uncertainty analysis into predictive models. Although the uncertainty band for a given level of confidence in the calculations may be broader for unsaturated-zone cases than for some saturated-zone conditions, the opportunity to invoke conservatism still exists.

(1b) "Should the ground-water travel time performance objective be limited to ground-water movement within the saturated zone?" Assuming that the ground-water travel time objective and favorable condition remain in the regulation, the travel time along any segment of the flow path including the unsaturated zone, should be creditable, provided that it can be demonstrated with "reasonable assurance" as discussed above.

(2) "Does ground-water travel time represent an appropriate measure of performance for a site within the unsaturated zone, or would an alternative performance objective . . . (e.g., maximum likely volumetric flow rate of ground water through the geologic repository) be more appropriate?" Travel time substantially exceeding 1,000 years, although a favorable condition, is not appropriate as a totally definitive performance objective for disposal in either the unsaturated or saturated zones. Ground-water travel time probably is the singularly most important element for evaluating the performance of a site; however, release criteria are ultimately the absolute measure of total performance. The method by which travel time is calculated must account for all elements of the ground-water flow system and must result in terms that can be used directly for determining transport and concentration of radionuclides in the ground water. Release criteria and radionuclide transport must be concerned with many factors such as ground-water flux and velocity (travel time), convective transport, dispersion and diffusion, chemical interaction with rocks along the flow path, and rates and concentrations at which radionuclides leached from the solidified waste enter the water. Realistic

estimation of release criteria for the unsaturated zone might not be possible until observations are made in the shafts and drifts.

While it may be possible to assign a maximum allowable flux rate--e.g., one that would assure the failure of containment under reasonable assumptions of chemistry, corrosion, and dissolution--it would still be more consistent with the multiple-barrier concept to incorporate such considerations only as favorable or potentially adverse conditions.

COMMENTS ON THE PROPOSED DEFINITION OF THE TERM GROUNDWATER (60.2)

Comment No. 15: R. R. Loux and C. A. Johnson, State of Nevada Nuclear Waste Project Office (8)

Redefining "groundwater" (ground water) for a regulatory purpose, particularly in view of the fact that the scientific community will make the field and laboratory determination, is not desirable. It would be much better for NRC to define and adopt a term or phrase that does not already have a precise meaning in technical community and literature, such as "subsurface moisture." "Groundwater" already has a widely accepted meaning which does not include vadose or unsaturated zone water.

Staff Reponse to Comment No. 15:

Presently there does not appear to be unanimity in the scientific community concerning how "groundwater" should be defined. Therefore, the staff has not "redefined" the term "groundwater," but rather has adopted one of the acceptable definitions of the term currently in use by members of the scientific community. Further, in final amendments the phrase "Earth's surface" is replaced by "land surface" for the sake of clarity.

Comment No. 16: M. J. Lawrence, U.S. Department of Energy (9)

The NRC is to be commended on the definition of the term "ground water." The NRC definition includes water in both the unsaturated and saturated zones. This definition is, however, inconsistent with the EPA definition in 40 CFR Part 191, wherein the EPA defines ground water to include only that water in the saturated zone. DOE agrees with the NRC definition. Using the EPA definition, DOE believes the proposed amendments would have to be revisited in their entirety.

Staff Response to Comment No. 16:

In its proposed environmental standards published in December, 1982 EPA defined the term "groundwater" as "water below the land surface in a zone of saturation" (47 FR 58205). With respect to the differences between the definition of the term "groundwater" adopted by NRC in §60.2 and that proposed by EPA the staff notes that it does not consider the two definitions to be inconsistent since the scope of the NRC definition will encompass water within the zone of saturation as well as water within the unsaturated zone. The staff considers it necessary for NRC to adopt a broader definition of the term so that it can effectively apply the provisions of Part 60 to the regulation of HLW disposal within unsaturated as well as saturated geologic media. Further, since EPA has not yet promulgated its final rule -- 40 CFR 191 the staff cannot anticipate whether or how "groundwater" will actually be defined by EPA.

Comment No. 17: A. Hirsch, Environmental Protection Agency (11)

NRC proposed to redefine the term "ground water" to include all water in both the saturated and unsaturated zones. This change apparently provides a simple regulatory means for applying existing criteria written several years ago for high level waste repository siting in the saturated zone to the unsaturated zone as well. While this expansion of applicability may be reasonable, EPA would prefer that the NRC retain the standard scientific meaning for the term (i.e., water within the zone of saturation). We are concerned that confusion may eventually arise among the public, particularly in their understanding of the application of methods of ground water monitoring.

Staff Response to Comment No. 17:

See response to Comment No. 15.

COMMENTS ON THE PROPOSED DEFINITION OF THE TERM "UNSATURATED ZONE"

Comment No. 18: R. R. Loux and C. A. Johnson, State of Nevada Nuclear Waste Project Office (8)

This is a questionable definition because "deepest water table" has been used. The definition is taken from Lohman et al. 1972,[1] but is not, to our knowledge, widely accepted. In some terrain and climates it may lead to inclusion of extensive areas of saturation. The following is a more satisfactory definition for the unsaturated zone:

"The unsaturated zone is that region of the earth materials between landsurface and regionally saturated earth materials. There is discontinuous and incomplete saturation of the interconnected voids in the earth materials, and therefore no continuous positive hydraulic continuity with the regionally saturated zone. Perched zones (zones with void saturation and local positive potential and hydraulic continuity) may be present within the unsaturated zone."

This follows O.E. Meinzer's intent in definition, and incorporates local but not regionally perched water.

Staff Response to Comment No. 18:

In an effort to maintain internal consistency with other Federal agencies, the NRC staff has adopted or modified the hydrogeologic definitions presented in U.S. Geological Survey Water Supply Paper 1988 for use in the NRC regulations related to HLW disposal in geologic repositories whenever possible. To mimimize confusion surrounding this definition minor technical changes have been made in the final amendments to Part 60 including changing the phrase "deepest water table" to "regional water table." Similar conforming changes to the definition of "Saturated zone" have also been made.

Comment No. 19: A. Hirsch, Environmental Protection Agency (11)

"Unsaturated zone" should be defined as the zone between the land surface and the shallowest free water table, discounting "perched" tables. The definition written in the proposed regulation says, "deepest." This is confusing. The definition with "deepest" would be correct, however, if the term "water table" were also defined as the potentiometric surface beneath the land surface at atmospheric pressure.

[1]Lohman, S.W. et al., 1972, Definitions of Selected Ground-Water Terms Revisions and Conceptual Refinements, U.S. Geological Survey Water Supply Paper 1988, 21 p.

Staff Response to Comment No. 19:

See response to Comment No. 18. Also, the term "water table" is defined in 10 CFR Part 60 as "that surface in a groundwater body at which the water pressure is atmospheric." (48 FR 28219)

COMMENTS ON PROPOSED 60.122(b)(7)

Comment No. 20: J. J. Kearney, Edison Electric Institute (7)

These comments are being submitted by the Edison Electric Institute (EEI) and the Utility Nuclear Waste Management Group (UNWMG) in response to the above-referenced notice. We support amendment of the Commission's regulations in 10 CFR Part 60 so that the technical criteria for geologic disposal in the saturated zone may be equally applicable to disposal within the unsaturated zone. In particular, we support adoption of the specific amendments presented in the Commission's notice as appropriate for providing for such disposal with one exception.

Proposed §60.122(b)(7) would apply to disposal in both the saturated and unsaturated zones. As indicated in the rulemaking notice, however, determining groundwater travel time in the unsaturated zone may not be necessary nor always be possible. Under such circumstances, inability to demonstrate a "groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years" should not amount to the absence of a favorable condition. This is especially so in a case where the conditions prescribed in proposed §60.122(b)(8) exist. Accordingly, the groundwater travel time identified as a favorable condition in proposed §60.122(b)(7) should not apply to disposal in the unsaturated zone.

Staff Response to Comment No. 20:

The staff recognizes that there may be difficulties associated with groundwater travel time calculations given the current state of groundwater investigations. However, the staff has concluded that groundwater travel time calculations can be determined in the unsaturated zone provided that the proper level of site characterization analyses are conducted by the applicant. Following a detailed study of the public comments submitted on the Commission's questions pertaining to groundwater travel time in the unsaturated zone (Comment Nos. 6-14), the staff believes it is feasible for DOE to demonstrate the implementability of

the groundwater travel time provisions using currently available standard field and laboratory experiments. Further, as several commenters indicated, a substantial effort is presently underway both to improve existing techniques and to develop new methodologies for measuring the hydrogeologic parameters and flow properties that will provide the necessary input to groundwater travel time calculations. With respect to the commenter's final point, the staff notes that if, for a particular site, the value for pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment is deemed to be substantially in excess of 1,000 years so as to enhance the Commission's confidence that the performance objectives will be met, then it can appropriately be considered as a favorable condition. The commenter's reasons for connecting §§60.122(b)(7) and (8) are not clear to the staff. Finally, the staff reiterates NRC's position that it is important to recognize that a site is not disqualified as a result of the absence of a favorable condition (48 FR 28201).

Comment No. 21: B. Blanchard, U.S. Department of the Interior (13)

Section 60.122, Siting Criteria, (6), (7): "Prewaste-emplacement ground-water travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years." Add" . . . considering both unsaturated and saturated segments of the flow path." We believe that prewaste-emplacement ground-water travel time is conceptually an appropriate "favorable characteristic" for sites located in the unsaturated zone. However, it is a criterion that will be much more difficult to demonstrate in a legal sense at an unsaturated site than at a saturated site. As currently worded, the criterion is perhaps inappropriate for unsaturated and perhaps some types of saturated sites, such as salt and dense fractured crystalline rocks.

We believe that in order for the travel-time criterion to be effectively applied, it needs to incorporate a concept of areally and temporally averaged ground-water flow velocity (rather than the fastest one-dimensional pathway) and/or a flux constraint. Additionally, the current wording makes no provision for the quantity of water moving through the repository to the accessible

environment--only the velocity. It seems inappropriate to reject a site that might have 1 cubic meter of water moving through a repository to the accessible environment in 1,000 years and to accept a site that might have 1 million cubic meters of water moving through it to the accessible environment in 1,500 years. This example is, of course, hypothetical.

We also realize that there is an exception clause in the criterion for special considerations allowing the Commission to consider other factors when appropriate and when it can be demonstrated that a site would clearly meet EPA standards. However, it is not clear how that exception might be applied or what difficulties would be encountered in gaining acceptance by the technical community or various public interest groups for such an exception. Some of these difficulties might be overcome by one or more of the following options:

- Clarify some typical circumstances under which the travel-time criterion might be waived, such as by demonstrating that the flux is likely to be small or nil.

- Specify more precisely how the ground-water velocity (or travel time) should be calculated, using specific cross section area or other averaging or integrating conventions.

- Use a volumetric flow rate (flux) criterion for ground water in addition to or in place of ground-water travel time.

The principal hydrologic advantage of the unsaturated zone is minimizing or eliminating contact of the waste with flowing ground water. This advantage would most likely be more important than ground-water travel time in reducing total quantity of radionuclides which could potentially escape to the accessible environment. The rate of release of radionuclides to the accessible environment from a repository in the unsaturated zone is directly related to the nuclide concentration in the leachate, flux of leachate, dilution of leachate in the zone of saturation, and ground-water velocity (plus geochemical retardation and dispersion effects). Minimizing leachate flux would appear to be at least as important as maximizing ground-water travel time.

It might, therefore, be appropriate to specify a dual "either/or" criterion such that ground-water travel time is greater than 1000 years or ground-water flux through the host rock at the proposed site is less than some specified average rate. The rate could be based on nuclide solubility, leach rate criteria, and population exposure criteria (EPA concentration standards).

We believe that either a flux or travel-time criterion should be based upon an areally integrated or averaged calculation, over an area on the order of the cross-sectional area of the repository normal to the direction of expected flux, for both saturated and unsaturated sites. This would help reduce the uncertainty and controversy over how the "fastest pathway" can be determined. The fastest pathway for saturated fractured rocks, for unsaturated media, and for other highly heterogeneous media could be virtually impossible to calculate with reasonable confidence. However, areal averaged or integrated calculations and bounded estimates can be determined with reasonable confidence, usually by two or more independent methods. Also, qualitative evidence, such as the preservation of archeological artifacts, packrat middens, and other paleo-

materials can lend further confidence to long-term estimates of leach rates and water contact in arid unsaturated materials. If ground-water travel time is to remain a general performance objective criterion for the unsaturated zone, we believe the rule should specify a simple, straightforward, and consistent formula for site determination. We propose the following formula for consideration. Use of the formula is with the assumption that movement of water in the unsaturated zone is basically interstitial and that at least a continuous film of water is present. The formula would have doubtful application in dominantly fractured rock with very little interstitial effective porosity.

The vertical ground-water velocity through the unsaturated zone could be determined as the average vertical recharge rate over the approximate area of the repository, divided by the average volumetric moisture content of the subsurface medium. As a hypothetical example, if a site were determined to have an average recharge rate of 10mm per year and an average subsurface moisture content of 10 percent (10 percent of bulk volume contains water), an average velocity would be 10/0.1 or 100mm per year (0.1m per year). If it were 100mm above the water table, the travel time in the unsaturated zone alone would be 1000 years. It becomes obvious that a nearly zero moisture content would result in a theoretically infinite velocity. This is absurd, but does emphasize the need for prudent application of any mechanism with which to approximate conditions that defy accurate analysis. Ground-water velocity is one important element of performance and although this method is not precise or highly accurate, the method could form the basis for approximations that could be consistently applied to a variety of sites where unsaturated porous media are part of the flow system.

Staff Response to Comment No. 21:

The additional word changes suggested by the commenter with respect to 60.122(b)(7) have not been adopted since the definition of the term "groundwater" (60.2) will assure that both the unsaturated and saturated segments of a flow path are considered.

With respect to the commenter's second point, the staff anticipates that temporal and spatial variations in the hydrologic regime will be addressed in the evaluation of uncertainties surrounding the groundwater travel time calculations. The staff considers the fastest pathway criterion to be a more appropriate measure of performance than the suggested averaged velocity criterion. On the issue of flux as an alternative to travel time, the staff believes that it may be impractical to specify a minimum amount of flux or to otherwise define a

performance objective based on flux through a geologic repository. However, the staff notes that flux is an important hydrologic parameter that should be considered in future NRC evaluations of whether or not a site meets the required performance objectives. Finally, on the commenter's last point in the second paragraph, NRC's primary interest is not the quantity of groundwater moving towards the accessible environment per se, but rather the radionuclides contained in that groundwater.

The commenter's third point on the exception clause of the groundwater travel time criterion was discussed at length by the Commission at 48 FR 21896-21897.

The staff agrees with most of the technical discussion presented in the fourth paragraph. The commenter's statement that minimizing leachate flux would appear to be at least as important as maximizing groundwater travel time has been addressed in the above discussion.

The staff does not consider it necessary to specify a dual "either/or" groundwater criterion as suggested by the commenter since under the provisions of §60.113(b) the Commission already has the flexibility to approve or specify some other radionuclide release rate, designed containment period or pre-waste-emplacement groundwater travel time on a case-by-case basis.

With respect the commenter's final point the staff anticipates that groundwater travel time and flux calculations which involve averaging or areal integration will be addressed in the evaluation of uncertainties surrounding groundwater travel time calculations during the licensing review process.

COMMENTS ON PROPOSED 60.122(b)(8)(i)

Comment No. 22: M. J. Lawrence, U.S. Department of Energy (9)

The words "and nearly constant" should be removed so that this section reads "Low moisture flux in the host rock and in the overlying and underlying hydrogeologic units."

DOE notes that recharge is not constant in either time or space. Rather, recharge is sporadic, occurring in response to individual heavy rainfalls, extended periods of rainfall (wet season), or snowmelt. Between these recharge events, water in the unsaturated zone is held in tension and flux becomes negligible - an obvious advantage of disposal in the unsaturated zone. These findings led Dames & Moore to conclude in NUREG/CR-3130 that the flux and the frequency of wetting events were the primary factors in determining releases from wastes disposed in the unsaturated zone.

Staff Response to Comment No. 22:

The commenter's point is well taken. The phrase "and nearly constant" has been deleted from the provisions of 60.122(b)(8)(i).

Comment No. 23: B. Blanchard, U.S. Department of the Interior (13)

Section 60.122(b)(8)(i): "Low and nearly constant moisture flux in the host rock and in the overlaying and underlying hydrogeologic units." This is an improvement over the earlier "low and constant moisture content" in that it avoids the erroneous implication that low moisture content necessarily means low flux. However, "nearly constant" . . . flux is not necessarily an advantage, as evidenced by the conflict with "free drainage."

Section 60.122(b)(8)(iv). A low, constant rate of flux would seem to offer better opportunity for dissolution processes than would an average low, but episodically high flux. There is some evidence also that some materials for waste canisters may be more resistant to corrosion under episodic wetting and drying. Basically, it seems best to address only a single concept or factor in a single statement of condition. Also, change "overlaying" to "overlying."

Staff Response to Comment No. 23:

See response to Comment Nos. 22 and 28. Also, the typographical error in the word "overlying" will be corrected in the final rule.

COMMENTS ON PROPOSED 60.122(b)(8)(ii)

Comment No. 24: M. J. Lawrence, U.S. Department of Energy (9)

DOE is concerned with the NRC approach to the concept of capillary fringe as described in this condition and on page A-1 of Appendix A to NUREG-1046. DOE

notes that the upper surface of the zone of tension saturation (capillary fringe) is neither constant nor planar; rather, it is dynamic and at different heights in materials of different pore sizes owing to the higher capillary rise in smaller pores.

The NRC has addressed the DOE concern about the number or percent of fully saturated voids continuous with the water table in NUREG-1046, wherein they have suggested a definition of capillary fringe as a planar surface, at which 50 percent of the pore space is filled with water. This suggested definition corresponds with the usage in USGS Water-Supply Paper 1988.

However, the suggested definition can be interpreted as applying to any material having a degree of saturation of 50 percent or greater. DOE notes that, at a degree of saturation of 50 percent, no pore spaces have to be completely filled with water (and hence it would be above the capillary fringe). DOE believes the intent of the definition is a planar surface at which 50 percent of all pore spaces are completely filled with water (50 percent of all pore spaces are not completely filled with water). DOE does not believe that either approach can be defined by field measurements.

DOE believes the concept of avoiding waste emplacement in the capillary fringe is valid, though the definition of the capillary fringe will always elude precision. The capillary fringe is something that everyone knows exists, but which no one can adequately define. Even if an unambiguous, non-arbitrary definition is found, the upper limit of the zone of "fully saturated voids continuous with the water table" can probably not be defined by field measurements, particulary under conditions of heterogeneous materials and infiltrating water. However, in very few, if any, cases could the upper limit of the capillary fringe be more than a few tens of meters. DOE recommends this section be revised to recognize that it is physically limited to a few tens of meters.

Staff Response to Comment No. 24:

The staff recognizes that the location of the upper limit of the zone of "fully saturated voids continuous with the water table" may be a difficult parameter to determine by field measurements. However, proposed alternatives do not avoid the difficulties both in measuring this zone's top and in determining its hydrologic connection with the water table. Also, the staff does not consider it appropriate to quantify a generic upper limit for this zone due to its site-specific nature. The staff believes that both the extent and nature of the capillary fringe will be highly site-specific parameters.

With respect to DOE's comments in the second and third paragraphs related to the discussion provided in the definition of the term "capillary fringe" in Appendix A of draft NUREG-1046, of the level at which 50% of the pore spaces are filled with water the staff notes that DOE has misconstrued the intent of the statement "For instance, this limit may be defined as the level at which 50 percent of the pore space is filled with water" (pA-1). This statement was included in the definition of the "capillary fringe" provided in USGS Water Supply Paper 1988 (1972) and appeared to represent an example of how the upper limit of the capillary fringe may be more or less defined arbitrarily in some quantitative studies. The NRC staff did not intend this statement to be interpreted in the manner DOE has stated, and notes that no regulatory use should be derived from its inclusion in the definitions provided in Appendix A of draft NUREG-1046. To avoid further ambiguity and confusion in this matter the definition of the term "capillary fringe" will be deleted from the final NUREG-1046 report.

Comment No. 25: B. Blanchard, U.S. Department of the Interior (13)

Section 60.122(b)(8)(ii): "A water table sufficiently below the underground facility such that fully saturated voids continuous with the water table do not encounter the underground facility." This condition has also been improved over the earlier version, which depended on a rather inappropriate definition of "capillary fringe." However, it still appears to be incumbent on the applicant to prove that there are no continuous paths of water occupying saturated pores--an impossible task. We suggest changing the favorable condition to read as follows:

> "(ii) Conditions that preclude, or limit, capillary rise from the water table to the underground facility;"

This directly addresses the concerns expressed by the NRC staff regarding siting a facility in the capillary fringe but avoids definition of the term "capillary fringe."

Staff Response to Comment No. 25:

The staff can discern no advantage in adopting the suggested wording because the capillary rise would, in many cases, also be difficult to determine.

Further, the suggested wording would preclude the consideration of downward moving groundwater. See also staff response to Comment No. 24.

COMMENTS ON PROPOSED 60.122(b)(8)(iii)

Comment No. 26: R. R. Loux and C. A. Johnson, State of Nevada Nuclear Waste Project Office (8)

The NRC stated conditions favorable for an unsaturated zone repository are based on the current level of knowledge of the various transport processes that may operate in unsaturated zones. This level of knowledge is still quite limited. One condition in particular, Item 8iii (FR5937), seems more speculative than others. An overlying low permeability hydrogeologic unit which prevents or impedes downward moving moisture may likewise impede upward moving water vapor. If radionuclides are present in upward moving water vapor driven by strong thermal gradients created by the waste, such water vapor may be forced to move laterally below the hydrogeologic unit until it condenses. The condensed water vapor, if concentrated in a localized zone of permeability, might have the opportunity to flow as perched water to points of discharge at land surface. Considerable uncertainty exists in terms of radionuclide migration with water vapor, but the above scenario suggests that the low permeability hydrogeologic unit could act to concentrate moisture with radionuclides, and permit discharge of this moisture if the hydrogeologic unit intersects land surface in the vicinity of the repository. Therefore, it is not clear that the low permeability hydrogeologic unit would be generally favorable if radionuclides migrate with water vapor driven from the repository zone.

Staff Response to Comment No. 26:

The commenter has interpreted the favorable condition in question as a local condition, while NRC's intent was to consider regional hydrogeologic conditions. The staff also notes that conditions which preclude water movement would not necessarily preclude vapor movement. See also staff response to Comment No. 31.

Comment No. 27: M. J. Lawrence, U.S. Department of Energy (9)

DOE recommends that this section be revised to read "A hydrogeologic condition above the host rock that would inhibit the downward movement of water, divert downward moving water to a location beyond the limits of the underground facility, or divert a significant portion of downward moving water, including that produced by sporadic, intense recharge events, away from the location of waste emplacement."

This rewording addresses the DOE concern that hydrogeologic conditions other than a low permeability unit, such as a contrast in permeabilities in adjacent hydrogeologic units sufficient to create a capillary break, may result in the desired effect. In addition, the rewording recognizes the favorable effect of vertical flow conduits, even within the boundaries of the underground facility, in diverting water away from the emplaced wastes.

The ability of a hydrogeologic condition, such as a capillary break, to inhibit water movement (or radionuclide transport) supports the previously recommended revision to the term "barrier."

Staff Response to Comment No. 27:

The staff considers the wording proposed by DOE to be overly vague and declines to make the suggested change.

Comment No. 28: B. Blanchard, U.S. Department of the Interior (13)

Section 60.122(b)(8)(iv): " A host rock that provides for free drainage; or . . . " We suggest that "or" should be changed to "and."

Staff Response to Comment No. 28:

The NRC staff declines to make the suggested change since it may prove extremely difficult, if not impossible, for one site to be characterized simultaneously by all five hydrogeologic conditions set forth in 60.122(b)(8). The staff considers that the presence of any one of these five hydrogeologic conditions will constitute a favorable siting criteria for unsaturated sites.

Comment No. 29: B. Blanchard, U.S. Department of the Interior (13)

Section 60.122(b)(8)(v): "A climatic regime in which the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration." The term "small percentage" is vague and inappropriate, in our opinion. We suggest specifying an absolute value of average recharge as a maximum, perhaps on the order of 50mm or less.

Staff Response to Comment No. 29:

The qualitative phrase "small percentage" is used in this provision because the average annual historic precipitation and potential evapotranspiration will vary from site to site. Therefore, the staff does not consider a generic quantitative parameter appropriate in this instance.

COMMENTS ON PROPOSED 60.122(c)(23)

Comment No. 30: M. J. Lawrence, U.S. Department of Energy (9)

DOE recommends rewording this section to clarify its meaning as follows: "Potential for existing or future perched water bodies that may saturate portions of an underground facility or provide a faster flow path from an underground facility to the accessible environment."

Staff Response to Comment No. 30:

The suggested change has been adopted in the final rule.

Comment No. 31: A. Hirsch, Environmental Protection Agency (11)

The Commission proposes to amend Section 60.122 by adding new paragraphs (b)(8) and (c)(23). There seems to be a conflict in the criteria outlined under portions of the two respective paragraphs. Paragraph (b)(8)(iii) requires that hydrogeologic conditions in the unsaturated zone provide for "a laterally extensive, low permeabiltiy unit above" the repository to inhibit downward migration of water into the underground facility. Paragraph (c)(23) presumably calls for the unsaturated zone to be free of the potential for "perched water bodies that may have the effect of saturating portions of the underground facility." It seems that these are in conflict because the laterally extensive, low permeability unit encouraged to be located above the repository as outlined in paragraph (b)(8) increases the potential for the formation of perched water bodies immediately above the unit. Although the low permeability strata may serve to inhibit downward migration, it encourages the possibility of perched water bodies that may result in saturated flow conditions above and immediately surrounding the limits of the underground repository. Conversely, paragraph (c)(23) discourages siting in areas where the potential for existing or future perched conditions exists. EPA recommends that this inconsistency be resolved.

Staff Response to Comment No. 31:

The commenter has incorrectly identified 60.122(b)(8)(iii) as a requirement, rather than as a favorable condition. The staff notes that the two provisions in question are not necessarily mutually exclusive. Further, only perched water bodies that may saturate portions of the underground facility or provide a faster flow path from an underground facility in the unsaturated zone to the accessible environment would be considered as potentially adverse under §60.122(c)(23).

Comment No. 32: J. K. Bates, Argonne National Labs (4)

Proposed Amendment: Potential for vapor transport of radionuclides from the underground facility located in the unsaturated zone to the accessible environment, as a potentially adverse condition.

This is an ambiguous, and as written, meaningless statement that could, under certain conditions, be applied to any repository site. The detailed explanation in NUREG-1046, pg. II.b.8 is confusing and does little to address the issues. Several points need to be clarified.

1. What is vapor transport? If it is transport of radionuclides in the vapor phase, then it is not unique to the unsaturated zone for such transport will occur at any site until resaturation occurs. If it is transport of radionuclides in water vapor through rock, then it should not be identified as a separate transport mode because transport by water vapor meets the NRC definition of groundwater. Also, according to the NRC (NUREG/CR-3206, pg. 118), no soluble contaminants will be transported away from the repository by water vapor, making the proposed amendment unclear.

2. Where is the vapor transport occurring and when it is important? Vapor phase transport might occur in the repository rock. However, before such transport could occur, the contaminants have to get to the rock. This would involve vapor phase transport of contaminants from the waste package, across potentially significant void spaces, to the rock. Transport in these two diverse media is likely to involve different processes and should be distinguished since the technical references refer only to transport through rock.

It makes little sense to mention vapor phase transport in rock unless the terms and conditions are well defined. It could make sense to identify vapor phase transport from the waste package to the rock as an advantage for the unsaturated zone, since it is likely far fewer radionuclides (amount and number) would be transported through the "vapor" (unsaturated repository) than would be transported through liquid (saturated repository). This void space is an additional barrier that impedes the movements of many contaminants. Certainly this is an area that deserves further attention by the NRC staff.

Staff Response to Comment No. 32:

The discussion provided by this commenter served to illuminate several areas of the NRC's treatment of the issue of vapor phase transport which may have caused some confusion. Most of this confusion appears to surround the use of the term "vapor transport." To clarify its initial intent NRC has modified 60.122(c)(24) by deleting the reference to vapor transport. This provision now reads

"potential for the movement of radionuclides in a gaseous state through the air-filled pore spaces of unsaturated geologic media to the accessible environment." This wording modification is also responsive to the commenter's question of where vapor transport is occurring. Further, NRC notes that draft NUREG-1046 is currently being revised in light of public comments received and subsequent changes in the final amendments. The staff anticipates that a clearer discussion of the movement of radionuclides in a gaseous state can now be provided in this document due to results obtained recently from NRC funded research in this field.

With respect to the issue of when vapor transport is important, NRC recognized in draft NUREG-1046 (p. 15) that vapor formation may not be a potentially adverse condition, but that vapor transport of radionuclides away from the underground facility potentially could have an adverse effect on the integrity of the geologic repository. The staff stated that it would like the opportunity to evaluate whether or not vapor transport could adversely affect the repository system, i.e. to evaluate the importance of vapor transport at a particular site. Therefore, the question of how important vapor phase transport would be is one issue that NRC expects would be answered during a site review process, when specific parameters such as rock type, backfill design, thermal loading, waste form, etc. can be used to better delimit the potential for transport of radionuclides in a gaseous state.

With respect to the commenter's final point, NRC agrees that vapor phase transport across various barriers may need to be considered, and anticipates that future research in this area will result in a better understanding of

vapor phase transport among different types of barriers within a geologic repository system.

Comment No. 33: B. Blanchard, U.S. Department of the Interior (13)

Section 60.122(c)(24): We suggest adding quantitative clarification to this criterion. As currently worded, it allows no potential vapor-phase transport of radionuclides by molecular diffusion or perhaps by convective transport. Although these fluxes might be miniscule, they would not be zero at any unsaturated site. Therefore, if this criterion is ever considered as a disqualifying factor it will need qualification as regards release rate of nuclides such as ^{129}I and ^{14}C. Related to this question is the interpretation of the boundary for the accessible environment. It is not clear to us from the definition in 10 CFR 60 whether the "accessible environment" includes the airspace immediately above the ground surface directly over the repository or only the atmosphere beyond the boundary.

Differences in these two interpretations could have major impacts on how the vapor transport criterion is tested.

Staff Response to Comment No. 33:

The staff considers it inappropriate at present to add a quantitative statement to the provisions of 60.122(c)(24) because the movement of radionuclides in a gaseous state is, to a large extent, dependent upon site- and design-specific parameters. NRC would like the opportunity to examine the potential movement of radionuclides in a gaseous state away from the geologic repository to determine if the isolation capability of the geologic setting may be compromised. With respect to the comment on the accessible environment, item (1) of the definition set forth in 60.2 lists "the atmosphere" as part of the accessible environment (48 FR 28217). This would include the airspace directly over the repository.

Comment No. 34: A. N. Turcan, Jr., Capital Area Groundwater Conservation Commission (14)

There is a discussion of vapor transport in the rules and the need for consideration on a case by case basis of the problem in the Rules Section, "Issues examined by the Commission." Hopefully, the Commission's conclusion is satisfactory or is more in-depth caution required?

Staff Response to Comment No. 34:

The discussion referred to by the commenter (48 FR 5935) served to raise the issue of vapor transport to public attention at an early stage so that further thought may be given to the associated positive aspects and potential concerns. It is recognized that more detailed information will be necessary to enable NRC to evaluate the importance of transport of radionuclides in a gaseous state through unsaturated geologic media especially during the licensing review process. To that end, NRC is currently sponsoring research in vapor phase transport in unsaturated fractured rocks.

THE FOLLOWING NEW SITING CRITERIA WERE SUGGESTED BY COMMENTERS

Comment No. 35: R. R. Loux and C. A. Johnson, State of Nevada Nuclear Waste Project Office (8)

Two additional favorable conditions are suggested for NRC's consideration:

1. Thermal characteristics of the hydrogeologic unit, such that exposure to high temperature gradients would not cause compaction or volume changes in the packaging or surrounding media.

If compaction should occur, it could influence the hydraulic conductivity in a negative sense, as well as influence the structural stability of the area around the cannisters. Compaction due to high thermal gradients is suggested in studies by Constantz.*

2. Host rock that is capable of accelerated drying.

Due to temperatures reached in the near field, vapor transport in the unsaturated zone is initiated shortly after waste emplacement. This vapor phase moves outward towards cooler regions where it condenses. The condensed water then moves back towards the cannisters. This sets up a circulation system which is dominated by the vapor phase; that is, the water phase is small compared to the vapor phase. Prolonged circulation tends to reduce the total amount of water in the area surrounding the cannisters because more and more vapor is lost to the surrounding system. Eventually there is no water left as either vapor or condensate; in short, the host medium becomes dry. Therefore, a host rock which encourages this type of behavior to occur before the cannisters begin to deteriorate (and leak) is advantageous. However, accelerated drying after the cannisters begin to deteriorate (and leak) may be

*Constantz, Jim, 1983, "Laboratory Analysis of Water Retention in Unsaturated Zone Materials at High Temperature, in The Role of the Unsaturated Zone in Radioactive and Hazardous Waste Disposal, eds. J.W. Mercer, P.S. Rao, I.W. Marine, Ann Arbor Sciences, 1983, Ann Arbor, Michigan.

a disadvantage to long-term isolation and requires further analysis. This drying behavior is described in work by Pollock.**

An additional comment on conditions for disposal in the unsaturated zone concerns hydrogeochemical considerations. For the saturated zone 10 CFR Part 60 [60.122(c)(9)] identifies a non-reducing environment as an adverse condition. It is probable that the unsaturated zone is an oxidizing environment. An additional condition addressing hydrogeochemical conditions in the unsaturated zone is necessary.

Staff Response to Comment No. 34:

The staff notes that both conditions proposed by the commenter could be either favorable or potentially adverse conditions, depending on the site selected. These phenomena are not conclusive, and therefore, the staff has not adopted the suggested wording.

With respect to the commenter's final point, the staff notes that in the final amendments, the qualifying phrase "for disposal in the saturated zone" has been deleted from §60.122(c)(9). This change should ensure that this provision will be equally applicable to geochemical conditions in both the saturated and unsaturated zones.

THE FOLLOWING PROPOSED REVISIONS TO EXISTING PROVISIONS OF 10 CFR PART 60 WERE SUGGESTED BY THE COMMENTERS

Comment No. 36: M. J. Lawrence, U.S. Department of Energy (9)

§60.2, Definition of Disturbed Zone

With incorporation of the unsaturated zone provisions into 10 CFR Part 60, DOE believes the definition of disturbed zone should be reconsidered. DOE believes the disturbed zone should not include the volume of rock in which changes will occur which will improve the isolation capability of the repository. For example, the Supplementary Information and NUREG-1046 indicate there may be the creation of a drying zone extending hundreds of meters from a repository located in the unsaturated zone. This drying zone (and the accompanying increase in degree of saturation at some farther distance) will create a hydraulic gradient in all directions toward the repository - a favorable condition which will exist throughout the temperature pulse. DOE recommends

**Pollock, David Warren, 1982, "Fluid Flow and Energy Transport in a High-Level Waste Repository in Unsaturated Alluvium", Ph.D. Thesis, University of Illinois - Urbana, Champaign, Illinois.

that the NRC revise the definition of the term "disturbed zone" to apply to that volume of rock in which changes will occur which will have a significant adverse effect on the performance of the repository.

Staff Response to Comment No. 36:

The "disturbed zone" concept is currently under review by the NRC staff, and the commenter's concerns will be considered during this review.

Comment No. 37: M. J. Lawrence, U.S. Department of Energy (9)

§60.2, Definition of Barrier

DOE recommends revising the definition to mean any material, structure, or condition that prevents, or substantially delays, movement of water or radionuclides. The basis for this recommendation is discussed in the comment on Section 60.122(b)(8)(iii).

Staff Response to Comment No. 37:

See response to Comment No. 27.

Comment No. 38: M. J. Lawrence, U.S. Department of Energy (9)

§60.122(b)(2)(iii)

The phrase "low hydraulic potential" should be revised to either "low hydraulic gradient" or "small difference of hydraulic potential" to be hydraulically correct.

Staff Response to Comment No. 38:

The phrase "low hydraulic potential" has been replaced by the phrase "low hydraulic gradient" in the final amendments.

Comment No. 39: B. Blanchard, U.S. Department of the Interior (13)

Section 60.122(b)(2)(iii): To be hydraulically correct, the phrase "low hydraulic potential between" should be "low hydraulic gradient between" or "small difference of hydraulic potential between." This concept is also applicable to the unsaturated zone and is implicit in the wording "Low . . . moisture flux in the host rock . . ."

Staff Response to Comment No. 39:

See response to Comment No. 38.

Comment No. 40: M. J. Lawrence, U.S. Department of Energy (9)

§60.122(b)(5)

DOE believes that, although a minimum depth of 300 meters for waste emplacement is a favorable condition, the application of this favorable condition to the unsaturated zone is non-conservative in that it ignores the greater benefit to isolation derived from maximizing the thickness of the unsaturated zone between the underground facility and the water table. Instead, it supports the concept of "the deeper, the better" (see page 19 of NUREG-1046) without consideration of the lesser likelihood of exhumation by erosion, the lesser likelihood of intrusion by deep water well drilling in isolated arid environments, or the advantages of maximizing the thickness of the unsaturated zone between the underground facility and the water table. To achieve a meaningful balance between favorable conditions for the unsaturated and saturated zones, DOE recommends adoption of a favorable condition for the unsaturated zone that acknowledges the favorability of a substantial distance between the underground facility and the water table. Adoption of such favorable condition is consistent with NRC concerns in Section 60.122(b)(8)(ii) and 60.122(c)(22).

Staff Response to Comment No. 40:

The staff has not adopted the suggested change because it could result in an underground facility being situated close to the land surface, and hence, close to the accessible environment. The staff does not understand the reasoning behind this suggestion since the staff considers the provisions of 60.122(b)(8)(ii) already accommodate DOE's concerns related to distance between the underground facility and the water table.

Comment No. 41: A. N. Turcan, Jr. Capital Area Groundwater Conservation Commission (14)

The requirement of a minimum depth of 300 meters may minimize to some degree the effects of climatic changes. But there should be a required minimum predetermined interval between the top of the water table and the bottom of burial depth to prevent water entering the repository.

Staff Response to Comment No. 41:

See staff response to Comment No. 40.

Comment No. 42: M. J. Lawrence, U.S. Department of Energy (9)

§60.133(f)

This section, now applicable to disposal in either the unsaturated or saturated zone, on rock excavation design criteria states that the potential for creating a preferential ground-water pathway must be limited. However, in the unsaturated zone, a preferential ground-water pathway may be preferred in order to have a freely draining host rock as contained in the proposed Section 60.122(b)(8)(iv). DOE recommends revising this section to "The design of the underground facility shall incorporate excavation methods that will limit the potential for creating pathways that could compromise the ability of the repository to meet the performance objectives," to allow internal consistency in the technical rule for the unsaturated zone. This recommended change is consistent with the wording contained in Section 60.133(a).

Staff Response to Comment No. 42:

The provisions of §60.133(f) have been modified to reflect the fact that it is groundwater contact with the waste packages that is of primary concern. Also, the phrase "radioactive waste migration" has been replaced by "for radionuclide migration" for the sake of clarity. These changes should be responsive to DOE's concerns in this matter.

Comment No. 43: M. J. Lawrence, U.S. Department of Energy (9)

§60.134(b)

As in the preceding comment, DOE believes that in the unsaturated zone, it may be beneficial to "seal" boreholes and shafts so as to create a preferential pathway for ground water along at least part of the length of the borehole or shaft. For example, it may be desirable to have a preferential pathway for ground water from an overlying unit where the groundwater may tend to perch naturally, to an underlying unit or completely through the repository horizon (but not in areas of emplaced wastes) to an underlying permeable zone. DOE believes the unsaturated zone offers some interesting opportunities for innovative methods and materials for backfilling and sealing, as noted by G. Roseboom in USGS Circular 903.

DOE recommends either revising Section 60.134(b) to be applicable to only the saturated zone, or rewording it to read "Materials and placement methods for seals shall be selected to reduce, to the extent practicable, the potential for creating pathways that compromise the ability of the repository to meet the performance objectives." This recommended change is consistent with the wording contained in Section 60.134(a).

Staff Response to Comment No. 43:

The provisions of §60.134(b)(1) now refer to creating a preferential pathway for groundwater to contact the waste packages. The wording of §60.134(b)(2)

has been clarified by referring to radionuclide migration instead of to radioactive waste migration.

Comment No. 44: M. J. Lawrence, U.S. Department of Energy (9)

§60.141(c)

Several of the minimum measurements required in this section, particularly changes in ground-water conditions and rock pore-water pressures (including those along fractures and joints) may be unnecessary, of limited use, or difficult to measure in the unsaturated zone, especially given the creation of a drying zone which may reduce moisture contents so low or create such high negative pressures as to exceed the range of measurement for available instrumentation. DOE recommends revising Section 60.141 to replace the term "as a minimum" with the term "where practicable." This recommended change is consistent with the wording already contained in Section 60.140.

Staff Response to Comment No. 44:

The NRC staff considers it reasonable for the applicant to monitor perturbations in the hydrologic regime induced by the construction and operation of a geologic repository. In the event that a given measurement is technologically unfeasible, the applicant will need to rely on indirect methods to assure compliance with this section. Therefore, no change has been made to the provisions of §60.141(c).

Comment No. 45: B. Blanchard, U.S. Department of the Interior (13)

Section 60.122(b)(2)(iv): We endorse extracting this as 60.122(b)(7), as proposed, and adding the statement suggested above to make it clear that the travel time in the unsaturated zone should be creditable.

DEFINITIONS

"Accessible environment." We strongly suggest that aquifers be incorporated in this definition.

Staff Response to Comment No. 45:

With respect to the commenter's first point, see staff response to Comment No. 20. On the issue of incorporating aquifers into the definition of the term "accessible environment" the staff notes that aquifers located outside

the controlled area would be included under item 5 of the definition of accessible environment set forth at 48 FR 28217. Item 5 identifies "the portion of the lithosphere that is outside the controlled area" as part of this definition.

COMMENTS ON DRAFT NUREG-1046

In conjunction with the proposed amendments, NRC also published for public comment draft NUREG-1046 which presented an examination of the issues considered by NRC during the development of the proposed amendments. The following comments explicitly addressed draft NUREG-1046. NRC has considered these comments during its efforts to revise the NUREG document, and finds most of the comments to be technically valid. The NRC staff would note that the apparent reliance on NUREG/CR-3158 referred to by one of the commenters was due to the fact that few detailed studies of deep, unsaturated hard rock existed at the time NUREG-1046 was drafted. There was no intent on the part of the staff to relate this document to any specific site currently under consideration by DOE. Rather, the staff hoped to provide a generic study, based upon existing scientific publications, of the pertinent issues that the Commission might wish to consider in reaching a decision on whether or not to expand the scope of 10 CFR Part 60 to include HLW disposal within the unsaturated zone.

Comment No. 46: R. E. Williams, Williams & Associates, Inc. (3)

This report explains the differences between saturated and unsaturated zones in a clear and concise manner. Comments are presented by page number as follows.

Page 3 - Defining groundwater as the entire volume of water below the earth's surface is a somewhat unusual but very appropriate approach.

Page 4 - Paragraphs 2 and 4 relate to movement due to gravity in the unsaturated zone. However, at the high moisture tensions that occur in arid regions with a deep water table the movement may be vertically upward due to evaporation at the surface. Soil moisture does not necessarily ultimately percolate downward in arid environments.

Page 5 - Top of page - In our opinion the flow into fractured granite would be considerably different than fractured tuff. In some types of tuff, water in the fractures would be "absorbed" into the adjacent intergranular pores. This would not occur in granite because it is

less porous. Therefore, downward movement may not be as rapid in tuff because the fractures would dewater due to water moving out into the pores. These ideas should be investigated either in the laboratory or in the field as discussed at the bottom of page 6 and top of page 7.

Pages 7 and 8 - These pages present a good discussion of heat flow from the repository and the formation of a "vapor envelope" around the repository.

Page 10 - Paragraph 4 - The authors point out that under unsaturated flow conditions the liquid flow occurs only on the surface of mineral particles wherefore the removal of radionuclides is more likely than at saturated flow conditions. However, according to the heat, liquid and vapor flow analysis, the flow away from the repository is in the form of vapor while the flow toward the repository is in the form of liquid on the particle surfaces. The radionuclides therefore would have to be in the vapor phase, not in the liquid phase.

Pages 14 and 15 - Vapor and gaseous transport of contaminants - The discussion of the transport is good but it would be advisable to conduct additional research on this topic by means of physical model that could be used to verify the mathematical model developed at Arizona. A complete analysis of the "vapor envelope" might show that there is no movement of either liquid or vapor from the envelope to the surrounding material. An energy balance of this phenomenon would have the heat produced at the repository constitute the energy source for the recirculating flow of vapor away from the repository and flow of liquid toward the repository.

Pages 20 and 21 - We agree with the discussion on shafts, boreholes and backfill regarding design. Specifically the proper design may be the opposite of the proper design for such structures under saturated flow conditions.

Comment No 47: D. W. Moos, Department of Ecology, State of Washington (12)

We are fully in agreement with the proposed amendments to 10 CFR 60 which accommodate candidate repository sites in the unsaturated zone.

However, it is apparent that the main body of reasoning and examples covered in the draft applies to the Nevada Test Site. The principal technical reference, in fact, is NUREG/CR-3158, which contains in its title the phrase, "Emphasis on the Nevada Test Site."

We have never been fully satisifed with the pre-NWPA siting decision process which led the U.S. Department of Energy to put its Hanford Reference Repository Location deep in the saturated zone, stratigraphically close to aquifers of great economic importance. As the principal water management agency for a state where future water quality and availability are sensitive, highly-charged issues, we are deeply concerned with any risk of contamination, no matter how slight.

The proposed amendments can be interpreted as a signal that the Nuclear Regulatory Commission, like the state of Washington, wants to see all reasonable alternatives examined and, where indicated, re-examine before final commitment to a deep, difficult site such as the Hanford location in the saturated zone.

APPENDIX A

March 6, 1984

Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, DC 20555

DOCKET NUMBER
PROPOSED RULE PR-60 (1)
(49 FR 5934)

Sir:

RE: 10 CFR Part 60, Disposal of High-Level Radioactive Wastes in the Unsaturated zone, Proposed amendment of rules, Federal Register, V. 49, No. 33

It is extremely important to be aware of the fact that "unsaturated" is NOT synonymous with a low moisture content. The last paragraph beginning on p. 5934 of the Federal Register notice referred to states that "Perhaps the most positive aspect associated with disposal of HLW within the unsaturated zone is that the HLW would be emplaced in a relatively dry (i.e., low moisture content) geologic medium." This implies that all unsaturated rocks are dry. This is patently untrue. Unsaturated merely means that the pore space in the rock is not filled with water. The actual water content depends on the amount of pore space. Thus a rock that has a porosity of 5% and which is saturated has exactly the same amount of contained water as a rock with a porosity of 10% which is 50% saturated. In fact, many of the rocks to which the USGS refers to as unsaturated have a very high porosity and a relatively high saturation, although less than 100%, and in fact contain much more water than saturated rocks with a lower porosity. Many volcanic tuffs in the Great Basin, in fact, contain considerably more water than granites in the more humid regions, even though the granites are saturated and the tuffs are not. Water content and the speed of the movement are the important factors; the percentage of "saturation" is really an insignificant factor.

With regard to the question of whether or not groundwater travel time represents an appropriate measure of performance for a site within the unsaturated zone, I feel that it is absolutely essential that the same standard of measure be applied to all rock types and all sites, regardless of their setting with respect to the water table. I have no idea how groundwater travel time in the unsaturated zone can be determined; neither do I have any idea how groundwater travel time through salt can be measured. Maximum likely volumetric flow rate of groundwater through the repository might well be a more appropriate measure of performance, but if so, then this same measure should be applied to all rock types and all sites. It would be absolutely unacceptable to use the alternative performance measure for a rock situated in the unsaturated zone (even though containing a considerable amount of water and, in fact, possibly be "near" saturation) and apply a different measure for a site in a salt host rock, which in fact contains an amount of water almost defying measurement and with a "groundwater travel time" (if that term can even be applied) that is so slow as to be beyond comprehension.

Thank you for the opportunity to comment.

Sincerely,

Ben Dover

Benjamin Dover
Geologist
657 Indian Mound Road
Columbus, Ohio 43213

(49FR5934)

Mar 14 -84

from the pen of EMERY NEMETHY

DOCKETED
USNRC

[redacted]
BOX 221
BLOOMSBURG 17815

'84 MAR 19 A11:1

ATT: DOCKETING & SERVICE BRANCH
NRC - Wash, DC 20555

OFFICE OF SECRETA
DOCKETING & SERVI
BRANCH

Re: Fed Reg Notice - Feb 16-84
HLW Disposal

Gentlemen -

The discussion in this notice limits itself to waste burial in saturated and unsaturated zones.

Has the Commission given any consideration to above-ground repositories for HLW? Over the past few years, this approach has been written about, a number of times.

Should HLW be entombed in this manner, and if the containment were in the shape of a pyramid,* it might withstand earthquakes, tornadoes and concussion from bomb blasts.

Very truly,

Secy

*(tetrahedron)

Acknowledged by card. 3/20/84

WILLIAMS & ASSOCIATES, INC.

P.O. Box 48, Viola, Idaho 83872 (208) 883-0153 (208) 875-0147

Hydrogeology • Mineral Resources Waste Management • Geological Engineering • Mine Hydrology

March 15, 1984
Contract No. NRC-02-82-046
Communication No. 36

Mr. Jeff Pohle
Division of Waste Management
Mail Stop 623-SS
U. S. Nuclear Regulatory Commission
Washington, D. C. , 20555

Dear Jeff:

This letter constitutes the comments of Williams and Associates, Inc. on NRC NUREG 1046 entitled "Disposal of High Level Radioactive Wastes in the Unsaturated Zone: Technical Considerations". As you pointed out in your note, the NUREG is a draft report for comment. We are directing these comments to you with the anticipation that you will transfer them to Tom Nicholson. The primary review of the report was done by Dr. George Bloomsburg. I have added some comments of my own and edited his. The comments are as follows.

This report explains the differences between saturated and unsaturated zones in a clear and concise manner. Comments are presented by page number as follows.

Page 3 - Defining groundwater as the entire volume of water below the earth's surface is a somewhat unusual but very appropriate approach.

Page 4 - Paragraphs 2 and 4 relate to movement due to gravity in the unsaturated zone.. However, at the high moisture tensions that occur in arid regions with a deep water table the movement may be vertically upward due to evaporation at the surface. Soil moisture does not necessarily ultimately percolate downward in arid environments.

Page 5 - Top of page - In our opinion the flow into fractured granite would be considerably different than fractured tuff. In some types of tuff, water in the fractures would be "absorbed" into the adjacent intergranular pores. This would not occur in granite because it is less porous. Therefore, downward movement may not be as

3/27/84 DC

rapid in tuff because the fractures would dewater due to water moving out into the pores. These ideas should be investigated either in the laboratory or in the field as discussed at the bottom of page 6 and top of page 7.

Pages 7 and 8 - These pages present a good discussion of heat flow from the repository and the formation of a "vapor envelope" around the repository.

Page 10 - Paragraph 4 - The authors point out that under unsaturated flow conditions the liquid flow occurs only on the surface of mineral particles wherefore the removal of radionuclides is more likely than at saturated flow conditions. However, according to the heat, liquid and vapor flow analysis, the flow away from the repository is in the form of vapor while the flow toward the repository is in the form of liquid on the particle surfaces. The radionuclides therefore would have to be in the vapor phase, not in the liquid phase.

Pages 14 and 15 - Vapor and gaseous transport of contaminants - The discussion of the transport is good but it would be advisable to conduct additional research on this topic by means of a physical model that could be used to verify the mathematical model developed at Arizona. A complete analysis of the "vapor envelope" might show that there is no movement of either liquid or vapor from the envelope to the surrounding material. An energy balance of this phenomenon would have the heat produced at the repository constitute the energy source for the recirculating flow of vapor away from the repository and flow of liquid toward the respository.

Pages 20-21 - We agree with the discussion on shafts, boreholes and backfill regarding design. Specifically the proper design may be the opposite of the proper design for such structures under saturated flow conditions.

If you have any questions regarding these comments, please call.

Sincerely,

Roy Williams

Roy E. Williams
Ph.D. Hydrogeology
Registered in Idaho

REW:sl

cc: appropriate NRC offices
M. D. Mifflin

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439
Telephone 312/972-4385

(49FR5934)

DOCKETED
USNRC

March 30, 1984

'84 APR 12 A11:25

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Attn: Docketing and Service Branch

Sir:

This is a comment to proposed NRC amendments to 10 CFR Part 60 concerning unsaturated geologic media. (Ref. Federal Register, Vol 49, No. 33, pg 5934.)

Proposed Amendment: Potential for vapor transport of radionuclides from the underground facility located in the unsaturated zone to the accessible environment, as a potentially adverse condition.

This is an ambiguous, and as written, meaningless statement that could, under certain conditions, be applied to any repository site. The detailed explanation in NUREG-1046, pg. II.b.8. is confusing and does little to address the issues. Several points need to be clarified.

1) What is vapor transport? If it is transport of radionuclides in the vapor phase, then it is not unique to the unsaturated zone for such transport will occur at any site until resaturation occurs. If it is transport of radionuclides in water vapor through rock, then it should not be identified as a separate transport mode because transport by water vapor meets the NRC definition of groundwater. Also, according to the NRC (NUREG/CR-3206, pg. 118), no soluble contaminants will be transported away from the repository by water vapor, making the proposed amendment unclear.

2) Where is the vapor transport occurring and when it is important? Vapor phase transport might occur in the repository rock. However, before such transport could occur, the contaminants have to get to the rock. This would involve vapor phase transport of contaminants from the waste package, across potentially significant void spaces, to the rock. Transport in these two diverse media is likely to involve different processes and should be distinguished since the technical references refer only to transport through rock.

It makes little sense to mention vapor phase transport in rock unless the terms and conditions are well defined. It could make sense to identify vapor phase transport from the waste package to the rock as an advantage for the unsaturated zone, since it is likely far fewer radionuclides (amount and number) would be transported through the "vapor" (unsaturated repository) than would be transported through liquid (saturated repository). This void space is an additional barrier that impedes the movement of many contaminants. Certainly this is an area that deserves further attention by the NRC staff.

Sincerely,

John K. Bates
Chemical Technology Division

JKB:rr

4/13/84 pdl

STATE OF
WISCONSIN

RADIOACTIVE WASTE REVIEW BOARD

921 Tenney Building
110 E. Main Street
Madison, WI 53702
(608) 266-0597
(608) 267-7615

(49 FR 5934)

'84 APR 13 P3:11

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

April 11, 1984

Mr. Samuel J. Chilk, Secretary
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attn: Docketing & Service Branch

Re: Comments on the Proposed Rule for Amending 10 CFR Part 60, Disposal of High-Level Radioactive Wastes in the Unsaturated Zone

The Wisconsin Radioactive Waste Review Board has reviewed the proposed revisions to 10 CFR 60 for disposal of high-level radioactive wastes in the unsaturated zone. This proposed rule appears to have considerable merit since it opens up another alternative for disposal. It also appears the Commission has identified the pertinent technical concerns with disposal in the unsaturated zone.

Thank you for the opportunity to comment on this rule.

Sincerely,

James S. Kleinhans

James S. Kleinhans
Executive Director

cc: Radioactive Waste Review Board Members
Technical Advisory Council Members
Policy Advisory Council Members

Acknowledged by card 4/17/84
pa

ENDORSED NOTE ... (49FR5934) (60)

DOCKETED
USNRC

'84 APR 16 P1:30

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

State of Rhode Island and Providence Plantations

EXECUTIVE CHAMBER
PROVIDENCE

J. JOSEPH GARRAHY
GOVERNOR

April 13, 1984

Mr. Samuel J. Chilk
Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Chilk:

I am pleased to submit on behalf of the State of Rhode Island our comments on the Commission's proposed rule regarding disposal of high-level radioactive wastes in the unsaturated zone.

These comments were drafted with the assistance of members of the Rhode Island Crystalline Rock Project Review Team, which was formed last year to respond to the Department of Energy's high-level waste repository program. Contributors to this effort were Mr. Victor Bell, Chief of the Office of Environmental Coordination, R.I. Department of Environmental Management, and Mr. Daniel Varin, Chief of the Office of State Planning.

Any questions regarding our comments may be directed to me at (401) 277-3500.

Sincerely,

Bruce Vild
Project Facilitator

Acknowledged by card. 4/17/84 pd

72 Orange St.,
GOVERNOR'S ENERGY OFFICE • ~~80 DEAN STREET~~ PROVIDENCE, RI 02903 • 401/277-3370

COMMENTS BY THE STATE OF RHODE ISLAND ON THE PROPOSED RULE REGARDING THE DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN THE UNSATURATED ZONE

Most ground water in Rhode Island is drawn from relatively shallow stratified-drift aquifers. Hydrologists in the Division of Land Resources have informed us that in many areas the water table is but a few meters below the surface. While some wells tap water which collects in rock fractures, such water also is found relatively close to the surface. According to our Water Resources Board, only a half-dozen or so water supply wells go below 500 feet (150 meters). This suggests a thin unsaturated zone. It is extremely unlikely, then, based on present evidence, that the Department of Energy could locate a nuclear waste repository in the unsaturated zone in Rhode Island and be able to satisfy its own minimum depth requirement of 200 meters (DOE siting guidelines, Sec. 960.4-2-5(d)). On the other hand, as indicated in the proposed rule, unsaturated zones in other areas, particularly those found in arid or semi-arid regions of the country, may be of sufficient thickness to allow the minimum depth requirement to be met.

Regardless of whether a site is chosen within the saturated zone or the unsaturated zone, our primary concern over the long term should be the isolation of nuclear waste from the accessible environment. Disposal in the unsaturated zone has the advantage of minimizing contact between the implanted waste and ground water. As ground water is the most likely pathway for radionuclides to the outside, Rhode Island would support considering such an option for disposal. We have stated on a number of occasions, particularly in regard to DOE's siting guidelines, that the repository should not contaminate ground water of potential use by present or future generations. The relative dryness of a thick unsaturated zone would help reduce the probability that contaminated ground water would reach Man.

However, ground water does flow in the unsaturated zone, and to demonstrate that its repository complies with stated performance objectives, the Department of Energy will have to assess ground water flow in both liquid and vapor phases. Ground water travel time in the unsaturated zone will be difficult to calculate, as the proposed rule indicates, because of "large associated uncertainties." Some quantification and generalization concerning ground water travel time will be necessary nonetheless to determine if proposed "potentially adverse conditions" (c)(22) and (c)(23) are present (49 FR 5937). Absent another parameter upon which to evaluate performance, DOE will have to attempt a "reasonable" estimate of ground water travel time to be corroborated to the

extent possible when the Department characterizes the candidate site. As there may be much debate over which level of data is "reasonable" in the earlier stages of screening, Rhode Island would urge DOE and NRC to consult freely with the state geological contacts on this matter.

In its consideration of ground water flow (however that parameter is to be determined), we would recommend that NRC direct DOE to examine how the rate and direction of ground water flow is affected by withdrawal. Rhode Island's experience indicates that changes do occur in shallow aquifers and in some cases these changes are significant. This would appear to be a matter of concern in any case where ground water flow is discontinuous and heavily dependent on spatial and temporal events, as in the unsaturated zone.

JOHN J. KEARNEY, Senior Vice President

EDISON ELECTRIC INSTITUTE
The association of electric companies

1111 19th Street, N.W.
Washington, D.C. 20036
Tel: (202) 828-7400

April 13, 1984

(7)

PROPOSED RULE PR-60
(49 FR 9650)

Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Docketing and Service Branch

Re: Proposed Rule: Disposal of High-Level Radioactive Wastes in the Unsaturated Zone; 10 CFR Part 60 (49 Fed. Reg. 5934)

Dear Mr. Secretary:

These comments are being submitted by the Edison Electric Institute (EEI) and the Utility Nuclear Waste Management Group (UNWMG) in response to the above-referenced notice. We support amendment of the Commission's regulations in 10 CFR Part 60 so that the technical criteria for geologic disposal in the saturated zone may be equally applicable to disposal within the unsaturated zoned. In particular, we support adoption of the specific amendments presented in the Commission's notice as appropriate for providing for such disposal with one exception.

Proposed §60.122(b)(7) would apply to disposal in both the saturated and unsaturated zones. As indicated in the rulemaking notice, however, determining groundwater travel time in the unsaturated zone may not be necessary nor always be possible. Under such circumstances, inability to demonstrate a "groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years" should not amount to the absence of a favorable condition. This is especially so in a case where the conditions prescribed in proposed §60.122(b)(8) exist. Accordingly, the groundwater travel time identified as a favorable condition in proposed §60.122(b)(7) should not apply to disposal in the unsaturated zone.

To further amplify our position, we offer the following answers to the two questions presented in the Commission's notice.

1. How can groundwater travel time in the unsaturated zone be determined with reasonable assurance? Should the groundwater travel time performance objective be limited to groundwater movement within the saturated zone?

EEI/UNWMG are not aware of any general, acceptable method for determining groundwater travel time in the unsaturated zone with reasonable assurance. However, there is no reason to strictly limit the groundwater travel time performance objective to groundwater movement within the saturated zone. We agree with the Commission's current thinking on this issue, as described in the rulemaking notice, that if DOE can demonstrate in a particular case with reasonable assurance that travel time for groundwater movement through the unsaturated zone can be quantified, then the Department should be allowed to include such travel time when demonstrating compliance with 10 CFR §60.113(a)(2).

2. Does groundwater travel time represent an appropriate measure of performance for a site within the unsaturated zone, or would an alternative performance objective for the geologic setting, (e.g., maximum likely volumetric flow rate of groundwater through the geologic repository) be more appropriate?

EEI/UNWMG believe that groundwater travel time can, in certain circumstances, represent an appropriate measure of performance for a site within the unsaturated zone. Where it does not, however, we do not believe that an alternative performance objective, such as maximum likely volumetric flow rate, would necessarily be more appropriate. Rather, consistent with one of the alternatives posed by the Commission in the rulemaking notice, we would favor utilization of the approach set forth in 10 CFR §60.113(b) providing the Commission with the basis to specify variations in performance objectives on a case-by-case basis, as long as the overall system performance objective is met. In this connection, the Commission should specifically note in the statement of considerations accompanying the adoption of a final rule that the approach in section 60.113(b) may be particularly appropriate in the case of disposal in the unsaturated zone.

We appreciate this opportunity to comment on the proposed rule and hope that this response will be of assistance to the Commission.

Respectfully submitted,

John J. Kearney
Senior Vice President

JJK:rsd

RICHARD H. BRYAN
Governor

STATE OF NEVADA

PROPOSED RULE PR-60
(49 FR 5934)
(8)

DOCKETED
USNRC

'84 APR 16 P2:04

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

NUCLEAR WASTE PROJECT OFFICE
OFFICE OF THE GOVERNOR
Capitol Complex
Carson City, Nevada 89710
(702) 885-3744

April 13, 1984

Secretary of the Commission
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Docketing and Service Branch

SUBJECT: 10 CFR Part 60 - Proposed Rule on Disposal in the Unsaturated Zone

Dear Mr. Secretary:

The February 16, 1984, Federal Register Notice (Vol. 49, No. 33, FR 5934 to FR 5937) requested comment on 10 CFR Part 60 Proposed Rule for Disposal of High-Level Radioactive Wastes in the Unsaturated Zone. The State of Nevada has reviewed the proposed rule and support documents identified in the subject notice. We are satisfied with the intent of the proposed rule and feel it is in line with the State's thinking on disposal in the unsaturated zone. However, we have some comments and suggested changes to improve the proposed rule.

60.2 DEFINITIONS

Groundwater:

Redefining "groundwater" (ground water) for a regulatory purpose, particularly in view of the fact that the scientific community will make the field and laboratory determination, is not desirable. It would be much better for NRC to define and adopt a term or phrase that does not already have a precise meaning in technical community and literature, such as "subsurface moisture." "Groundwater" already has a widely accepted meaning which does not include vadose or unsaturated zone water.

Unsaturated Zone:

This is a questionable definition because "deepest water table" has been used. The definition is taken from Lohman et al. 1973 [1], but is not, to our knowledge, widely accepted. In some terrain and climates it may lead to inclusion of extensive areas of saturation. The following is a more satisfactory definition

for the unsaturated zone:

"The unsaturated zone is that region of the earth materials between landsurface and regionally saturated earth materials. There is discontinuous and incomplete saturation of the interconnected voids in the earth materials, and therefore no continuous positive hydraulic continuity with the regionally saturated zone. Perched zones (zones with void saturation and local positive potential and hydraulic continuity) may be present within the unsaturated zone."

This follows O.E. Meinzer's intent in definition, and incorporates local but not regionally perched water.

60.122 SITING CRITERIA

The NRC stated conditions favorable for an unsaturated zone repository are based on the current level of knowledge of the various transport processes that may operate in unsaturated zones. This level of knowledge is still quite limited. One condition. In particular, Item 8iii (FR5937), seems more speculative than others. An overlying low permeability hydrogeologic unit which prevents or impedes downward moving moisture may likewise impede upward moving water vapor. If radionuclides are present in upward moving water vapor driven by strong thermal gradients created by the waste, such water vapor may be forced to move laterally below the hydrogeologic unit until it condenses. The condensed water vapor, if concentrated in a localized zone of permeability, might have the opportunity to flow as perched water to points of discharge at land surface. Considerable uncertainty exists in terms of radionuclide migration with water vapor, but the above scenario suggests that the low permeability hydrogeolgic unit could act to concentrate moisture with radionuclide, and permit discharge of this moisture if the hydrogeologic unit intersects land surface in the vicinity of the repository. Therefore, it is not clear that the low permeability hydrogeologic unit would be generally favorable if radionuclides migrate with water vapor driven from the repository zone.

[1] Lohman, S.W. et al.,1972, Definitions of Selected Ground-Water Forms Revisions and Conceptual Refinements, U.S. Geological Survey Water Supply Paper 1988, 21 p.

Two additional favorable conditions are suggested for NRC's consideration:

1. Thermal characteristics of the hydrogeologic unit, such that exposure to high temperature gradients would not cause compaction or volume changes in the packaging or surrounding media.

If compaction should occur, it could influence the hydraulic conductivity in a negative sense, as well as influence the structural stability of the area around the cannisters. Compaction due to high thermal gradients is suggested in studies by Constantz.[2]

2. Host rock that is capable of accelerated drying.

Due to temperatures reached in the near field, vapor transport in the unsaturated zone is initiated shortly after waste emplacement. This vapor phase moves outward towards cooler regions where it condenses. The condensed water then moves back towards the cannisters. This sets up a circulation system which is dominated by the vapor phase; that is, the water phase is small compared to the vapor phase. Prolonged circulation tends to reduce the total amount of water in the area surrounding the cannisters because more and more vapor is lost to the surrounding system. Eventually there is no water left as either vapor or condensate; in short, the host medium becomes dry. Therefore, a host rock which encourages this type of behavior to occur before the cannisters begin to deteriorate (and leak) is advantageous. However, accelerated drying after the cannisters begin to deteriorate (and leak) may be a disadvantage to long-term isolation and requires further analysis. This drying behavior is described in work by Pollock.[3]

An additional comment on conditions for disposal in the unsaturated zone concerns hydrogeochemical considerations. For the saturated zone 10 CFR Part 60 [60.122(c)(9)] identifies a non-reducing environment as an adverse condition. It is probable that the unsaturated zone is an oxidizing environment. An additional condition addressing hydrogeochemical conditions in the unsaturated zone is necessary.

[2] Constantz, Jim, 1983, "Laboratory Analysis of Water Retention in Unsaturated Zone Materials at High Temperature:, in The Role of the Unsaturated Zone in Radioactive and Hazardous Waste Disposal, eds. J.W. Mercer, P.S. Rao, I. W. Marine, Ann Arbor Sciences, 1983, Ann Arbor, Michigan.

NRC QUESTIONS FOR PUBLIC COMMENT (FR 5937)

1. "How can groundwater travel time in the unsaturated zone be determined with reasonable assurance? Should the groundwater travel time performance objective be limited to groundwater movement within the saturated zone?"

In our opinion, it is premature to answer the first part of the question due to the limited research devoted to the question presently. Groundwater travel time in the unsaturated zone cannot now be determined with any assurance. With time, travel time in the unsaturated zone may prove to be as predictable (with similar levels of uncertainty) as travel times in saturated media. However, groundwater travel time is also subject to considerable uncertainty in the saturated zone, with the uncertainty generally increasing in fractured low permeability rocks. From our perspective, there is little confidence that determinations can be made with reasonable assurance in either media presently.

In response to the second question, there seems to be no demonstrated basis for establishing unsaturated zone travel time performance. It is acknowledged that ground water travel time is an acceptable performance measure in the saturated zone and may be appropriate for the unsaturated zone, however, presently there is no scientific basis to support a precise number for unsaturated zone travel time performance. The 1,000 year pre-emplacement ground water travel time performance objective now established for the unsaturated zone cannot be projected with reasonable certainty into the unsaturated zone. We believe this uncertainty does not preclude the use of a 1,000-year travel time, but that its use should be cautioned by the lack of scientific support to base the number. If the 1,000-year travel time is selected as a performance measure, the NRC should consider revisiting this performance standard later when a better understanding of moisture movement in the unsaturated zone is known.

2. "Does groundwater travel time represent an appropriate measure of performance for a site within the unsaturated zone, or would an alternative performance objective for the geologic setting, (e.g., maximum likely volumetric flow rate of groundwater through the geologic repository) be more appropriate?

[3] Pollock, David Warren, 1982, "Fluid Flow and Energy Transport in a High-Level Waste Repository in Unsaturated Alluvium", Ph.D. Thesis, University of Illinois - Urbana, Champaign, Illinois.

Ground-water (unsaturated zone moisture) travel time may be appropriate in the unsaturated zone, and associated time credit to the accessible environment be considered as a measure of performance, however, the Commission should recognize several important factors believed to be involved in a travel time consideration of performance.

1. Travel time, and direction, may prove to be different for liquid and vapor phase moisture in the unsaturated zone.

2. Radionuclide transport may prove more complex in unsaturated flow than in saturated flow, and not closely related to moisture flux.

Performance based upon maximum likely volumetric flow rates may be even more speculative than groundwater travel time. Presently, recharge rates (a measure of volumetric flow rate) cannot be determined with precision, especially during variable climatic conditions. We believe that, although not ideal, ground water travel time in the unsaturated zone may be an acceptable performance measure at the present time, if the factors described previously are considered.

Alternative to a travel time performance standard, it is suggested the EPA standard be the performance measure by which the geologic setting is judged, or the Commission utilize the approach set forth in 60.113(b) of 10 CFR Part 60. This section provides the Commission with the flexibility to specify variations in performance objectives on a case-by-case basis. The prime reason for suggesting this approach is the current absence of detailed understanding of moisture regimens in unsaturated zone environments, and the associated radionuclide transport by both liquids and gases in this type of environment. As more established relationships and techniques of analysis are developed for each site, an appropriate performance objective may be possible.

If you have any questions, please do not hesitate to contact me.

Sincerely,

Robert R. Loux
Director

Carl A. Johnson
Technical Manager

RRL:CAJ:sk

PROPOSED RULE PR
(49 FR 5934) (9)

DOCKETED
USNRC

'84 APR 16 P4:24

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

Department of Energy
Washington, D.C. 20585

APR 16 1984

Mr. Samuel J. Chilk
Secretary of the Commission
Attention: Docketing and Service Branch
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Chilk:

The Department of Energy is pleased to respond to the request of the Nuclear Regulatory Commission (NRC) for comments on the proposed amendments to 10 CFR 60, published on February 16, 1984 (49 Federal Register 5934). The proposed amendments would make the regulation applicable to disposal of high-level radioactive wastes in both the saturated and unsaturated zones. Our comments are contained in two enclosures to this letter: the first contains specific comments on the proposed amendments with recommended alternative language where appropriate; the second contains the Department's response to the questions posed by NRC in the Supplementary Information section of the Federal Register notice.

The Department believes the performance objective for a minimum 1000-year groundwater travel time should only be applied to sites located in the saturated zone. The Department recommends an alternative performance objective, related to the geologic setting, for sites located in the unsaturated zone. The Department will provide a suggested alternative performance objective for NRC consideration by separate letter after the close of the public comment period. The Department will make every effort to provide this information by May 15, 1984.

The Department believes that the proposed amendments, as revised to incorporate the Department's comments, will make 10 CFR 60 effective regulation applicable to sites located in the unsaturated or saturated zones. We are available to meet with NRC concerning the enclosed comments.

Sincerely,

Michael J. Lawrence

Michael J. Lawrence
Acting Director
Office of Civilian Radioactive
Waste Management

Enclosures

Acknowledged by card. 4/17/84

ENCLOSURE 1. Comments on Proposed Amendments to 10 CFR Part 60 for the Unsaturated Zone

1.	§60.2, Definition of Ground Water	The NRC is to be commended on the definition of the term "ground water." The NRC definition includes water in both the unsaturated and saturated zones. This definition is, however, inconsistent with the EPA definition in 40 CFR Part 191, wherein the EPA defines ground water to include only that water in the saturated zone. DOE agrees with the NRC definition. Using the EPA definition, DOE believes the proposed amendments would have to be revisited in their entirety.
2.	§60.2, Definition of Disturbed Zone	With incorporation of the unsaturated zone provisions into 10 CFR Part 60, DOE believes the definition of disturbed zone should be reconsidered. DOE believes the disturbed zone should not include the volume of rock in which changes will occur which will improve the isolation capability of the repository. For example, the Supplementary Information and NUREG-1046 indicate there may be the creation of a drying zone extending hundreds of meters from a repository located in the unsaturated zone. This drying zone (and the accompanying increase in degree of saturation at some farther distance) will create a hydraulic gradient in all directions toward the repository - a favorable condition which will exist throughout the temperature pulse. DOE recommends that the NRC revise the definition of the term "disturbed zone" to apply to that volume of rock in which changes will occur which will have a significant adverse effect on the performance of the repository.
3.	§60.2, Definition of Barrier	DOE recommends revising the definition to mean any material, structure, or condition that prevents, or substantially delays, movement of water or radionuclides. The basis for this recommendation is discussed in the comment on Section 60.122(b)(8)(iii).
4.	§60.122(b)(2)(iii)	The phrase "low hydraulic potential" should be revised to either "low hydraulic gradient" or "small difference of hydraulic potential" to be hydraulically correct.

5. §60.122(b)(5)

DOE believes that, although a minimum depth of 300 meters for waste emplacement is a favorable condition, the application of this favorable condition to the unsaturated zone is non-conservative in that it ignores the greater benefit to isolation derived from maximizing the thickness of the unsaturated zone between the underground facility and the water table. Instead, it supports the concept of "the deeper, the better" (see page 19 of NUREG-1046) without consideration of the lesser likelihood of exhumation by erosion, the lesser likelihood of intrusion by deep water well drilling in isolated arid environments, or the advantages of maximizing the thickness of the unsaturated zone between the underground facility and the water table. To achieve a meaningful balance between favorable conditions for the unsaturated and saturated zones, DOE recommends adoption of a favorable condition for the unsaturated zone that acknowledges the favorability of a substantial distance between the underground facility and the water table. Adoption of such favorable condition is consistent with NRC concerns in Sections 60.122(b)(8)(ii) and 60.122(c)(22).

6. §60.122(b)(8)(i)

The words "and nearly constant" should be removed so that this section reads "Low moisture flux in the host rock and in the overlying and underlying hydrogeologic units."

DOE notes that recharge is not constant in either time or space. Rather, recharge is sporadic, occurring in response to individual heavy rainfalls, extended periods of rainfall (wet season), or snowmelt. Between these recharge events, water in the unsaturated zone is held in tension and flux becomes negligible - an obvious advantage of disposal in the unsaturated zone. These findings led Dames & Moore to conclude in NUREG/CR-3130 that the flux and the frequency of wetting events were the primary factors in determining releases from wastes disposed in the unsaturated zone.

7. §60.122(b)(8)(ii)

DOE is concerned with the NRC approach to the concept of capillary fringe as described in this condition and on page A-1 of Appendix A to NUREG-1046. DOE notes that the upper surface of the zone of tension saturation (capillary fringe) is neither constant nor planar; rather, it is dynamic and at different heights in materials

of different pore sizes owing to the higher capillary rise in smaller pores.

The NRC has addressed the DOE concern about the number or percent of fully saturated voids continuous with the water table in NUREG-1046, wherein they have suggested a definition of capillary fringe as a planar surface, at which 50 percent of the pore space is filled with water. This suggested definition corresponds with the usage in USGS Water-Supply Paper 1988.

However, the suggested definition can be interpreted as applying to any material having a degree of saturation of 50 percent or greater. DOE notes that, at a degree of saturation of 50 percent, no pore spaces have to be completely filled with water (and hence it would be above the capillary fringe). DOE believes the intent of the definition is a planar surface at which 50 percent of all pore spaces are completely filled with water (50 percent of all pore spaces are not completely filled with water). DOE does not believe that either approach can be defined by field measurements.

DOE believes the concept of avoiding waste emplacement in the capillary fringe is valid, though the definition of the capillary fringe will always elude precision. The capillary fringe is something that everyone knows exists, but which no one can adequately define. Even if an unambiguous, non-arbitrary definition is found, the upper limit of the zone of "fully saturated voids continuous with the water table" can probably not be defined by field measurements, particularly under conditions of heterogeneous materials and infiltrating water. However, in very few, if any, cases could the upper limit of the capillary fringe be more than a few tens of meters. DOE recommends this section be revised to recognize that it is physically limited to a few tens of meters.

8. §60.122(b)(8)(iii)

DOE recommends that this section be revised to read "A <u>hydrogeologic condition</u> above the host rock that would inhibit the downward movement of water, divert downward moving water to a location beyond the limits of the underground facility, or divert a significant portion of downward moving water, including that produced by sporadic,

intense recharge events, away from the location of waste emplacement."

This rewording addresses the DOE concern that hydrogeologic conditions other than a low permeability unit, such as a contrast in permeabilities in adjacent hydrogeologic units sufficient to create a capillary break, may result in the desired effect. In addition, the rewording recognizes the favorable effect of vertical flow conduits, even within the boundaries of the underground facility, in diverting water away from the emplaced wastes.

The ability of a hydrogeologic condition, such as a capillary break, to inhibit water movement (or radionuclide transport) supports the previously recommended revision to the term "barrier."

9. §60.122(c)(23)

DOE recommends rewording this section to clarify its meaning as follows: "Potential for existing or future perched water bodies that may saturate portions of an underground facility or provide a faster flow path from an underground facility to the accessible environment."

10. §60.133(f)

This section, now applicable to disposal in either the unsaturated or saturated zones, on rock excavation design criteria states that the potential for creating a preferential ground-water pathway must be limited. However, in the unsaturated zone, a preferential ground-water pathway may be preferred in order to have a freely draining host rock as contained in the proposed Section 60.122(b)(8)(iv). DOE recommends revising this section to "The design of the underground facility shall incorporate excavation methods that will limit the potential for creating pathways that could compromise the ability of the repository to meet the performance objectives," to allow internal consistency in the technical rule for the unsaturated zone. This recommended change is consistent with the wording contained in Section 60.133(a).

11. §60.134(b)

As in the preceding comment, DOE believes that in the unsaturated zone, it may be beneficial to "seal" boreholes and shafts so as to create a preferential pathway for ground water along at least part of the length of the borehole or shaft. For example, it may be desirable to have

a preferential pathway for ground water from an overlying unit where the ground water may tend to perch naturally, to an underlying unit or completely through the repository horizon (but not in areas of emplaced wastes) to an underlying permeable zone. DOE believes the unsaturated zone offers some interesting opportunities for innovative methods and materials for backfilling and sealing, as noted by G. Roseboom in USGS Circular 903.

DOE recommends either revising Section 60.134(b) to be applicable to only the saturated zone, or rewording it to read "Materials and placement methods for seals shall be selected to reduce, to the extent practicable, the potential for creating pathways that compromise the ability of the repository to meet the performance objectives." This recommended change is consistent with the wording contained in Section 60.134(a).

12. §60.141(c)

Several of the minimum measurements required in this section, particularly changes in ground-water conditions and rock pore-water pressures (including those along fractures and joints) may be unnecessary, of limited use, or difficult to measure in the unsaturated zone, especially given the creation of a drying zone which may reduce moisture contents so low or create such high negative pressures as to exceed the range of measurement for available instrumentation. DOE recommends revising Section 60.141 to replace the term "as a minimum" with the term "where practicable." This recommended change is consistent with the wording already contained in Section 60.140.

ENCLOSURE 2. Responses to Specific Questions Raised in the Supplementary Information

Question 1. This question, as stated in the Supplementary Information Section, consisted of two questions which are addressed separately below.

A. "How can ground-water travel time in the unsaturated zone be determined with reasonable assurance?"

Ground-water flux can be determined, using measurements of ambient water content, degree of saturation, matric potential, and hydraulic conductivity to determine moisture-characteristic curves relating these parameters to one another. These curves can be developed so as to predict the constitutive relationships over a wide range of conditions (varying degrees of saturation and different matric potentials). From these relationships and flux determinations, velocity and subsequently ground-water travel time can be estimated.

In situ monitoring techniques, including tracer tests, are undergoing development and may broaden the range of rock types and conditions for which it is feasible to estimate velocity and ground-water travel time. NNWSI program investigations also presently include exploratory shaft tests on infiltration rates and sampling of intact fractured blocks for laboratory experiments. These techniques and investigations are state-of-the-art and should provide a direct determination, with reasonable assurance, of the ground-water flux used to estimate the ground-water travel time. In addition, DOE believes that reasonable bounds may be developed by less direct methods such as recharge rates determined from water budgets, perturbations of thermal gradients, or in situ monitoring of temporal changes in moistures profiles.

Reasonable assurance, therefore, may be gained in estimating ground-water travel time using results of laboratory testing, state-of-the-art direct determinations in the field or laboratory, and bounding estimates developed by indirect methods. In addition, reasonable assurance may also be gained by incorporating uncertainty analysis into predictive models. Although the uncertainty band for a given level of confidence in the calculations may be broad owing to the inability to measure ground-water velocities along all segments of the unsaturated zone travel paths or under all combinations of moisture conditions and matric potentials, the opportunity to invoke conservatism in the ground-water travel time calculations still exists.

B. "Should the ground-water travel time performance objective be limited to ground-water movement in the saturated zone?"

For a repository in the unsaturated zone, DOE does not believe the ground-water travel time objective should be limited to the saturated zone because this would not be an accurate indicator of actual radionuclide transport from the original waste location to the accessible environment (as discussed in the response to Question 2A). DOE has proposed, in discussions with the NRC on the siting guidelines (10 CFR Part 960), that this performance

objective be limited to only sites located in the saturated zone, with a separate performance objective developed for the geologic setting for sites situated in the unsaturated zone. (See response to Question 2b)

Question 2. This question, as stated in the Supplementary Information Section, also consisted of two questions which are addressed separately below.

A. "Does ground-water travel time represent an appropriate measure of performance for a site within the unsaturated zone?"

DOE does not believe that ground-water travel time represents an appropriate measure of performance for a site within the unsaturated zone. The flux through the repository, both in the unsaturated and saturated zones, is a more appropriate and direct measure of potential cumulative releases to the accessible environment. The amount of water moving past the wastes is one of the primary factors which set a limit, independent of flow velocity, flow path, or travel time, on the maximum number of curies of a particular radionuclide that can be released from a repository and subsequently be transported by ground water to the accessible environment. DOE notes that Dames & Moore reached essentially the same conclusion in NUREG/CR-3130 when they concluded that flux and the frequency of wetting events were the primary factors in determining releases from wastes disposed in the unsaturated zone.

Should the NRC, however, choose to keep a minimum 1000-year ground-water travel time as the performance objective for the geologic setting, DOE believes it should logically be applied to sites situated in the unsaturated zone only if the travel time will include the combined travel times in the unsaturated zone and the saturated zone so as to better approximate radionuclide transport. This may necessitate a revision to the definition of the term "disturbed zone," since the current definition is so vague as to possibly permit defining the disturbed zone as extending downward through the unsaturated zone all the way to the water table or upward through the unsaturated zone all the way to the ground surface. DOE believes it would be inappropriate to apply the minimum ground-water travel time to only the saturated zone underlying a repository in the unsaturated zone, since such application would conflict with three highly favorable conditions resulting from a highly transmissive (and short travel time) water-table aquifer underlying the repository. These are:

1. A highly transmissive aquifer can be expected to transmit any increased throughflow, resulting from increased precipitation during a glacial stage, with less rise in the water table and accordingly less likelihood of saturation of the repository from below.

2. A highly transmissive aquifer can be expected to significantly dilute any postulated releases from the repository since the characteristically low flux in the unsaturated zone would be a very small fraction of the throughflow in the aquifer.

3. A highly transmissive aquifer can be expected to significantly disperse any postulated releases from the repository since the dispersivity of the aquifer would be quite high.

Therefore, although a highly transmissive aquifer underlying a repository situated in the unsaturated zone may not provide a 1000-year ground water travel time to the accessible environment, it does not affect the flux through the unsaturated zone (hence it does not affect the cumulative release to the accessible environment over the 10,000 year period of interest). In addition, although the EPA standard is not based on dose, DOE notes a highly transmissive aquifer underlying a repository in the unsaturated zone provides a means of assuring the reduction of the concentration of (and hence dose received from) any postulated releases due to dilution and dispersion (thereby being applicable to both reactive and non-reactive radioisotopes without consideration of sorption and other retardation processes).

B. "Would an alternative performance objective for the geologic setting (e.g., maximum likely volumetric flow rate of ground water through the geologic repository) be more appropriate?"

DOE believes an alternative performance objective for the geologic setting for a repository located in the unsaturated zone is more appropriate. DOE has initiated a concerted effort to develop such a performance objective for proposal to the NRC. This activity is still in progress, and DOE will provide an alternative performance objective by separate letter after the close of the public comment period. DOE will make every effort to provide the alternative performance objective by May 15, 1984.

DOE believes that the volumetric flow rate (flux) of ground water through a geologic repository located in the unsaturated zone is the most important factor in determining the performance of the repository. However, DOE cannot at this time propose or endorse a numerical performance objective on maximum flux since the acceptable flux would be site-specific and design-specific. DOE will continue, however, to consider flux and other factors in its attempt to develop an alternative performance objective for the geologic setting for a repository located in the unsaturated zone.

DOCKET NUMBER
PROPOSED RULE PR-60
(49 FR 5934)

Public comment No. 9

Department of Energy
Washington, D.C. 20585

DOCKETED
USNRC

'84 JUL 12 P2:59

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

JUL 1 1 1984

Mr. Samuel J. Chilk
Secretary of the Commission
Attention: Docketing and Service
Branch
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Chilk:

The Department of Energy submitted comments on the proposed amendment to 10 CFR Part 60 for disposal in the unsaturated zone in a letter to you dated April 16, 1984. In that letter, the Department indicated it would provide a suggested alternative performance objective, related to the geologic setting for sites located in the unsaturated zone, by separate letter after the close of the public comment period.

This letter transmits the proposed alternative performance objective and the Department's rationale for the proposed performance objective.

As indicated in the Department's letter dated April 16, 1984, we are available to meet with the NRC concerning the previously transmitted comments or the enclosed material.

Sincerely,

Ben C. Rusche, Director
Office of Civilian Radioactive
Waste Management

Enclosures

Acknowledged by card.....

RATIONALE FOR PROPOSED ALTERNATIVE PERFORMANCE OBJECTIVE

As noted in the DOE comment letter to the NRC dated April 16, 1984, Dames & Moore concluded in NUREG/CR-3130 that the flux and the frequency of wetting events were the primary factors in determining releases from wastes disposed in the unsaturated zone. DOE stated that ground-water travel time does not represent an appropriate measure of performance for a site within the unsaturated zone and that the flux through the repository, both in the unsaturated and saturated zones, is a more appropriate and direct measure of potential cumulative releases to the accessible environment.

Accordingly, DOE has given considerable effort toward developing a proposed performance objective based on flux through a repository located in the unsaturated zone. Although this effort has reinforced the understanding that flux is the primary factor in determining releases from wastes disposed in the unsaturated zone, DOE has concluded that it is impractical to specify a minimum amount of flux or to otherwise define a performance objective for the geologic settings based on the flux through the repository. A determination of flux will be necessary, however, to demonstrate compliance with the EPA Standard.

As a result, DOE reviewed the NRC rationale for the performance objective specifying that the fastest likely path of radionuclide travel to the accessible environment shall be at least 1000 years or such other travel time

as may be approved or specified by the Commission. This performance objective can be interpreted as specifying a minimum time before release of radionuclides to the accessible environment. DOE concludes, based on this review and interactions between NNWSI Project staff and the NRC staff, that satisfying this performance objective is meant to provide an independent and redundant barrier to the engineered barrier system during that period of time when the wastes are most hazardous (46 FR 130, p. 35281). DOE notes that, for sites located in the unsaturated zone, this same effect may be derived, either in whole or to a large extent, from the creation of a drying zone around the underground facility during the period of the heat pulse. Therefore, the concept of a minimum time for release of radionuclides to the accessible environment forms a reasonable basis for a site performance objective for the unsaturated zone and is a more appropriate performance objective than ground-water travel time for the unsaturated zone.

The emplacement of radioactive waste canisters within an unsaturated zone repository leads to a situation wherein the heat generated by the wastes as they decay causes the moisture in the rock surrounding the waste canisters to migrate away from the waste canisters. Preliminary numerical modeling of this phenomenon[1] indicates that this migration creates a zone around the

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(1)B. Travis, H. Hudson, T. Nuttall, T. Cook, and R. Rundberg, 1984, "Preliminary Estimates of Water Flow and Radionuclide Transport in Yucca Mountain," LA-UR-84-40 (in Review), Los Alamos National Laboratory, Los Alamos, New Mexico.

canisters, extending for a few tens of meters in which there is no water available to either corrode the canisters, dissolve the wastes, or transport any radioactive material. The drying phase for a saturated zone repository is expected to last several hundred years before resaturation is complete (NUREG-0804). In an unsaturated zone repository, the time required for moisture to return to the waste packages is expected to be even longer because the rock will return to initial conditions primarily through capillary effects.

A site performance objective for the unsaturated zone, based upon the minimum time for release of radionuclides to the accessible environment, must consider four separate physical events. The first event is the creation of the drying zone. The second event, which is closely related to the creation of the drying zone, is the subsequent return of moisture to the rock surrounding the waste canisters. These two events encompass a time during which no water is available to either corrode the waste canisters, dissolve the waste material, or transport radionuclides to the accessible environment. The third event important to the release of radionuclides to the accessible environment is the transport of radionuclides in the unsaturated zone. Finally, the radionuclides are transported to the accessible environment by ground water movement in the saturated zone.

The minimum time for release of radionuclides to the accessible environment is the sum of times required for each of the four events because they are temporally sequential. The minimum time for release of radionuclides to the accessible environment for an unsaturated zone repository is thus the

sum of the time during which a drying zone exists around the waste canisters, the time it takes for the dry rock to return to initial moisture conditions, the time for ground water to travel through the unsaturated zone and the time for ground water to travel through the saturated zone to the accessible environment.

It is not inconceivable that the time for drying added to the time for return to initial moisture conditions could encompass the total 1000 year period required for fission products to decay to insignificant levels. When all four time components are added together, significantly higher confidence in protection of public health and safety is obtained than if only the time when radionuclides are actually moving were considered.

The NNWSI Project site characterization activities include studies of the drying phenomenon. In addition to the previously mentioned study of radionuclide transport and the formation of the drying zone, other numerical studies which model the physical responses, in the unsaturated zone, to the emplacement of waste canisters and heat are underway. In situ tests to obtain information about moisture migration in response to thermal loads are planned for the exploratory shaft. These tests include bulk permeability tests, canister scale heater experiments and waste package tests. The waste package tests are reduced scale but are designed to specifically investigate moisture conditions, particularly moisture movement during thermal and post thermal periods of storage. High frequency electromagnetic, ultrasonic and neutron methods are to be used to establish the moisture content in the area

surrounding the simulated canister before and after thermal cycling and to monitor fluid movement during the experiments. These activities should provide the necessary and sufficient information to support demonstration of compliance with the proposed alternative performance objective.

PROPOSED ALTERNATIVE PERFORMANCE OBJECTIVE

DOE proposes that Section 60.113(a)(2) be revised to Section 60.113(a)(2)(i) and a Section 60.113 (a)(2)(ii) be added as follows:

For a geologic repository located in the unsaturated zone, the minimum 1000 year travel time to the accessible environment shall include the time of existence of the drying zone around the emplaced wastes, the time required for rewetting to initial moisture conditions, the time of travel through the unsaturated zone, and the time of travel through the saturated zone.

MIDDLE SOUTH SERVICES, INC./BOX 61000/NEW ORLEANS, LA 70161/(504) 529-5262

April 13, 1984

Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
Attn: Docketing and Service Branch

Subject: NRC's Proposed Rule Concerning the Disposal of High-Level Radioactive Wastes in the Unsaturated Zone (49 FR 5934)

Dear Sir:

Middle South Services, Inc. (MSS) is a technical support company for the Middle South Utilities (MSU) System which serves the electrical requirements of approximately 1,800,000 customers in portions of Arkansas, Louisiana, Mississippi and Missouri. MSS has reviewed the proposed amendments and draft NUREG-1046, "Disposal of High-Level Radioactive Wastes in the Unsaturated Zone : Technical Considerations" and would like to express our support of the proposed amendment which allows the disposal of high-level radioactive waste (HLW) in the unsaturated geologic zone.

The Middle South System has four nuclear reactors in operation or nearing operational status, therefore Middle South Utilities has been closely following the progress being made toward the opening of the first high-level nuclear waste repository. The siting of these repositories must be limited to those geologic areas where the HLW can safely be disposed of without significant damage to the environment or harm to the public's health. A review of the proposed amendments and its associated NUREG shows that the unsaturated geologic zone is a viable alternative to disposal in the saturated zone. Each site, whether it is located in the saturated or the unsaturated zone, should be judged based on its overall ability to safely contain HLW. Currently, there is not sufficient technical justification to favor disposal in the saturated zone over the unsaturated zone. As mentioned in NUREG-1046, there are some factors which make disposal of HLW in the unsaturated zone preferable to disposal in the saturated zone. Two of these factors are: (1) wastes can be emplaced in a geologic medium with low moisture content which would minimize leaching of waste packages; and (2) enhanced retrievability-wastes would be more easily accessible in an unsaturated zone if this need should ever arise. There are factors

which make the saturated zone a more desirable location, however, as stated previously, each site must be reviewed based on all relevant factors, not simply on whether the site is located in a saturated or unsaturated zone. A balancing of all factors will ensure that the most suitable sites are chosen for the disposal of HLW.

MSS regrets that we are unable to provide NRC with the technical comments which have been requested. However, we appreciate this opportunity to comment on and express our support of this proposed amendment. The siting and the eventual operation of HLW repositories are of vital importance to the electric utility industry. MSU encourages and supports NRC in their endeavor to accomplish this goal within the time-frame established in the Nuclear Waste Policy Act.

Sincerely,

Joel D. Patterson
Manager of Environmental Affairs

JDP:LMW:cph

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
EXTERNAL AFFAIRS

APR 20 1984

Dr. Colleen Ostrowski
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Dr. Ostrowski:

In accordance with Section 309 of the Clean Air Act, as amended, the U.S. Environmental Protection Agency (EPA) is commenting on the U.S. Nuclear Regulatory Commission's (NRC) proposed amendment to 10 CFR 60, Disposal of High-level Radioactive Waste in the Unsaturated Zone. EPA generally supports the proposed rule.

EPA is developing Environmental Standards for Management and Disposal of Spent Nuclear Fuel, High-level and Transuranic Radioactive Wastes (40 CFR 191). Any disposal of high-level wastes will be subject to 40 CFR 191, and EPA appreciates the assistance NRC and other organizations has given us in the development of our rule.

Accordingly, EPA is submitting the enclosed comments to avoid differing regulatory approaches between the NRC and EPA rulemaking efforts. EPA will work with NRC to avoid conflicting approaches on the respective rules of the two agencies.

I appreciate the opportunity to comment on this proposal. If you have any questions concerning EPA's comments, please call Dr. W. Alexander Williams (382-5909) of my staff or Mr. Daniel Egan (557-8610) of EPA's Office of Radiation Programs.

Sincerely yours,

for Allan Hirsch, Director
Deputy Director
Office of Federal Activities

Enclosure

unsaturated zone. Instead, we believe that DOE should have the option of meeting a fairly stringent limit on the average annual flux of water through the repository to the accessible environment instead of the travel time requirement of section 60.113(a)(2). This limit should be chosen so that the corresponding total volume of water reaching the accessible environment within a thousand years would not be capable of transporting a significant amount of radioactivity, taking into account reasonable solubility limits. At a particular site, the Department should have the option of demonstrating compliance with either the minimum travel time requirement or the maximum water flux requirement.

DSD

IN SPELLMAN
Governor

DONALD W MOOS
Director

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
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DOCKETED
USNRC

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OFFICE OF SECRETARY
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BRANCH

April 13, 1984

DOCKET NUMBER
PROPOSED RULE PR-60 (12)
(49 FR 5934)

The Honorable Nunzio J. Palladino
Chairman
U.S. Nuclear Regulatory Commission
1717 H Street, N.W.
Washington, D.C. 20555

Dear Chairman Palladino:

Ref: NUREG-1046, "Disposal of High-Level Radioactive Wastes in the Unsaturated Zone...Draft Report for Comment."

We are fully in agreement with the proposed amendments to 10 CFR 60 which accommodate candidate repository sites in the unsaturated zone.

However, it is apparent that the main body of reasoning and examples covered in the draft applies to the Nevada Test Site. The principal technical reference, in fact, is NUREG/CR-3158, which contains in its title the phrase, "Emphasis on the Nevada Test Site."

We have never been fully satisfied with the pre-NWPA siting decision process which led the U.S. Department of Energy to put its Hanford Reference Repository Location deep in the saturated zone, stratigraphically close to aquifers of great economic importance. As the principal water management agency for a state where future water quality and availability are sensitive, highly-charged issues, we are deeply concerned with any risk of contamination, no matter how slight.

The proposed amendments can be interpreted as a signal that the Nuclear Regulatory Commission, like the state of Washington,

Acknowledged by card. 4/24/84
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wants to see all reasonable alternatives examined and, where indicated, re-examined before final commitment to a deep, difficult site such as the Hanford location in the saturated zone.

Sincerely,

Donald W. Moos
Director

DWM/kh

cc: David W. Stevens

PR-60 (13)
(49 FR 5934)

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

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USNRC

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DOCKETING & SERVICE
BRANCH

EIF-84/271

Mr. Samuel J. Chilk
Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Chilk:

The Department of the Interior has reviewed the proposed rule for Disposal of High-Level Radioactive Wastes in the Unsaturated Zone (10 CFR 60). Our detailed comments are attached.

We appreciate the opportunity to comment on this proposal.

Sincerely,

Bruce Blanchard, Director
Environmental Project Review

Enclosure

Acknowledged by card 4/24/84

REVIEW OF PROPOSED RULE FOR DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTE IN THE UNSATURATED ZONE (ER 84/271)

In commenting on the proposed unsaturated-zone amendments, it is convenient to separate discussion into: (1) responses solicited by NRC (49 FR 5937); (2) comments on the proposed amendments; (3) comments regarding saturated-zone criteria that are also applicable to the unsaturated zone, and (4) comments on definitions.

NRC SOLICITATIONS

(1a) "How can ground-water travel time in the unsaturated zone be determined with reasonable assurance?" While it may not be possible to define ground-water velocities along all segments of unsaturated-zone travel paths with precision, particularly those segments through moderately to highly fractured media, the velocities and travel times in some segments are less elusive. In the case of a relatively uniform, porous medium with low-fracture density, the medium will be capable of transmitting a flux that is approximately equivalent to its saturated hydraulic conductivity without rejecting water to fracture flow paths. Further, it is within the state-of-the-art to determine ambient water content and degree of saturation as well as moisture-characteristic curves for such media so that effective conductivity can be predicted for a range of conditions. In-situ monitoring techniques are undergoing development and may broaden the range of rock types and conditions for which it is feasible to estimate velocity and, hence, travel time. On a site-specific basis, certain bounds may be placed by less direct considerations such as recharge rates based on water budgets, perturbations of thermal gradients, or in-situ monitoring of temporal changes in moisture profiles by neutron logging. Finally, repository investigations presently include exploratory-shaft tests on infiltration rates and sampling of intact fractured blocks for laboratory experiments.

"Reasonable assurance" may also be gained by incorporating uncertainty analysis into predictive models. Although the uncertainty band for a given level of confidence in the calculations may be broader for unsaturated-zone cases than for some saturated-zone conditions, the opportunity to invoke conservatism still exists.

(1b) "Should the ground-water travel time performance objective be limited to ground-water movement within the saturated zone?" Assuming that the ground-water travel time objective and favorable condition remain in the regulation, the travel time along any segment of the flow path including the unsaturated zone, should be creditable, provided that it can be demonstrated with "reasonable assurance" as discussed above.

(2) "Does ground-water travel time represent an appropriate measure of performance for a site within the unsaturated zone, or would an alternative performance objective . . . (e.g., maximum likely volumetric flow rate of ground water through the geologic repository) be more appropriate?" Travel time substantially exceeding 1,000 years, although a favorable condition, is not appropriate as a totally definitive performance objective for disposal in either the unsaturated or saturated zones. Ground-water travel time probably is the singularly most important element for evaluating the performance of a

site; however, release criteria are ultimately the absolute measure of total performance. The method by which travel time is calculated must account for all elements of the ground-water flow system and must result in terms that can be used directly for determining transport and concentration of radionuclides in the ground water. Release criteria and radionuclide transport must be concerned with many factors such as ground-water flux and velocity (travel time), convective transport, dispersion and diffusion, chemical interaction with rocks along the flow path, and rates and concentrations at which radionuclides leached from the solidified waste enter the water. Realistic estimation of release criteria for the unsaturated zone might not be possible until observations are made in the shafts and drifts.

While it may be possible to assign a maximum allowable flux rate—e.g., one that would assure the failure of containment under reasonable assumptions of chemistry, corrosion, and dissolution—it would still be more consistent with the multiple-barrier concept to incorporate such considerations only as favorable or potentially adverse conditions.

PROPOSED AMENDMENTS

Section 60.122, Siting Criteria, (6), (7): "Prewaste-emplacement ground-water travel time along the fastest path of likely radionuclidie travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years." Add " . . . considering both unsaturated and saturated segments of the flow path." We believe that prewaste emplacement ground-water travel time is conceptually an appropriate "favorable characteristic" for sites located in the unsaturated zone. However, it is a criterion that will be much more difficult to demonstrate in a legal sense at an unsaturated site than at a saturated site. As currently worded, the criterion is perhaps inappropriate for unsaturated and perhaps some types of saturated sites, such as salt and dense fractured crystalline rocks.

We believe that in order for the travel-time criterion to be effectively applied, it needs to incorporate a concept of areally and temporally averaged ground-water flow velocity (rather than the fastest one-dimensional pathway) and/or a flux constraint. Additionally, the current wording makes no provision for the quantity of water moving through the repository to the accessible environment—only the velocity. It seems inappropriate to reject a site that might have 1 cubic meter of water moving through a repository to the accessible environment in 1,000 years and to accept a site that might have 1 million cubic meters of water moving through it to the accessible environment in 1,500 years. This example is, of course, hypothetical.

We also realize that there is an exception clause in the criterion for special considerations allowing the Commission to consider other factors when appropriate and when it can be demonstrated that a site would clearly meet EPA standards. However, it is not clear how that exception might be applied or what difficulties would be encountered in gaining acceptance by the technical community or various public interest groups for such an exception. Some of these difficulties might be overcome by one or more of the following options:

- Clarify some typical circumstances under which the travel-time criterion might be waived, such as by demonstrating that the flux is likely to be small or nil.

- Specify more precisely how the ground-water velocity (or travel time) should be calculated, using specific cross section area or other averaging or integrating conventions.

- Use a volumetric flow rate (flux) criterion for ground water in addition to or in place of ground-water travel time.

The principal hydrologic advantage of the unsaturated zone is minimizing or eliminating contact of the waste with flowing ground water. This advantage would most likely be more important than ground-water travel time in reducing total quantity of radionuclides which could potentially escape to the accessible environment. The rate of release of radionuclides to the accessible environment from a repository in the unsaturated zone is directly related to the nuclide concentration in the leachate, flux of leachate, dilution of leachate in the zone of saturation, and ground-water velocity (plus geochemical retardation and dispersion effects). Minimizing leachate flux would appear to be at least as important as maximizing ground-water travel time.

It might, therefore, be appropriate to specify a dual "either/or" criterion such that ground-water travel time is greater than 1000 years or ground-water flux through the host rock at the proposed site is less than some specified average rate. The rate could be based on nuclide solubility, leach rate criteria, and population exposure criteria (EPA concentration standards).

We believe that either a flux or travel-time criterion should be based upon an areally integrated or averaged calculation, over an area on the order of the cross-sectional area of the repository normal to the direction of expected flux, for both saturated and unsaturated sites. This would help reduce the uncertainty and controversy over how the "fastest pathway" can be determined. The fastest pathway for saturated fractured rocks, for unsaturated media, and for other highly heterogenous media would be virtually impossible to calculate with reasonable confidence. However, areal averaged or integrated calculations and bounded estimates can be determined with reasonable confidence, usually by two or more independent methods. Also, qualitative evidence, such as the preservation of archeological artifacts, packrat middens, and other paleo-materials can lend further confidence to long-term estimates of leach rates and water contact in arid unsaturated materials. If ground-water travel time is to remain a general performance objective criterion for the unsaturated zone, we believe the rule should specify a simple, straightforward, and consistent formula for site determination. We propose the following formula for consideration. Use of the formula is with the assumption that movement of water in the unsaturated zone is basically interstitial and that at least a continuous film of water is present. The formula would have doubtful application in dominantly fractured rock with very little interstitial effective porosity.

The vertical ground-water velocity through the unsaturated zone could be determined as the average vertical recharge rate over the approximate area of the repository, divided by the average volumetric moisture content of the subsurface medium. As a hypothetical example, if a site were determined to

have an average recharge rate of 10mm per year and an average subsurface moisture content of 10 percent (10 percent of bulk volume contains water), an average velocity would be 10/0.1 or 100mm per year (0.1m per year). If it were 100m above the water table, the travel time in the unsaturated zone alone would be 1000 years. It becomes obvious that a nearly zero moisture content would result in a theoretically infinite velocity. This is absurd, but does emphasize the need for prudent application of any mechanism with which to approximate conditions that defy accurate analysis. Ground-water velocity is one important element of performance and although this method is not precise or highly accurate, the method could form the basis for approximations that could be consistently applied to a variety of sites where unsaturated porous media are part of the flow system.

Section 60.122(b)(8): "For disposal in the unsaturated zone, hydrogeologic conditions that provide . . . "

Section 60.122(b)(8)(i): "Low and nearly constant moisture flux in the host rock and in the overlaying and underlying hydrogeologic units." This is an improvement over the earlier "low and constant moisture content" in that it avoids the erroneous implication that low moisture content necessarily means low flux. However, "nearly constant . . . flux is not necessarily an advantage, as evidenced by the conflict with "free drainage."

Section 60.122(b)(8)(iv): A low, constant rate of flux would seem to offer better opportunity for dissolution processes than would an average low, but episodically high flux. There is some evidence also that some materials for waste canisters may be more resistant to corrosion under episodic wetting and drying. Basically, it seems best to address only a single concept or factor in a single statement of condition. Also, change "overlaying" to "overlying."

Section 60.122(b)(8)(ii): "A water table sufficiently below the underground facility such that fully saturated voids continuous with the water table do not encounter the underground facility." This condition has also been improved over the earlier version, which depended on a rather inappropriate definition of "capillary fringe." However, it still appears to be incumbent on the applicant to prove that there are no continuous paths of water occupying saturated pores—an impossible task. We suggest changing the favorable condition to read as follows:

Section 60.122(b)(8)(iv): "A host rock that provides for free drainage; or . . . " We suggest that "or" should be changed to "and."

Section 60.122 (b), (8), (v): "A climatic regime in which the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration." The term "small percentage" is vague and inappropriate, in our opinion. We suggest specifying an absolute value of average recharge as a maximum, perhaps on the order of 50mm or less.

Section 60.122 (c), (24): We suggest adding quantitative clarification to this criterion. As currently worded, it allows no potential vapor-phase transport of radionuclides by molecular diffusion or perhaps by convective transport. Although these fluxes might be miniscule, they would not be zero at any unsaturated site. Therefore, if this criterion is ever considered as a disqualifying factor it will need qualification as regards release rate of nuclides such as ^{129}I and ^{14}C. Related to this question is the interpretation of the boundary for the accessible environment. It is not clear to us from the definition in 10 CFR 60 whether the "accessible environment" includes the airspace immediately above the ground surface directly over the repository or only the atmosphere beyond the boundary.

Differences in these two interpretations could have major impacts on how the vapor transport criterion is tested.

APPLICABLE SATURATED-ZONE CRITERIA

Section 60.122(b)(2)(iii): To be hydraulically correct, the phrase "low hydraulic potential between" should be "low hydraulic gradient between" or "small difference of hydraulic potential between." This concept is also applicable to the unsaturated zone and is implicit in the wording "Low . . . moisture flux in the host rock . . . . "

Section 60.122(b)(2)(iv): We endorse extracting this as 60.122(b)(7), as proposed, and adding the statement suggested above to make it clear that the travel time in the unsaturated zone should be creditable.

DEFINITIONS

"Accessible environment." We strongly suggest that aquifers be incorporated in this definition.

United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VA. 22092

In Reply Refer To:
WGS-Mail Stop 410

April 30, 1984

See Comment No. 13

Ms. Colleen Ostrowski, Geologist
Office of Nuclear Regulatory Research
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Ms. Ostrowski:

Thank you for your telephone call of April 25, 1984. There were indeed two typographical errors in the comments originating from the U.S. Geological Survey contained in the letter from Bruce Blanchard to Samuel J. Chilk of April 20, 1984, concerning review by the Department of the Interior of the proposed rule for Disposal of High-Level Radioactive Wastes in the Unsaturated Zone (10 CFR 60). The two errors that you so perceptively found are both on page 4 of the letter and can be corrected as found on the enclosed new page 4.

Sincerely yours,

John B. Robertson
Chief,
Office of Hazardous Waste Hydrology

Enclosure

have an average recharge rate of 10mm per year and an average subsurface moisture content of 10 percent (10 percent of bulk volume contains water), an average velocity would be 10/0.1 or 100mm per year (0.1m per year). If it were 100m above the water table, the travel time in the unsaturated zone alone would be 1000 years. It becomes obvious that a nearly zero moisture content would result in a theoretically infinite velocity. This is absurd, but does emphasize the need for prudent application of any mechanism with which to approximate conditions that defy accurate analysis. Ground-water velocity is one important element of performance and although this method is not precise or highly accurate, the method could form the basis for approximations that could be consistently applied to a variety of sites where unsaturated porous media are part of the flow system.

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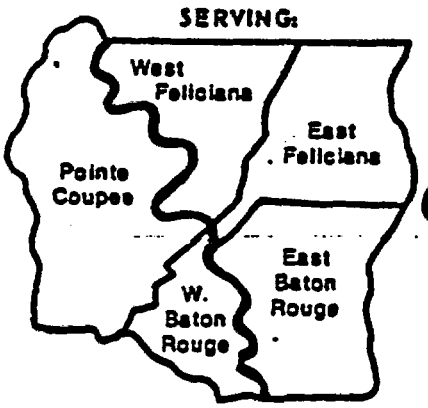
"(ii) Conditions that preclude, or limit, capillary rise from the water table to the underground facility;"

This directly addresses the concerns expressed by the NRC staff regarding siting a facility in the capillary fringe but avoids definition of the term "capillary fringe."

Section 60.122(b)(8)(iv): "A host rock that provides for free drainage; or . . . " We suggest that "or" should be changed to "and."

Section 60.122 (b), (8), (v): "A climatic regime in which the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration." The term "small percentage" is vague and inappropriate, in our opinion. We suggest specifying an absolute value of average recharge as a maximum, perhaps on the order of 50mm or less.

PROPOSED RULE PR -60 (14)
(49 FR 5934)



Capital Area Groundwater Conservation Commission

P. O. Box 64526
Baton Rouge, Louisiana 70896-4526
Telephone (504) 924-7420

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OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

April 23, 1984

Secretary of the Commission
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attn: Docketing and Service Branch

REF: NRC 10 CFR Part 60
Proposed rule

Dear Sir:

Unfortunately my comments are being offered after the expiration of the comment period. However, I believe the following practical comments extracted from U.S. Geological Survey Circular 903 titled, "Disposal of high level nuclear waste above the water table in arid regions," are pertinent to the referenced CFR from the Federal Register of February 16, 1984 (v.49, no. 33).

> "A major new concern would be shether future climatic changes could produce significant consequences due to possible rise of the water or increased flux of water through the repository. If spent fuel were used as a waste form, a second new concern would be the rates of escape of gaseous iodine-129 and carbon-14 to the atmosphere."

As NRC refer to the circular in the proposed rule, NRC has obviously considered these comments.

There is a discussion of vapor transport in the rules and the need for consideration on a case by case base of the problem in the Rules' Section, "Issued examined by the Commission." Hopefully, the Commission's conclusion is satisfactory or is more in-depth caution required?

The requirement of a minimum depth of 300 meters may minimize to some degree the effects of climatic changes? But there should be a required minimum predetermined interval between the top of the water table and the bottom of burial depth to prevent water entering the repository.

NRC has done an excellent job but I believe it is important to reexamine these two factors and possibly reemphasize more specific safety criteria.

Thanks for the opportunity to comment.

Very truly yours,

A. N. Turcan, Jr.
Director

ANT/ebo
cc: Dr. L. Hall Bohlinger
Pat Norton

APPENDIX B

Proposed Rules

Federal Register
Vol. 49, No. 33
Thursday, February 16, 1984

This section of the FEDERAL REGISTER contains notices to the public of the proposed issuance of rules and regulations. The purpose of these notices is to give interested persons an opportunity to participate in the rule making prior to the adoption of the final rules.

NUCLEAR REGULATORY COMMISSION

10 CFR Part 60

Disposal of High-Level Radioactive Wastes in the Unsaturated Zone

AGENCY: Nuclear Regulatory Commission.

ACTION: Proposed rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is considering amending its rules on the disposal of high-level radioactive wastes (HLW) in geologic repositories so that the technical criteria for geologic disposal in the saturated zone may be equally applicable to disposal within the unsaturated zone. The amendments are being proposed in response to public comments on the proposed technical criteria for geologic disposal in the saturated zone. Final technical criteria adopted by the Commission for disposal of HLW in the saturated zone were published in the Federal Register on June 21, 1983.

DATES: Comment period expires April 16, 1984. Comments received after this date will be considered if it is practical to do so, but assurance of consideration cannot be given except as to comments received on or before this date.

ADDRESSES: Send comments or suggestions to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, DC 20555, Attention: Docketing and Service Branch. Copies of comments received may be examined at the NRC Public Document Room, 1717 H Street NW., Washington, DC 20555.

FOR FURTHER INFORMATION CONTACT: Dr. Colleen Ostrowski, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, DC. 20555, telephone (301) 427–4343.

SUPPLEMENTARY INFORMATION:

Background

On February 25, 1981 the Nuclear Regulatory Commission (NRC) published a rule that established procedures for licensing the disposal of HLW in geologic repositories (46 FR 13971). NRC published proposed technical criteria to be used in the evaluation of license applications under those procedures on July 8, 1981 (46 FR 35280). In response to solicitation for public comments on the proposed technical criteria NRC received 93 comment letters. The Commission considered all public comments in developing the final technical criteria which were published on June 21, 1983 (48 FR 28194).

Several commenters on the proposed rule, including the U.S. Department of Energy (DOE), the U.S. Department of the Interior, and separately the U.S. Geological Survey (USGS), took issue with a statement made by the Commission at 46 FR 35281 which explained that the proposed technical criteria were developed specifically for disposal in saturated geologic media because DOE plans at that time called for HLW disposal at sufficient depth to be situated in the hydrogeologic region termed the saturated zone. The commenters considered disposal in the unsaturated zone [1] to be a viable alternative, and noted that since the technical criteria were generally applicable without regard to the possibility of saturation, their scope and applicability should not be unduly restricted. DOE, in its comments on this issue, suggested that since opportunities may arise for exploratory studies in unsaturated geologic media, the Commission should reexamine the rule and make whatever changes are necessary to ensure that the rule will apply to all geologic media. The U.S. Department of the Interior urged that the rule be modified because, under appropriate conditions, the unsaturated zone could provide one more natural barrier to the movement of radionuclides from the geologic repository to the water table.

The Commission has determined that disposal of HLW within the unsaturated zone is a realistic alternative to disposal within the saturated zone, provided that the site and the geologic repository design are carefully selected, and are capable of meeting the performance objectives of 10 CFR Part 60. In reaching this determination, the Commission has examined the arguments presented by the public commenters as well as the analysis of the principal issues associated with unsaturated zone disposal described in the NRC staff technical support document (draft NREG–1046) prepared in conjunction with the proposed amendments. This document identifies the positive aspects and possible concerns associated with disposal in the unsaturated zone and explains why the Commission has developed the following proposed amendments. Other issues which were discussed by public commenters but which did not result in proposed changes to the final rule are also addressed in the technical support document. Upon publication, a copy of draft NUREG–1046 entitled "Disposal of High-Level Radioactive Wastes in the Unsaturated Zone: Technical Considerations" will be placed in the Public Document Room, 1717 H Street NW., Washington, DC 20555. Since this document is available to the general public,[2] only a summary discussion of these issues is presented below.

Issues Examined by the Commission

The depth to the regional water table varies throughout the United States. Potential geologic repository sites within unsaturated geologic media may be identified in arid to semi-arid geographic regions of the country because such regions generally are characterized by a deep regional water table and hence, a relatively thick unsaturated zone. The unsaturated zone in certain arid regions of the United States has been documented as extending to depths of approximately 600 meters below the ground surface. In contrast, the unsaturated zone in humid regions is often only a few meters thick, or entirely non-existent.

Perhaps the most positive aspect associated with disposal of HLW within the unsaturated zone is that the HLW would be emplaced in a relatively dry (i.e., low moisture content) geologic

[1] The definition of the term "unsaturated zone" is derived from U.S. Geological Survey Water Supply Paper 1988 (Washington, DC, 1972).

[2] Free single copies of Draft NUREG–1046 may be requested for public comment by writing to the Publication Services Section, Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

medium. The Commission considers the relatively low moisture content of unsaturated sediment and rock as a positive aspect of HLW disposal in the unsaturated zone because the lack of available moisture could reduce leaching of the waste packages and thus, significantly reduce the likelihood of radionuclide transport by groundwater [3] migration. Further, it is generally recognized that vertical groundwater flux in the unsaturated zone is very small. A credible pathway for the migration of water soluble contaminants from a geologic repository located in the unsaturated zone to the accessible environment would probably be vertically downward to the underlying regional water table, and subsequently through the saturated groundwater units to the regional discharge points.

The Commission has reviewed several other issues that are of general concern to disposal of HLW in geologic repositories, regardless of the hydrogeologic zone involved. Such issues include the effects of climatic changes on the regional hydrologic systems, the potential for human intrusion into the geologic repository, and the effects of geologic processes (e.g., tectonism) on the structural stability of the geologic repository. The Commission does not believe that any of these issues would negate the generic concept of HLW disposal within the unsaturated zone. However, since the relative importance of these issues will depend upon natural conditions existing at a particular site, each must be evaluated on a site-by-site basis.

Vapor transport of contaminants has been identified by the Commission's staff as a potential concern associated with HLW disposal in the unsaturated zone. In unsaturated geologic media, water is transported in both liquid and vapor phases. The relative contribution of transport via liquid and vapor phases, and their direction of movement with respect to a geologic repository will have a direct influence on the containment of contaminants. Vapor transport, particularly when a thermal gradient is imposed may provide a possible mechanism for radionuclide migration from a geologic repository. However, positive aspects associated with vapor transport in the unsaturated zone may also be discerned since water vapor formed near the geologic repository may flow through air-filled openings and partially drained fractures, resulting in a drying of the surrounding host rock. This drying zone may extend hundreds of meters from the geologic repository, and thus may inhibit the movement of soluble contaminants. Therefore, the Commission views vapor transport as another issue which must be evaluated on a case-by-case basis to determine its effects (whether favorable or potentially adverse) on a particular site.

[3] The Commission recognizes that the term "groundwater" is generally applied by the technical community to water which occurs beneath the water table (i.e., phreatic water) while the term "vadose water" is more accurately applied to the soil water, gravitational water and capillary water which occur in the unsaturated zone (zone of aeration, vadose zone). However, for the sake of simplicity, groundwater is defined in the proposed amendments as all water which occurs below the Earth's surface.

Other Comments Considered by NRC

The Commission has reviewed the following six issues related to HLW disposal within the unsaturated zone which were addressed in the public comments on the proposed rule, as well as in a recent USGS publication,[4] and has determined that the final rule (48 FR 28194) accommodates these concerns. More detailed discussion of these issues is presented in draft NUREG–1048.

Minimum 300-Meters Depth for Waste Emplacement

One commenter on the proposed 10 CFR Part 60 technical criteria who advocated applying the rule equally to the saturated and unsaturated zones considered it necessary to change the siting criterion which sets a minimum depth of 300 meters for waste emplacement. However, the commenter incorrectly identified this provision (see § 60.122(b)) as a requirement, rather than as a favorable condition. The Commission notes that favorable conditions are those which may enhance waste isolation potential. Hence, a minimum depth of 300 meters for waste emplacement is considered a favorable condition because the deeper the HLW is emplaced, the less likely it is to be disturbed. Viewed in that light this depth is a favorable condition, irrespective of hydrogeologic zone. Since the unsaturated zone may extend to depths of up to 600 meters, the Commission considers this favorable condition to be a realistic one for both the saturated and unsaturated zones. Therefore, this provision of the rule has not been modified.

Requirements for Sealing Shafts and Boreholes

In USGS Circular 903 the view was expressed that, with respect to a geologic repository within the unsaturated zone, sealing shafts and boreholes tightly to inhibit water movement may be undesirable. The reasoning behind this view is that although shafts and boreholes need to be carefully sealed in the saturated zone so that they do not become future conduits for radionuclide migration, they may have an entirely different relation to an unsaturated zone repository. Shafts and boreholes would increase the amount of water moving through a geologic repository located within the unsaturated zone only if they diverted a significant amount of runoff to the subsurface.

The Commission has reviewed both the arguments of the USGS and the provisions of the final rule relating to the design of seals for shafts and boreholes (§ 60.134). The provisions of § 60.134 appear to be generally applicable to seals of shafts and boreholes in both hydrogeologic zones. Therefore, the Commission does not consider it necessary to modify § 60.134 at this time.

Backfill Requirements

Another issue which has been identified both in public comments on the proposed technical criteria and in USGS Circular 903 pertains to the necessity of backfill in a geologic repository located within the unsaturated zone. The USGS expressed the view that the role of backfill in the unsaturated zone would be the opposite of that in the saturated zone. Backfill material that would inhibit the flow of water to, and radionuclide migration from, the waste packages may be highly desirable in the saturated zone. In the unsaturated zone, however, the designers of a geologic repository may wish to promote drainage. The opinion has been expressed that within the unsaturated zone backfill should allow groundwater to drain readily, rather than serve as a barrier to drainage. It was suggested in USGS Circular 903 that if backfill is necessary to perserve structural or waste package integrity, a relatively permeable material (e.g., cobble-sized rock) could be used to permit continued drainage.

The final rule published by the Commission on June 21, 1983 contained only the general functional statement that the engineered barrier system (including backfill) be designed to assist the geologic setting in meeting the performance objectives for the period following permanent closure (§ 60.133(h), 48 FR 28227). This provision, as promulgated, should be

[4] Roseboom, E. H. Jr., 1983. Disposal of High-Level Nuclear Waste Above the Water Table in Arid Regions. U.S. Geological Survey Circular 903, Washington, DC, p. 21.

responsive to the concerns discussed above.

Waste Package Design Criteria

As defined at § 60.2, the term "waste package" means "the waste form and any containers, shielding, packing and other absorbent materials immediately surrounding an individual waste container" (48 FR 28219). The point has been raised that because of the different nature of the emplacement environment designs of waste package components for the saturated and unsaturated zones may be quite different. The Commission recognizes that several characteristics of the emplacement environment (e.g., oxidation conditions, lithostatic pressure, geochemistry, contact with groundwater, etc.) may vary significantly between the two hydrogeologic zones. This variation of emplacement environment may necessitate that DOE consider alternative designs for waste packages (including waste form, canisters, overpack, etc.) for geologic disposal in the unsaturated zone. The Commission has reviewed the performance objectives which pertain to the waste package (§ 60.111 and § 60.113), and believes that the provisions, as currently written, are equally applicable to waste packages emplaced within either the saturated or unsaturated zone. Similarly, the specific design criteria for the waste package and its components (§ 60.135, 48 FR 28227) have been determined to be generally applicable to both zones. Therefore, no changes have been made to the provisions of §§ 60.111, 60.113, or 60.135.

Ventilation

The issue of restricting the number of ventilation shafts associated with a geologic repository was addressed in USGS Circular 903. In the case of the saturated zone, the number of ventilation shafts may be kept at a minimum since the shafts could constitute potential pathways to the accessible environment. In USGS Circular 903 it is stated that in the case of the unsaturated zone additional shafts for ventilation would not compromise the geologic repository's performance because sealing shafts in the unsaturated zone is much simpler and of less consequence than in the saturated zone. Several potential benefits were cited by the USGS to support this view—e.g., reducing the problem of thermal load in the early phases of the geologic repository, removal of any water vapor during the operational period, drawing large amounts of desert air through the geologic repository to promote even drier conditions and increasing worker safety by providing alternative sources of ventilation and escape routes.

The number of ventilation shafts included in any geologic repository will be decided by the designer—DOE. No provision of 10 CFR Part 60 expressly limits the number of ventilation shafts that a geologic repository may contain. What is important is that the surface facility ventilation systems comply with the design critera in § 60.132(b) (48 FR 28226) and that the underground facility ventilation system be designed in accordance with § 60.133(g) (48 FR 28227). The Commission considers the design requirements for the ventilation systems set forth in §§ 60.132 and 60.133 to be applicable to both the saturated and unsaturated zones. As long as the ventilation system complies with provisions of §§ 60.111(a), 60.132, and 60.133 and does not compromise the integrity of the site to host a geologic repository, DOE will have broad flexibility in designing the system.

Exploratory Boreholes

Provisions relating to site characterization are set forth in the final rule at § 60.10 (48 FR 28219). Section 60.10(d)(2) requires that the number of exploratory boreholes and shafts be limited to the extent practical, consistent with obtaining the information needed for site characterization. The view was expressed in USGS Circular 903 that in the unsaturated zone, if the host rock already has a high vertical permeability, there is no reason to limit the number of drill holes. Thus, the USGS noted that if necessary, a proposed geologic repository could be explored like an ore body or coal bed, with drill holes every few hundred feet on a rectangular grid.

The Commission's view on the importance of not compromising the integrity of a site during the site characterization program of testing and exploration has been clearly stated at 44 FR 70409. However, if DOE should opt for a site exploration and characterization program which includes plans for drilling numerous boreholes then DOE would have the burden of showing the Commission that the ability of the site to isolate HLW has not been compromised during these activities.

Groundwater Travel Time in the Unsaturated Zone

The concept of groundwater travel time generally is applied in evaluations of saturated flow systems, where flow is continuous and temporal fluctuations in the potential of the systems are small. In contrast, water movement in the unsaturated zone is generally discontinuous and strongly dependent upon initial conditions (e.g., magnitude and spatial and temporal distribution recharge events) and the conductive properties of the partially saturated geologic media, which vary with moisture content. Reliable calculations and predictions of groundwater travel times and velocities require knowledge of these conditions and properties. Within the unsaturated zone the movement of a given volume of water over a given distance depends very strongly upon the nature of the recharge events. Additionally, the material properties (e.g., moisture characteristic curves, porosity, irreducible saturation, etc.) and the initial conditions (e.g., saturation, capillary pressure, matric potential) may be extremely difficult to measure on a representative scale for unsaturated porous and fractured geologic media.

For these reasons, calculations of pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel through the unsaturated zone may have large associated uncertainities, and may be of questionable value in estimating the capability of the geologic setting to isolate HLW from the accessible environment.

The new definition of the term "groundwater" which the Commission is proposing would have the effect of expanding the scope of the performance objectives set forth in § 60.113 to disposal in either the saturated or unsaturated zone. Similarly, the proposed amendment to the Siting Criteria (§ 60.122(b)(7)) would have the effect of making pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment which substantially exceeds 1,000 years a favorable condition for HLW disposal within either the saturated or unsaturated zone.

The Commission's current thinking on this issue is that if DOE can demonstrate with reasonable assurance that travel time for groundwater movement through the unsaturated zone can be quantified, then DOE should be allowed to include such travel time when demonstrating compliance with § 60.113(a)(2). However, such calculations of groundwater travel times through the unsaturated zone could involve considerable uncertainty. Further, long groundwater travel time possibly may be inconsistent with the proposed amendment which identifies a host rock that provides for free drainage as a

favorable hydrogeologic condition for disposal of HLW within the unsaturated zone. It may be more appropriate for the Commission to specify another parameter upon which performance may be evaluated for a geologic setting in the unsaturated zone, or to utilize the approach set forth in § 60.113(b) which provides the Commission with the flexibility to specify variations in performance objectives on a case-by-case basis, as long as the overall system performance objective is satisifed. Therefore, to solicit input in these matters the Commission is particularly seeking public comment on the following questions:

1. How can groundwater travel time in the unsaturated zone be determined with reasonable assurance? Should the groundwater travel time performance objective be limited to groundwater movement within the saturated zone?

2. Does groundwater travel time represent an appropriate measure of performance for a site within the unsaturated zone, or would an alternative performance objective for the geologic setting, (e.g., maximum likely volumetric flow rate of groundwater through the geologic repository) be more appropriate?

Environmental Impact: Negative Declaration

Pursuant to Section 121(c) of the Nuclear Waste Policy Act of 1982, the promulgation of these criteria shall not require the preparation of an environmental impact statement under Section 102(2)(C) of the National Environmental Policy Act of 1969 or any environmental review under subparagraph (E) or (F) of Section 102(2) of such Act.

Paperwork Reduction Review

The proposed rule contains no new or amended recordkeeping, reporting or application requirements, or any other type of information collection requirements subject to the Paperwork Reduction Act (Pub. L. 96-511).

Regulatory Flexibility Act Certification

In accordance with the Regulatory Flexibility Act of 1980 (5 U.S.C. 605(b)), the Commission certifies that this rule, if adopted, will not have a significant economic impact on a substantial number of small entities. The only entity subject to regulation under this rule is the U.S. Department of Energy.

List of Subjects in 10 CFR Part 60

High-level waste, Nuclear power plants and reactors, Nuclear materials, Penalty, Reporting and recordkeeping requirements, Waste treatment and disposal.

Issuance

For the reasons set out in the preamble and under the authority of the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, the Nuclear Waste Policy Act of 1982, and 5 U.S.C. 553, the Nuclear Regulatory Commission is proposing the following amendments to 10 CFR Part 60.

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

Authority: Secs. 51, 53, 62, 63, 65, 81, 161, 182, 183, 68 Stat. 929, 930, 932, 933, 935, 948, 953, 954, as amended (42 U.S.C. 2071, 2073, 2092, 2093, 2095, 2111, 2201, 2232, 2233); secs. 202, 206, 88 Stat. 1244, 1246, (42 U.S.C. 5842, 5846); secs. 10 and 14, Pub. L. 95-601, 92 Stat. 2951 (42 U.S.C. 2021a and 5851); sec. 102, Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332); sec. 121, Pub. L. 97-425, 96 Stat. 2228 (42 U.S.C. 1014).

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

1. Section 60.2 is amended by adding two new definitions in proper alphabetical sequence:

§ 60.2 Definitions.

* * * * *

"Groundwater" means all water which occurs below the Earth's surface.

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

* * * * *

2. Section 60.122 is amended by revising paragraph (b)(2)(iii), designating paragraph (b)(2)(iv) as (b)(7), and adding new paragraphs (b)(8), (c) (22), (23) and (24) to read as follows:

§ 60.122 Siting criteria.

* * * * *

(b) * * *

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

* * * * *

(7) Pre-waste-emplacement groundwater trave time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years.

(8) For disposal in the unsaturated zone, hydrogeologic conditions that provide—

(i) Low and nearly constant moisture flux in the host rock and in the overlaying and underlying hydrogeologic units;

(ii) A water table sufficiently below the underground facility such that fully saturated voids continuous with the water table do not encounter the underground facility;

(iii) A laterally extensive low-permeability hydrogeologic unit above the host rock that would inhibit the downward movement of water or divert downward moving water to a location beyond the limits of the underground facility;

(iv) A host rock that provides for free drainage; or

(v) A climatic regime in which the average annual historic precipitation is a small percentage of the average annual potential evapotranspiration.

* * * * *

(c) * * *

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

(23) Potential for existing or future perched water bodies that may have the effect of saturating portions of the underground facility or providing a faster flow path for radionuclide movement from an underground facility located in the unsaturated zone to the accessible environment.

(24) Potential for vapor transport of radionuclides from the underground facility located in the unsaturated zone to the accessible environment.

Dated at Washington, D.C., this 13th day of February 1984.

For the Nuclear Regulatory Commission.

Samuel J. Chilk,

Secretary of the Commission.

[FR Doc. 84-4306 Filed 2-15-84; 8:45 am]

BILLING CODE 7590-01-M

Comments of the U.S. Environmental Protection Agency on the U.S. Nuclear Regulatory Commission's Proposed Rule for Disposal of High-level Radioactive Wastes in the Unsaturated Zone

1. 10 CFR §60.2 (Definitions)

NRC proposed to redefine the term "ground water" to include all water in both the saturated and unsaturated zones. This change apparently provides a simple regulatory means for applying existing criteria written several years ago for high level waste repository siting in the saturated zone to the unsaturated zone as well. While this expansion of applicability may be reasonable, EPA would prefer that the NRC retain the standard scientific meaning for the term (i.e., water within the zone of saturation). We are concerned that confusion may eventually arise among the public, particularly in their understanding of the application of methods of ground water monitoring.

"Unsaturated zone" should be defined as the zone between the land surface and the shallowest free water table, discounting "perched" tables. The definition written in the proposed regulation says, "deepest." This is confusing. The definition with "deepest" would be correct, however, if the term "water table" were also defined as the potentiometric surface beneath the land surface at atmospheric pressure.

2. 10 CFR §60.122 (siting criteria)

The Commission proposes to amend Section 60.122 by adding new paragraphs (b) (8) and (c) (23). There seems to be a conflict in the criteria outlined under portions of the two respective paragraphs. Paragraph (b) (8) (iii) requires that hydrogeologic conditions in the unsaturated zone provide for "a laterally extensive, low permeability unit above" the repository to inhibit downward migration of water into the underground facility. Paragraph (c) (23) presumably calls for the unsaturated zone to be free of the potential for "perched water bodies that may have the effect of saturating portions of the underground facility." It seems that these are in conflict because the laterally extensive, low permeability unit encouraged to be located above the repository as outlined in paragraph (b) (8) increases the potential for the formation of perched water bodies immediately above the unit. Although the low permeability strata may serve to inhibit downward migration, it encourages the possibility of perched water bodies that may result in saturated flow conditions above and immediately surrounding the limits of the underground repository. Conversely, paragraph (c) (23) discourages siting in areas where the potential for existing or future perched conditions exists. EPA recommends that this inconsistancy be resolved.

3. With respect to the three questions on which the Commission particularly seeks comment:

Question: "How can ground water travel time in the unsaturated zone be determined with reasonable assurance?"

EPA Reply: EPA's Office of Solid Waste will soon publish Procedures for Modeling Flow Through Clay Liners to Determine Required Liner Thickness in its series of Technical Resource Documents. This manual presents a numerical simulation model to estimate travel time of water through unsaturated sediments. Once copies are available from GPO, we will forward one to Dr. Colleen Ostrowski at the NRC.

Measuring natural tritium (^3H) concentrations in ground water samples from a vertical profile in unsaturated geologic formations may be another technique for estimating travel time. Since the atmospheric testing of nuclear weapons, ground water recharge (i.e., precipitation) has contained levels of this radioactive isotope above the naturally low levels existing before the testing began. Consequently, tritium may serve as an indicator or tracer of "new" water in a geologic profile, and thus may indicate approximate travel times from the recharge point.

Question: "Should the ground water travel time performance objective be limited to ground water movement within the saturated zone?"

EPA Reply: No. To allow DOE to take credit for the delay in water reaching the water table after passing an unsaturated zone repository (when considering NRC's existing 1,000 year "ground water" travel time requirement), NRC proposes to redefine the term "ground water" to include all water below the land surface, not just water below the water table, in the saturated zone. We do not think it is necessary to change the widely understood meaning of this term to accomplish NRC's objective. EPA agrees that DOE should be able to take credit for any such delays in the unsaturated zone. However, it would be more appropriate to make the existing section 60.113(a)(2) apply only to repositories in the saturated zone and to add a parallel section for unsaturated zone repositories that allows the Department to add the water travel times in the saturated and unsaturated zones to compare against the 1,000-year time period. Even if NRC redefines the term "ground water" for 10 CFR 60, EPA has no plans or need to make a corresponding change in 40 CFR 191.

Question: "Does ground water travel time represent an appropriate measure of performance for a site within the unsaturated zone, or would an alternative performance objective for the geologic setting be more appropriate?"

EPA Reply: No, it does not. An alternative option should be available. EPA does not believe that such a "water" travel time is appropriate as the only quantitative measure of performance for a site within the

ENCLOSURE E

REGULATORY ANALYSIS
10 CFR PART 60

1. Statement of the Problem

10 CFR Part 60 -- "Disposal of High-Level Radioactive Wastes in Geologic Repositories," as currently written (48 FR 28194), was primarily developed for disposal of high-level radioactive wastes (HLW) within the hydrogeologic region termed the saturated zone. The provisions of 10 CFR Part 60 were originally directed towards the saturated zone because at the time they were being developed the licensee -- the U.S. Department of Energy (DOE) -- was only considering potential repository sites at sufficient depths to be contained within the saturated zone. The saturated zone, as defined in existing 10 CFR 60.2 means "that part of the earth's crust beneath the deepest water table in which all voids, large and small, are ideally filled with water under pressure greater than atmospheric" (48 FR 28218).

Commenters on the proposed 10 CFR Part 60 technical criteria (46 FR 35280) viewed this limitation as unduly restrictive, and considered geologic disposal within the unsaturated zone to be a realistic alternative to disposal within the saturated zone. Additionally, in its comment letter on the proposed technical criteria DOE, noting that opportunities may arise for exploratory studies in unsaturated geologic media, requested that NRC ensure that 10 CFR Part 60 will apply to all geologic media. Since DOE may submit site characterization plans to NRC for potential repository sites that may be situated within the unsaturated zone, it is necessary to modify the appropriate provisions of 10 CFR Part 60 in a timely manner so that the NRC may review license applications that may be submitted for geologic repositories within the unsaturated zone. The term "Unsaturated zone" as used by NRC means "the zone between the land surface and the regional water table. Generally, fluid pressure in this zone is less than atmospheric pressure, and some of the voids

may contain air or other gases at atmospheric pressure. Beneath flooded areas or in perched water bodies the water pressure locally may be greater than atmospheric."

Existing provisions of 10 CFR Part 60 are generally applicable to disposal within either the saturated or unsaturated zone. However, minor modifications are still necessary to ensure that the rule applies equally to sites in both hydrogeologic zones. On February 16, 1984, NRC published for comment proposed amendments to 10 CFR Part 60 related to the unsaturated zone (49 FR 5934). In response to its solicitation of public input on the proposed amendments NRC received 14 comment letters. These letters represented the views of other Federal agencies, States, representatives of industry and public interest groups. In general these commenters were supportive of both NRC's decision to consider the licensing of HLW disposal in the unsaturated zone and the provisions set forth in the proposed amendments. The public comment letters primarily addressed questions posed by NRC on groundwater travel time calculations in the unsaturated zone, and suggested minor word changes for the sake of clarity and technical accuracy.

The final amendments should not result in any additional costs to DOE, and will clarify the Commission's regulations concerning the licensing of HLW disposal in unsaturated geologic media.

2. Objectives

The objective of the proposed regulatory action is to broaden the scope of 10 CFR Part 60 to cover licensing of the disposal of HLW within the unsaturated zone.

3. Alternatives

(1) Leave the final provisions of 10 CFR Part 60 intact. (48 FR 28194)

(2) Develop an entirely separate rule to apply to the unsaturated zone.

(3) Publish proposed guidelines for HLW disposal in the unsaturated zone as a regulatory guide.

4. Consequences

(a) Proposed Action: Publish final amendments to make 10 CFR Part 60 equally applicable to license applications for HLW repositories in both the saturated and unsaturated zones.

The final amendments would provide NRC with the maximum flexibility with respect to reviewing license applications for HLW disposal with the minimum expenditure of time or money. The amendments were developed after consideration of the public comments received on the proposed 10 CFR Part 60 technical criteria (46 FR 35280). Many of the points raised by commenters with respect to modifying 10 CFR Part 60 to apply to both the saturated and the unsaturated zones were accommodated in the final technical criteria (48 FR 28194) in response to comments received on other issues. The final technical criteria were reviewed in light of these comments and the staff considered the minor modifications presented as proposed amendments (49 FR 5934) sufficient to make the rule equally applicable to reviewing license applications submitted for HLW disposal in either hydrogeologic zone. This view generally was supported by the public commenters on the proposed amendments relating to the unsaturated zone.

The impacts associated with this action (i.e., promulgating the final amendments) are minimal. The impacts associated with disposal of HLW in geologic repositories within the unsaturated zone should be comparable with saturated zone repositories since the general performance objectives for the natural and engineered barriers apply to each hydrogeologic zone. The addition of the final amendments to 10 CFR Part 60 should result in no changes to the radiological safety consequences or to the impacts relating to safeguards, operations, economics, environments or general information collection associated with disposal in the saturated zone. Finally, the cost of the proposed action to NRC would be negligible.

(b) Alternative 1: Leave the provisions of the final rule - 10 CFR Part 60 intact.

As noted previously, public comments on the proposed technical criteria (46 FR 35280) requested that NRC modify its original decision to limit the technical criteria to HLW repositories within the saturated zone. Further, public comments on the proposed amendments published in February, 1984 reinforced the view that disposal of HLW within the unsaturated zone should be considered. NRC received comment letters from the U.S. Department of Energy, U.S. Environmental Protection Agency, the U.S. Department of the Interior, and the U.S. Geological Survey supporting the concept of HLW disposal within the unsaturated zone.

Potentially, this alternative would have few associated impacts since it would not represent any change in the status quo. DOE could still file a license application for a geologic repository within the unsaturated zone under the existing provisions of 10 CFR Part 60. In considering such an application NRC would need to determine if the proposed site conformed with the provisions of the technical criteria set forth in Part 60. However, certain of these existing provisions may be technically inappropriate for an unsaturated zone site and could result in inappropriate analyses of the site-specific data. Therefore, this alternative could result in a certain degree of technical ambiguity which could complicate and delay the license review process.

(c) Alternative 2: Develop a separate regulation for disposal of HLW within the unsaturated zone.

It would be possible for NRC to develop a parallel regulation to 10 CFR Part 60 which would set forth provisions for disposal of HLW within the unsaturated zone. This alternative would offer no preferred benefits to the proposed action, and would drastically increase the amount of time and money associated with this type of action.

Reviews of 10 CFR Part 60 by both the public commenters and the NRC staff indicated that only minor changes to the final technical criteria are necessary to

ensure that the rule is equally applicable to HLW disposal in either the saturated or unsaturated zone. Therefore, the staff considers that there would be no justifiable reason for developing a new parallel regulation.

(d) Alternative 3: Publish additional criteria for disposal in the unsaturated zone as a regulatory guide.

If this alternative were adopted, disposal within the saturated zone would still be comprehensively governed by the regulations of 10 CFR Part 60, while disposal in the unsaturated zone would need to receive additional guidance in the form of a regulatory guide. There would be no legal requirements to be met in the latter instance. Therefore, the regulatory guide approach would not achieve the objective of equally applicable provisions for HLW disposal within both the saturated and unsaturated zones.

5. Decision Rationale

The NRC staff has evaluated the proposed action and three alternative courses of action in light of the public comments received on the proposed technical criteria as well as the staff's review of the issues involved in disposal within the unsaturated zone. The staff prepared a technical support document -- draft NUREG-1046 which explored pertinent issues and presented a review of the provisions of the final rule - 10 CFR Part 60 with respect to these issues. The public comment letters on the proposed unsaturated zone amendments (49 FR 5934) and draft NUREG-1046 were reviewed in detail. Generally, the Commission's approach was favorably viewed by these commenters. Some changes and clarifications were made in the rule as a result of the comments received. Additionally, draft NUREG-1046 will be revised to reflect changes made as a result of public comments, and will be published as a final NUREG report.

The final amendments contain provisions for modifying those sections of 10 CFR Part 60 related to the definitions, siting criteria and design requirements. The NRC staff considers the proposed action as the most direct and cost - effective method of ensuring that the provisions of 10 CFR Part 60 are equally applicable to HLW disposal within the saturated and unsaturated zone.

ENCLOSURE F

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

August 14, 1984

Honorable Nunzio J. Palladino
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Dr. Palladino:

SUBJECT: ACRS COMMENTS ON PROPOSED AMENDMENTS TO 10 CFR PART 60, "DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES"

During its 292nd meeting, August 9-11, 1984, the Advisory Committee on Reactor Safeguards discussed the amendments proposed by the NRC Staff to expand the coverage of 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," to include disposal in the unsaturated zone. This matter was also a subject of discussion during meetings of our Waste Management Subcommittee on July 11 and August 8, 1984.

In presenting the proposed change to the ACRS, the NRC Staff stated that the expansion in the scope of 10 CFR 60 to include disposal within the unsaturated zone should not be interpreted as meaning that they favor the disposal of high-level wastes in this zone. The NRC Staff is simply recognizing that disposal in the unsaturated zone is a possible alternative to disposal in the saturated zone.

The only matters on which we had questions were the definitions of certain terms in the proposed amendments. We have been informed that the NRC Staff intends to modify the proposed amendments to address these matters.

We concur in the amendments as modified.

Sincerely,

Jesse C. Ebersole

Jesse C. Ebersole
Chairman

References:

1. Draft memo for the Commissioners from William J. Dircks, Subject: 10 CFR Part 60--Disposal of High-Level Radioactive Wastes in Geologic Repositories--Final Amendments, transmitted to ACRS July 2, 1984
2. U.S. Nuclear Regulatory Commission, "Disposal of High-Level Radioactive Wastes in the Unsaturated Zone: Technical Considerations," Draft USNRC Report for Comment, NUREG-1046, dated February 1984

Enclosure F

3. Note from Colleen Ostrowski, Waste Management Branch, Division of Radiation Programs and Earth Sciences, RES, to R. C. Tang, ACRS, Subject: Revisions to Draft 10 CFR Part 60 Final Amendments Related to Disposal of High-Level Radioactive Wastes in the Unsaturated Zone dated August 3, 1984

ENCLOSURE G

DRAFT CONGRESSIONAL LETTER

Dear Mr. Chairman:

Enclosed for your information is a copy of a notice of rulemaking to be published in the Federal Register.

On February 16, 1984 the Commission published for public comment proposed amendments to its regulations on the disposal of high-level radioactive wastes (HLW) in geologic repositories (49 FR 5934). The proposed amendments were developed to ensure that the provisions of 10 CFR Part 60 would be applicable to HLW disposal within either the saturated or the unsaturated zone. The Commission received fourteen comment letters in response to its solicitation of public input on the proposed amendments. These commenters generally supported both the Commission's decision to expand the scope of its regulations and the provisions of the proposed amendments. The Commission made several changes and clarifications in the amendments as a result of the comments received. The Commission will continue to keep you informed of future rulemaking actions in the area of HLW disposal in geologic repositories.

Sincerely,

Robert B. Minogue, Director
Office of Nuclear Regulatory Research

Enclosure: As stated