



Department of Energy

Washington, DC 20585

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Mr. Joseph J. Holonich, Director  
Repository Licensing & Quality Assurance  
Project Directorate  
Division of High-Level Waste Management  
Office of Nuclear Material Safety  
and Safeguards  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555

Reference: (1) Ltr, Shelor to Linehan, dtd 12/14/90  
(2) Ltr, Bernero to Bartlett, dtd 7/31/91

Dear Mr. Holonich:

On December 14, 1990, the U.S. Department of Energy (DOE) transmitted its responses to objections, comments, and questions presented in the U.S. Nuclear Regulatory Commission's (NRC) Site Characterization Analysis (SCA) (Reference 1). The NRC staff evaluated these responses, closing some of the items and creating open items of the remainder (Reference 2). Four of the items, identified below as enclosures, have been addressed through various actions and progress in the program.

Enclosures 1 through 4 of this letter summarize the administrative records with respect to the following SCA items: Comment 3, Comment 7, Comment 45, and Question 38. The administrative records for the open items in the enclosures consist of: (1) DOE's December 14, 1990, response to the open item; (2) NRC's July 31, 1991, evaluation of this response; and (3) a supplemental response with further explanation or additional information to resolve the open item.

DOE believes that the responses provided are sufficient to close SCA Comment 3, Comment 7, Comment 45, and Question 38, and awaits NRC confirmation.

If you have any questions, please contact Ms. Sheila Long at 202-586-1447 or Mr. Chris Einberg at 202-586-8869.

Sincerely,

*J. P. Roberts*  
Dwight E. Shelor  
Associate Director for

Systems and Compliance  
Office of Civilian Radioactive  
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Enclosures:

1. Administrative Record for  
SCA Comment 3
2. Administrative Record for  
SCA Comment 7
3. Administrative Record for  
SCA Comment 45
4. Administrative Record for  
SCA Question 38

cc: w\enclosures

C. Gertz, YMPO

T. J. Hickey, Nevada Legislative Committee

R. Loux, State of Nevada

D. Bechtel, Las Vegas, NV

Eureka County, NV

Lander County, Battle Mountain, NV

P. Niedzielski-Eichner, Nye County, NV

W. Offutt, Nye County, NV

L. Bradshaw, Nye County, NV

C. Schank, Churchill County, NV

F. Mariani, White Pine County, NV

V. Poe, Mineral County, NV

J. Pitts, Lincoln County, NV

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B. Mettam, Inyo County, CA

C. Abrams, NRC

Section 8.1 Rationale for the Site Characterization Program

Section 8.3 Planned Tests, Analyses, and Studies

COMMENT 3

The SCP describes a program that relies heavily on the Formal Use of Expert Judgment (Expert Elicitations) to supply licensing information and data or to substitute for quantitative analyses. To the extent that a subjective approach is planned in situations where quantitative analyses based on empirical evidence are available, investigations that should be considered in the SCP are not considered. Thus, the SCP does not identify a full program of investigations needed for a complete, high-quality license application. Without stating criteria for the formal use of expert judgment, it is not clear that the license application will comply with the requirement of 10 CFR 60.24 that the application be as complete as possible in terms of information reasonably available.

BASIS

- o As noted in CDSCP Comment 4, the use of expert elicitation will be examined to determine whether the subjective approach was necessary because objective approaches were unavailable.
- o One way in which expert elicitation will be inappropriately relied on is noted in Comments 93 and 98. Weighting alternative conceptual models according to the judgment that they are likely to be correct is not a good substitute for field studies to determine which model is correct.
- o Page 8.3.5.13-115 states: "The form of the joint probability distribution of state variables, and the ranges of those state variables, will inevitably be determined by judgment. Whenever possible, judgment will be enhanced and supplemented with site specific actuarial data concerning magnitudes and frequencies of the phenomenon that determine the state variables." This joint probability distribution is central to the calculation of the CCDF, which quantifies total system performance; hence, it is crucial to demonstrating compliance with the EPA standard. There are two problems with the proposed approach: (1) the priority of the use of judgment instead of site specific data is reversed; site specific and other types of data should be supplemented by judgment when there is no other practicable recourse; (2) to the extent that judgment is used in determining the joint probability distribution, the DOE should assure that the facts, analysis, and rationale on which the judgments are based are fully documented.
- o Page 8.3.5.13-126 states: "The processes and events that are determined to play potential roles in release scenarios are then subjectively arranged in series, and an attempt is made to discover the effects of realization of each series on the performance of one or more of the isolation barriers for the total system. This part of the analysis is necessarily subjective because the number of series formed in this way could be astronomical if the intuition and knowledge of the analyst is not applied to reduce the number of possibilities to a manageable size." The text then articulates two nonsubjective principles that may be used

to guide the formulation of these series. The NRC advocates that wherever possible objective methods should be used preferentially over subjective methods. Development or extension of analytical procedures may render this problem largely objective. If subjective methods are used, the intuition and knowledge on which the analyst relies must be fully documented.

o Section 8.1.2.3 states:

"Two fundamental premises should be mentioned before the steps in the process are discussed. First, a full performance assessment cannot be conducted after each study to determine if the information obtained is sufficient to resolve issues. The site characterization program is extremely complex and comprehensive. While many of the critical elements needed for the full performance assessments will be completed until much later, and some not until the end of site characterization. To wait until the complete set of information is available to evaluate the testing is not prudent. Therefore, elements of this program will be evaluated individually with respect to adequacy of the information obtained without resorting to full performance assessments. Part of this evaluation will involve some analysis. The extent of such analysis is discussed below.

"Therefore, the first steps in the process are to initiate the studies under the various investigations (step 7) and to conduct analyses as the data become available (steps 8a and 8b). For the purpose of deciding if the data are sufficient, the principal result of these analyses is an estimate of the confidence that the particular parameter goals specified for the study are met. This estimate will depend not only upon the uncertainties in those parameters, but also the uncertainties in the models and hypotheses upon which the parameters are based, and these uncertainties must be taken into account in making the estimates. In some cases, the estimates may be quantitative; but in many cases judgment, supported with appropriate documentation, will be the principal basis for the estimates. All reviews and documentation will be performed in accordance with established quality assurance procedures as described in Section 8.6."

This approach to issue resolution may not succeed because of at least three problem areas:

1. Evaluating elements of the program individually, without resorting to full performance assessment, may fail to take account of important interactions and synergisms in the very complex, interrelated repository system. Although individual components or elements may be found to perform acceptably, system performance may be inadequate if important interactions are not accounted for until a full performance assessment after all testing is complete.
2. The text correctly states that the estimates of confidence that a particular goal is met depends not only on the uncertainty in the parameter, but also on the uncertainties in the models and hypotheses upon which the parameters are based. However, the goals themselves depend on the initial concept of systems performance and

the preliminary judgment of how elements of the system interact. These goals may only be re-evaluated by a full performance assessment that accounts for important interactions.

3. It is not clear that judgment is a suitable replacement for analysis in making the determination that the parameter goals are achieved with a suitable degree of confidence. Documentation of such judgments is not a suitable replacement for a quantitative analysis of the confidence in an estimate taking into account the complex interaction of various data used to arrive at the estimate.
- o In discussing the Issue Resolution Strategy for Issue 1.8 (NRC Siting Criteria), the SCP states (pp. 8.3.5.17-8 to 9): "Issue 1.8 has many similarities to Issue 1.1; the two issues take many of the same site conditions into account, and both deal with the effects of site conditions on the isolation of the waste. They do not, however, have to be structure identically. Although each of the two issues will require both quantitative and qualitative arguments for resolution, the DOE expects that the resolution of Issue 1.8 will rely more heavily on expert geotechnical judgment. The resolution of Issue 1.1 will result in a definitive quantitative demonstration of compliance by the construction of the cumulative complementary distribution function. This resolution will rely on qualitative reasoning primarily for the justification of the conceptual models it uses and for showing the reasonable assurance required by 10 CFR 60.101. Because 10 CFR 60.122 makes explicit reference to meeting the waste-isolation performance objectives, the resolution of Issue 1.8 cannot be wholly qualitative. It can, however, be a forum for full expression of sound qualitative technical judgment on the site's ability to isolate waste. The DOE expects that such judgments can frequently be made without recourse to complex calculations of releases to the accessible environment; for example, modeling of ground-water flow may be used to address increases in water-table elevations and infiltration. Such simpler calculations and the use of expert geotechnical judgment will play import roles in the resolution of Issue 1.8. The NRC staff believes that compliance with 10 CFR 60.122 requires that performance assessments, rather than judgments, need to be used to provide an early and ongoing evaluation of whether any of the various potentially adverse conditions (60.122) significantly affect the ability of the site to meet the 10 CFR Part 60 performance objectives and whether data being gathered is adequate to make this determination.
  - o Pages 8.1-13 to 14 describe how judgments will be made at three levels "to determine whether to extend or curtail any of the testing originally planned." The three levels of judgment cited are: (1) technical judgment at the study level, (2) technical and management judgment at the investigation level, and (3) management judgment at the issue level.

Studies, investigations, and issues require increasing degrees of integration and interrelation of data. It is not clear that judgment rather than analysis is the appropriate mechanism to achieve the needed degree of integration and interrelation. Furthermore, it is not clear what role "management" judgment plays in resolving a set of technical issues or that such management judgments are appropriate.

## RECOMMENDATIONS

- o State criteria for the formal use of expert judgment to assure that objective, quantitative analyses based on empirical data are used in preference to expert elicitation wherever possible.
- o Modify the site characterization plan, in an early update, to assure the requisite data will be available.

## RESPONSE

The U.S. Department of Energy (DOE) does not plan to rely on expert judgment as a substitute for objective, quantitative analyses based on empirical data. However, where appropriate mechanistic models are not available or the collected data are consistent with differing interpretations, DOE plans to rely on expert judgment, as appropriate.

DOE intends to preserve the flexibility to define the level of judgment or review to be applied in each specific case when use of subjective methods become necessary. DOE also intends to control the use of subjective methods and the documentation of the results of any reviews or decision-making in accordance with established quality assurance (QA) procedures, as described in Site Characterization Plan Section 8.6.6. The level of the review or the controls placed on any given use of subjective methods will be consistent with the importance to the licensing process of the subject or material under review.

Section 8.1 Rationale for the Site Characterization Program  
Section 8.3 Planned Tests, Analyses, and Studies

SCA COMMENT 3

The SCP describes a program that relies heavily on the Formal Use of Expert Judgment (Expert Elicitation) to supply licensing information and data or to substitute for quantitative analyses. To the extent that a subjective approach is planned in situations where quantitative analyses based on empirical evidence are available, investigations that should be considered in the SCP are not considered. Thus, the SCP does not identify a full program of investigations needed for a complete, high-quality license application. Without stating criteria for the formal use of expert judgment, it is not clear that the license application will comply with the requirement of 10 CFR 60.24 that the application be as complete as possible in terms of information reasonably available.

EVALUATION OF DOE RESPONSE

- o In Comment 3, the NRC staff was concerned that DOE's proposed program might rely so heavily on the formal use of expert judgment (expert elicitation) that needed investigations and quantitative analyses would not be undertaken in the site characterization program. The NRC staff notes that, in its response, DOE gives assurances that it does not intend to rely on expert judgment as a substitute for objective, quantitative analyses based on empirical data. DOE also states that it intends to preserve flexibility in defining the level of judgment or review needed in each specific case consistent with importance of the issue at hand to licensing.
- o The NRC staff recognizes the need for such flexibility in determining what degree of formality in using (or level of) expert judgment should be used in a given case.
- o The NRC staff was also concerned that DOE should state criteria for the formal use of expert judgment so as to be sure that the gathering of necessary information and conducting necessary analyses would not be precluded. In its response to Comment 3, DOE states that it plans to rely on expert judgment where appropriate mechanistic models are not available or where collected data are consistent with differing interpretations. The NRC staff considers that DOE is proposing two possible criteria for determining when to use expert judgment. Taken in the context of DOE's response, these criteria would apply when available objective information has been exhausted. The NRC staff considers these criteria to be appropriate as far as they go. However, the NRC staff is concerned not only that available information be fully used prior to reliance on expert judgment, but also that information that is reasonably obtainable, given the significance of the issue, be fully used. It is still unclear whether this second point has been accepted.
- o For example, DOE does not commit itself to applying the criteria as early in the program as possible. It is important to recognize that some investigations must be planned early in the program. These may well

include investigations designed to clarify the interpretation of existing data. An early decision to use expert judgment can preclude timely initiation of needed investigations.

- o Finally, DOE states that it intends to "control the use of subjective methods and the documentation of the results of any reviews or decision-making in accordance with established quality assurance (QA) procedures." The NRC staff agrees that such controls are needed and re-emphasizes the importance of including documentation of both facts and rationale for expert judgments.
- o Specific points in the basis of SCA's Comment 3 were not addressed in DOE's response. DOE's response to Comment 3 represents an initial concurrence with stated principles about the use of expert judgment. The NRC staff considers this comment open until DOE has explicitly recognized the need to obtain any information that is reasonably obtainable given the importance of the issue.

**SUPPLEMENTAL RESPONSE TO SCA COMMENT 3**

As indicated in the response of December 14, 1990, DOE does not plan to rely on expert judgment as a substitute for objective, quantitative analyses based on empirical data. Additionally, DOE recognizes the need to obtain any information that is reasonably obtainable given the importance of the issue.

On November 18-20, 1992, DOE conducted a workshop in Albuquerque, New Mexico, on the use of expert judgment. Based on the comments of DOE managers at that workshop, it is clear that DOE intends to use expert judgment sparingly and on a case-by-case basis. The examples of selected studies cited in that workshop indicate that the DOE has used expert judgment early in the site characterization program to prioritize investigations and to assist with other management decisions. No conclusions resulting in the reduction of information to be obtained have occurred. DOE intends to continue the use of expert judgment in the site characterization program and to continue to involve the NRC in reviewing that use.

**Enclosure 2**

**SCA Comment 7 and DOE Response (12/14/90)**

**NRC Evaluation of DOE Response (7/31/91)**

**Supplemental Response to SCA Comment 7 Open Item**

Section 8.3: Planned Tests, Analyses, and Studies

COMMENT 7

The clarified role of subjective methods (e.g., formal use of judgment) in site characterization has not been applied to all segments of site characterization to determine when it is best to use experts in the analysis itself and when it is best to call for peer review of investigations, calculations or judgments.

BASIS

- o In response to CDS CP Comment 4 (and CDS CP Question 2), overview sections have been revised to describe generally the need for using expert judgment in some aspects of site characterization. Examples of such general sections are Sections 8.1.2, Issue Resolution Strategy; 8.3.11, Overview of the Site Program; Role of Alternative Conceptual Models; and 8.3.5.8, Strategy for Post-closure Performance Assessment.
- o In the description of many of the specific activities, the need for using expert judgment or peer review has been properly identified. An example is the use of peer review in the activity: Studies of calcite and opaline silica vein deposits (p. 8.3.1.5-111).
- o However, the "subjective weighting of alternatives (conceptual models) based on peer review" (p. 8.3.5.12-17, 3rd paragraph) is an example of two kinds of misapplication of expert judgment. The first is described in Comment 98; the second misapplication is the use of peer review to make an initial judgment. Peer review should be reserved for review of information or judgments reached by other means.
- o Section 8.3.5.8, pp. 8.3.5.8-6 to 7, states:

"The process shown in Figure 8.3.5.8-2 requires numerous applications of judgment. Each decision on whether data are sufficient requires such judgment. The need for iterations and further developments will be decided through judgments of whether the work has provided a basis on which the NRC may find the "reasonable assurance" called for by 10 CFR Part 60. These decisions may involve the routine use of expert judgment, the formal use of expert judgment, or the use of peer review as defined in Altman et al. (1988). The DOE will subject the licensing assessment work to rigorous peer review, using experts from its repository programs as well as from the outside technical community. The use of subjective methods involving judgment through peer review is an important process in all the activities shown in Figure 8.3.5.8-2. The general role of subjective methods (i.e., use of expert judgment) in site characterization is discussed in Section 8.1)"

This paragraph is ambivalent about whether the decisions indicated in Figure 8.3.5.8-2 are to be aided by a variety of uses of expert judgment or whether peer review alone will be used. In the essential area of performance assessment, the uses of expert judgment should be clearly stated.

## RECOMMENDATION

In further developing and implementing the site characterization program, the DOE should assess the activities to ensure that problems to be addressed by experts are clearly identified, and that appropriate uses of peer review and initial application of expert judgment are distinguished from each other.

## RESPONSE

In completing the Site Characterization Plan (SCP), the U.S. Department of Energy (DOE) has used the term "peer review" only when it is appropriate and consistent with U.S. Nuclear Regulatory Agency publication NUREG-1298 (NRC publication 1988). Accordingly, the possible use of peer review is specifically identified in the discussion of the DOE approach to model validation in Section 8.3.5.20. In all other instances, DOE has used only more general terms like "judgment" and "technical review" (which involves reviewer judgment). See, for example, SCP Section 8.1.2, which describes the use of judgment in building confidence in the selection of conceptual models for site behavior, and Section 8.3.5.8, which describes the role of judgment in decision-making and performance assessment.

DOE intends to preserve the flexibility to define the level of judgment or review to be applied in each specific case when the use of subjective methods become necessary. DOE also intends to control the use of subjective methods and the documentation of the results of any reviews or decision-making in accordance with established quality assurance procedures, as described in Section 8.6.6. The level of the review or the controls placed on any given use of subjective methods would be consistent with the importance of the subject or material under review relative to the licensing process.

## REFERENCES

NRC (U.S. Nuclear Regulatory Commission), 1988. Qualification of Existing Data for High-Level Nuclear Waste Repositories, NUREG-1298, Prepared by W.D. Altman, J.P. Donnelly, and J.E. Kennedy, Washington, D.C.

## Section 8.3 Planned Tests, Analyses, and Studies

### SCA COMMENT 7

The clarified role of subjective methods (e.g., formal use of judgment) in site characterization has not been applied to all segments of site characterization to determine when it is best to use experts in the analysis itself and when it is best to call for peer review of investigations or judgments.

### EVALUATION OF DOE RESPONSE

- o This comment calls attention to the need for clearly distinguishing the role of expert judgment (a means to generate original work) and the role of peer review (an in-depth critique of original work) and using them appropriately. DOE cites the NRC staff position on peer review, NUREG-1297 (the citation given is NUREG-1298, but this is apparently a typographical error) in support of its distinction between expert judgment and peer review. NUREG-1297 defines a peer review in terms of it being a critique. However, the examples cited in the response leave DOE's interpretation somewhat ambiguous. Some discussion with DOE is needed to resolve this aspect of the comment.
- o DOE repeats the same paragraph about preserving flexibility to define the level of judgment or review that was used in its response to Comment 3.
- o The NRC staff considers that DOE has not demonstrated that analyses and models that will be used to predict future conditions and changes in the geologic setting will be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests which are representative of field conditions, monitoring data, and natural analogue studies.
- o The NRC staff considers this comment open.

## Supplemental Response to SCA Comment 7

NRC's NUREG-1298, "Generic Technical Position on Qualification of Existing Data for High-Level Nuclear Waste Repositories," February 1988, provides a definition for and discussion of peer review. NUREG-1298 characterizes peer review as an in-depth critique of original work. NUREG-1298 refers to the NRC "Generic Technical Position on Peer Review for High-Level Nuclear Waste Repositories" (NUREG-1297, February 1988) as one of the acceptable methods for qualifying existing data. The definitions of peer review in NUREG-1297 and NUREG-1298 are identical. DOE's use of peer review in SCP Section 8.3.5.20 is consistent with those definitions.

DOE's use of judgment, as used, for example, in SCP Sections 8.1.2 and 8.3.5.8, refers to the evaluations performed by qualified professionals in the course of their work or analyses. Judgment is always applied when generating original work. The term expert judgment is typically reserved for formal elicitation procedures as presented in DOE's workshop on expert judgment held on November 18-20, 1992. Formal expert judgment is not called out, per se, in the discussion of subjective methods of decision-making described in SCP Sections 8.1.2 and 8.3.5.8. DOE views formal expert judgment simply as a special form of judgment that involves proceduralized and documented elicitation, typically from a diverse group of experts. DOE will apply formal expert judgment on a case-by-case basis, and especially when estimating and quantifying confidence in various decisions, particularly the more complicated and important ones, such as those depicted in SCP Figure 8.3.5.8-2.

The use of expert judgment and peer review is illustrated by the process used in preparing the Early Site Suitability Evaluation (ESSE) (Report SAIC-91/800, January 1992). The team of scientists who conducted the ESSE used a structured elicitation process to reach consensus about the group's confidence in compliance of the Yucca Mountain site with DOE's siting criteria in 10 CFR 960. This process relied upon the use of available site data and performance assessment calculations, together with expert judgments about the meaning of these data and calculations with regard to confidence in meeting the siting criteria. Those siting criteria are expressed as disqualifying conditions, which must not be present, and qualifying conditions, which must be present, in order for a site to comply with the siting criteria. The team reached consensus conclusions about the presence or absence of each qualifying and disqualifying condition, and about the confidence they had in this judgment. After documenting these conclusions and supporting information, an external peer review was conducted to review the completeness of the supporting information and the objectivity of the conclusions. This review was conducted according to approved quality assurance procedures for peer review. All comments by the peer reviewers, responses to their comments, and resulting revisions to the text were documented in a report of the peer review.

The use of judgment and peer review described above supports the analyses and models that will be used to predict future conditions and changes in the geologic setting. Those analyses and models are developed from data gathered by field tests, in situ tests, laboratory tests representative of field conditions, monitoring data, and natural analogue studies. DOE believes its current site characterization program as implemented by the array of study plans, including the testing program in the expanded Exploratory Studies Facility (ESF), adequately supports model and analysis development. The Preliminary Test Planning Package for Support of Pre-Title II Design Studies - Planned Exploratory Studies Facility Tests (YMP/TPP 91-5, Revision 0, September 1992) describes the extent of this in situ testing. In addition, DOE's increased consideration of natural analogue study data from Cigar Lake, Canada; Alligator Rivers, Australia; and Pocos Caldes, Brazil, will further support model development.

**Enclosure 3**

**SCA Comment 45 and DOE Response (12/14/90)**

**NRC Evaluation of DOE Response (7/31/91)**

**Additional Information Relevant to SCA Comment 45 Open Item**

Section 8.3.1.8 Overview of the postclosure tectonics program: Description of future tectonics processes and events required by the performance and design issues.

COMMENT 45

Reliance on volcanic rate calculations that are developed largely independent of consideration of the underlying volcano-tectonic processes appears likely to underestimate potential impacts on the performance of the repository.

BASIS

- o The SCP indicates that the annual probability of a volcanic eruption penetrating the repository is not greatly dependent on the regional model (Tables 8.3.1.8-7 and 8). However, regional tectonic models of crustal and mantle processes would appear to be essential in estimating whether magma generation will be increasing or decreasing in the future and, therefore, seemingly have a significant effect on the uncertainty of probabilities of future volcanic events. Chapter 1 (p. 1-203) indicates that volcanism appears to be directly linked to tectonic processes in the region.
- o Probability calculations appear to be based on establishing a rate of volcanic activity during the Quaternary which averages the activity over at least 2.0 million years. Probabilities calculated in this manner do not appear to be conservative in establishing the hazard to the repository in that they assume a uniform distribution of volcanism through time and appear to overlook possible structural control, uncertainty in the processes responsible for volcanism, and uncertainty in dating Quaternary volcanic events.

RECOMMENDATION

More consideration should be given to characterizing volcanic processes acting in the geologic setting.

RESPONSE

The three concerns in this comment are (1) volcanic rate calculations (the recurrence rate of volcanic events) were developed largely independent of volcano-tectonic processes, (2) probability calculations were not dependent on the regional tectonic models, (3) calculations appeared to be based on averages of volcanic activity during the Quaternary. These concerns are discussed separately.

1. An idealistic approach to calculating the probability of magmatic disruption of a repository at Yucca Mountain would be to base the calculations on numerical models of volcanic and tectonic processes. However, this approach implies an understanding of these processes that is beyond the current capabilities of geosciences. Moreover, it is unrealistic to provide expectations that this expertise could be developed within the planned period of site characterization studies. The alternative is to base the volcanic recurrent rate calculations on the geologic record. This approach was used for the Site

Characterization Plan (SCP). The implicit assumption of this approach is that the underlying volcano-tectonic processes of the region are reflected in the record of volcanism. It is a fundamental assumption of geology that the past geologic record provides the primary basis for predicting or bounding future geologic events.

2. The probability calculations are partly dependent on regional tectonic models. It is important to evaluate a range of permissible volcano-tectonic models for the patterns of basaltic volcanism in the Yucca Mountain region. For each model, evaluations need to be conducted to determine if the model could lead to predictions that recurrence rates of volcanic events are increasing, decreasing, or are steady-state. These predictions should be either factored into probability calculations or it should be demonstrated that an approach used is conservative from the perspective of volcano-tectonic models. The U.S. Department of Energy would consider revising SCP Tables 8.3.1.8-7 and -8 to indicate that the probability of repository disruption is partly dependent on regional tectonic models. These changes may be reflected in the SCP's technical baseline or a Study Plan revision.

At this stage of development of site characterization work, it is premature to expect probability calculations to reflect regional tectonic models. The models are under development as part of the process of site characterization. Future input for this part of revised probability calculations will be provided from Investigation 8.3.11.7.4, Preclosure tectonics data collection and analysis, and Activity 8.3.1.8.5.1.5, Evolution of basaltic volcanic fields (the title of the activity has been renamed after publication of the SCP). An expanded discussion of Activity 8.3.1.8.5.1.5 is provided in Study Plan 8.3.1.8.5.1 (Characterization of Volcanic Features). The method for revising probability calculations using input from these two activities is described in Study Plan 8.3.1.8.1.1, Probability of magmatic disruption of the repository (Activity 8.3.1.8.1.1.4, Probability calculations and assessment).

3. A stochastic approach to probability calculations is based on an assumption of rate uniformity of modeled events. This is a fundamental requirement of a probabilistic approach (Poisson event distribution, no event memory). This approach can be nonconservative if there have been changes (increases) in the modeled rate. However, the probability calculations discussed in the SCP used a dual approach to establishing volcanic rates: stochastic (cone counts) and magma volume versus time. The latter approach is based on an evaluation of the magma effusion rate, by plotting the curve of the cumulative magma volume of volcanic events versus age of the volcanic events. The slope of this curve is the magma effusion rate and it is very sensitive to changes in rates. This plot can be used to test whether a stochastic approach is conservative or nonconservative. Crowe and Vaniman (1981) and Crowe, Johnson, and Beckman (1982) presented evidence that magma effusion rates may be decreasing in the Yucca Mountain region during the Pliocene and Quaternary. If this interpretation is consistent with more detailed work planned for the site characterization studies, it suggests that a stochastic approach to probability calculations for the Yucca Mountain

site is a conservative approach. The development, use, and documentation of application of a diagram of cumulative magma volume versus time for calculating volcanic recurrent rates is described by Crowe and Perry (1990). A discussion of the advantages and disadvantages of different methods for calculating volcanic recurrent rates is also described in Study Plan 8.3.1.8.1.1, Probability of Magmatic Disruption of the Repository.

REFERENCES:

DOE (U.S. Department of Energy), 1990. Study Plan 8.3.1.8.5.1, Characterization of Volcanic Features, Yucca Mountain Project Office, Las Vegas, NV.

DOE (U.S. Department of Energy), 1990. Study Plan 8.3.1.8.1.1, Probability of Volcanic Eruption Penetrating the Repository, Yucca Mountain Project Office, Las Vegas, NV.

Crowe, B.M., M.E. Johnson, and R. J. Beckman, 1982. "Calculation of the Probability of Volcanic Disruption of a High-Level Radioactive Waste Repository within Southern Nevada, USA," Radioactive Waste Management and the Nuclear Fuel Cycle, Vol. 3, No. 2, pp. 167-190.

Crowe, B.M., and F.V. Perry, 1990. "Volcanic Probability Calculations for the Yucca Mountain Site: Estimation of Volcanic Rates," in Proceedings of the Nuclear Waste Isolation in the Unsaturated Zone, FOCUS '89 Conference, American Nuclear Society, pp. 326-324.

Crowe, B.M., and D. T. Vaniman, 1981. Geology and Petrology of the Basalts of Crater Flat: Applications to volcanic risk assessment for the Nevada Nuclear Waste Storage Investigations, 167; LA0884-MS, Los Alamos National Laboratory, SCP Chapter 1.

**Section 8.3.1.8 Overview of the postclosure tectonics program:  
Description of future tectonic processes and events  
required by the performance and design issues**

**SCA COMMENT 45**

Reliance on volcanic rate calculations that are developed largely independent of consideration of the underlying volcano-tectonic processes appears likely to underestimate potential impacts on the performance of the repository.

**EVALUATION OF DOE RESPONSE**

- o The response to this comment indicates that the only possible alternative in volcanic rate calculations is to rely on "a fundamental assumption of geology that the past geologic record provides the primary basis for predicting or bounding future geologic events." The staff supports such a deterministic approach. Further, the staff considers that supplemental activities exist (e.g., natural analog studies; deep seismic surveys) that, combined with the geologic record, provide mechanisms for approaching an understanding of Quaternary geologic processes at the site. In addition, the accuracy of assumptions stemming from an examination of the geologic record alone is largely dependent on the record being "robust" enough to provide an adequate data base for predicting or bounding future geologic events. The staff considers that evidence suggesting that the geologic record of Quaternary volcanism is "robust" to the point of accurately predicting the future likelihood of volcanic events has not been documented.
- o DOE states that "At this stage of development of site characterization work, it is premature to expect probability calculations to reflect regional tectonic models." The staff considers that alternative tectonic models do exist for the Yucca Mountain region at the present time and that these alternatives should be incorporated into characterization activities and preliminary calculations about the likelihood of future volcanic events. An example of an alternative tectonic model for basaltic volcanism in the Yucca Mountain region is that proposed by Smith and others (1990) for structural control of basaltic volcanism at Yucca Mountain.
- o DOE states that calculations of magma effusion rates suggest that a stochastic approach to probability calculations for the Yucca Mountain site is a conservative approach. The staff does not consider the calculations of magma effusion rates as presently defined to be robust enough to accurately or precisely predict whether magma production will increase or decrease in the next 10,000 yrs, particularly in the absence of the consideration of alternative models of magma rate production. Therefore, the staff does not consider the stochastic approach to probability calculations for volcanism at Yucca Mountain to necessarily be conservative.
- o DOE suggests that this comment can be resolved after additional site characterization leads to development of regional tectonic models (Investigation 8.3.11.7.4; Study Plans 8.3.1.8.5.1 and 8.3.1.8.1.1) and calculations of magma effusion rates (Study Plan 8.3.1.8.1.1). Resolution of this comment must await NRC staff evaluations of the referenced study

plans and results of investigations which should consider volcano-tectonic processes, regional tectonic models, and volcanic rate calculations.

- o The NRC staff considers this comment open.

REFERENCE

Smith, E.I., Feuerbach, D.L., Naumann, T.R., and Faulds, J.E., 1990, The area of most recent volcanism near Yucca Mountain, Nevada: Implications for volcanic risk assessment, in Proceedings High Level Waste Management, 1990, American Nuclear Society, p. 81-90.

#### SUPPLEMENTAL RESPONSE TO SCA COMMENT 45

The transmittal of Study Plan 8.3.1.8.1.1, Revision 2, "Probability of Magmatic Disruption of the Repository" provides the basis to explicitly address Site Characterization Analysis (SCA) Comment 45 open item. Two concerns are expressed by the NRC in Site Characterization Analysis Comment 45. First, NRC expressed concern that alternative tectonic models for the Yucca Mountain, Nevada, region should be incorporated into calculations of the probability of future volcanic events. The DOE fully intends to consider all structural/tectonic models and to calculate the disruption parameter iteratively as new information becomes available. Study Plan Section 3.2.2.2 has been revised to clarify this position. Ambiguous examples of disruption parameter calculations have been deleted and a summary paragraph has been added clarifying that all structural/tectonic models will be considered along with new information as obtained.

The second NRC concern is that the stochastic approach to probability calculations is not necessarily conservative and that alternative methods of calculating the volcanic recurrence rate should be considered. The DOE believes that a stochastic approach to probability calculations is conservative for the Yucca Mountain region based on several lines of evidence pointing to a decrease in magma production with time. However, DOE fully intends to incorporate all methods (e.g., stochastic, poisson, weibull) for probability calculations. Section 3.4.2.1 has been completely revised to replace incorrect examples of probability calculations with more accurate example calculations and an updated explanation of the strategy for their use. In addition to the above two major revisions, several sections of Study Plan 8.3.1.8.1.1 (Sections 1.1, 1.2, 3.4.2.2., and 4.0) have been revised to clarify that both the intrusion and eruption scenarios will be considered in the calculation of the probability of future volcanic activity in the Yucca Mountain region.

**Enclosure 4**

**SCA Question 38 and DOE Response (12/14/90)**

**NRC Evaluation of DOE Response (7/31/91)**

**Supplemental Response to SCA Question 38 Open Item**

Section 8.3.4.2.G. Waste package fabrication and handling before emplacement.  
Design goal for handling. p. 8.3.4.2-31 para. 1.

QUESTION 38

One of the design goals (#3) to avoid damage from handling that affects performance is not to emplace any container that is scratched so that the metal is thinned by 1-mm or more.

What is the basis for the 1-mm thinning criterion? How does this relate to the variation/tolerance in the nominal wall thickness of the canister material? What is the allowed variation in canister wall thickness? Is the scratch design goal of 1-mm depth independent of the canister material? Would a scratch depth of a mm or less create a potential location for crevice corrosion?

BASIS

- o Corrosion response of a scratch/scratched region will depend upon the characteristics of the scratch, e.g., its width, depth, root radius, scratch density, any chemical contamination of the scratched region with the object that produced the scratch, etc. The SCP does not provide any characteristics of the scratch other than its depth.
- o Techniques that will be used to measure the wall thinning at the location of the scratch are not given in the SCP.

RECOMMENDATIONS

- o Provide a more complete definition of the pertinent characteristics of a scratch.
- o Scratch acceptance criteria should provide the maximum acceptable scratch length, depth, width, areal density, total number of scratches per canister, total length of scratches per canister, and other features of a scratch that could affect the performance of the canister.
- o Criteria for evaluation of the suitability of a scratched canister should be supported by experimental evidence of material performance of a scratched region.
- o Techniques that will be used to detect scratches and measure wall thinning at the location of the scratch should be provided.

RESPONSE

The 1-mm criterion is an estimate from conceptual design analysis and will be evaluated as detailed designs, material performance data, and performance scenarios are developed.

Section 8.3.4.2.G. Waste package fabrication and handling before emplacement.  
Design goal for handling. p. 8.3.4.2-31 para. 1

SCA QUESTION 38

One of the design goals (#3) to avoid damage from handling that affects performance is not to emplace any container that is scratched so that the metal is thinned by 1-mm or more.

What is the basis for the 1-mm thinning criterion? How does this relate to the variation/tolerance in the nominal wall thickness of the canister material? What is the allowed variation in canister wall thickness? Is the scratch design goal of 1-mm depth independent of the canister material? Would a scratch depth of 1-mm or less create a potential location for crevice corrosion?

EVALUATION OF DOE RESPONSE

- o DOE does not provide the basis for the 1 mm thinning criterion, but indicates that the criterion will be evaluated as detailed designs, material performance data, and performance scenarios are developed.
- o DOE did not respond to the question about whether the scratch design goal is independent of canister material.
- o DOE did not respond to the question about a scratch depth of 1-mm or less creating a potential location for crevice corrosion, nor did they describe techniques for detecting scratches and measuring wall thinning of scratch locations.
- o The NRC staff considers this question open.

**SUPPLEMENTAL RESPONSE TO QUESTION 38**

The basis for specifying the container surface is so that the container meets the requirements of 10 CFR 60.113. Scratches or dings, therefore, are to be avoided. The requirements for the condition of the surface will be determined as a result of the test program.

The initial value of 1 mm for waste package thinning, that was presented in the Site Characterization Plan, was strictly a preliminary estimate of the depth for initiation of a pit or stress-corrosion crack that could be expected with corrosion-resistant materials. DOE is not intending to either defend this initial planning basis, or necessarily meet this value as a design requirement at this time. Rather, DOE does plan to determine levels and significance of the degradation mechanism during waste package design. This activity will be performed once the operating environment is better defined and the material selection for waste packages is performed. Once the criterion is determined, then techniques to assure it is not exceeded will be developed.