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TOPICAL REPORT ON "METHODOLOGY TO ASSESS FAULT DISPLACEMENT AND VIBRATORY GROUND MOTION HAZARDS AT YUCCA MOUNTAIN" (SCPB: N/A)

Reference: Ltr, Bell to Milner, dtd 9/7/94

In your letter of September 7, 1994 (Reference 1), you stated that the U.S. Nuclear Regulatory Commission (NRC) considers the U.S. Department of Energy (DOE) Topical Report, "Methodology to Assess Fault Displacement and Vibratory Ground Motion Hazards at Yucca Mountain," unacceptable for detailed review. You and your staff clarified your concerns in the October 7, 1994, technical meeting between the NRC and the DOE. The discussions at that meeting indicated that the staff's main concern with initiating its review of this report is that the DOE has failed to adequately explain its overall strategy for addressing seismic hazard assessment and seismic design issues. In response to your letter and those discussions, this letter provides a general overview of the DOE approach to addressing seismic hazard assessment and seismic design issues through a series of topical reports. This letter also provides responses to the specific concerns stated in your September 7, 1994, letter.

The DOE is planning to develop three seismic topical reports and submit them to the NRC for review. Seismic Topical Report I, the subject of this letter, describes the methodology that will be used to perform a comprehensive probabilistic seismic hazard assessment at the Yucca Mountain, Nevada, site. Seismic Topical Report II, currently being developed by the DOE, will describe the Yucca Mountain seismic design methodology. Seismic Topical Report III will apply these methodologies to develop the set of seismic design inputs for a Yucca Mountain repository. Enclosure 1 to this letter is a more comprehensive overview of the DOE strategy for addressing seismic issues.

It includes a description of the information that has been or will be provided in each seismic topical report, and an explanation of how the three reports relate to one another.

The following are our responses to the specific concerns contained in your September 7, 1994, letter regarding Seismic Topical Report I:

Concern 1 - Deterministic Design Element:

The DOE seismic design process for geologic repository operations area systems, structures, and components at Yucca Mountain contains both a probabilistic and deterministic component. The probabilistic component is composed of a probabilistic seismic hazard assessment that integrates overall input interpretations and provides the annual probabilities with which different values of fault displacement or ground motion will be exceeded at sites of interest. The maximum magnitude earthquake for each seismic source is included, along with an assessment of uncertainty, as part of the input to the probabilistic hazard assessment. In this sense, the probabilistic assessment encompasses a traditional deterministic hazard assessment, while placing all earthquakes in their proper context relative to the total seismic hazard. The contribution of individual seismic sources to the total hazard will be examined for probability levels of interest as part of the sensitivity analyses and will form part of the information base available for design and regulatory decisions. Hence, the DOE methodology includes the capability to evaluate the results of traditional deterministic hazard assessments.

The deterministic component of the process involves defining design earthquakes from the probabilistic assessment and developing seismic design inputs through deterministic procedures. For appropriate probability levels determined from the seismic design requirements to be described in Topical Report II, the results of the probabilistic assessment are de-aggregated to identify the earthquakes (magnitude and distance) that dominate the hazard. These earthquakes are then treated deterministically to develop seismic design inputs. The process thus uses a probabilistic assessment which accounts for all input interpretations to identify design basis earthquakes, then treats the design basis events deterministically in developing seismic design inputs. By providing a more comprehensive understanding of the contributors to seismic hazard at a site, the probabilistic seismic hazard assessment forms a sound foundation for development of appropriately conservative seismic design inputs.

The DOE approach combines probabilistic and deterministic components in a manner similar to those proposed in the draft American Society of Civil Engineers' Report, "Seismic and Dynamic Analysis and Design Considerations for High Level Nuclear Waste Repositories," and in the outline of the draft NRC Regulatory Guide DG-1032, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motions" (enclosure 7 to SECY-94-194 [July 27, 1994]). The DOE approach also takes into account the Staff Technical Position on Investigations to Identify Fault Displacement Hazards and Seismic Hazards at a Geologic Repository (McConnell K. I., M. E. Blackford, and A. K. Ibrahim, 1992, NUREG-1451), which states, "Appendix A to 10 CFR Part 100 does not apply to the geologic repository program." The DOE methodology for combining deterministic and probabilistic elements will be presented in detail in Seismic Topical Report III.

Concern 2 - Consideration of Fault Displacement in Design:

The approach that will be taken for considering Type I faults when locating important safety systems, structures, and components is part of the overall design methodology that will be described in Seismic Topical Report II. It is anticipated that this approach will be consistent with the technical positions concerning hazards resulting from fault displacement at a geologic repository, as contained in the NRC's guidance document NUREG-1494, "Consideration of Fault Displacement Hazards in Geologic Repository Design."

Concern 3 - Expert Elicitation:

Interpretation of geologic data by experts will be used to provide inputs to the probabilistic seismic hazard assessment. The DOE approach to developing and documenting these interpretations will be similar to that used by the Electric Power Research Institute for similar applications (EPRI NP-4726-A, "Probabilistic Seismic Hazard Methodology for the Central and Eastern United States"). The details are currently being developed in Study Plan 8.3.1.17.3.6, entitled "Probabilistic Seismic Hazard Assessment." This study plan will be provided to the NRC for formal review when it is completed in mid-1995. Current planning calls for using multiple teams of experts to develop interpretations through a series of structured workshops. These workshops will encourage and facilitate extensive interactions among the experts. Through such interactions, hypotheses that are poorly supported by the data and scientifically indefensible models may be eliminated or downweighted by the experts while other hypotheses and models that are more strongly supported by the data will be given higher weight by the experts. This process is referred to as behavioral

aggregation through interaction and is intended to result in a full expression of scientific uncertainty on faulting and ground motion interpretations. The overall results will be developed by simple mechanical aggregation of (assigning equal weights to) the experts' seismic hazard results. The expert interpretations and computations will be thoroughly documented to enable comprehensive reviews.

We believe that this information addresses the concerns in your September 7, 1994, letter and provides you with a general understanding of the DOE's approach and plans for documenting its seismic hazard assessment and seismic design process. If you desire, we will incorporate the enclosed overview as another appendix to the final version of the topical report, following NRC review. With the provision of this additional information, we believe that Seismic Topical Report I meets the criteria for review that are contained in the NRC Office of Nuclear Material Safety and Safeguards Division of Waste Management Topical Report Review Plan. Therefore, we request that you begin your review of this topical report in accordance with that plan. If, however, you desire further clarification of some of the information contained herein, we suggest that the DOE and the NRC hold a technical exchange to further discuss seismic-related issues.

If you have any questions or desire any further clarification, please contact me at (702) 794-7971.

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AMSL:TWB-557

Enclosure:
Overview of the DOE's Proposed
Geologic Repository Operations
Area Seismic Design Process

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ENCLOSURE

OVERVIEW OF THE U.S. DEPARTMENT OF ENERGY'S PROPOSED GEOLOGIC REPOSITORY OPERATIONS AREA SEISMIC DESIGN PROCESS

The elements of the U.S. Department of Energy's (DOE's) proposed seismic design evaluation process for the Yucca Mountain geologic repository operations area (GROA) are discussed in the Topical Report, "Methodology to Assess Fault Displacement and Vibratory Ground Motion Hazards at Yucca Mountain" (Seismic Topical Report I), Section 1.4, and illustrated schematically in Figure [1]. The following is an elaboration of that discussion in response to the technical meeting between the U.S. Nuclear Regulatory Commission (NRC) staff and the DOE representatives on October 7, 1994 to discuss the NRC's comments regarding Seismic Topical Report I. The principle elaboration is to provide more details linking elements of the evaluation process contained in the three topical reports that together describe the DOE's proposed seismic design evaluation process. In addition, more details of the contents of planned Seismic Topical Reports II and III are provided.

The DOE's proposed seismic design evaluation process for the Yucca Mountain GROA logically divides into three closely linked elements: (1) methodology to assess fault displacement and vibratory ground motion hazards; (2) seismic design methodology; and (3) determination of fault displacement and vibratory ground motion seismic design requirements. Accordingly, the DOE intends to develop topical reports describing each of these elements of the process and submit them for review and acceptance by the NRC. These are designated Topical Report I, Topical Report II, and Topical Report III in the attached figure taken from Topical Report I. By submitting the elements of the proposed seismic design process for the Yucca Mountain GROA separately, the DOE is seeking to obtain the NRC's early feedback and guidance on the application of its proposed methodology to assess fault displacement and vibratory ground motion hazards, as well as its proposed seismic design criteria and methodology (Topical Report II, to be submitted in mid-1995), before proceeding with determination of fault displacement and vibratory ground motion loads appropriate for seismic design of the systems, structures, and components (SSCs) of the Yucca Mountain GROA. The first two elements of the seismic design evaluation process logically stand alone and are amenable to early review and resolution. Details of the contents of the three topical reports and the way in which they together support the determination of fault displacement and vibratory ground motion values appropriate for the design of the Yucca Mountain GROA SSCs are given below.

Topical Report I: "Methodology to Assess Fault Displacement and Vibratory Ground Motion Hazards at Yucca Mountain"

As stated in Section 1.1 of Topical Report I, the objective of this topical report is to describe the DOE's methodology to assess vibratory ground motion and fault displacement hazards. The term "hazards" is used here in its currently accepted meaning in the earthquake engineering profession as the probability of exceeding a given value of a parameter of interest, e.g., ground motion or fault displacement. The methodology itself does not determine the value of the parameter that is appropriate for the design of facility SSCs. Rather, the application of the methodology (intended as part of the preparation of Topical Report III) at the Yucca Mountain site will develop hazard results that will be used as part of the larger information base that supports the determination of fault displacement and vibratory ground motion values appropriate for the seismic design of the GROA SSCs. Other parts of the information base that will be integrated in Topical Report III are the safety performance requirements, to be established in Topical Report II, and deterministic assessments of faulting and ground motion from dominant seismic sources, to be determined by de-aggregating the probabilistic seismic hazard results.

The DOE intends to apply the methodology described in Topical Report I in the development of Topical Report III, described below. Accordingly, the DOE considers it important to have the NRC's review of the proposed methodology as early as possible in order to proceed, without undue regulatory risk, with the development of Topical Report III.

Topical Report II: "Seismic Design Methodology for a Geologic Repository at Yucca Mountain"

The DOE intends to submit Topical Report II early in 1995 for NRC review. This topical report will describe the seismic design methodology and criteria that the DOE proposes to use to provide assurance that fault displacements or vibratory ground motions do not unduly compromise the safety functions of the Yucca Mountain GROA SSCs. It is intended that the seismic design methodology and criteria will be based on the philosophy that the DOE uses in the design of its other facilities, as described in DOE-STD-1020-94, "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities." The performance goal-based methodology is considered to be appropriate for the Yucca Mountain facility because it provides a structured approach to relating the importance of an SSC to the hazard level that it is designed to withstand, in order to achieve the desired safety performance. Safety performance categories will be established for the GROA SSCs depending on their failure consequences for public safety (i.e., safety of workers, the general public and

the environment) and will take account of mission and cost impact. For the SSCs in the highest safety performance category, it is intended that the seismic design criteria and requirements will be consistent with the NRC's well-established nuclear plant practice. For SSCs that have no radiological safety significance, the seismic design criteria and requirements will be founded in established codes and practice (e.g., the Uniform Building Code) governing the seismic design of non-critical facilities. It is intended that the report will describe criteria and procedures for categorizing SSCs using a graded approach such that the numerical performance goal of an SSC category is proportional to the safety consequences associated with its failure. For the highest safety performance category, the numerical performance goal is intended to be consistent with established nuclear power reactor safety performance. For SSCs that have no radiological safety significance, it is intended that the numerical safety performance goal will be consistent with established safety performance achieved by building codes for non-critical facilities.

Topical Report II also will describe the methodology and criteria that the DOE proposes to use to design the Yucca Mountain GROA SSCs for fault displacement. It is intended that the methodology and criteria will be consistent with the guidance in NUREG-1494, "Staff Technical Position on Consideration of Fault Displacement Hazards in Geologic Repository Design." The report will describe the criteria that the DOE plans to follow for avoiding faults as well as criteria for fault displacement design of SSCs when design is the appropriate mitigation action.

Application of the methodologies described in Topical Reports I and II to determine seismic design values for the GROA SSCs is the objective of Topical Report III, described below. Accordingly, the DOE considers it important to obtain the NRC's early review of these reports in order to avoid expending efforts inappropriately in the preparation of Topical Report III.

Topical Report III: "Determination of Fault Displacement and Vibratory Ground Motion Design Values for the Yucca Mountain Systems, Structures and Components"

The DOE intends to determine fault displacement and vibratory ground motion values appropriate for the design of the Yucca Mountain GROA SSCs based on combined probabilistic hazard results and deterministic evaluations. It is intended that the methodology described in Topical Report I be implemented to perform probabilistic assessments of fault displacement and vibratory ground motion hazards at the Yucca Mountain site. The seismic design requirements for the repository facility SSCs described in Topical Report II form the basis for determining the seismic hazard levels appropriate for design. Thus, it is

intended that Topical Report III will apply both the methodology described in Topical Report I and the methodology and criteria described in Topical Report II. The output of Topical Report III will be a comprehensive set of seismic design inputs for Yucca Mountain. It is anticipated that this report will be provided to the NRC around the end of 1996.

Approaches to combine probabilistic hazard assessments with deterministic evaluations to determine seismic design loads are described in the draft ASCE Guideline, "Seismic and Dynamic Analysis and Design Considerations for High Level Nuclear Waste Repositories" and in the outline of the NRC's draft regulatory guide DG-1032, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motions," (SECY-94-194, July 27, 1994). The DOE intends to apply an approach similar to those described in these documents to determine fault displacement and vibratory ground motion values appropriate for the seismic design of the Yucca Mountain facility SSCs. The approach will involve de-aggregating probabilistic seismic hazards at probability levels established by the seismic design requirements described in Topical Report II. The de-aggregation will result in identifying the seismic sources (and associated magnitudes and distances) that dominate the vibratory ground motion at the site. It is anticipated that the de-aggregation will be accomplished for a combination of the range of SSC performance categories and ground motion frequencies of interest as well as for fault displacement. Thus, different seismic sources may be controlling depending on the performance category and the ground motion frequency. For controlling seismic sources, it is anticipated that deterministic evaluations of ground motions at the site will be made. These evaluations will use dominant seismic source magnitudes and distances from the site determined from the seismic hazard de-aggregation. Similarly, it is anticipated that identification of Type I faults will be facilitated by de-aggregating the seismic hazard results. The DOE intends to apply the guidelines contained in NUREG-1451, "Staff Technical Position on Investigations to Identify Fault Displacement Hazards and Seismic Hazards at a Geologic Repository," to confirm that Type I faults have been identified and appropriately evaluated. It is anticipated that the appropriate magnitudes for the deterministic evaluations of Type I faults will be obtained from the de-aggregated seismic hazard results. The DOE anticipates following procedures similar to those described in draft DG-1032 to determine the appropriate fault displacement and vibratory ground motion design loads based on combined probabilistic results and deterministic evaluations. The details of how the DOE proposes to apply the combined procedure and its application for Type I faults will be described in Topical Report III.