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U.S. NUCLEAR REGULATORY COMMISSION'S RESOLUTION REPORT ON TYPE I FAULTS AND TECTONIC MODELS

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I. INTRODUCTION AND SIGNIFICANCE TO PERFORMANCE

The U.S. Nuclear Regulatory Commission (NRC) is preparing to review and comment on U.S. Department Of Energy's (DOE's) Total System Performance Assessment-Viability Assessment (TSPA-VA) and a potential license application for a high-level radioactive waste repository at Yucca Mountain. Issue Resolution Status Reports (IRSRs), such as the one summarized here[1], are the primary mechanism that the staff will use to provide DOE feedback on key technical issues (KTIs) and subissues that may significantly affect repository performance. One of the KTIs to be resolved is Structural Deformation and Seismicity (SDS), of which Type I faults and tectonic models are subissues. The SDS KTI broadly stated is: have seismotectonic features, events and processes that may significantly affect the performance of a repository at Yucca Mountain been identified and adequately characterized, their significance sufficiently understood and fully considered, and relevant interpretations (e.g., abstractions and models) used appropriately to evaluate long-term performance by DOE?

Subissues that must be resolved in order for the SDS KTI to be resolved, include:

(1) Fault Slip - What are the viable models of faults and fault displacements at Yucca Mountain? [Type I faults are a part of this subissue].

(2) Seismic Motion - What are the viable models of seismic sources and seismic motion at Yucca Mountain?

(3) Fractures and Site Discontinuities - What are the viable models of fractures and site discontinuity features at Yucca Mountain?

(4) Tectonics and Crustal Conditions - What are the viable tectonic models and crustal conditions at Yucca Mountain? [Tectonic models are a part of this subissue].

DOE's Waste Containment and Isolation Strategy (WCIS)[2] continues to rely on both natural and engineered barriers to limit radionuclide movement. A primary goal of WCIS is the near-complete containment of radionuclides within waste packages for several thousand years. Therefore, the probability and consequences of mechanical failure modes, such as direct disruption by faulting or seismically-induced fall of rock or concrete liner onto waste packages, would need to be understood. Type I faults need to be considered in design and performance assessments because they could mechanically disrupt waste packages through rockfall, or provide zones of preferential flow or barriers to flow, and are potential seismic sources. Tectonic models are in and of themselves neither hazards nor enhancements, but they are prerequisites for an evaluation of potential tectonic effects. Tectonic models need to be considered because they provide geological and geophysical limits on, and alternative scenarios for, tectonic activities.

II. REVIEW METHODS AND ACCEPTANCE CRITERIA

The staff's review of DOE's conclusions about future seismotectonic behavior of the site will be based on the staff's analyses and professional judgment regarding the completeness and acceptability of DOE's data and interpretations.

A. Type I Faults

Type I faults are faults or fault zones that are subject to displacement and are of sufficient length and located such that they may affect repository design and/or performance of structures, systems and components important to safety, containment or waste isolation (sscis/wi) and/or may provide significant input into models used in the assessment of sscis/wi[3]. In this IRSR, Type I

faults apply only to those faults that can directly affect the repository design or performance by ground motion or direct fault slip. Fault-displacement hazards are relevant only to those faults that lie within the controlled area. Therefore, the criteria for the identification of Type I faults outside or inside the controlled area differ. Outside the controlled area, only those Type I faults large enough to generate sufficient seismic energy during an earthquake to shake the site beyond a given threshold of ground motion (i.e., 0.1 g) need to be considered. The following acceptance criteria were applied to determine what are the Type I faults at Yucca Mountain:

(1) Approved quality assurance and control procedures and standards were applied.

(2) If used, expert elicitations were conducted in accordance with NUREG-1563[4].

(3) Faulting component of the geologic setting[5] was adequately determined.

(4) Maximum earthquake for each candidate Type I fault was adequately determined.

(5) Maximum trace length of each candidate Type I fault was measured from acceptable sources.

(6) Peak ground motion acceleration for each Type I fault was adequately determined.

(7) Shortest distance to site boundary of each Type I fault was adequately measured.

(8) Geologic age of last movement of each Type I fault was adequately determined.

(9) Potential for future slip was adequately determined.

B. Viable Tectonic Models

Technical bases for review and acceptance criteria are primarily derived from consideration of geologic and geophysical data and the assessment of the models used as tools to evaluate seismic sources, faulting probability, structural control of groundwater, heat and magma flow. The following acceptance criteria were applied to determine the full range of viable tectonic models of the Yucca Mountain region:

(1) Approved quality assurance and control procedures and standards were applied.

(2) If used, expert elicitations were conducted in accordance with NUREG-1563[4].

(3) Alternative tectonic models of Yucca Mountain and surrounding region were adequately determined.

(4) Viable tectonic models are consistent with existing geophysical, geological, seismological, and geodetic data, and explained inconsistent data.

(5) Viable tectonic models clearly elucidate the tectonic, structural, or seismic elements, and the uncertainties associated with each element, critical for the model's intended purpose.

III. DISCUSSION AND RELEVANCE TO RADIOACTIVE WASTE MANAGEMENT

A. Type I Faults

The main differences between the NRC and DOE studies were interpretations of fault lengths in regions in which the mapped trace lengths are ambiguous, the choice of an appropriate attenuation function, utilization of the mean or 84th percentile for identifying the 0.1-g criterion, and consideration of fault orientation within the in situ stress field[1,8]. The communication of NRC's acceptance criteria for Type I faults[1] should facilitate early resolution between DOE and NRC of additional faults that may be candidates for Type I[9,10].

B. Viable Tectonic Models

At meetings in 1996, it was clear that five of eleven tectonic models of the Yucca Mountain region were supported by the existing data[1,12]. The five models can be considered in two general categories of deformation, dominantly extensional and dominantly strike-slip. The models are not mutually exclusive. The communication of NRC's acceptance criteria for tectonic models with accompanying analyses and conclusions[1] should facilitate early resolution between DOE and NRC of variations of existing viable tectonic models[11] and new models that may arise, thereby facilitating the licensing process.

IV. STATUS OF RESOLUTION OF TYPE I FAULTS AND TECTONIC MODELS

Issue resolution at the staff level during pre-licensing is achieved when the staff has no further questions or comments (i.e., open items) at a point in time, regarding how the DOE program is addressing an issue. There may be some cases where resolution at the staff level may be limited to documenting a common understanding regarding differences in the NRC and the DOE points of view. Pertinent additional information could raise new questions or comments regarding a previously resolved issue.

A. Type I Faults

The following items in the subissue on fault slip are resolved (each fault described in Refs. (1,8,10):

(1) Eighty-four specific faults are considered to be Type I faults by NRC staff[1] and should be considered by DOE. The IRSR documents differences with DOE on 21 of these.

(2) DOE's identification of thirty-three faults as Type III (detailed investigation not needed now).

(3) DOE's boundary of the faulting component of the geologic setting is the 100 km radius from the Yucca Mountain site center; and the controlled area is the appropriate area for the assessment of direct effects of fault displacement.

(4) DOE's use of Wells and Coppersmith equation[6] to estimate maximum capable earthquake.

(5) DOE's use of 0.1 g threshold ground motion at the site.

(6) DOE's use of 84th percentile peak ground acceleration value, as long as it compensates for DOE's use of non-conservative attenuation model (for faults closer than about 30 km to the site).

(7) DOE's selection of the minimum faulting earthquake of Mw=5.8, based on the Fort Sage event.

(8) DOE's use of Piety's map[7] as the principal source of data on age of faulting events.

B. Viable Tectonic Models

The following items in the subissue on tectonic and crustal conditions are resolved (each model described in Refs. (1, 11)):

(1) DOE's identification of viable tectonic models and its screening of other models.

(2) DOE's consideration that the Bare Mountain fault is the dominant fault of the region.

(3) DOE's consideration that the dominant mode of deformation is that of extension.

(4) DOE's concept of structural domains.

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