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MEMORANDUM TO: Michael Bell, Chief
Engineering and Geosciences Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

FROM: Goutam Bagchi, Chief
Civil Engineering and Geosciences Branch
Division of Engineering Technology
Office of Nuclear Reactor Regulation

SUBJECT: REVIEW OF DEPARTMENT OF ENERGY (DOE) TOPICAL REPORT "METHODOLOGY TO ASSESS FAULT DISPLACEMENT AND VIBRATORY GROUND MOTION HAZARDS AT YUCCA MOUNTAIN"

As you requested, the Civil Engineering and Geosciences Branch (ECGB) has reviewed the DOE topical report titled "Methodology to Assess Fault Displacement and Vibratory Ground Motion Hazards at Yucca Mountain". Our comments on this report are contained in the Attachment. The review was performed by G. V. Giese-Koch and D. C. Jeng of the ECGB.

Attachment: As stated

cc: A. K. Ibrahim
A. J. Murphy

Contact G. V. Giese-Koch, 415-2736

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REVIEW OF A DEPARTMENT OF ENERGY TOPICAL REPORT "METHODOLOGY TO ASSESS FAULT DISPLACEMENT AND VIBRATORY GROUND MOTION HAZARDS AT YUCCA MOUNTAIN"

The staff of the Civil Engineering and Geosciences Branch (ECGB), Office of Nuclear Reactor Regulation has reviewed the Department Of Energy (DOE) report, titled "Methodology to Assess Fault Displacement and Vibratory Ground Motion Hazards at Yucca Mountain". In general, the basic philosophy and the overall frame work of the proposed methodology logical. However, when they are applied to the Geologic Repository Operations Area (GROA) facility design and evaluation activities, whose service life ranges from 100 years for the pre-closure period to some 10,000 years for the confinement and waste isolation period there is no empirical data to fall back on. For such extremely long durations, the applicable seismic loads including fault displacement effects are severe, and use of a risk-based hazard definition approach when adequately supported by reasonable engineering experience and practical design and evaluation criteria can be judged as reasonable. However, the proposed methodology as it is presented in the topical report now has many deficiencies and unverified assumptions which need to be improved or further justified. A topical report is a vehicle to convey to the interested parties a method or methodology envisioned to resolve a particular issue or problem. Therefore, it must contain specific methods and criteria which when applied will allow unambiguous and specific conclusions. This report does not supply the necessary decision making criteria which will render a favorable or unfavorable conclusion. The detail of information provided in the report is judged insufficient for a topical report. More detailed information describing the bases for key assumptions or positions taken and how a proposed methodology is to be implemented with pertinent examples should be included in the report. We recommend that the report be amended to provide more specific information on the methodology to be used and the criteria to be applied to render the results acceptable such that we can evaluate its potential success in resolving the issues for the GROA. The following paragraphs contain comments some suggestions to arrive at such a usable product.

On page 10 the report states that: "...Recent applications of probabilistic methodologies, associated lessons learned and ongoing evaluations and integration of seismic hazard methodologies provide the basis for the methodology described in this report..." However, nowhere in the report is reference made to the revised Probabilistic Seismic Hazard Characterization (PSHC) Program developed by LLNL, supported both by DOE and Nuclear Regulatory Commission (NRC), which is the most recent product of lessons learned in the field of probabilistic seismic hazard assessment. We recommend that the revised LLNL PSHC methodology be incorporated to obtain hazard estimates at the Yucca Mountain site. Although, reference is made to the Senior Seismic Hazard Analysis Committee (SSHAC) study, which was a project sponsored jointly by NRC, DOE, and the Electric Power Research Institute (EPRI) there is no mention as to the extent of its use in the proposed methodology. The final report of the SSHAC, which is available in draft form presents a process for performing probabilistic seismic hazard analyses. This process was developed over the past few years by leading practitioners in the fields of seismology, geophysics, geology, probabilistic hazard assessment, and decision theory. We recommend that, as much as possible, the process developed by the SSHAC be incorporated in the methodology.

On page 17 the report mentions both the LLNL (Monte Carlo) and the EPRI (fault tree) seismic hazard assessment methodologies. We would recommend that both methodologies be considered and that sensitivity studies be conducted to assess any differences in the results of the two methodologies.

In Appendix A, page A-14 the report discusses the possibility of future nuclear explosion tests and the manner in which they will be incorporated in the assessments. We suggest that the issue of future nuclear explosion tests and the manner in which they may affect the Yucca Mountain site be treated as a separate issue because (a) the occurrences and magnitude (yield) of nuclear explosion tests will be known factors and thus not random in nature and, (b) the process of earthquakes that may be triggered by these explosions is a separate and phenomenologically different. It is therefore not appropriate to assume that their behavior can be assessed under the same probabilistic approach as the natural earthquake issue.

We have particular concerns about the consistency between the design results obtained from the proposed performance based methodology and those from a traditional seismic design methodology. We recommend adoption of a transition period during which the GROA facility designers be required to use both the performance-based, and the traditional deterministic seismic hazard assessment approach and NRC's safety related structural design criteria (e.g., maximum credible earthquake; ACI, AISC codes; Appendix A to 10 CFR Part 100; GDCs # 2 and # 4, Appendix A, to 10 CFR Part 50, and Sections 2 and 3 of NRC Standard Review Plans, modified to suit GROA needs, as appropriate) to ascertain that the design or evaluation results obtained from the proposed methodology are generally consistent with relevant past experience and reasonable for the following reasons:

- The methodology proposed is basically UNTESTED in engineering design offices and rudimentary in several aspects with unverified assumptions.

- The methodology involves the use of very long return periods ranging from 10E 3 to 10E 5 to define the probability of exceeding certain levels of strong motion or fault displacements which would be used in the structures, systems and components (SSCs) design. Many believe that the current knowledge in seismicity and ground motion/fault displacement data do not support a sole dependence of GROA facility design to such values which have extremely large uncertainties.

- There is definitely a need for a learning period to demonstrate the effectiveness and practicality of the performance-based methodology as well as for building up design engineers' confidence in the methodology through adoption of a transition design period.

This topical report does not address the details of structures, systems, and components (SSC) design criteria, load combinations, allowable stresses/strains, element deflection and building drift limits and design

detailing requirements, etc. They are supposed to be discussed in a second topical report. This makes it impossible for us to render a judgment at this juncture about the acceptability of the entire methodology including details of facility design and evaluation criteria.
There is a need for the report to provide a more clear-cut guidance on how to assign SSCs into performance categories. As appropriate, provide example lists of SSCs belonging to each performance category for the GROA facility.

Also, the report is supposed to apply to design and evaluation of all SSCs of a GROA facility. However, much of the discussion appears to be directed to structures and not enough attention is directed towards design and evaluation of systems and components. The topical report should be revised to provide more detailed guidance for implementation of the performance-goal based design and evaluation of mechanical and electrical components. The report should address potential implication of the adoption of the proposed methodology on the equipment testing standards and requirements for qualification of the same.

Guidance in setting minimum design and evaluation standards and requirements for SSCs whose probabilistically determined evaluations lead to minimal seismic load demand (e.g., to require that all SSCs be designed for a minimum acceleration of, say, 0.1 gas used for nuclear power plants) should be provided.

SPECIFIC QUESTIONS

1. Item 3, page 10 of section 2.1, states that the methodology has a way of accommodating the issue of temporal and spatial clustering of earthquake occurrence and that simultaneous rupture on multiple faults are being accommodated. More detailed discussion of the basis of this statement should be provided.

2. Paragraph 3, page 12, states, "In developing the overall seismic hazards program, it is thus assumed that decision concerning seismic design and long-term waste isolation performance should be based on risk." Elaboration as to whose assumption was this is needed If this risk-based approach was the result of an DOE policy decision rather than an assumption by someone, please clarify this fact. The reference which discusses the rationale of the policy decision is needed. On the other hand, if this indeed was an assumption by the author or someone else, then, the basis of the assumption is needed.

3. Section 2.3.1.5, page 15, "Evaluation and Propagation of Uncertainty," states that two approaches for propagating the uncertainty associated with the seismic hazard estimate represented by Equation (2) of the same page, are available, i.e.; the Logic Tree approach and the Monte Carlo approach. However, the section lacks needed guidance regarding the minimum acceptance criteria for demonstrating that uncertainty propagation was adequately implemented using either approach. As a minimum, the report should discuss with some details the level of calculations for propagating uncertainties which would render the results of seismic hazard estimate acceptable for application in the Yucca Mountain site. Guidance for how to select alternatives for input parameters (Logic Tree approach) and rational selection of multiple

subjective probability distributions for various parameters (Monte Carlo approach) should also be given.

4. Paragraph 4, page C-5, states that for most seismic environments, use of the Poisson exponential recurrence relationship as represented by equation (C-4) is appropriate, but for Yucca Mountain site, consideration of non-stationary model of earthquake occurrence, such as, some forms of renewal models may be needed and such evaluation will have to be performed. An elaboration on the basis and criteria for requiring consideration of recurrence models with temporal and magnitude dependence in light of relevant Yucca Mountain site data is needed. Also indicate that if time dependency is used, what particular number of T (the pre-closure period of 100 years or the entire repository waste confinement and isolation period of the order of 10,000 years) will be used for integration to obtain probability of exceedance of a value z over the entire period T>1?

5. Regarding the subject of fault displacement relationships mentioned under section C3.3, page C-6, the discussion provided therein is too brief and general to serve the purpose of a topical report. A more detailed discussion on how the empirical observations of Basin and Range ruptures will be used to develop the Yucca Mountain specific fault displacement relationships, including an example of such application in developing the hazard curves for fault displacement should be provided. Also, some discussion of engineering basis and minimum acceptance criteria for designing against a prescribed fault displacement hazard within the Yucca Mountain GROA should be provided.

6. With respect to section C4.1.3, variability in ground motion or fault displacement, only brief mention is made regarding how to generally assess the fault displacement relationships on existing primary and secondary Type I faults within the Yucca Mountain GROA. A more detailed discussion of how such an evaluation will be implemented with an example is needed.

7. Referring to the last paragraph of page D-4 and Equation D-1 of the same page, provide a quantitative supporting rationale for stating that P_H, shown in Table D-2 produces ground motion levels which are consistent with UBC levels, NRC regulated fuel facility evaluation levels and nuclear power plant SSE levels for Performance Categories 1, 3 and 4, respectively.

8.. The use of Equation D-1, i.e.; $P_H = R_H (P_F)$ in conjunction with Tables D-1 and D-2 implies that the actually realized limit states of SSCs, whose design complies with design and acceptance criteria as represented by design codes and standards (e.g.; UBC stress and strain related acceptance criteria for performance category 1 SSCs; criteria similar to those of NRC's SRP including ACI, AISC, ASME, etc. for performance category 4 SSCs), are demonstrated to be identical or consistent with the seismic performance goal descriptions delineated in Table D-1. Provide more quantitative justification for making such an assumption of equivalence in SSC performance. To the extent that such demonstration of equivalence can not be effected, the implied claim of achieving the stated "Numerical Seismic Performance Goal, P_F" should not be made without reservation. Further refinement in showing correlations between limit states of SSCs defined in the context of compliance with code based design and evaluation criteria and the narrative seismic performance goal descriptions is needed to render the proposed seismic hazard assessment methodology as well as the numerical seismic performance goal P_F more credible.