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August 15, 2008 Via e-mail

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Savannah River Site
Building 730-4B, Room 3125
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Dear Mr. Salomone:

Reference: *Central and Eastern United States Seismic Source Characterization for Nuclear Facilities:* Participatory Peer Review Report on Workshop No. 1.

**Acronyms**

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| CEUS | Central and Eastern United States |
| COLA | Combined Operating License Application |
| EPRI | Electric Power Research Institute |
| PPRP | Participatory Peer Review Panel |
| PSHA | Probabilistic Seismic Hazard Analysis |
| SOG | Seismicity Owners Group |
| SSC | Seismic Source Characterization |
| SSHAC | Senior Seismic Hazard Analysis Committee |
| TI | Technical Integrator |
| USGS | U.S. Geological Survey |

This letter constitutes the report of the Participatory Peer Review Panel on Workshop No. 1 (WS-1), "Significant Issues and Databases," for the referenced project. The workshop was held July 22–23, 2008, at EPRI headquarters in Palo Alto, California.

Following guidance described in the implementation plan for the PPRP[1], and consistent with the expectations of the SSHAC process[2], the PPRP participated in WS-1 in order to be informed and to review both procedural and technical aspects of the workshop.

Five members of the PPRP (J. Ake , W. Arabasz, W. Hinze, A. Kammerer, and D. Moore) and one of the Sponsor Representatives (C. Munson) attended WS-1 and were able to fully observe all aspects of the workshop. The other three PPRP members (J. Kimball, M. Petersen, and C. Stepp) and the other Sponsor Representative (B. Gutierrez) were subsequently provided with electronic copies of all presentations made at WS-1.

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[1] *Implementation of the PPRP's Participation in the CEUS SSC Project*: Written statement communicated by J. Carl Stepp to L. Salomone and the TI Team on June 16, 2008.
[2] Budnitz, R. J., G. Apostolakis, D. M. Boore, L. S. Cluff, K. J. Coppersmith, C. A. Cornell, and P. A. Morris, 1997. *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts.* NUREG/CR-6372, Washington, DC, U.S. Nuclear Regulatory Commission.

Based on our observations we offer the following comments and recommendations:

1. ***Basic goals of workshop —*** Under the pressure of an aggressive schedule, the Management and TI teams (hereafter "Project Team") organized a successful workshop that achieved many of the basic goals of WS-1. The TI Team effectively framed the CEUS SSC project and gave useful, informative introductory overviews to the project participants. Results of detailed sensitivity analyses were presented that provide a sound basis for initiating the identification and evaluation of issues that will be of primary significance to the SSC project. The resource experts that were convened described and discussed diverse databases pertinent to the assessments required for development of a CEUS SSC model, and they generated productive discussions.

   We concur in general with the important seismic hazard issues identified in the presentation on sensitivity results. However, evaluating these requires some fundamental considerations such as those elaborated in Item #3, below. These include a state-of-knowledge understanding of the mechanisms involved in earthquake occurrence in the CEUS, the definition of earthquake sources, the assessment of maximum earthquake magnitude, and the characterization of the New Madrid and Charleston seismic zones.[3]

   While the resource experts did a high-quality job of describing data sets, the uncertainty in the data sets was not generally described. Uncertainty involving both quality and quantity of data—including non-uniqueness of interpretation—is fundamentally important for assessing a SSC model, both for evaluating alternatives and for considering the longevity of the results of the study. Future improvements in the quantity and quality of the data being used in the analysis may have an important effect on uncertainty and thus the stability of seismic hazard assessment. Evaluation and understanding of the present uncertainty in the data sets should be a key element of the assessment. <u>In order to fully address this important need, we recommend that the TI Team continue to interact with the data resource experts to evaluate the uncertainty in their data.</u> In this connection, we emphasize the importance of obtaining germane reference lists from the resource experts.

2. ***How will data sets be used? —*** As the workshop unfolded, the tight schedule resulted in decoupling two aspects that were intended to be more integrated. The stated goal of WS-1 was "to identify the issues of highest significance to a SSC model for the CEUS and to identify the data and information that will be required

[3] The considerations referred to in this paragraph were originally described in a memorandum from the PPRP to the Project Manager and the TI Team on June 3, 2008 to aid in planning WS-1. The memorandum was accompanied by elaborations on key issues for the CEUS SSC written by three individual PPRP members. We include a copy of these materials here as Attachment A, which serves simply as an information item and for useful documentation.

to address those issues."[4] The parts were presented, but the whole was not developed to the extent that it was clear how the data sets described and discussed, other than the earthquake catalog, will be used by the TI Team in assessing the SSC model. We recognize that evaluation and use of diverse databases will be the focus of efforts by the TI Team before Workshop #2, but we are concerned whether the schedule for data compilation will fully support these efforts.

We note the following potential scheduling conflicts and issues:

- The schedule for the project specifies that a preliminary SSC model be completed over the period December 2008 to August 2009. However, the data sets, including the earthquake catalog, that will be used to evaluate and assess sources are not scheduled to be completed until June 2009. We recommend prioritizing this work element to ensure that the critical data sets are completed early so that the assessment is not left until the final two months of the assessment effort**.**

  Use of the data sets would be very much enhanced if the quality and quantity of the data over the CEUS could be identified in the data maps and within the data sets and if the information is clearly documented. This concern arises because of the highly variable nature of data quality and quantity over the CEUS. Further, documentation of the quality of any data incorporated into the SSC will ultimately be a requisite for this and future PSHAs.

- A comprehensive data set of seismic reflection profiling over the CEUS was not presented at the Workshop, and it is not clear that procedures are in place to identify relevant seismic reflection profiles and to make them available to the project. A number of important reflection profiles, either acquired from industry or conducted by academic institutions, have been interpreted in terms of crustal structure and tectonic elements relevant to the CEUS SSC. Interpretations of these data that are in the public domain are spread throughout the geoscience literature. In view of the potential significance of the information from the seismic reflection profiles, not only for identifying seismic source zones and their properties but also for evaluating competing tectonic models, we recommend that interpretations of relevant seismic reflection profiles over the CEUS that are in the public domain be compiled for use in the project.

Experience from past projects shows that unless the scientific utility of diverse data sets is thought through at an early stage, the default will be heavy reliance on historical and instrumental seismicity. The issue of stationarity must be addressed—while keeping in mind that an implicit goal of the project is to achieve a good predictor of seismicity for the next 50 years.

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[4] Task 5: Workshop #1 Significant Issues and Databases, *Project Plan: Central and Eastern United States Seismic Source Characterization for Nuclear Facilities*, EPRI, June 2008, p. 4-4.

3. ***Identifying key SSC issues and alternative viewpoints —*** The PPRP recognizes the difficulty of identifying the SSC issues and relevant alternative interpretations that will be central to achieving the goals of Workshop #2 (WS-2). We recommend that the TI Team initiate identification and evaluation of these issues and interpretations as early as possible—to allow time for their full consideration prior to WS-2 and to ensure completeness vis-à-vis the diversity of views within the informed technical community. To this end, the PPRP has identified some key issues that should be considered when preparing for WS-2; these are listed below.

    - **Seismotectonic Model** — A fundamental requirement for the CEUS SSC is a state-of-knowledge understanding of the tectonic mechanisms (i.e., processes that explain the occurrence of earthquakes in time and space) involved in the occurrence of earthquakes within the study region. Important issues related to elements of the model would include: (1) the origin, direction, and strength of ambient stress; (2) the potential influence of variations in tectonic structure and crustal material properties on variations in the stress field; (3) the time-frame over which the stress field can be considered stationary; (4) the current knowledge base for age of tectonic faulting and for the correlation of age of tectonic faulting with tectonic domains and tectonic history; and (5) properties of the intermediate crust at depths where most earthquakes nucleate and the spatial correlation of these properties with historic and instrumental seismicity.

    - **Definition of Earthquake Sources** — A systematic approach and procedure for defining earthquake sources would contribute to the consistency and transparency of the assessment. A transparent approach would be to develop a matrix of criteria that would be used to perform a weighted integrated assessment of the state of knowledge. This would apply to observed tectonic structures and tectonic structure domains, knowledge about the age of tectonic faulting, knowledge about the material properties of the crust, and knowledge about seismicity rates. All of this would be in the context of the seismotectonic model used for defining and characterizing tectonic structure-specific sources, area tectonic domain sources, and tectonic-based background sources.

    - **Approach to Establishing Earthquake Rates Using Smoothed Seismicity** — For a trial area source zone it may be useful to compare results using the USGS approach to smoothing seismicity (for the U.S. National Seismic Hazard Maps) versus the smoothing options used in the EPRI-SOG project[5]. Such a comparison could help in understanding

[5] Seismic Hazard Methodology for the Central and Eastern United States, 10 Volumes, EPRI NP-4726, July 1986.

differences between the two approaches and in establishing a suitable basis for assessing use of the two approaches in the current study.

- **Assessment of Maximum Earthquake Magnitude** — An approach is needed for assessing maximum magnitudes for earthquake sources that takes into account current knowledge and uses systematic procedures for assessing maximum magnitude based on the tectonic characteristics of an earthquake source—whether a structure-specific source, an area source, or a background source.

- **Characterization of New Madrid and Charleston Seismic Zones** — A fundamental issue relates to the interpreted repeat occurrence within the past few thousand years of large earthquakes in the CEUS (specifically, earthquakes associated with the New Madrid and Charleston seismic zones)—without evidence of substantial deformation in the near-surface rocks during post-Cretaceous time. The body of observed data and information (paleo-liquefaction mapping and interpretations) that form the basis for these interpreted repeat earthquakes should be critically evaluated. Also, the uncertainties in both the observations and interpretations need to be thoroughly understood. Further, interpretations of these data that postulate localized high rates of seismic strain release within the recent past—without observed significant surface deformation—require explanation in the context of a viable tectonic model.

We consider a comprehensive implementation of this step of the SSC assessment to be central and essential in order to achieve the shared goals of the Project Team and the Project Sponsors for (a) the stability of the SSC assessment and (b) its desired broad use into the future. Because of the key importance of WS-2, we recommend that the Project Team actively engage the PPRP in reviewing and commenting on the planning of WS-2 and in the development of the workshop agenda.

4. ***Longevity of the SSC and ability to update it in the future —*** In the Project Plan, *longevity* was defined to mean "that the technical underpinnings will remain valid in the future, despite the development of new scientific findings." Anticipating industry and regulatory needs, the PPRP urges careful attention to two aspects of the SSC process: (1) that there be transparency in the SSC model, the technical bases of the SSC model, the related uncertainties, and the SSC process—so that the resulting product can readily be updated in the future and (2) that front-end decisions not compromise the usefulness of the SSC product in the future.

   To explain what we mean by the second statement, consider the working criterion suggested at WS-1 to define a threshold of significance in the sensitivity analyses (namely, a specific percentage change in hazard). While such an approach is useful in focusing attention on what is important, we want to ensure that such a cutoff does not curtail analysis or documentation that may be important later. An example might be the elimination of logic-tree branches with an assigned low weighting (at this time). When users in the future ask how the SSC team would

have treated a particular new development, the question should be answerable from the documentation of the CEUS SSC project.

5. ***Six test sites for hazard calculations*** **—** The PPRP believes that the six (or more) test sites to be selected for hazard calculations as part of the CEUS SSC project (Project Tasks 4 and 9) will be fundamentally important to the success of the project, both scientifically and vis-à-vis stakeholder interests. Accordingly, the PPRP has an ongoing interest in learning more about how the test sites will be selected and how hazard calculations at the selected sites will guide future stages of the project. The selection of sites can usefully be used "to challenge the process" of the SSC modeling, and it can test the influence of major seismic sources outside the study area.

   We note that the Project Plan called for the selection of six test sites (under Task 4) prior to WS-1 for sensitivity studies to assess key SSC issues, but this was not accomplished. Instead, sensitivity calculations were presented for a group of sites ("Group A sites") extending along a line roughly transverse to a major line source and for another group of sites ("Group B sites") at differing distances from a major areal source.

   Insofar as the planned test sites (a) have not yet been selected and (b) apparently will play an important role later in the SSC process, the criteria for site selection will be of great interest to the PPRP beyond the example given in the Project Plan. We note that in the discussion of the test site selection in the Project Plan (see p. 4-4) the provision is made that the sites should be "as generic as possible." We recommend that the sites should be *representative* of the range of seismogenesis over the region of applicability of the CEUS SSC model.

6. ***Applicable study region*** **—** The CEUS SSC model assessed in this study will be used for developing site-specific PSHAs for sites within the United States eastward of the Rocky Mountains. Regarding database coverage, the Project Plan issued in June 2008 (p. 4-1) states:

   > "The database will be designed to include the following regional data layers to provide coverage of the entire CEUS and extend a minimum of 200 miles beyond the coastline (or the edge of the continental slope if it is less) and 200 miles from the US borders with Canada and Mexico. The western boundary of the study region will be the foothills of the Rocky Mountains (about longitude 105° W), except that it will include the Rio Grande Rift system . . ."

   We observe that various discussions during WS-1 touched on the potential importance of large magnitude sources distant from a site, which might include, for example, seismic sources in the Caribbean or Canada beyond the planned 200-mile limit. Thus, in considering scoping issues for database and SSC coverage, the Project Team needs to be mindful of limitations that may result in the applicability of the project's products for future siting in some parts of the CEUS. Recent COLA applications regarding geographic areas of potential interest for future siting

(e.g., Texas, Florida) and appropriate interactions with industry sponsors can help inform the decision-making about geographic scoping.

These observations and recommendations are our primary ones at this time. We thank you for facilitating our participation in WS-1 and for the opportunities to pursue discussions with you and other members of the Project Team.

Do not hesitate to contact us if you wish to discuss any of our observations and comments.

Sincerely,

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Attachment: Copy of memo (with three enclosures) from PPRP to L Salomone, K. Coppersmith, and TI Team, communicated by e-mail on June 3, 2008

Copy:
PPRP Members
Sponsor Representatives