July 5, 2013

Ms. Kimberly A. Keithline
Senior Project Manager
Nuclear Energy Institute
1776 I Street NW, Suite 400
Washington, DC 20006-3708

SUBJECT: RESPONSE TO NUCLEAR ENERGY INSTITUTE REQUEST FOR REVIEW OF ELECTRIC POWER RESEARCH INSTITUTE GROUND MOTION MODEL REVIEW PROJECT FINAL REPORT ASSOCIATED WITH RESOLUTION OF FUKUSHIMA NEAR-TERM TASK FORCE RECOMMENDATION 2.1: SEISMIC"

Dear Ms. Keithline:

On behalf of the U.S. Nuclear Regulatory Commission (NRC or the staff), I am responding to the Nuclear Energy Institute's (NEI's) June 3, 2013, letter[1] transmitting the Electric Power Research Institute (EPRI) final product, EPRI (2004, 2006) Ground-Motion Model (GMM) Review Project (EPRI GMM Report). The June NEI letter transmitted the final EPRI GMM Report for NRC staff endorsement by August 30, 2013. The updated GMM was developed for use by nuclear power plants in the central and eastern United States in responding to site-specific seismic hazard reevaluations requested by NRC letter dated March 12, 2012, per Title 10 to the *Code of Federal Regulations*, Section 50.54(f).

The staff has reviewed the EPRI GMM Report and has provided comments in the enclosure. The staff is unable to endorse the EPRI GMM Report until the enclosed comments are addressed. The staff has scheduled a public meeting to discuss the EPRI GMM Report and to clarify its comments on August 6, 2013.[2]

[1] The EPRI Report can be found in the Agencywide Document Access and Management System (ADAMS) at package Accession No. ML13155A553.
[2] The meeting notice can be found in ADAMS at Accession No. ML13164A194 and on the NRC's public meeting website, http://www.nrc.gov/public-involve/public-meetings/index.cfm.

If you have any questions, please contact Ms. Lisa Regner at 301-415-1906 or by email at Lisa.Regner@NRC.gov.

Sincerely,

Matthew A. Mitchell, Chief
Projects Management Branch
Japan Lessons-Learned Project Directorate
Office of Nuclear Reactor Regulation

Enclosure:
NRC Staff Comments

cc: see enclosed list

If you have any questions, please contact Ms. Lisa Regner at 301-415-1906 or by email at Lisa.Regner@NRC.gov.

Sincerely,

/RA/

Matthew A. Mitchell, Chief (L. Regner for)
Projects Management Branch
Japan Lessons-Learned Project Directorate
Office of Nuclear Reactor Regulation

Enclosure:
NRC Staff Comments

cc: see enclosed list

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OFFICE	NRR/JLD/LA	NRR/JLD/PMB/ PM	NRR/JLD/PMB/ BC
NAME	SLent	LRegner (NF for)	MMitchell (LR for)
DATE	7/3/2013	7/5/2013	7/5 /2013

OFFICE	NRO/DSEA/ SLS *	NRO/DSEA/ DD*
NAME	CMunson	NChokshi
DATE	7/3/2013	7/3/2013

Comments on Electric Power Research Institute (EPRI) 2013
Central and Eastern United States (CEUS)
Ground Motion Model (GMM) Update Review Project

Question 1. Section 7.10 contains a discussion of the development and rationale for the updated aleatory uncertainty (sigma) model used in the 2013 Ground Motion Model (GMM) update. The Electric Power Research Institute(EPRI) (2006) model for aleatory uncertainty was based on preliminary PEER NGA models for sigma from active tectonic regions with adjustments that account for differences between active and stable tectonic regions. The model for sigma used in the present study is again based on preliminary aleatory uncertainty models that have been under development for active tectonic regions as part of the NGA-West 2 project. Subsequent to the publication of the EPRI (2006) aleatory variability study, the final NGA-West sigma models were published and differed significantly from those referenced in the EPRI study. Specifically, magnitude dependence in sigma was incorporated into the models. Considering the preliminary state of the NGA-West 2 sigma models and the potential for future modifications, discuss the use of the NGA-West 2 sigma models as the basis for the aleatory uncertainty model used for the EPRI (2013) GMM update.

Question 2. The PEER NGA-East database includes estimates of epicentral and hypocentral distance measures for each earthquake recording. Section 7.2.4 of the EPRI (2013) GMM update provides a discussion of the procedures used to estimate the rupture and Joyner-Boore distance measures that are applied to the NGA-East database given the epicentral and hypocentral distances. The two paragraphs following equation 7.2.4-2 describe the assumptions used to compute the vertical and horizontal location of the simulated ruptures and the simulation process. Please provide a clear definition of the hypocentral depth ratio and additional discussion on the simulation process.

Question 3. The EPRI (2004) GMPEs were developed to provide estimates of ground motion on hard rock sites with shear-wave velocities of 2,800 m/s or greater, and this is also the reference site condition utilized in the EPRI (2013) GMM update. As there are no stations with measured or estimated shear-wave velocities at or near the 2,800 m/s in the PEER NGA-East database, a procedure has been used for the EPRI (2013) GMM update to adjust the recorded ground motions to the hard-rock reference condition. This adjustment was performed using two alternative approaches: an analytical approach for sites with a measured shear-wave velocity profile, and an empirical approach for sites where the shear-wave velocity is inferred from geologic conditions. In order for the staff to better understand these two approaches; please provide further clarification regarding the following:

a. As described in Section 7.3 of the report, for sites located on stiff soil or soft/intermediate rock conditions site corrections were estimated. For sites with measured near-surface shear-wave velocity profiles an analytical approach was used to calculate site-specific amplification functions. For sites without measured near-surface shear-wave velocity profiles an empirical approach to estimate site correction factors for broad site classes was employed. The results obtained from these calculations were then used to correct the observed data prior to estimating the quality of the fit of each GMPE used in the updated GMM. There is significant uncertainty in estimating and extrapolating the shear-wave velocity profile to depth for the analytical approach and in classifying the sites in the empirical approach. The report recognizes these uncertainties and attempts to estimate them and propagate them through the process (as described in Section 7.4.3). However, the degree to which these uncertainties influence the final

choice of weights in the model is not made clear. Please discuss and document the impact of the uncertainties on the final model.

b. The EPRI (2013) GMM update report indicates in several places that sites with measured or inferred V_{S30} values less than 500 m/s are not used in the analysis. However, in the discussion of the analytical approach in Section 7.3.1.2 (pg. 7-13) the bulleted list of methods used to estimate kappa used in the EPRI SPID describes how soil sites with V_{S30} < 500 m/s are treated. Please clarify the treatment of these types of sites for the GMM update with regard to whether they are or are not used as part of the analysis.

c. In Section 7.3.3 of the EPRI (2013) GMM update report, example amplification factors developed using the empirical and analytical methods are compared. It is not clear from the description provided in Section 7.3.3 how the empirical results shown in Figures 7.3.3-1 through -4 were developed. Please clarify how the empirical results were obtained. Specifically, clarify which of the three empirical Models was used how the residuals are computed (relative to EPRI 2004 or the update GMM).

d. In the last paragraph of Section 7.3.3, reference is made to Figure 7.3.3-5 which is from the NGA summary report of Abrahamson et al. (2008). The text indicates that the figure illustrates consistency with the proposed EPRI (2013) amplification factors. Provide clarification on whether the cited figure is the appropriate figure and supports the conclusions in the text.

e. In Section 7.4.3.1 the report describes the process used in the calculation of weights for a particular frequency, cluster, and approach for adjusting to reference site conditions. This approach works with the amplitude predicted for each GMPE (equation 7.4.3-1). In Equation 7.4.3-3 the process for including the uncertainty in site adjustment is described. The term δC_{JK} is identified as the uncertainty in the adjustment factor to reference rock for the kth station (with standard deviation $\sigma_{C,jk}$). However, these terms are non-zero only for the empirical soft-rock stations (see Figures 7.3.3-1 through -4). Also, following the description in Section 7.3, for a single station and a single GMPE using the empirical approach the uncertainty in the amplification is zero. The uncertainty for a single GMPE arises from looking at residuals across all stations of a given site type (soft-rock*).* Provide additional clarification on how this approach to incorporating the uncertainty is employed for the sites with empirical site corrections. In addition, provide additional clarification and discussion of how the standard deviation described in Section 7.4.3.1 is developed for the empirical stations.

Question 4. In Section 7.6.2 the cluster median GMMs are developed and presented. Equation 7.6.2-2 specifies the functional form for Cluster 2. This equation, specifically the expression for R', does not match the equation in the Hazard Input Document (Appendix I of the report). Please provide an explanation for the discrepancy.

Question 5. In Section 7.11.1 the EPRI GMM update report describes the rationale for developing a separate GMPE for the Gulf Coast and the boundaries of that region. Specifically, the report notes: "The southern part of the Gulf Coastal Plain is underlain by thinned continental crust that was affected by early Mesozoic extensional tectonics associated with the formation of the Gulf of Mexico (Salvador, 1991a; EPRI/DOE/NRC, 2012). This crustal thinning can be expected to have some impact on the propagation of the Lg phase." The report further states

that: "An additional factor affecting attenuation in this region is the presence of an extremely thick Mesozoic and Cenozoic sedimentary section in the region affected by crustal extension. Near the coastline in Texas, Louisiana, and Mississippi, the sedimentary section reaches a thickness in excess of 10 km (Salvador, 1991b)."

While the above statements are supported by the references in a broad sense, it is not clear that the Florida peninsula falls into the same geophysical and geological category as the rest of the Gulf Coast. While very thick sequences of geologically young sediments do exist under the Gulf Coast of Texas, Louisiana, Mississippi, and Alabama, these same types of deposits are not present beneath much of Florida. Much of the basis for developing the correction factors to apply to the Mid-Continent GMPEs (the different regional Q values) comes from the analysis of data from the EarthScope Travelling Array. The TA is just now beginning to be deployed in the Florida region. Hence, data is not available to verify regional Q values in the Florida peninsula.

Given that: the southeastern boundary of the updated Gulf Coast region differs from that utilized in the EPRI (2004) model, basic data to very regional Q-values in Florida are not available, and the thickness of the young sediments beneath the Florida peninsula is much less than that beneath the rest of the Gulf Coast, the definition of the southeastern boundary of the Gulf Coast attenuation region may be subject to considerable uncertainty. Please provide additional discussion and justification for the proposed boundary in Florida.

Question 6. Section 7.2.2.1 of the EPRI (2013) GMM update report briefly described the processing of the database, which was performed by Cramer as part of the NGA-East project, and references Cramer et al. (2013). In order for the staff to better understand the processing of the database, please respond to the following questions.

a. Section 7.2.2.1 states that each recording was assigned a quality code, typically either "A" or "?", and that generally only records with quality level "A" were retained for this project. In addition, some recordings assessed as "?" were also retained for the project. Provide a description of the criteria used to (1) assess the quality of the recording and (2) retain recordings evaluated as questionable with a "?".
b. With respect to the NGA-East report (Cramer et al. (2013)), clarify how pre-event noise was obtained for triggered instruments or other instruments with limited pre-event memory.
c. The NGA-East strong motion processing report on page 9 states that a 2% cosine taper was used. Provide more detail on the use of the 2% cosine taper, especially for recordings with little or no pre-event memory.
d. Provide more detail on the signal processing filtering of the data (Butterworth?), including the order of the filter and the criteria for selecting the corner frequencies. In addition, provide more detail on the processing and combination of the two horizontal channels.
e. Provide further detail on the type of weak-motion recordings (broadband, short-period) retained for the project as well as the percentage relative to the strong-motion recordings.
f. Elaborate on the filtering of long-periods and the potential for over prediction at large period.
g. Provide further detail on the criteria for determining the size of the structure for the recording sites. Were the ANSS definitions used?

Question 7. Section 7.13 of the report provides sensitivity calculations to investigate the effects of a number of alternative assumptions. One alternative assumption that is not discussed is the

overall impact of including additional uncertainty to account for magnitude scaling. Please provide a discussion of the relative importance of adding this factor, specifically with respect to the within-cluster epistemic uncertainty.

Question 8. Table A.6-1 contains the information on the ~1890 recordings used in this project. The unadjusted PGA and SA values are contained in this flat-file. Table A.6-4 contains the analytically adjusted PGA and SA values for the approximately 90 recordings obtained at stations where shear-wave profiles exist and the analytical adjustment could be performed. By simply taking the ratios of these values the analytical adjustment factors can be obtained. However, no comparable table of the empirically adjusted spectral accelerations is provided. Please provide the flat-file for the empirically adjusted spectral accelerations.