Ronald B. Clary
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SCE&G®
A SCANA COMPANY

September 11, 2009
NND-09-0266

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

ATTN: Document Control Desk

Subject: Virgil C. Summer Nuclear Station (VCSNS) Units 2 and 3 Combined License Application (COLA) - Docket Numbers 52-027 and 52-028 Supplemental Response to NRC Request for Additional Information (RAI) Letter No. 060

Reference:
1) Letter from Chandu P. Patel (NRC) to Alfred M. Paglia (SCE&G), Request for Additional Information Letter No. 060 Related to SRP Section 02.05.02 for the Virgil C. Summer Nuclear Station Units 2 and 3 Combined License Application, dated July 30, 2009.
2) Letter from Ronald B. Clary (SCE&G) to Document Control Desk (NRC) dated August 31, 2009, Response to NRC Request for Additional Information (RAI) Letter No. 060.

The enclosure to this letter provides the South Carolina Electric & Gas Company (SCE&G) supplemental response to RAI items 02.05.02-20 and 02.05.02-27 included in the above referenced letter from the NRC to SCE&G.

The enclosure also identifies any associated changes that will be incorporated in a future revision of the VCSNS Units 2 and 3 COLA.

The supplemental information contained in the files on the enclosed CD is provided to support the NRC's review of the VCSNS Units 2 and 3 COLA, but does not comply with the requirements for electronic submissions as stated in NRC Guidance Document, "Guidance for Electronic Submissions to the NRC," dated October 29, 2008. The NRC staff requested that these files be provided in their native format as required for utilization in the software employed to support the COLA review. Formatting the data to comply with the guidance on electronic submissions would not serve the request to provide these files in their native formats.

Should you have any questions, please contact Mr. Al Paglia by telephone at (803) 345-4191, or by email at apaglia@scana.com.

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NRO

I declare under penalty of perjury that the foregoing is true and correct.

Executed on this 11th day of September, 2009.

Sincerely,

Ronald B. Clary

Ronald B. Clary
Vice President
New Nuclear Deployment

AMM/RBC/am
Enclosure
c:

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NRC RAI Letter No. 060 Dated July 30, 2009

SRP Section: 02.05.02 – Vibratory Ground Motion

Questions for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-20

In response to RAI 2.5.2-1, the applicant provided an electronic data file containing the mean seismic hazard by source for each of the EPRI teams, for 1 Hz and 10 Hz spectral acceleration. In addition, the applicant provided a file which consisted of the total mean hazard curves for 1, 2.5, 5, 10, 25, and 100 Hz structural frequencies. The staff is trying to determine the contribution to the total mean hazard (1 and 10 Hz) from the updated Charleston seismic source zone, the New Madrid seismic source zone, as well as the ETSZ seismic sources as defined by the Nuclear Energy Institute (NEI) (ML#081720144) study. For this reason, please also provide an additional file that contains the total mean hazard values for 1 Hz and 10 Hz spectral accelerations as well as the actual weighting of each source, the corresponding contributions from the updated Charleston seismic source zone, the New Madrid seismic source zone, the ETSZ seismic sources as defined by the Nuclear Energy Institute (NEI) (ML#081720144) study, as well as the remaining hazard.

VCSNS RESPONSE:

File MEAN_BY_SOURCE_R1.TXT contains electronic data for 1 Hz and 10 Hz consisting of 1 column of ground motion amplitude, 53 columns of mean hazard curves for 53 team sources, 1 column of mean hazard from the New Madrid source, 4 columns of mean hazard from the 4 geometries of the Charleston characteristic source, and 4 columns of mean hazard from the 4 geometries of the Charleston exponential source. The 8 columns of mean hazards from the Charleston sources have the probability for each geometry included in the mean hazard. The 53 team sources are those used in the seismic hazard calculation; no additional sources were added from the NEI study. The last 3 columns consist of the following: (1) the total weighted hazard taken from individual mean hazard curves (in the previously described columns), calculated as the sum of hazards for the 53 team sources divided by 6 (because 1/6 is the weight on each team), plus the sum of hazards from the New Madrid and Charleston sources (because these are common to all 6 teams); (2) the total hazard reported previously, which was calculated from software that calculates the distribution of total hazard; and (3) the % difference between the previous two columns. The last column indicates that, for ground motions with mean hazards exceeding 10^{-6} per year, the total hazard calculated from software is slightly conservative (less than 1.5% in hazard) because of approximations to the distribution of hazard made for each source for reasons of efficiency, and because of roundoff in the calculations (adding the sum of many small hazards to 1 or 2 much larger hazards).

ASSOCIATED VCSNS COLA REVISIONS:

None

ASSOCIATED ATTACHMENTS:

CD containing file MEAN_BY_SOURCE_R1.TXT

NRC RAI Letter No. 060 Dated July 30, 2009

SRP Section: 02.05.02 – Vibratory Ground Motion

Questions for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-27

The staff reviewed your response to RAI 2.5.2-14. However, the figures provided by you in your response (i.e. Figure RAI-14A and RAI-14B) are difficult to read. Please provide electronic versions of the data used to plot these figures in order for the staff to verify your conclusions that the two more recent equations, published since the EPRI (2004) study, are consistent with the EPRI (2004) study. In addition, please clarify whether the "weighted average" of Equations 1 through 12 in RAI response Figure RAI-14A and RAI-14B reflects the actual weights of these equations as represented in the EPRI 2004 ground motion model (i.e. ground motion model clusters, individual models, and weights recommended when multiple source types are used for hazard calculations) or whether it reflects an equally weighted average. If an equally weighted average was used, please provide justification for not using the actual EPRI weights. Furthermore, in Figure RAI-14B, which plots predicted ground motions for M=5.7, the EPRI models EQ10, EQ11, and EQ12 should not be included because they are only for earthquakes with magnitudes larger than 6.0.

In your response, you provided a plot of ground motion amplitudes for 1 Hz spectral acceleration for M=7 earthquakes versus distance for the 12 equations used from EPRI (2004), and for the Tavakoli and Pezishk (2005) and Atkinson and Boore (2006) references (i.e. Figure RAI-14A). You also provided a plot of ground motion amplitudes for 10 Hz spectral acceleration for M=5.7 (i.e. Figure RAI-14B). Since FSAR Table 2.5.2-218 shows that the controlling earthquakes for the VCSNS site range from M 6.1 to 7.3, please also provide additional plots for M=5.2, 6.1, and 7.3 in addition to those provided in response to RAI 2.5.2-14. You also stated in your response that the Petersen et al. (2008) ground motion model, which was used in the latest version of the USGS National Seismic Hazard Maps, does not constitute an independent ground motion model because it involves a weighting of many of the equations used in the EPRI (2004). However, it is the weights, not the particular set of models, that are crucial in determining the particular ground-motion values (as they are in the EPR 2004 model). Therefore, please provide further justification for not considering the Peterson et al. (2008) model as a separate and new ground-motion model.

In addition, please explain why the controlling earthquake for 5 and 10 Hz at 10^{-5} annual frequency of exceedance is not M ~ 5.0 to 5.5 at a distance of approximately 0 to 20 km (i.e. based on FSAR Figure 2.5.2-239), instead of M 6.1 at 70 km as listed in FSAR Table 2.5.2-218? FSAR Figure 2.5.2-239 shows that small, local earthquakes dominate the high frequency, and also that some contribution also occurs for low frequency motions from large, distant earthquakes in the Charleston SC region (i.e. closest distance to the Charleston seismic source zone is slightly greater than 100 km).

VCSNS RESPONSE:

Electronic versions of the data plotted in VCSNS Figures RAI-14A and RAI-14B are contained in text file RAI14_figures_data.txt. The "weighted average" curve uses the weights given in Figure 5-3 of EPRI (2004) for the 12 equations for "non-general area sources," not equal weights. Figure RAI 2.5.2-27.1 below re-plots the equations for M 5.7, 10 Hz, using the 9 "general area source" equations from EPRI (2004), and for this plot, the "weighted average" curve uses the weights given in Figure 5-2 of EPRI (2004) for the 9 equations for "general area sources." In this plot the Atkinson and Boore (2006) (AB06) and Tavakoli and Pezeshk (2005) (TP05) equations are shown as thick dashed lines. It is noted that EPRI (2004) recommends that the 12 "non-general area source" equations be used for sources where magnitudes >6.0 are the dominant contributors to ground motion, and smaller magnitudes within that same source should use the same 12 equations.

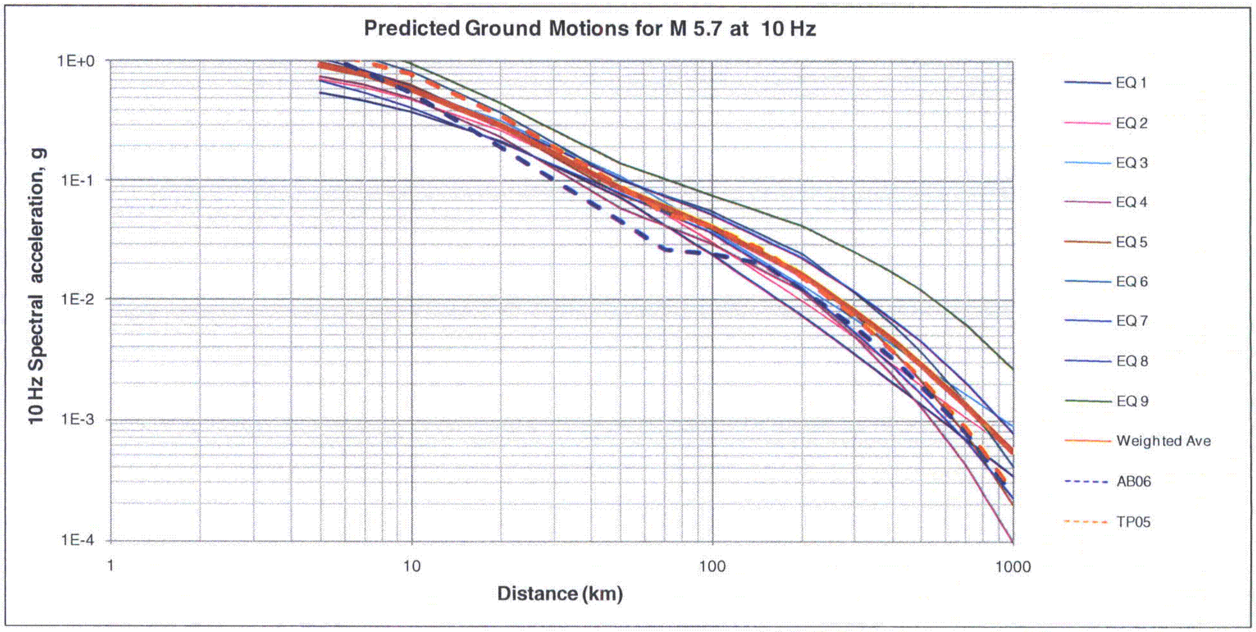

Figure RAI 2.5.2-27.1

10 Hz spectral accelerations predicted for M 5.7 for the EPRI (2004) models and for the Atkinson and Boore (2006) and Tavakoli and Pezeshk (2005) references, using the 9 "general area source" equations from EPRI (2004).

Plots comparing 1 Hz and 10 Hz spectral accelerations for **M**=5.2, 6.1, and 7.3 are included below as Figures RAI 2.5.2-27.2 through RAI 2.5.2-27.7. For **M**=5.2, the 9 EPRI equations for "general area sources" are plotted, and the "Weighted Ave" equation uses the weights given in Figure 5-2 of EPRI (2004) for these 9 equations. In all of these plots, the "Weighted Ave" EPRI equation is shown as a thick red line, and the AB06 and TP05 equations are shown as thick dashed lines.

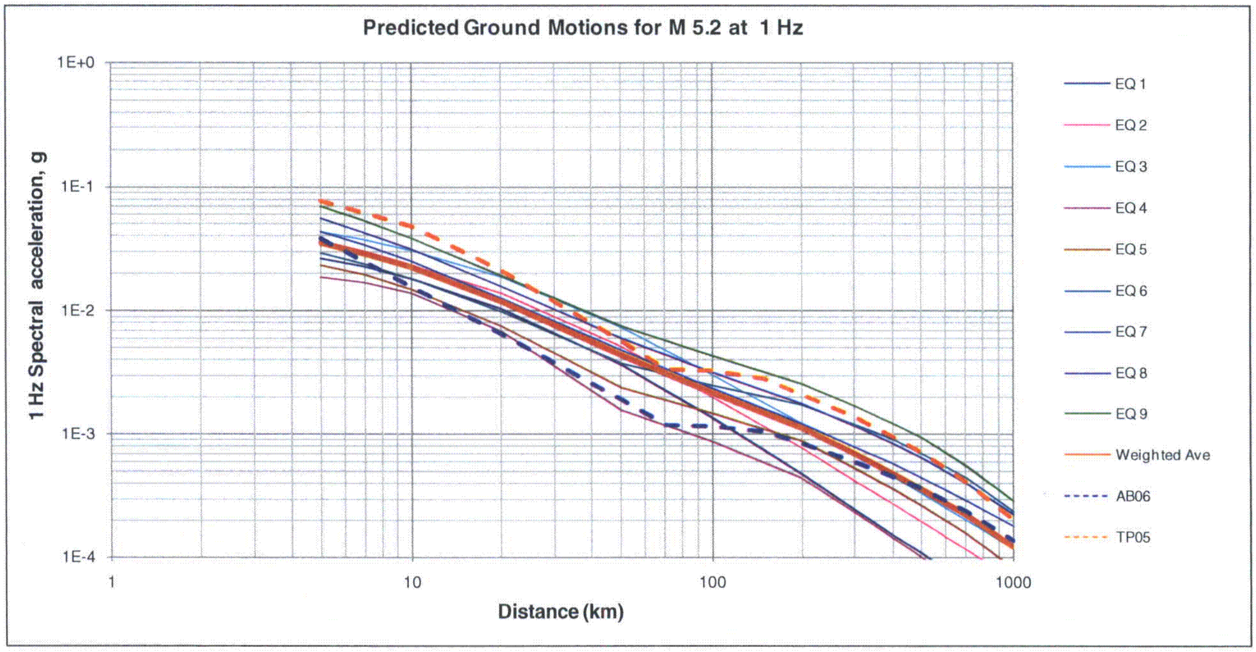

Figure RAI 2.5.2-27.2

1 Hz spectral accelerations predicted for M 5.2 for the EPRI (2004) models and for the Atkinson and Boore (2006) and Tavakoli and Pezeshk (2005) references, using the 9 "general area source" equations from EPRI (2004).

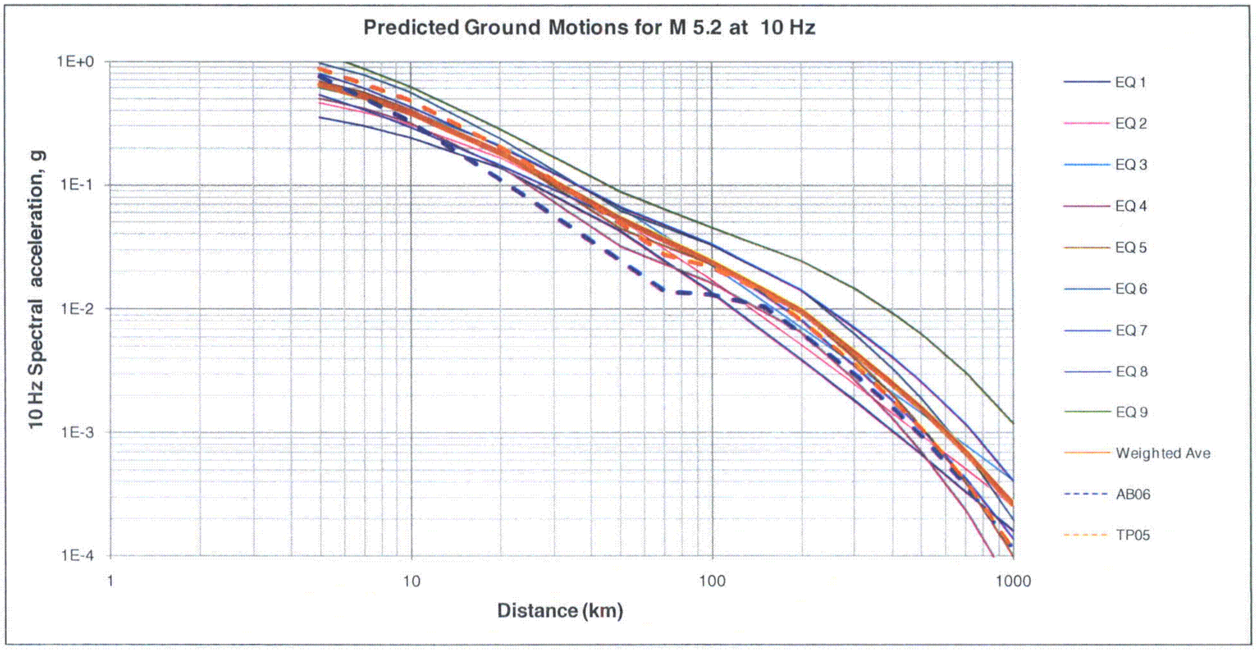

Figure RAI 2.5.2-27.3

10 Hz spectral accelerations predicted for M 5.2 for the EPRI (2004) models and for the Atkinson and Boore (2006) and Tavakoli and Pezeshk (2005) references, using the 9 "general area source" equations from EPRI (2004).

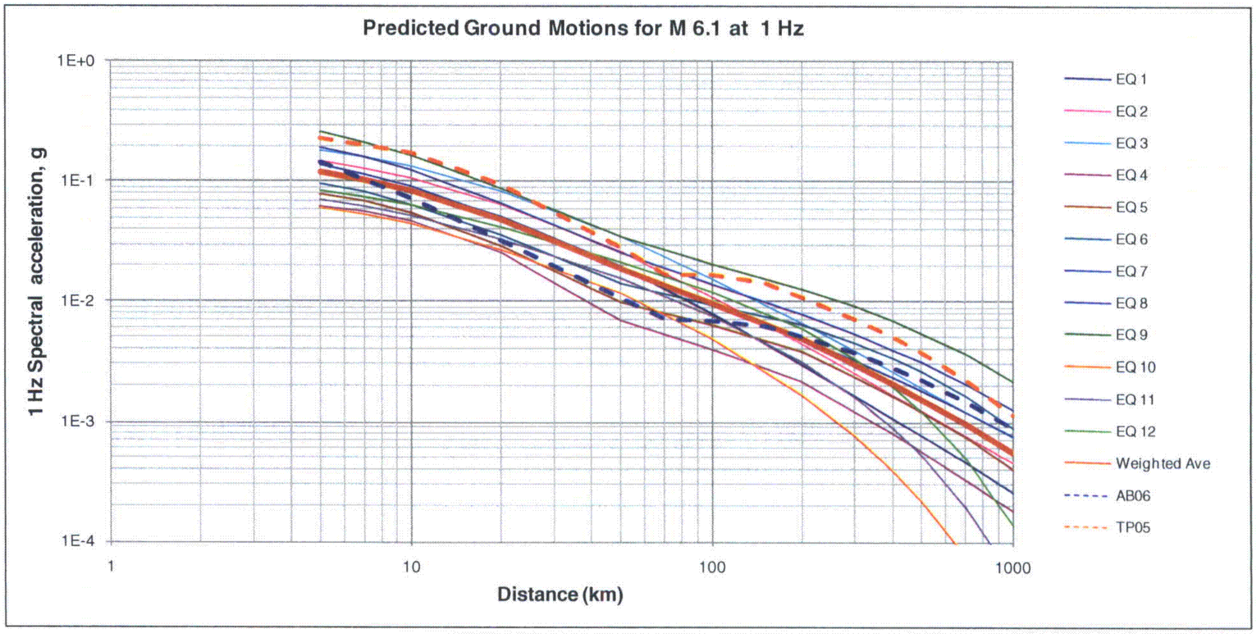

Figure RAI 2.5.2-27.4

1 Hz spectral accelerations predicted for M 6.1 for the EPRI (2004) models and for the Atkinson and Boore (2006) and Tavakoli and Pezeshk (2005) references, using the 12 "non-general area source" equations from EPRI (2004).

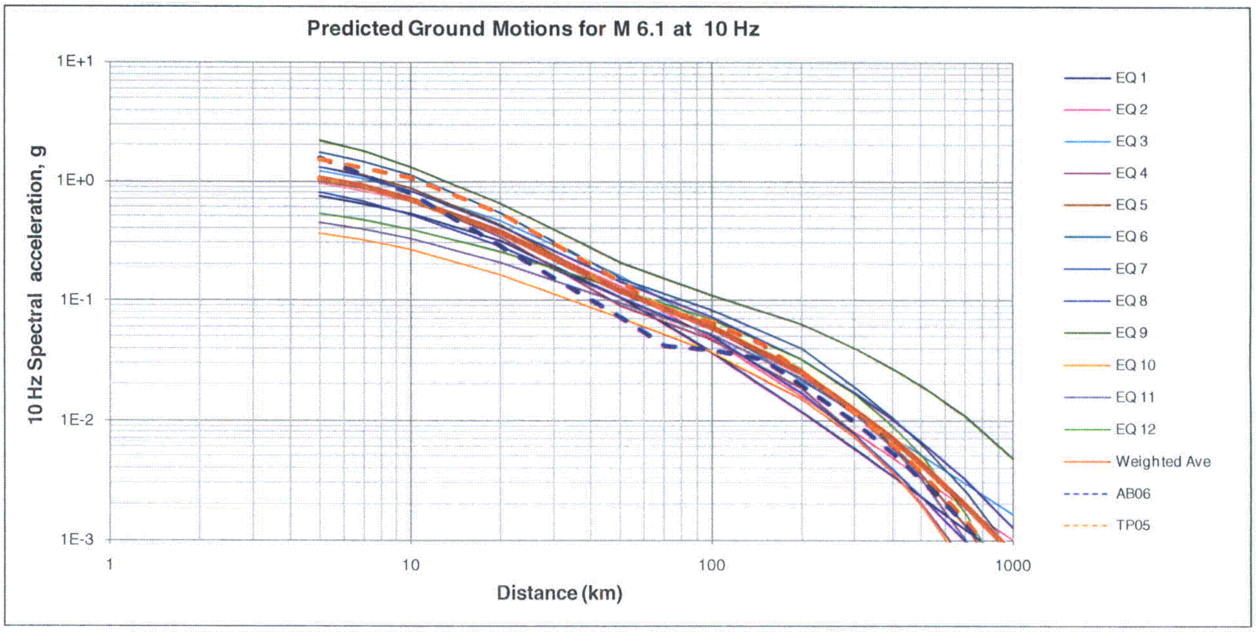

Figure RAI 2.5.2-27.5

10 Hz spectral accelerations predicted for M 6.1 for the EPRI (2004) models and for the Atkinson and Boore (2006) and Tavakoli and Pezeshk (2005) references, using the 12 "non-general area source" equations from EPRI (2004).

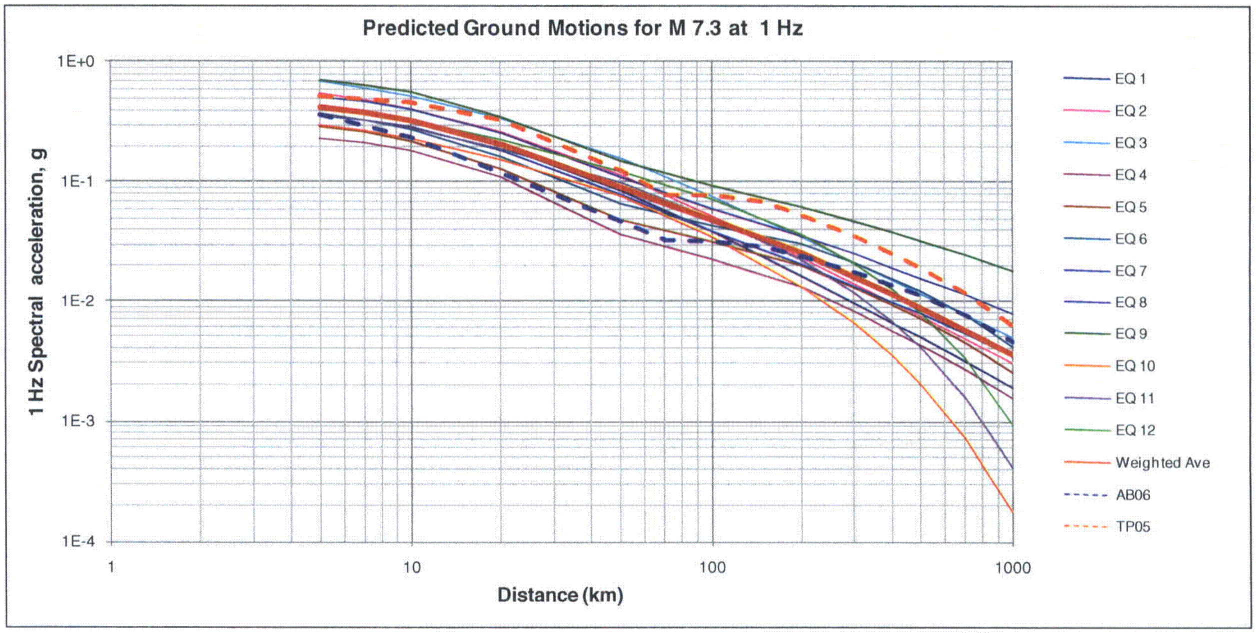

Figure RAI 2.5.2-27.6

1 Hz spectral accelerations predicted for M 7.3 for the EPRI (2004) models and for the Atkinson and Boore (2006) and Tavakoli and Pezeshk (2005) references, using the 12 "non-general area source" equations from EPRI (2004).

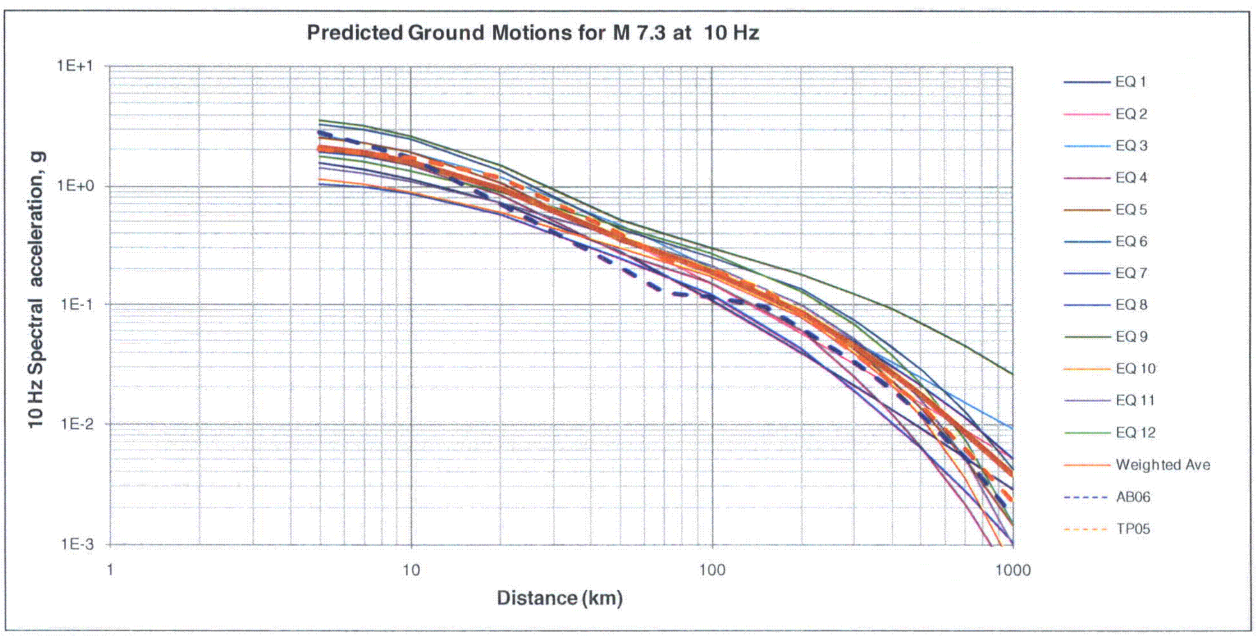

Figure RAI 2.5.2-27.7

10 Hz spectral accelerations predicted for M 7.3 for the EPRI (2004) models and for the Atkinson and Boore (2006) and Tavakoli and Pezeshk (2005) references, using the 12 "non-general area source" equations from EPRI (2004).

Inspecting the 10 Hz plots for **M**=6.1 and 7.3 (Figures RAI 2.5.2-27.5 and RAI 2.5.2-27.7), the weighted average EPRI curve lies above the middle of the range of the ground motions from the AB06 and TP05 equations for distances between 30 and 120 km. These magnitude and distance ranges span the controlling earthquake magnitudes and distances for 10^{-4} and 10^{-5} high-frequency motion (**M** 6.2 to 6.9, R 31 to 120 km). Thus inclusion of the AB06 and TP05 equations into the hazard analysis likely would reduce the 10^{-4} and 10^{-5} high-frequency Uniform Hazard Response Spectra (UHRS) values.

Inspecting the 1 Hz plot for **M**=7.3 (Figure RAI 2.5.2-27.6), the AB06 equation lies near the weighted average of the EPRI equations for R=200 km, and the TP05 equations lies above these two. The controlling earthquake magnitudes and distances for 10^{-4} and 10^{-5} low-frequency motion are **M**~7.3, R~210 km. Thus inclusion of the AB06 and TP05 equations into the hazard analysis likely would increase the 10^{-4} and 10^{-5} UHRS low-frequency values. However, Figure RAI 2.5.2-27.6 shows that the TP05 equation lies above 11 of the 12 EPRI equations and therefore would be considered an outlier with low weight. The likely effect on the low-frequency UHRS of including these 2 additional equations would be small.

Regarding the Petersen et al. (2008) ground motion model, this is not an *independent* ground motion model because many of the same equations used in the EPRI (2004) study were used by Petersen et al. (2008). The weights used by Petersen et al. (2008) are documented only by describing the categorization of models (i.e. single corner—finite fault, single corner—point source, dynamic corner frequency, full waveform simulation, or hybrid empirical) and the weights assigned to each category (and each equation within a category). By contrast, the EPRI (2004) ground motion study assigned weights to ground motion clusters based on quantitative evaluation using 3 criteria: consistency with CEUS data, strength of seismological principles, and consideration of epistemic uncertainty. The latter evaluation is consistent with documentation for a Senior Seismic Hazards Analysis Committee (SSHAC) Level 3 study (SSHAC, 1997). As a further consideration, it would not be appropriate to use one set of ground motion models for low spectral frequencies, and another set for high spectral frequencies. Adoption of the Petersen et al. (2008) ground motion models for all spectral frequencies likely would reduce the high-frequency UHRS values. Use of the EPRI (2004) ground motion model is more conservative at high frequencies, which is an additional justification for using this model.

Regarding the 5 Hz and 10 Hz deaggregation at 10^{-5}, several changes have been made to this deaggregation. First, the hazard changed slightly as a result of more accurate assumptions made about magnitudes below 5.0 with the CAV filter, which modified the 10^{-5} UHRS values slightly. Second, the calculation of mean distance was made using the exponent of the average logarithmic distance, which is recommended in Regulatory Guide 1.208, rather than using the mean arithmetic distance. A deaggregation plot is included below as Figure RAI 2.5.2-27.8. As a result of these changes, the mean magnitude and distance for this deaggregation are 6.2 and 31 km. The mean magnitude is 6.2 rather than 5.0 to 5.5 because the contributions by magnitude, while showing a mode in the range of 5.0 to 5.5, have a long tail, with contributions as high as M 7.0 to 7.5. (Figure RAI 2.5.2-27.8 also shows a very small contribution from higher magnitudes coming from the New Madrid seismic zone.) The mean magnitude of this highly skewed distribution is 6.2. Also, the contributions by distance, while having a mode in the range 0 to 20 km, have a long tail, with contributions as far as 200 to 220 km. (Figure RAI 2.5.2-27.8 also shows a very small contribution from longer distances coming from the New Madrid seismic zone.) The logarithmic mean of this highly skewed distance distribution is 31 km. The VCSNS FSAR will be updated to reflect the revised mean magnitudes and distances.

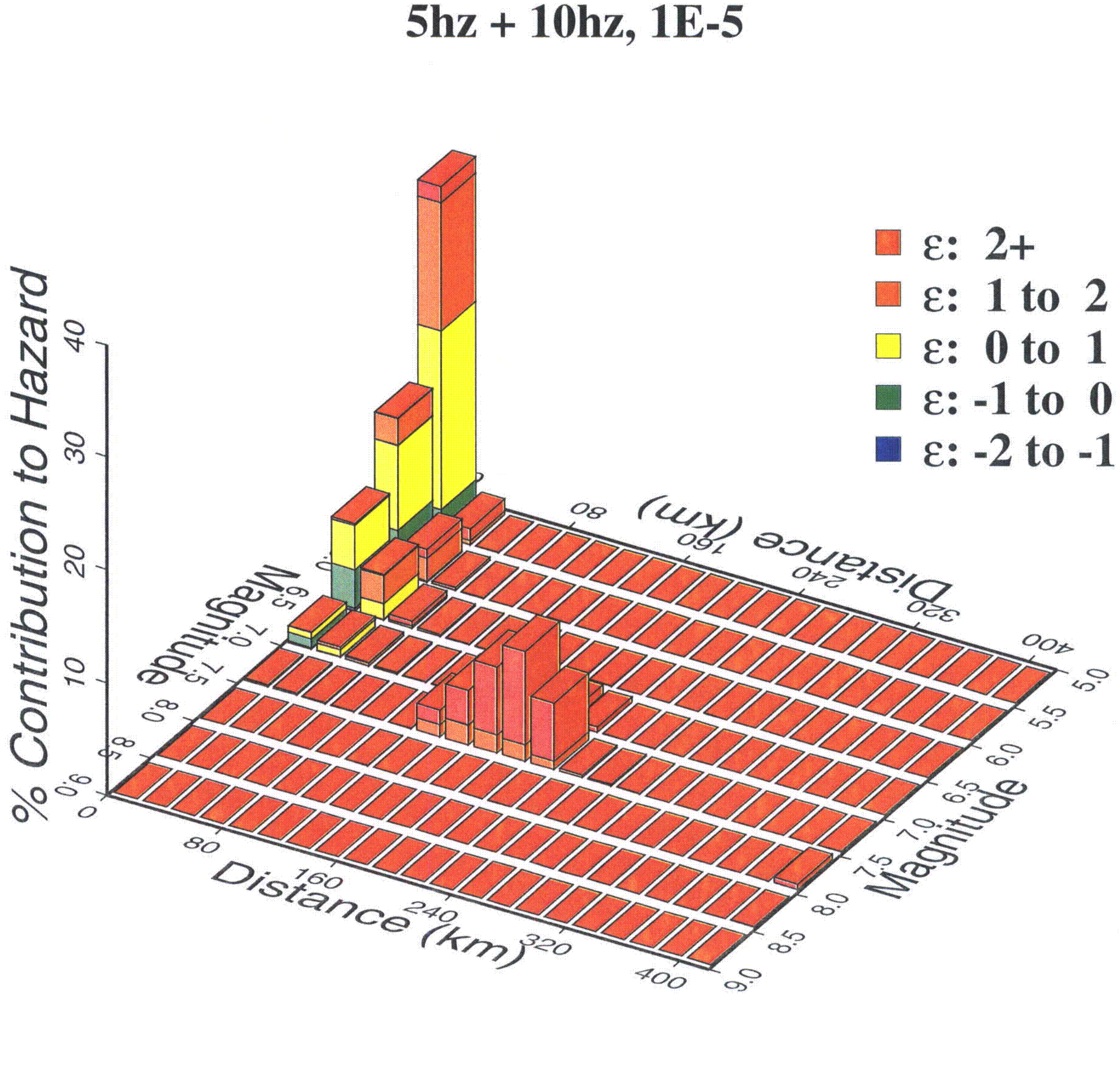

Figure RAI 2.5.2-27.8

Mean 10E-5 deaggregation plot for 5 and 10 Hz.

REFERENCES FOR THE RESPONSE:

Atkinson, G. M. and Boore, D. M., *Earthquake Ground-Motion Prediction Equations for Eastern North America*, Bulletin of the Seismological Society of America, v 96: 2181 – 2205, 2006.

EPRI, *CEUS Ground Motion Project Final Report*, Technical Report 1009684, December 2004.

Petersen, M. D., et al., *Documentation for the 2008 update of the United States national seismic hazard maps*; U.S. Geological Survey Open-File Report 2008-1128, 128 p., 2008.

Senior Seismic Hazards Analysis Committee, *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts*, Prepared by Senior Seismic Hazard Analysis Committee (SSHAC), NUREG/CR-6372, 1997.

Tavakoli, B. and Pezeshk, S., *Empirical-Stochastic Ground-Motion Prediction for Eastern North America*, Bulletin of the Seismological Society of America, v 95: 2283 - 2296., 2005

ASSOCIATED VCSNS COLA REVISIONS:

VCSNS FSAR Figure 2.5.2-239 will be updated to reflect the revised mean magnitudes and distances shown in Figure RAI 2.5.2-27.8 in the next VCSNS FSAR revision.

VCSNS FSAR Table 2.5.2-218 will be replaced with the Table shown below in the next VCSNS FSAR revision.

Table 2.5.2-218
Mean Magnitudes and Distances from Deaggregation

Struct. Frequency	Annual Freq. Exceed.	Overall Hazard		Hazard from R>100 km	
		M	R, km	M	R, km
1 & 2.5 Hz	1E-4	7.1	160	7.2	210
5 & 10 Hz	1E-4	6.9	120	7.2	190
1 & 2.5 Hz	1E-5	7.0	122	7.3	210
5 & 10 Hz	1E-5	6.2	31	7.2	180
1 & 2.5 Hz	1E-6	6.8	66	7.3	220
5 & 10 Hz	1E-6	5.8	13	7.2	170

Shaded cells indicate values used to construct UHRS.

ASSOCIATED ATTACHMENTS:

CD containing file RAI14_figures_data.txt