PMTurkeyCOLPEm Resource

From: Comar, Manny
Sent: Wednesday, January 04, 2012 9:12 AM
To: TurkeyCOL Resource
Subject: FW: RAIs concerning SSHAC level 2
Attachments: L-2011-496 signed 11-16-2011 Response to NRC RAI Letter No. 037 (eRAI 5896).pdf; L-2011-460 signed 10-31-2011 Response to NRC RAI Letter No 037 (eRAI 5896).pdf

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From: Franzone, Steve [mailto:Steve.Franzone@fpl.com]
Sent: Friday, December 30, 2011 10:15 AM
To: Comar, Manny
Cc: Burski, Raymond
Subject: FW: RAIs concerning SSHAC level 2

Are these the two RAIs you all would like to discuss?

Steve Franzone
NNP Licensing Manager - COLA
"Success is not the key to happiness. Happiness is the key to success. If you love what you are doing, you will be successful." - Herman Cain
561.694.3209 (office)
754.204.5996 (cell)

From: Burski, Raymond
Sent: Friday, December 30, 2011 9:24 AM
To: Franzone, Steve
Subject: RAIs concerning SSHAC level 2

Steve,

I found 2 RAI's that asked about SSHAC level 2.

02.05.02-2 letter L-2011-496

02.05.02-3 letter L-2011-460

I have attached our response letters to the RAIs.

Ray

Hearing Identifier: TurkeyPoint_COL_Public
Email Number: 535

Mail Envelope Properties (377CB97DD54F0F4FAAC7E9FD88BCA6D0806FBBDB66)

Subject: FW: RAIs concerning SSHAC level 2
Sent Date: 1/4/2012 9:12:29 AM
Received Date: 1/4/2012 9:12:33 AM
From: Comar, Manny

Created By: Manny.Comar@nrc.gov

Recipients:
"TurkeyCOL Resource" <TurkeyCOL.Resource@nrc.gov>
Tracking Status: None

Post Office: HQCLSTR01.nrc.gov

Files	**Size**	**Date & Time**
MESSAGE	1483	1/4/2012 9:12:33 AM

L-2011-496 signed 11-16-2011 Response to NRC RAI Letter No. 037 (eRAI 5896).pdf
797568
L-2011-460 signed 10-31-2011 Response to NRC RAI Letter No 037 (eRAI 5896).pdf
389866

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

FPL

L-2011-496
10 CFR 52.3

November 16, 2011

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

Re: Florida Power & Light Company
Proposed Turkey Point Units 6 and 7
Docket Nos. 52-040 and 52-041
Response to NRC Request for Additional Information Letter No. 037
(eRAI 5896) SRP Section - 02.05.02 Vibratory Ground Motion

Reference:

1. NRC Letter to FPL dated September 29, 2011, Request for Additional Information Letter No.037 Related to SRP Section 02.05.02 - Vibratory Ground Motion for the Turkey Point Nuclear Plant Units 6 and 7 Combined License Application
2. FPL Letter to NRC dated October 31, 2011, Response and Response Schedule to NRC Request for Additional Information Letter No. 037 (eRAI 5896) SRP Section - 02.05.02 Vibratory Ground Motion

Florida Power & Light Company (FPL) provides, as attachments to this letter, its responses to the Nuclear Regulatory Commission's (NRC) Request for Additional Information (RAI) 02.05.02-2, RAI 02.05.02-5, RAI 02.05.02-8 and RAI 02.05.02-9 provided in Reference 1. FPL provided a schedule for the responses to RAI 02.05.02-2, RAI 02.05.02-5, RAI 02.05.02-8, and RAI 02.05.02-9 in Reference 2. The attachment identifies changes that will be made in a future revision of the Turkey Point Units 6 and 7 Combined License Application (if applicable).

If you have any questions, or need additional information, please contact me at 561-691-7490.

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

Executed on November 16, 2011

Sincerely,

William Maher
Senior Licensing Director – New Nuclear Projects

WDM/RFB

Florida Power & Light Company
700 Universe Boulevard, Juno Beach, FL 33408

Attachment 1: FPL Response to NRC RAI No. 02.05.02-2 (eRAI 5896)
Attachment 2: FPL Response to NRC RAI No. 02.05.02-5 (eRAI 5896)
Attachment 3: FPL Response to NRC RAI No. 02.05.02-8 (eRAI 5896)
Attachment 4: FPL Response to NRC RAI No. 02.05.02-9 (eRAI 5896)

cc:
PTN 6 & 7 Project Manager, AP1000 Projects Branch 1, USNRC DNRL/NRO
Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Plant 3 & 4

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-2 (eRAI 5896)

FSAR Subsection 2.5.2.4.5 describes new ground motion prediction equations (GMPEs) that the applicant developed for Caribbean region seismic sources. The basis of the new GMPEs is a scientific study conducted by Motazedian and Atkinson (2005) in the Puerto Rico area. In accordance with NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion":

a. Please explain why ground motion prediction models developed by Motazedian and Atkinson (2005) for the Puerto Rico region, which is primarily a subduction zone, provide an adequate basis for the larger Caribbean region, especially for the region between Cuba and Florida.

b. Please provide the complete Senior Seismic Hazard Analysis Committee (SSHAC) documentation for the Level 2 study conducted to develop the Caribbean GMPEs for the staff to specifically evaluate the makeup of the Technical Integrator (TI) team, the peer review panel, how the experts' opinions were integrated into the development of the final GMPE, whether any conflicting opinions among the experts were dealt with, and how the final GMPEs represent the consensus of the informed community.

c. Please provide copies of the following supporting calculations: Report #: 25409-000-K0C-0000-00009, Report#: 25409-000-K0C-0000-00024, Report #: 25409-000-K0C-0000-00034 to enable the staff to evaluate the technical details of the final GMPEs.

d. In order for the staff to be able to compare the new Caribbean GMPEs with the 2004/2006 EPRI mid-continent GMPEs, please provide plots showing both ground motion models for earthquake magnitudes of 6.0, 7.0, and 8.0 in the distance range of 200 km to 1000 km at all seven frequencies defined in the EPRI 2004 and 2006 GMPEs.

e. Discuss evidence, if any, that seismic source scaling varies regionally and/or between source types in the Caribbean. For example, is there any evidence that stress parameter varies systematically between the northern Hispaniola sources, the Caribbean plate-boundary transform fault sources, and the Cuba sources? If so, what are the implications for the attenuation models and hazard calculated at TPNPP?

FPL RESPONSE:

Part a:

As noted in Garcia et al. (FSAR Reference 255), there are currently no calibrated ground motion prediction equations (GMPEs) for Cuba and the surrounding region. Strong motion instruments have only recently been installed in 1998 and the amount of recorded empirical ground motion data from these instruments, which is operated by the Cuban agency (FSAR Reference 255), is limited or unavailable. In the absence of a local regionally based empirical GMPE, Garcia et al. (FSAR Reference 255) employed the use of other GMPEs from similar regions. One specific GMPE that was used in their probabilistic seismic hazard analysis (PSHA) study for the Cuba region was the Motazedian and Atkinson (FSAR Reference 287) GMPE, which was developed for Puerto Rico for soft rock site conditions.

As presented in the Motazedian and Atkinson (FSAR Reference 287) study, a dataset of approximately 300 earthquakes of magnitude 3.0-5.5 located on and around the island of Puerto Rico was used to develop regional ground motion attenuation and source parameters. These authors acknowledge that their ground motion dataset consisted of both crustal and subduction zone earthquakes, as one would expect based on the tectonic setting for the island of Puerto Rico. In addition, Motazedian and Atkinson (FSAR Reference 287) note that the separation of the earthquakes into crustal and subduction events used in their dataset was not possible based on the limited station coverage for the region.

To address this possible concern about the influence of using both subduction and crustal events to estimate the regional attenuation and source parameters, Motazedian and Atkinson (FSAR Reference 287) provide a comparison of their GMPE developed based on the Puerto Rico strong motion dataset of events with representative GMPEs for central and eastern United States (FSAR Reference 210), California (Atkinson and Silva, 2000), and an empirically-based subduction GMPE based on the global ground motion dataset for subduction zones (Atkinson and Boore, 2003). Based on the comparison of GMPEs from these different regions, they conclude that their GMPE developed for the Puerto Rico region is similar to the two crustal models for California and eastern North America, and shows a significant difference (i.e., the subduction zone attenuation curves are lower) to the empirically-based subduction models. This comparison and noted results provide a technical justification for using the source and attenuation parameters from the Puerto Rico ground motion dataset (FSAR Reference 287) for the development of applicable GMPEs for the Caribbean seismic sources.

Based on the lack of a region-specific GMPE for the Cuba region, the accepted practice of using an applicable GMPE from similar regions was used in the development of regional ground motion relationships for the Cuba and Caribbean region. In performing a literature review of applicable GMPEs, the regional attenuation and source parameters developed from the Puerto Rico dataset of earthquakes (FSAR Reference 287) were selected as an acceptable dataset to develop simulation-based ground motions for the estimation of a regional suite of empirical ground motion attenuation relationships in PSHA.

Part b:

A formal Senior Seismic Hazard Analysis (SSHAC) Level 2 study was not conducted for the development of the Caribbean GMPE. The development followed a SSHAC Level 1 study with the additional interaction between the Technical Integrator (TI) team and a resource expert and the Technical Advisory Group (TAG). The later interactions occurred during the three TAG meetings. The TI team consisted of two Bechtel seismologists:

Dr. Nick Gregor
Dr. Behrooz Tavakoli

The resource expert was,

Dr. Dariush Motazedian (Carleton University, Ottawa, Canada)

The TAG members were:

Dr. Robert Kennedy (RPK Structural Mechanics Consulting)
Dr. William McCann (Earth Scientific Consultants)
Mr. Donald Moore (Southern Nuclear Operating Company)
Dr. J. Carl Stepp (Earthquake Hazards Solutions)
Dr. Robert Youngs (Geomatrix Consultants, currently AMEC-Geomatrix)

These TAG meetings provided a forum for the TAG members to be participatory peer review members for the project and to offer guidance on the development of the Caribbean GMPEs. Initially a literature review was performed with the goal of retrieving acceptable ground motion prediction equations (GMPEs) for the Cuba and Caribbean region. However, this literature review only retrieved one GMPE developed recently by Motazedian and Atkinson (FSAR Reference 287). In addition to the participatory interaction with the TAG members, correspondence was conducted with Professor Motazedian during the initial development of the Caribbean GMPEs. These initial technical discussions were for the possible application of the published Motazedian and Atkinson (FSAR Reference 287) GMPE for the PSHA study. However, based on the limitations of this GMPE (e.g., incomplete suite of necessary spectral frequencies, limited application for distances greater than 500 km, and site-specific ground conditions of soft rock), it was determined that this published GMPE was not acceptable for use in the PSHA.

For the development of the GMPEs for the Cuba and Caribbean region, the regionally determined source and attenuation parameters from Motazedian and Atkinson (FSAR Reference 287) were used with a point-source stochastic ground motion methodology to develop an applicable large-distance GMPE for the magnitude and distance range needed for the PSHA.

There was agreement amongst the TAG members on the methodology and results performed for the development of the GMPEs for the Caribbean seismic sources. As part

of the TAG feedback and to resolve any technical concerns from the TAG members, a sensitivity analysis was performed to examine the ground motion effects, if any, on epistemic uncertainty of alternative GMPEs for use in the PSHA.The alternative attenuation relationships considered an adopted double corner (2C) seismic source model that might be expected to occur in a more active tectonic environment such as the western United States (WUS) rather than the less active tectonic environment of the central and eastern United States (CEUS). In addition a Gulf Coast region anelastic attenuation factor (Q) model rather than the Puerto Rico region-specific Q model from Motazedian and Atkinson (FSAR Reference 287) was analyzed, recognizing that much of the propagation path from the Caribbean sources to the Turkey Point site is through the Gulf Coast crust.

It was found that adoption of these alternatives (i.e., different suite of regional attenuation and seismic source parameter values) led to ground motion values that were equal to (at large distances based on the anelastic attenuation rates) or lower than (based on the different magnitude scaling from the WUS based double corner model) the suite of original nine new ground motion attenuation models adopted for the Cuba and Caribbean region. A comparison of the weighted combination of the original nine GMPE models and the inclusion of these additional sensitivity models resulted in a slightly lower weighted mean ground motion attenuation curve over the magnitude and distance range needed for the PSHA. Thus, their incorporation into the final PSHA results would have slightly lowered the already low hazards and thus the use of the original nine GMPE models was accepted by the TAG members with the understanding that the inclusion of these additional GMPE models would be expected to lead to lower ground motion results.

The development of the GMPEs used in the PSHA for the Caribbean seismic sources followed a SSHAC Level 1 methodology with the additional interaction of a resource expert for the region. This methodology was approved by the TAG members during the multiple workshop meetings. Based on the sensitivity analysis presented at the workshop, the final suite of GMPEs recommended for the PSHA was selected with the technical understanding that they represent more conservative (i.e., higher) ground motion prediction values than would be expected from the inclusion of other candidate GMPE models.

<u>Part c:</u>

The following three calculations are available for inspection in the Reading Room for eRAI 5896.

- Calculation 25409-000-K0C-0000-00009, Rev. 001
- Calculation 25409-000-K0C-0000-00024, Rev. 001
- Calculation 25409-000-K0C-0000-00034, Rev. 000

<u>Part d:</u>

Ground motion attenuation curve plots are provided for the EPRI (FSAR References 242 and 203) and Caribbean ground motion prediction equations (GMPEs). Note that EPRI (FSAR Reference 203) is only a recommendation for the associated aleatory uncertainty and therefore does not impact the comparison plots of the weighted mean ground motion

attenuation curve. The plotted mean attenuation curve is the weighted mean of the individual median attenuation curves as defined in EPRI (FSAR Reference 242). These attenuation plots are provided for three specific moment magnitude (M_w) values: 6, 7, and 8 for distances between 200 km and 1,000 km. Note that the EPRI (FSAR Reference 242) ground motion attenuation model is defined as a function of epicentral distance, whereas the Caribbean ground motion attenuation model is defined as a function of hypocentral distance. However, because the closest distance is 200 km, the difference between the epicentral and hypocentral distances would be less than 1% for a typical crustal depth of 10 km and even smaller for larger distances out to 1,000 km.

The weighted mean ground motion attenuation curves for the EPRI (FSAR Reference 242) model are given in Figures 1 through 7 for the three magnitudes and seven spectral frequencies requested in the RAI. The weighted mean Caribbean ground motion attenuation curve plots for the same suite of magnitudes, distances, and spectral frequencies are shown in Figures 8 through 14.

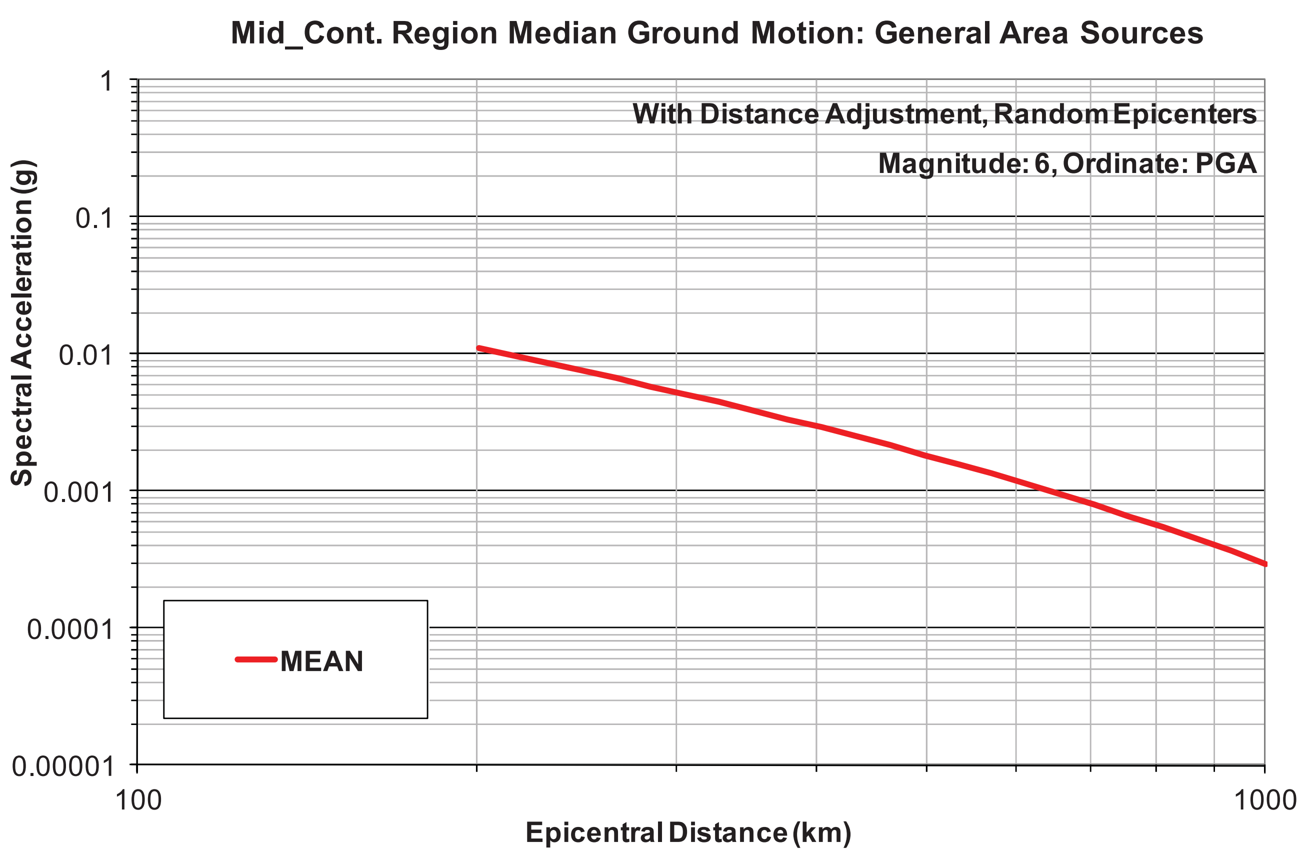


Figure 1a. EPRI (FSAR Reference 242) Mid Continent PGA weighted mean attenuation curve for a magnitude 6 earthquake.

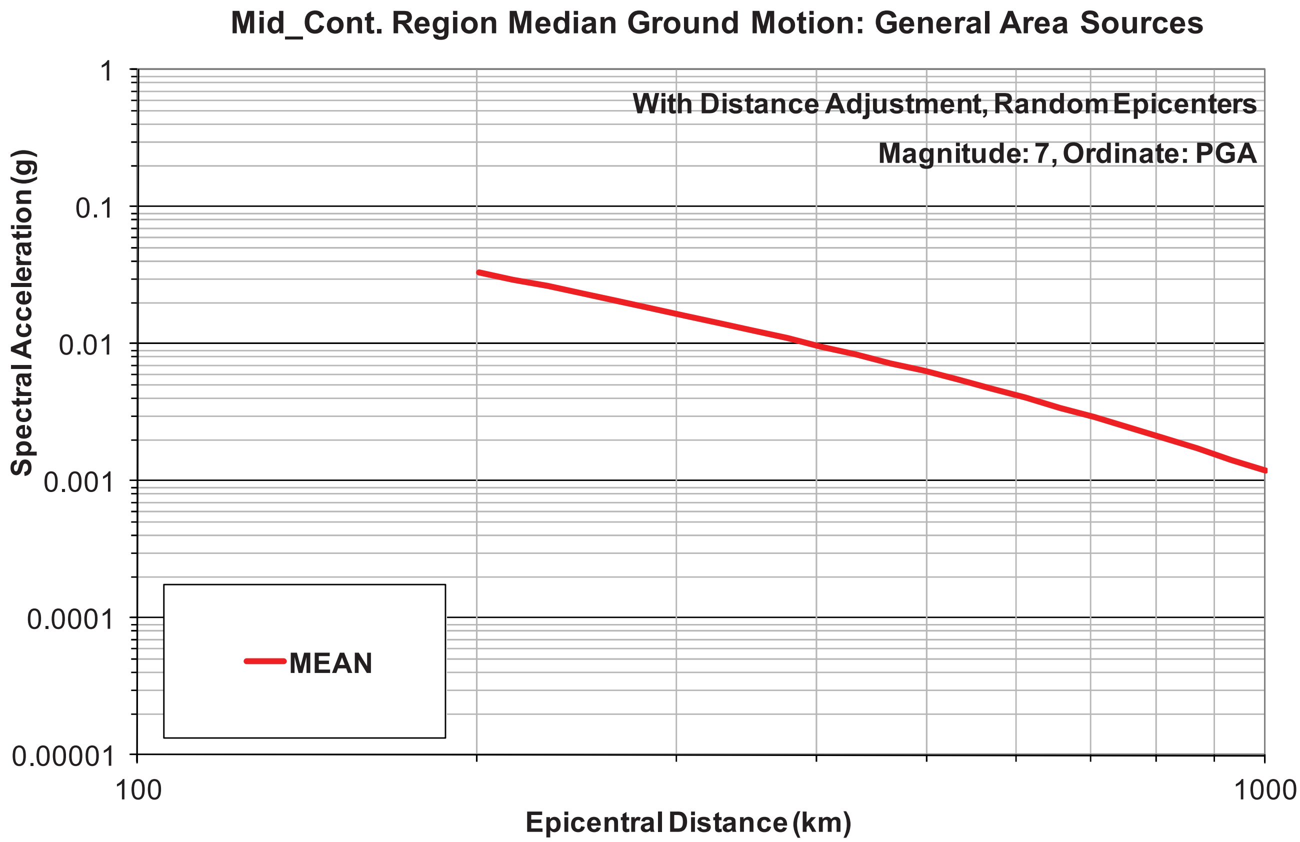


Figure 1b. EPRI (FSAR Reference 242) Mid Continent PGA weighted mean attenuation curve for a magnitude 7 earthquake.

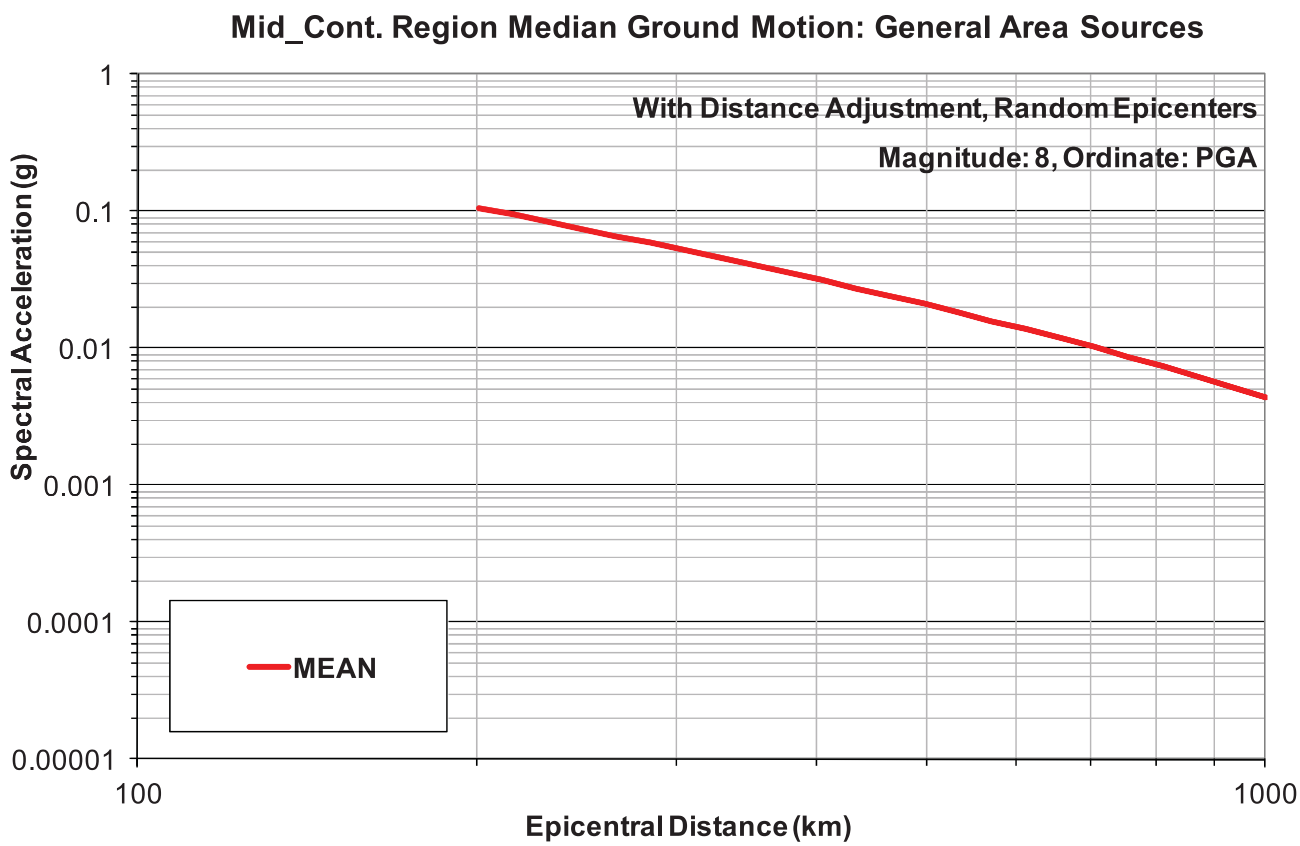


Figure 1c. EPRI (FSAR Reference 242) Mid Continent PGA weighted mean attenuation curve for a magnitude 8 earthquake.

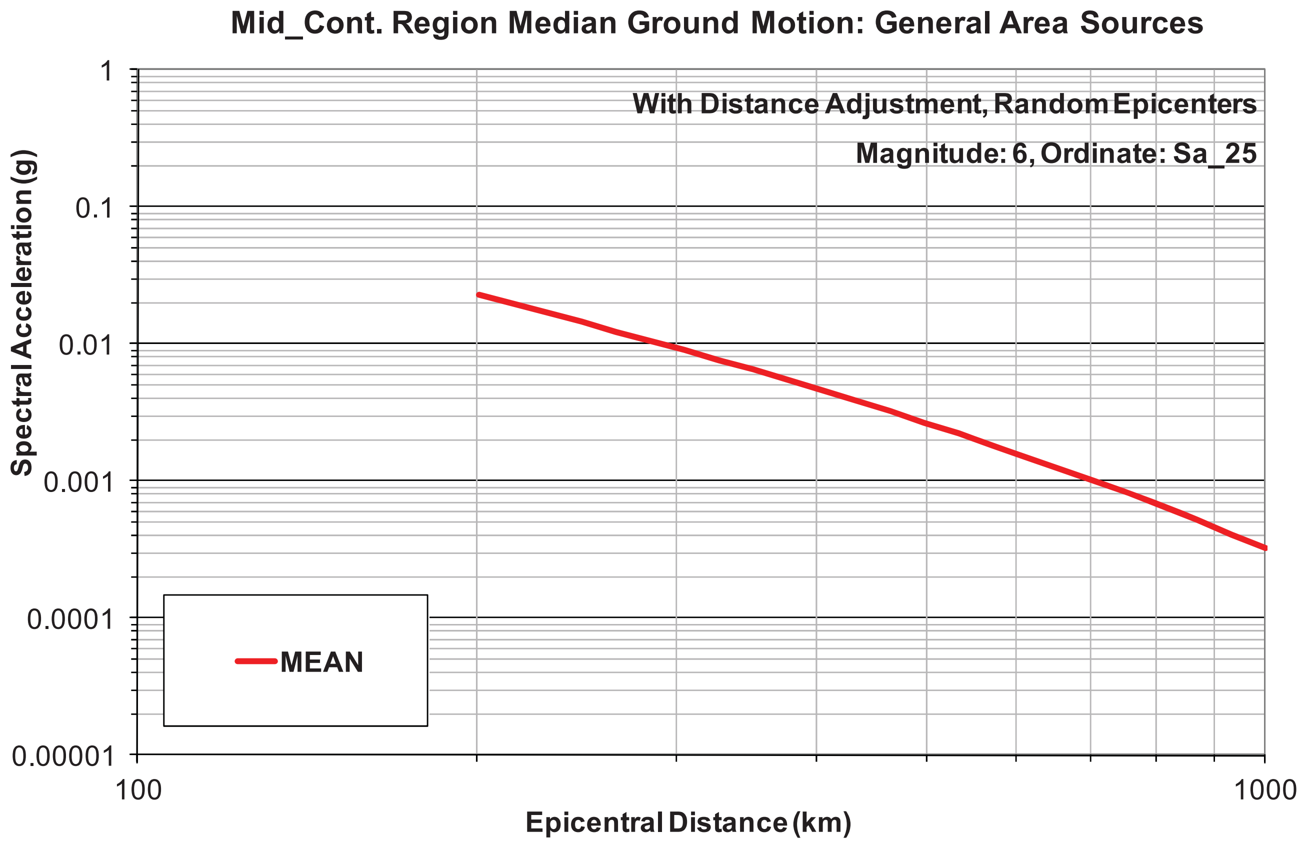


Figure 2a. EPRI (FSAR Reference 242) Mid Continent 25Hz weighted mean attenuation curve for a magnitude 6 earthquake.

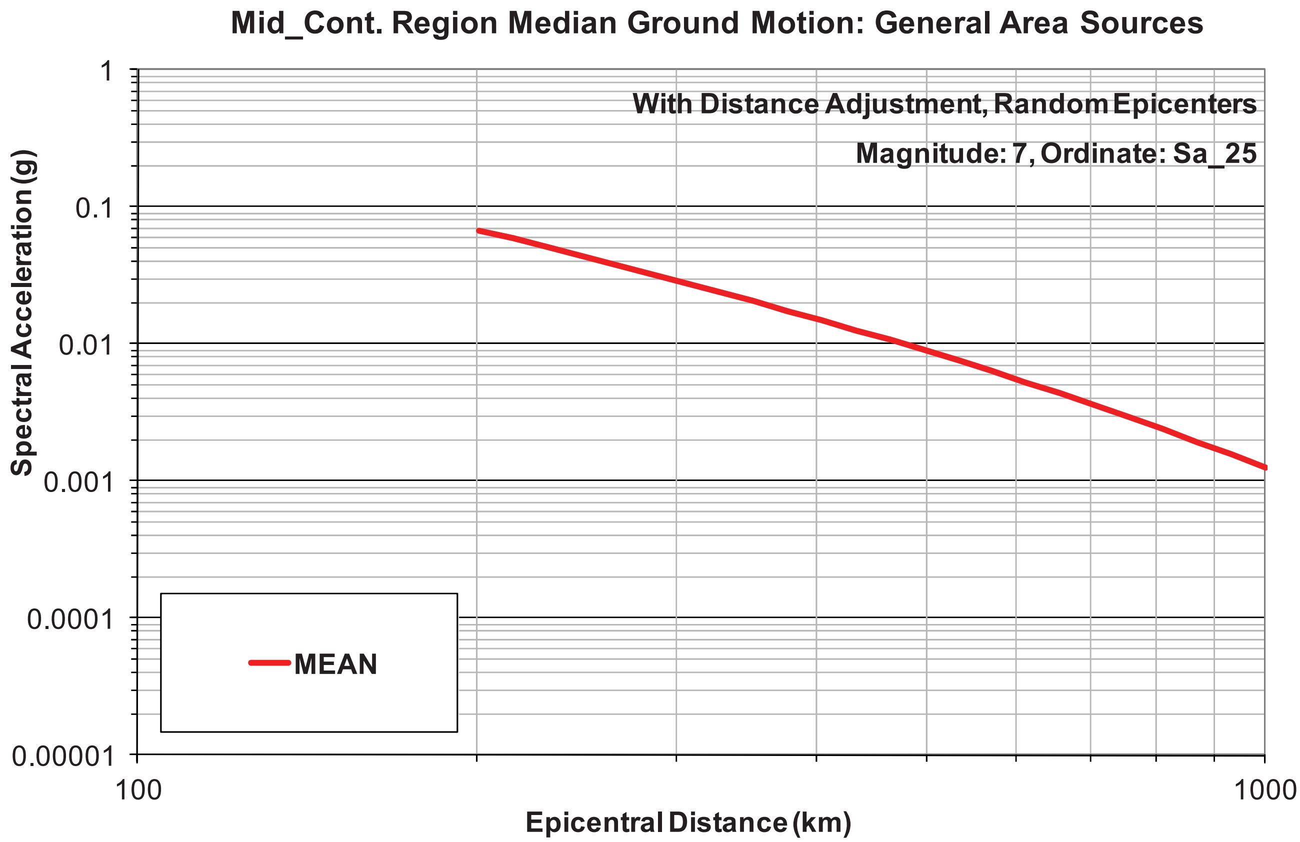


Figure 2b. EPRI (FSAR Reference 242) Mid Continent 25Hz weighted mean attenuation curve for a magnitude 7 earthquake.

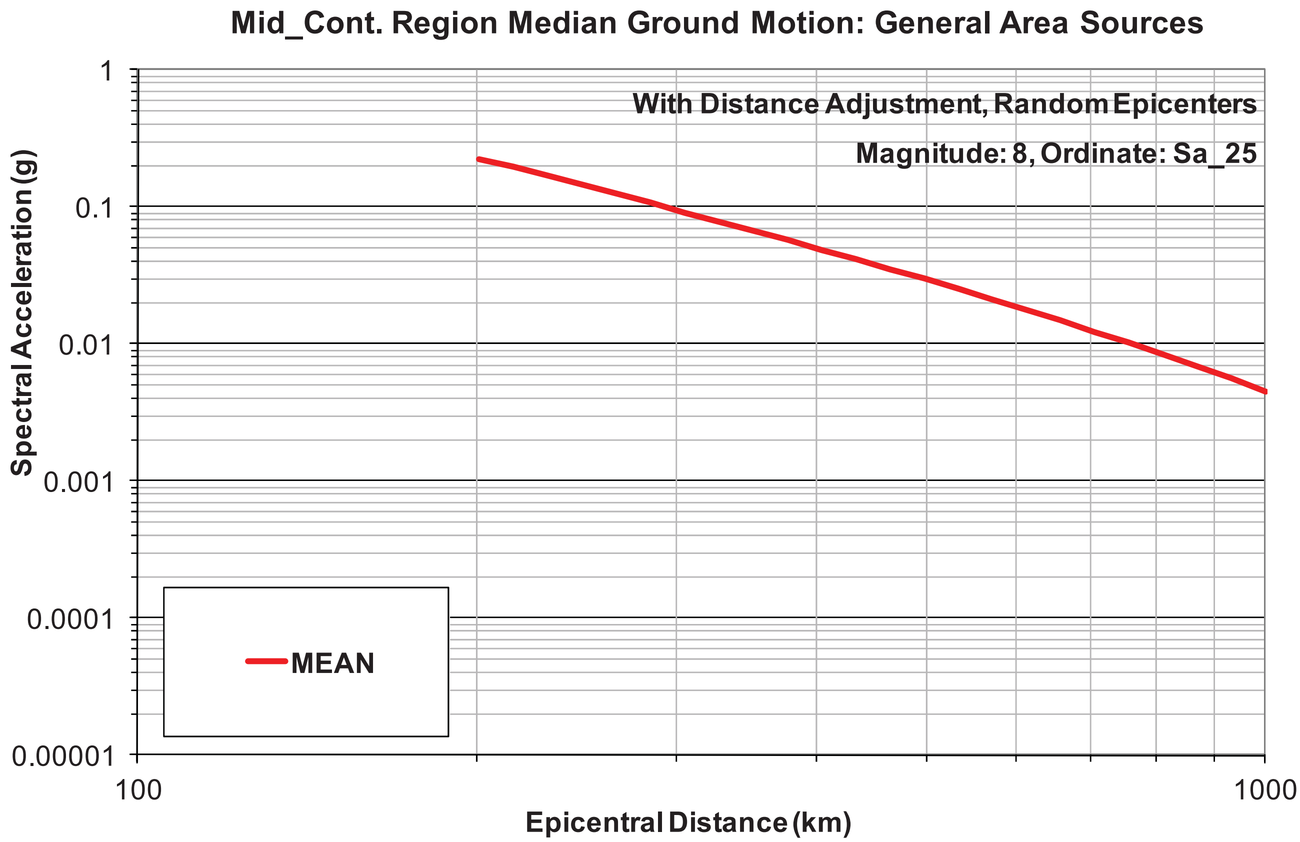


Figure 2c. EPRI (FSAR Reference 242) Mid Continent 25Hz weighted mean attenuation curve for a magnitude 8 earthquake.

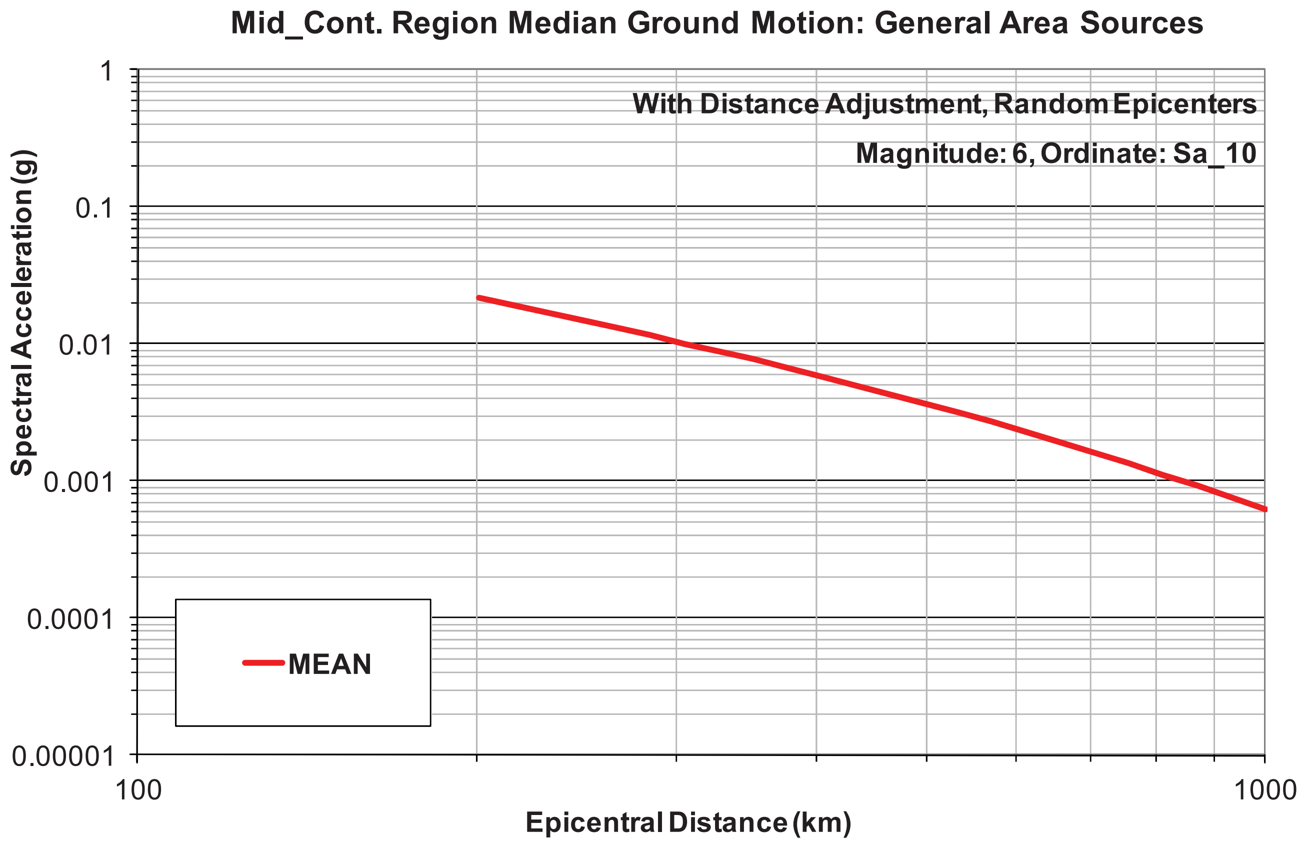


Figure 3a. EPRI (FSAR Reference 242) Mid Continent 10Hz weighted mean attenuation curve for a magnitude 6 earthquake.

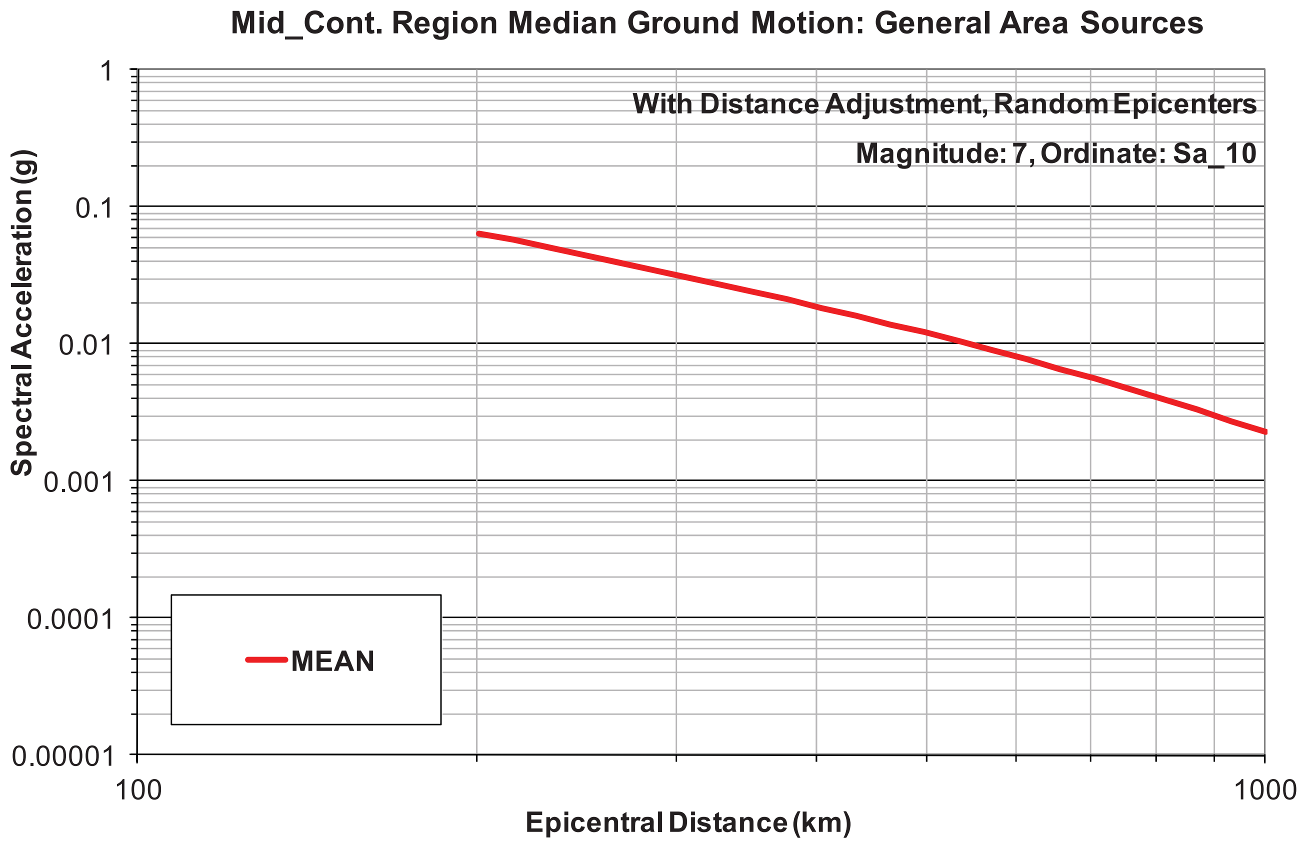


Figure 3b. EPRI (FSAR Reference 242) Mid Continent 10Hz weighted mean attenuation curve for a magnitude 7 earthquake.

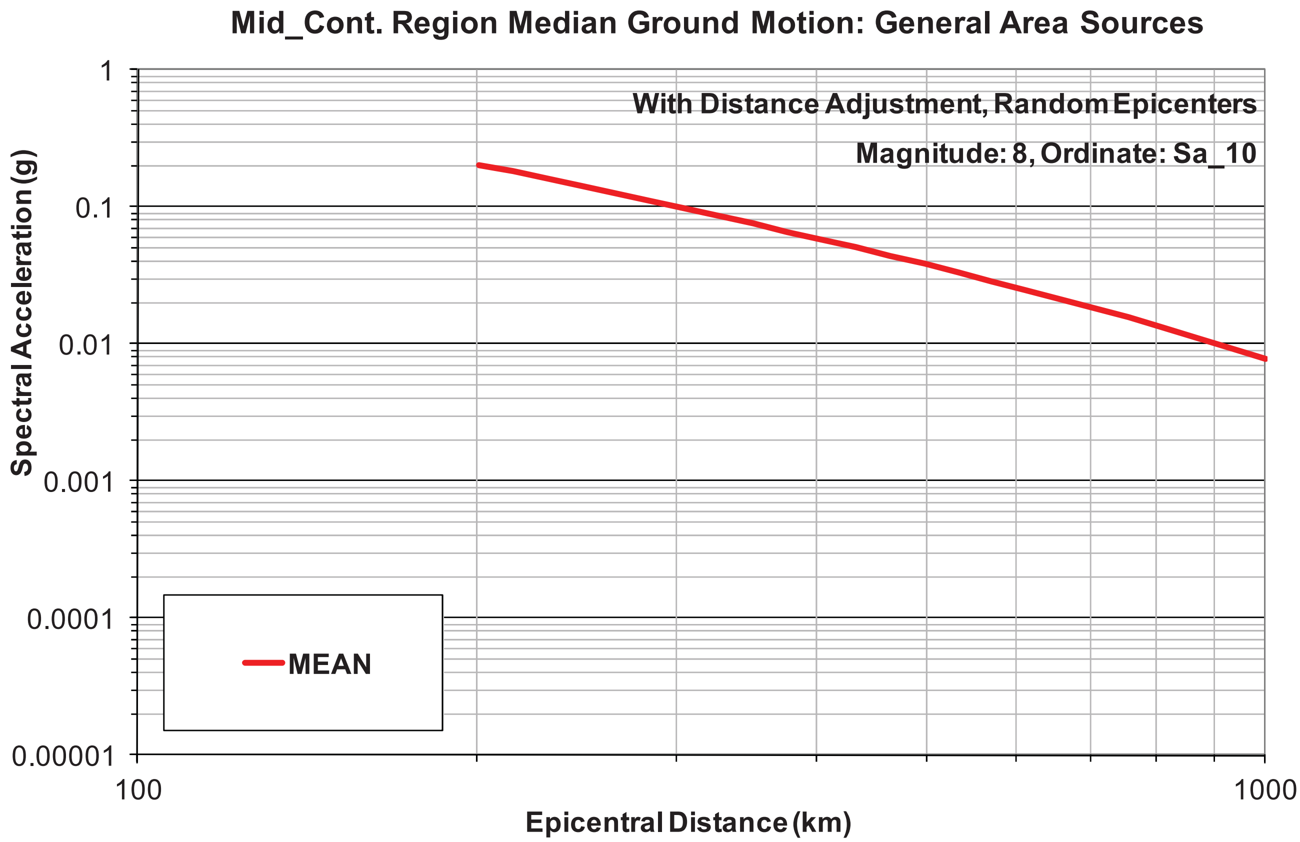


Figure 3c. EPRI (FSAR Reference 242) Mid Continent 10Hz weighted mean attenuation curve for a magnitude 8 earthquake.

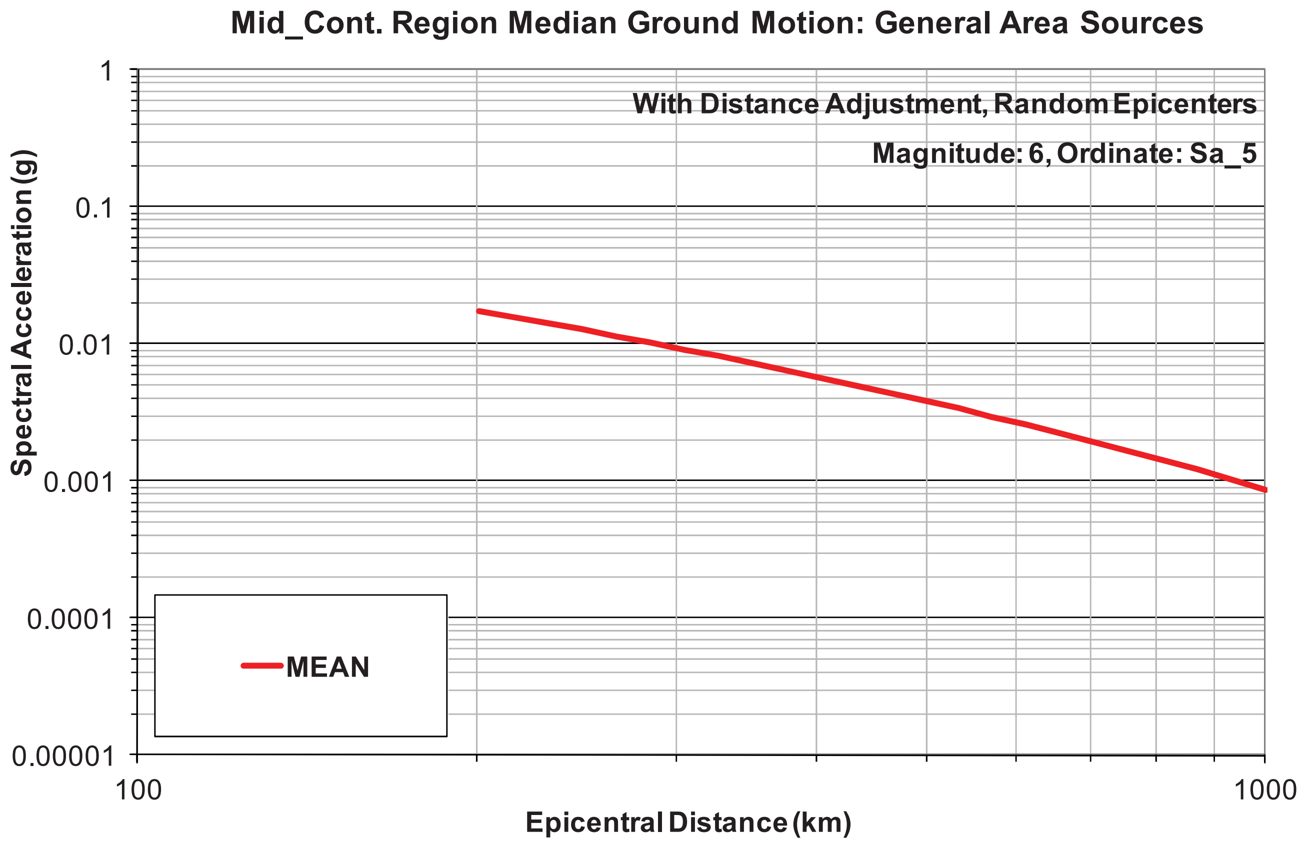


Figure 4a. EPRI (FSAR Reference 242) Mid Continent 5Hz weighted mean attenuation curve for a magnitude 6 earthquake.

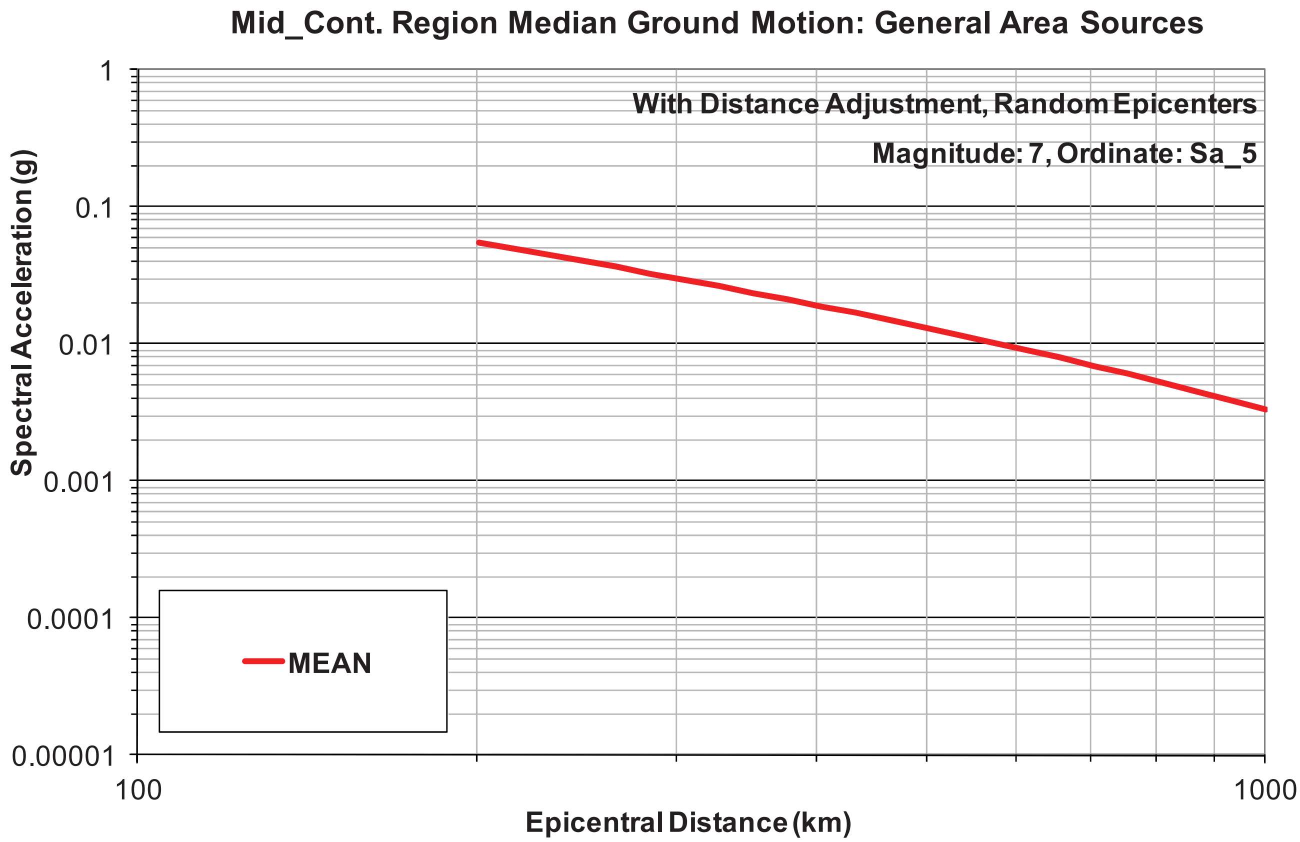


Figure 4b. EPRI (FSAR Reference 242) Mid Continent 5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

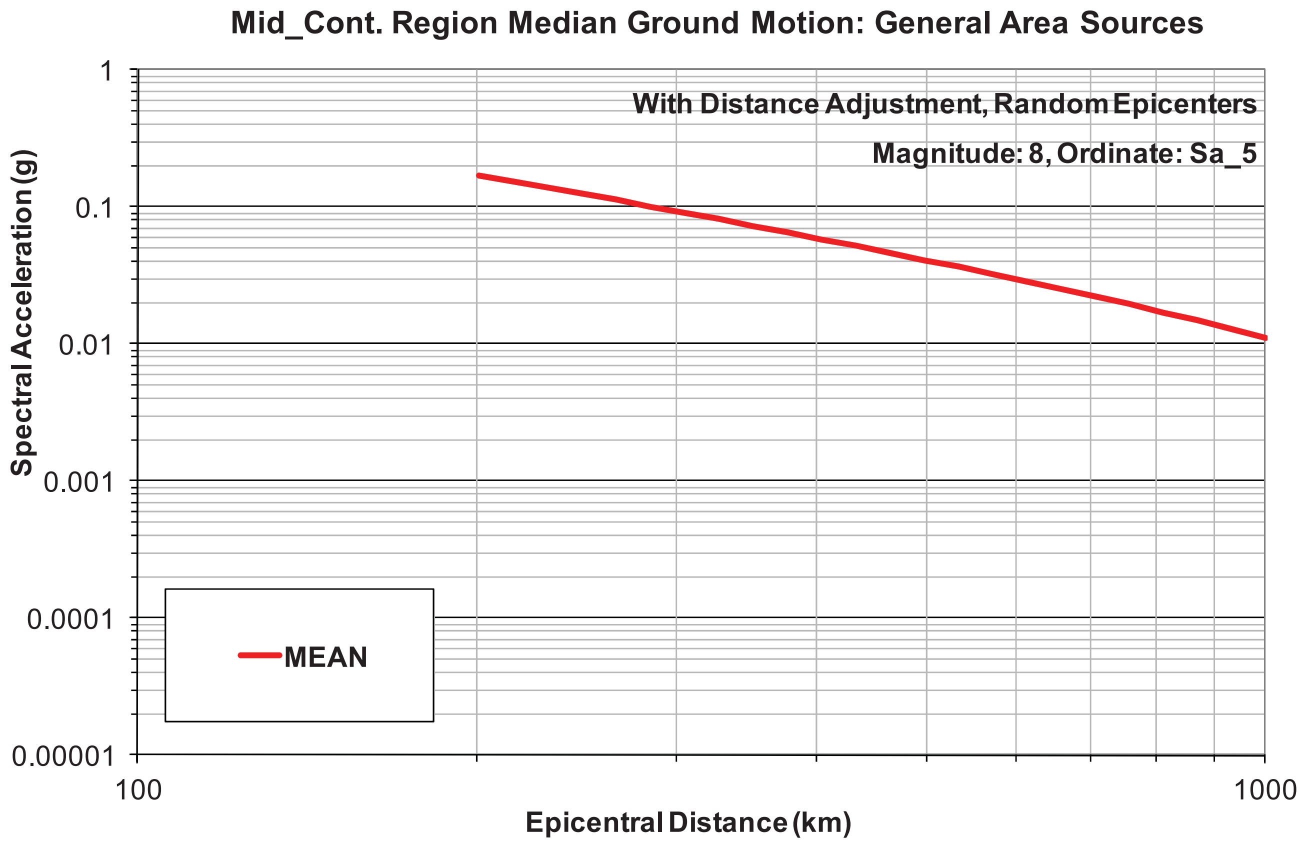


Figure 4c. EPRI (FSAR Reference 242) Mid Continent 5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

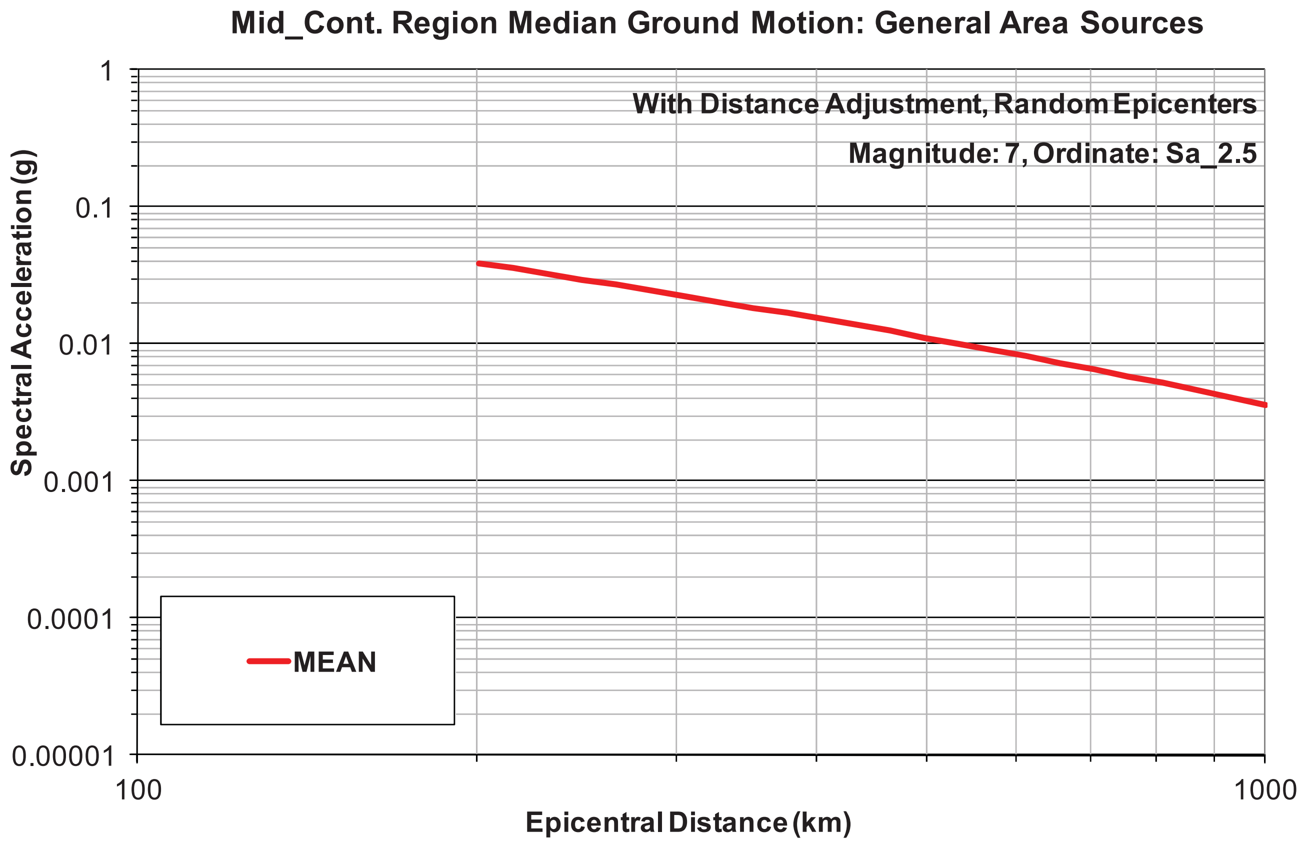


Figure 5b. EPRI (FSAR Reference 242) Mid Continent 2.5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

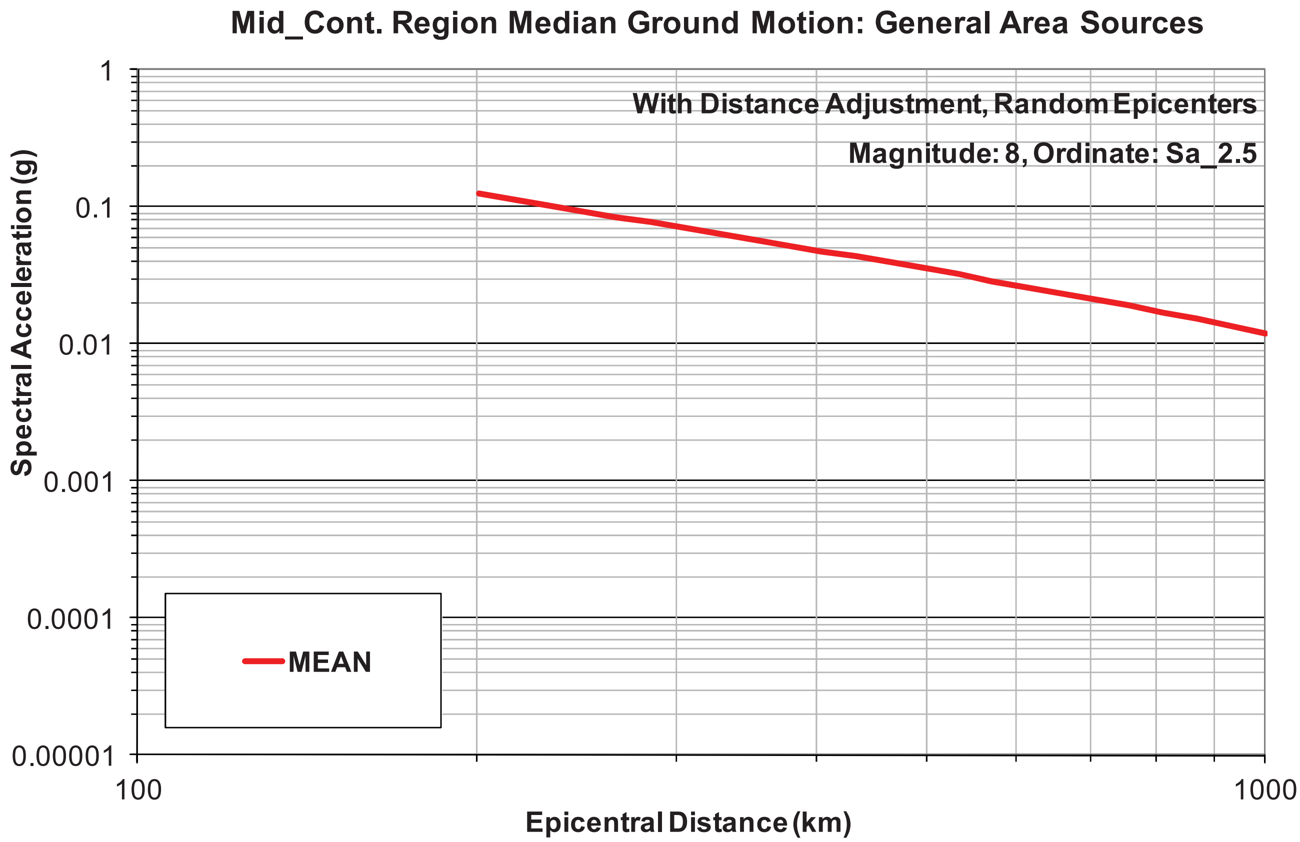


Figure 5c. EPRI (FSAR Reference 242) Mid Continent 2.5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

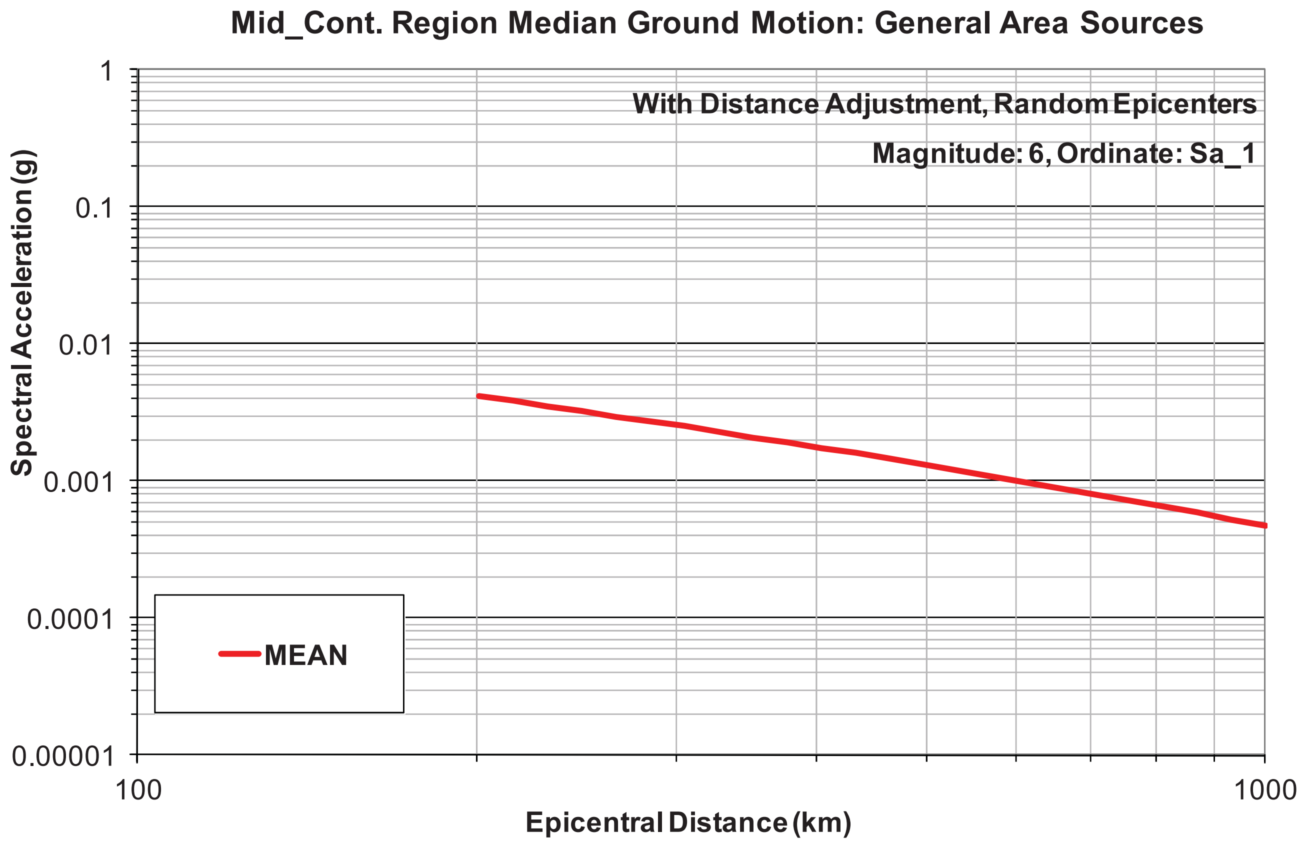


Figure 6a. EPRI (FSAR Reference 242) Mid Continent 1Hz weighted mean attenuation curve for a magnitude 6 earthquake.

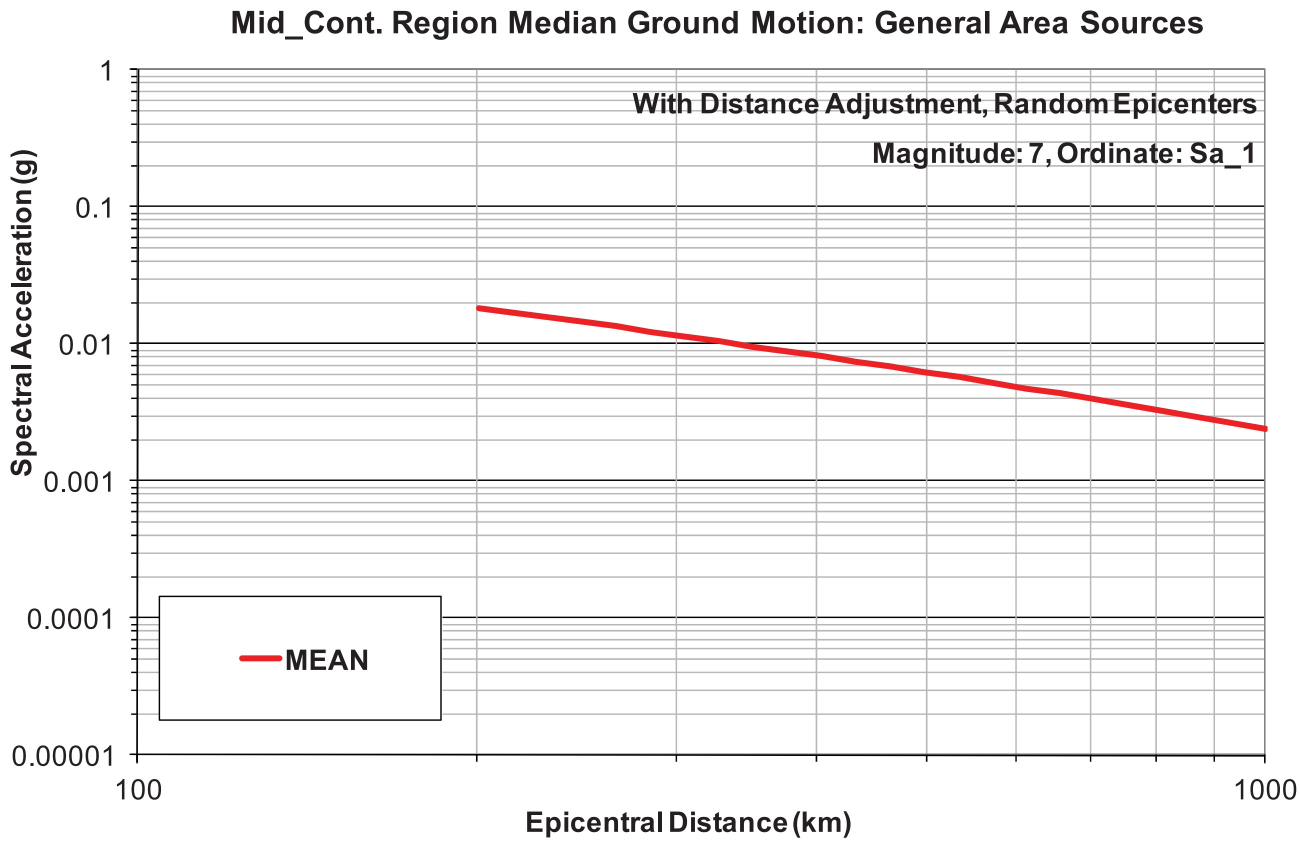


Figure 6b. EPRI (FSAR Reference 242) Mid Continent 1Hz weighted mean attenuation curve for a magnitude 7 earthquake.

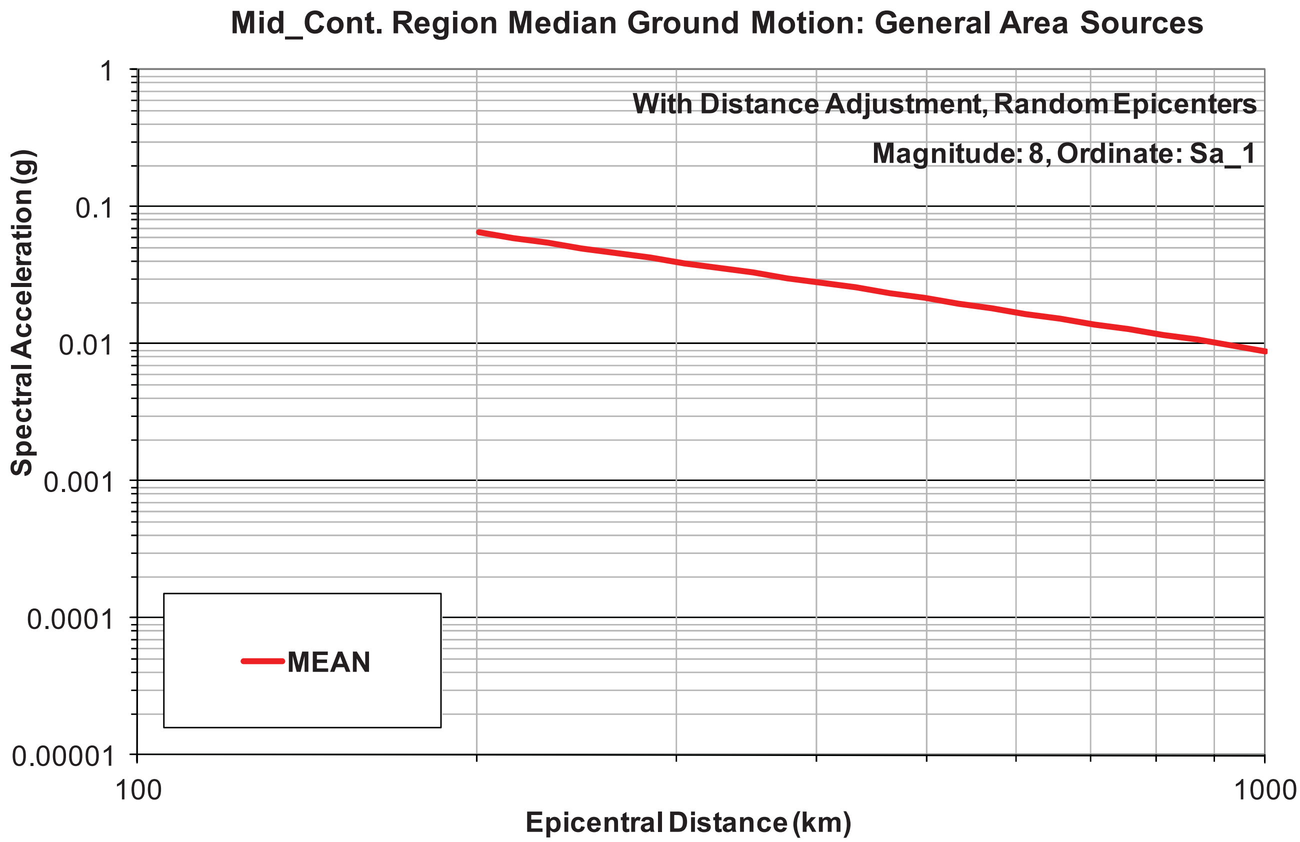


Figure 6c. EPRI (FSAR Reference 242) Mid Continent 1Hz weighted mean attenuation curve for a magnitude 8 earthquake.

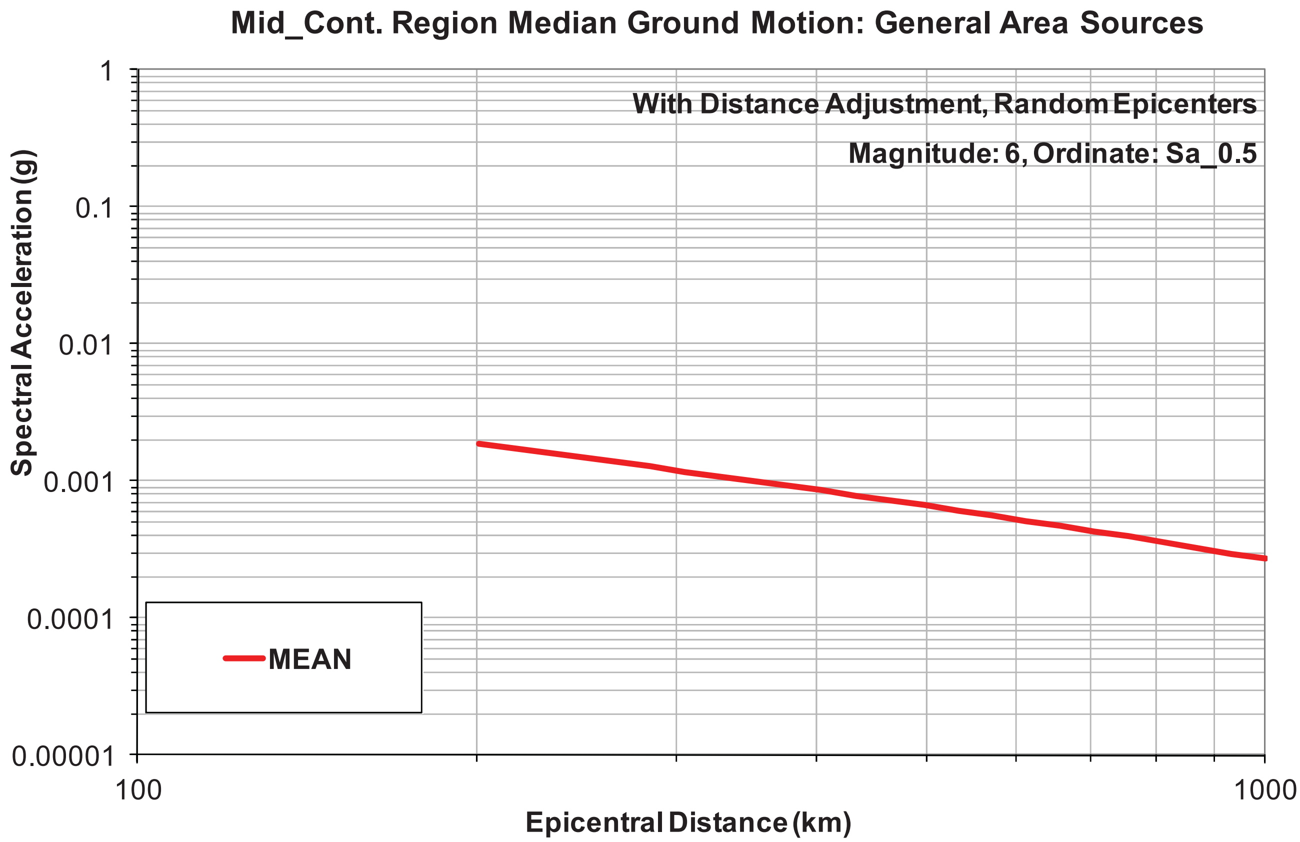


Figure 7a. EPRI (FSAR Reference 242) Mid Continent 0.5Hz weighted mean attenuation curve for a magnitude 6 earthquake.

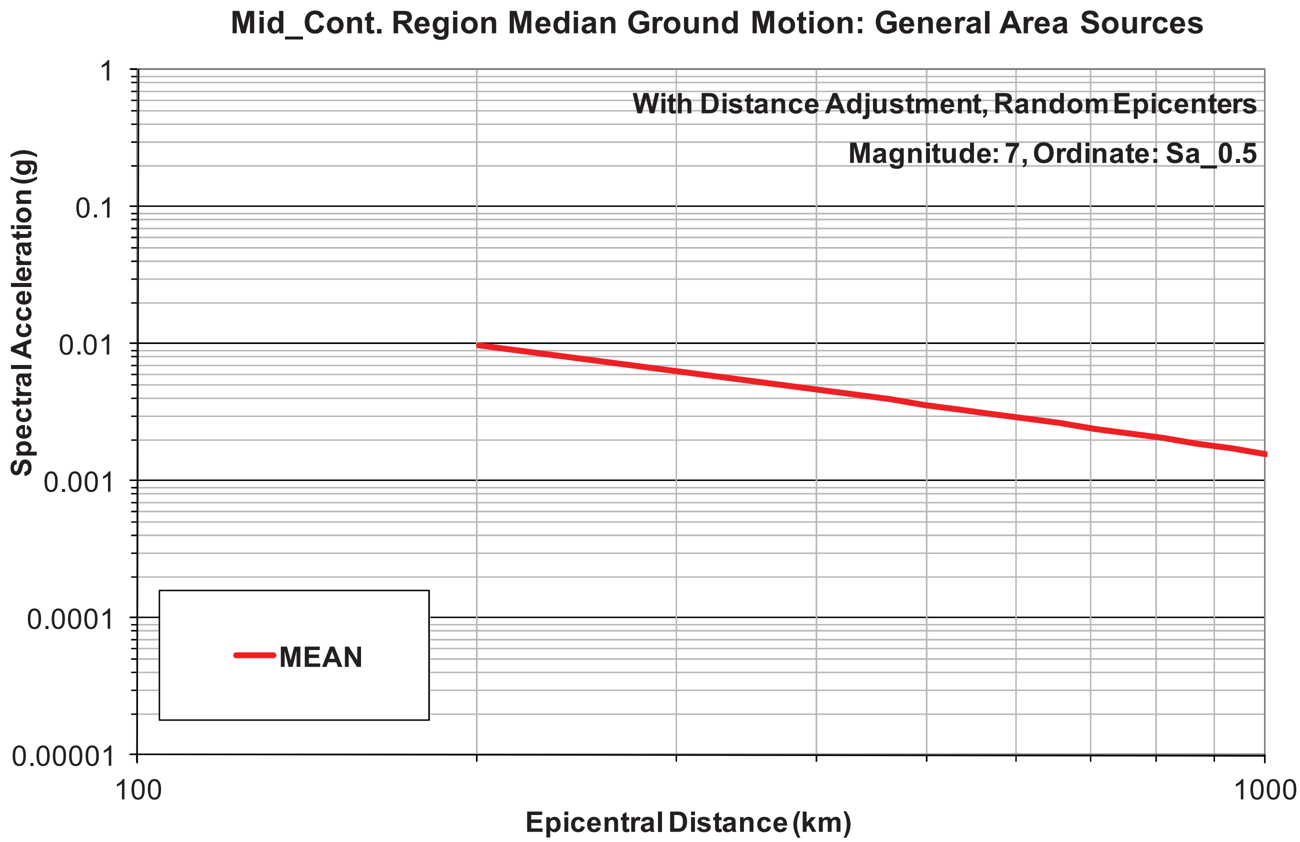


Figure 7b. EPRI (FSAR Reference 242) Mid Continent 0.5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

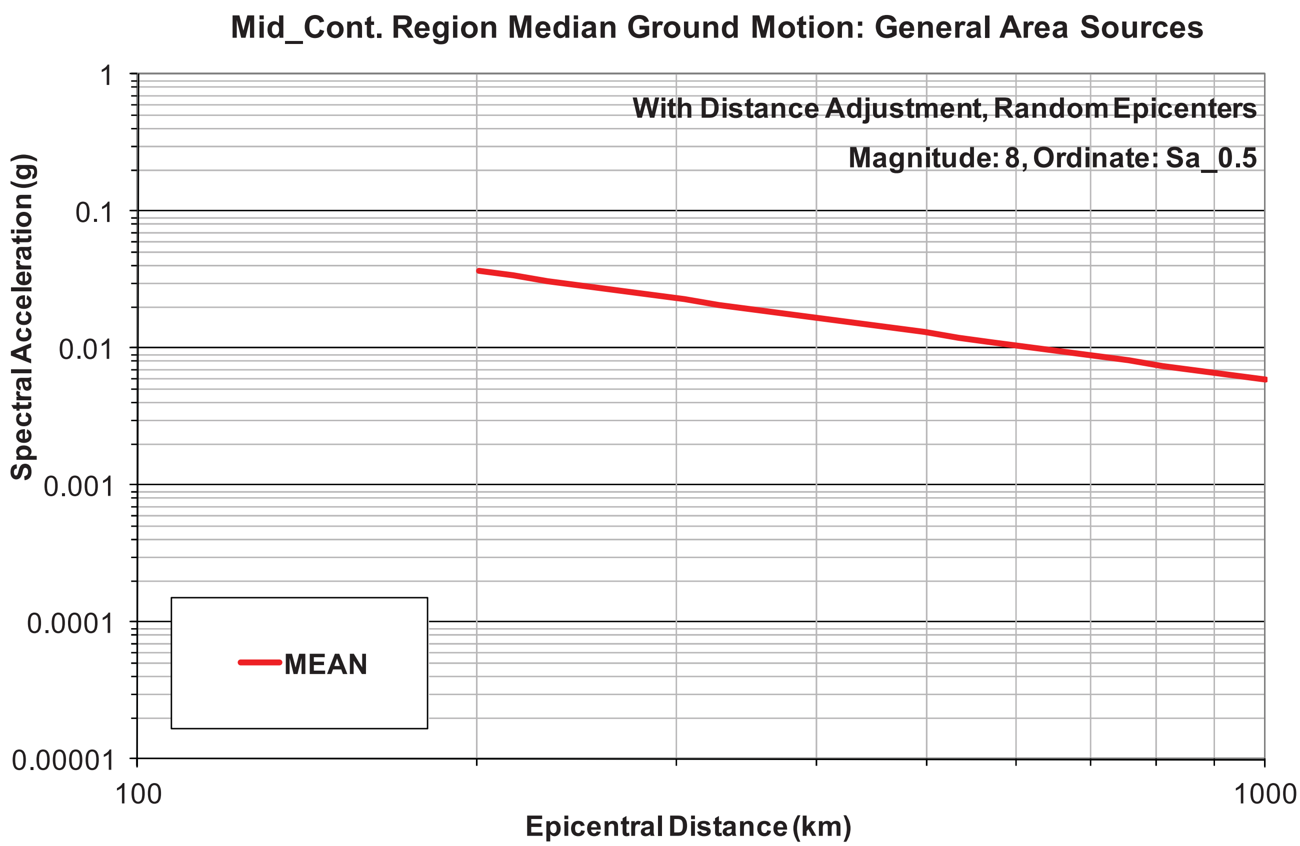


Figure 7c. EPRI (FSAR Reference 242) Mid Continent 0.5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

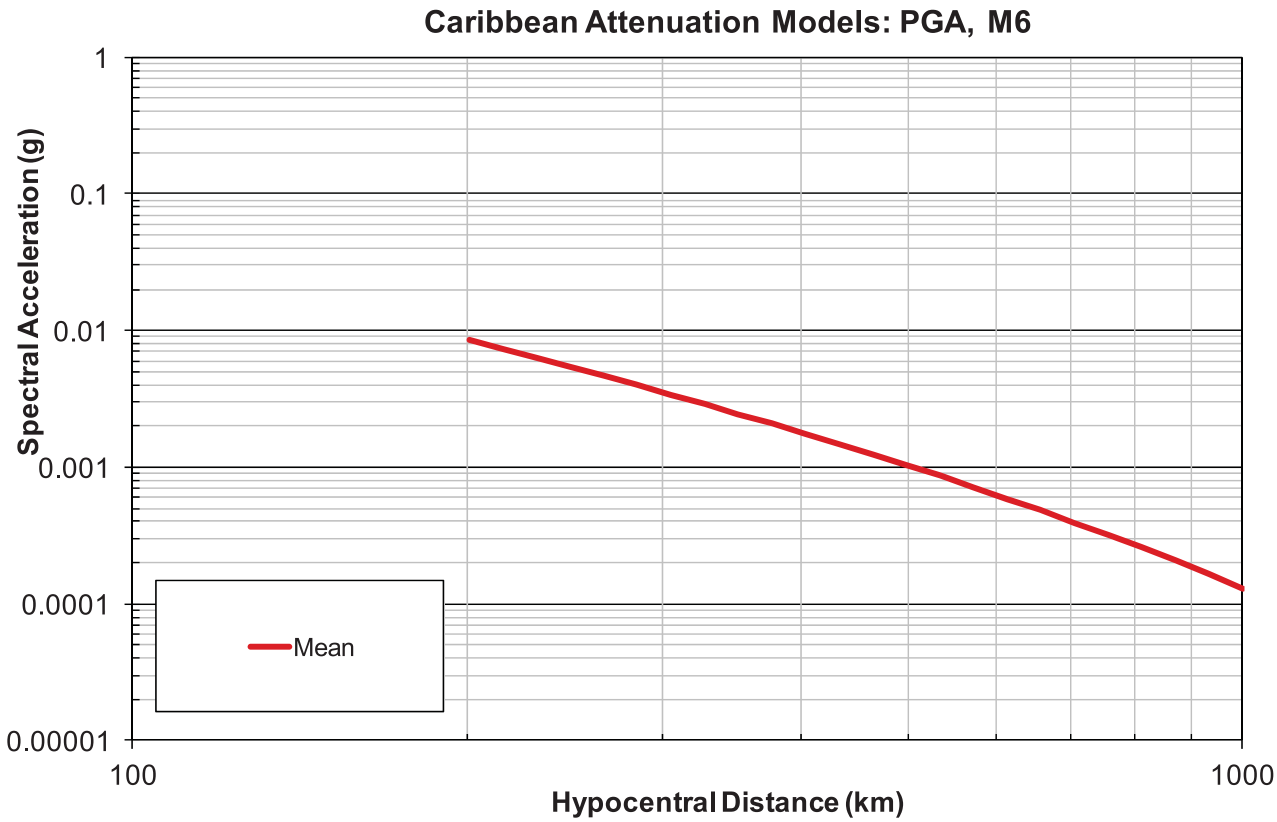


Figure 8a. Caribbean PGA weighted mean attenuation curve for a magnitude 6 earthquake.

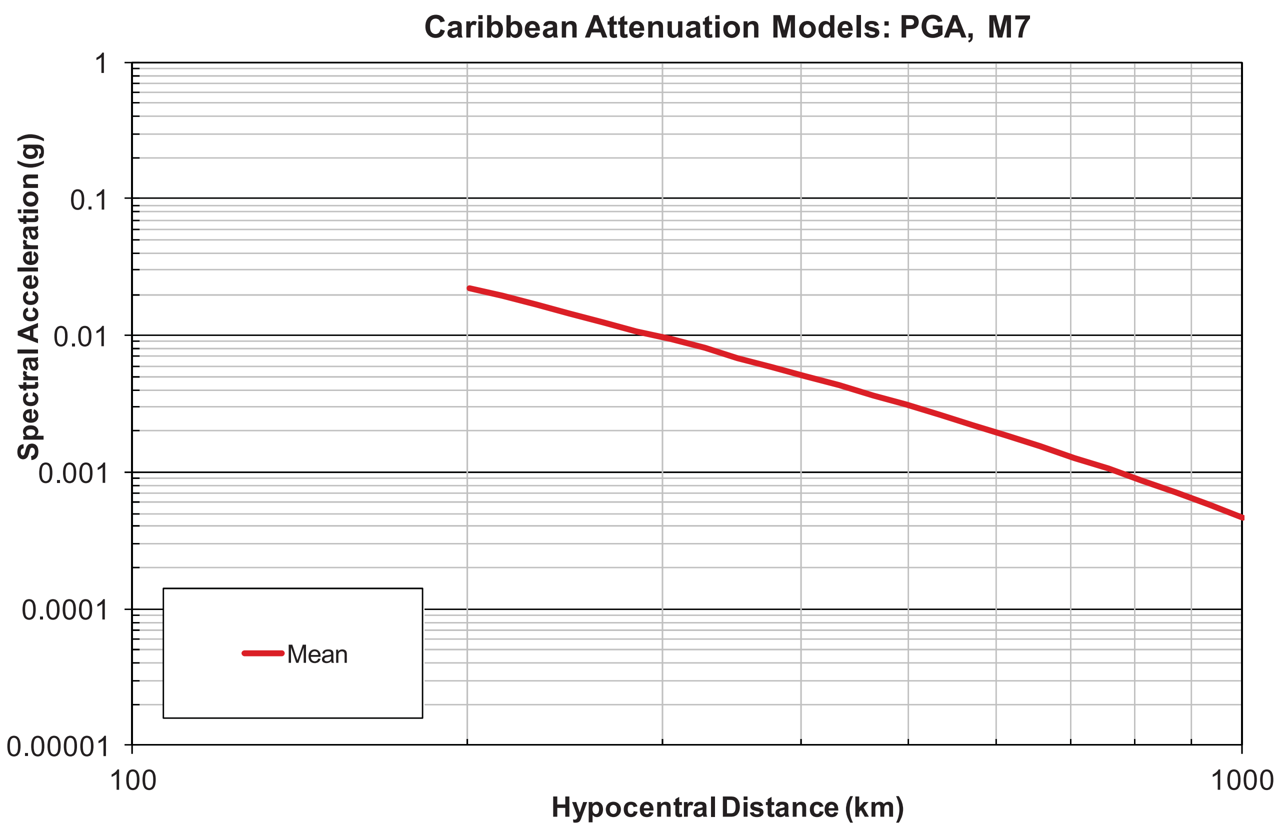


Figure 8b. Caribbean PGA weighted mean attenuation curve for a magnitude 7 earthquake.

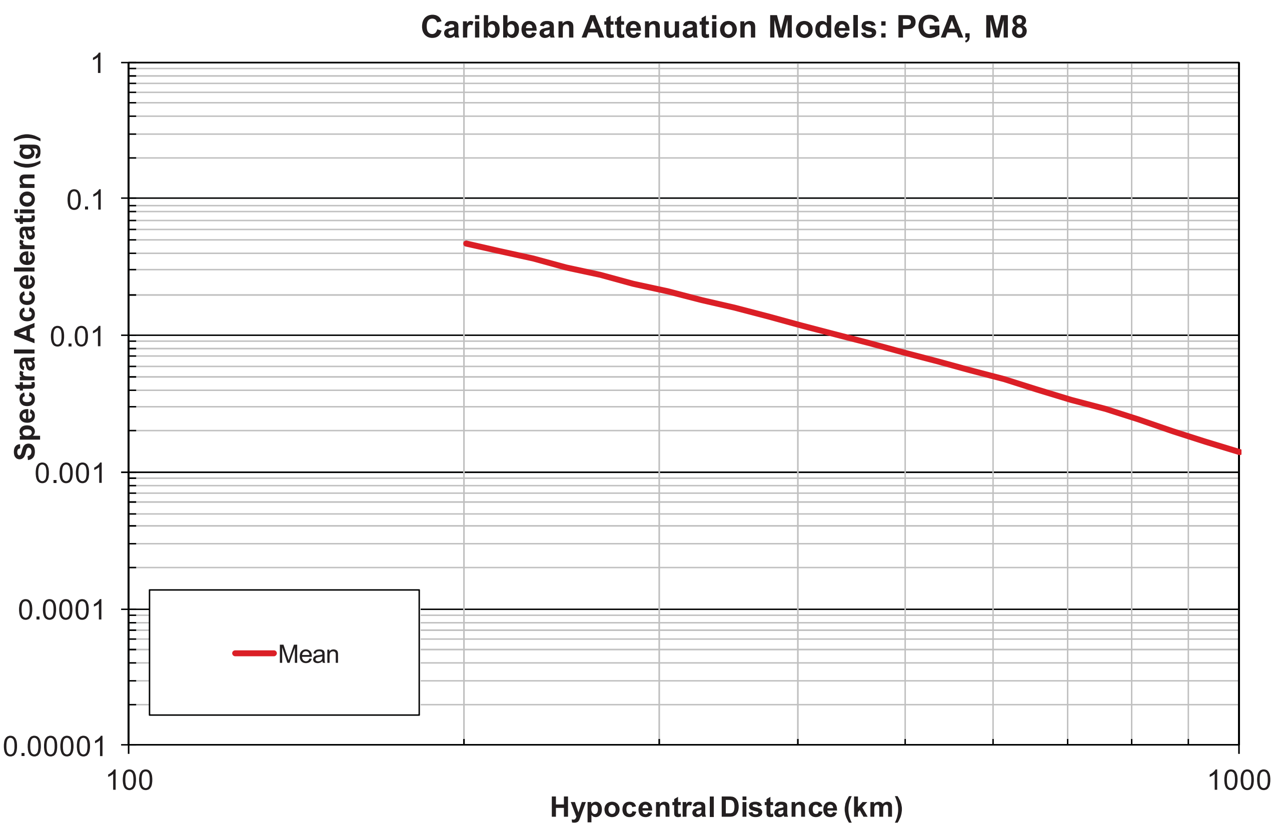


Figure 8c. Caribbean PGA weighted mean attenuation curve for a magnitude 8 earthquake.

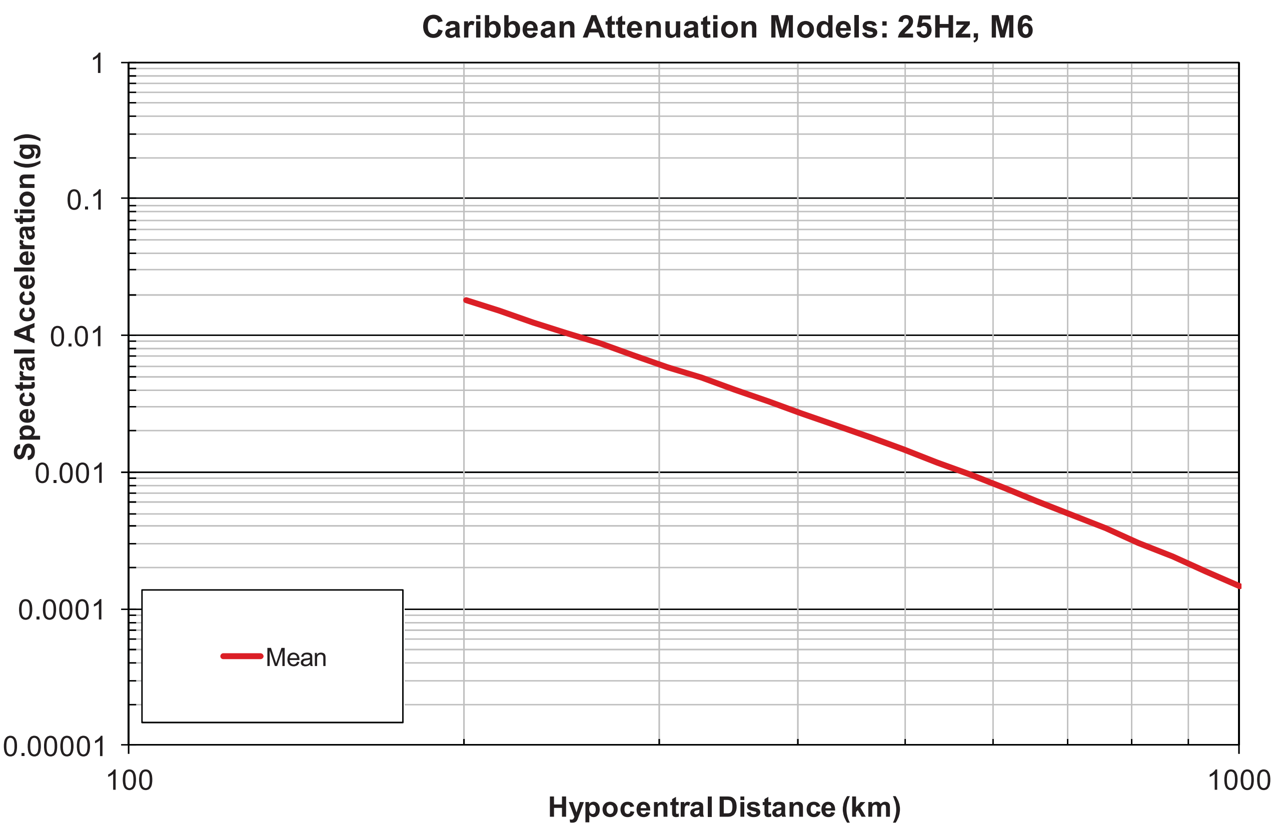


Figure 9a. Caribbean 25Hz weighted mean attenuation curve for a magnitude 6 earthquake.

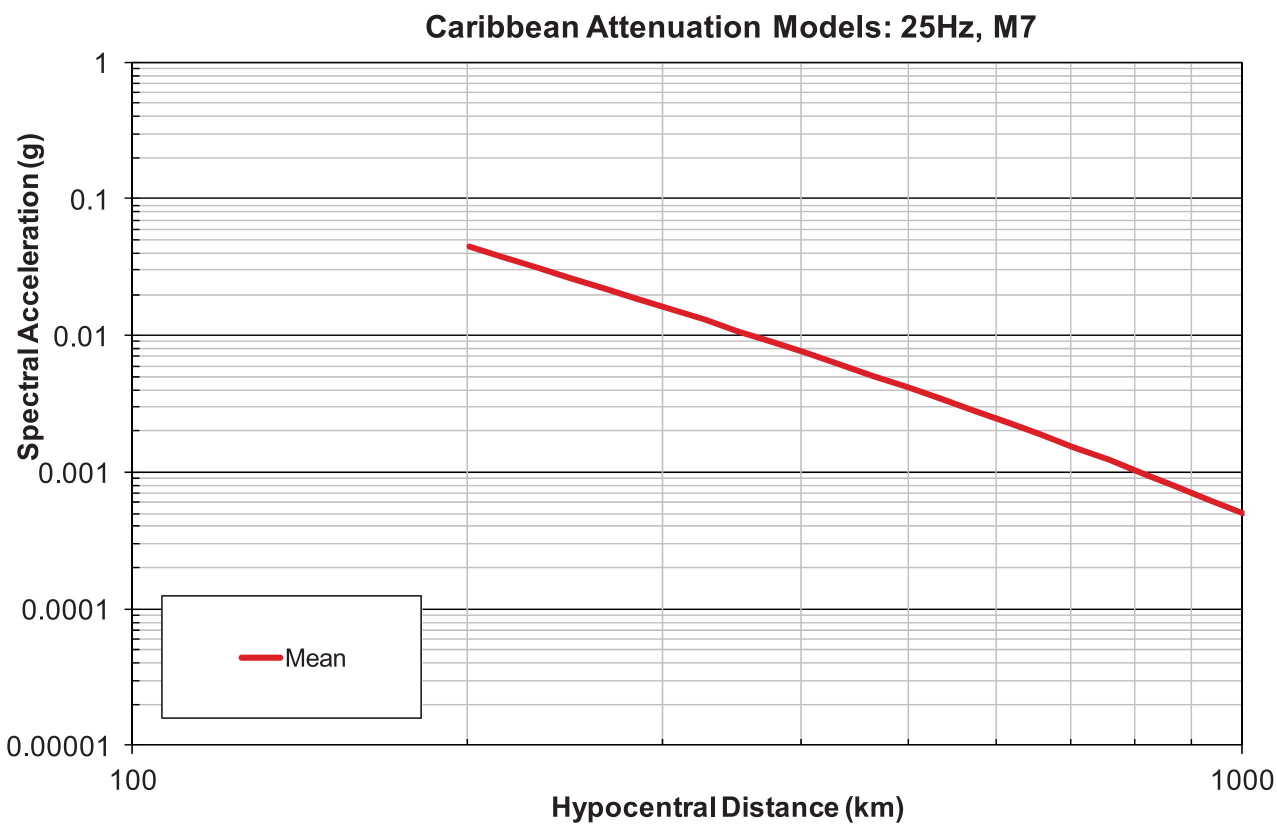


Figure 9b. Caribbean 25Hz weighted mean attenuation curve for a magnitude 7 earthquake.

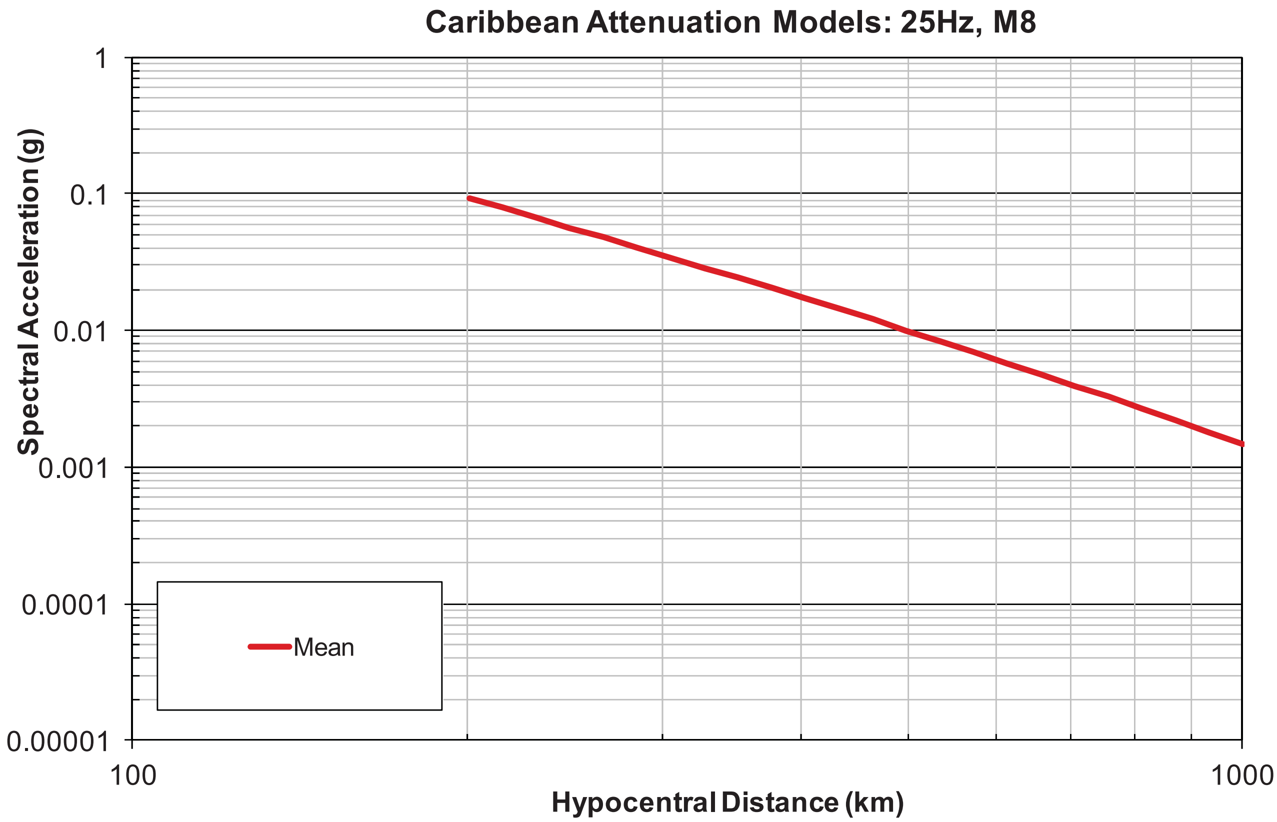


Figure 9c. Caribbean 25Hz weighted mean attenuation curve for a magnitude 8 earthquake.

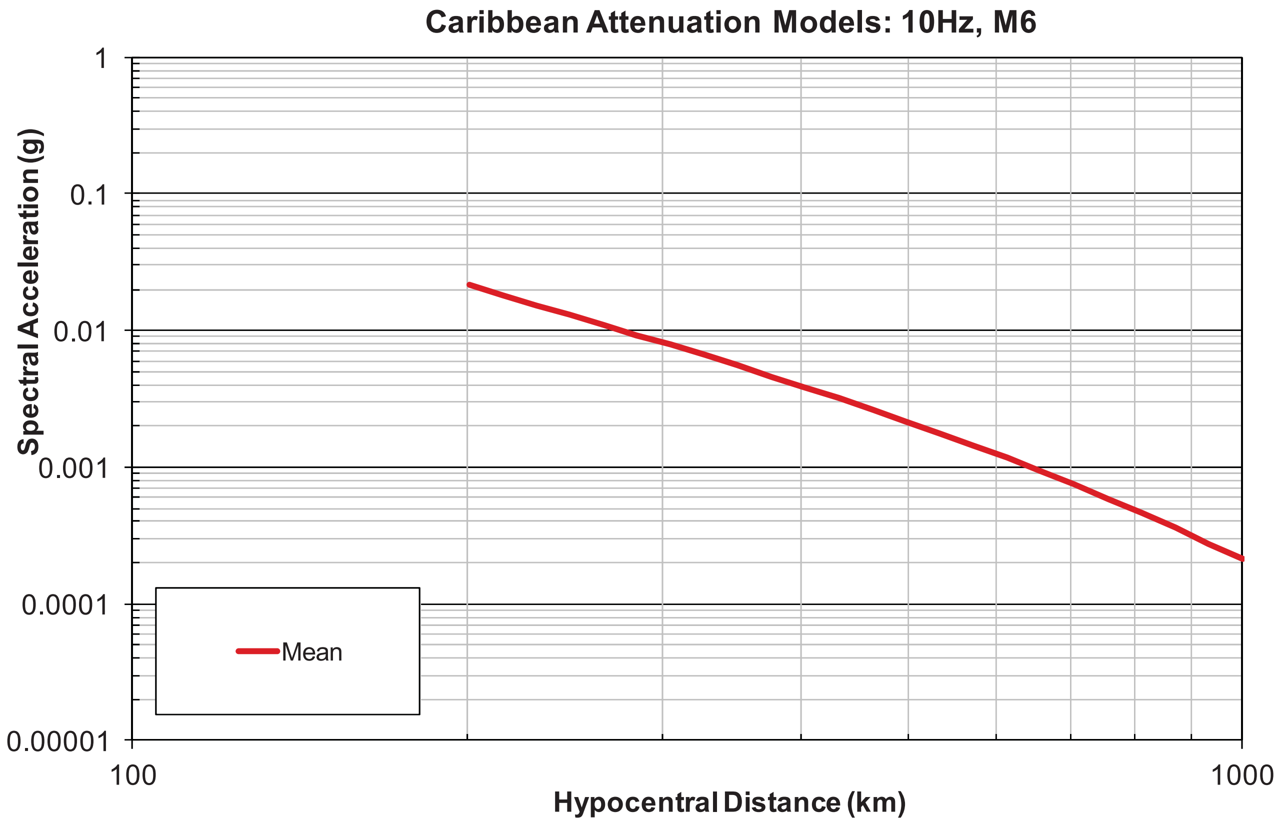


Figure 10a. Caribbean 10Hz weighted mean attenuation curve for a magnitude 6 earthquake.

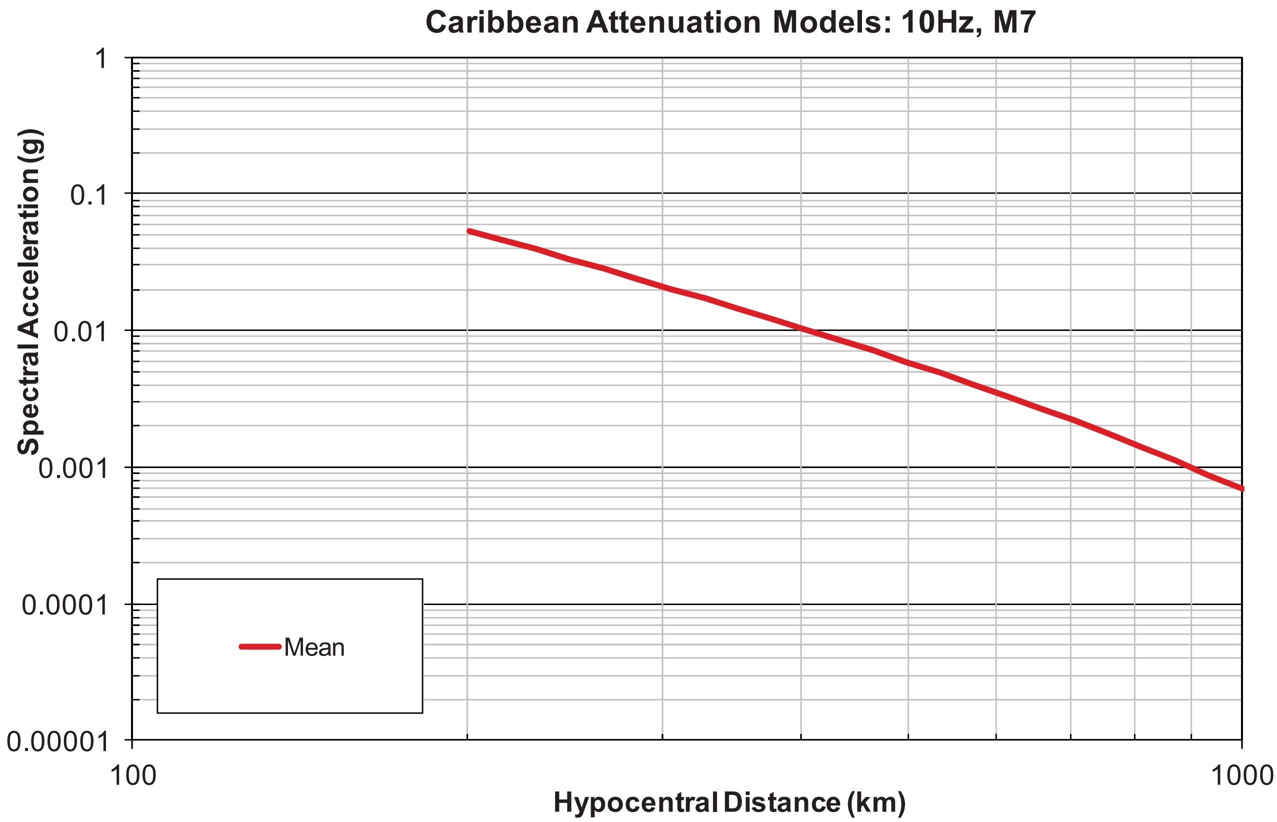


Figure 10b. Caribbean 10Hz weighted mean attenuation curve for a magnitude 7 earthquake.

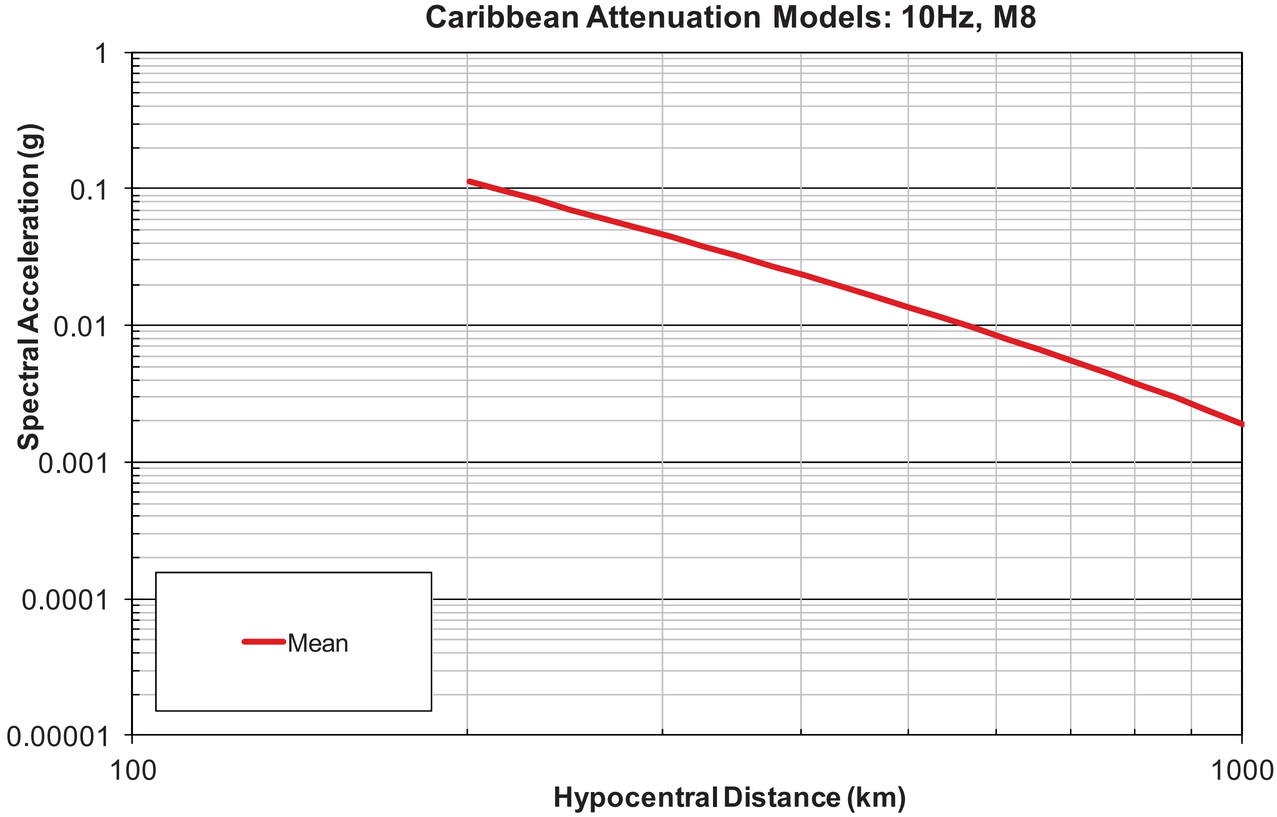


Figure 10c. Caribbean 10Hz weighted mean attenuation curve for a magnitude 8 earthquake.

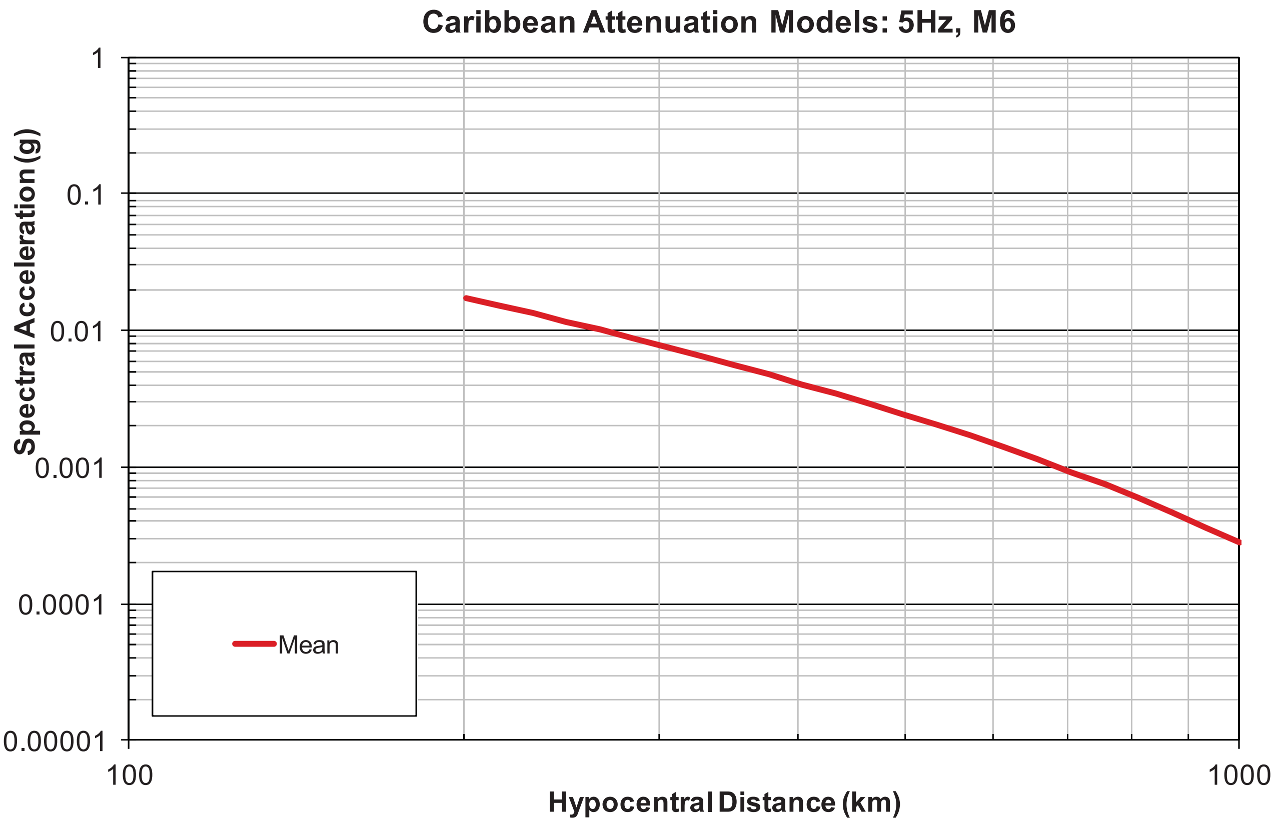


Figure 11a. Caribbean 5Hz weighted mean attenuation curve for a magnitude 6 earthquake.

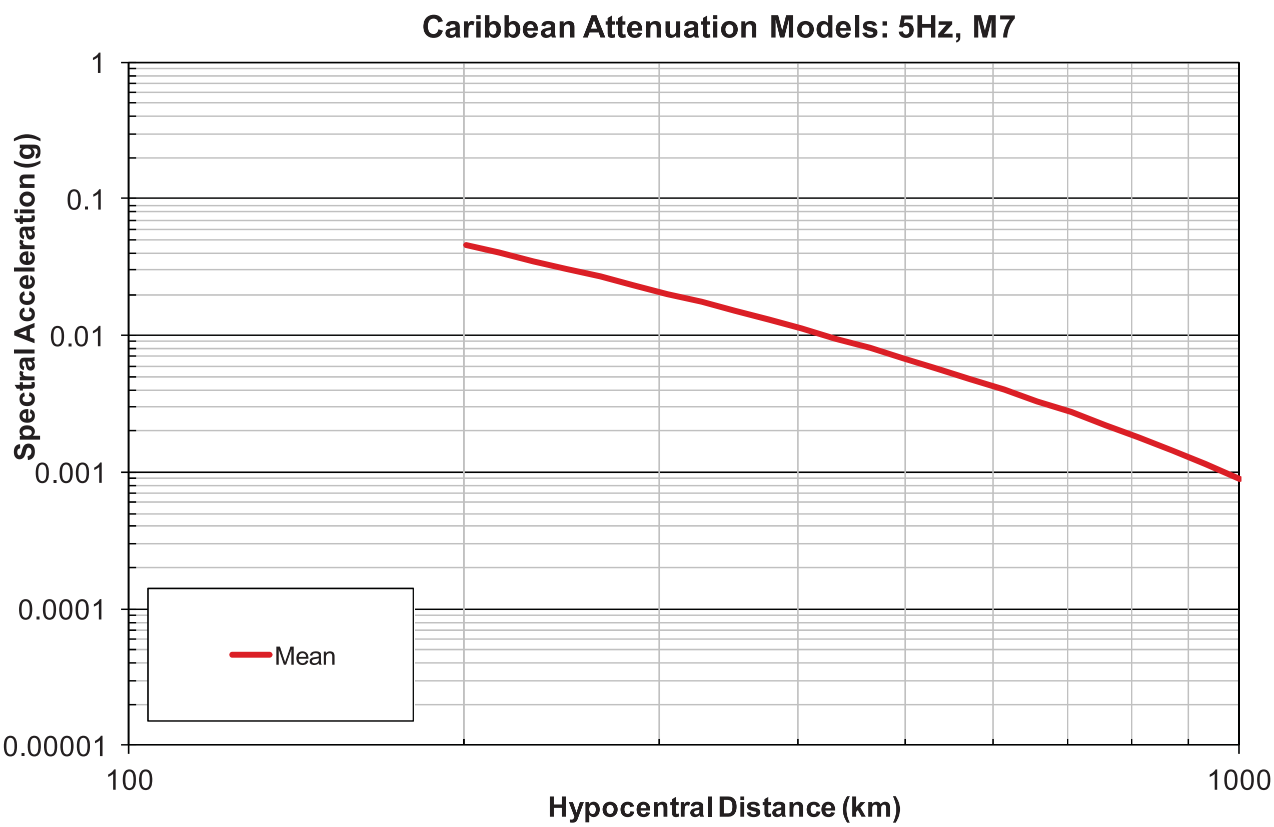


Figure 11b. Caribbean 5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

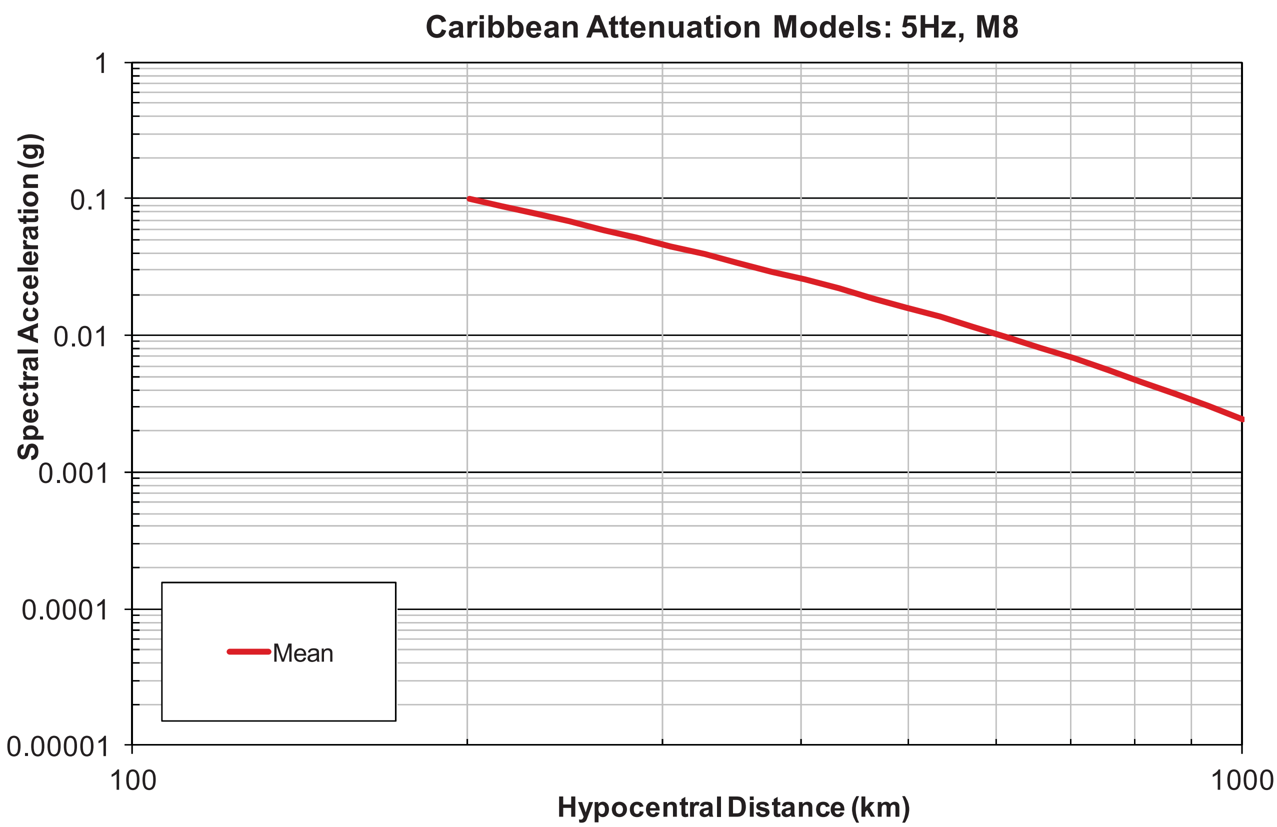


Figure 11c. Caribbean 5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

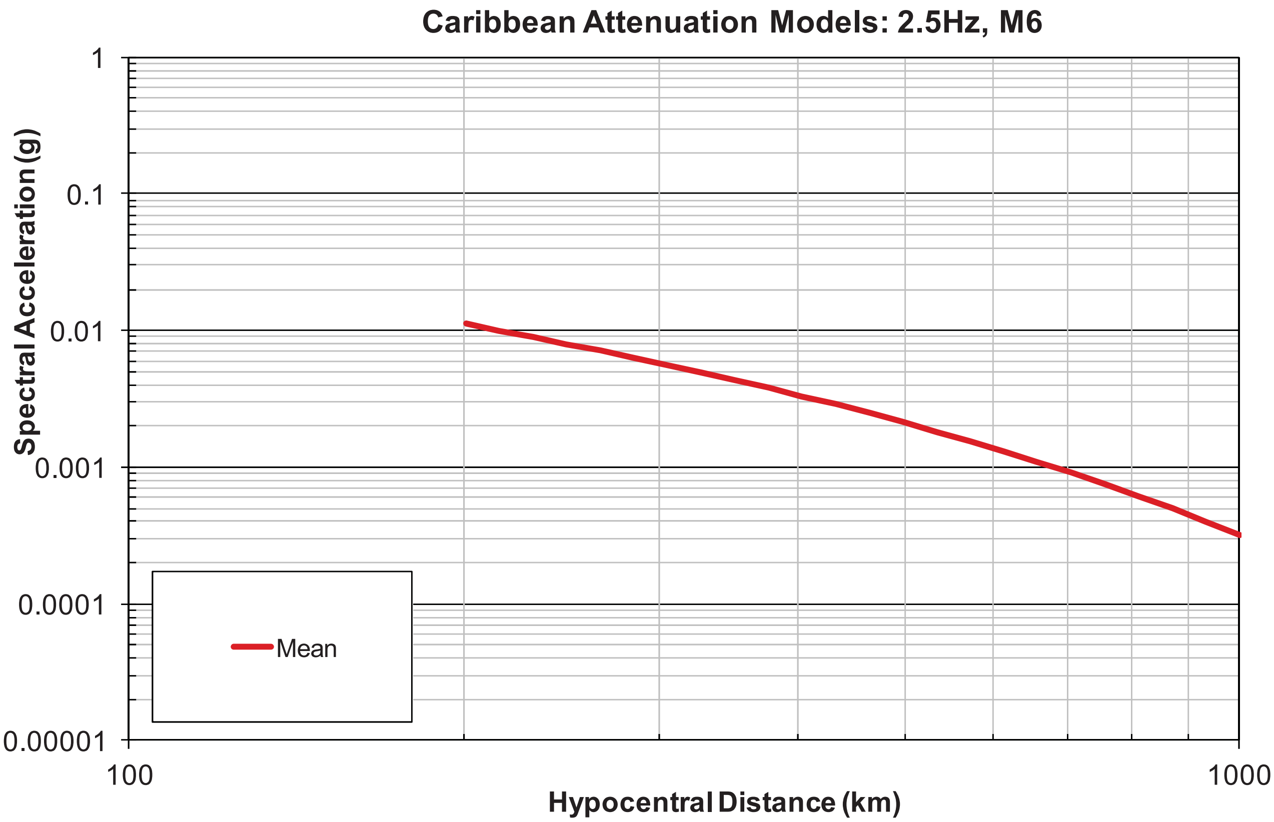


Figure 12a. Caribbean 2.5Hz weighted mean attenuation curve for a magnitude 6 earthquake.

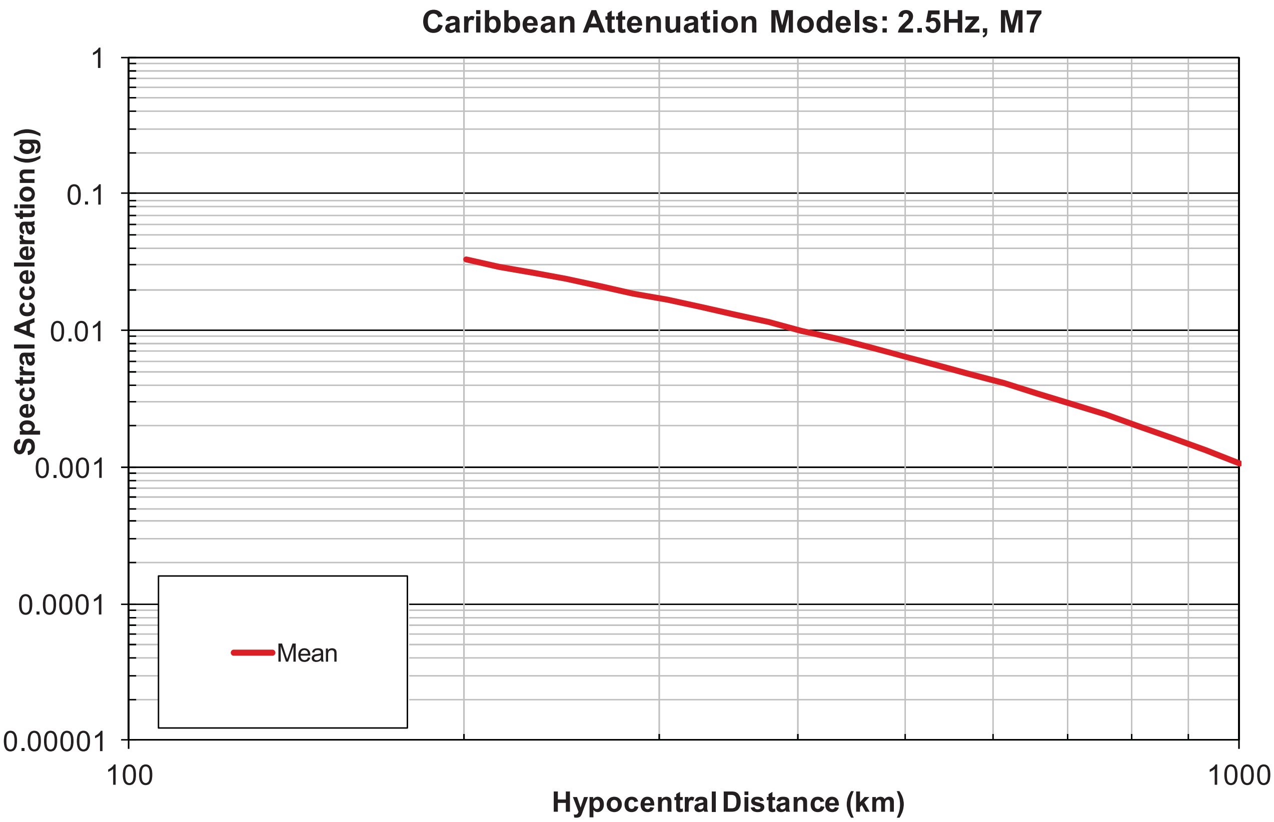


Figure 12b. Caribbean 2.5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

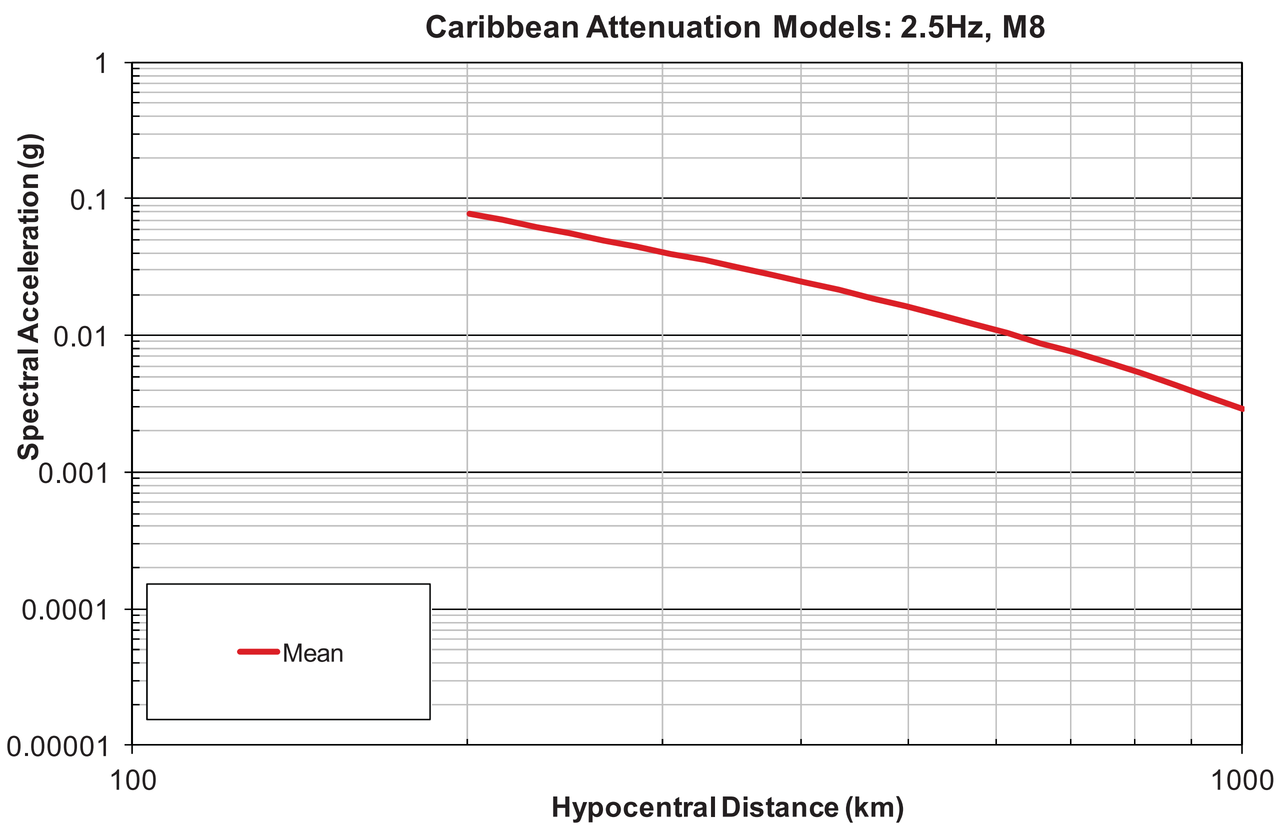


Figure 12c. Caribbean 2.5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

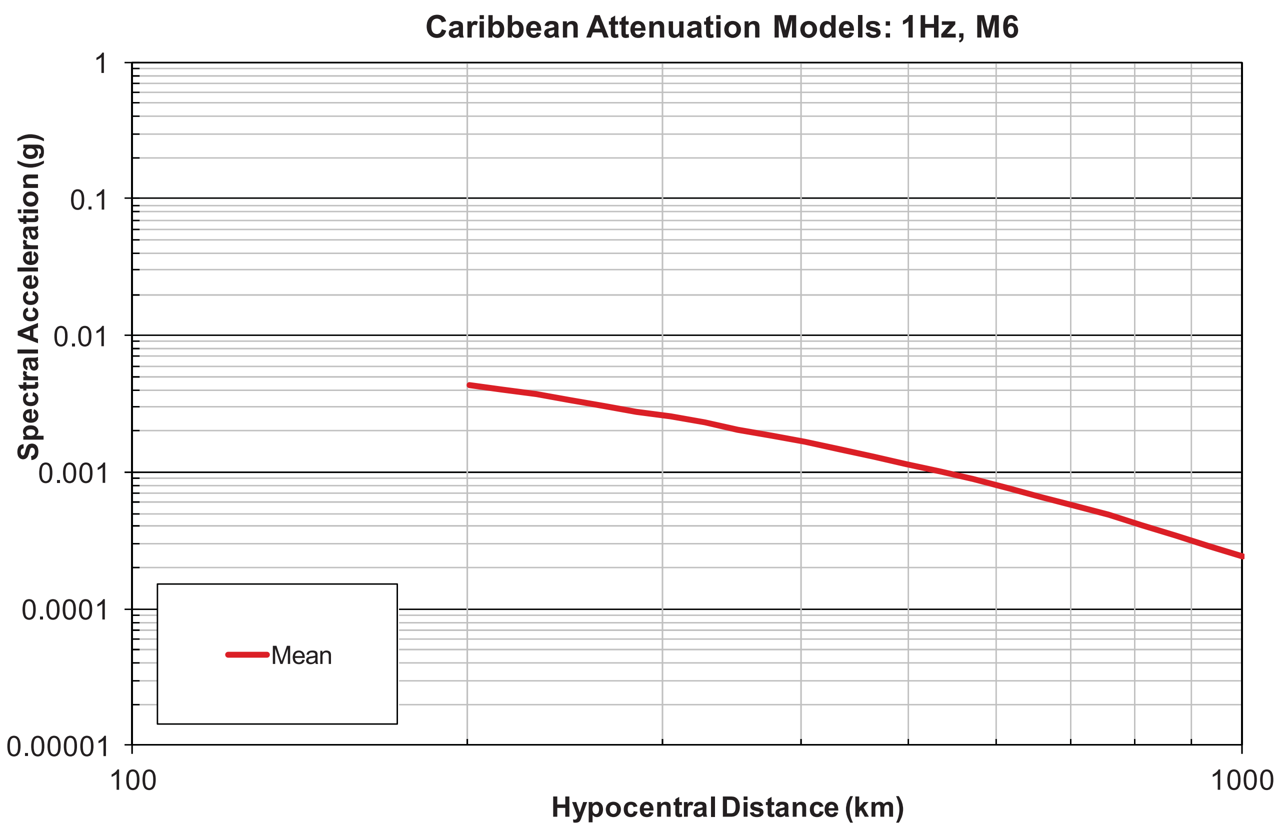


Figure 13a. Caribbean 1Hz weighted mean attenuation curve for a magnitude 6 earthquake.

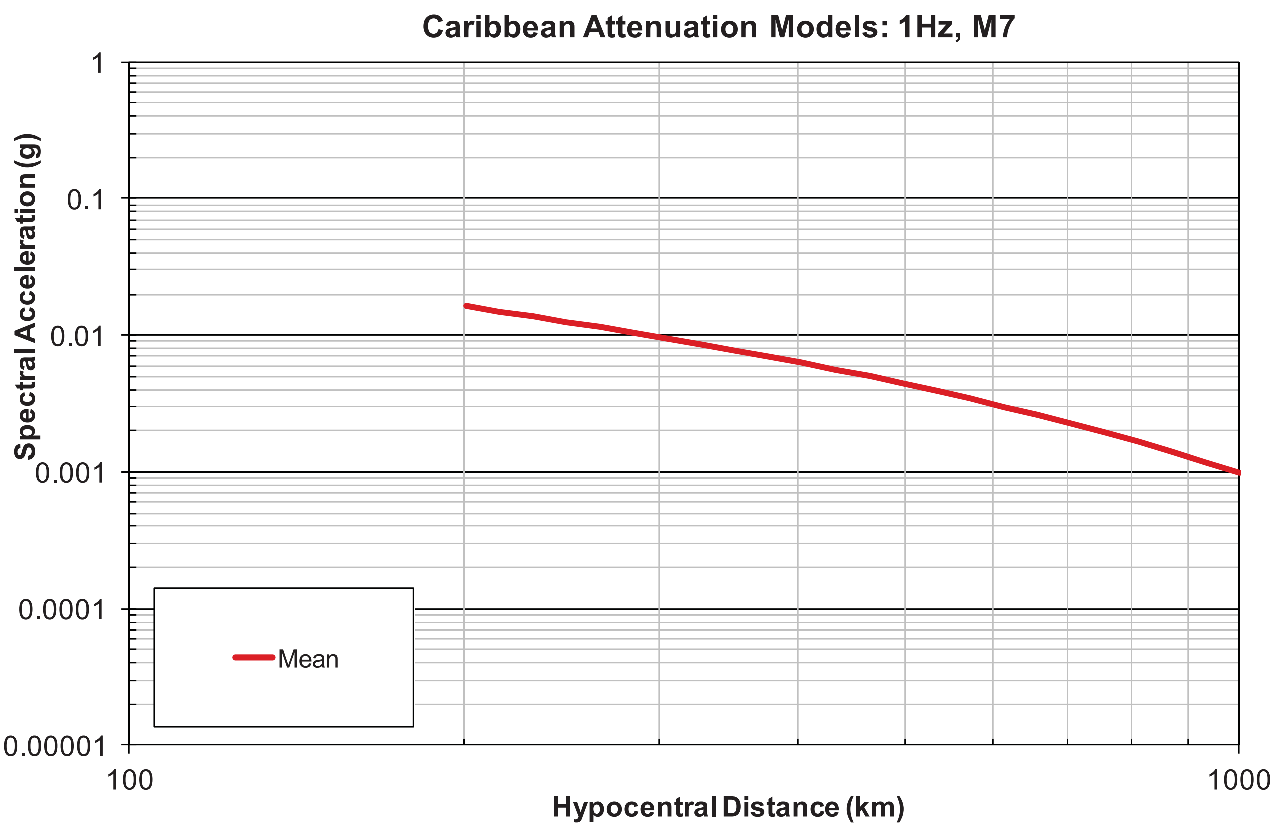


Figure 13b. Caribbean 1Hz weighted mean attenuation curve for a magnitude 7 earthquake.

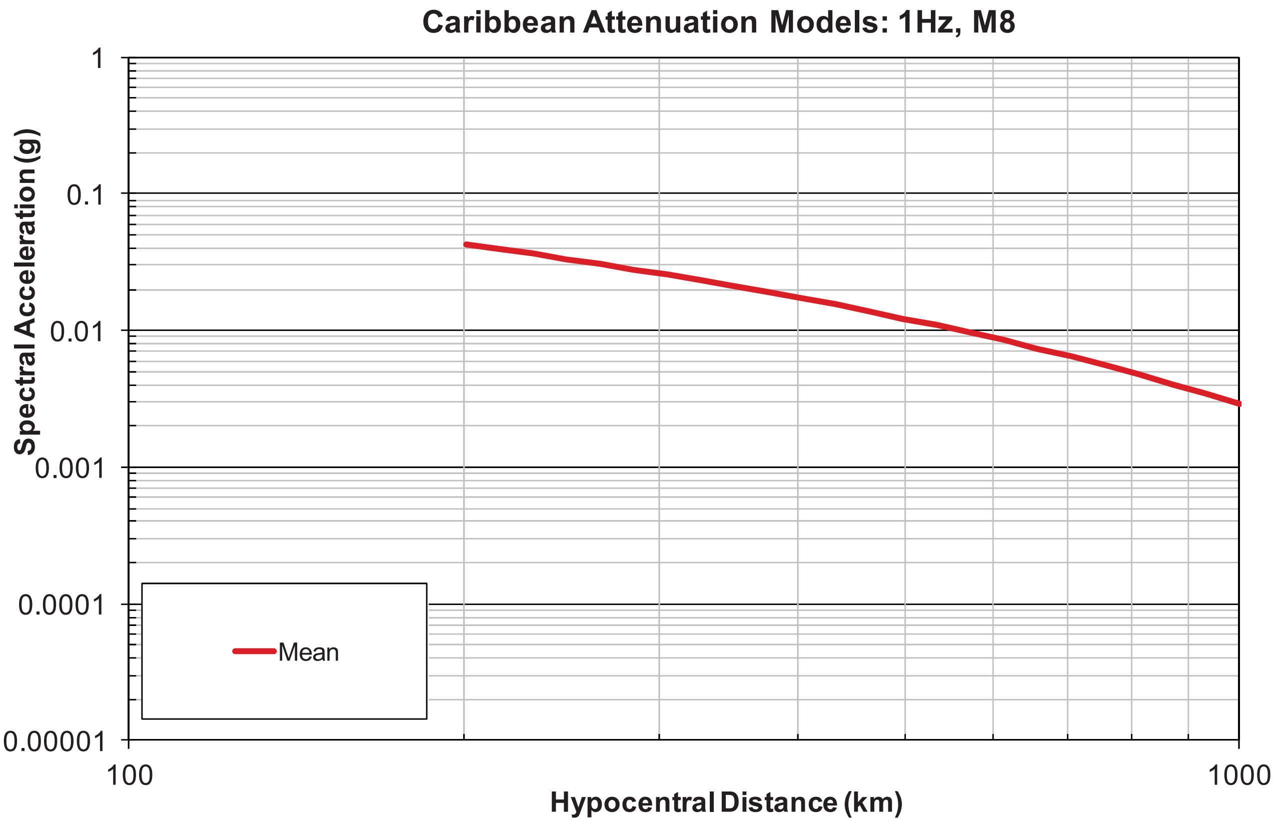


Figure 13c. Caribbean 1Hz weighted mean attenuation curve for a magnitude 8 earthquake.

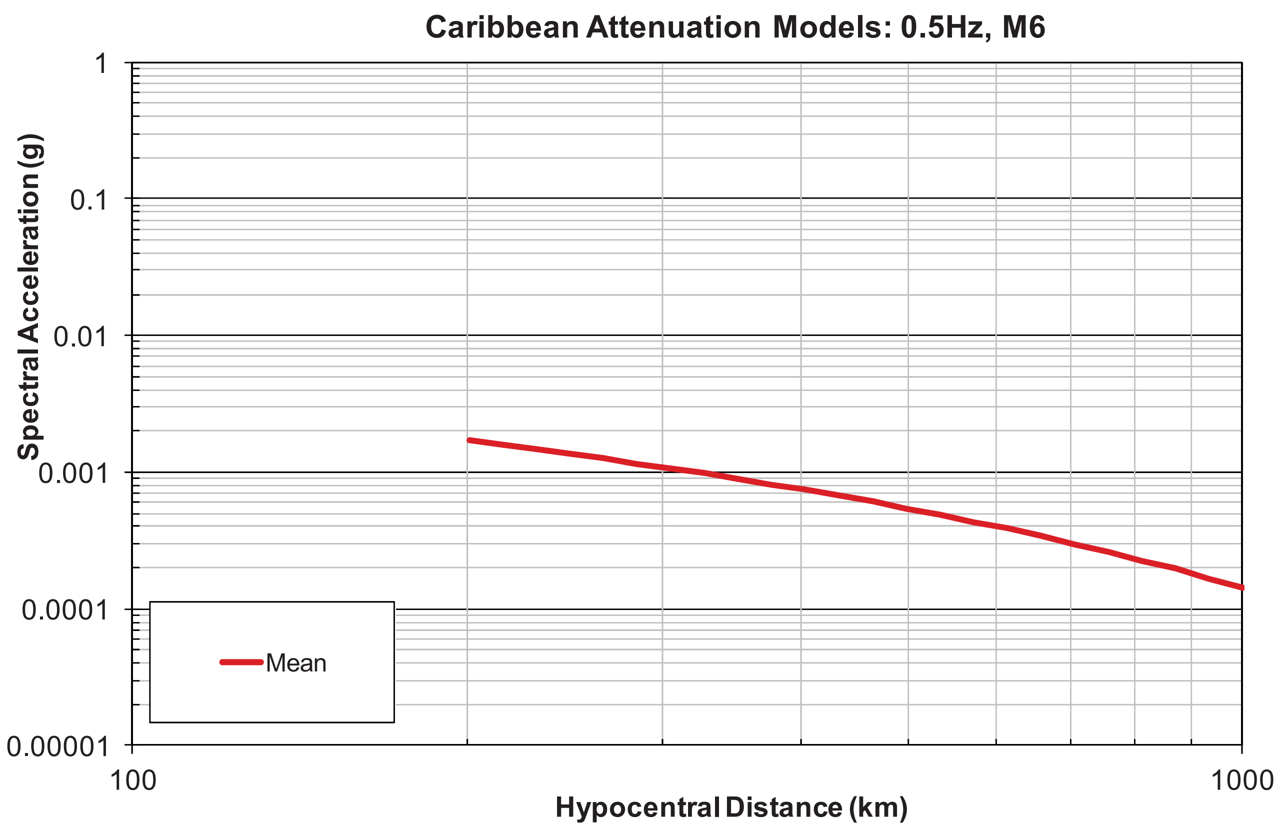


Figure 14a. Caribbean 0.5Hz weighted mean attenuation curve for a magnitude 6 earthquake.

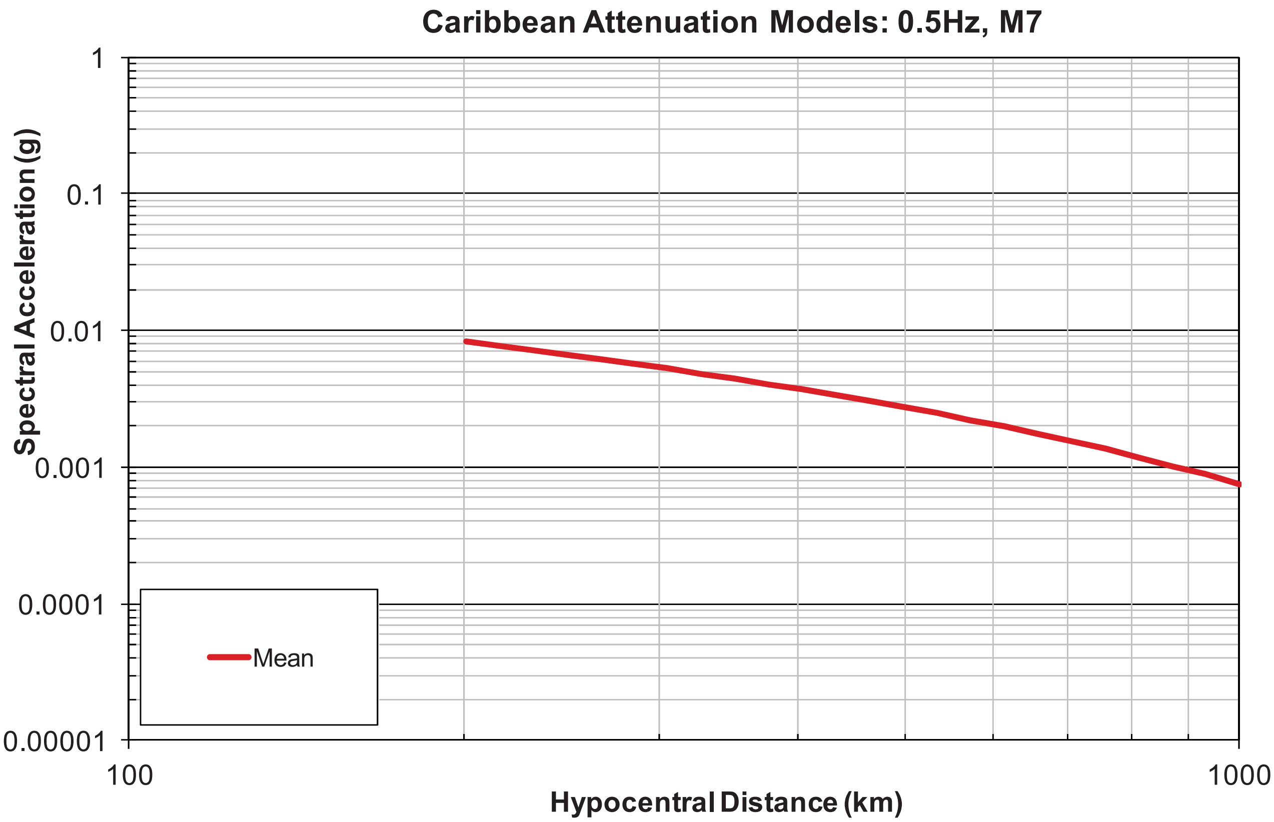


Figure 14b. Caribbean 0.5Hz weighted mean attenuation curve for a magnitude 7 earthquake.

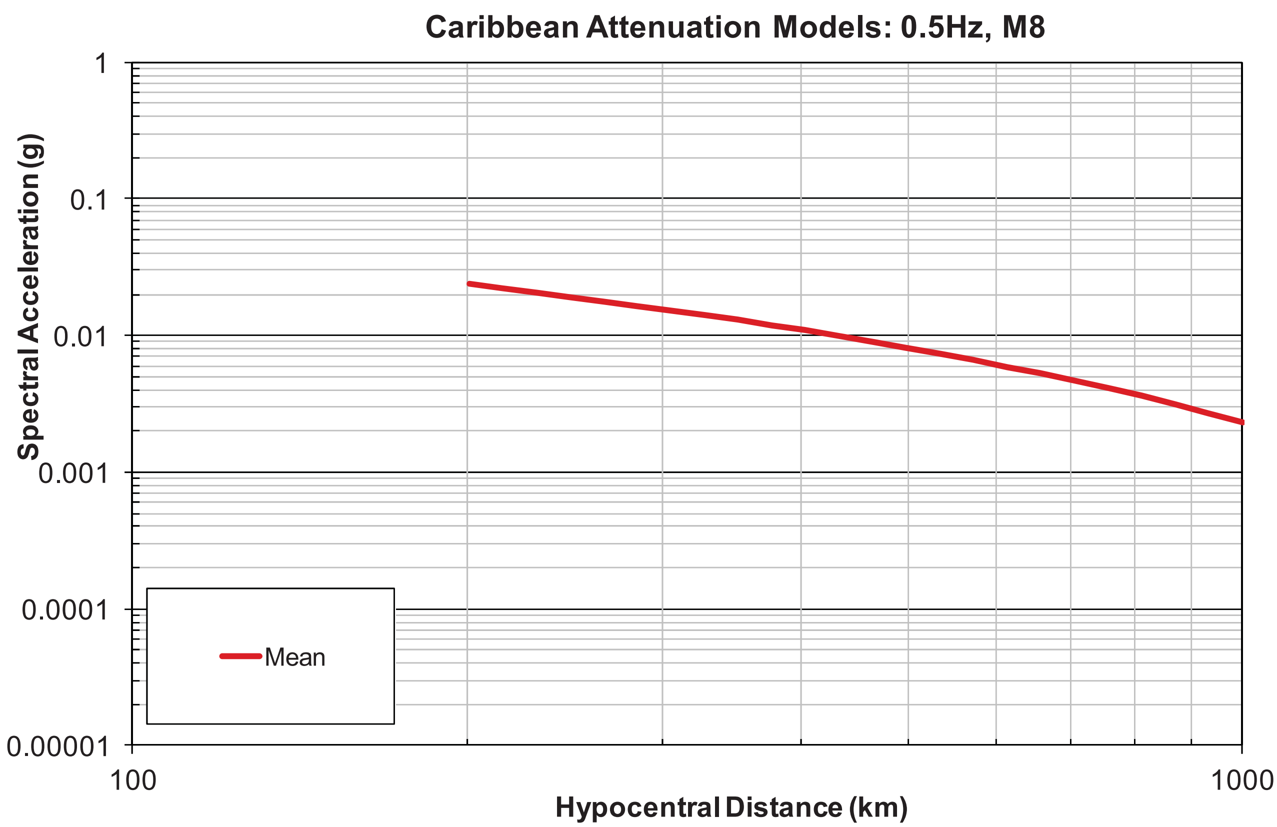


Figure 14c. Caribbean 0.5Hz weighted mean attenuation curve for a magnitude 8 earthquake.

Part e:

Based on the relatively moderate to high levels of observed seismicity in the Caribbean region, the investigation into any potential seismic source variation on either a local or regional scale could, in theory, be studied. However, based on the limited seismic networks in the region, only one such study was discovered in the literature. This study by Motazedian and Atkinson (FSAR Reference 287) studied a dataset of ground motion recordings in and around the island of Puerto Rico to develop a seismic source model including the stress parameter for the region. As they note this ground motion dataset contains both crustal and subduction earthquakes but could not be subdivided based on the earthquake type. No studies were found during a literature review that specifically addresses any potential stress parameter variation between earthquakes associated with the Northern Hispaniola, Caribbean plate-boundary transform faults, and Cuba sources.

As part of this study, Motazedian and Atkinson (FSAR Reference 287) compared their attenuation model based on the Puerto Rico data and associated stress parameter with ground motion prediction equations (GMPEs) for central and eastern United States (CEUS), California, and subduction ground motion models. Note that the CEUS and California models are based on a similar stochastic ground motion methodology that was

used by Motazedian and Atkinson (FSAR Reference 287) whereas the subduction model is based on empirical data. Their conclusion was that the Puerto Rico based model is similar to the CEUS and California models and based on their attenuation curve plots, their model predicts significantly larger (i.e., larger by factors of 5 – 10 or greater) ground motions than the empirically-based subduction GMPE.

For the probabilistic seismic hazard analysis (PSHA) performed for Turkey Point site, a total of 10 seismic sources were considered for the Caribbean region. Of these 10 sources the two Northern Hispaniola sources (i.e., western and eastern) are identified as being associated with the tectonic subduction zone in the region. Based on the comparison plots given in the Motazedian and Atkinson study (FSAR Reference 287) and the large distance from the Turkey Point site to these individual subduction seismic sources, the use of an empirically derived GMPE for the subduction seismic source zones would lead to lower ground motions than the use of GMPEs based on the Motazedian and Atkinson (FSAR Reference 287) source and attenuation scaling. Thus the PSHA results are understood to have higher ground motion results than if a subduction GMPE was used for those specific Caribbean subduction seismic source zones.

References:

Atkinson, G., Boore, D., “Empirical Ground Motion Relation for Subduction Zone Earthquakes and their Application to Cascadia and other regions,” Bulletin of the Seismological Society of America, v. 93, no. 4, pp. 1703-1729, 2003.

Atkinson, G., Silva, W., “Stochastic Modeling of California Ground Motions,” Bulletin of the Seismological Society of America, v. 90, no. 2, pp. 255-274, 2000.

ASSOCIATED COLA REVISIONS:

None

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-5 (eRAI 5896)

FSAR Subsection 2.5.2.1.3.1 states that **M**w was used as the uniform magnitude measure in Phase II (Caribbean region) earthquake catalog development efforts. Phase I earthquake catalog (EPRI updates), on the other hand, uses mb as the uniform magnitude measure. In accordance with NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG)1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion", please explain the rationale for selecting **M**w as the uniform magnitude measure for the Caribbean earthquake catalog rather than mb. Discuss what impact, if any, this choice had on the number of earthquakes listed in the Caribbean earthquake catalog. Were there any earthquakes with mb of 3.0 (or perhaps larger) that did not make the **M**w >= 3.0 cut used in Phase II catalog development?

FPL RESPONSE:

Seismologists performing current conventional probabilistic seismic hazard analyses, as well as development of ground motion prediction equations (e.g., the 2008 USGS seismic hazard maps [FSAR Reference 300] and the 2008 Next Generation of Ground-Motion Attenuation models [Chiou et al., 2008]), prefer the use of moment magnitude (Mw) over other magnitude scales, including body-wave magnitude (m_b), as it is a more direct indication of the seismic energy associated with an earthquake, particularly for both shallow and deep focus earthquakes with large fault dimensions and/or complex rupture mechanisms that occur in the Caribbean. The m_b magnitude scale saturates or is progressively insensitive to very large earthquakes with magnitudes greater than about 7.5 due to the difference in the period and the seismic wave type used in determining the magnitude size. While the magnitudes of earthquakes within the central and eastern United States are adequately represented by the m_b scale, the largest events in the Caribbean are not. This rationale for selecting moment magnitude was the basis for its use in developing the Phase 2 earthquake catalog.

The update of the Phase 1 earthquake catalog was constrained to maintain the magnitude scale in m_b because both the EPRI-SOG seismicity catalog and recurrence characterization of the EPRI-SOG seismic sources already used the m_b scale.

It should be noted that both the SRP [NUREG-0800] Section 2.5.2 and Reg. Guide 1.206 specify that the "[earthquake catalog] should include all earthquakes having Modified Mercalli Intensity (MMI) greater than or equal to IV or magnitude greater than or equal to 3.0 that have been reported within 320 km (200 miles) of the site. Large earthquakes outside of this area that would impact the SSE, should be reported." The Phase 1 and Phase 2 catalogs were developed to meet these requirements. The magnitude scale is not explicitly specified in these requirements, however, both documents later state that "magnitude designations such as m_b, M_L, M_s, M_w should be identified." There is no specification of the magnitude scale for the earthquake catalog given in Reg. Guide 1.208.

The magnitude conversion relations between the moment magnitude scale and many other scales, such as m_b, show that the magnitudes less than about 4.5 (very short fault lengths) are assumed to be numerically equivalent to M_w and that the conversion relations are nonlinear at large magnitude values to reflect the saturation of some magnitude scales (Heaton et al., 1986). Therefore, in the development of the Phase 2 catalog, all small earthquakes of any magnitude scale less than 4.5 were retained to be numerically equivalent to M_w. As a result of this assumption for small events, the selected threshold magnitude scale $M_w \geq 3.0$ for the Phase 2 earthquake catalog and m_b (or (E)mb) ≥ 3.0 for the Phase 1 earthquake catalog presents no inconsistency in terms of minimum size or minimum seismic energy of a given earthquake considered in the two catalogs. Therefore, all earthquakes of magnitude 3.0 and larger, regardless of characterization as moment magnitude or body-wave magnitude, are included in both Phase 1 and Phase 2 earthquake catalogs, and there is no impact on the number of earthquakes in the two earthquake catalogs associated with the different magnitude scales used in the two earthquake catalogs.

This response is PLANT SPECIFIC.

References:

Chiou, B., R. Darragh, N. Gregor, and W. Silva (2008). NGA Project Strong-Motion Database, Earthquake Spectra v.24, pp.23-44.

Heaton, T., F. Tajima and A. W. Mori (1986). Estimating ground motions using recorded accelerograms. Surveys in Geophysics, v.8, p 25-83.

ASSOCIATED COLA REVISIONS:

None

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-8 (eRAI 5896)

FSAR Subsection 2.5.2.4.6 lists the Cuba areal source as one of the major contributing seismic sources to the total hazard. However, the deaggregation results shown in FSAR Figure 2.5.2-226 indicate only a minor contribution from the distance range of the Cuba areal source. In accordance with NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion", please explain this apparent discrepancy. What is the percentage of the Cuba areal source's hazard contribution (at 10E-04 and 10E-05 levels) to the total site hazard at all seven frequencies defined by the EPRI 2004 and 2006 GMPEs? Are these consistent with the deaggregation results?

FPL RESPONSE:

FSAR section 2.5.2.4.6 states that distant sources have the major contribution to low-frequency rock hazard and these sources include the Cuba areal source, Caribbean faults, and Charleston source. Table 1 shows the rock hazard from the Cuba areal source alone for the overall 10^{-4} and 10^{-5} amplitudes and also shows the percent contribution to the total 10^{-4} and 10^{-5} rock hazard. These percentages are consistent with the deaggregation plots (FSAR Figures 2.5.2-226 through 2.5.2-229). Note, for example, that at 10^{-4}, contributions from the Cuba areal source at 1 Hz and 2.5 Hz are 14.6% and 29.7% respectively, which average to approximately 22%. This contribution in FSAR Figure 2.5.2-226 (for 1 Hz and 2.5 Hz) is spread over about 25 magnitude-distance bins with magnitudes ranging from 6.0 to 7.5 and distances ranging from 210 km to about 480 km. This example illustrates that the percent contributions in Table 1 are consistent with the deaggregation plots (FSAR Figures 2.5.2-226 through 2.5.2-229).

Table 1. Percent contribution of total mean rock hazard from the Cuba areal source.

	% Contribution at 10^{-4}		% Contribution at 10^{-5}	
Frequency (Hz)	Mean Hazard (Cuba Areal Source)	% Contribution	Mean Hazard (Cuba Areal Source)	% Contribution
0.5	6.13E-06	6.1	4.33E-07	4.3
1	1.46E-05	14.6	1.21E-06	12.1
2.5	2.97E-05	29.7	1.45E-06	14.5
5	3.10E-05	31.0	5.82E-07	5.8
10	2.08E-05	20.8	1.52E-07	1.5
25	4.50E-06	4.5	6.97E-09	0.1
100 (PGA)	1.25E-05	12.5	4.49E-08	0.4

This response is PLANT SPECIFIC.

References:

None

ASSOCIATED COLA REVISIONS:

None

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-9 (eRAI 5896)

FSAR Subsection 2.5.2.5.1 states that P-wave velocities from eight deep wells were used to develop the deeper (>636 ft) sections of the site response model. The wells that provide the P-wave velocity information are approximately 100 km to 180 km away from the site. In accordance with Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground
Motion", please provide:

a. additional information on the applicability of seismic velocity information obtained at such great distances to the Turkey Point site. How was the variation in geology considered in these projections?

b. individual velocity profiles for each of the eight wells used in estimating the average profile shown in FSAR Figure 2.5.4-211

c. further details on how larger uncertainties in deeper layers' thicknesses/depths are taken into account in the randomization of the site profile

FPL RESPONSE:

Sonic logs 0001, 0002, 0005, 0007, 0008 and 0010 were derived from wells located approximately 66 miles, 62 miles, 81 miles, 110 miles, 82 miles, and 71 miles from the FPL Turkey Point site, respectively (FSAR Figure 2.5.4-210). The measurements recorded by the probe were depth, expressed in feet below the drill rig's Kelly bushing, and the interval travel time, Delta T (DT_p), expressed in microseconds (10^{-6} seconds) per foot. The logs were initiated at an upper depth of 3,610 ft to 4,100 ft below each drill rig's Kelly bushing and terminated at a lower depth of 11,600 ft to 11,920 ft below Kelly bushing.

Sonic logs LAB-TW and PBF-12 were derived from wells located approximately 115 miles and 64 miles from the FPL Turkey Point site, respectively (FSAR Figure 2.5.4-210). The measurements recorded by the probe were depth, expressed in feet below land surface, and interval travel time, expressed in microseconds per foot. The logs were initiated at an upper depth of 500 to 900 ft below land surface and terminated at a lower depth of 1,900 to 2,350 ft below land surface.

This response is structured to respond to parts a, b, and c of the RAI.

a) The well locations with the sonic logs used for this analysis are shown on FSAR Figure 2.5.4-210. FSAR Figure 2.5.1-232 shows a north-south geologic cross section (Section E-F) through the Upper Mesozoic and Lower Cenozoic rock in southern Florida. Point 39 on the profile (and on the Locator Map on FSAR Figure 2.5.1-232) is in the vicinity of the majority of the sonic log locations on

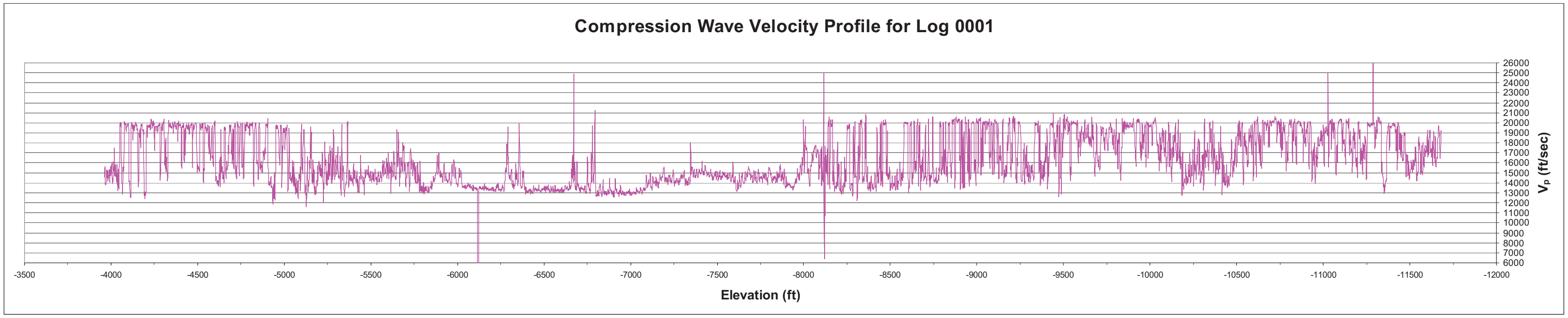
FSAR Figure 2.5.4-210. The distance from Point 39 to the Turkey Point site is about 80 miles. Based on the review of publications, regional geologic cross sections and the sonic logs, there is relatively little variation in the stratigraphy in the upper 6,000 ft between the Point 39 area and the Turkey Point site. Considering that stratigraphy generally shows less variation with increasing depth, it is reasonable to assume that the lack of stratigraphic variation on the scale shown in FSAR Figure 2.5.1-232 continues below 6,000 ft. This consistency of the stratigraphy and the gentle regional dip of the stratigraphic units confirms the appropriateness of using data from the eight deep wells to develop the site response model.

b) The velocity profiles for each of the 8 wells are shown in Figure 1.

c) The uncertainties in the dynamic properties of the deeper layers were taken into account by the following two steps.

1. The calculated logarithmic standard deviation of the converted shear-wave velocity (Vs) was increased to account for uncertainty in Poisson's ratio and to account for the number of profiles used to construct the deep portion of the base case profile.
2. The layer thicknesses of each synthetic profile were obtained using a randomization approach where the rate of layer boundaries at a given depth (which is closely related to the probability of having a layer boundary at that depth) is the sum of a smooth continuous function and a non-smooth function that takes non-zero values where the base case profiles has discontinuities in Vs. The value of the latter function is proportional to the relative change in Vs and inversely proportional to the logarithmic standard deviation of Vs. Because the size of the steps in the base case Vs profile is relatively small compared to the logarithmic standard deviation of Vs, these discontinuities tend to occur at different depths in different synthetic profiles, as can be verified in FSAR Figure 2.5.2-239. This implies that the layer thicknesses are strongly randomized in the lower portion of the profile.

Figure 1. Compression Wave Velocity Profiles for Sonic Logs 0001, 0002, 0005, 0007, 0008, 0010, LAB-TW and PBF-12



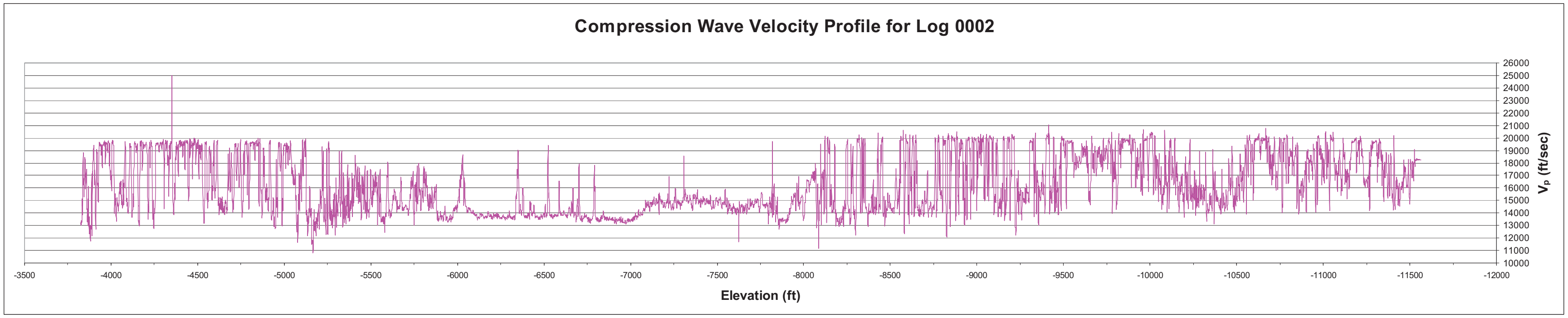
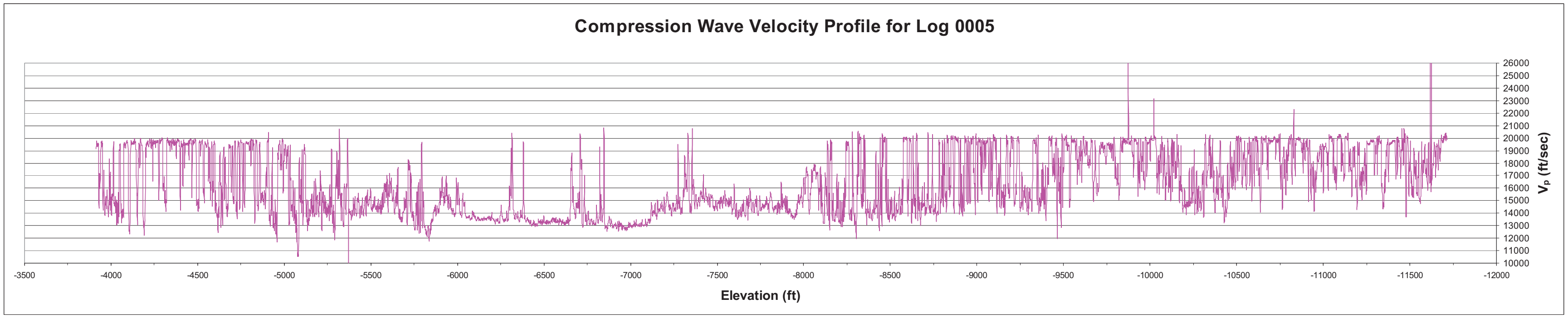
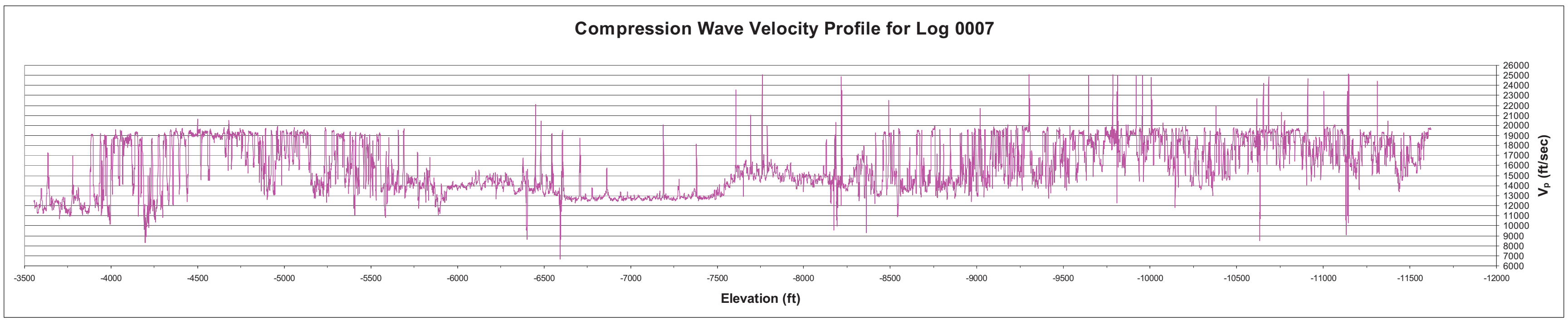


Figure 1. Compression Wave Velocity Profiles for Sonic Logs 0001, 0002, 0005, 0007, 0008, 0010, LAB-TW and PBF-12 Cont'd





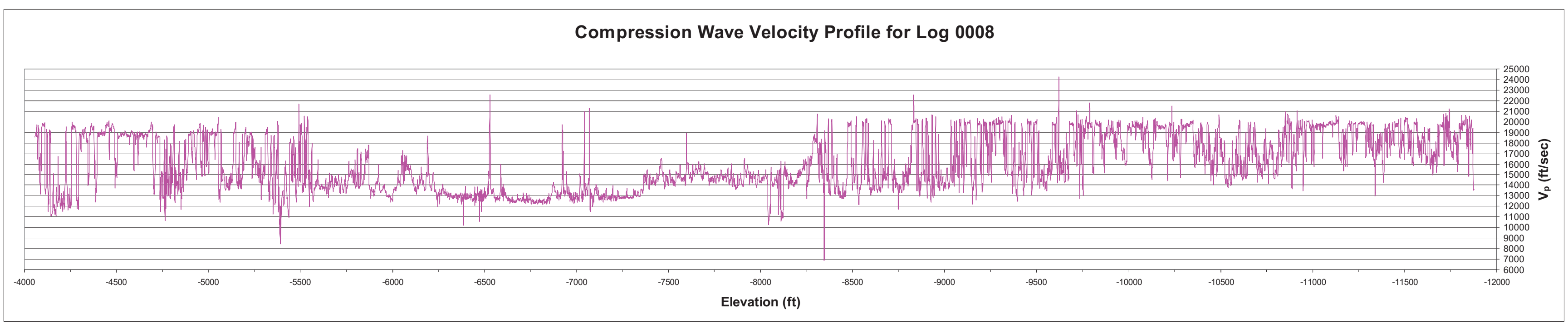
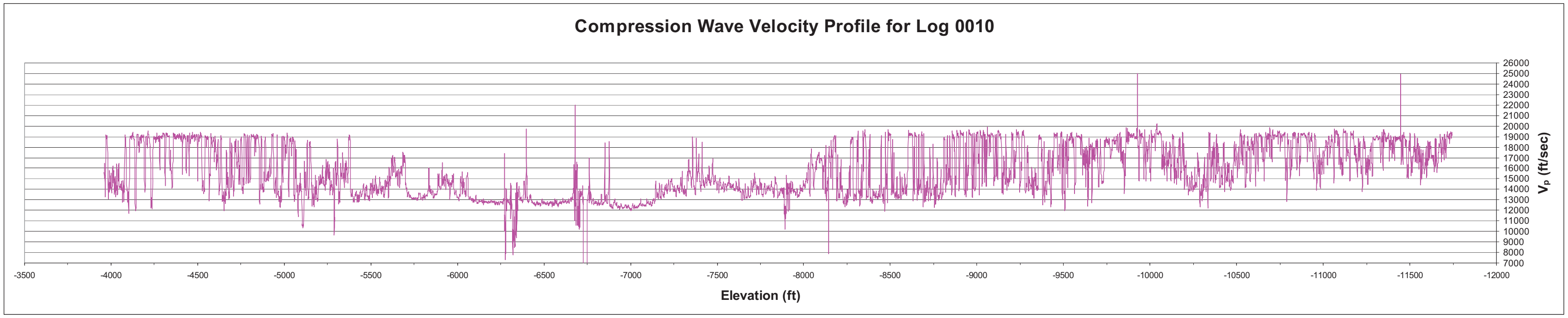
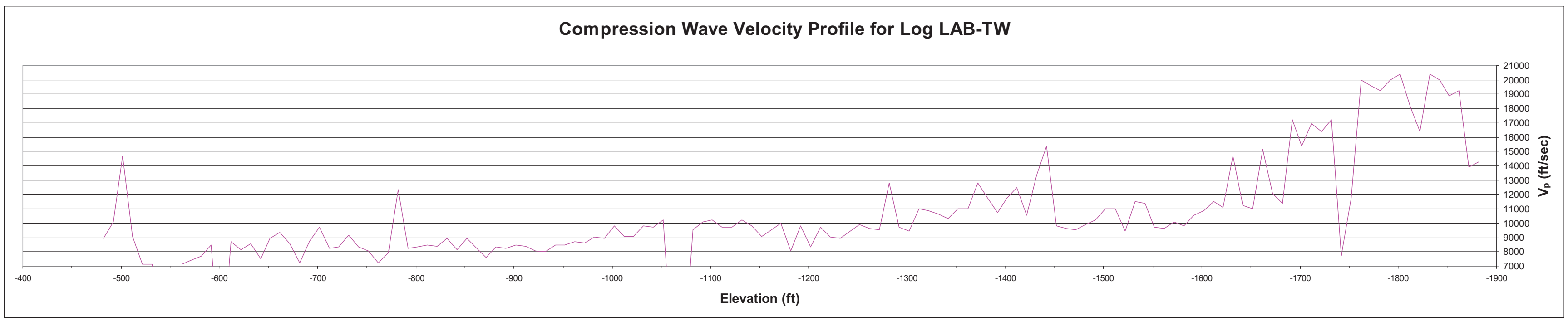
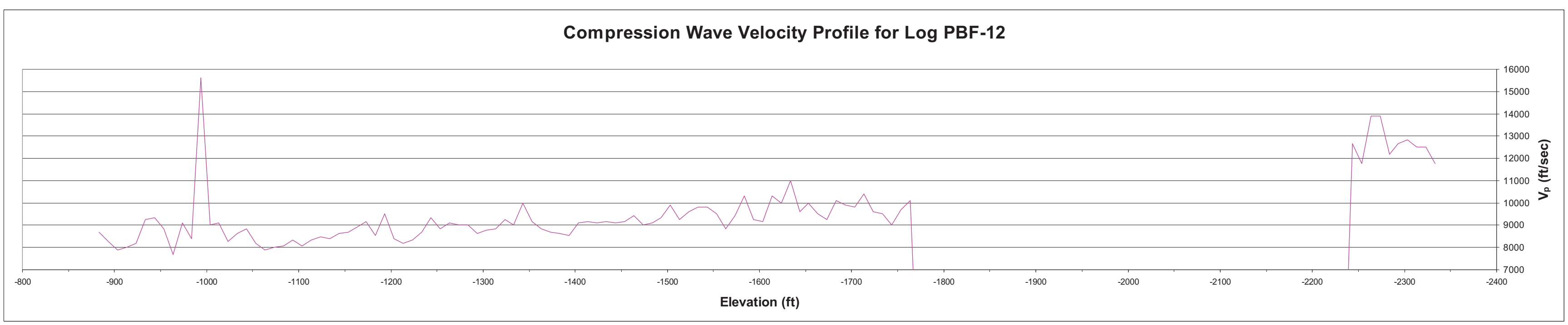


Figure 1. Compression Wave Velocity Profiles for Sonic Logs 0001, 0002, 0005, 0007, 0008, 0010, LAB-TW and PBF-12 Cont'd







This response is PLANT SPECIFIC.

References:

None

ASSOCIATED COLA REVISIONS:

None

ASSOCIATED ENCLOSURES:

None

L-2011-460
10 CFR 52.3

October 31, 2011

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

Re: Florida Power & Light Company
Proposed Turkey Point Units 6 and 7
Docket Nos. 52-040 and 52-041
Response and Response Schedule to NRC Request for Additional Information
Letter No. 037 (eRAI 5896) SRP Section - 02.05.02 Vibratory Ground Motion

Reference:

1. NRC Letter to FPL dated September 21, 2011, Request for Additional Information Letter No.037 Related to SRP Section 02.05.02 - Vibratory Ground Motion for the Turkey Point Nuclear Plant Units 6 and 7 Combined License Application

Florida Power & Light Company (FPL) provides, as attachments to this letter, its responses to the Nuclear Regulatory Commission's (NRC) Request for Additional Information (RAI) 02.05.02 -3, RAI 02.05.02 -6, RAI 02.05.02 -10, RAI 02.05.02 -11, and RAI 02.05.02 -13 provided in Reference 1. The attachment identifies changes that will be made in a future revision of the Turkey Point Units 6 and 7 Combined License Application (if applicable).

Additionally, the Nuclear Regulatory Commission (NRC) requested Florida Power & Light Company (FPL) to respond to the Request for Additional Information (RAI) within 30 days of the date of the referenced letter. If FPL was unable to provide a response within 30 days, NRC requested FPL to provide a schedule to provide the responses. This letter also provides the FPL schedule to respond to the NRC Requests for Additional Information (RAI) 02.05.02-2, 02.05.02-4, 02.05.02-5, 02.05.02-7, 02.05.02-8, 02.05.02-9, and 02.05.02-12 provided in the referenced letter.

The responses to RAI 02.05.02-2, RAI 02.05.02-5, RAI 02.05.02-8, and RAI 02.05.02-9 are scheduled to be provided by November 17, 2011.

The responses to RAI 02.05.02-4, RAI 02.05.02-7, RAI 02.05.02-12 are scheduled to be provided by November 30, 2011.

If you have any questions, or need additional information, please contact me at 561-691-7490.

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

Executed on October 31, 2011

Sincerely,

William Maher
Senior Licensing Director – New Nuclear Projects

WDM/RFB

Attachment 1: FPL Response to NRC RAI No. 02.05.02 -3 (eRAI 5896)
Attachment 2: FPL Response to NRC RAI No. 02.05.02 -6 (eRAI 5896)
Attachment 3: FPL Response to NRC RAI No. 02.05.02 -10 (eRAI 5896)
Attachment 4: FPL Response to NRC RAI No. 02.05.02 -11 (eRAI 5896)
Attachment 5: FPL Response to NRC RAI No. 02.05.02 -13 (eRAI 5896)

cc:
PTN 6 & 7 Project Manager, AP1000 Projects Branch 1, USNRC DNRL/NRO
Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Plant 3 & 4

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-3 (eRAI 5896)

FSAR Subsection 2.5.2.4.4.3.1 describes summary information related to the SSHAC Level 2 study on new seismic source models for the Cuba and northern Caribbean region. In accordance with NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion", and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion," please provide the complete SSHAC documentation detailing specifically:

a. Procedures and any assumptions made in developing the Caribbean seismic sources,
b. The questionnaire used in obtaining expert opinions,
c. The TI any advisory groups and/or peer reviewers used,
d. How the experts' opinions were integrated into the development of the final models. Discuss expert opinions and/or suggestions that were left out of the final model and justifications for doing so,
e. How conflicting opinions among the experts were dealt with,
f. How the final models represent the consensus of the informed community

FPL RESPONSE:

<u>a. Procedures and any Assumptions Made in Developing the Caribbean Seismic Sources</u>

The seismic source characterization for Cuba and the northern Caribbean region developed for the Turkey Point Units 6 & 7 project was performed through the use of the Senior Seismic Hazard Analysis Committee (SSHAC) Level 2 process, defined in SSHAC (1997) (FSAR Reference 318). The SSHAC developed a formal process for conducting expert assessments and the use of expert judgment to incorporate uncertainties in probabilistic seismic hazard analysis (PSHA) (FSAR Reference 318). The goal of the SSHAC process is to “represent the center, the body, and the range of technical interpretations that the larger informed technical community would have if they were to conduct the study” (FSAR Reference 318, p. 21). The SSHAC process also identifies a clear definition of “ownership” of the input parameters into the PSHA, and hence ownership of the PSHA results. Ownership means “intellectual responsibility” such that the regulator will know the individuals who are responsible for developing the PSHA.

SSHAC (1997) (FSAR Reference 318) defines four levels of effort for capturing the range of uncertainty by the informed technical community (ITC). These are termed Levels 1 through 4. With each increasing level, there is increasing direct involvement of the ITC and, thus, increasing confidence and documentation that the center, body, and range of uncertainty in the ITC have been captured. Regardless of level of study, however, the goal of the SSHAC process is “to provide a representation of the informed scientific community’s view of the important components and issues and, finally, the seismic hazard” (FSAR Reference 318, p. 26). Moreover, “regardless of the scale of the PSHA study, the goal

remains the same: to represent the center, the body, and the range that the larger informed technical community would have if they were to conduct the study" (FSAR Reference 318, p. 21). FSAR Section 2.5.2.4.4.3 describes the seismic source characterization for Cuba and the northern Caribbean region developed for the Turkey Point Units 6 & 7 project. Development of this seismic source characterization followed the SSHAC Level 2 process. According to FSAR Reference 318, a Level 2 study is appropriate for issues with "significant uncertainty and diversity", and for issues that are "controversial" and "complex" (FSAR Reference 318, p. 23).

b. The Questionnaire Used in Obtaining Expert Opinions

The SSHAC Level 2 process utilizes an individual, team, or company to act as the Technical Integrator (TI). In a SSHAC Level 2 study, the TI is responsible for reviewing data and literature and contacting experts who have developed interpretations or who have specific knowledge of the seismic sources. The TI interacts with these resource experts to identify issues and interpretations, and to assess the center, body, and range of informed expert opinion. In other words, the role of the TI is to "evaluate the viability and credibility of the various hypotheses with an eye toward capturing the range of interpretations, their credibilities, and uncertainties" (FSAR Reference 318, p. 27).The SSHAC Level 2 process performed for the Turkey Point Units 6 & 7 project began with a comprehensive literature search and review performed by the TI team. Based on this literature review, the TI team developed a preliminary straw man seismic source characterization. Also based on this literature review, the TI team identified resource experts with specialized knowledge of the region. These resource experts span a wide range of disciplines including geology, seismology, geodesy, and geophysics. FSAR Table 2.5.2-216 provides a list of the resource experts contacted as part of this process.

The TI team conducted interviews with resource experts by phone, email, and/or face-to-face discussions. To provide a framework and starting point for these discussions, resource experts were given a standard questionnaire pertaining to the straw man seismic source characterization and key issues regarding seismic sources in Cuba and the northern Caribbean. This questionnaire is provided herein as Enclosure A. The interviews with resource experts were not a formal process of expert interrogation to obtain from each expert all of the specific parameters and weights to be used in the model. Instead, the resource experts were encouraged to speak to their own areas of expertise.

c. The TI and Advisory Groups and/or Peer Reviewers Used

The TI team assembled to develop the seismic source characterization for Cuba and the northern Caribbean region for the Turkey Point Units 6 & 7 project comprised four William Lettis & Associates, Inc. geologists:

- Dr. Ross Hartleb
- Mr. Roland LaForge
- Mr. Scott Lindvall
- Dr. Steve Thompson

Peer review for this process was provided by the project Technical Advisory Group (TAG). At TAG meetings 1 through 3, TAG members included:

- Dr. Robert Kennedy (RPK Structural Mechanics Consulting)
- Dr. William McCann (Earth Scientific Consultants)
- Mr. Donald Moore (Southern Nuclear Operating Company)
- Dr. J. Carl Stepp (Earthquake Hazards Solutions)
- Dr. Robert Youngs (Geomatrix Consultants, currently AMEC-Geomatrix)

Additional guidance and peer review were provided during TAG meeting 4. TAG meeting 4 was convened to discuss issues related to the update to FSAR Sections 2.5.1, 2.5.2, and 2.5.3, including re-evaluation of the seismic source characterization for Cuba and the northern Caribbean region. TAG meeting 4 differed from previous TAG meetings by including members with more specialized knowledge of the tectonics of Cuba, the Caribbean region, and the eastern United States. TAG members for meeting 4 included:

- Prof. Robert Hatcher (University of Tennessee at Knoxville)
- Prof. John Lewis (George Washington University)
- Prof. Paul Mann (University of Texas)
- Dr. William McCann (Earth Scientific Consultants)
- Dr. J. Carl Stepp (Earthquake Hazards Solutions)

<u>d. How the Experts' Opinions Were Integrated into the Development of the Final Models</u>

Based on discussions with, and guidance from, the resource experts, the TI team performed additional literature review and analysis, prepared a preliminary seismic source characterization, and conducted follow-up interviews with some of the resource experts to modify or validate the preliminary seismic source characterization. The TI team presented the seismic source characterization, at varying stages of completion, to TAGs 1 through 4.

Following the collection of additional data and information, the TI team conducted additional discussions with resource experts and TAG reviewers to evaluate and finalize the proposed models for use in the PSHA. The TI team was responsible for combining the feedback from resource experts and TAG reviewers with data from the published literature to capture the range of technically defensible interpretations into the final seismic source characterization for Cuba and the northern Caribbean region.

<u>e. How Conflicting Opinions Among the Experts Were Dealt With</u>

The SSHAC Level 2 process allows for the incorporation of conflicting opinions of the informed technical community by definition of uncertainty in source parameter values and weights. For example, the slip-rate distribution and weights for the Septentrional fault source incorporate both geologic (FSAR Reference 304) and geodetic (FSAR Reference 273) data. In general, there were few conflicting opinions among resource experts and TAG reviewers involved in the SSHAC Level 2 seismic source characterization for Cuba and the northern Caribbean region. The decision to model intraplate Cuba as an area source, however, was a specific focus of discussion. Most resource experts contacted provided

little input and feedback for Cuba, citing lack of personal knowledge and/or the lack of available published information for Cuba. In email correspondence to the TI team, however, one expert suggested the idea to further subdivide Cuba into additional zones or add more “fault-like” sources, citing Garcia et al. (2003) (FSAR Reference 254). Despite this, subsequent publications indicate that Dr. Garcia favors moving away from defining multiple fault-like sources in intraplate Cuba, in favor of a smoothed seismicity approach. For example, Garcia et al. (2008) (FSAR Reference 255, p. 173) state that their rationale for adopting a smoothed seismicity approach for Cuba is “to avoid drawing seismic sources in a region where the seismogenic structures are not well known”. Moreover, they state that “since the northern part of the Cuban region lies in an intraplate region and is characterized by a moderate seismicity [sic], the association of earthquakes to faults is problematic and, consequently, the definition of [seismic sources] is based, in some cases, on subjective decisions” (FSAR Reference 255, p. 174). This issue was discussed at length by the TI team and the TAG members, as described in the paragraph that follows.

f. How the Final Models Represent the Consensus of the Informed Community

Through use of the SSHAC Level 2 process, the TI team developed a seismic source characterization for Cuba and the northern Caribbean region that is intended to represent the center, body, and range of technical interpretations that the larger informed technical community would have if they were to conduct the study. The decision to model intraplate Cuba as single area source zone was a specific point of discussion with TAG members, especially at TAG meeting 4. At this meeting, TAG member Prof. Robert Hatcher suggested including “fault-like” seismic sources for intraplate Cuba. However, discussions concluded with TAG consensus that the single area source approach is appropriate, given: (1) the lack of knowledge regarding slip rates, geometries, and maximum magnitudes for individual faults in intraplate Cuba; and (2) the fact that this seismic source characterization is intended for use at a site in southern Florida, as opposed to a site in Cuba.

This response is PLANT SPECIFIC.

References:

None

ASSOCIATED COLA REVISIONS:

No COLA changes have been identified as a result of this response.

ASSOCIATED ENCLOSURES:

Enclosure A: SSHAC Caribbean Questionnaire

Enclosure A

SSHAC Caribbean Questionnaire

4 Pages

May 19, 2008

Re: Northern Caribbean seismic hazard – Questions for SSHAC level 2 process

Dear Expert,

We are conducting an investigation into seismic hazards in the northern Caribbean region, for the purpose of analyzing such hazard to an electrical generation plant in southern Florida. To this end, we are preparing a seismic source model for the northern Caribbean, and since you have been identified as having relevant experience in this region, we ask that you take some time to answer the attached questions.

Please note that our questionnaire may not address all of the relevant issues. If you have knowledge of additional issues we should know about, or know of other researchers whom it would be in our interest to contact, please add comments at the end of your reply. We are also interested in any references or publications that would help us in this task. If a question falls outside your area of expertise, please indicate to that effect.

Thank you in advance for your time. Your responses will be confidential.

Sincerely,

SSHAC Caribbean Questionnaire **May 19, 2008**

PREAMBLE:

As a preliminary “straw man” model, we have identified the following six seismic sources in the northern Caribbean region as relevant to seismic hazard in southern Florida (see attached figure):

(1) West-central Cuba (area source)
(2) Southeastern Cuba (area source)
(3) Oriente fault zone west, between Cuba and the Cayman spreading center
(4) Oriente fault zone east, directly south of Cuba
(5) Septentrional fault, between the northern Dominican Republic and eastern Cuba
(6) North Hispaniola thrust fault, north of the Dominican Republic
(7) Swan Island fault zone, west of the Cayman spreading center
(8) Walton fault zone, between Jamaica and the Cayman spreading center
(9) Plantain Garden-Enriquillo fault zone, between southern Dominican Republic and Jamaica

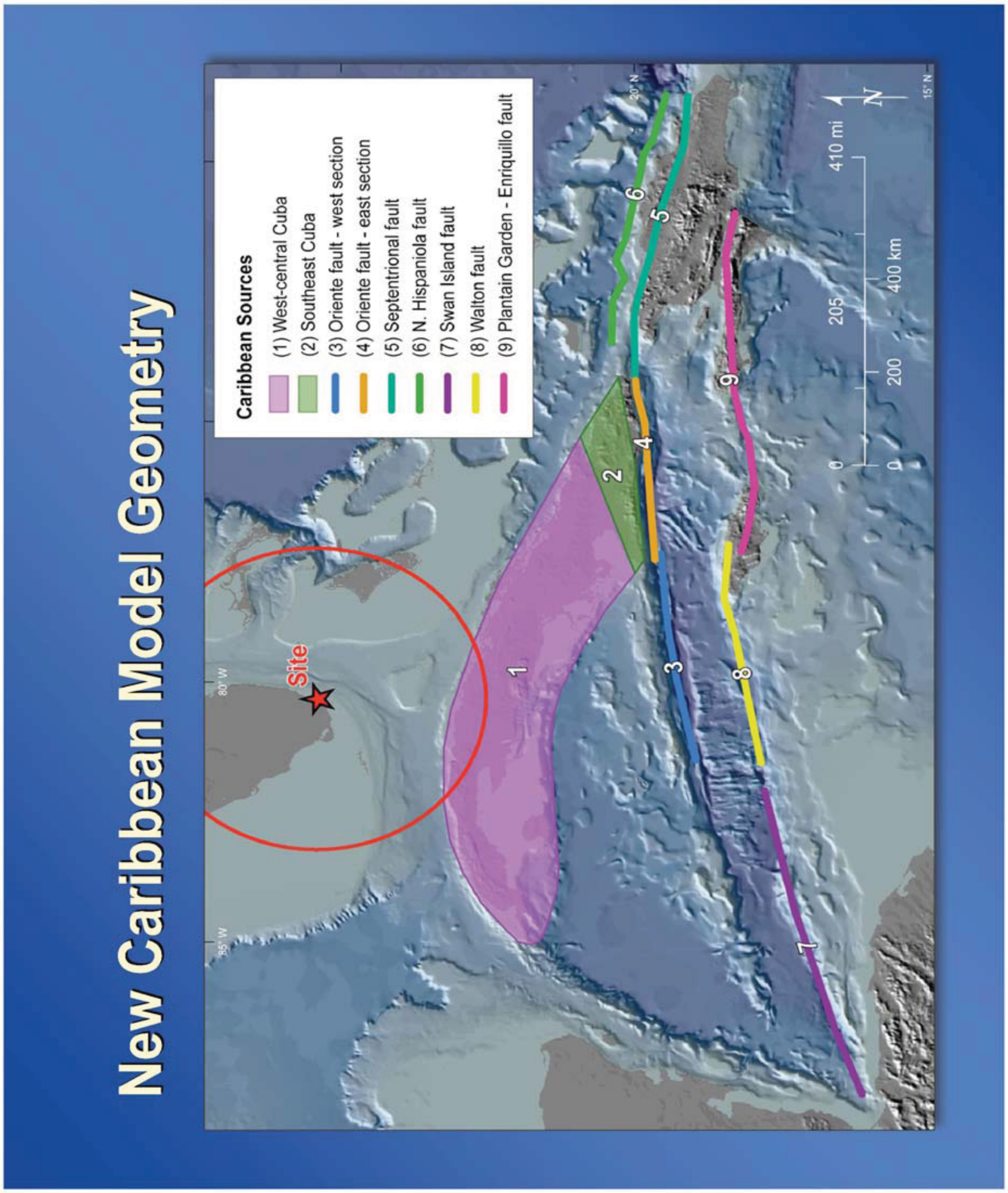
It is our assessment that faults in Cuba are not sufficiently characterized to warrant fault (line) sources. The source zone boundaries for Cuba are defined by tectonic landforms, geology, and seismicity (see figure).

QUESTIONS:

1) Are all possible sources of magnitude 7 or greater events within ~1,000 km of south Florida included? If not, what are other potential sources?

2) For each fault source, in your opinion:
   a) What is the maximum magnitude the fault is capable of generating?
   b) What is the maximum seismogenic depth of each fault?
   c) Do you have or know of any estimates of recurrence times for large ($M \geq 7$) events on any or all of these faults?
   d) What is the magnitude distribution of large events on any or all of these faults?
   e) What is the best estimate of slip rate and seismic coupling on these faults?

3) In regards to seismic hazards on the island of Cuba:
   a) Do you know of any individuals of groups that are studying and/or have published reports on active faulting on the island of Cuba? If so please provide names and references.
   b) Do you have any knowledge or opinions regarding seismic hazards on Cuba?


New Caribbean Model Geometry
Caribbean Sources
(1) West-central Cuba
(2) Southeast Cuba
(3) Oriente fault - west section
(4) Oriente fault - east section
(5) Septentrional fault
(6) N. Hispaniola fault
(7) Swan Island fault
(8) Walton fault
(9) Plantain Garden - Enriquillo fault
Site
1
2
3
4
5
6
7
8
9
0
205
410 mi
0
200
400 km
N
80° W
85° W
20° N
15° N

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-6 (eRAI 5896)

FSAR Subsection 2.5.2.2.1 describes that among the six EPRI-SOG earth science teams only one team identified more than one seismic source within the site region. In accordance with NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion", please explain:

a. Whether any attempt has been made to identify potential EPRI seismic sources that are outside the site region, but might contribute to the site hazard above the 1% of the total hazard.

b. Whether the use of the updated EPRI (2004, 2006) GMPEs significantly increases the hazard contributions of any of the EPRI seismic sources that are outside the site region to justify their use in the TPNPP PSHA calculations?

FPL RESPONSE:

a. All EPRI-SOG seismic sources within the site region (200 miles) were identified. In addition, sources beyond the site region that might contribute to hazard (including Charleston and New Madrid seismic sources) were identified. A seismic hazard sensitivity study was performed to determine if the sources beyond the site region contributed to the hazard. Those sources that were found to have a low contribution to hazard (denoted by a single asterisk in Table 1) were excluded from the rock seismic hazard base calculation. For these sources, the sum of hazard is less than 1% of the total rock hazard from all sources, at 10 Hz and 1 Hz spectral accelerations corresponding to about 10^{-4} annual frequency of exceedance. Table 1 shows the results of the evaluation of the seismic sources.

b. The EPRI (2004, 2006) ground motion prediction equations were used in the sensitivity calculations to evaluate significant contributions to seismic hazard, including outside the site region (summarized in Table 1). Their use does not increase the hazard contributions of any source.

Table 1. Evaluation of seismic sources used for the PSHA at the Turkey Point Site.

Source Model	Team	Sources Within Site Region	Sources Beyond Site Region	Final Sources Used for Rock Base Calc
EPRI-SOG	BEC	BEC-BZ1	N/A	BEC-BZ1_A**
		BEC-SUPP		BEC-SUPP
	DAM	DAM-20	DAM-52	DAM-20_A**
		DAM-SUPP	DAM-53	DAM-SUPP
	LAW	LAW-126	LAW-C09*	LAW-126_A**
		LAW-SUPP	LAW-C10*	LAW-SUPP
	RND	RND-49-05 (C01)	NA	RND-C01_A**
		RND-51		RND-51_A**
		RND-SUPP		RND-SUPP
	WCC	WCC-BG-35	NA	WCC-BG
	WGC	WGC-107	NA	WGC-107_A**
		WGC-SUPP		WGC-SUPP
Caribbean	NA	CUBA	--	CUBA
			NO-HISP_EAST	NO-HISP_EAST
			NO-HISP_WEST	NO-HISP_WEST
			ORIENTE_EAST	ORIENTE_EAST
			ORIENTE_WEST	ORIENTE_WEST
			PLAN_GE	PLAN_GE
			SEPTENTRIONAL	SEPTENTRIONAL
			SWAN_ISL_E	SWAN_ISL_E
			SWAN_ISL_W	SWAN_ISL_W
			WALT_DUA	WALT_DUA
Charleston	NA	NA	C-A	C-A
			C-B	C-B
			C-BP	C-BP
			C-C	C-C
			C-A-EXP*	
			C-B-EXP*	
			C-BP-EXP*	
			C-C-EXP*	
New Madrid	NA	NA	BLYTHE*	
			EASTP*	
			REELFOOT*	

* Sources determined to have low contribution to hazard were removed for the rock seismic hazard base calc.
** Sources that include _A at the end of their name indicate they are an EPRI SOG source that was augmented to include more degree cells to the east and west of Florida

This response is PLANT SPECIFIC.

References:

None

ASSOCIATED COLA REVISIONS:

No COLA changes have been identified as a result of this response.

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-10 (eRAI 5896)

FSAR Subsection 2.5.2.1.2 describes the updated Phase 1 and Phase earthquake catalogs. Of the 34 source earthquake catalogs listed on pages 2.5.2-3 through 2.5.2-5 for Phase 1 updates, 15 cite Reference 307, which is the USGS NEIC “Earthquake Search” website. A similar situation exists for the Phase 2 catalog update. In accordance with Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion", please clarify the relationship between Reference 307 and the corresponding 15 source catalogs used in the Phase 1 seismicity update. Specifically, how is the contribution from each sub-catalog identified?

FPL RESPONSE:

Reference 307 is cited as the source for several catalogs used for both the Phase 1 and Phase 2 earthquake catalogs, discussed in FSAR Sections 2.5.2.1.2 and 2.5.2.1.3, respectively. The reference listed in FSAR 2.5.2.7 References as Reference 307 is incorrect. The correct Reference 307 should be given as:

> 307. National Geophysical Data Center [NGDC]. The Seismicity Catalog CD-ROM Collection: Volume 1: North America, 1492-1996 A.D., Volume 2: Global and Regional, 2150 B.C. - 1996 A.D., National Oceanic and Atmospheric Administration / National Geophysical Data Center, World Data Center-A Solid Earth Geophysics, 325 Broadway, E/GC1, Boulder, Colorado, 2 volume CD-ROM, 1996. The CD-ROM data are available on-line at http://www.ngdc.noaa.gov/hazard/fliers/se-0208.shtml.

The earthquake data from this 1996 CD-ROM collection, used for the FSAR evaluations, are now available on the NGDC web site: http://www.ngdc.noaa.gov/hazard/fliers/se-0208.shtml. The web site describes the compilation as follows:

> *A two-CDROM compilation of seismicity catalogs from NOAA's National Geophysical Data Center and U.S. Geological Survey's National Earthquake Information Center is available online. The two-volume CD-ROM collection contains data on over four million earthquakes dating from 2100 B.C. to 1995 A.D. The data include information on epicentral time of origin, location, magnitudes, depth and other earthquake-related parameters.*
>
> *Three types of catalogs are included on the CDs:* ***local*** *(containing data from single stations or local networks);* ***regional*** *(containing data from regional networks, such as CALNET in central California) and* ***teleseismic*** *(containing data from around the world). Records have been contributed from various worldwide industrial, academic, governmental, and private sources. The CDs also contain auxiliary data bases (such*

as world stress, tsunami, volcanic, fault parameters, etc.) which aid in earthquake investigations

[Note: while otherwise accurate in its description of the CD-ROM data, the web site quotation above has a typo in the date range of "2100 B.C. to 1995 A.D." As given in the reference citation, the correct date range of the seismicity data is 2150 B.C. - 1996 A.D.]

The identification of the contribution from each sub-catalog is indicated in the ***Catalog Reference*** column in Tables 2.5.2-201 [Phase 1] and 2.5.2-203 [Phase 2] either by reference to the parenthetical symbolic name indicated in the bulleted lists of the catalogs in FSAR Sections 2.5.2.1.2 and 2.5.2.1.3 or by footnotes to the FSAR Tables 2.5.2-201 and 2.5.2-203

This response is PLANT SPECIFIC.

References:

None

ASSOCIATED COLA REVISIONS:

The text in Revision 2 of FSAR subsection 2.5.2.1.2, Updated Seismicity Data in the Phase 1 Investigation Region, 18th bullet below the second paragraph on existing page 2.5.2-4, will be revised as follows in a future update of the FSAR.

- National Geophysical Data Center **USGS "PDE" Catalog** (Reference 307)

The text in Revision 2 of FSAR subsection 2.5.2.1.3, Caribbean Seismicity Data in the Phase 2 Investigation Region, 10th bullet below the seventh paragraph on existing page 2.5.2-9, will be revised as follows in a future update of the FSAR.

- National Geophysical Data Center **USGS "PDE" Catalog** (Reference 307)

Reference 307 in Revision 2 of FSAR Subsection 2.5.2.7, References, on existing page 2.5.2-98, will be revised as follows in a future update of the FSAR.

~~307. Rinehart, W., Ganse, R., and Teik, P., National Geophysical Data Center (NGDC); Arnold, E., and Stover, C., U.S. Geological Survey (USGS), and Smith, R.H., (CIRES), National Earthquake Information Center (NEIC), Seismicity of Middle America, National Geophysical Data Center and National Earthquake Information Service, U.S. Geological Survey, 1982. Available at http://neic.usgs.gov/neis/epic/code_catalog.html, accessed February 15, 2008.~~

307. National Geophysical Data Center [NGDC]. The Seismicity Catalog CD-ROM Collection: Volume 1: North America, 1492-1996 A.D., Volume 2: Global and Regional, 2150 B.C. - 1996 A.D., National Oceanic and Atmospheric Administration / National Geophysical Data Center, World Data Center-A Solid Earth Geophysics, 325 Broadway, E/GC1, Boulder, Colorado, 2 volume CD-ROM, 1996. The CD-ROM data are available on-line at http://www.ngdc.noaa.gov/hazard/fliers/se-0208.shtml.

Footnote (a) of Tables 2.5.2-201 and 2.5.2-203 in Revision 2 of FSAR Subsection 2.5.2, Vibratory Ground Motion, on existing pages 2.5.2-127 and 2.5.2-137, will be revised as follows in a future update of the FSAR.

Footnote to Table 2.5.2-201

(a) "EPRIm" are the "MAIN" events from the EPRI catalog.
"***c" are constituent catalogs from IPGH catalog
"***wy" are constituent catalogs from Wysession et al. catalog (Reference 338)
"***me" are constituent catalogs from the Mexico Composite Catalog
"***np" are constituent catalogs from National Geophysical Data Center **USGS "PDE"** catalog

Footnote to Table 2.5.2-203

(a) "***c" are constituent catalogs from IPGH catalog
"***np" are constituent catalogs from National Geophysical Data Center **USGS "PDE"** catalog

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-11 (eRAI 5896)

FSAR Subsection 2.5.2.4.4.1 describes the supplemental source zones which are developed to extend the original EPRI zones to cover the entire site region. The FSAR discusses that updated *a* and *b* values are borrowed from peninsular Florida for the supplemental zones, but the parameters are not provided. In accordance with NUREG-0800, Standard Review Plan, Chapter 2.5.2, "Vibratory Ground Motion," and Regulatory Guide (RG) 1.208, "A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion" please provide the *a* and *b* parameters for each supplemental zone.

FPL RESPONSE:

An average rate (a-value) and b-value for the 15 degree-cells comprising the Florida peninsula were calculated using the updated earthquake catalog, because this is the most up-to-date information available. The average values for the 15 degree-cells are a = -2.28 and b = 1.03. The a-value is the base 10 logarithm of the annual rate of earthquakes with body-wave magnitude (mb) between 3.3 and 3.9, per equatorial square degree. The a-value and b-value were used for each supplemental source by converting them into a total rate for each supplemental source, using the area of each supplemental source given in FSAR Table 2.5.2-211.

This response is PLANT SPECIFIC.

References:

None

ASSOCIATED COLA REVISIONS:

No COLA changes have been identified as a result of this response.

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-037

SRP Section: 02.05.02 - Vibratory Ground Motion

Question for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

NRC RAI Number: 02.05.02-13 (eRAI 5896)

The FSAR does not list the USGS national seismic hazard map project as a potential source for EPRI seismic source model updates. The USGS regularly updates its own national seismic hazard maps using the most recent data and information. Within the last decade, the USGS published two comprehensive national seismic hazard reports in 2002 and 2008. RG 1.208 indicates that existing seismic source models should be evaluated in light of more recent data and evolving knowledge. Please discuss why the USGS national seismic hazard maps and model parameters are not discussed as potential studies to be considered in updating the existing EPRI seismic source geometries and/or model parameters.

FPL RESPONSE:

With the exception of the discussion on the Charleston seismic source update in Subsections 2.5.2.4.4.2.2 and 2.5.2.4.4.2.3, the FSAR does not describe seismic sources from the U.S. Geological Survey's (USGS) National Seismic Hazard Maps (NSHM) (FSAR Reference 300). This is primarily because the NSHM include only a single seismic source within the site region. The Extended Margin source zone covers only a portion of the Units 6 & 7 site region, and more seismically active areas such as Cuba and the Caribbean to the south are devoid of any seismic sources in NSHM. Thus, the seismic source characterization in the NSHM underestimates the ground motion hazard at the site due to a lack of Cuban and Caribbean seismic sources, and a direct comparison between the two seismic source models is not presented in the FSAR.

Additionally, the NSHM are designed for use in seismic provisions of building codes, insurance rate structures, risk assessments, and other public policy. As such, the NSHM focus is on ground motions with annual frequencies of exceedance (AFE) in the range of 10^{-2} to 10^{-3}. For nuclear PSHA purposes, ground motions with AFE in the range of 10^{-4} to 10^{-6} are required. Therefore, it may be inappropriate to use the NSHM model parameters in FSAR analyses because the parameter uncertainties were not developed to specifically support the needs of a nuclear PSHA.

This response is PLANT SPECIFIC.

References:

None

ASSOCIATED COLA REVISIONS:

No COLA changes have been identified as a result of this response.

ASSOCIATED ENCLOSURES:

None