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U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555
ATTN: David B. Matthews, Director
Division of New Reactor Licensing

SUBJECT: COMANCHE PEAK NUCLEAR POWER PLANT, UNITS 3 AND 4
DOCKET NUMBERS 52-034 AND 52-035
SUPPLEMENTAL INFORMATION FOR THE RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION NO. 1889

Dear Sir:

Luminant Generation Company LLC (Luminant) herein submits supplemental information for the response to Request for Additional Information No. 1889 for the Combined License Application for Comanche Peak Nuclear Power Plant Units 3 and 4. The affected Final Safety Analysis Report pages are included with the responses.

The digital data requested in Question 02.05.02-20 are provided on the attached CD in their native format as required by the NRC and do not meet the submittal criteria established in the "Guidance for Electronic Submissions to the NRC, Rev. 5."

Should you have any questions regarding these responses, please contact Don Woodlan (254-897-6887, Donald.Woodlan@luminant.com) or me.

There are no commitments in this letter.

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

Executed on December 14, 2009.

Sincerely,

Luminant Generation Company LLC

Donald R. Woodlan for

Rafael Flores

Attachments: 1. Supplemental Response to Request for Additional Information No. 1889 (CP RAI #11)
2. CD Containing Electronic Files

D090
NRO

cc: Stephen Monarque w/all attachments

Electronic Distribution w/Attachment 1

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Attachment 1

Supplemental Response to
Request for Additional Information No. 1889 (CP RAI #11)

SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 1889 (CP RAI #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 7/1/2009

QUESTION NO.: 02.05.02-16

The Meers fault is about 270 km from the CPNPP site with an Mmax distribution of 6.85±0.15 (Table 2.5.2-213) and a dominant recurrence interval of 1265 years. Considering these parameters, the staff is unclear why the Meers source's contribution to mean hazard is almost invisible in the 1 to 2.5 Hz deaggregations, and only a small contributor to the 5 to 10 Hz deaggregations of Figures 2.5.2-223 to 227. Please explain the near invisibility of the Meers source in FSAR Figures 2.5.2-223 to 227.

SUPPLEMENTAL INFORMATION:

The seismic hazard assessment of the Meers fault was originally calculated using the Gulf Coast Region ground motion equations from EPRI (2004). The hazard has been recalculated using the Mid-Continent Region ground motion equations from EPRI (2004) (FSAR Ref. 2.5-401), which are considered more appropriate. This recalculation indicates that the Meers fault is a significant contributor to the hazard at the CPNPP site. FSAR text, tables and figures have been revised to reflect the contribution of the Meers fault. The attached information supplements the response to this question submitted on September 28, 2009 via Luminant letter TXNB-09049 (ML092740182).

Impact on R-COLA

See table of attached marked-up FSAR Revision 1 pages and figures on the next page.

Impact on S-COLA

None.

Impact on DCD

None.

FSAR Pages	FSAR Figures
2.5-112	2.5.2-215
2.5-113	2.5.2-216
2.5-115	2.5.2-217
2.5-116	2.5.2-218
2.5-121	2.5.2-219
2.5-123	2.5.2-220
2.5-124	2.5.2-221
2.5-126	2.5.2-222
2.5-343	2.5.2-223
2.5-344	2.5.2-224
2.5-345	2.5.2-225
2.5-346	2.5.2-226
2.5-347	2.5.2-229
2.5-348	2.5.2-230
2.5-349	2.5.2-231
2.5-350	2.5.2-233
2.5-351	2.5.2-234
	2.5.2-235
	2.5.2-236
	2.5.2-237
	2.5.2-238
	2.5.2-239
	2.5.2-246
	2.5.2-247
	2.5.2-248
	2.5.2-249
	2.5.2-250
	2.5.2-251
	3.7-201

A preliminary calculation of rock seismic hazard was made with the EPRI-SOG sources plus the Meers fault and New Madrid faults, using the EPRI ground motion equations (Reference 2.5-401) with the EPRI aleatory uncertainties (Reference 2.5-403) and no CAV filter. Sensitivity studies indicated that of the faults identified in Subsection 2.5.2.4.2.3, only the New Madrid and Meers faults contributed significantly to the hazard. The other faults discussed in Subsection 2.5.2.4.2.3 (the Rio Grande Rift faults and the Cheraw fault) did not contribute 1% of the total hazard for 10 Hz and 1 Hz spectral acceleration. The preliminary calculation of hazard was done for the purpose of deaggregating the hazard. The CAV filter was not used for this analysis because the CAV filter depends on site amplitude and shear-wave velocity in the top 30 meters from the surface. The reason was that incoming seismic waves that might produce low-amplitude rock motions and be removed by the CAV filter, might also be amplified by local soil conditions, producing higher amplitudes on soil that would not be removed by the CAV filter. ~~Figures 2.5.2-217 and 2.5.2-220 show mean 10 Hz and 1 Hz rock hazard curves for the EPRI-SOG sources plus the Meers fault and New Madrid faults, using the EPRI ground motion equations (Reference 2.5-401) with the EPRI aleatory uncertainties (Reference 2.5-403) and no CAV filter. The total mean and fractile rock hazard curves are shown for all sources. In addition, the mean hazard from the New Madrid faults is shown (this is included in the total curves). The New Madrid faults dominate the 1 Hz hazard at most amplitudes, and contribute a significant part of the hazard for 10 Hz amplitudes below about 0.15 g.~~ RCOL2_02.05.02-16 S01

Figures 2.5.2-215 through 2.5.2-221 show total rock hazard as the mean, 15th, 50th, and 85th fractile curves for the EPRI-SOG sources plus the Meers fault and New Madrid faults, using the EPRI ground motion equations (Reference 2.5-401) with the EPRI aleatory uncertainties (Reference 2.5-403) and no CAV filter. The total mean and fractile rock hazard curves are shown for all sources. In addition, the mean hazard from the New Madrid faults is shown (this is included in the total curves). The Meers fault and New Madrid faults dominate the hazard for frequencies of 5 Hz and lower, and contribute a significant part of the hazard for 10 Hz amplitudes and higher. One of the characteristics of the hazard curves at low spectral frequencies (2.5 Hz and lower) is that the mean rock hazard curves exceeded the 85th fractile at high ground motion amplitudes. This exceedance occurs because the New Madrid seismic source dominates the hazard, and is caused by a few EPRI ground motion equations (Reference 2.5-401) indicating relatively high hazards for the large distance between the New Madrid seismic source and the CPNPP Units 3 and 4 site. RCOL2_02.05.02-16 S01

Figure 2.5.2-222 shows the mean and median 10^{-4} and 10^{-5} UHRS for hard rock conditions, based on the seven ground motion frequencies for which ground motion estimates are available. Numerical values for the mean UHRS are shown in Table 2.5.2-219.

The seismic hazard was deaggregated following the guidelines of Regulatory Guide 1.208 (USNRC, 2007). Specifically, the mean contributions to seismic hazard for 5 Hz and 10 Hz hazards were deaggregated by magnitude and

distance for the mean 10^{-4} ground motions at 5 Hz and 10 Hz, and these deaggregations were combined. Figure 2.5.2-223 shows this combined deaggregation. Similar deaggregations of the mean hazard were performed for 1 and 2.5 Hz spectral accelerations (Figure 2.5.2-224). Deaggregations of the mean hazard for 10^{-5} and 10^{-6} ground motions are shown in Figures 2.5.2-225 through 2.5.2-228. Deaggregation of the mean seismic hazard is recommended in Regulatory Guide 1.206 (USNRC, 2007). The contribution of the New Madrid source to seismic hazard is plotted in the deaggregation figures in the last distance interval, which represents 400+ km; the New Madrid source is actually about 870 km from the Comanche Peak site.

Figures 2.5.2-223 through 2.5.2-228 include the contribution to hazard by ε, which is the number of logarithmic standard deviations that the applicable ground motion (10^{-4}, 10^{-5}, or 10^{-6}) is above the logarithmic mean. These figures indicate that the largest contribution to hazard for 10^{-4} and 10^{-5} ground motions comes from values between 0 and 2 standard deviations above the mean, which is a common result.

The deaggregation plots in Figures 2.5.2-223 through 2.5.2-228 for 10^{-4} and 10^{-5} ground motions indicate that the Meers fault and New Madrid faults have~~seismic source has a~~ major contributions to seismic hazard at the Comanche Peak site. For 10^{-4} annual frequency of exceedance, the~~i~~se sources ~~is~~are the largest contributors to seismic hazard for both 5 and 10 Hz (Figure 2.5.2-223) and 1 and 2.5 Hz (Figure 2.5.2-224). For an annual frequency of 10^{-5}, the Meers fault and New Madrid faults are also ~~a~~ dominant contributors to seismic hazard, even for high frequencies (Figures 2.5.2-225 and 2.5.2-226). For an annual frequency of 10^{-6}, most of the hazard at high frequencies comes from local sources (Figure 2.5.2-227), while low frequencies still have a dominant contributions from the New Madrid faults (Figure 2.5.2-228). All of these observations are confirmed qualitatively in Figures 2.5.2-217 through 2.5.2-220, which compare the hazard from the Meers fault and the New Madrid ~~source~~faults to the hazard from all sources for 10, 5, 2.5, and 1 Hz. RCOL2_02.05.02-16 S01 RCOL2_02.05.02-16 S01

Table 2.5.2-220 summarizes the mean magnitude and distance resulting from these deaggregations, for all contributions to hazard and for contributions with distances exceeding 100 km. For the 1 and 2.5 Hz results, contributions from events with R>100 km exceed 5% of the total hazard. As a result, following the guidance of RG1.208, the controlling earthquake for low-frequency ground motions was selected from the R>100 km calculation, and the controlling earthquake for high-frequency ground motions was selected from the overall calculation. The values of Mw and R selected in this way are shown in shaded cells in Table 2.5.2-220.

Tables 2.5.2-221 through 2.5.2-226 document the deaggregation of seismic hazard for the following deaggregations: 10^{-4} high frequencies, 10^{-4} low

The subsurface conditions necessary to predict and model the seismic wave transmission characteristics for CPNPP Units 3 and 4 were determined from both site-~~-~~specific and regional data. ~~This~~These data included both stratigraphic and representative shear and compressional wave measurements that were used to develop the site profile and ~~is~~are summarized in Table 2.5.2-227. A detailed discussion of the data and methodology for developing the stratigraphy and corresponding dynamic properties used to define the dynamic profile for the site is provided in Subsection 2.5.4.4.2.2. CTS-00916 RCOL2_02.05.02-16 S01 RCOL2_02.05.02-16 S01 CTS-00916

The profile is divided into the shallow profile (surface to about 500 ft) and the deep profile (about 500 ft to "basement"). The shallow profile represents depth to which extensive characterization has been performed. The lateral and vertical control on the subsurface strata (layering) was defined primarily on lithology and material properties. The velocity measurements in the shallow profile have been developed from 15 suspension logs from borings drilled as part of the foundation exploration described in Subsection 2.5.4.4.2.1.

The foundation basemats of all ~~category 1~~seismic Catergory I structures will be founded on a limestone unit (denoted as Layer C in Subsection 2.5.4), with the exception of ~~category 1~~seismic Category I electrical duct banks that will be embedded in compacted fill adjacent to the nuclear island. Excavation to Layer C will remove the shallower units (layers A, B1, and B2) and, where the top of Layer C is below the bottom of the elevation, fill concrete will be placed to achieve the bottom of basemat elevation. The average thickness of Layer C is greater than 60 ft and dips less than 1°. The average shear wave velocity of Layer C is greater than 5800 ft/sec, as determined from the 15 suspension log borings. Profiles for development of the GMRS and FIRS are detailed in Subsection 2.5.2.6 and provide the criteria for exclusion or inclusion of specific layers including fill concrete and compacted fill. CTS-00916 CTS-00916

The deep profile was characterized from regional wells and maps. Strata that define the deep profile are based primarily on lithology and stratigraphic surfaces projected to the CPNPP site to estimate the elevation. Velocity data for the deep profile was limited to only a few wells and consisted primarily of compressional wave velocities except where shear wave velocity data was available from a single well as discussed in the following section on uncertainties. Basement was defined as the depth at which a shear wave velocity of 9200 ft/sec and greater was achieved. Basement was therefore defined as the top of the Ellenburger limestone located at a depth of about 5300 ft at the site. The Ellenburger is a regionally extensive unit with an estimated shear wave velocity of nearly 11,000 ft/sec.

2.5.2.5.1 Aleatory and Epistemic ~~Uncertainity~~Uncertainty CTS-01098

The shallow profile has been extensively characterized from over 150 geotechnical borings and geologic mapping of the area. The profile has been stratified based on vertical changes in lithology that can be mapped laterally from boring to boring. Standard deviations for the top of each shallow profile layer are

less than 2 ft for the upper 200 ft of the profile. The standard deviation for the layers defining the shallow profile from about 200 ft to about 500 ft range from about 1 to 5 ft. Velocity data for the shallow profile acquired from 15 suspension borings demonstrated a strong correlation between the layering and places where simulated down-hole travel time gradient "breaks" occurred.

The deep profile was developed from regional wells and results in a higher ~~uncertainity~~uncertainty in both the layering (stratigraphy) and velocity measurements. Shear wave velocity measurements were available from a single well located about 6 mi from the site and ~~was~~were limited to the Barnett Shale (a shale unit at a depth of about 5000 ft) for a total depth interval of about 4000 ft (about 5000 ft depth to about 9000 ft depth). This data was used to develop a linear extrapolation to estimate shear wave velocity from available pressure wave velocities from other wells to complete the deep profile. Thus, the epistemic uncertainty for the deep profile is much greater than for the shallow profile. See Subsection 2.5.4.4.2.2 for detailed discussion. CTS-01098 CTS-00916

The deep profile lacks a statistical basis for estimating a robust standard deviation for all layer velocities. The coefficient of variation (CoV=standard deviation/mean) calculated as 31% for the Atoka formation demonstrated the highest CoV for all deep profile layers. Therefore, the variability in velocity was calculated at 31% for all deep profile layers. The velocity range for the shallow profile was defined as 25% of the mean velocity of each layer. Subsection 2.5.4.4.2.2 provides a detailed discussion of the data and methodology for development of the dynamic profile.

Table 2.5.2-227 summarizes the layer properties including depth, thickness, velocities and assigned variabilities based on the aleatory and epistemic uncertainties discussed.

2.5.2.5.2 Description of Site Response Analysis

The site response analysis was conducted in three steps that are common to analyses of this type. First, the site geology and geotechnical properties were reviewed and used to generate multiple synthetic profiles of site characteristics. Second, sets of rock spectra were selected to represent rock ground motions corresponding to mean annual exceedence frequencies of 10^{-4}, 10^{-5}, and 10^{-6}. Finally, site response was calculated using an equivalent-linear technique, using the multiple synthetic profile and the sets of rock spectra representing input motions. These three steps are described in detail in the following sections.

2.5.2.5.2.1 Generation of Synthetic Profiles

To account for the epistemic and aleatory uncertainties in the site's dynamic properties, ~~multiple of~~ 60 synthetic profiles were generated using the stochastic model developed by Toro (Reference 2.5-432), with some modifications to account for the conditions at the Comanche Peak site. These synthetic profiles represent the site column from the top of the bedrock to the elevations where the GMRS and the various FIRS are defined (see Subsection 2.5.2.6). Bedrock is RCOL2_02.05.02-16 S01

- Ultimate Heat Sink
- Turbine Building
- Auxiliary Building
- Essential Service Water Pipe Tunnel
- Power Source Fuel Storage Vaults
- East and West Power Source Buildings

In some cases, slight amounts of over-excavation will be required below the planned foundation subgrade elevations to reach the stiff limestone (Layer C). In these cases, a relatively thin layer of fill concrete will be placed on the cleaned limestone sub-excavation and extended to the foundation subgrade elevation. The thickness of the fill concrete will potentially range from about 0 ft to less than 2 ft.

Ground motion response spectra (GMRS) were calculated for horizontal and vertical motion by the methods discussed below.

2.5.2.6.1.1 Horizontal GMRS Spectrum

~~The GMRS for horizontal motion was calculated for~~A seismic hazard calculation was made using the site amplification factors for the GMRS elevation, which is elevation 782 ft (top of Layer C). Figure 2.5.2-233 shows the median amplification factor (AF) and logarithmic standard deviation of AF for this elevation, using broad-banded input motions (the envelope of the spectra in Figures 2.5.2-229 through 2.5.2-231). This calculation was made at the seven spectral frequencies at which ground motion equations were available from the 2004 EPRI study (Reference 2.5-401) (100 Hz, 25 Hz, 5 Hz, 2.5 Hz, 1 Hz, and 0.5 Hz). RCOL2_03.07.02-1 RCOL2_03.07.02-1

The seismic hazard for horizontal motion was calculated by integrating the horizontal amplification factors shown in Figure 2.5.2-233 with the rock hazard and applying the CAV filter. This corresponds to Approach 3 in ~~the NRC standard,~~ NUREG/CR-6769. RCOL2_02.05.02-16 S01

The horizontal GMRS was developed from the horizontal UHRS using the approach described in ASCE/SEI Standard 43-05 (Reference 2.5-371) and Regulatory Guide 1.208. The ASCE/SEI Standard 43-05 (Reference 2.5-371) approach defines the GMRS using the site-specific UHRS, which is defined for Seismic Design Category SDC-5 at a mean 10^{-4} annual frequency of exceedance. The procedure for computing the GMRS is as follows.

For each spectral frequency at which the UHRS is defined, a slope factor A_R is determined from:

range encompasses all the energy of the rock ground motions for earthquakes in the Central and Eastern United States and meets the requirements in Subsection 3.4 "Hazard Assessment" in item C "Regulatory Position" of Regulatory Guide 1.208. The natural frequency of the GMRS soil column is 0.29 Hz. Because of the very flat appearance of the spectra at the seven spectral frequencies at which hazard calculations were made, log-log interpolation between available hazard values was used, with the exception of the following frequency ranges. RCOL2_03.07.02-1

1 Hz to 5Hz: Within this frequeney range, a peak ~~inside~~in site spectra occurs at 2.5 Hz, reflecting a site amplification at about 2 Hz. To reflect this amplification, the ~~1E-5~~10^{-5} spectral amplitude at 2.5 Hz was broadened using rock spectral shapes from NUREG/CR-6728 and using the broad-banded values of M=~~7.7~~7.5 and R=~~890~~650 km for ~~1E-5~~10^{-5} (on which the site amplification calculations were based). This is an acceptable approximation given that the rock spectrum is decreasing between 2.5 and 1 Hz. RCOL2_02.05.02-16 S01 CTS-00916 RCOL2_03.07.02-1

0.5 Hz to 0.1 Hz: Below 0.5 Hz, the assumption ~~was~~is made that spectral accelerations are proportional to f down to ~~0.125 Hz (where f is frequency), and are proportional to f^2 between 0.125 Hz and~~ 0.1 Hz (where f is frequency). This is a common assumption for spectral shapes at low frequencies for the site region. CTS-01098 RCOL2_03.07.02-1 RCOL2_02.05.02-16 S01

~~Spectra for the four FIRS conditions (FIRS2, FIRS3, FIRS4, and FIRS4-CoV50 were calculated in a similar way. Note that the FIRS3 spectra have peaks at about 2 Hz and 10 Hz, and that the FIRS4 and FIRS4-CoV50 spectra have peaks at about 1.5 Hz and 5 Hz. These peaks were broadened in an approximate way similar to the procedure used for the GMRS.~~

These GMRS spectrum is~~and FIRS spectra are~~ plotted in Figures 2.5.2-247 along with the 10^{-5} UHRS~~ through 2.5.2-251 with the 1E-5 spectrum for each condition also plotted~~. Table 2.5.2-236 shows the numerical values for the ~~1E-5~~10^{-5} and GMRS spectra~~, and Table 2.5.2-237 shows the numerical values for the 1E-5 and FIRS spectra~~.

2.5.2.6.1.2 Vertical GMRS Spectrum

Vertical motions at the CPNPP Units 3 and 4 site are addressed by reviewing results in NUREG/CR-6728 for V/H ratios at deep soil sites, for both the western US (WUS) and the CEUS. Example results presented in the ~~US-APWR DCD~~NUREG/CR-6728 indicate that for earthquakes >40 km from a deep soil site, V/H ratios are expected to be less than unity for all frequencies (Figures J-31 and J-32 in Appendix J of the ~~DCD~~NUREG/CR-6728). For the 10^{-5} ground motion, expected distances from deaggregation are greater than 100 km (Table 2.5.2-220). Any exceedance of unity occurs for high frequencies (>10 Hz) for short source-to-site distances. Also, for ground motions with peak horizontal accelerations <0.2g, the recommended V/H ratios for hard rock conditions are less than unity; see Table 4-5 of the ~~DCD~~NUREG/CR-6728. The conclusion is that V/H ratios for the CPNPP Units 3 and 4 site will be less than unity for all spectral CTS-00916 CTS-00916 CTS-00916

frequencies. Therefore, the vertical GMRS will be below the horizontal GMRS shown in Figure 2.5.2-~~233~~234. RCOL2_02.05.02-16 S01

Figure 2.5.2-234 shows that the horizontal DCD spectrum exceeds the horizontal GMRS. The vertical DCD spectrum equals or does not exceed the horizontal DCD spectrum for frequencies above 3.5 Hz. The conclusion is that the vertical DCD spectrum will also exceed the vertical GMRS. Under this condition, the DCD minimum vertical design motion will govern the vertical response, just as the DCD minimum horizontal design motion will govern the horizontal response.

Vertical GMRS and FIRS spectra were developed using vertical-to-horizontal (V/H) ratios. NUREG/CR-6728 and RG 1.60 indicate proposed V/H ratios for design spectra for nuclear facilities, and these V/H ratios are plotted in Figure 2.5.2-252. The V/H ratios in Figure 2.5.2-252 taken from NUGREG/CR-6728 (the blue curve) are recommended for hard sites in the CEUS. The Comanche Peak site is a deep, soft-rock site with shale~~s~~ and limestone~~s~~ near the surface having shear-wave velocities of about 2600 fps, and the V/H ratios for this site condition will be similar to those for hard roick sites. CTS-00916

Based on these comparisons, it is concluded that the applicable V/H ratios at the Comanche Peak site will be ≤ 1.0 at all spectral frequencies between 100 Hz and 0.1 Hz. As a conservative assumption, the V /H ratio is assumed to be equal to 1.0 at all spectral frequencies. This assumption is also plotted in Figure 2.5.2-252.

The result of this assumption is that the spectra plotted in Figures 2.5.2-247 through 2.5.2-251 for the GMRS and four FIRS conditions apply to both the horizontal and vertical motions.

Tables 2.5.2-236 and 2.5.2-237 document (respectively) the 10^{-5} UHRS and GMRS, and the 10^{-5} UHRS and FIRS. Because V /H is assumed to be equal to unity, these spectra apply to both horizontal and vertical motions.

2.5.2.6.2 Foundation Input Response Spectrum

Site response analyses were conducted for an additional four cases (FIRS 2, FIRS 3, FIRS 4_CoV30, and FIRS 4_CoV50) to consider foundation input response spectra for specific conditions different from the GMRS elevation. These four cases are as follows:

FIRS 2 - Set at elevation 787 ft.

This FIRS represents generic site response conditions for structures resting on fill concrete layer in which the fill concrete thickness and horizontal extent away from the edge of the foundation is significant and thus modeled as a horizontally infinite layer.

FIRS4_CoV30: elevation 822 ft. The elevation for FIRS 4 is the same as for FIRS 3, but the profile consists of sub-excavation to stiff limestone at elevation 782 ft, and backfilling to plant grade with cohesionless engineered compacted fill.

FIRS4_CoV50: elevation 822 ft. This profile is the same as for FIRS 4 except it uses a coefficient of variation (CoV) of 50% (instead of 30%) for the Vs of the fill material.

Figures 2.5.2-235 through 2.5.2-238 show median amplification factors and logarithmic standard deviations for these four FIRS cases, for the 10^{-4}, 10^{-5}, and 10^{-6} broadband input motions.

The seismic hazard for each FIRS case was calculated by integrating the horizontal amplification factors shown in Figures 2.5.2-235 through 2.5.2-238 with the rock hazard and applying the CAV filter. This is an analogous calculation to the calculation of hazard for the GMRS elevation. For all FIRS cases the hazard curves at low amplitudes rolled over to an annual frequency of exceedance that was less than 10^{-4}. As was the case for the GMRS, the FIRS spectra were calculated using the 10^{-5} UHRS and applying the factor from Eq. 2.5.2-3; i.e., FIRS = 0.45 × SA(10^{-5}).

Figure 2.5.2-239 plots the four horizontal FIRS and compares them to the horizontal minimum DCD spectrum. The minimum DCD spectrum envelops all four FIRS, down to frequencies of 0.5 Hz. ~~For this reason, detailed spectral shapes were not fit to the FIRS spectra between the seven spectral frequencies for which ground motion equations are available.~~ Values of the horizontal 10^{-5} UHRS and FIRS are shown in Table 2.5.2-229 for the seven spectral frequencies. RCOL2_02.05.02-16 S01

Smooth horizontal spectra for the four FIRS conditions (FIRS2, FIRS3, FIRS4, and FIRS4-CoV50) were calculated in a manner similar to the way in which the smooth GMRS was calculated, as described om Section 2.5.2.6.1.1. Note that the FIRS3 spectra have peaks at about 2.5 Hz and 10 Hz, and that the FIRS4 and FIRS4-CoV50 spectra have peaks at about 1.5 Hz and 5 Hz. These peaks were broadened in an approximate way similar to the procedure used for the GMRS. RCOL2_03.07.02-1

The FIRS spectra are plotted in Figures 2.5.2-248 through 2.5.2-251 with the 10^{-5} spectrum for each condition also plotted. Table 2.5.2-237 shows the numerical values for the 10^{-5} and FIRS spectra.

For vertical FIRS motions, the same considerations used for the GMRS were used for the FIRS. That is, for large source-to-site distances, results in the ~~US-APWR DCD (Reference 2.5.2-288)~~NUREG/CR-6728 indicate that V/H ratios will be less than unity for all frequencies. V/H ratios are likely to be considerably less than unity at frequencies below 5 Hz. Appendix J of ~~Ref 2.5.2-288~~NUREG/CR-6728 indicates that for distances exceeding 40 km, soil sites in both the WUS and CTS-00916 CTS-00916

Table 2.5.2-230
Calculation of Duration and Effective Strain Ratio for Rock Input Motions Considered in Site Response Calculations

Case	Magnitude M	Distance R (km)	Seismic Moment Mo (dyn-cm)	Corner Frequency fc (Hz)	Duration T (sec)	Eff Strain Ratio
1E-4 HF	~~7.2~~6.9	~~450~~300	~~7.08E+26~~2.51E+26	~~0.09~~0.13	~~33.04~~22.46	~~0.62~~0.59
1E-4 BB	~~7.6~~7.3	~~820~~570	~~2.82E+27~~1.00E+27	~~0.06~~0.08	~~57.70~~40.32	~~0.65~~0.63
1E-5 BB	~~7.7~~7.4	~~860~~620	~~3.98E+27~~1.41E+27	~~0.05~~0.08	~~61.74~~44.26	~~0.65~~0.64
1E-6 BB	~~7.8~~7.5	~~860~~660	~~5.62E+27~~2.00E+27	~~0.05~~0.07	~~64.02~~47.88	~~0.65~~0.65

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Table 2.5.2-231
Amplification Factors for the GMRS/FIRS1 Site Column

	Amplification Factor for 10^{-4}		Amplification Factor for 10^{-5}		Amplification Factor for 10^{-6}	
Freq (Hz)	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.
0.1	~~1.13~~1.10	0.06	~~1.13~~1.10	~~0.07~~0.06	~~1.13~~1.10	~~0.07~~0.06
0.125	~~1.16~~1.14	0.08	~~1.16~~1.14	~~0.09~~0.08	~~1.16~~1.14	~~0.09~~0.08
0.15	~~1.20~~1.18	0.11	~~1.20~~1.19	0.11	~~1.20~~1.19	0.11
0.2	~~1.31~~1.30	~~0.17~~0.16	~~1.31~~1.30	0.16	~~1.31~~1.30	0.16
0.3	~~1.47~~1.46	~~0.18~~0.17	1.46	~~0.17~~0.18	1.46	~~0.17~~0.18
0.4	~~1.45~~1.43	0.17	1.43	0.17	1.43	0.17
0.5	~~1.39~~1.37	~~0.18~~0.17	1.37	~~0.18~~0.17	1.37	~~0.18~~0.17
0.6	~~1.38~~1.36	0.16	1.36	0.16	1.36	0.16
0.7	~~1.40~~1.37	~~0.15~~0.14	1.37	0.14	1.38	0.14
0.8	~~1.43~~1.39	~~0.12~~0.11	1.40	0.12	1.40	0.12
0.9	~~1.43~~1.39	~~0.11~~0.10	1.39	0.10	1.39	0.10
1	~~1.45~~1.41	0.12	~~1.37~~1.38	0.11	1.37	0.11
1.25	~~1.66~~1.60	~~0.17~~0.16	1.61	0.17	1.61	0.17
1.5	~~1.82~~1.75	0.19	1.75	0.19	1.74	0.19
2	~~1.80~~1.71	0.13	~~1.72~~1.71	0.13	~~1.72~~1.71	0.13
2.5	~~1.53~~1.44	~~0.14~~0.16	1.42	~~0.14~~0.15	1.41	0.14
3	~~1.22~~1.12	~~0.15~~0.17	~~1.14~~1.12	~~0.16~~0.17	1.12	0.16
4	~~0.94~~0.83	~~0.13~~0.16	~~0.86~~0.84	~~0.14~~0.15	0.83	0.15
5	~~0.87~~0.74	~~0.12~~0.15	~~0.78~~0.75	~~0.13~~0.14	0.74	0.14
6	~~0.85~~0.72	~~0.14~~0.17	~~0.75~~0.73	~~0.15~~0.17	0.71	~~0.18~~0.17
7	~~0.80~~0.66	~~0.16~~0.20	~~0.69~~0.66	~~0.17~~0.19	0.64	0.21
8	~~0.74~~0.59	~~0.15~~0.20	~~0.63~~0.60	~~0.17~~0.19	~~0.56~~0.57	0.21
9	~~0.71~~0.56	~~0.15~~0.19	~~0.59~~0.56	~~0.17~~0.19	0.52	0.21
10	~~0.72~~0.55	~~0.16~~0.20	~~0.58~~0.55	~~0.17~~0.19	~~0.50~~0.51	~~0.23~~0.22
12.5	~~0.74~~0.54	~~0.21~~0.26	~~0.57~~0.54	~~0.23~~0.26	0.49	~~0.31~~0.30
15	~~0.73~~0.52	~~0.19~~0.24	~~0.55~~0.51	~~0.22~~0.25	0.47	0.29
20	~~0.63~~0.42	~~0.14~~0.18	~~0.45~~0.39	~~0.16~~0.19	0.34	0.24
25	~~0.58~~0.37	~~0.12~~0.15	~~0.39~~0.33	~~0.14~~0.16	~~0.28~~0.27	0.20
30	~~0.55~~0.35	~~0.11~~0.14	~~0.38~~0.32	~~0.12~~0.14	0.26	0.17
35	~~0.55~~0.35	~~0.11~~0.13	~~0.38~~0.32	~~0.11~~0.13	0.26	0.16
40	~~0.55~~0.36	~~0.11~~0.12	~~0.39~~0.33	~~0.11~~0.12	0.26	0.14
45	~~0.56~~0.37	~~0.10~~0.11	~~0.40~~0.34	~~0.10~~0.11	0.27	0.13
50	~~0.58~~0.39	~~0.10~~0.11	~~0.42~~0.36	~~0.10~~0.11	~~0.28~~0.29	0.13
60	~~0.66~~0.44	~~0.09~~0.10	~~0.49~~0.42	~~0.09~~0.10	~~0.33~~0.34	~~0.12~~0.11
70	~~0.78~~0.53	~~0.08~~0.10	~~0.60~~0.52	~~0.09~~0.10	~~0.40~~0.41	0.11
80	~~0.91~~0.63	~~0.08~~0.10	~~0.72~~0.63	~~0.09~~0.10	~~0.48~~0.50	0.11
90	~~1.03~~0.73	~~0.08~~0.10	~~0.83~~0.73	~~0.09~~0.10	~~0.56~~0.59	0.11
100	~~1.12~~0.79	~~0.08~~0.10	~~0.91~~0.81	~~0.09~~0.10	~~0.62~~0.66	0.11

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Table 2.5.2-232
Amplification Factors for the FIRS2 Site Column

	Amplification Factor for 10^{-4}		Amplification Factor for 10^{-5}		Amplification Factor for 10^{-6}	
Freq (Hz)	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.
0.1	~~1.12~~1.09	~~0.06~~0.05	~~1.12~~1.09	~~0.07~~0.05	~~1.12~~1.09	0.06
0.125	~~1.14~~1.12	0.08	~~1.14~~1.12	0.08	~~1.14~~1.12	0.08
0.15	~~1.18~~1.16	~~0.11~~0.10	~~1.18~~1.16	~~0.11~~0.10	~~1.18~~1.16	0.11
0.2	~~1.27~~1.26	0.16	~~1.27~~1.26	0.16	~~1.27~~1.26	0.16
0.3	~~1.43~~1.42	0.18	~~1.43~~1.42	0.18	1.43	0.18
0.4	1.44	0.17	1.44	0.17	1.44	0.17
0.5	1.40	0.18	1.40	0.18	1.40	0.18
0.6	1.37	0.15	~~1.38~~1.37	0.15	1.38	0.15
0.7	1.37	0.13	1.37	0.13	~~1.38~~1.37	0.13
0.8	1.39	0.10	1.39	0.10	1.39	0.10
0.9	1.41	0.11	1.41	0.11	1.40	0.11
1	1.45	0.14	1.41	0.13	1.41	0.13
1.25	1.64	0.19	1.65	0.19	1.65	0.19
1.5	1.83	0.18	1.83	0.18	1.83	0.18
2	~~1.73~~1.72	0.14	~~1.73~~1.72	0.13	1.72	0.13
2.5	~~1.39~~1.38	~~0.16~~0.17	~~1.37~~1.36	~~0.15~~0.16	1.36	0.15
3	~~1.10~~1.07	~~0.17~~0.18	~~1.10~~1.08	~~0.17~~0.18	1.08	0.17
4	~~0.85~~0.80	~~0.14~~0.16	~~0.84~~0.81	~~0.14~~0.15	0.81	0.15
5	~~0.80~~0.75	~~0.15~~0.17	~~0.78~~0.76	~~0.16~~0.17	0.74	0.17
6	~~0.79~~0.73	~~0.17~~0.20	~~0.76~~0.74	~~0.18~~0.19	0.72	0.20
7	~~0.73~~0.66	~~0.19~~0.24	~~0.70~~0.67	~~0.21~~0.23	0.64	~~0.25~~0.24
8	~~0.67~~0.59	~~0.20~~0.25	~~0.63~~0.60	~~0.22~~0.25	~~0.56~~0.57	~~0.28~~0.27
9	~~0.65~~0.56	~~0.20~~0.26	~~0.60~~0.56	~~0.23~~0.25	~~0.52~~0.53	~~0.29~~0.28
10	~~0.65~~0.56	~~0.20~~0.26	~~0.60~~0.56	~~0.23~~0.25	~~0.51~~0.52	0.29
12.5	~~0.67~~0.57	~~0.25~~0.32	~~0.61~~0.57	~~0.29~~0.32	~~0.52~~0.53	~~0.37~~0.36
15	~~0.64~~0.54	~~0.23~~0.30	~~0.56~~0.52	~~0.27~~0.31	0.48	0.36
20	~~0.55~~0.42	~~0.15~~0.22	~~0.45~~0.39	~~0.20~~0.23	0.34	0.28
25	~~0.52~~0.37	~~0.14~~0.19	~~0.40~~0.34	~~0.17~~0.21	0.28	0.25
30	~~0.51~~0.36	~~0.14~~0.20	~~0.39~~0.33	~~0.18~~0.21	0.27	0.25
35	~~0.50~~0.36	~~0.14~~0.19	~~0.39~~0.33	~~0.17~~0.20	0.27	0.25
40	~~0.51~~0.37	~~0.13~~0.17	~~0.40~~0.34	~~0.15~~0.17	0.27	0.20
45	~~0.52~~0.37	~~0.12~~0.15	~~0.41~~0.35	~~0.13~~0.15	0.28	0.18
50	~~0.54~~0.39	~~0.11~~0.14	~~0.43~~0.37	~~0.13~~0.15	0.29	0.17
60	~~0.61~~0.45	~~0.11~~0.13	~~0.50~~0.43	~~0.12~~0.13	0.34	0.15
70	~~0.72~~0.54	~~0.10~~0.13	~~0.61~~0.53	~~0.11~~0.12	~~0.41~~0.42	0.14
80	~~0.85~~0.64	~~0.10~~0.12	~~0.73~~0.64	~~0.11~~0.12	~~0.49~~0.51	0.14
90	~~0.97~~0.74	~~0.10~~0.12	~~0.84~~0.74	~~0.11~~0.12	~~0.57~~0.60	0.14
100	~~1.05~~0.80	~~0.10~~0.12	~~0.93~~0.82	~~0.11~~0.12	~~0.63~~0.67	0.14

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Table 2.5.2-233
Amplification Factors for the FIRS3 Site Column

	Amplification Factor for 10^{-4}		Amplification Factor for 10^{-5}		Amplification Factor for 10^{-6}	
Freq (Hz)	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.
0.1	~~1.12~~1.09	~~0.08~~0.07	~~1.12~~1.09	~~0.08~~0.07	~~1.12~~1.09	~~0.08~~0.07
0.125	~~1.14~~1.13	~~0.11~~0.10	~~1.14~~1.13	~~0.11~~0.10	~~1.14~~1.13	~~0.11~~0.10
0.15	~~1.18~~1.17	0.14	~~1.18~~1.17	0.14	~~1.18~~1.17	0.14
0.2	~~1.27~~1.26	0.19	~~1.27~~1.26	0.19	~~1.27~~1.26	0.19
0.3	1.39	0.19	1.39	0.19	1.39	0.19
0.4	1.39	0.16	1.39	0.16	1.39	0.16
0.5	1.37	0.17	1.36	~~0.18~~0.17	1.36	~~0.18~~0.17
0.6	1.35	0.16	1.35	0.16	1.35	~~0.17~~0.16
0.7	1.35	0.13	1.35	0.13	1.36	0.13
0.8	1.40	~~0.12~~0.11	1.40	~~0.12~~0.11	1.40	~~0.12~~0.11
0.9	1.44	0.12	~~1.44~~1.43	0.12	1.43	0.12
1	1.46	0.14	1.41	0.13	1.41	0.13
1.25	1.60	0.20	~~1.60~~1.61	0.20	1.60	0.20
1.5	1.78	0.18	1.78	0.18	~~1.78~~1.77	0.18
2	~~1.66~~1.65	0.15	1.66	0.15	1.66	~~0.15~~0.18
2.5	~~1.37~~1.35	~~0.22~~0.23	~~1.35~~1.34	~~0.20~~0.21	1.34	0.20
3	~~1.13~~1.10	~~0.21~~0.22	~~1.12~~1.11	~~0.20~~0.21	1.10	0.21
4	~~0.89~~0.84	~~0.16~~0.18	~~0.87~~0.85	0.17	0.85	0.17
5	~~0.84~~0.80	~~0.18~~0.21	~~0.83~~0.81	~~0.18~~0.20	0.79	0.20
6	~~0.84~~0.79	~~0.20~~0.23	~~0.83~~0.80	~~0.21~~0.22	0.79	0.23
7	~~0.82~~0.77	~~0.25~~0.29	~~0.80~~0.77	~~0.26~~0.28	~~0.75~~0.76	~~0.30~~0.29
8	~~0.80~~0.74	~~0.28~~0.33	~~0.77~~0.75	~~0.30~~0.32	0.72	0.34
9	~~0.83~~0.76	~~0.32~~0.37	~~0.79~~0.77	~~0.35~~0.37	0.74	0.39
10	~~0.88~~0.81	~~0.33~~0.38	~~0.84~~0.82	~~0.36~~0.38	0.79	~~0.41~~0.40
12.5	~~0.94~~0.88	~~0.29~~0.35	~~0.90~~0.88	~~0.33~~0.35	0.86	~~0.38~~0.37
15	~~0.81~~0.74	~~0.30~~0.36	~~0.76~~0.72	~~0.34~~0.37	0.69	0.41
20	~~0.68~~0.57	~~0.25~~0.33	~~0.59~~0.55	~~0.31~~0.35	0.51	0.40
25	~~0.59~~0.46	~~0.19~~0.26	~~0.48~~0.42	~~0.24~~0.28	0.37	0.33
30	~~0.55~~0.41	~~0.16~~0.22	~~0.43~~0.37	~~0.19~~0.23	0.32	0.27
35	~~0.53~~0.40	~~0.16~~0.21	~~0.43~~0.37	~~0.18~~0.22	0.31	~~0.26~~0.25
40	~~0.54~~0.41	~~0.15~~0.20	~~0.43~~0.38	~~0.18~~0.21	0.31	~~0.25~~0.24
45	~~0.55~~0.42	~~0.15~~0.20	~~0.45~~0.39	~~0.17~~0.20	0.32	0.23
50	~~0.57~~0.44	~~0.14~~0.29	~~0.47~~0.41	~~0.16~~0.19	0.34	0.22
60	~~0.65~~0.50	~~0.13~~0.18	~~0.55~~0.48	~~0.15~~0.17	~~0.39~~0.40	0.20
70	~~0.77~~0.60	~~0.13~~0.17	~~0.67~~0.59	~~0.14~~0.17	~~0.47~~0.49	~~0.20~~0.19
80	~~0.91~~0.71	~~0.13~~0.17	~~0.80~~0.71	~~0.14~~0.16	~~0.57~~0.59	0.19
90	~~1.03~~0.82	~~0.13~~0.16	~~0.92~~0.83	~~0.14~~0.16	~~0.66~~0.69	0.19
100	~~1.12~~0.89	~~0.12~~0.16	~~1.01~~0.92	~~0.14~~0.16	~~0.73~~0.77	0.19

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Table 2.5.2-234
Amplification Factors for the FIRS4 Site Column

	Amplification Factor for 10^{-4}		Amplification Factor for 10^{-5}		Amplification Factor for 10^{-6}	
Freq (Hz)	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.
0.1	~~1.12~~1.10	~~0.06~~0.05	~~1.13~~1.10	~~0.06~~0.05	~~1.13~~1.10	~~0.06~~0.05
0.125	~~1.15~~1.13	~~0.08~~0.07	~~1.15~~1.13	~~0.08~~0.07	~~1.15~~1.13	~~0.08~~0.07
0.15	~~1.19~~1.18	0.10	~~1.19~~1.18	0.10	~~1.19~~1.18	0.10
0.2	~~1.29~~1.28	0.15	~~1.29~~1.28	0.15	1.29	0.15
0.3	1.45	0.18	~~1.46~~1.45	0.18	1.46	0.18
0.4	~~1.44~~1.43	0.17	1.44	0.17	1.45	0.17
0.5	1.37	0.17	1.37	~~0.18~~0.16	~~1.38~~1.39	0.18
0.6	1.35	~~0.16~~0.15	1.36	0.16	1.38	0.17
0.7	~~1.38~~1.39	0.14	1.39	0.14	1.43	0.16
0.8	1.45	0.13	1.46	0.14	1.50	0.17
0.9	1.49	0.14	~~1.49~~1.50	0.14	~~1.54~~1.55	~~0.19~~0.20
1	1.54	0.15	1.51	0.15	~~1.57~~1.58	~~0.21~~0.22
1.25	~~1.79~~1.80	0.19	~~1.82~~1.83	0.19	~~1.92~~1.94	~~0.24~~0.25
1.5	1.98	0.22	~~2.02~~2.03	0.23	~~2.14~~2.15	~~0.29~~0.30
2	~~1.92~~1.93	~~0.15~~0.16	~~1.99~~2.01	~~0.19~~0.20	2.14	0.26
2.5	~~1.62~~1.63	~~0.23~~0.25	~~1.69~~1.70	~~0.28~~0.29	~~1.80~~1.79	0.31
3	1.42	~~0.30~~0.32	1.52	~~0.35~~0.36	1.58	0.35
4	1.50	~~0.47~~0.49	1.53	0.44	1.52	0.40
5	1.85	~~0.48~~0.49	~~1.77~~1.76	~~0.43~~0.44	~~1.57~~1.55	0.40
6	~~2.04~~2.00	~~0.40~~0.41	~~1.82~~1.77	~~0.39~~0.40	~~1.44~~1.43	0.45
7	~~1.87~~1.80	~~0.38~~0.41	~~1.61~~1.55	~~0.42~~0.44	~~1.24~~1.23	0.49
8	~~1.63~~1.54	~~0.40~~0.44	~~1.38~~1.32	~~0.44~~0.46	1.06	~~0.52~~0.51
9	~~1.41~~1.31	~~0.40~~0.44	~~1.19~~1.13	~~0.42~~0.43	0.90	0.45
10	~~1.23~~1.12	~~0.32~~0.36	~~1.04~~0.99	~~0.33~~0.34	0.79	0.36
12.5	~~1.09~~0.99	~~0.26~~0.29	~~0.93~~0.88	~~0.27~~0.29	~~0.71~~0.70	0.31
15	~~1.05~~0.94	~~0.27~~0.31	~~0.87~~0.81	~~0.28~~0.30	~~0.65~~0.64	0.34
20	~~0.91~~0.76	~~0.26~~0.31	~~0.70~~0.63	~~0.29~~0.32	~~0.49~~0.48	0.35
25	~~0.82~~0.66	~~0.22~~0.27	~~0.61~~0.53	~~0.24~~0.27	~~0.41~~0.39	0.29
30	~~0.78~~0.61	~~0.20~~0.24	~~0.58~~0.50	~~0.21~~0.23	~~0.38~~0.37	0.25
35	~~0.77~~0.61	~~0.20~~0.23	~~0.58~~0.50	~~0.20~~0.22	~~0.38~~0.37	0.23
40	~~0.77~~0.61	~~0.19~~0.22	~~0.59~~0.51	~~0.19~~0.20	0.38	0.21
45	~~0.78~~0.62	~~0.18~~0.21	~~0.60~~0.53	~~0.18~~0.20	0.40	0.20
50	~~0.81~~0.65	~~0.18~~0.20	~~0.64~~0.56	~~0.18~~0.19	0.42	0.19
60	~~0.92~~0.74	~~0.17~~0.19	~~0.74~~0.66	~~0.17~~0.18	~~0.49~~0.50	0.18
70	~~1.09~~0.89	~~0.17~~0.19	~~0.90~~0.81	~~0.16~~0.17	~~0.60~~0.61	0.18
80	~~1.29~~1.06	~~0.17~~0.19	~~1.08~~0.98	~~0.16~~0.17	~~0.72~~0.74	~~0.18~~0.17
90	~~1.46~~1.22	~~0.17~~0.19	~~1.25~~1.14	~~0.16~~0.17	~~0.83~~0.87	0.17
100	~~1.58~~1.33	~~0.16~~0.19	~~1.37~~1.26	~~0.16~~0.17	~~0.92~~0.97	0.17

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Table 2.5.2-235
Amplification Factors for the FIRS4_CoV50 Site Column

	Amplification Factor for 10^{-4}		Amplification Factor for 10^{-5}		Amplification Factor for 10^{-6}	
Freq (Hz)	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.	Median	Logarithmic Std. Dev.
0.1	~~1.13~~1.10	~~0.06~~0.05	~~1.14~~1.10	~~0.06~~0.05	~~1.14~~1.11	~~0.06~~0.05
0.125	~~1.15~~1.13	~~0.08~~0.07	~~1.16~~1.13	~~0.08~~0.07	~~1.16~~1.14	~~0.08~~0.07
0.15	~~1.19~~1.18	0.10	~~1.20~~1.18	0.10	~~1.20~~1.19	0.10
0.2	~~1.29~~1.28	0.15	~~1.30~~1.29	0.15	~~1.31~~1.30	0.15
0.3	~~1.46~~1.45	0.18	~~1.47~~1.46	0.18	1.48	0.19
0.4	1.44	0.17	1.45	0.17	1.48	0.20
0.5	1.38	0.18	1.39	~~0.18~~0.19	1.44	~~0.23~~0.24
0.6	1.36	0.16	1.39	0.18	1.45	0.25
0.7	1.40	0.15	~~1.43~~1.44	~~0.18~~0.19	1.51	~~0.25~~0.26
0.8	1.47	0.14	1.52	~~0.20~~0.21	1.60	0.27
0.9	~~1.51~~1.52	0.15	~~1.56~~1.57	~~0.22~~0.23	1.65	~~0.28~~0.29
1	1.57	0.17	~~1.59~~1.60	0.23	~~1.69~~1.70	0.30
1.25	~~1.84~~1.86	~~0.21~~0.22	~~1.94~~1.96	~~0.28~~0.29	2.04	0.33
1.5	~~2.06~~2.07	~~0.28~~0.29	~~2.13~~2.15	0.32	2.20	~~0.30~~0.31
2	~~2.05~~2.06	~~0.28~~0.29	2.11	~~0.30~~0.31	~~2.10~~2.11	~~0.28~~0.29
2.5	1.76	~~0.36~~0.37	~~1.75~~1.73	0.35	1.73	0.33
3	~~1.55~~1.54	~~0.44~~0.45	~~1.51~~1.49	~~0.39~~0.38	1.48	0.38
4	~~1.47~~1.43	0.49	~~1.40~~1.38	~~0.44~~0.46	~~1.31~~1.30	0.47
5	~~1.61~~1.57	~~0.50~~0.53	~~1.48~~1.44	~~0.48~~0.50	~~1.21~~1.19	~~0.44~~0.43
6	~~1.66~~1.57	~~0.45~~0.47	~~1.42~~1.36	~~0.42~~0.44	~~1.12~~1.11	~~0.48~~0.47
7	~~1.52~~1.43	~~0.41~~0.45	~~1.31~~1.25	~~0.45~~0.47	~~1.02~~1.01	0.50
8	~~1.40~~1.30	~~0.39~~0.43	~~1.18~~1.12	~~0.42~~0.44	0.93	0.51
9	~~1.33~~1.23	~~0.36~~0.41	~~1.12~~1.06	~~0.42~~0.45	0.87	0.52
10	~~1.27~~1.15	~~0.35~~0.40	~~1.06~~1.00	~~0.40~~0.43	0.80	~~0.51~~0.50
12.5	~~1.13~~1.01	~~0.30~~0.34	~~0.92~~0.86	~~0.33~~0.36	~~0.69~~0.68	0.43
15	~~1.04~~0.91	~~0.28~~0.32	~~0.84~~0.77	~~0.31~~0.35	~~0.61~~0.60	0.41
20	~~0.88~~0.73	~~0.25~~0.30	~~0.67~~0.60	~~0.28~~0.31	~~0.46~~0.45	0.36
25	~~0.82~~0.64	~~0.23~~0.28	~~0.60~~0.51	~~0.25~~0.29	~~0.40~~0.39	~~0.35~~0.36
30	~~0.79~~0.62	~~0.23~~0.27	~~0.58~~0.50	~~0.25~~0.28	~~0.38~~0.37	~~0.31~~0.32
35	~~0.76~~0.60	~~0.21~~0.24	~~0.57~~0.49	~~0.21~~0.24	0.37	0.27
40	~~0.76~~0.60	~~0.21~~0.23	~~0.58~~0.50	~~0.20~~0.22	0.37	0.24
45	~~0.78~~0.61	~~0.20~~0.22	~~0.60~~0.52	~~0.19~~0.21	0.38	~~0.22~~0.21
50	~~0.81~~0.64	~~0.20~~0.21	~~0.63~~0.55	~~0.18~~0.20	0.41	~~0.21~~0.20
60	~~0.92~~0.73	~~0.20~~0.21	~~0.73~~0.64	~~0.18~~0.19	0.48	0.19
70	~~1.09~~0.87	~~0.19~~0.20	~~0.89~~0.79	~~0.18~~0.19	~~0.58~~0.59	0.19
80	~~1.28~~1.04	~~0.19~~0.20	~~1.06~~0.95	0.18	~~0.70~~0.72	~~0.19~~0.18
90	~~1.45~~1.19	~~0.19~~0.20	~~1.23~~1.11	0.18	~~0.81~~0.84	0.18
100	~~1.57~~1.30	~~0.19~~0.20	~~1.35~~1.23	0.18	~~0.90~~0.94	0.18

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Table 2.5.2-236
1E-5 and GMRS Amplitudes for GMRS Elevation, Horizontal and Vertical

Horizontal and vertical amplitudes for GMRS elevation		
Frequency	1E-5 UHRS	GMRS
100	~~7.43E-02~~8.26E-02	~~3.34E-02~~3.72-E-02
90	~~7.48E-02~~8.33E-02	~~3.37E-02~~3.75E-02
80	~~7.54E-02~~8.42E-02	~~3.39E-02~~3.79E-02
75	~~7.57E-02~~8.46E-02	~~3.41E-02~~3.81E-02
70	~~7.61E-02~~8.51E-02	~~3.42E-02~~3.83E-02
60	~~7.68E-02~~8.62E-02	~~3.46E-02~~3.88E-02
50	~~7.78E-02~~8.76E-02	~~3.50E-02~~3.94E-02
40	~~7.89E-02~~8.92E-02	~~3.55E-02~~4.01E-02
30	~~8.04E-02~~9.14E-02	~~3.62E-02~~4.11E-02
25	~~8.14E-02~~9.28E-02	~~3.66E-02~~4.18E-02
20	~~8.53E-02~~9.74E-02	~~3.84E-02~~4.38E-02
15	~~9.05E-02~~1.04-E01	~~4.07E-02~~4.66E-02
12.5	~~9.40E-02~~1.08E-01	~~4.23E-02~~4.85E-02
10	~~9.85E-02~~1.13E-01	~~4.43E-02~~5.09E-02
9	~~9.99E-02~~1.14E-01	~~4.49E-02~~5.14E-02
8	~~1.01E-01~~1.'6E-01	~~4.57E-02~~5.20E-02
7.5	~~1.02E-01~~1.16E-01	~~4.61E-02~~5.23E-02
7	~~1.03E-01~~1.17E-01	~~4.65E-02~~5.27E-02
6	~~1.05E-01~~1.19E-01	~~4.74E-02~~5.35E-02
5	~~1.08E-01~~1.21E-01	~~4.86E-02~~5.45E-02
4	~~1.31E-01~~1.42E-01	~~5.91E-02~~6.39E-02
3	~~1.51E-01~~1.58E-01	~~6.78E-02~~7.13E-02
2.5	~~1.55E-01~~1.62E-01	~~6.98E-02~~7.29E-02
2	~~1.55E-01~~1.54E-01	~~6.99E-02~~7.13E-02
1.8	~~1.54E-01~~1.50E-01	~~6.92E-02~~6.75E-02
1.5	~~1.43E-01~~1.36E-01	~~6.42E-02~~6.14E-02
1.25	~~1.28E-01~~1.20E-01	~~5.76E-02~~5.41E-02
1	~~1.09E-01~~1.00E-01	~~4.91E-02~~4.50E-02
0.9	~~1.08E-01~~9.65E-02	~~4.86E-02~~4.34E-02
0.8	~~1.07E-01~~9.27E-02	~~4.80E-02~~4.17E-02
0.7	~~1.05E-01~~8.85E-02	~~4.74E-02~~3.98E-02
0.6	~~1.04E-01~~8.40E-02	~~4.67E-02~~3.78E-02
0.5	~~1.02E-01~~7.89E-02	~~4.59E-02~~3.55E-02
0.4	~~8.16E-02~~6.31E-02	~~3.67E-02~~2.84E-02
0.3	~~6.12E-02~~4.73E-02	~~2.75E-02~~2.13E-02
0.2	~~4.08E-02~~3.16E-02	~~1.84E-02~~1.42E-02
0.15	~~3.06E-02~~2.37E-02	~~1.38E-02~~1.07E-02
0.125	~~2.55E-02~~1.97E-02	~~1.15E-02~~8.88E-03
0.1	~~1.63E-02~~1.58E-02	~~7.34E-03~~7.10E-03

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Table 2.5.2-237
1E-5 and FIRS Amplitudes for FIRS Elevations, Horizontal and Vertical

	FIRS2		FIRS3		FIRS4		FIRS4-CoV50	
Frequency	1E-5 UHRS	FIRS2	1E-5 UHRS	FIRS3	1E-5 UHRS	FIRS4	1E-5 UHRS	FIRS4-CoV50
100	~~3.31~~8.49 E-02	~~1.49~~3.82 E-02	~~3.73~~1.01 E-~~02~~01	~~1.68~~4.55 E-02	~~5.45~~1.51 E-~~02~~01	~~2.45~~6.80 E-02	~~5.45~~1.48E-~~02~~01	~~2.45~~6.66 E-02
90	~~3.33~~8.58 E-02	~~1.50~~3.86 E-02	~~3.79~~1.03 E-~~02~~01	~~1.71~~4.64 E-02	~~5.53~~1.54 E-~~02~~01	~~2.49~~6.93 E-02	~~5.53~~1.51E-~~02~~01	~~2.49~~6.79 E-02
80	~~3.35~~8.69 E-02	~~1.51~~3.91 E-02	~~3.86~~1.05 E-~~02~~01	~~1.74~~4.75 E-02	~~5.63~~1.57 E-~~02~~01	~~2.53~~7.07 E-02	~~5.62~~1.54E-~~02~~01	~~2.53~~6.93 E-02
75	~~3.36~~8.75 E-02	~~1.51~~3.94 E-02	~~3.90~~1.07 E-~~02~~01	~~1.76~~4.80 E-02	~~5.68~~1.59 E-~~02~~01	~~2.56~~7.16 E-02	~~5.67~~1.56E-~~02~~01	~~2.55~~7.01 E-02
70	~~3.38~~8.81 E-02	~~1.52~~3.96 E-02	~~3.95~~1.08 E-~~02~~01	~~1.78~~4.87 E-02	~~5.74~~1.61 E-~~02~~01	~~2.58~~7.25 E-02	~~5.72~~1.58E-~~02~~01	~~2.57~~7.10 E-02
60	~~3.40~~8.95 E-02	~~1.53~~4.03 E-02	~~4.04~~1.11 E-~~02~~01	~~1.82~~5.02 E-02	~~5.87~~1.66 E-~~02~~01	~~2.64~~7.45 E-02	~~5.84~~1.62E-~~02~~01	~~2.63~~7.30 E-02
50	~~3.44~~9.12 E-02	~~1.55~~4.10 E-02	~~4.16~~1.15 E-~~02~~01	~~1.87E~~5.2 0-02	~~6.02~~1.71 E-~~02~~01	~~2.71~~7.70 E-02	~~5.98~~1.67E-~~02~~01	~~2.69~~7.54 E-02
40	~~3.48~~9.33 E-02	~~1.57~~4.20 E-02	~~4.31~~1.21 E-~~02~~01	~~1.94~~5.42 E-02	~~6.22~~1.78 E-~~02~~01	~~2.80~~8.02 E-02	~~6.17~~1.74E-~~02~~01	~~2.77~~7.84 E-02
30	~~3.53~~9.62 E-02	~~1.59~~4.33 E-02	~~4.51~~1.27 E-~~02~~01	~~2.03~~5.73 E-02	~~6.49~~1.88 E-~~02~~01	~~2.92~~8.45 E-02	~~6.41~~1.83E-~~02~~01	~~2.88~~8.25 E-02
25	~~3.57~~9.80 E-02	~~1.61~~4.41 E-02	~~4.64~~1.32 E-~~02~~01	~~2.09~~5.94 E-02	~~6.66~~1.94 E-~~02~~01	~~3.00~~8.73 E-02	~~6.57~~1.90E-~~02~~01	~~2.96~~8.53 E-02
20	~~3.74~~1.03 E-~~02~~01	~~1.68~~4.63 E-02	~~5.32~~1.55 E-~~02~~01	~~2.40~~6.96 E-02	~~7.33~~2.14 E-~~02~~01	~~3.30~~9.61 E-02	~~7.35~~2.13E-~~02~~01	~~3.31~~9.60 E-02
15	~~3.98~~1.10 E-~~02~~01	~~1.79~~4.94 E-02	~~6.11~~1.93 E-~~02~~01	~~2.75~~8.67 E-02	~~8.29~~2.42 E-~~02~~01	~~3.73~~1.09 E-~~02~~01	~~8.49~~2.49E-~~02~~01	~~3.82~~1.12 E-~~02~~01
12.5	~~4.13~~1.14 E-~~02~~01	~~1.86~~5.14 E-02	~~6.54~~2.02 E-~~02~~01	~~2.94~~9.10 E-02	~~8.96~~2.62 E-~~02~~01	~~4.03~~1.18 E-~~02~~01	~~9.30~~2.74E-~~02~~01	~~4.18~~1.23 E-~~02~~01
10	~~4.33~~1.20 E-~~02~~01	~~1.95~~5.40 E-02	~~6.98~~2.08 E-~~02~~01	~~3.14~~9.36 E-02	~~9.86~~2.88 E-~~02~~01	~~4.44~~1.30 E-~~02~~01	~~1.04~~3.08E-01	~~4.68~~1.39 E-~~02~~01
9	~~4.38~~1.21 E-~~02~~01	~~1.97~~5.43 E-02	~~6.77~~1.99 E-~~02~~01	~~3.04~~8.97 E-02	~~1.11~~3.25 E-01	~~5.00~~1.46 E-~~02~~01	~~1.12~~3.30E-01	~~5.04~~1.48 E-~~02~~01
8	~~4.44~~1.22 E-~~02~~01	~~2.00~~5.47 E-02	~~6.52~~1.89 E-~~02~~01	~~2.93~~8.52 E-02	~~1.24~~3.64 E-01	~~5.59~~1.64 E-~~02~~01	~~1.20~~3.52E-01	~~5.42~~1.58 E-~~02~~01
7.5	~~4.47~~1.22 E-~~02~~01	~~2.01~~5.79 E-02	~~6.38~~1.84 E-~~02~~01	~~2.87~~8.27 E-02	~~1.31~~3.83 E-01	~~5.90~~1.73 E-~~02~~01	~~1.25~~3.62E-01	~~5.61~~1.63 E-~~02~~01
7	~~4.51~~1.23 E-~~02~~01	~~2.03~~5.51 E-02	~~6.23~~1.78 E-~~02~~01	~~2.80~~8.01 E-02	~~1.38~~4.03 E-01	~~6.20~~1.81 E-~~02~~01	~~1.29~~3.73E-01	~~5.80~~1.68 E-~~02~~01
6	~~4.59~~1.24 E-~~02~~01	~~2.06~~5.56 E-02	~~5.88~~1.65 E-~~02~~01	~~2.65~~7.41 E-02	~~1.52~~4.43 E-01	~~6.83~~1.99 E-~~02~~01	~~1.37~~3.94E-01	~~6.18~~1.77 E-~~02~~01
5	~~4.68~~1.25 E-~~02~~01	~~2.11~~5.63 E-02	~~5.45~~1.49 E-~~02~~01	~~2.45~~6.71 E-02	~~1.65~~4.80 E-01	~~7.43~~2.16 E-~~02~~01	~~1.45~~4.12E-01	~~6.53~~1.85 E-~~02~~01
4	~~5.51~~1.43 E-~~02~~01	~~2.48~~6.44 E-02	~~6.33~~1.66 E-~~02~~01	~~2.85~~7.45 E-02	~~1.48~~4.10 E-01	~~6.64~~1.84 E-~~02~~01	~~1.40~~3.83E-01	~~6.32~~1.72 E-~~02~~01
3	~~6.17~~1.57 E-~~02~~01	~~2.77~~7.06 E-02	~~7.01~~1.77 E-~~02~~01	~~3.16~~7.95 E-02	~~1.24~~3.23 E-01	~~5.57~~1.45 E-~~02~~01	~~1.30~~3.40E-01	~~5.87~~1.53 E-~~02~~01
2.5	~~6.28~~1.59 E-~~02~~01	~~2.83~~7.16 E-02	~~7.11~~1.77 E-~~02~~01	~~3.20~~7.97 E-02	~~1.08~~2.71 E-01	~~4.84~~1.22 E-~~02~~01	~~1.21~~3.08E-01	~~5.45~~1.39 E-~~02~~01

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2	~~6.49~~1.55 E-~~02~~01	~~2.92~~6.97 E-02	~~7.34~~6.97 E-~~02~~01	~~3.30~~7.79 E-02	~~1.08~~2.58 E-01	~~4.84~~1.16 E-~~02~~01	~~1.18~~2.86E-01	~~5.31~~1.29 E-~~02~~01
1.8	~~6.50~~1.52 E-~~02~~01	~~2.93~~6.84 E-02	~~7.34~~1.70 E-~~02~~01	~~3.30~~7.67 E-02	~~1.05~~2.47 E-01	~~4.71~~1.11E-~~02~~01	~~1.14~~2.71E-01	~~5.12~~1.22 E-~~02~~01
1.5	~~6.13~~1.40 E-~~02~~01	~~2.76~~6.30 E-02	~~6.91~~1.57 E-~~02~~01	~~3.11~~7.06 E-02	~~9.65~~2.23 E-~~02~~01	~~4.34~~1.01 E-~~02~~01	~~1.04~~2.41E-01	~~4.66~~1.08 E-~~02~~01
1.25	~~5.57~~1.25 E-~~02~~01	~~2.51~~5.62 E-02	~~6.27~~1.40 E-~~02~~01	~~2.82~~6.30 E-02	~~8.61~~1.96 E-~~02~~01	~~3.87~~8.81 E-02	~~9.13~~2.08E-~~02~~01	~~4.11~~9.37 E-02
1	~~4.80~~1.05 E-~~02~~01	~~2.16~~4.73 E-02	~~5.40~~1.18 E-~~02~~01	~~2.43~~5.31 E-02	~~7.29~~1.62 E-~~02~~01	~~3.28~~7.29 E-02	~~7.65~~1.70E-~~02~~01	~~3.44~~7.64 E-02
0.9	~~4.75~~1.01 E-~~02~~01	~~2.14~~4.56 E-02	~~5.33~~1.15 E-~~02~~01	~~2.40~~5.16 E-02	~~7.14~~1.57 E-~~02~~01	~~3.21~~7.07 E-02	~~7.46~~1.64E-~~02~~01	~~3.36~~7.36 E-02
0.8	~~4.69~~9.73 E-02	~~2.11~~4.38 E-02	~~5.25~~1.11 E-~~02~~01	~~2.36~~4.99 E-02	~~6.97~~1.52 E-~~02~~01	~~3.14~~6.82 E-02	~~7.25~~1.57E-~~02~~01	~~3.26~~7.06 E-02
0.7	~~4.63~~9.30 E-02	~~2.08~~4.19 E-02	~~5.16~~1.07 E-~~02~~01	~~2.32~~4.81 E-02	~~6.79~~1.46 E-~~02~~01	~~3.06~~6.56 E-02	~~7.02~~1.50E-~~02~~01	~~3.16~~6.73 E-02
0.6	~~4.55~~8.83 E-02	~~2.05~~3.97 E-02	~~5.06~~1.02 E-~~02~~01	~~2.28~~4.60 E-02	~~6.58~~1.39 E-~~02~~01	~~2.96~~6.27 E-02	~~6.77~~1.42E-~~02~~01	~~3.05~~6.37 E-02
0.5	~~4.47~~8.30 E-02	~~2.01~~3.74 E-02	~~4.95~~9.72 E-02	~~2.23~~4.37 E-02	~~6.35~~1.32 E-~~02~~01	~~2.86~~5.94 E-02	~~6.48~~1.33E-~~02~~01	~~2.92~~5.97 E-02
0.4	~~3.58~~6.64 E-02	~~1.61~~2.99 E-02	~~3.96~~7.78 E-02	~~1.78~~3.50 E-02	~~5.08~~1.06 E-~~02~~01	~~2.29~~4.75 E-02	~~5.18~~1.06E-~~02~~01	~~2.33~~4.78 E-02
0.3	~~2.68~~4.98 E-02	~~1.21~~2.24 E-02	~~2.97~~5.83 E-02	~~1.34~~2.62 E-02	~~3.81~~7.92 E-02	~~1.71~~3.56 E-02	~~3.89~~7.96E-02	~~1.75~~3.58 E-02
0.2	~~1.79~~3.32 E-02	~~8.05~~1.49 E-~~03~~02	~~1.98~~3.89 E-02	~~8.91~~1.75 E-~~03~~02	~~2.54~~5.28 E-02	~~1.14~~2.38 E-02	~~2.59~~5.31E-02	~~1.17~~2.39 E-02
0.15	~~1.34~~2.49 E-02	~~6.03~~1.12 E-~~03~~02	~~1.49~~2.92 E-02	~~6.68~~1.31 E-~~03~~02	~~1.91~~3.96 E-02	~~8.57~~1.78 E-~~03~~02	~~1.94~~3.98E-02	~~8.75~~1.79 E-~~03~~02
0.125	~~1.12~~2.08 E-02	~~5.03~~9.34 E-03	~~1.24~~2.43 E-02	~~5.57~~1.09 E-~~03~~02	~~1.59~~3.30 E-02	~~7.14~~1.49 E-~~03~~02	~~1.62~~3.32E-02	~~7.29~~1.49 E-~~03~~02
0.1	~~7.15~~1.66 E-~~03~~02	~~3.22~~7.47 E-03	~~7.92~~1.94 E-~~03~~02	~~3.56~~8.75 E-03	~~1.02~~2.64 E-02	~~4.57~~1.19 E-~~03~~02	~~1.04~~2.65E-02	~~4.67~~1.19 E-~~03~~02

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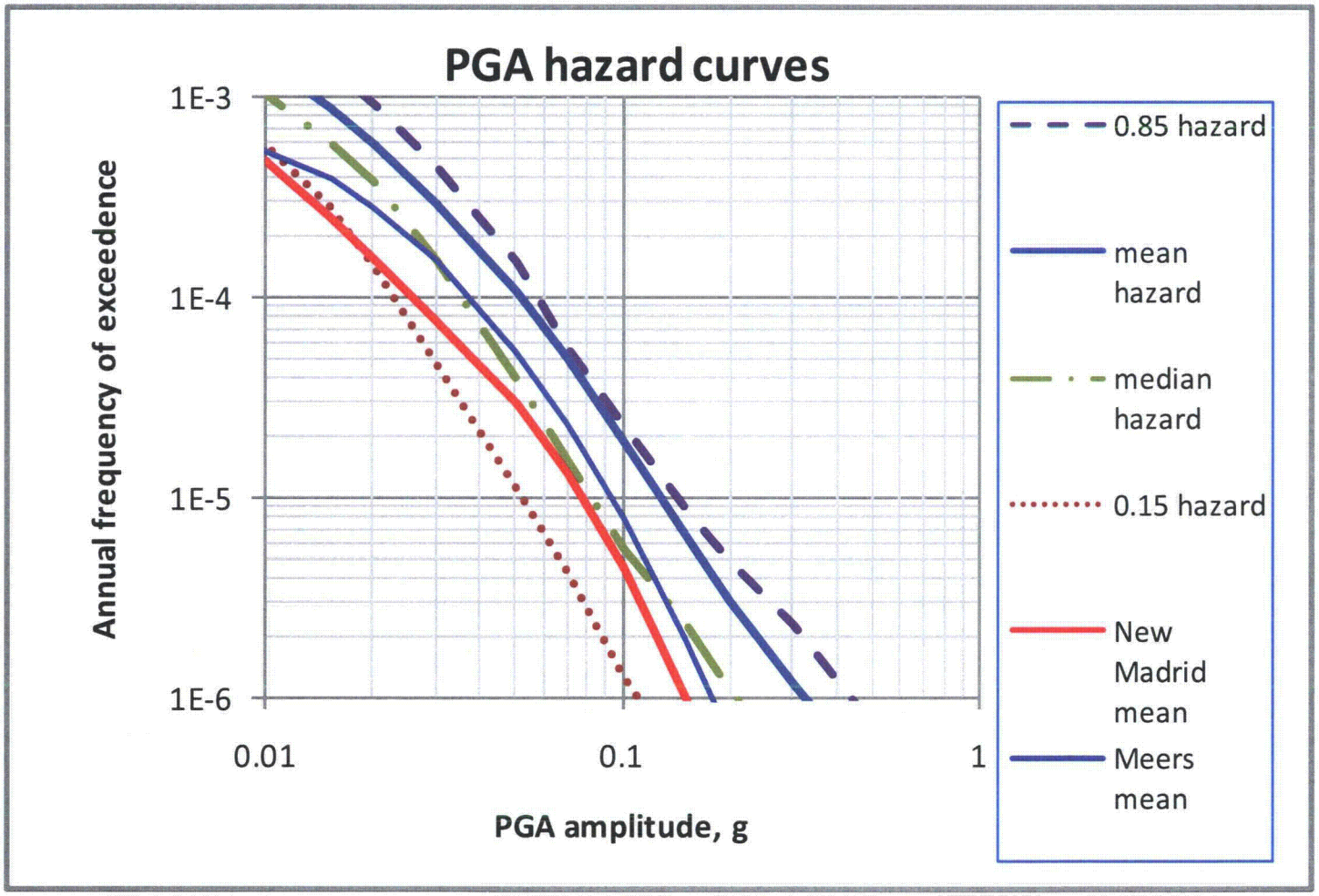

Figure 2.5.2-215 PGA Rock Seismic Hazard Curves for all Sources and for New Madrid Faults Alone

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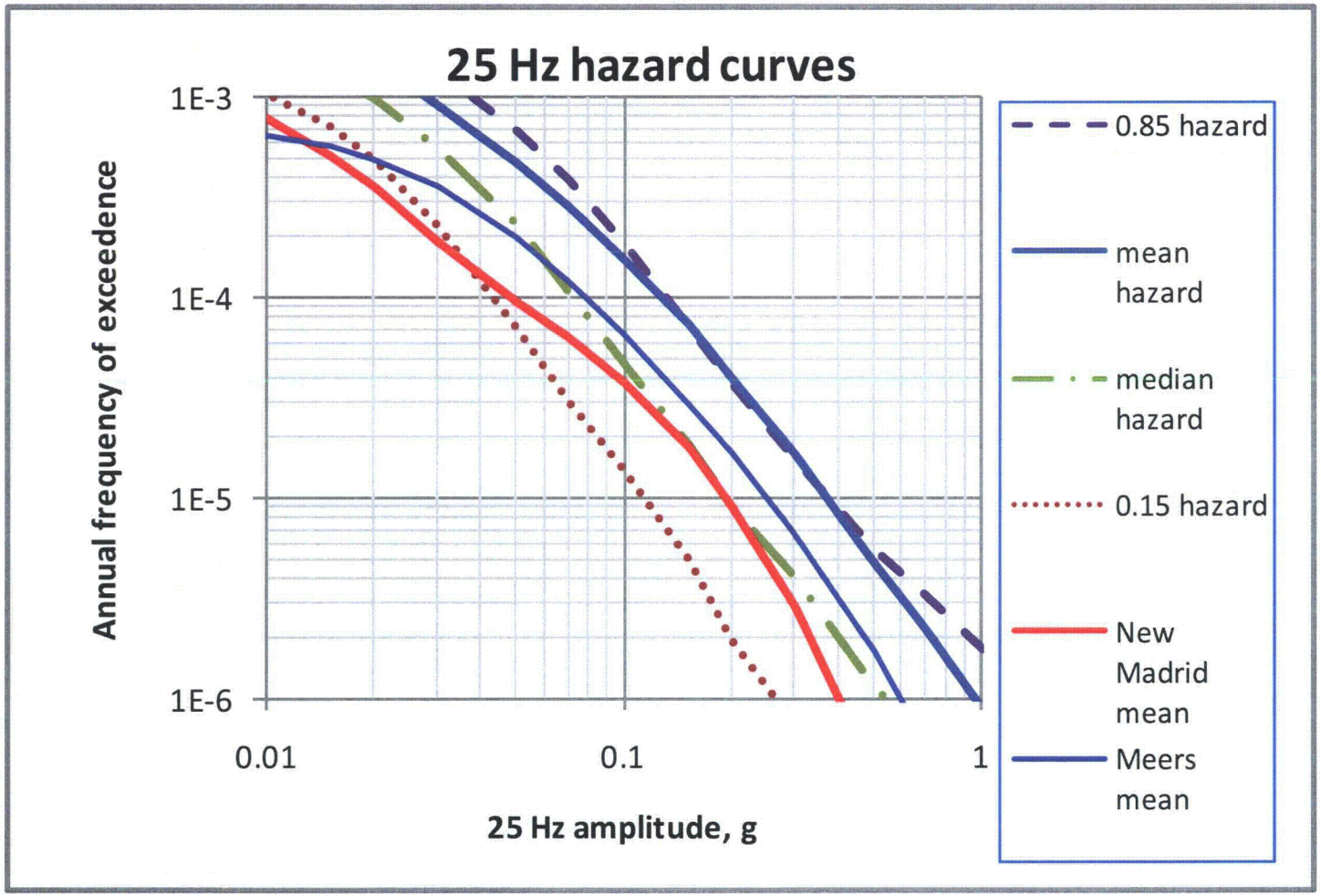

Figure 2.5.2-216 25 Hz Rock Seismic Hazard Curves for all Sources and for New Madrid Faults Alone

RCOL2_02.05.02-16 S01

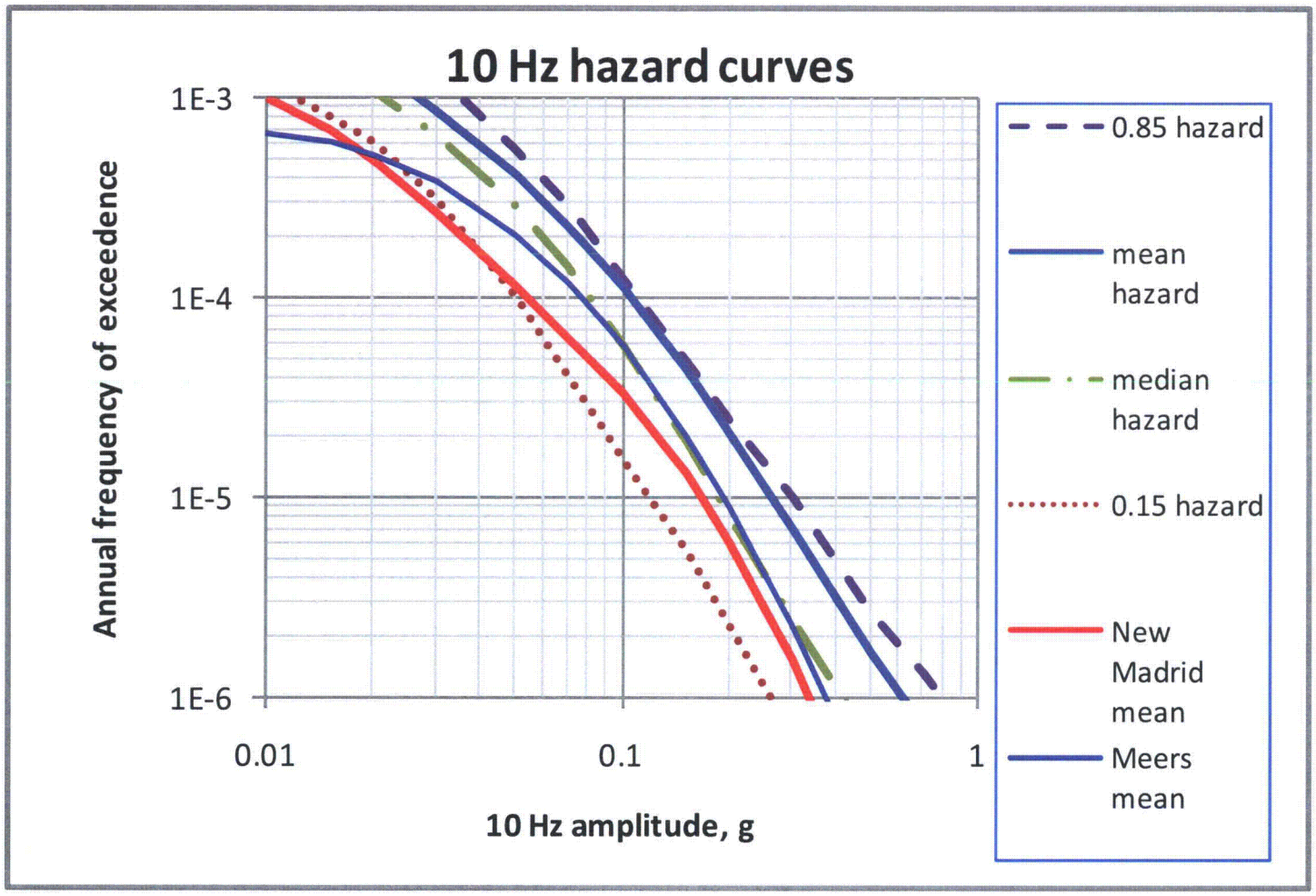

Figure 2.5.2-217 10 Hz Rock Seismic Hazard Curves for all Sources and for New Madrid Faults Alone

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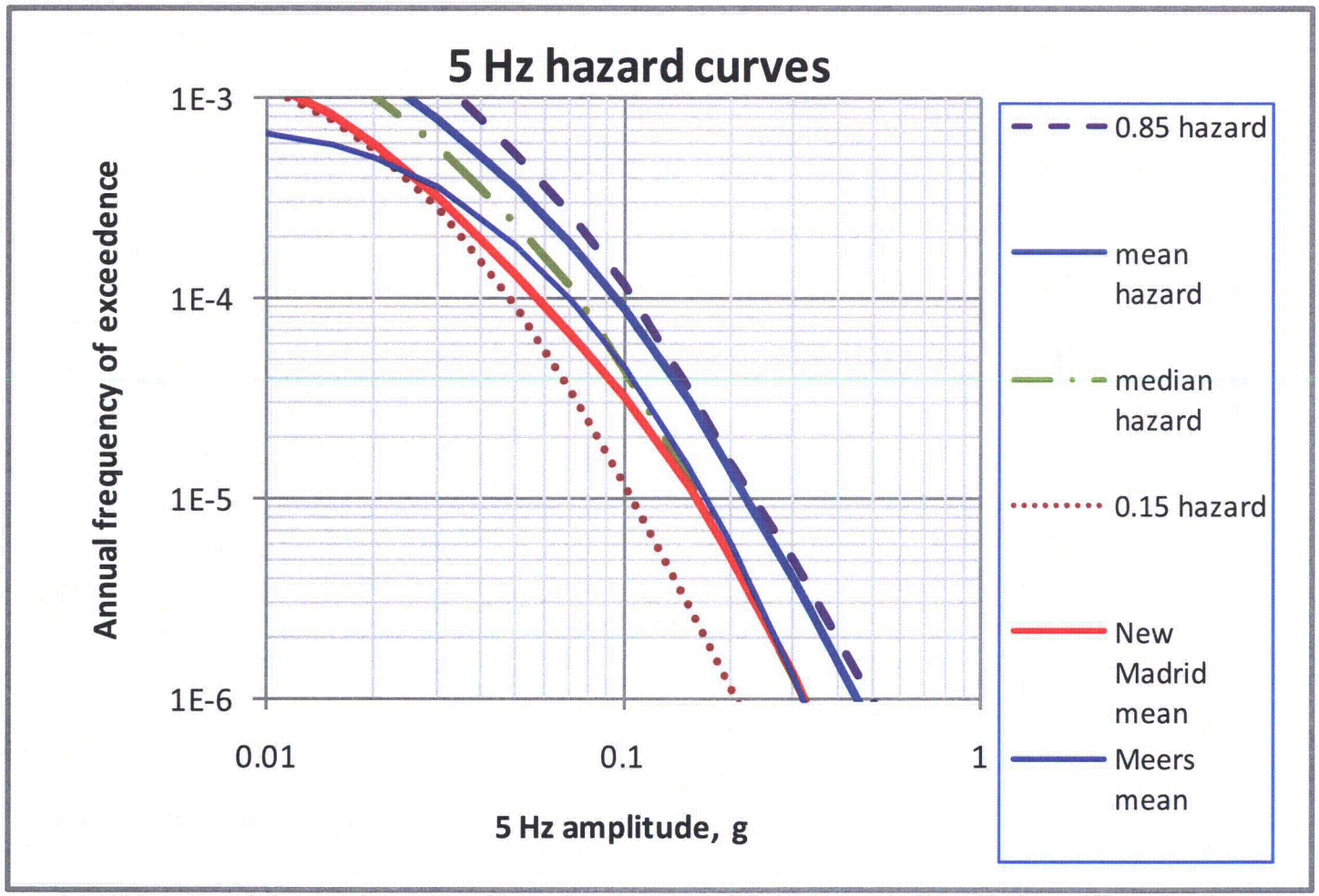


Figure 2.5.2-218 5 Hz Rock Seismic Hazard Curves for all Sources and for New Madrid Faults Alone

RCOL2_02.05.02-16 S01

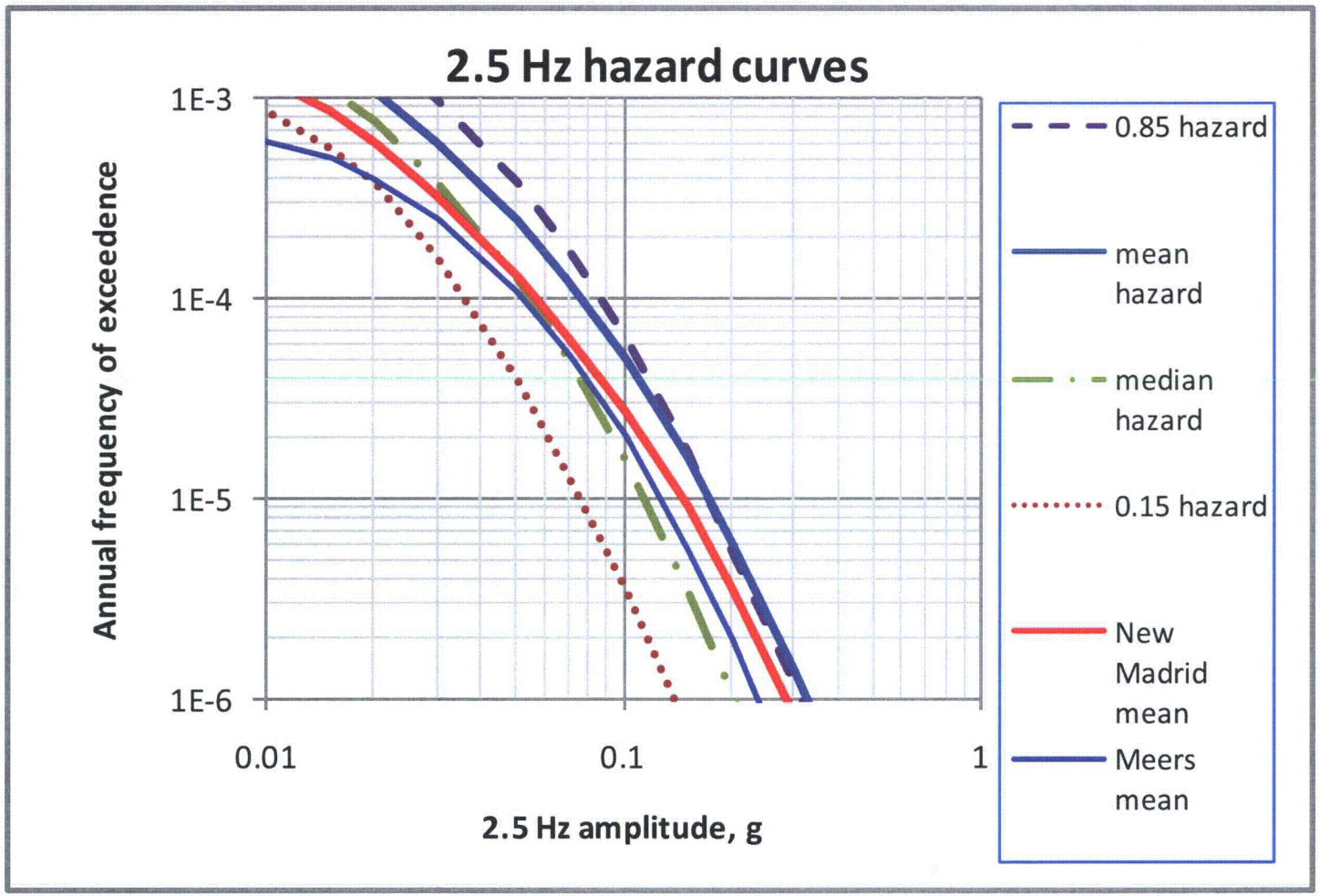


Figure 2.5.2-219 2.5 Hz Rock Seismic Hazard Curves for all Sources and for New Madrid Faults Alone

RCOL2_02.05.02-16 S01

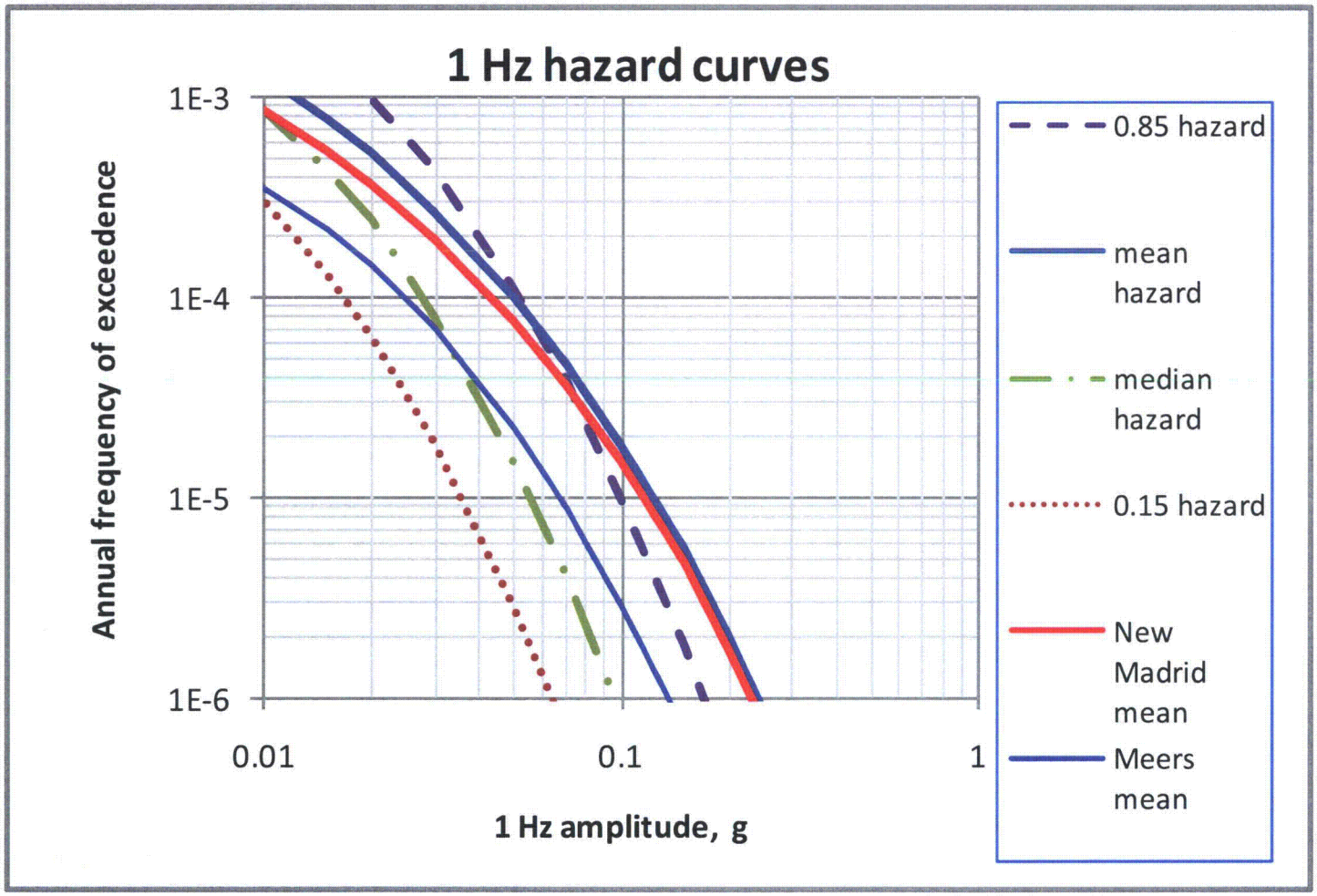


Figure 2.5.2-220 1 Hz Rock Seismic Hazard Curves for all Sources and for New Madrid Faults Alone

RCOL2_02.05.02-16 S01

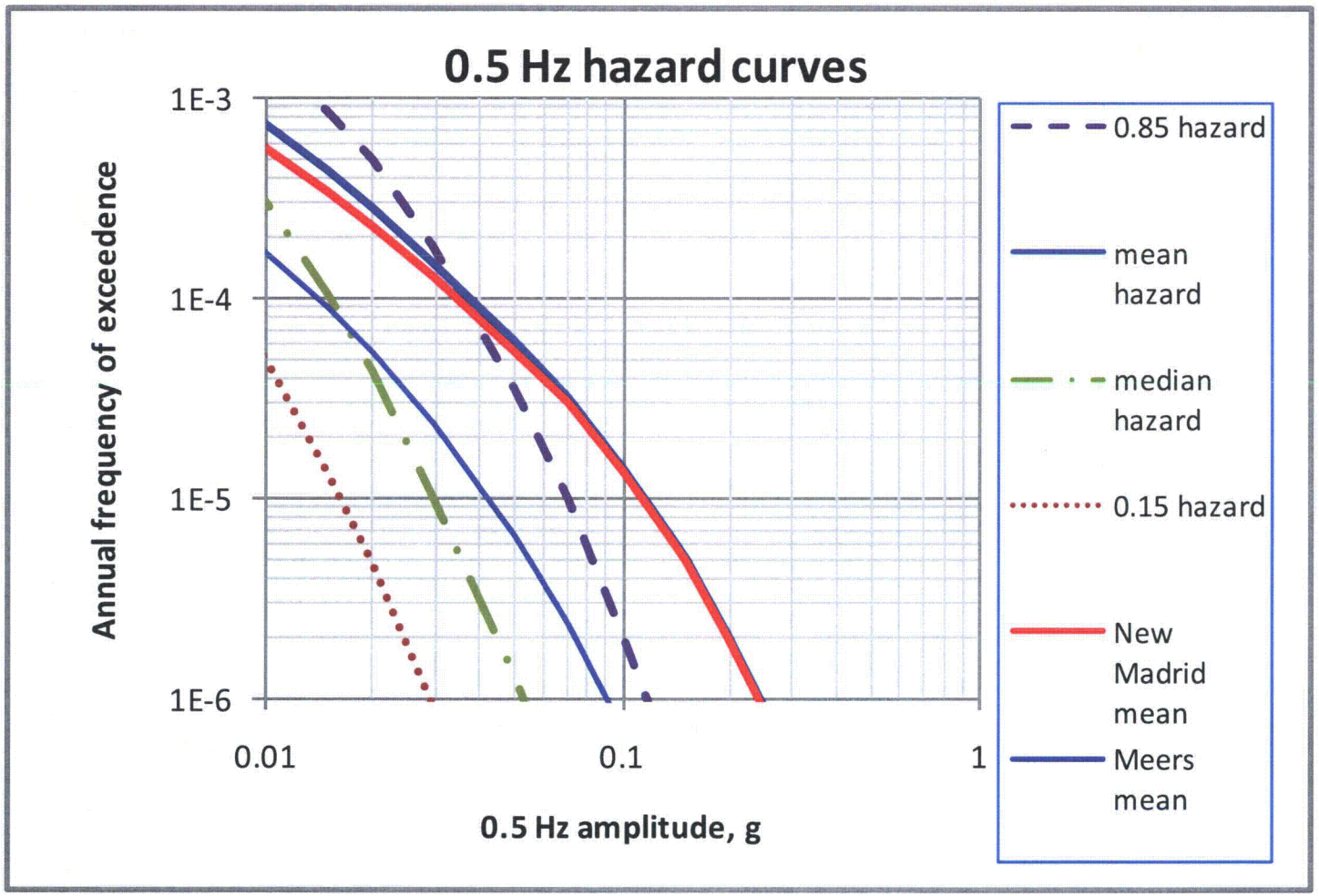


Figure 2.5.2-221 0.5 Hz Rock Seismic Hazard Curves for all Sources and for New Madrid Faults Alone

RCOL2_02.05.02-16 S01

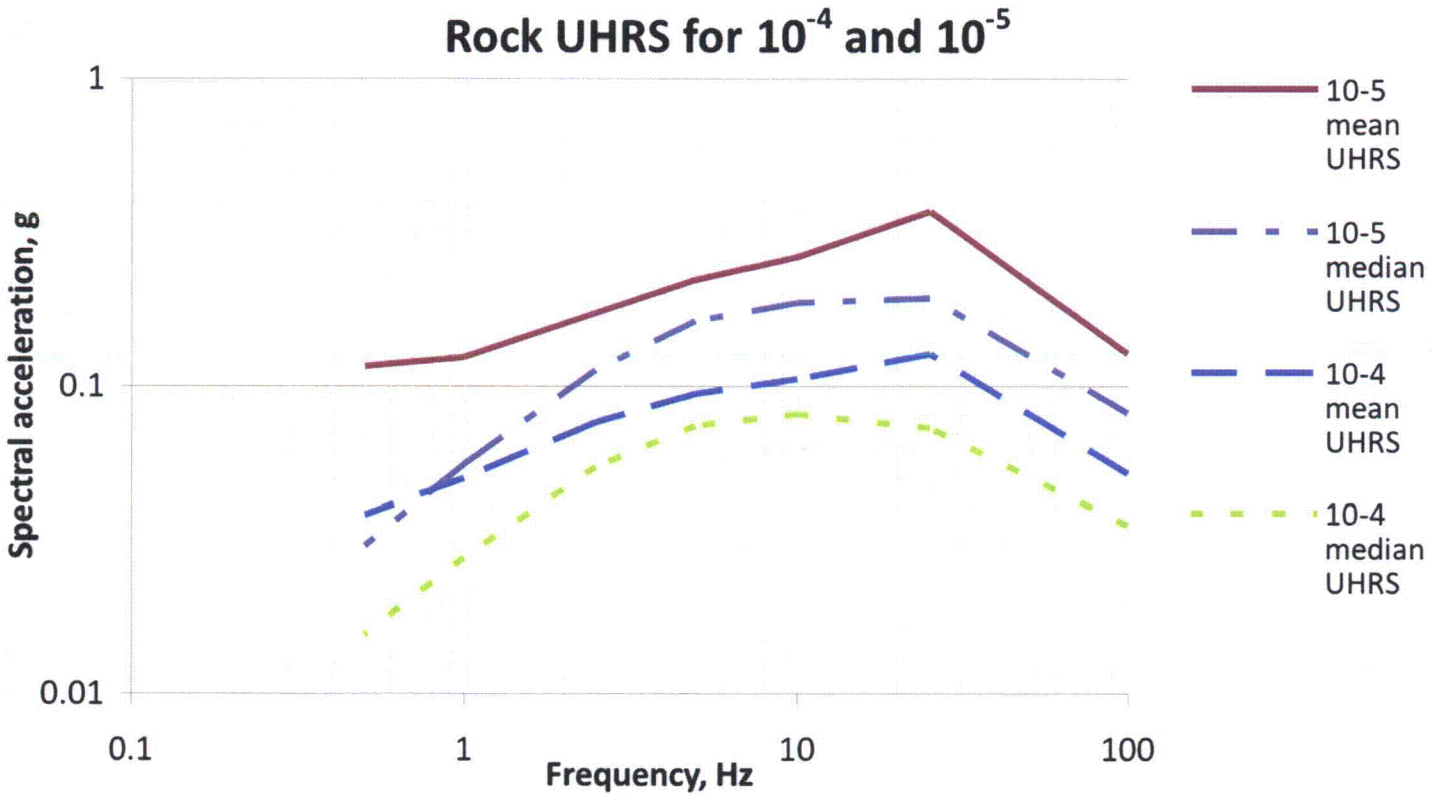


Figure 2.5.2-222 Mean and Median Rock UHRS for 10^{-4} and 10^{-5} Annual Frequencies of Exceedance

RCOL2_02.0
5.02-16 S01

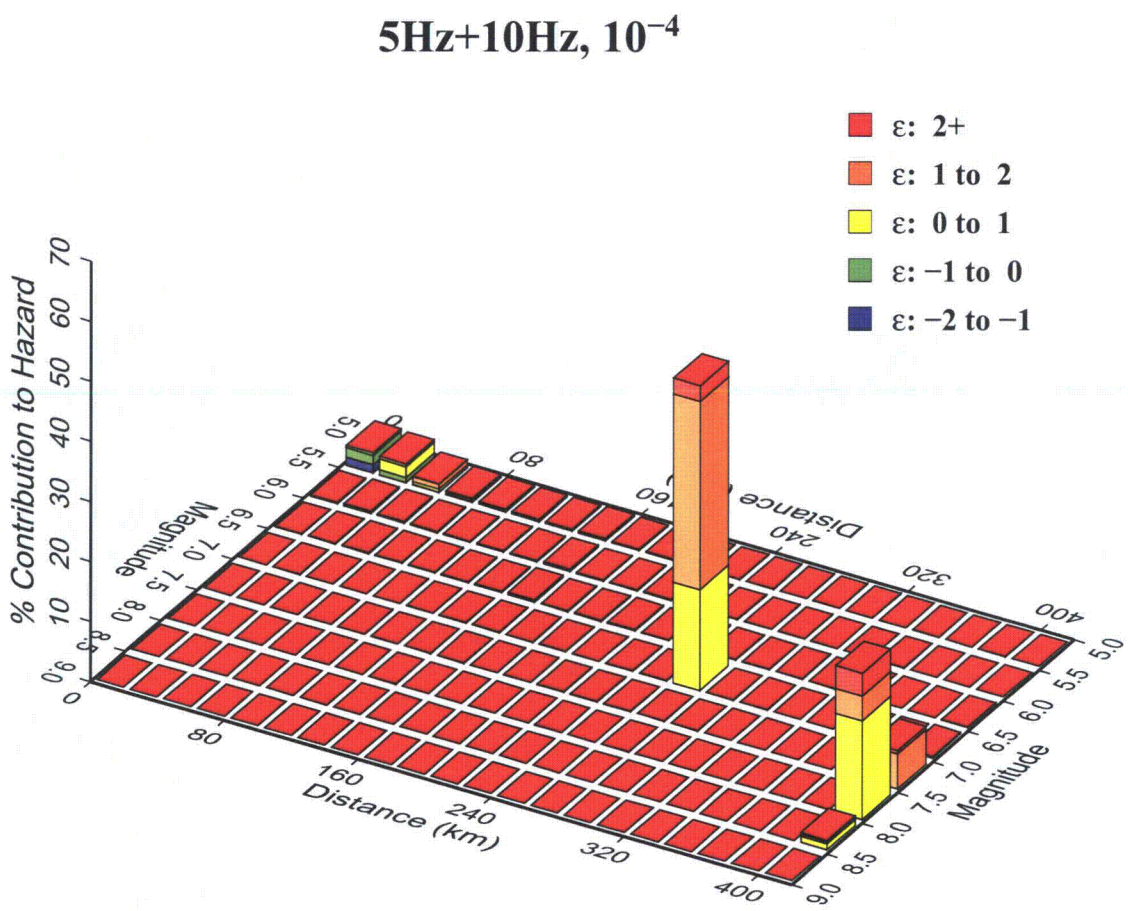


Figure 2.5.2-223 Deaggregation of 10^{-4} Rock Hazard for 5 and 10 Hz

RCOL2_02.05.02-16 S01

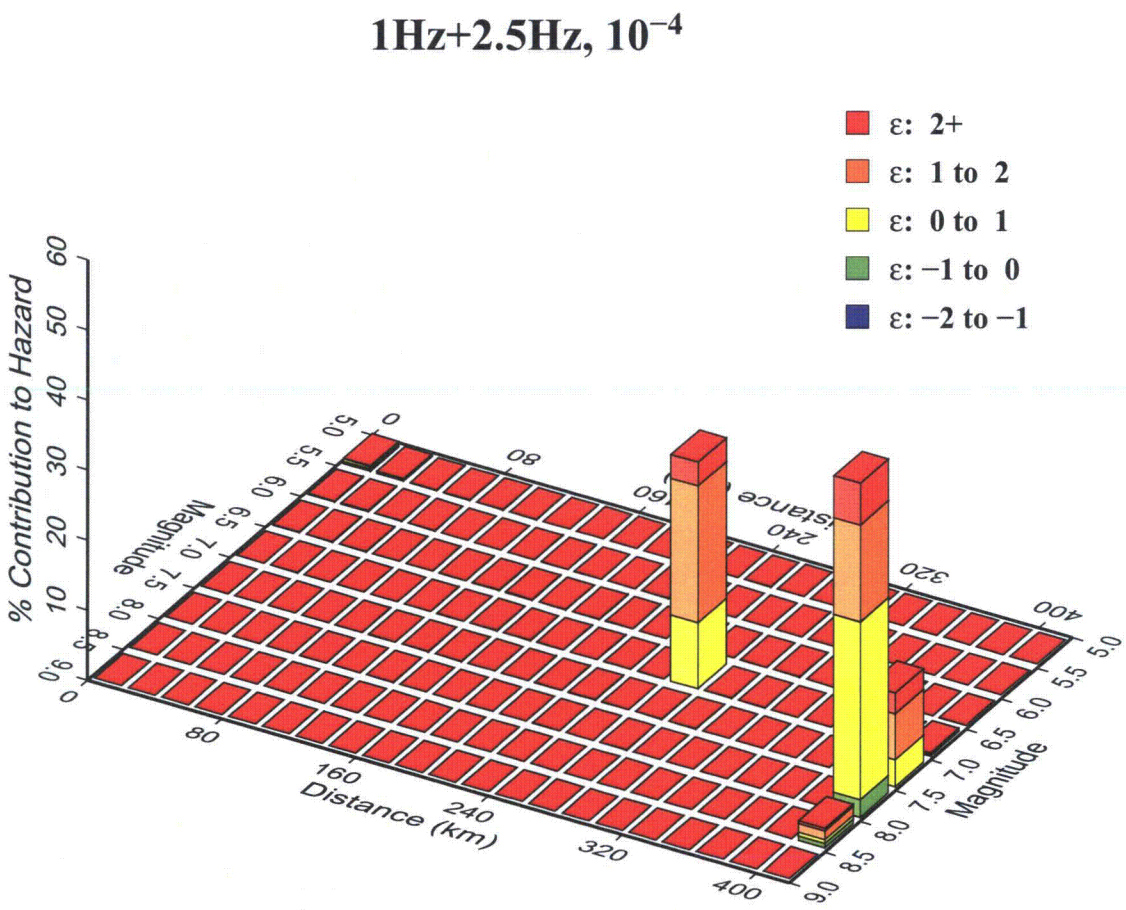


Figure 2.5.2-224 Deaggregation of 10^{-4} Rock Hazard for 1 and 2.5 Hz

RCOL2_02.0
5.02-16 S01

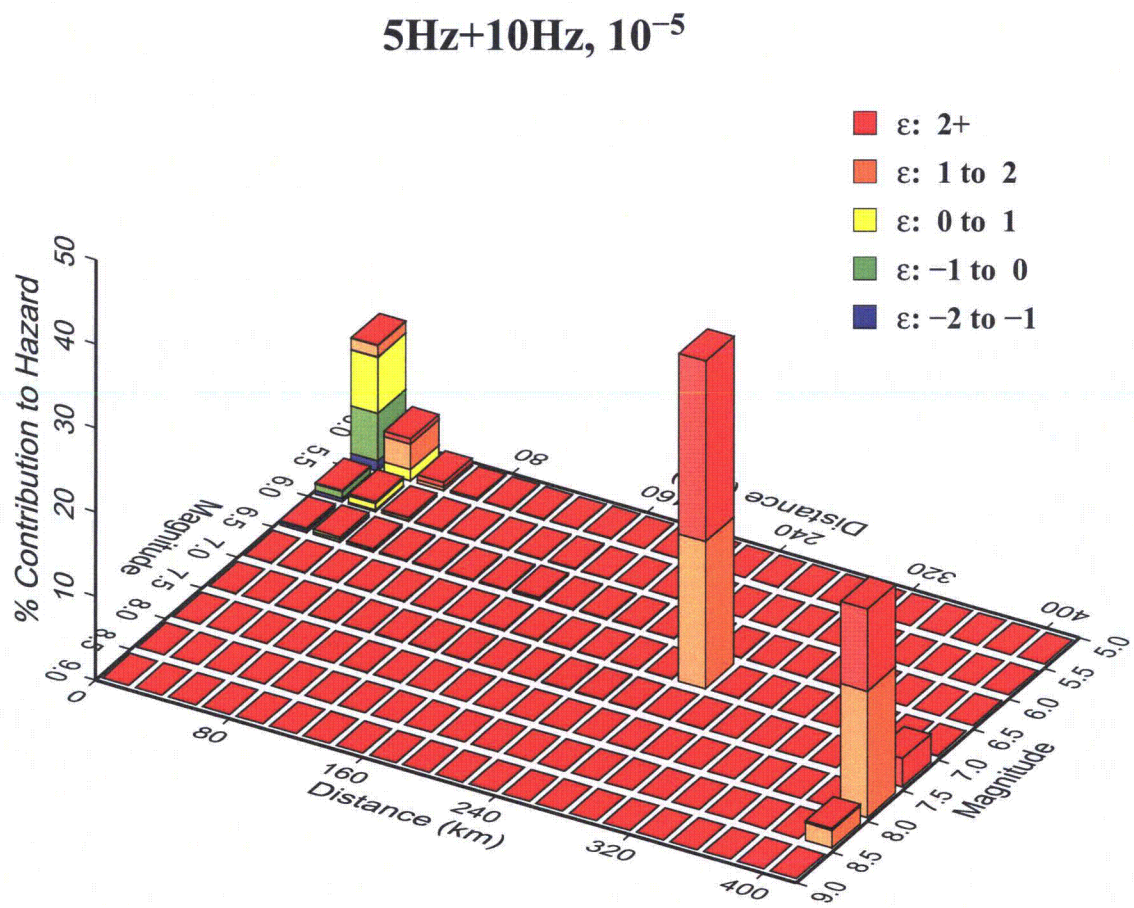


Figure 2.5.2-225 Deaggregation of 10^{-5} Rock Hazard for 5 and 10 Hz

RCOL2_02.0
5.02-16 S01

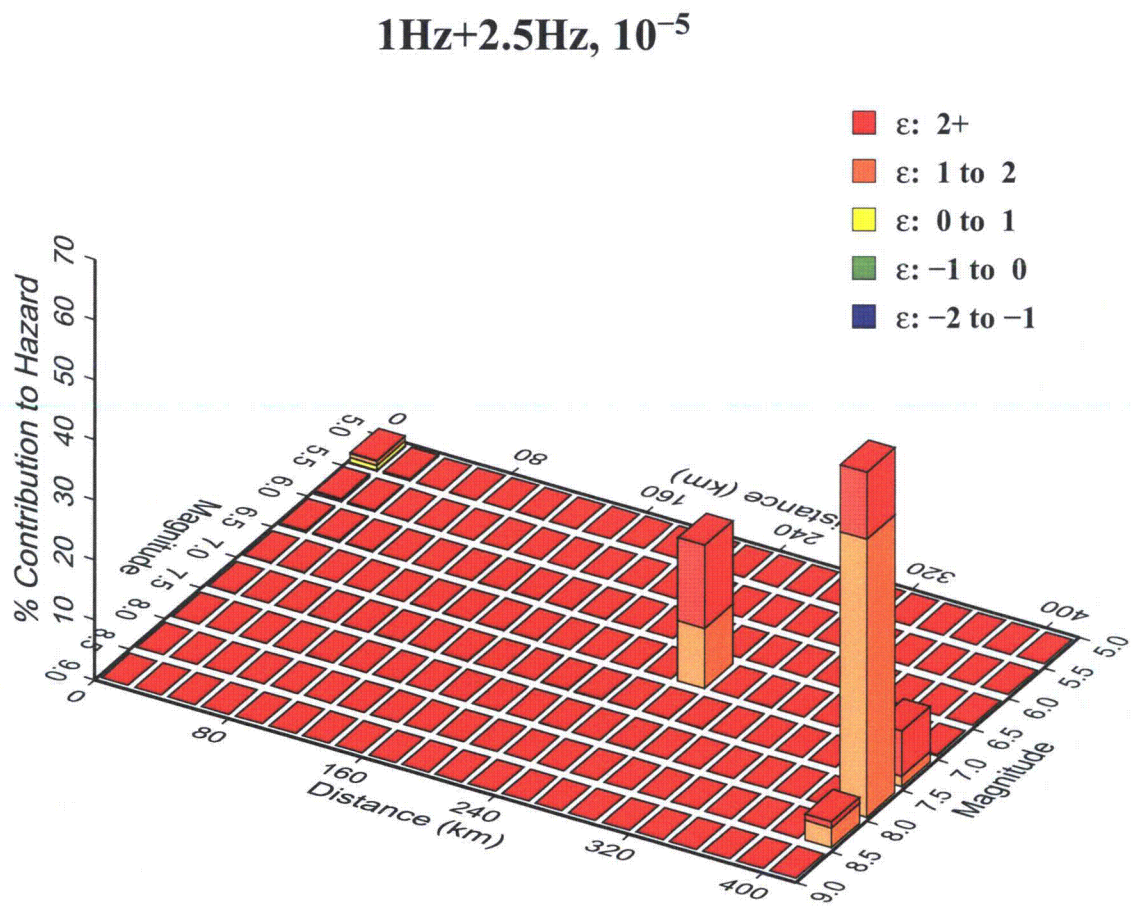


Figure 2.5.2-226 Deaggregation of 10^{-5} Rock Hazard for 1 and 2.5 Hz

RCOL2_02.05.02-16 S01

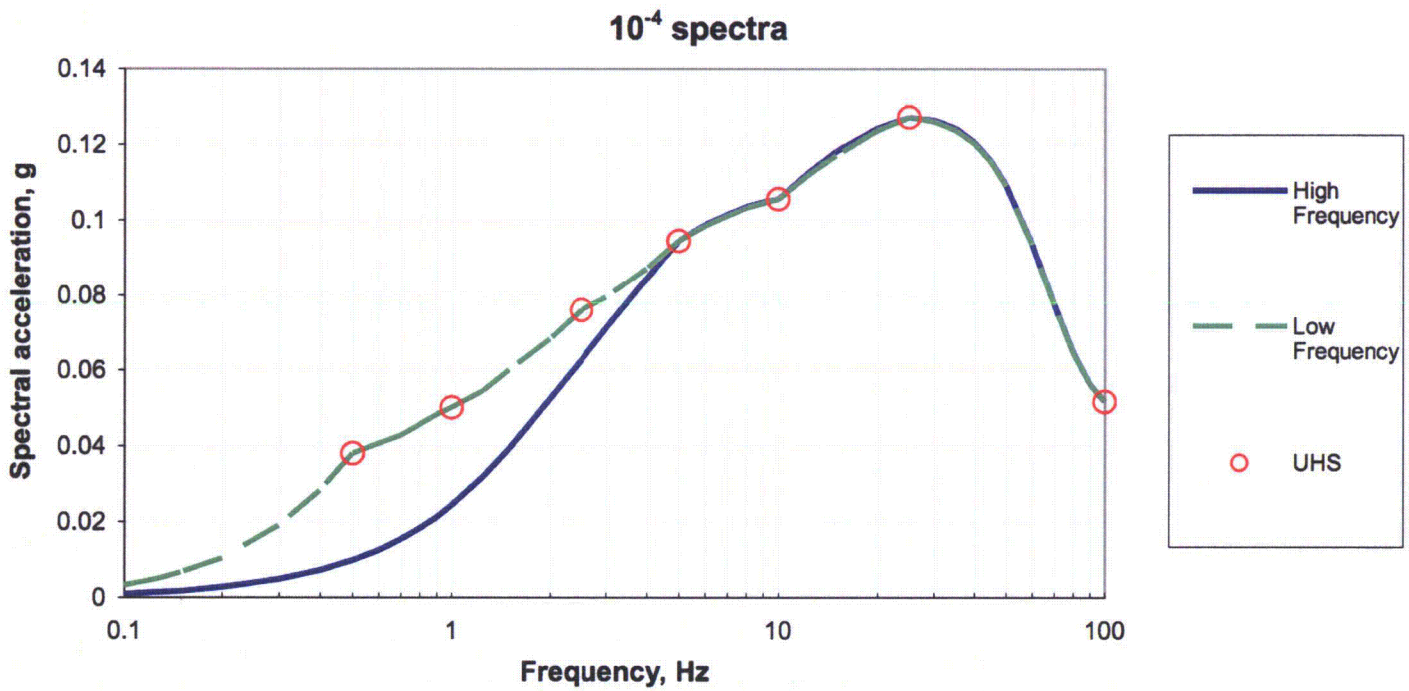


Figure 2.5.2-229 Smooth 10^{-4} Rock UHRS for High and Low Frequencies

RCOL2_02.05.02-16 S01

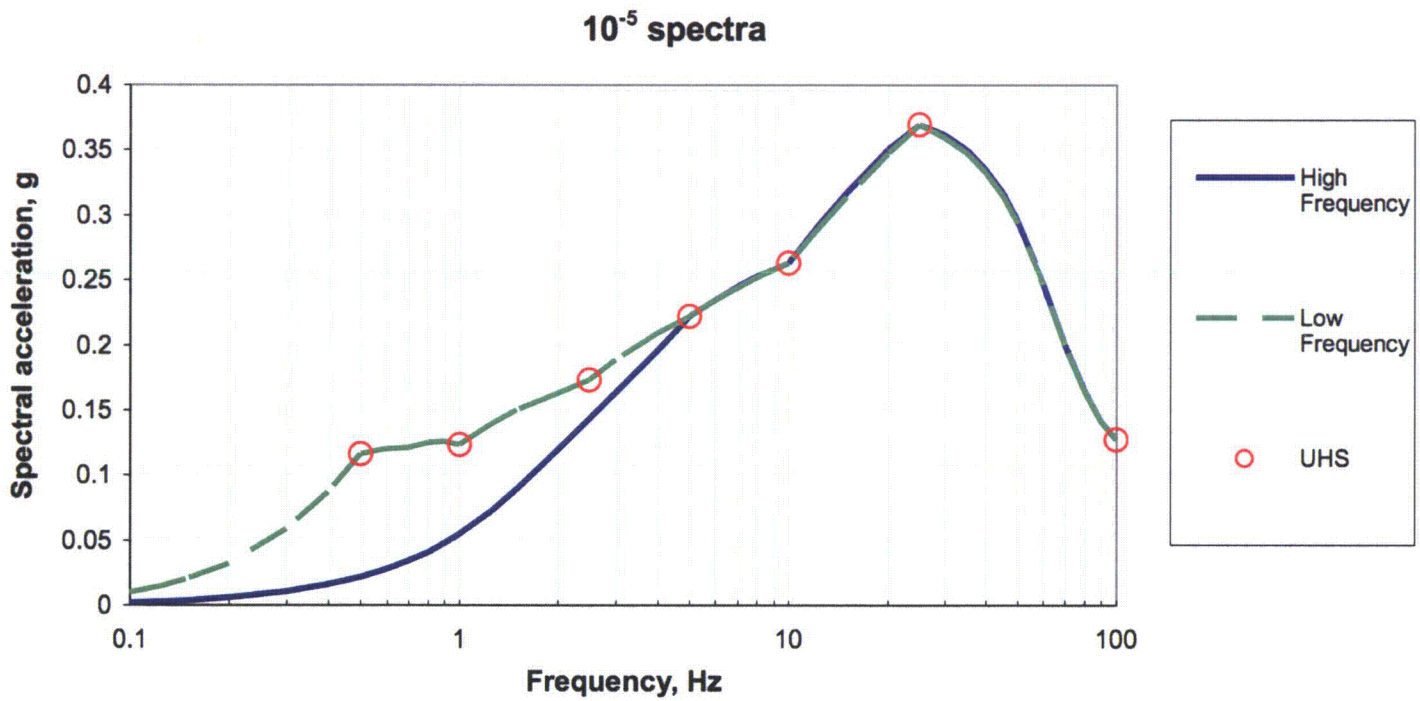


Figure 2.5.2-230 Smooth 10^{-5} Rock UHRS for High and Low Frequencies

RCOL2_02.05.02-16 S01

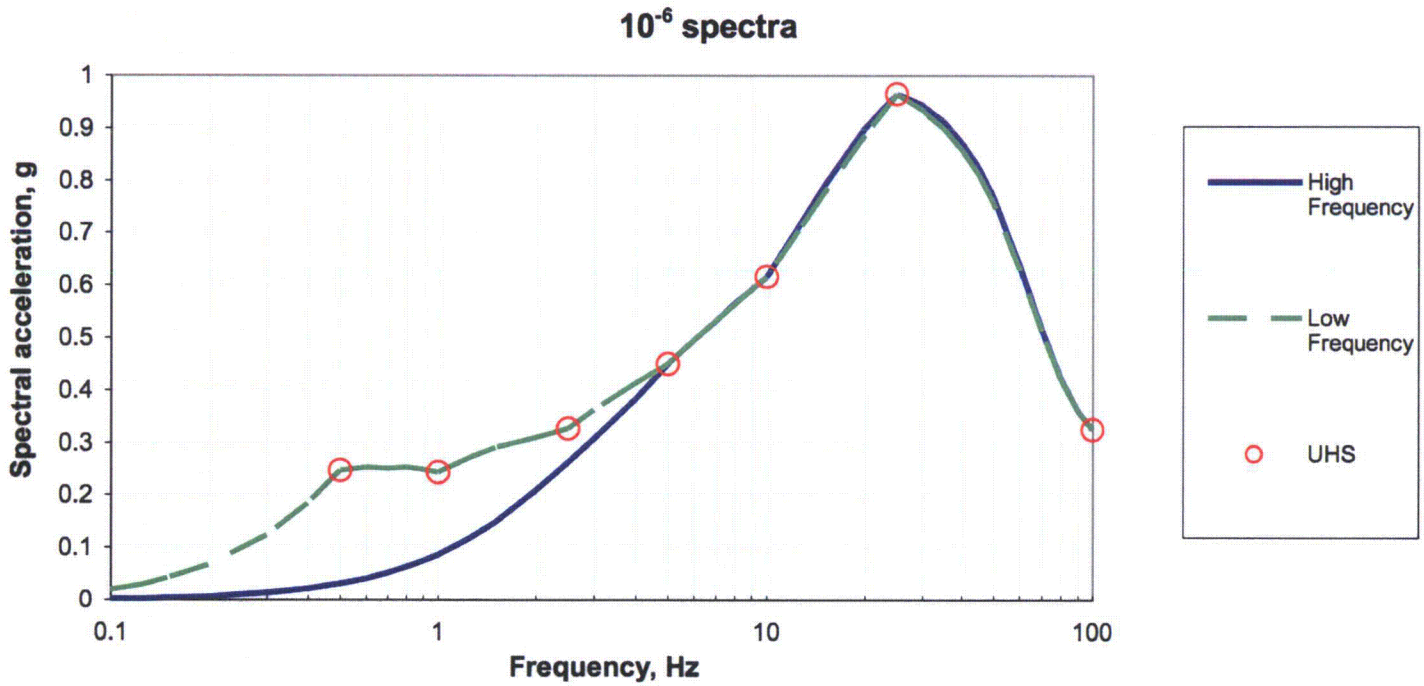


Figure 2.5.2-231 Smooth 10^{-6} Rock UHRS for High and Low Frequencies

RCOL2_02.05.02-16 S01

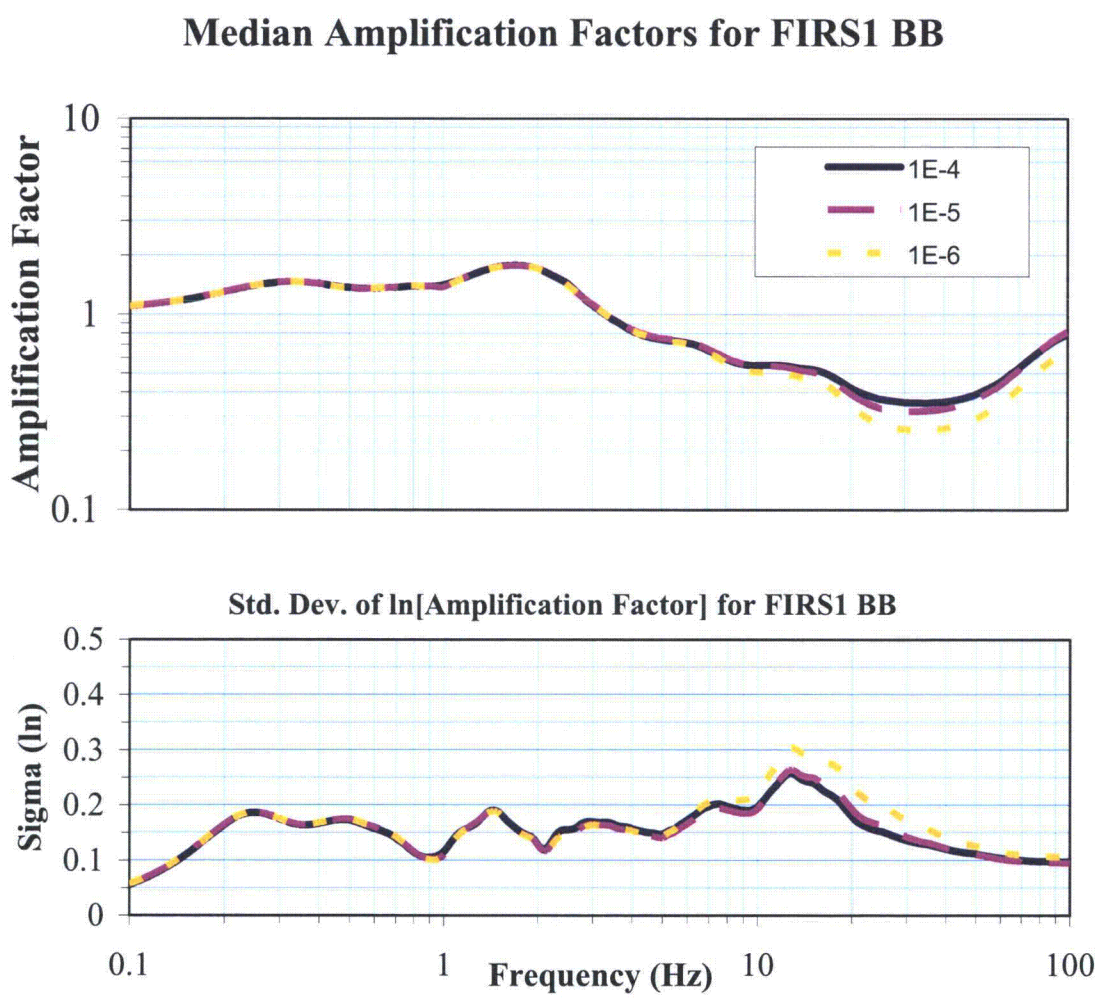


Figure 2.5.2-233 Median Amplification Factor and Logarithmic Standard Deviation of Amplication Factor for GMRS (Elevation 782'), Using Broad-Banded (BB) Input Motion

RCOL2_02.05.02-16 S01

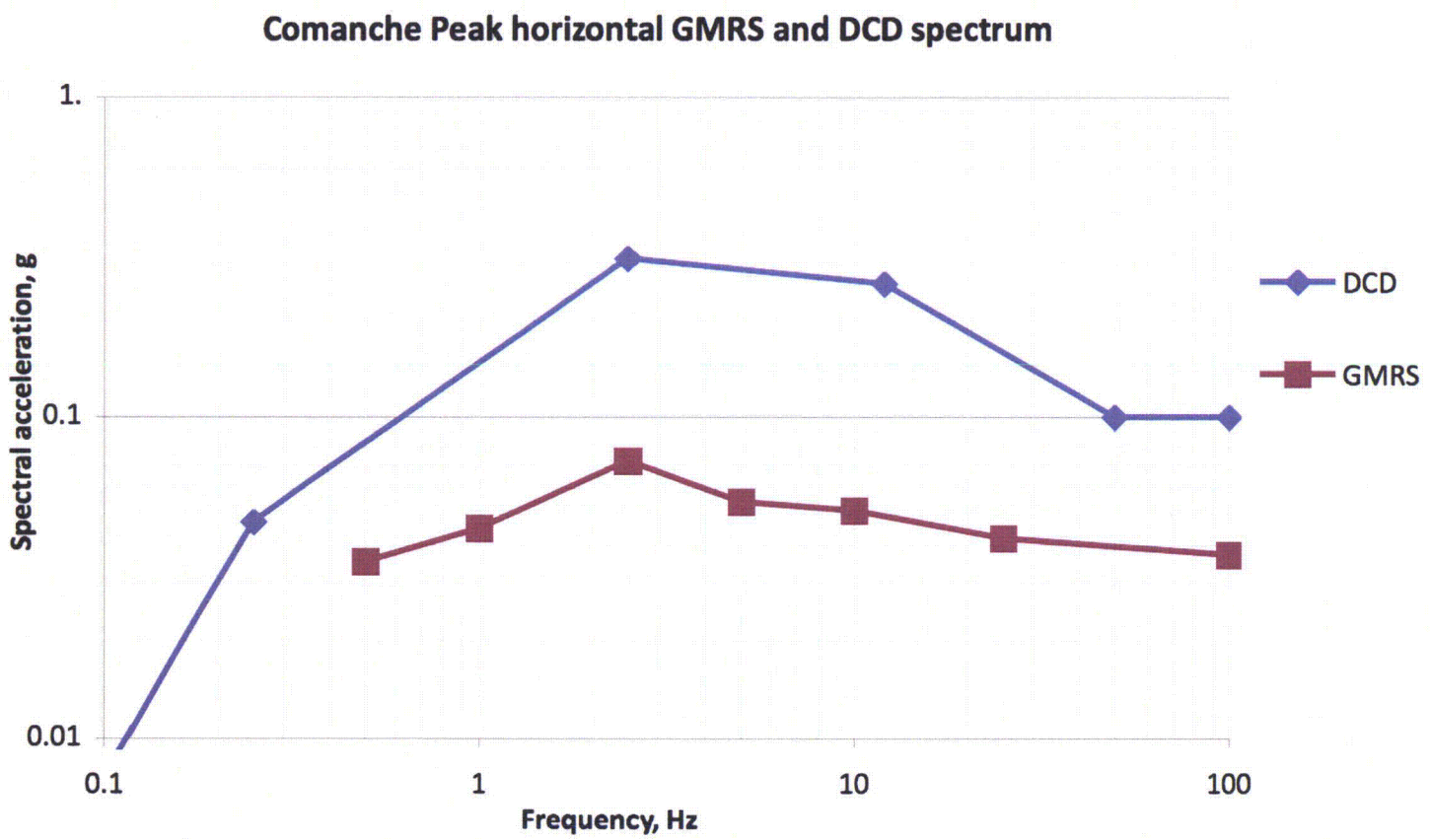


Figure 2.5.2-234 Comanche Peak Horizontal GMRS Compared to DCD Spectrum

RCOL2_02.05.02-16 S01

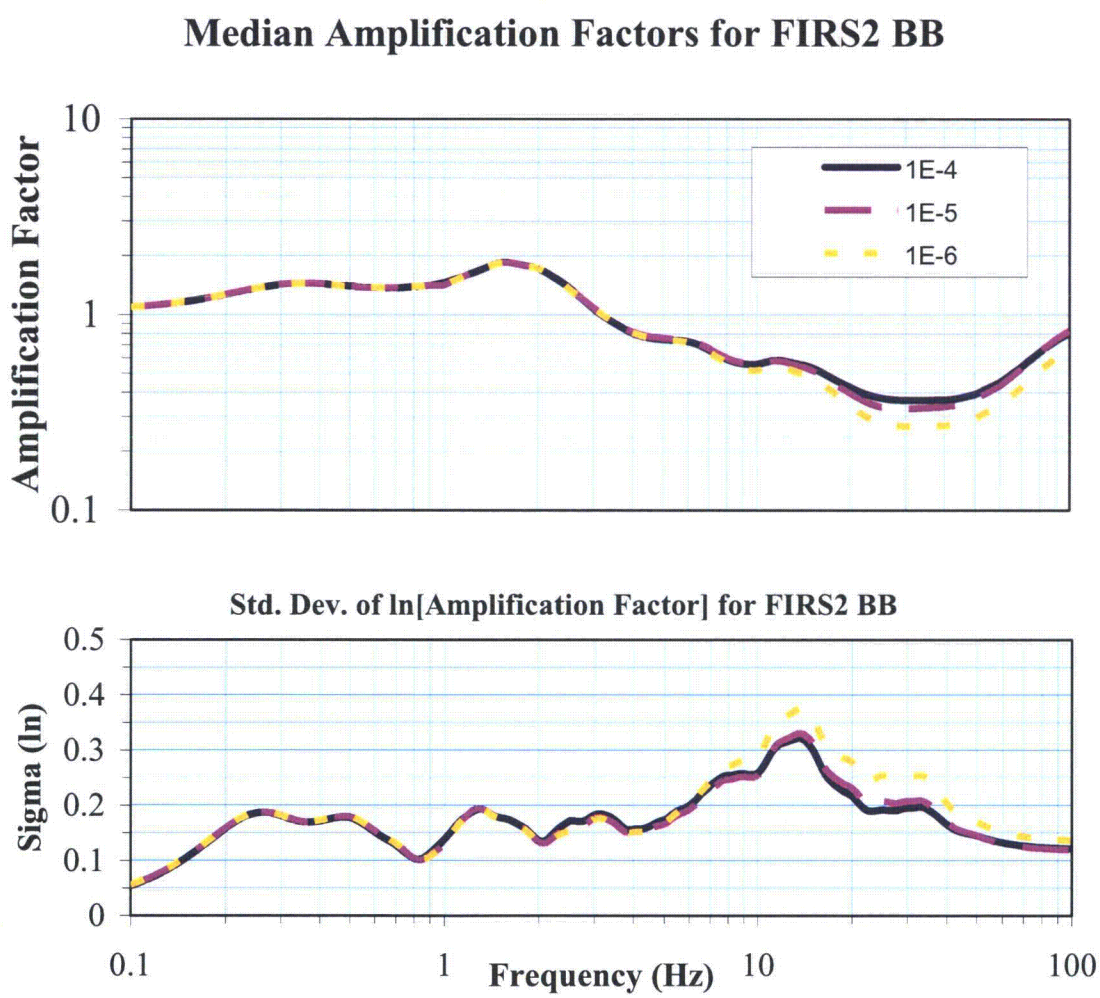


Figure 2.5.2-235 Median Amplification Factor and Logarithmic Standard Deviation of Amplication Factor for FIRS2, Using Broad-Banded (BB) Input Motion

RCOL2_02.05.02-16 S01

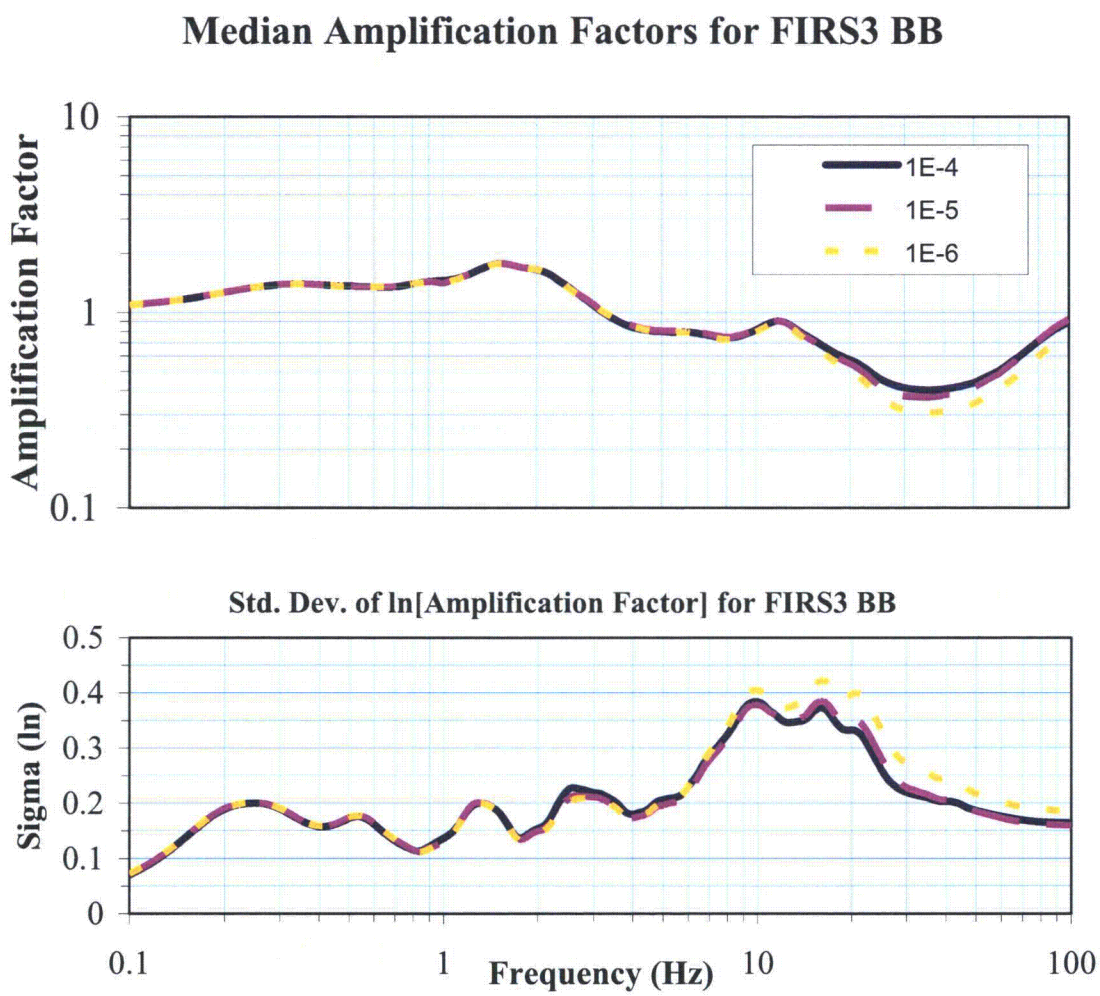


Figure 2.5.2-236 Median Amplification Factor and Logarithmic Standard Deviation of Amplication Factor for FIRS3, Using Broad-Banded (BB) Input Motion

RCOL2_02.05.02-16 S01

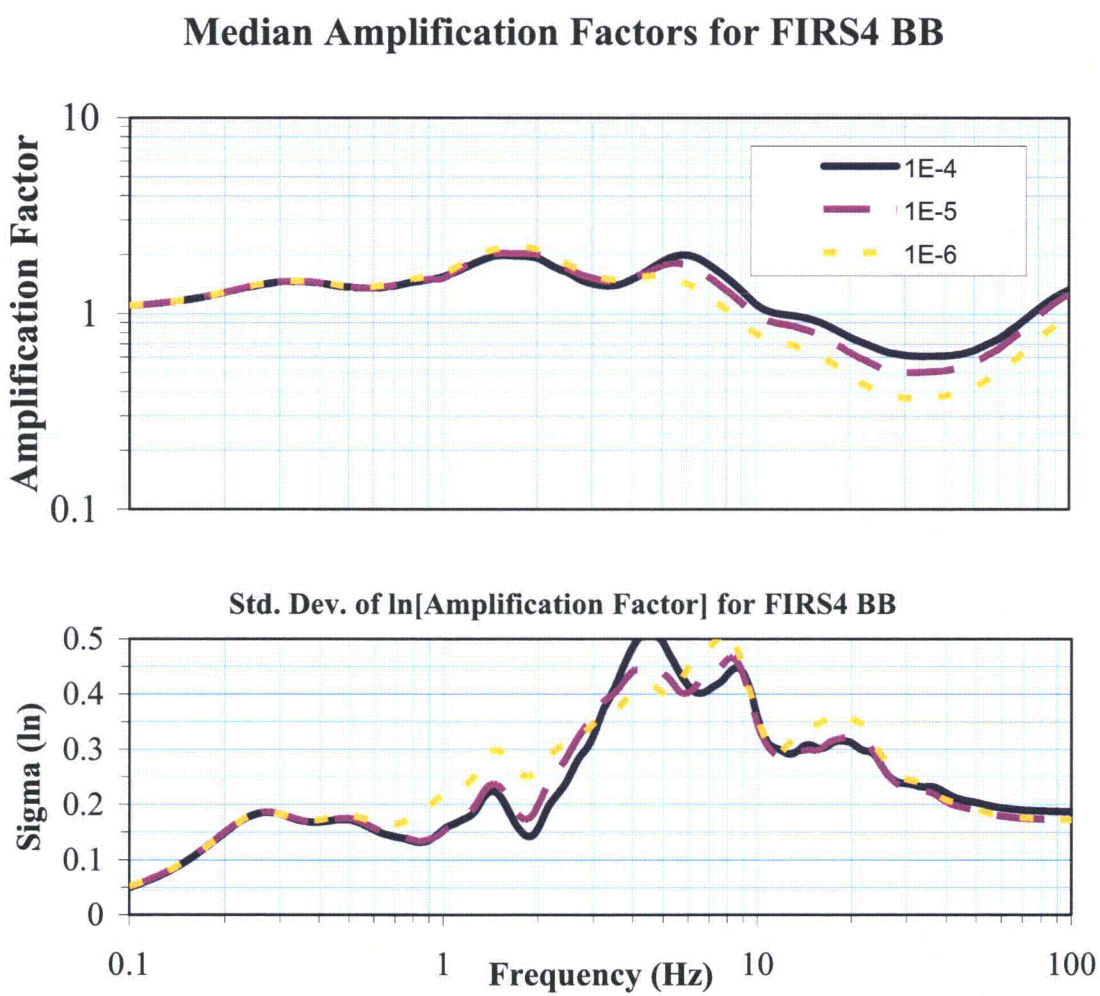


Figure 2.5.2-237 Median Amplification Factor and Logarithmic Standard Deviation of Amplication Factor for FIRS4, Using Broad-Banded (BB) Input Motion

RCOL2_02.05.02-16 S01

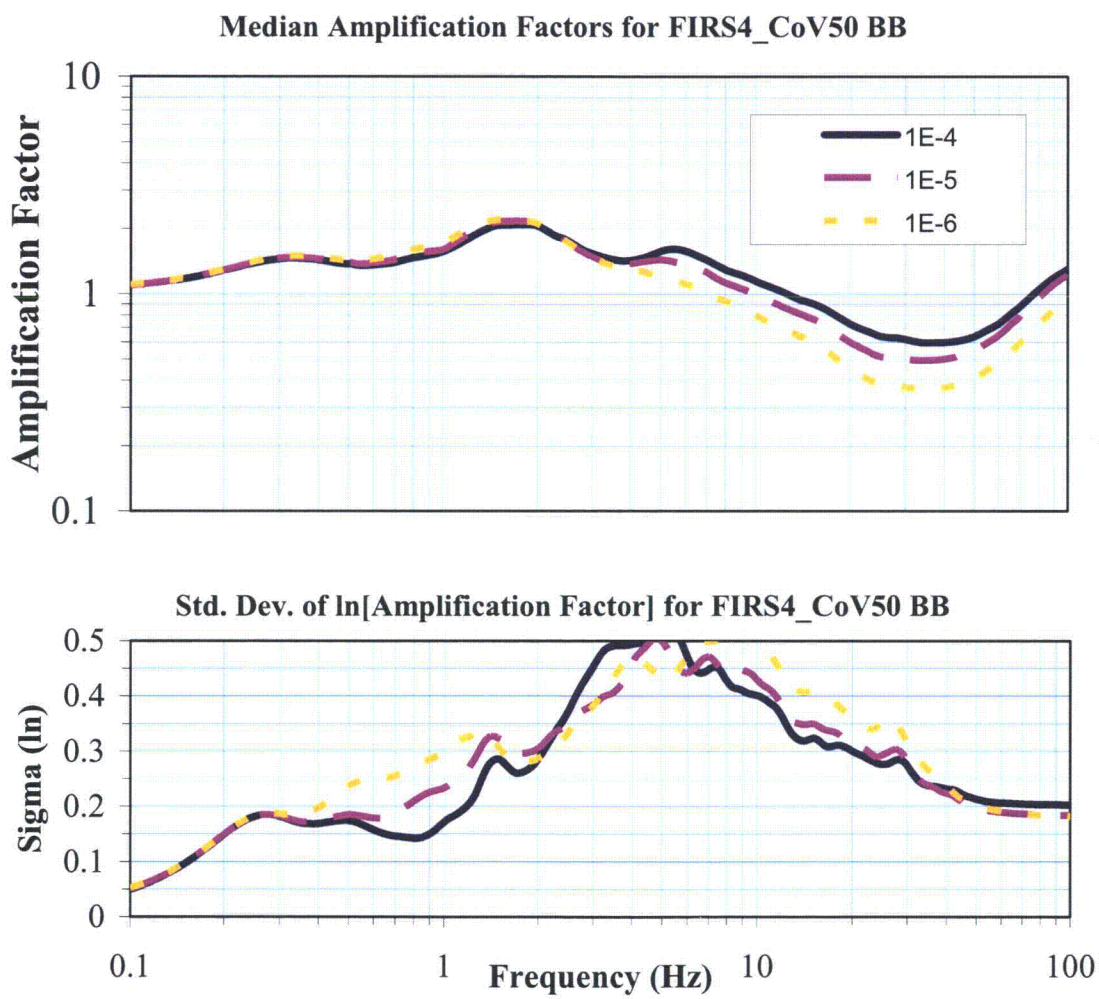


Figure 2.5.2-238 Median Amplification Factor and Logarithmic Standard Deviation of Amplication Factor for FIRS4_CoV50, Using Broad-Banded (BB) Input Motion

RCOL2_02.05.02-16 S01

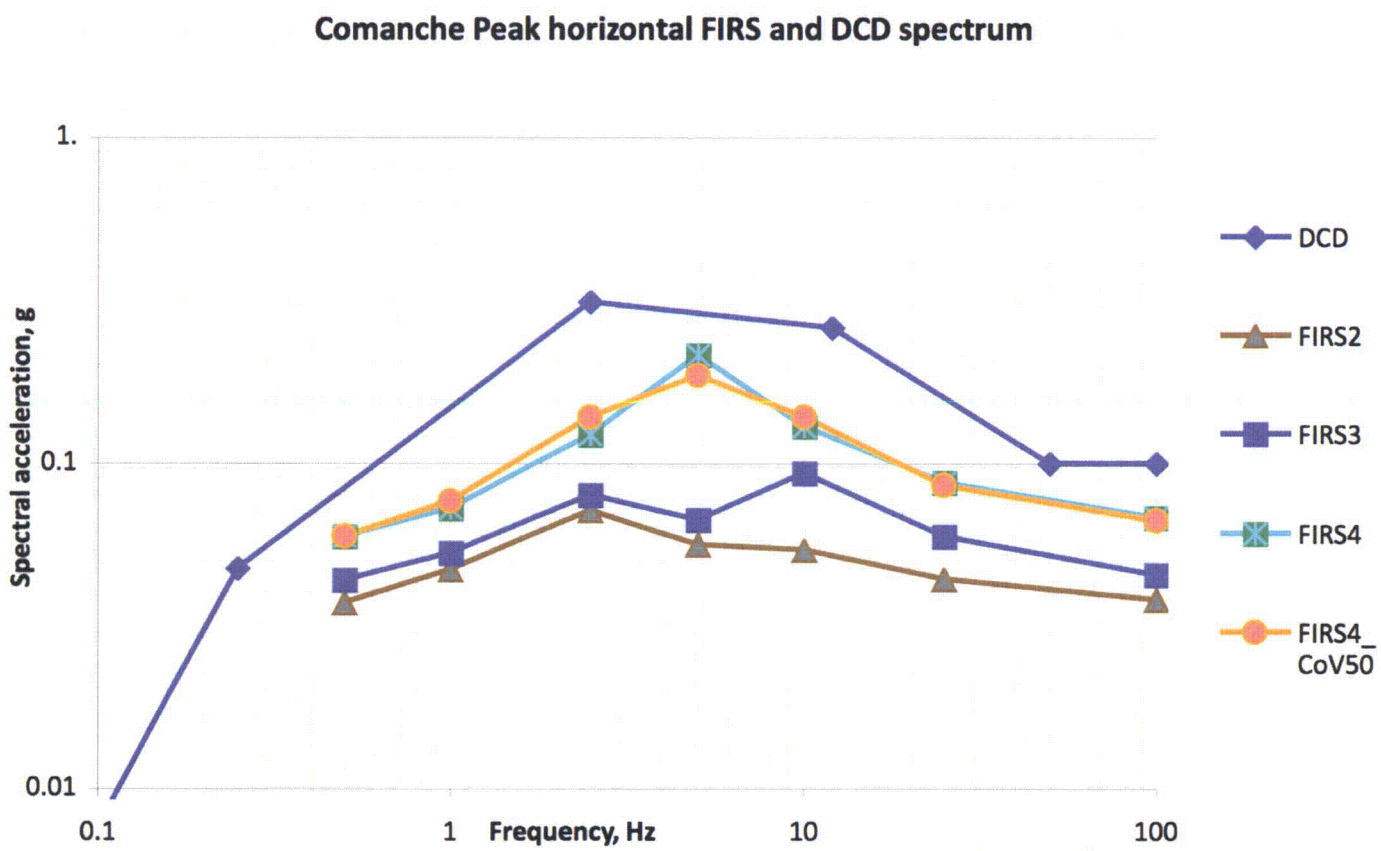


Figure 2.5.2-239 Comanche Peak Horizontal FIRS Compared to DCD Spectrum

RCOL2_02.05.02-16 S01

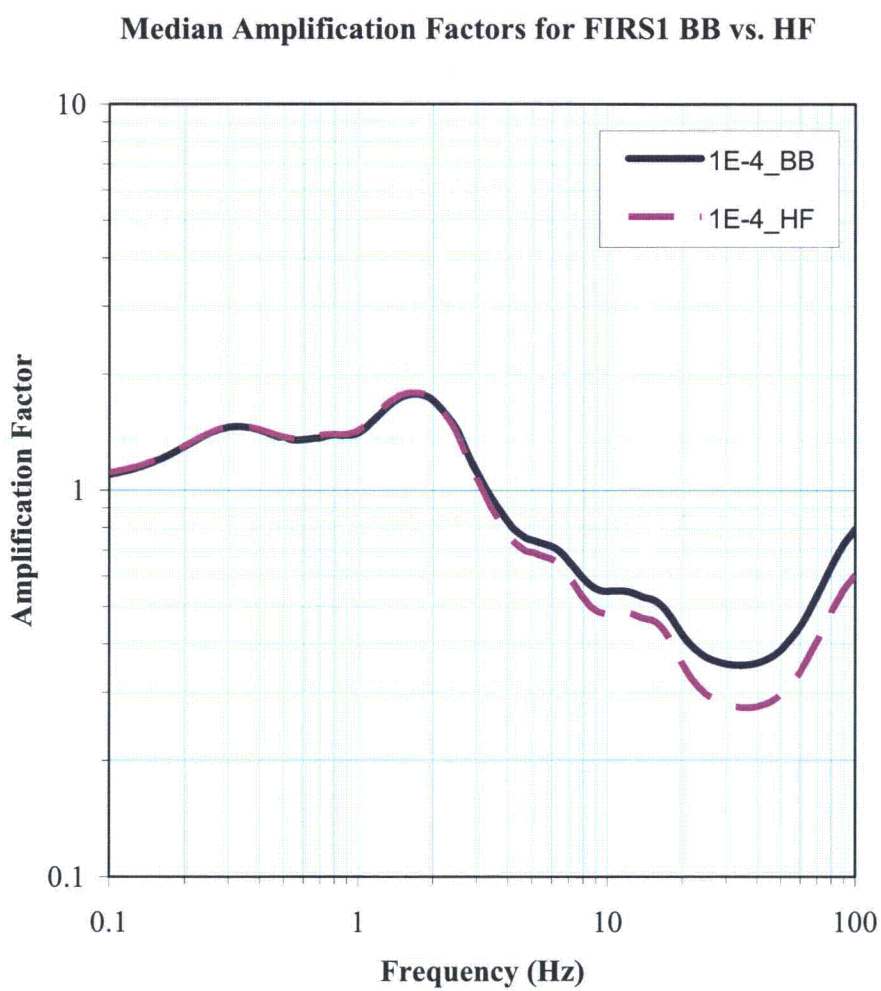


Figure 2.5.2-246 Comparison of Median Amplification Factors for GMRS/FIRS1 Site column: HF vs BB Inputs

RCOL2_02.05.02-16 S01

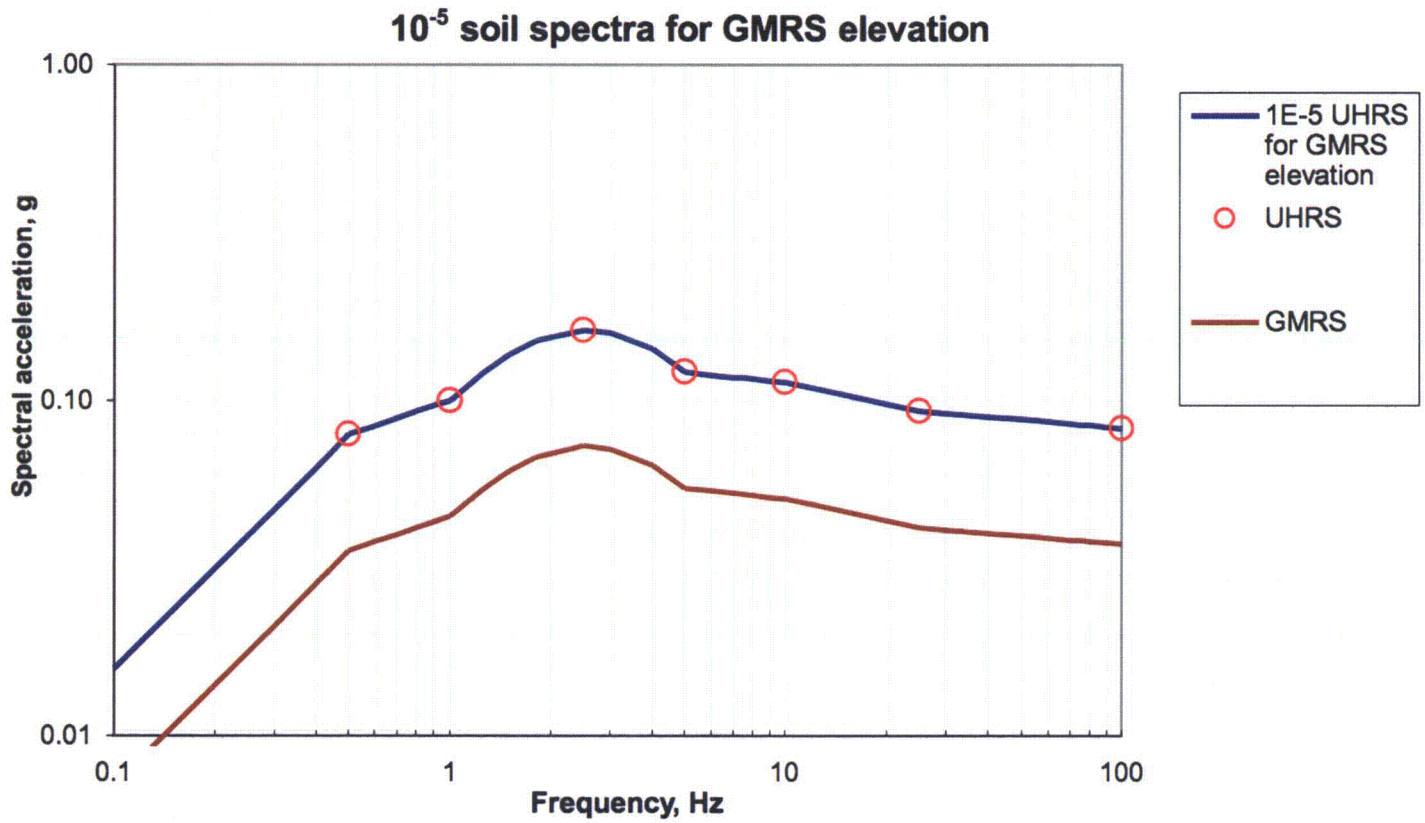


Figure 2.5.2-247 Comanche Peak 1E-5 UHRS (for GMRS Conditions) and GMRS, Horizontal and Vertical

RCOL2_02.05.02-16 S01

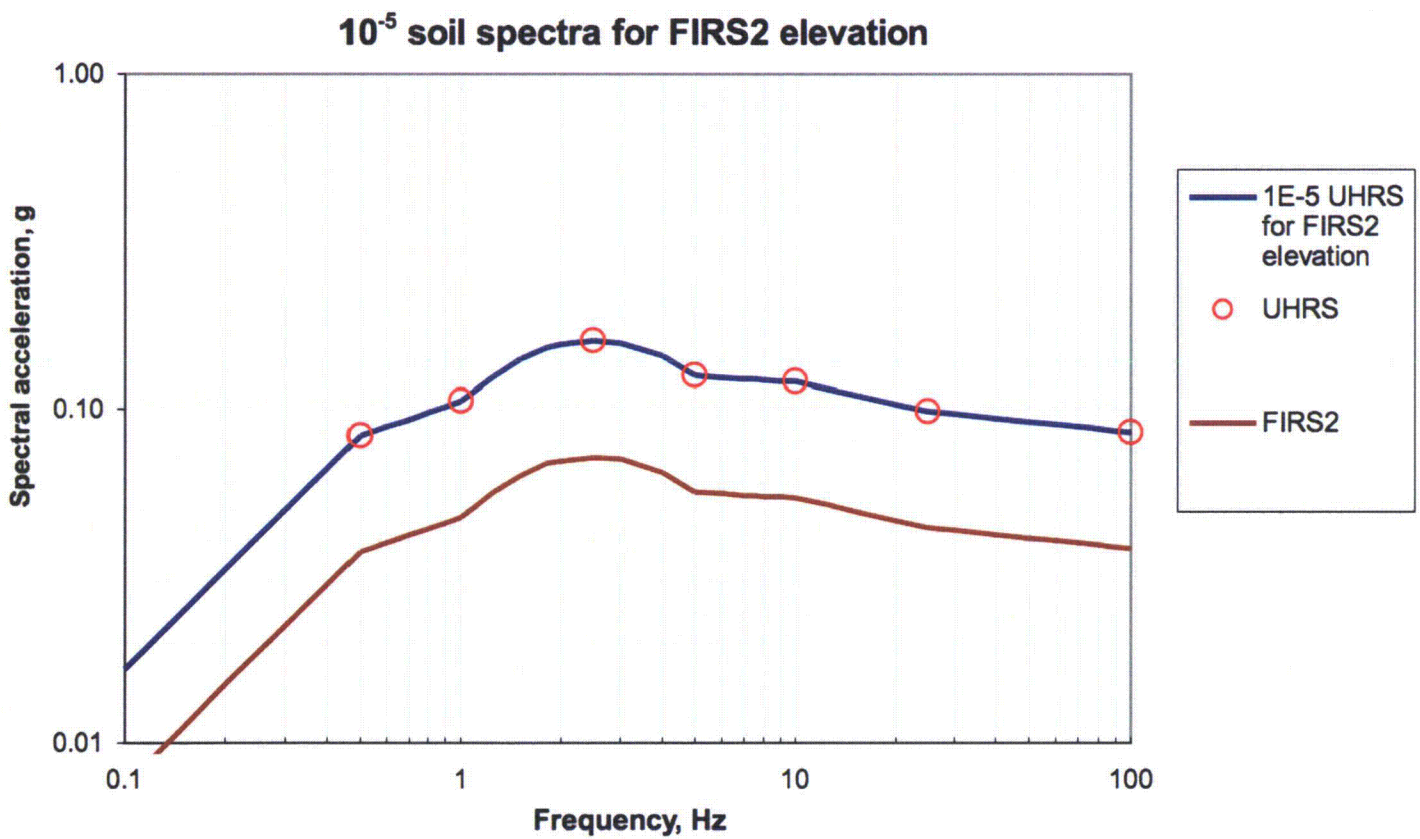


Figure 2.5.2-248 Comanche Peak 1E-5 UHRS (for FIRS2 Conditions) and FIRS2, Horizontal and Vertical

RCOL2_02.05.02-16 S01

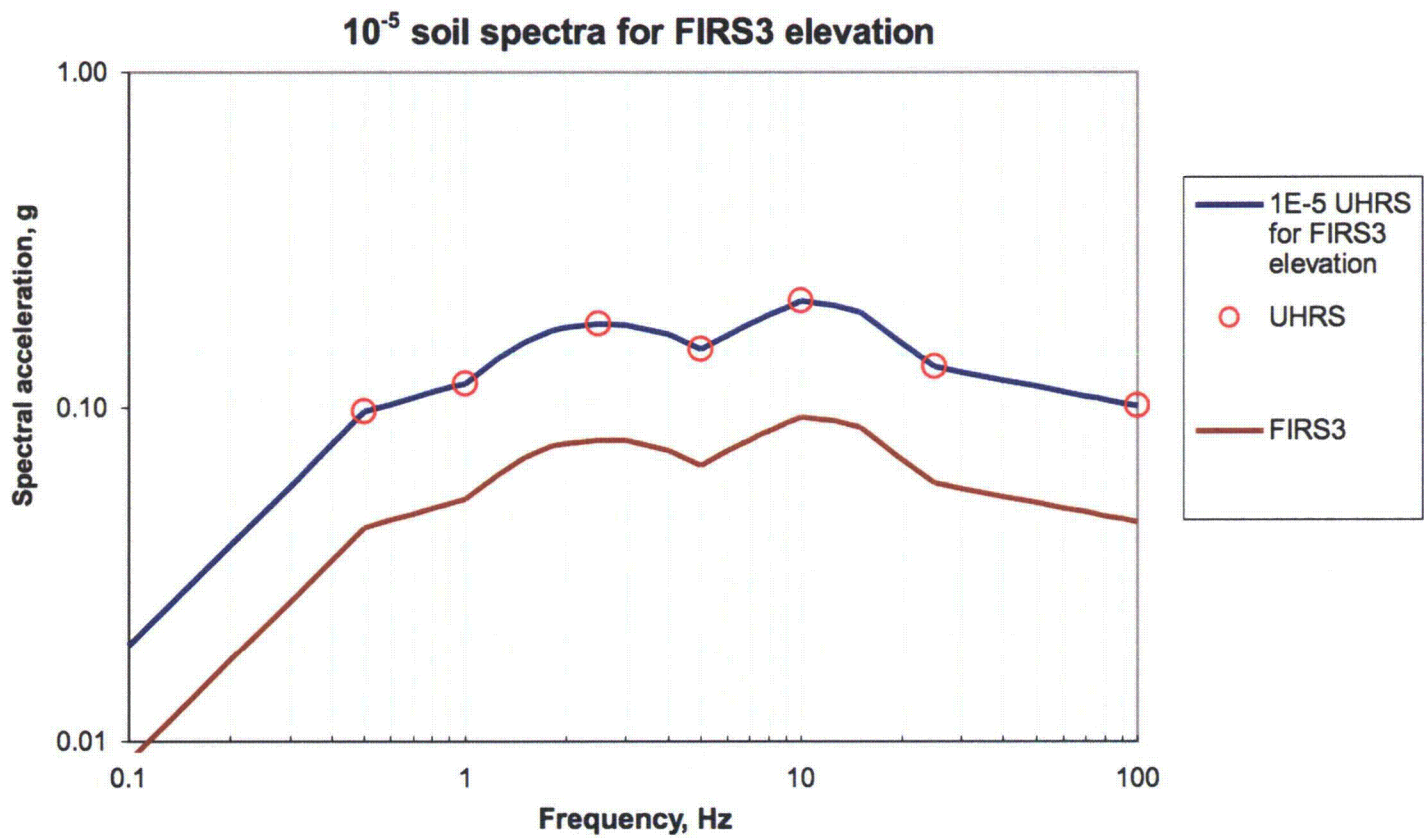


Figure 2.5.2-249 Comanche Peak 1E-5 UHRS (for FIRS3 Conditions) and FIRS3, Horizontal and Vertical

RCOL2_02.05.02-16 S01

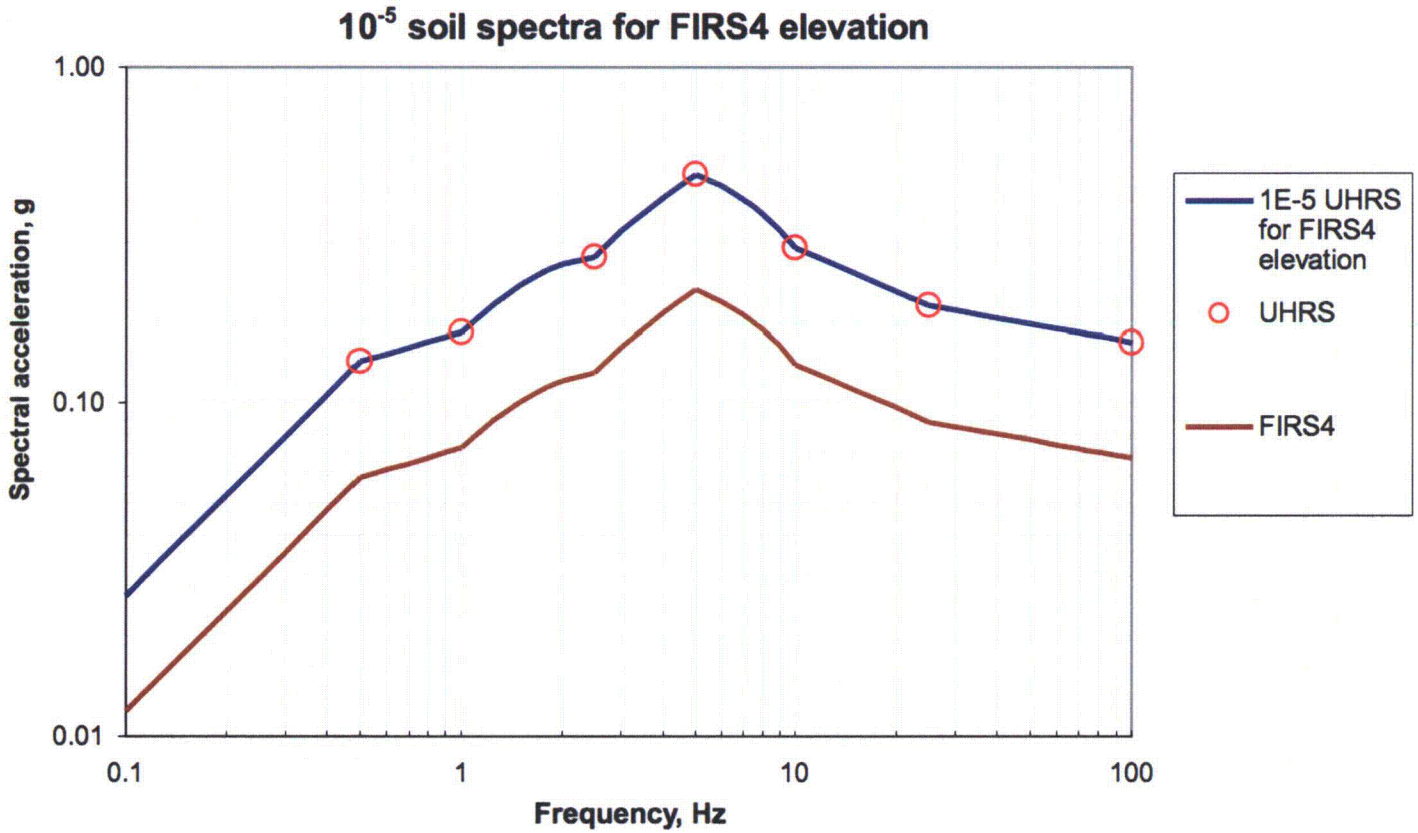


Figure 2.5.2-250 Comanche Peak 1E-5 UHRS (for FIRS4 Conditions) and FIRS4, Horizontal and Vertical

RCOL2_02.05.02-16 S01

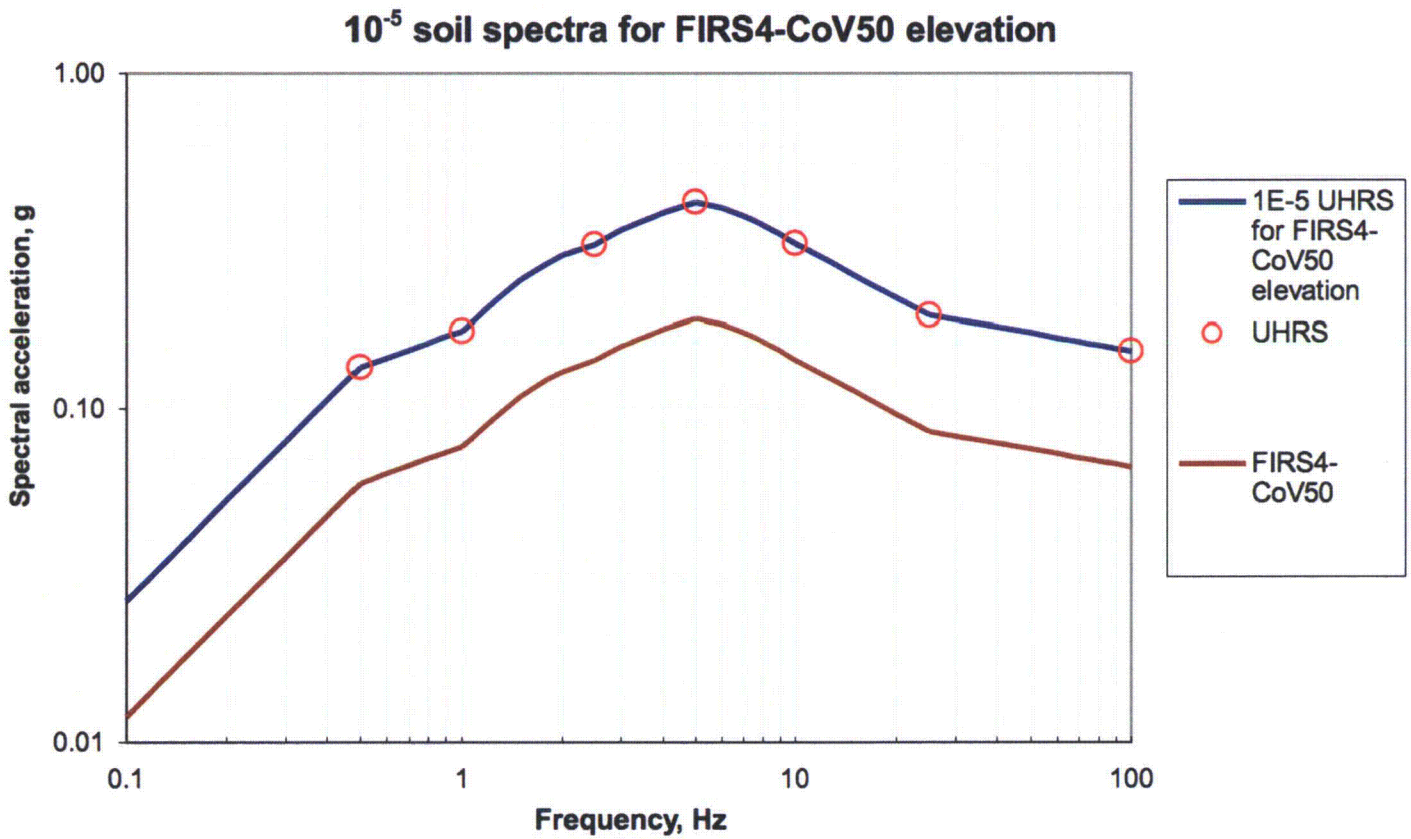
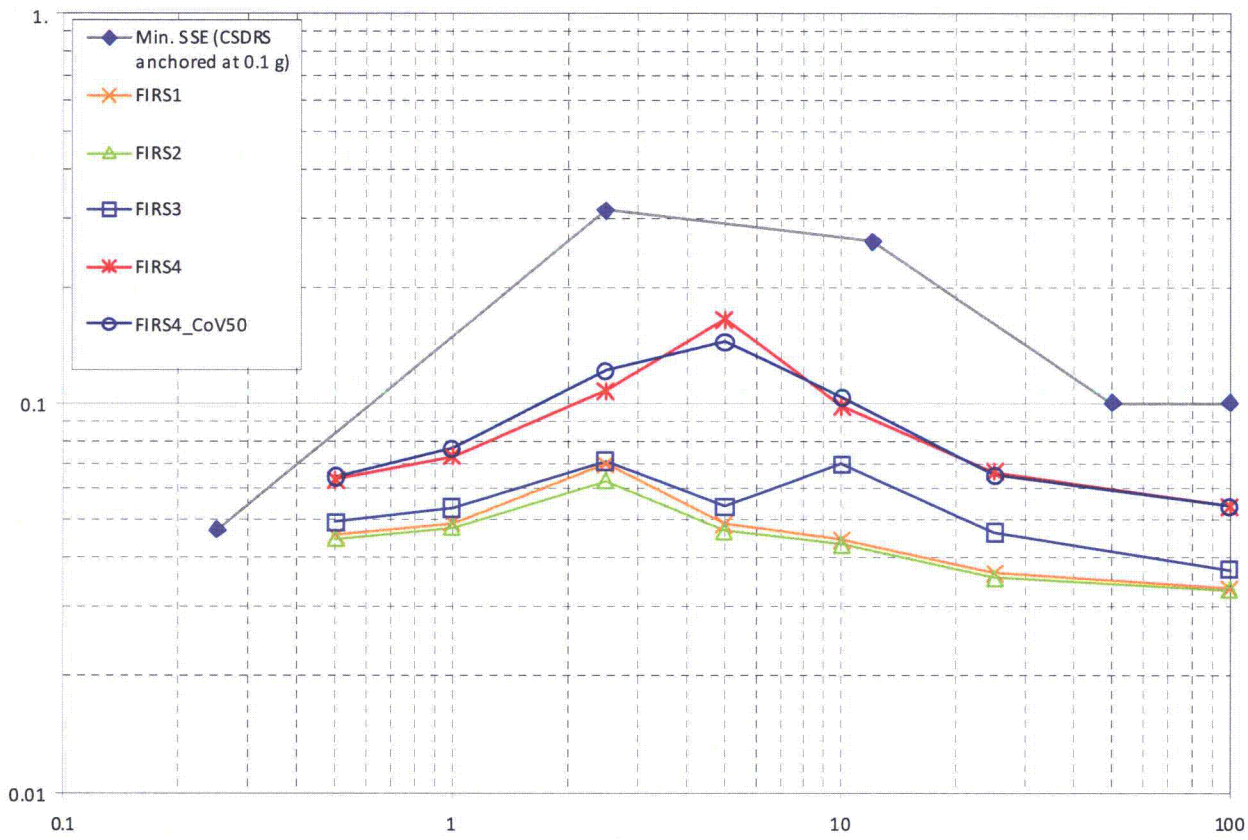


Figure 2.5.2-251 Comanche Peak 1E-5 UHRS (for FIRS4-CoV50 Conditions) and FIRS4-CoV50, Horizontal and Vertical



RCOL2_02.05.02-16

CP COL 3.7(5)
CP COL 3.7(6)

Figure 3.7-201 Nominal Horizontal GMRS and FIRS(1),(2) (Sheet 1 of 2)

SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

Comanche Peak, Units 3 and 4

Luminant Generation Company LLC

Docket Nos. 52-034 and 52-035

RAI NO.: 1889 (CP RAI #11)

SRP SECTION: 02.05.02 – VIBRATORY GROUND MOTION

QUESTIONS for Geosciences and Geotechnical Engineering Branch 1 (RGS1)

DATE OF RAI ISSUE: 7/1/2009

QUESTION NO.: 02.05.02-20

Please provide the following data in digital format

a. Smooth Rock UHRS values for annual exceedance frequencies of 10-4, 10-5, and 10-6

b. Geographic coordinates of all seismic source geometries used in the Comanche Peak PSHA study

c. Median Amplification Factors used in site response calculations for 10-4, 10-5, and 10-6 annual exceedance frequencies in digital format.

d. The shear wave velocity profile used in site response calculations in digital format.

e. Mean total hazard curves for 0.5, 1, 2.5, 5, 10, 25, and 100 Hz as well as the hazard curves of all individual seismic sources

f. Shear modulus and damping degradation curves shown in FSAR Figure 2.5.2-232

g. Soil UHRS curves electronically for 10-4, 10-5, and 10-6 annual exceedance frequencies

h. Updated earthquake catalog

ANSWER:

The revised digital files containing the requested material are being provided on CD (see attachments) in their native format.

Impact on R-COLA

None.

Impact on S-COLA

None.

Impact on DCD

None.

Attachments (on CD)

a. Smooth Rock UHRS values for annual exceedance frequencies of 10-4, 10-5, and 10-6

   File Name -ROCK_UHRS

b. Geographic coordinates of all seismic source geometries used in the Comanche Peak PSHA study

   File Name -SOURCE_GEOM

c. Median Amplification Factors used in site response calculations for 10-4, 10-5, and 10-6 annual exceedance frequencies in digital format.

   File Name -SITE_AMPLIF

d. The shear wave velocity profile used in site response calculations in digital format.

   File Name -VS_median_profile

   File Name -FIRS1_randomization_velstat.out

e. Mean total hazard curves for 0.5, 1, 2.5, 5, 10, 25, and 100 Hz as well as the hazard curves of all individual seismic sources

   File Name -MEAN_HAZ_CURVES

f. Shear modulus and damping degradation curves shown in FSAR Figure 2.5.2-232

   File Name -FSAR_figure_252-232

g. Soil UHRS curves electronically for 10-4, 10-5, and 10-6 annual exceedance frequencies

   File Name -SOIL_UHRS

h. Updated earthquake catalog

   File Name -CATALOG_UPDATE