SIERRA GEOPHYSICS
Consulting • Software • Research

84TH PERCENTILE VERTICAL RESPONSE SPECTRUM
SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1

SUBMITTED TO:

SOUTHERN CALIFORNIA EDISON
2244 WALNUT GROVE AVENUE
ROSEMEAD, CALIFORNIA 91370

JANUARY, 1984

SGI-R-84-103

15446 Bell-Red Road • Suite 400 • Redmond, (Seattle) WA 98052 • (206) 881-8833 • Telex: 152437

TABLE OF CONTENTS

1.0 INTRODUCTION

The two-thirds vertical to horizontal ratio of peak ground acceleration (PGA) adopted for design of SONGS was based upon data from many historic earthquakes. Since the adoption of the design and construction of SONGS I the data base of near-field strong ground motion accelerograms has increased significantly. The goal of this study is to review the more recent data and the associated investigations by previous investigators in order to assess the adequacy of the SONGS I vertical seismic design basis.

A recent major earthquake to raise a serious question regarding the adequacy of the 2/3 ratio was the 1979, M = 6.9, Imperial Valley earthquake. As is well known, this event was a major strike-slip earthquake occurring in a deep, alluviated basin. Initial modeling studies of the earthquake (Helmberger and Hadley, 1979; Del Mar Technical Associates, 1980; Archuleta, 1982) suggests that the high vertical accelerations resulted from P-waves excited by faulting within the thick sedimentary sequence, producing caustic phases PP, PPP and so on. This interpretation seemed to be well supported by the seismic refraction studies of Fuis and others, (1982), where the phases PP and PPP were clearly observed along profiles within the valley. It is important to note that the caustic P-wave interpretation, as pointed out by Archuleta (1982), did not fully explain the observations. Two problems persisted: (1) As the P-phases PP and PPP travel in the lower velocity shallow layers of the earth, these phases should arrive at the accelerograph slightly later than observed; and (2) the amplitude of the P-waves seemed to be largest along the fault, where the P-wave radiation pattern would suggest a null. Because of the expected heterogeneity of faulting, at length scales commensurate with the very high frequencies associated with the large amplitude vertical accelerations (LAVA's), the second problem was not viewed as too serious. However, the first problem is more critical and, in part, promoted additional research into the origin of the LAVA's.

The more recent studies of accelerograms from the Imperial Valley have found that the arrival time of the LAVA's (problem 1 above) require a seismic source below the sedimentary basin, located in the higher velocity basement rocks (see for example: Liu, 1983; Archuleta, 1984). This conclusion vitiates the caustic P-phase model and focuses attention on the effects of velocity structure and attenuation on P- and S- wave amplitudes and frequency content. As the seismic energy leaves the source and propagates towards the surface, several competing phenomena alter the amplitude and spectra of the radiated energy. Of principal interest in this study are the effects of impedance amplification associated with the lower velocity surficial sediments and anelastic attenuation between the source and the surface. Impedance amplification clearly increases amplitudes with decreasing near-surface velocity, while attenuation, or Q^{-1} (which is well correlated with velocity), decreases amplitudes. The studies of Campbell (1981) and Joyner and Boore (1981) show that for peak acceleration for the horizontal component (i.e., S-waves), the two competing effects nearly cancel: soil and rock sites record essentially the same PGA. Comparable, detailed studies for the P-wave amplitudes have not been previously completed. Within this study we present both modeling and empirical results that clearly show, for P-waves, the effects of impedance amplification dominate over anelastic attenuation. Stated another way, we show that the vertical to horizontal ratio of PGA is site dependent.

To achieve the goal of this study we have constructed an 84th percentile SONGS site specific vertical response spectrum. The development of this spectrum is facilitated by decomposing the problem into two parts: (1) development of an 84th percentile PGA value; and (2) development of a spectral shape. As is well known, the response spectral shape, particularly at the longer periods, is very dependent upon site conditions. The above discussion indicates that this site dependent character extends to zero period for the vertical component. The correct shape of the response spectra could be derived from a regression analysis over magnitude, distance and site conditions. Similar studies have been done for San Onofre for the horizontal response spectra. However, the available data set for vertical motions is somewhat more restricted. In considering the data base, we concluded that a different approach would make more use of both empirical and modeling results and would produce a more stable and defendable result.

The approach used to develop the vertical spectral shape is based upon first developing a site specific spectral ratio between the vertical and horizontal components and then using this ratio to convert the existing SONGS I horizontal empirical spectrum to a vertical spectrum. This approach has two advantages over the standard regression analysis. First, the spectral ratio minimizes the effects of source characteristics. This eliminates a major source of "noise" in the empirical data in a study aimed at quantifying site effects. In addition, the ratio, by reducing the effects of the source, largely reduces the impact of source assumptions in modeling studies, focusing attention on site effects. The second major benefit accrues from the ability to draw upon the much more extensive studies that quantify shape and uncertainty for the SONGS I horizontal spectrum. By transforming the horizontal spectrum with the derived spectral ratio, the previous experience and reliability are carried into the final vertical spectral shape.

The following sections describe the development of a SONGS site specific (M = 7, distance = 8 km) 84th percentile PGA (Section 2), the development of the vertical to horizontal spectral ratios (Section 3), and the final comparison of the derived vertical 84th percentile spectrum with the Housner design basis spectrum (Section 4). The last section concludes that the Housner design basis spectrum envelopes, at all periods, the derived vertical response spectrum.

2.0 DEVELOPMENT OF A SITE-SPECIFIC VERTICAL PGA

Within this section we review and develop seven different approaches for estimating an 84th percentile vertical PGA value for SONGS. Table 2.1 summarizes each approach and shows the ensemble average value of 0.28g for the 84th percentile.

2.1 CAMPBELL

Campbell (1982) presented a preliminary regression study of vertical accelerations. The limited data base and the depth of the study greatly restricted the conclusions regarding site effects:

> "The results have not as yet been carefully reviewed with respect to the effects that various earthquake or site parameters may have on the results, except for fault type. Therefore, it is not known whether these parameters will affect the computed ratios." (Campbell, 1982)

Within this study we examine in more detail the three most significant strike-slip events considered by Campbell (Parkfield, Coyote Lake and Imperial Valley, 1979). In total, the records from these three events comprise 67% of Campbell's entire data base for magnitudes greater than 5.5 and 90% of the strike-slip, $M \geqq 5.5$ data base. We conclude that both the available PGA data and the results from recent modeling studies show that site conditions significantly affect vertical acceleration. Recognizing that Campbell's vertical PGA regression equation does not account for site conditions, Table 2.1 (Item 1) shows Campbell's 84th Percentile value of 0.43g.

2.2 IV79 VERTICAL/HORIZONTAL

The 1979 Imperial Valley earthquake produced some of the highest vertical/horizontal ratios of PGA observed to date. At a distance of 8 km from the fault the mean observed ratio was 0.74, (see Figures 2-3 and 2-4, Supplement III, Del Mar Technical Associates, 1980),

TABLE 2.1

SONGS - UNIT 1

MULTI-METHOD APPROACH TO 84th PERCENTILE PGA
VERTICAL

1. CAMPBELL = 0.43g

2. [IV79 RATIO VERTICAL/HORIZONTAL] X
[SONGS 84TH HORIZONTAL] X

[0.74] X [0.50] = 0.37

3. [CAMPBELL - 84TH VERT] X
[EUSGCS2/EUSGCS3 - (NUREG/CR-3102)]

[0.43] X [0.67] = 0.28

4. [IV79 84TH VERTICAL] X
[EUSGCS2/EUSGCS3 - (NUREG/CR-3102)] X
[PGA M = 7.0/PGA M = 6.9]

[0.37] X [0.67] X [1.08] = 0.26

5. A) [SUPPLEMENT I] X [1σ]
[.11] X [1.5] = 0.17

B) [(SUPPLEMENT I + III)/2] X [1σ]
[(.11 + .18)/2] X [1.5] = 0.21

AVERAGE - A & B = 0.19

6. [SUPPLEMENT III VERT/HORIZ] X
[SONGS 84TH HORIZONTAL]

[0.57] X [0.50] = 0.28

7. [PARKFIELD - STA. 2, 5, 8, 12 & TEMBLOR - VERT/HORIZ] X
[SONGS 84TH HORIZONTAL]

[0.42] X [0.50] = 0.21

AVERAGE = 0.28

slightly higher than the 0.67 ratio used for design. Multiplication of this ratio by the 84th PGA horizontal value of 0.50g for SONGS results in a second estimate for the vertical component of 0.37g. It is important to note that this value is somewhat lower than the Campbell value even though it is derived with a vertical to horizontal ratio recorded in a very soft site environment.

2.3 CORRECTED CAMPBELL

A recent study by Apsel and others (1983), simulated over 5,000 components of motion, forming a basic parameter study over site conditions, fault type, depth and distance. Although the velocity models employed in this parameter study were generic, the near surface conditions of two models closely match the observed conditions at San Onofre and the Imperial Valley. Model EUSGCS3 ("Soft Soil") has a surface S-wave velocity of 200 m/sec extending to a depth of 50m. The El Centro accelerograph station measurements by Shannon and Wilson (1975) show an average shear wave velocity of about 210 m/s extending to a depth of about 35 m. Similarly, Model EUSGCS2 ("Average Soil") has a surface velocity of 850 m/s compared with 620 m/s for SONGS (Table 5-1, Del Mar Technical Associates, 1978). Drawing upon the results of Apsel and others, (1983), the simulated values of vertical PGA for these two earth models are shown on Figure 2.1. The two linear lines on the figure show the average attenuation of PGA for the soft soil (upper line) and average soil (lower line). At 8 Km the ratio between the average soil and the soft soil PGA is 0.67. As Campbell's study is dominated by data from soft soil site conditions, this ratio can be used to approximately correct Campbell's vertical PGA value (Section 2.1) for site conditions. Table 2.1 (Item 3) shows the corrected value of 0.28g.

2.4 IV79 CORRECTED FOR SITE CONDITIONS AND MAGNITUDE

The 84th percentile PGA value for IV79, at 8 Km, was 0.37g (Figure 2-4, Supplement III, Del Mar Technical Associates, 1980). Using the magnitude scaling of Campbell to correct for magnitude (M6.9

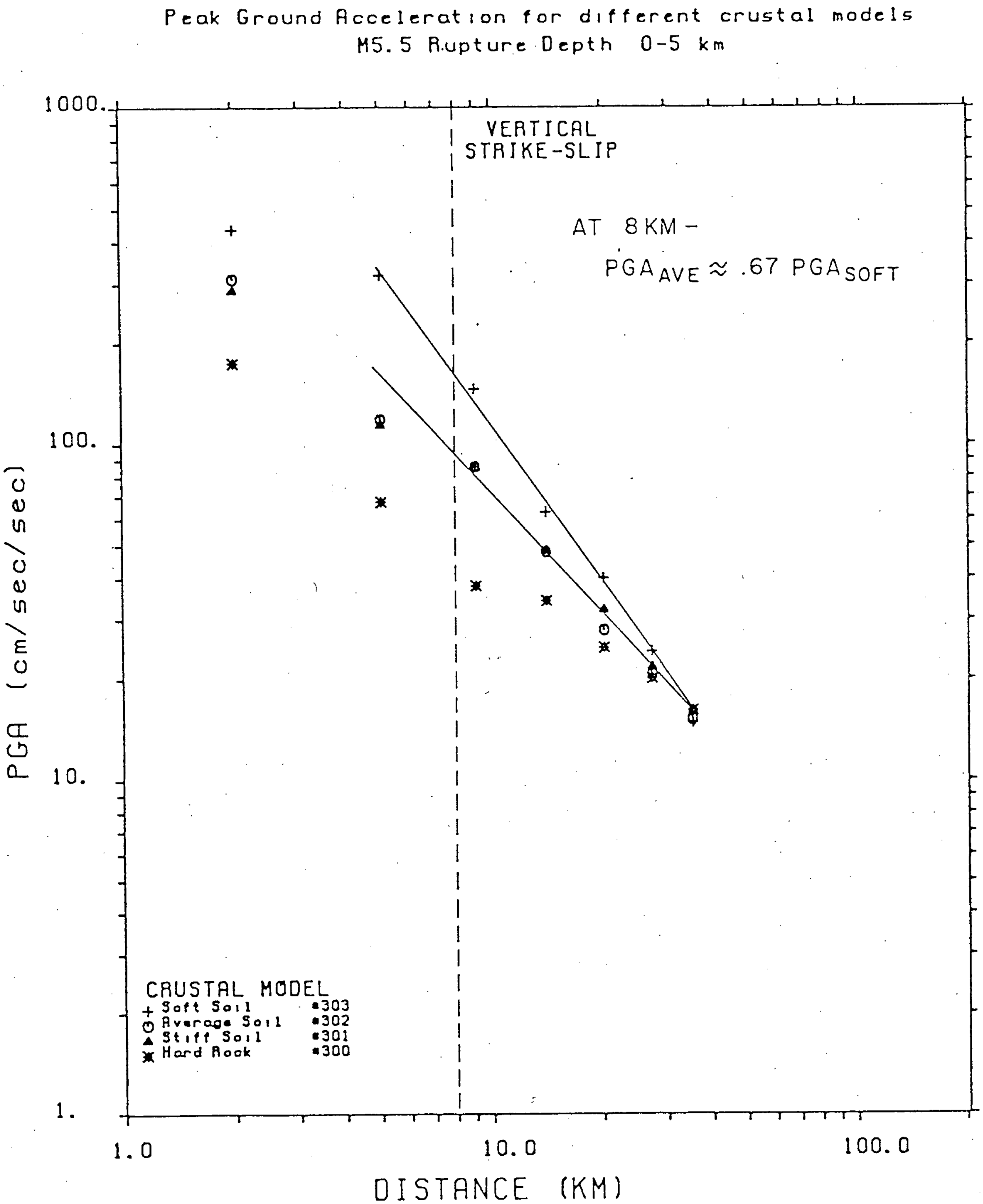

Figure 2.1. Simulated PGA for four soil profiles. Data from Apsel and others (1983).

versus M7.0) increases the observed value by 8%. Correcting for the difference in site conditions between Imperial Valley and San Onofre, i.e., multiplication by 0.67, (see Section 2.3), results in an estimated 84th percentile PGA for SONGS of 0.26g.

2.5 DELTA MODELING STUDIES

Over the course of previous reviews of San Onofre, Southern California Edison, NRC staff and associated consultants have generally agreed that the spectra presented in the Del Mar Technical Associates (Delta) studies represent good estimates of the mean spectra. NRC staff have suggested that reasonable 84th percentile spectra be computed by multiplying the mean spectra by 1.5 (1σ). Table 2.1 (Item 5A) lists the simple calculations for the values from Supplement I (i.e., the preferred value). Following staff's suggestion, Table 2.1- (Item 5B) also presents the calculations for the average of the results from Supplement I and Supplement III. In order to avoid bias towards the modeling results in the final average PGA value, only the average of 5A and 5B is included in the right hand column of Table 2.1.

2.6 HYBRID MIX OF MODELING AND OBSERVATION

Of the various modeling studies carried out by Delta, the work described in Supplement III (1980) resulted in a refinement in the modeling capability for vertical accelerations. This resulted from the direct efforts to model the 1979 Imperial Valley earthquake. The resulting modeling capability was next exercised with the magnitude and site conditions at San Onofre. It is important to note that the model was not recalibrated against the other earthquakes discussed in Supplement I. Hence, although the results of Supplement III represent a refinement in the modeling process, the results of Supplement I are best calibrated against observation. However, the possible bias in the absolute spectra from Supplement III can be largely avoided if we consider the ratio of the simulated vertical to horizontal spectra. This ratio minimizes uncertainties in the source rupture process (i.e., calibration) while still using the most refined modeling capability exercised with the San Onofre site conditions.

The Supplement III vertical to horizontal PGA ratio for SONGS is 0.57. Multiplication by the 84th percentile horizontal PGA of 0.50g results in a value of 0.28g.

2.7 PARKFIELD VERTICAL TO HORIZONTAL RATIO

The Parkfield earthquake is the largest strike-slip event (M_S = 6.4) recorded under site conditions most similar to San Onofre. A comparison of site conditions is found in Del Mar Technical Associates (1978). For Stations 2, 5, 8, 12 and Temblor, the average vertical to horizontal PGA ratio is 0.42. Multiplication of this ratio by the 84th percentile horizontal PGA value of 0.50g results in an estimated value of 0.21g for the vertical component.

2.8 COYOTE LAKE EARTHQUAKE

The M_L = 5.9, 1979 Coyote Lake earthquake was recorded by six accelerographs located in the nearfield. Three of the stations (Gilroy Array 1, 6, and San Martin) were located on Franciscan rocks. The remaining three stations were located on soft alluvium (Gilroy Array 2, 3, and 4). Refraction profiles through the region are discussed by Mooney and Luetgert (1982) and the shallow velocity structure at the soft sites is discussed by Joyner and others (1981). The average shear wave velocity in the top 40 m for the soft sites is about 300 m/s. The observed ratio for the vertical to horizontal PGA for the Franciscan sites are 0.52, 0.45 and 0.70 (average 0.55), whereas the ratios for the three soft soil sites are 0.81, 0.58, 1.80 (average 0.95). Assuming that the horizontal value is insensitive to soil conditions (see above), this limited data base implies that the vertical component of motion on a rock site is about 60% of that recorded on the soil site. This is in good agreement with the modeling results discussed in Section 2.3 above and strongly supports the conclusion that the vertical to horizontal PGA ratio is site dependent.

3.0 DEVELOPMENT OF A SITE SPECIFIC VERTICAL TO HORIZONTAL SPECTRAL RATIO

It is well recognized that response spectra at longer periods are site dependent. In addition, the results from Section 2 above strongly support the conclusion that the site dependent character of the vertical response spectra extends to zero period. Within this section we examine the character of the vertical to horizontal response spectral ratio, for 2 percent damping, as a function of site condition. The empirical data are drawn from the 1979 Imperial Valley and the Coyote Lake earthquakes. Finally these empirical results are compared with the spectral ratio computed from the simulations discussed in Supplement III of Del Mar Technical Associates (1980). These comparisons result in a final site-specific curve that quantifies the vertical to horizontal spectral ratio.

Figure 3.1 shows the average horizontal spectra for seven stations that recorded the 1979 Imperial Valley earthquake. Each spectrum represents the average of the two horizontal components. The distance from the fault trace ranges from 6 to 13 km, i.e., the most relevant distance range for SONGS. The heavy solid line represents the mean of all 14 components of motion. Figure 3.2 presents the corresponding vertical response. Figure 3.3 summarizes the average spectral shape for the two components, normalized at a period of 0.04 sec to unity, and the vertical to horizontal spectral ratio. Note that the spectral ratio shows a dramatic dynamic amplification of 60-70% over the period range 0.04-0.15 sec. Figure 3.4 shows the corresponding spectral shapes and ratio for the six stations in the distance range 0-6 km. Comparison of Figures 3.3 and 3.4 show that this dynamic amplification is more severe for the vertical component, period range 0.05-0.1 sec, for the stations located at the greater distance from the fault.

Data from the 1979 Coyote Lake earthquake provide a second example of the general character of the vertical to horizontal response spectral ratio. Figure 3.5 shows the response for the Gilroy array stations 2, 3, and 4. As discussed in Section 2.8, these three stations

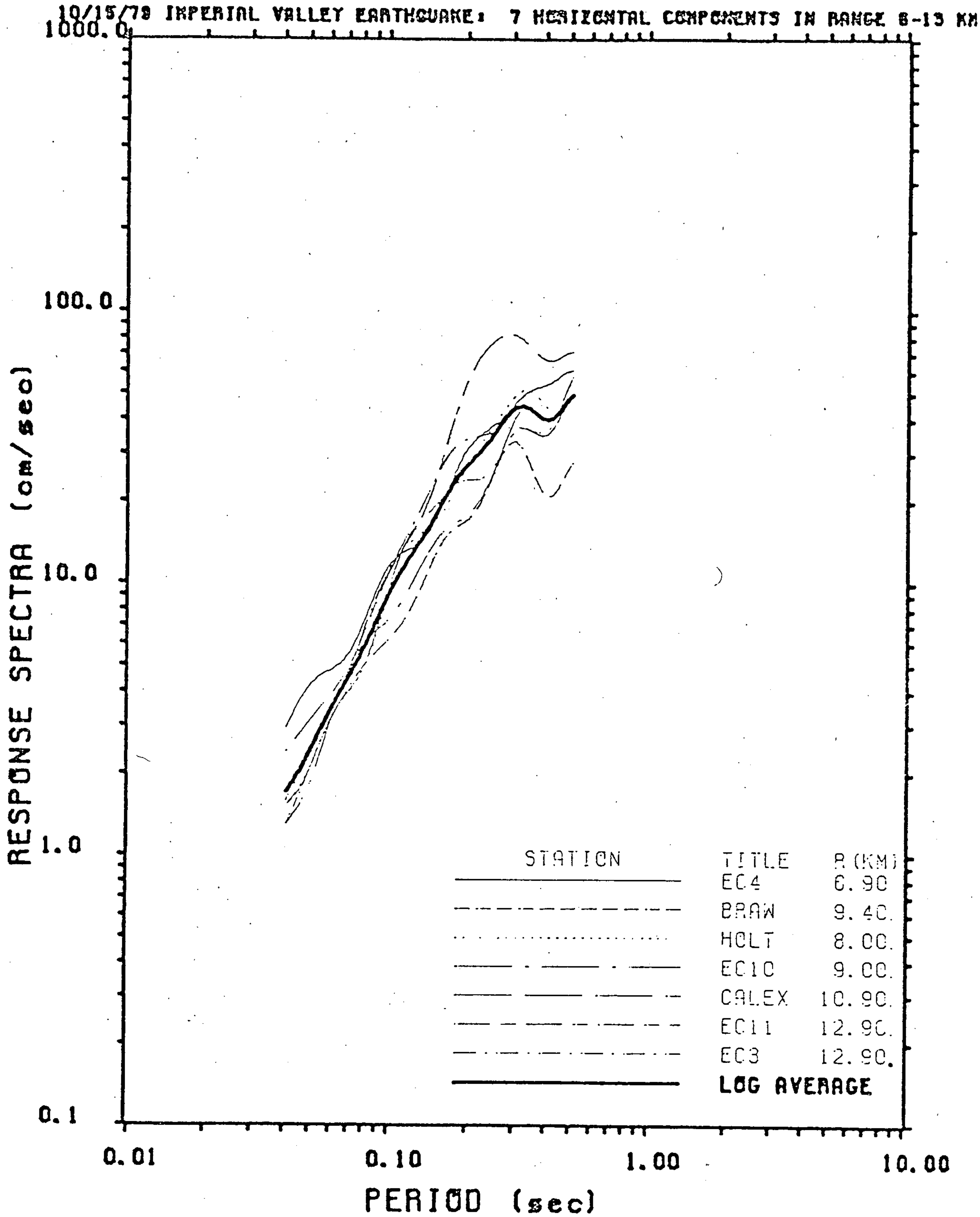

Figure 3.1. Average horizontal response spectra, distance range 6-13 km, Imperial Valley 1979 earthquake.

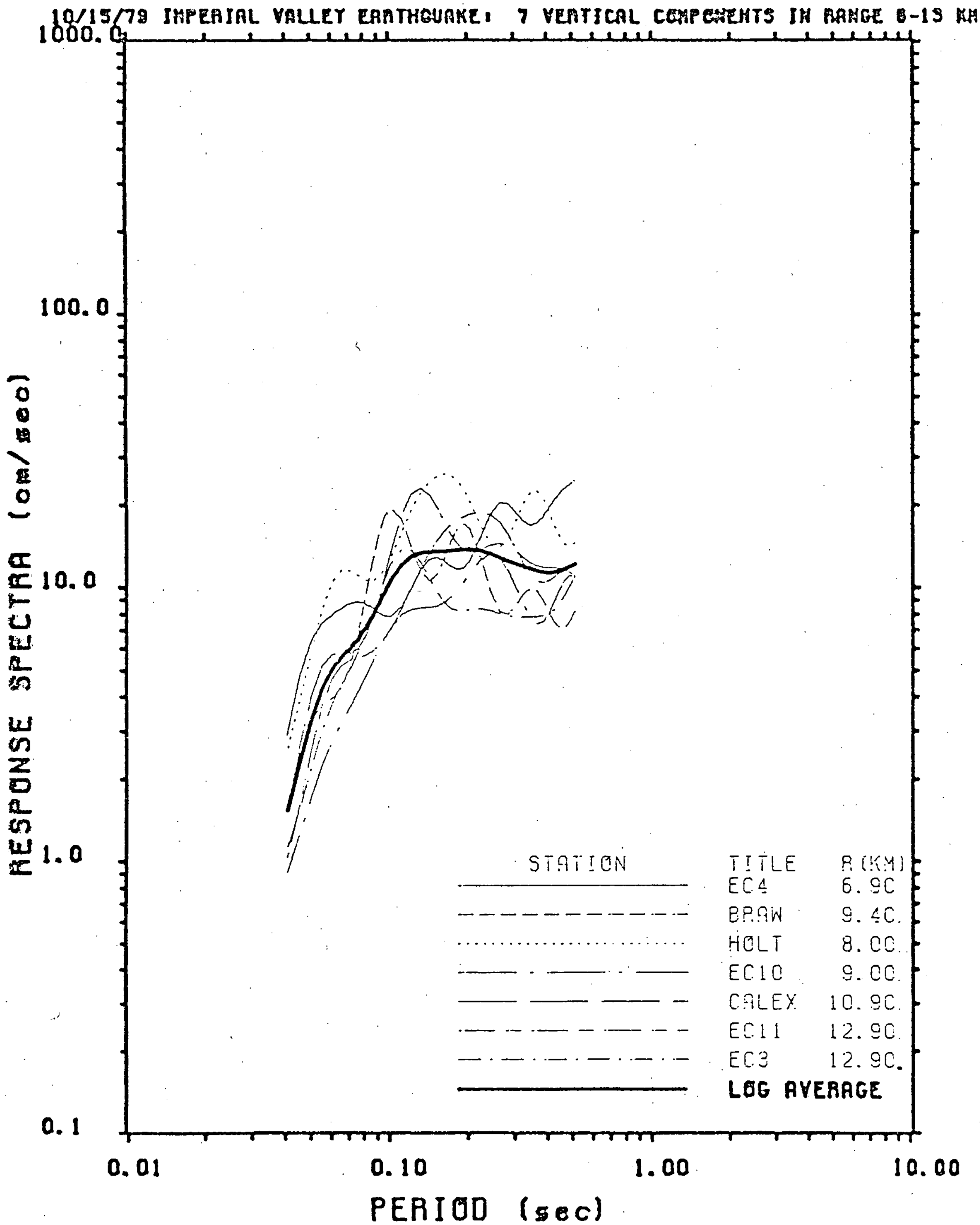

Figure 3.2. Average vertical response spectra, distance range 6-13 km, Imperial Valley 1979 earthquake.

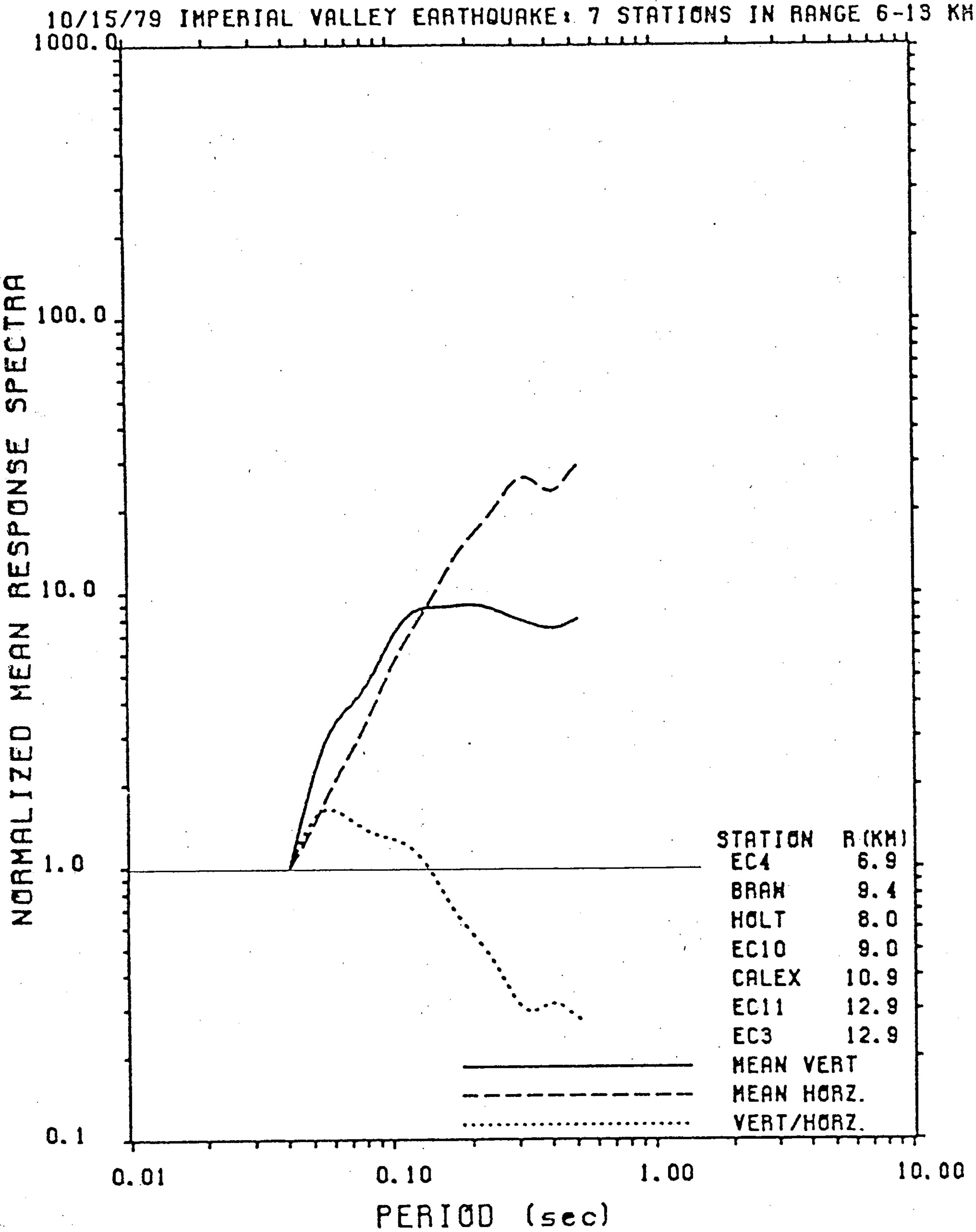

Figure 3.3. Normalized average horizontal and vertical response spectral shape and response ratio, distance range 6-13 km, Imperial Valley 1979 earthquake.

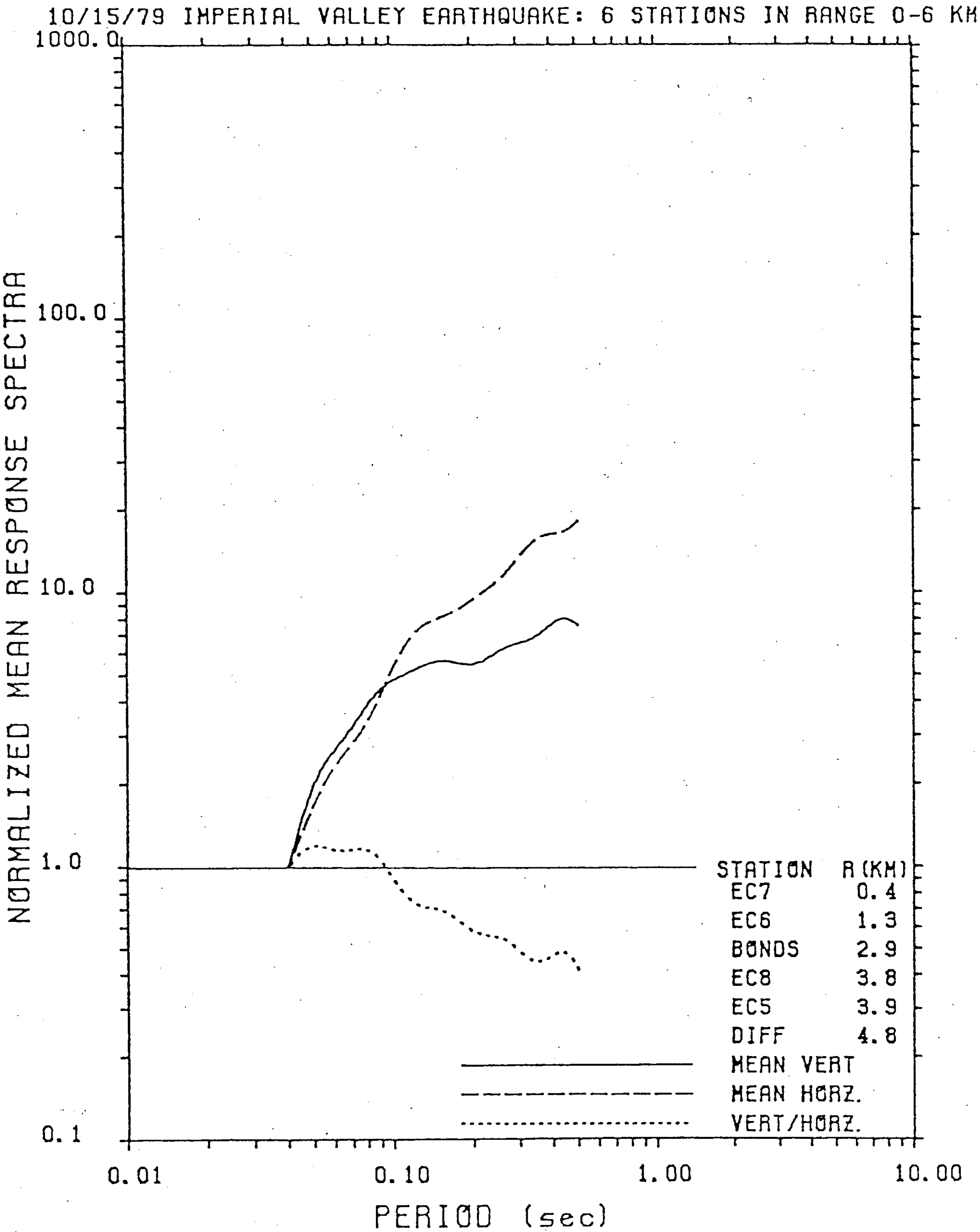

Figure 3.4. Normalized average horizontal and vertical response spectral shape and response ratio, distance range 0-6 km, Imperial Valley 1979 earthquake.

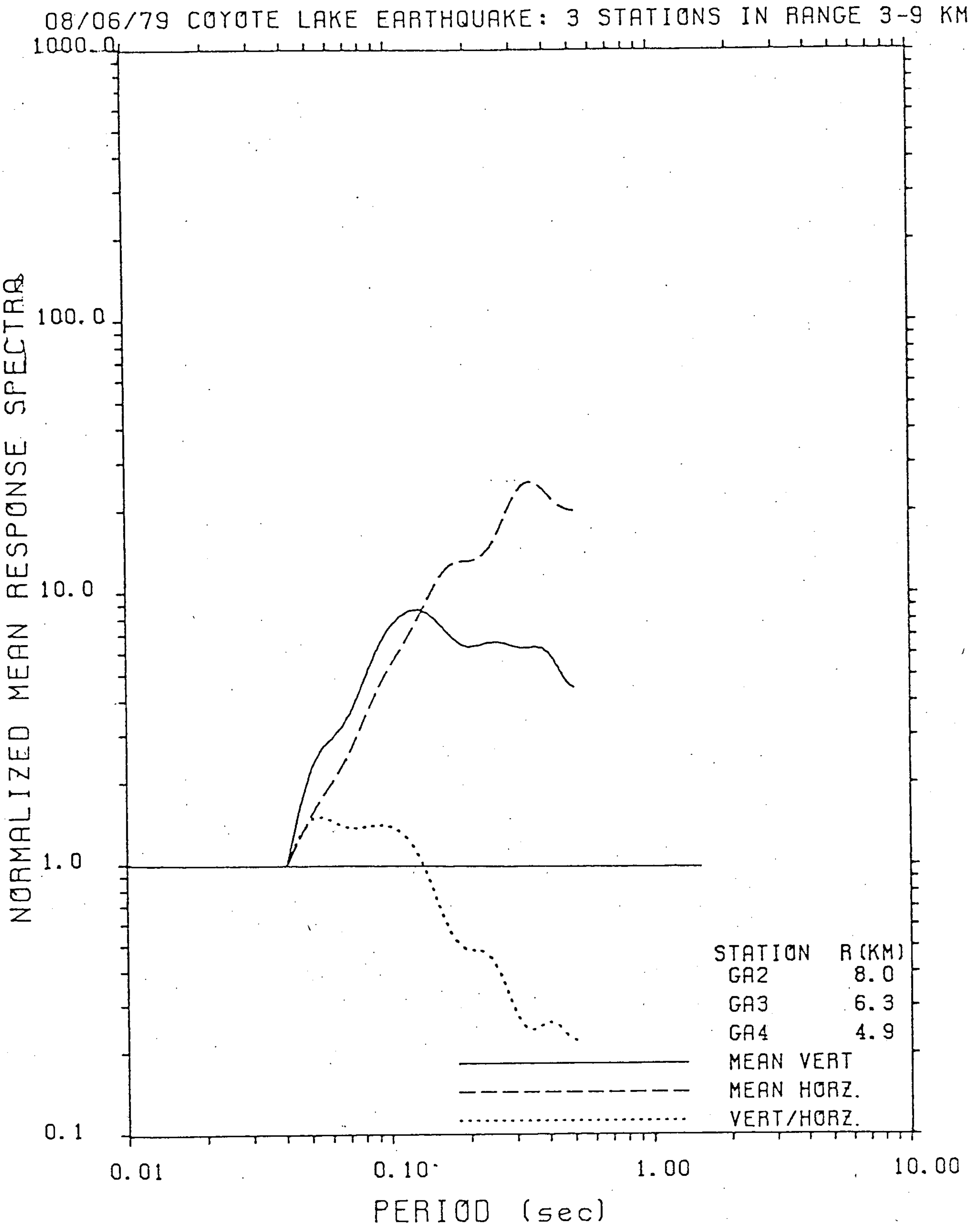

Figure 3.5. Normalized average horizontal and vertical response spectral shape and response ratio, soft soil sites, Coyote Lake earthquake.

are sited on soft alluvium. Note that this response spectral ratio is very similar to that shown on Figure 3.3 for the Imperial Valley, i.e., 60-70% amplification over the period range 0.04-0.15, changing to a substantial reduction at longer periods. Figure 3.6 shows the corresponding response spectral ratio for the three stations located on the Franciscan rock (Gilroy Array 1, 6, and San Martin). In comparison with the data shown on Figure 3.5, the response spectral ratio from the rock sites show small dynamic amplification at the short period end and significantly less reduction at the long period end. These data add additional support to the conclusion that the shape of the vertical response spectra, extending from long periods to zero period, is site dependent.

An ideal data base for developing a site specific vertical response spectrum for SONGS would include data from a M~7 earthquake recorded on sites with stiff soil profiles. As the available vertical acceleration data base is more limited than the corresponding horizontal data base and, as the above discussion documents, site effects are more significant for the vertical component, it is concluded that an empirical approach for developing the required spectrum is not optimal. An alternative method for developing the spectrum, as discussed in Section 1.0, draws upon numerical simulation of earthquakes. By focusing on spectral ratios of the vertical to horizontal response, the effects of model source characteristics are greatly reduced, emphasizing the effects of site conditions. Figure 3.7 presents the normalized vertical and horizontal spectra and the corresponding response ratio, as developed and discussed in Supplement III of Del Mar Technical Associates (1980). For the reasons discussed in Section 2.6, these spectral shapes are the most relevant data available for determining a site specific ratio of the vertical to horizontal response. It is important to note that this site specific ratio is in very good agreement with the amplitude and character of the empirical data discussed above, i.e., dynamic amplification at short periods decreasing to a reduction at long periods.

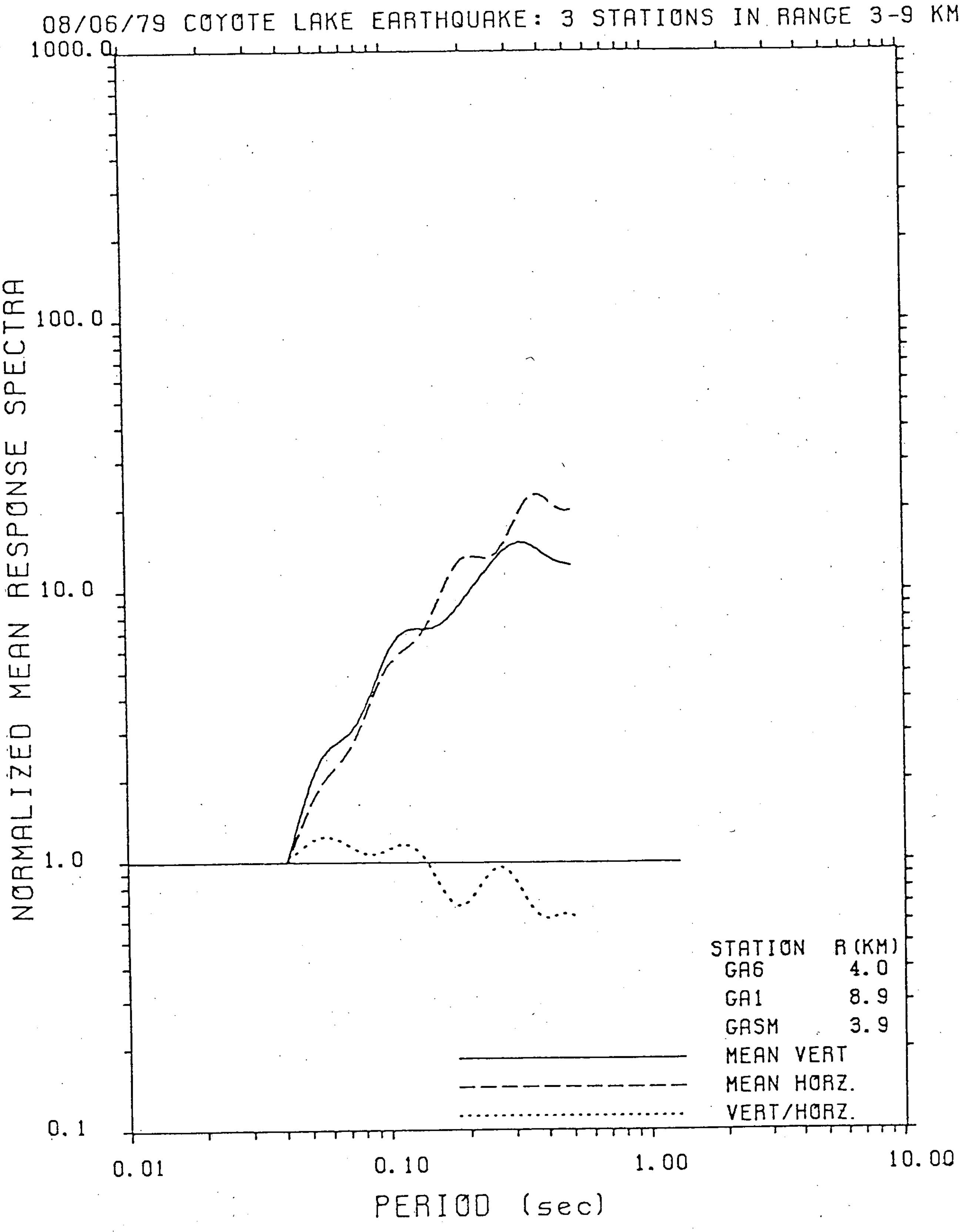

Figure 3.6. Normalized average horizontal and vertical response spectral shape and response ratio, rock sites, Coyote Lake earthquake.

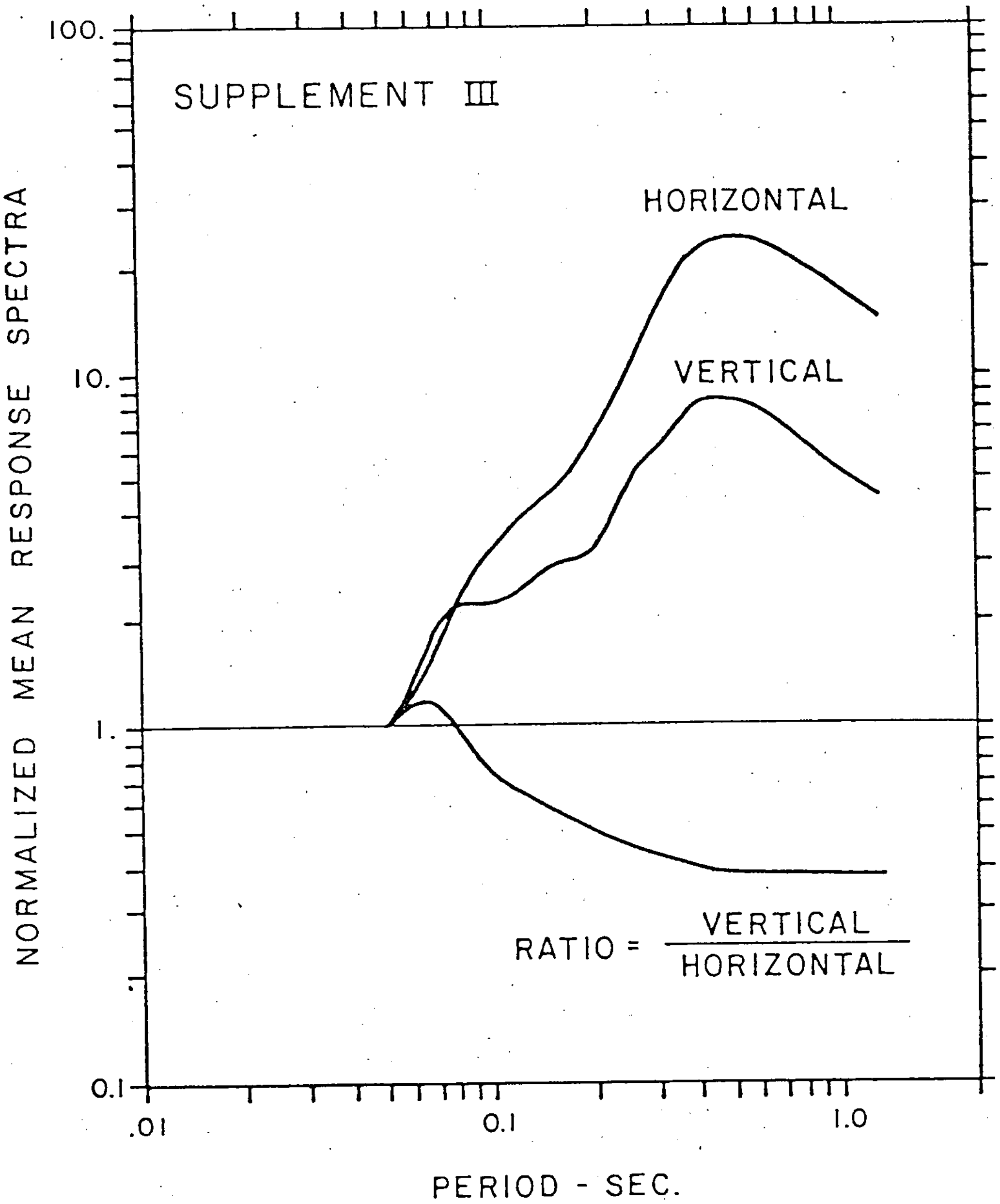

Figure 3.7. Normalized SONGS site specific horizontal and vertical response spectral shape and response ratio. (Data from Del Mar Technical Associates, 1980).

The numerical simulations used to develop the ratio shown on Figure 3.7 were carried out over the frequency range 0-20 hz. During routine processing of accelerograms the high frequency end of the pass-band is generally 25 hz. The corresponding response spectra have a minimum period of 0.04 sec. As the response spectral ratio is required for scaling an empirical horizontal spectrum, we have smoothly extended the ratio shown in Figure 3.7 from 0.05 sec to 0.04 sec, following the behavior of the empirical ratios. Figure 3.8 shows the final extended site specific response spectral scaling curve. This curve quantifies the difference in response spectral shape between the horizontal and the vertical components.

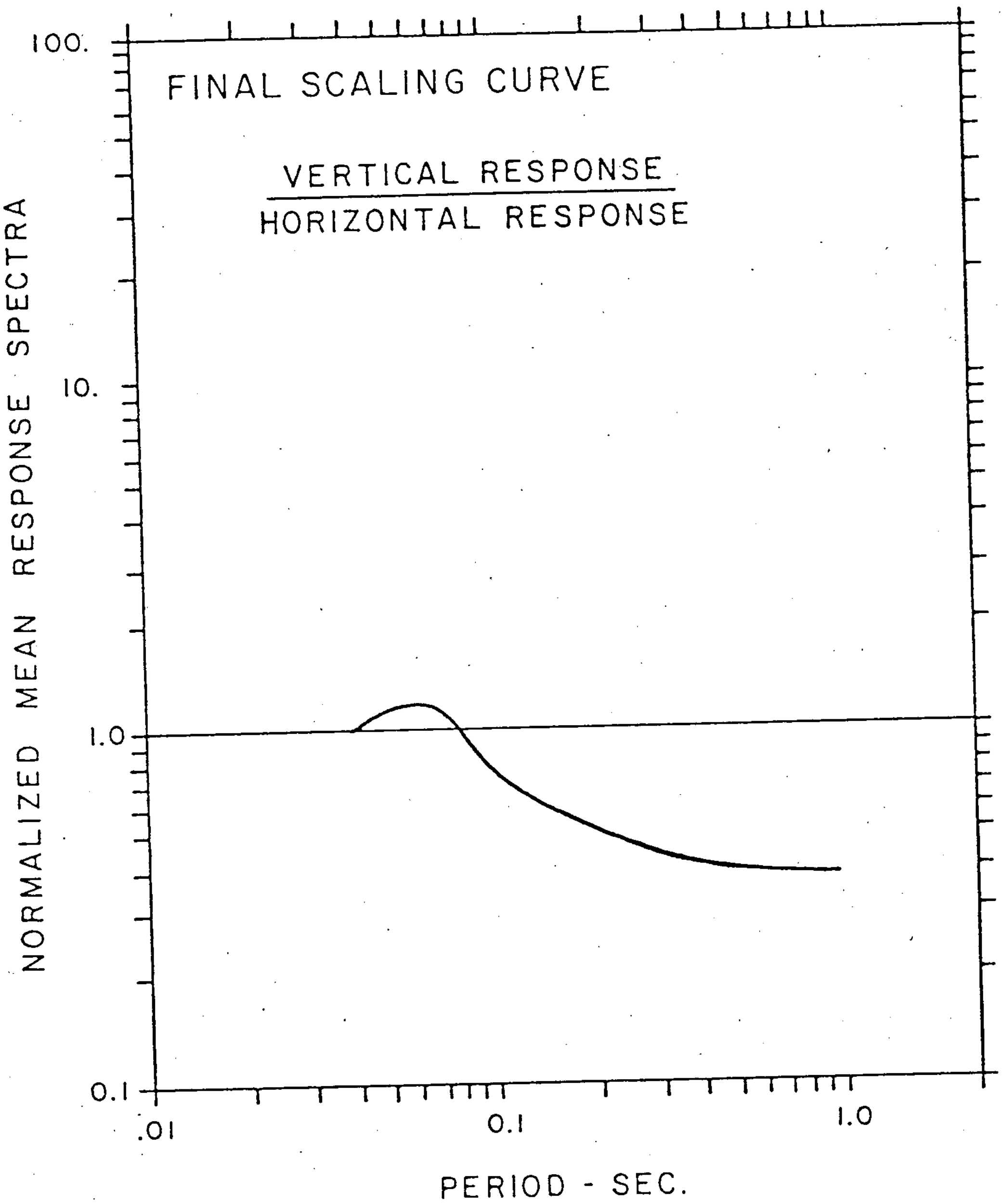

Figure 3.8. Final SONGS site specific vertical to horizontal response spectral ratio.

4.0 COMPARISON WITH THE HOUSNER

Figure 3.7 quantifies the difference in spectral shape between the vertical and horizontal components for a SONGS site specific earthquake. Figure 4.1 summarizes three empirical studies of the 84th percentile horizontal spectra for the relevant conditions at SONGS. The studies leading to Figure 4.1 are discussed in Woodward-Clyde Consultants (1982). The shape of the vertical response is directly estimated by multiplying the values of the vertical to horizontal spectral ratio, at each period, by the corresponding horizontal response. For the current study we have used the most recent analysis of the horizontal response, the curve labeled "From Current Ground Motion Analysis", Figure 4.1. The final derived 84th percentile, 2 percent damped, vertical response spectra is obtained by anchoring the vertical spectral shape to a PGA value of 0.28g (derived in Section 2). Figure 4.2 shows the comparison between the final vertical 84th percentile response spectrum and the unmodified 0.44g Housner vertical seismic design basis. This comparison is presented as a spectral ratio, where values greater than unity indicate exceedence of the Housner. The NRC staff has recommended that the Housner spectrum be increased by 10% over the period range 0.05-0.15 sec. Figure 4.3 presents the comparison between the vertical 84th percentile response spectrum and the 10% modified Housner vertical seismic design basis.

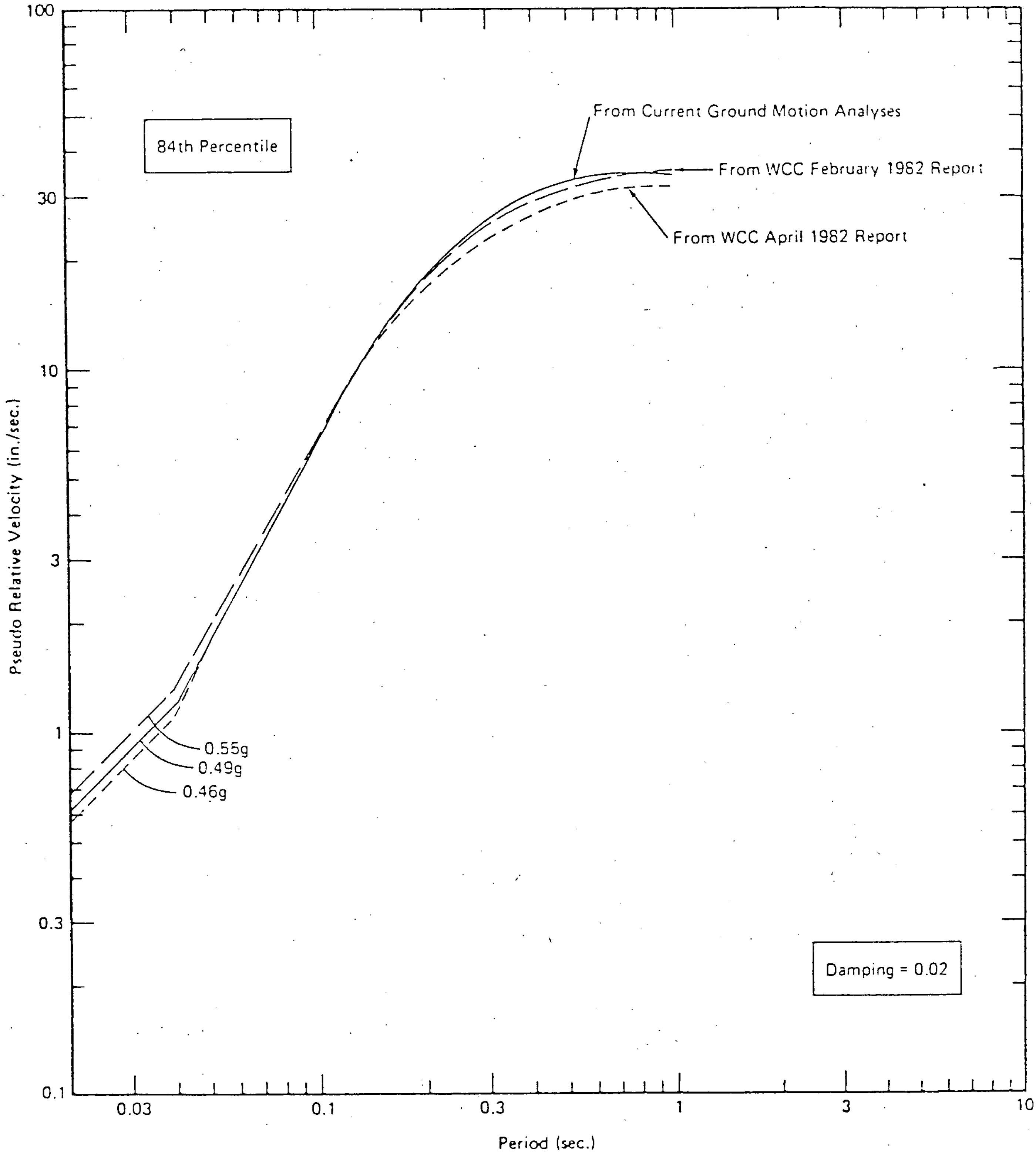

Figure 4.1. Empirical SONGS site specific 84th percentile horizontal response spectra. (From Woodward-Clyde Consultants, 1982).

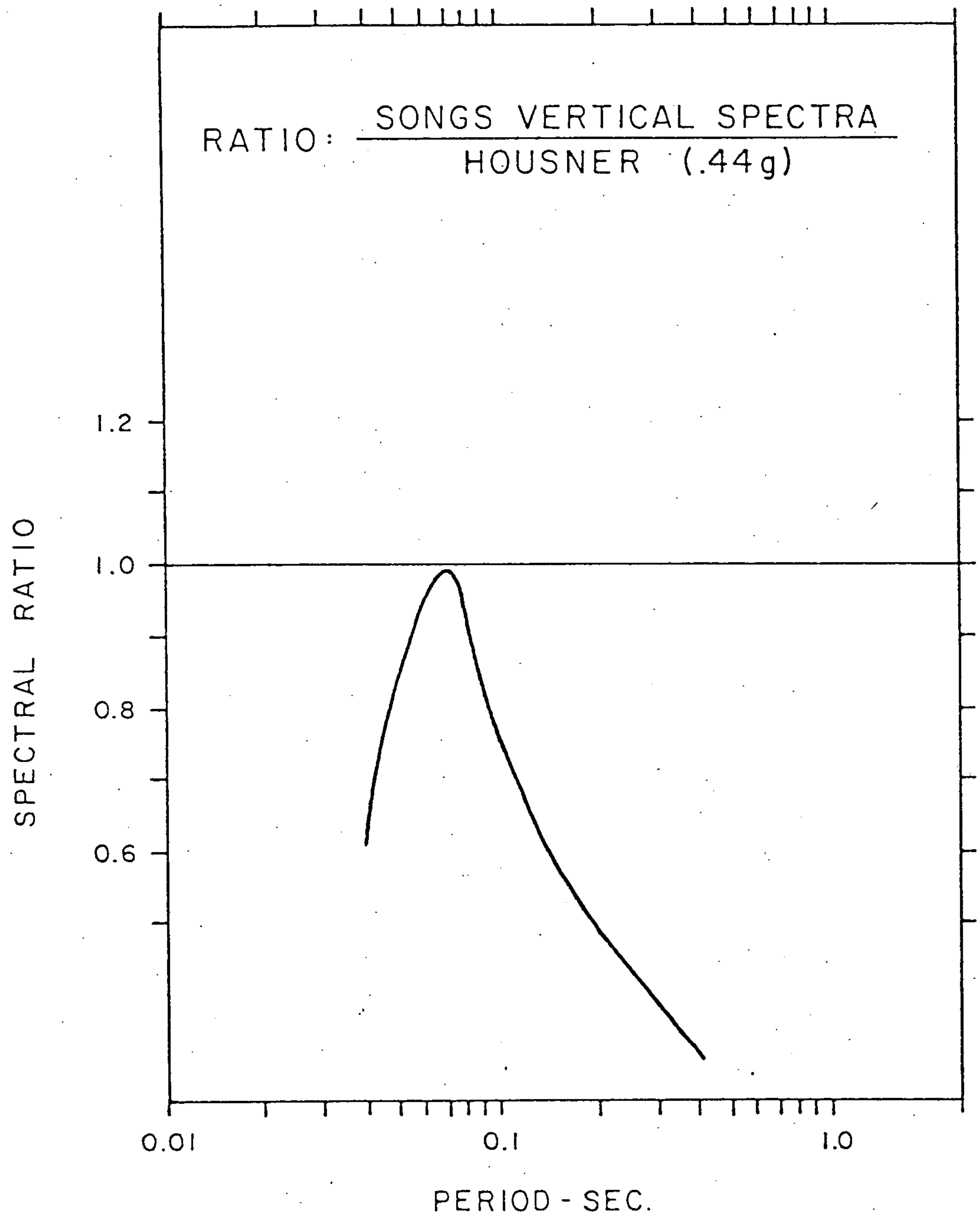

Figure 4.2. Comparison between the SONGS 84th percentile vertical response spectrum and the 0.44g unmodified Housner. Note that the Housner exceeds the vertical spectrum developed in this study at all periods.

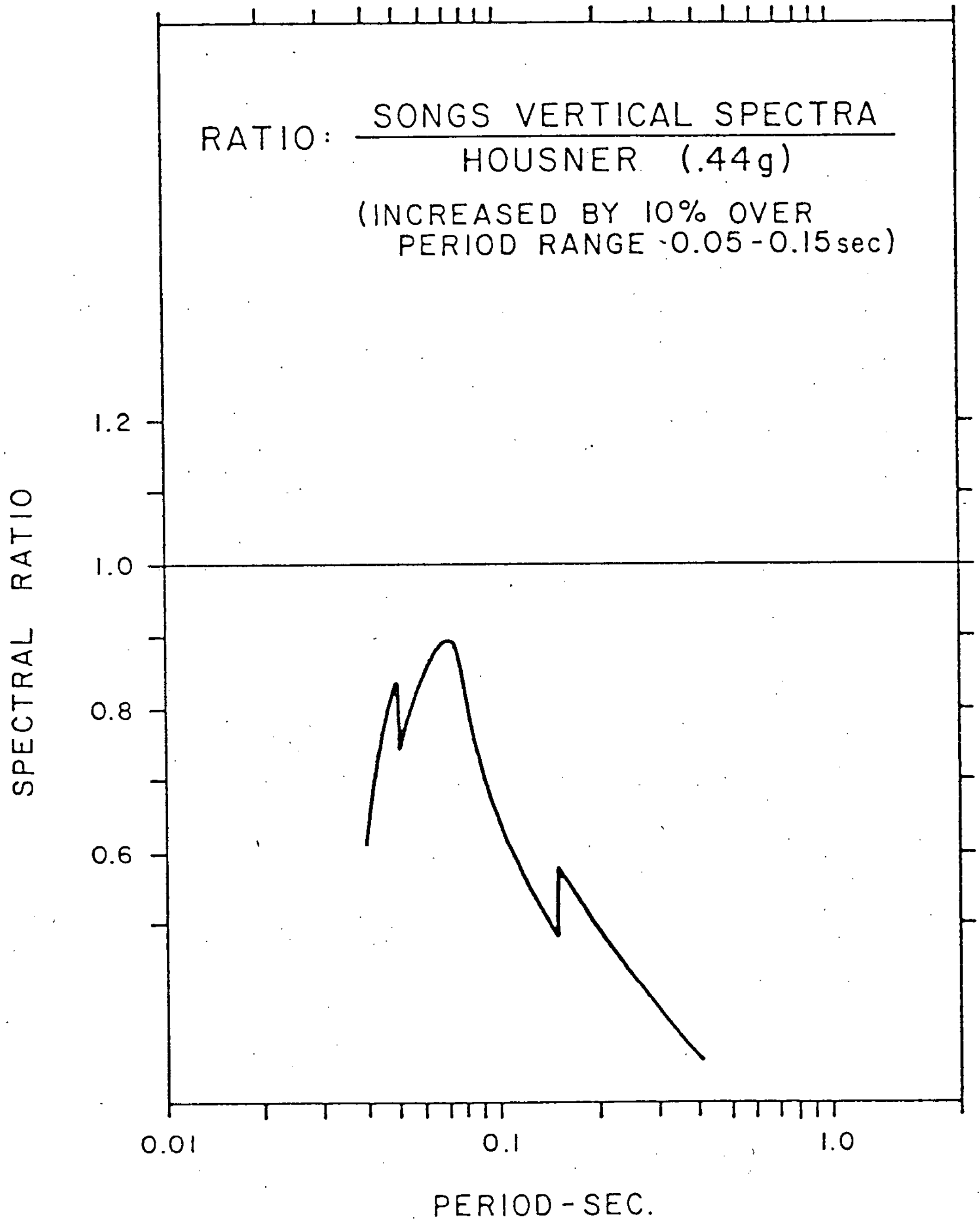

Figure 4.3. Comparison between the SONGS 84th percentile vertical response spectrum and the modified 0.44g Housner.

5.0 SUMMARY AND CONCLUSIONS

The goal of this study has been to develop a SONGS site specific 84th percentile vertical spectrum. This goal has been achieved by developing an 84th percentile PGA value and a normalized vertical spectral shape. The final 84th percentile spectrum was computed by anchoring the normalized shape to the 84th percentile PGA value.

The 84th percentile vertical PGA value of 0.28g was computed from a broad compilation of seven different approaches for estimating ground motion. Both the observational data and many numerical simulation studies strongly support the conclusion that vertical PGA is site dependent. Derivation of the vertical response spectrum shape combined the simulation derived site specific ratio of vertical to horizontal response spectra with the best empirical estimate of the SONGS 84th percentile horizontal spectrum. To further increase confidence in the spectral ratio shape, data from the Imperial Valley and Coyote Lake earthquakes were also examined. The Coyote Lake data set provides particularly strong evidence that the entire vertical response spectral shape is site dependent. Finally, the derived vertical 84th percentile spectrum was compared with both the Housner design basis spectrum and the modified Housner design basis spectrum. Both design basis spectra envelope the site specific 84th percentile vertical spectrum developed in this study.

6.0 REFERENCES

Apsel, R.J., D.M. Hadley and R.S. Hart, 1983, Effects of earthquake rupture shallowness and local soil conditions on simulated ground motions, NUREG/CR-3102, 123 p.

Archuleta, R.J., 1982, Analysis of near-source static and dynamic measurements from the 1979 Imperial Valley earthquake, Bul. Seis. Soc. Am., V. 72, pp. 1927-1956.

Archuleta, R.J., 1984, A faulting model for the 1979 Imperial Valley earthquake, J. Geoph. Res., in press.

Campbell, K.W., 1981, Near-source attenuation of peak horizontal acceleration, Bul. Seis. Soc. Am., V. 71, pp. 2039-2070.

Campbell, K.W., 1982, A study of the near-source behavior of Peak vertical acceleration (Abstract), EOS, V. 63, p. 1037.

Del Mar Technical Associates, 1978, Simulation of earthquake ground motions for San Onofre Nuclear Generating Station, Unit 1, Final Report.

Del Mar Technical Associates, 1979, Simulation of earthquake ground motions for San Onofre Nuclear Generating Station, Unit 1, Supplement I.

Del Mar Technical Associates, 1980, Simulation of earthquake ground motions for San Onofre Nuclear Generating Station, Unit 1, Supplement III.

Fuis, G.S., W.D. Mooney, J.H. Healy, G.A. McMechan, and W.J. Lutter, 1982, Crustal structure of the Imperial Valley region: The Imperial Valley, California, Earthquake, October 15, 1979, U.S. Geological Survey Professional Paper 1254, pp. 25-50.

Helmberger, D.V. and D.M. Hadley, 1979, A note on the high frequency vertical strong ground motions recorded in sedimentary basins, (Abstract) Earthquake Notes, V. 50, N. 4, p. 50.

Joyner, W.B. and D.M. Boore, 1981, Peak horizontal acceleration and velocity from strong-motion records including records from the 1979 Imperial Valley, California, Earthquake, Bul. Seis. Soc. Am., V. 71, pp. 2011-2038.

Joyner, W.B., R.E. Warrick and T.E. Fumal, 1981, The effect of quaternary alluvium on strong ground motion in the Coyote Lake, California, Earthquake of 1979, Bul. Seis. Soc. Am., V. 71, pp. 1333-1349.

Liu, Hsui-Lin, 1983, Interpretation of near-source ground motions and implications, Ph.D Thesis, California Institute of Technology, 184 p.

Mooney, W.D. and J.H. Luetgert, 1982, A seismic refraction study of the Santa Clara Valley and Southern Santa Cruz mountains, West Central California, Bul. Seis. Soc. Am., V. 72, pp. 901-909.

Shannon and Wilson, 1975, Geotech and strong motion earthquake data from U.S. Accelerograph Stas., Ferndale, Cholame, and El Centro, CA., Vol. 1, prepared for Office of Nuclear Regulatory Research, PB-257 234, 344 p.

Woodward-Clyde Consultants, 1982, Development of instrumental response spectra for the San Onofre site.