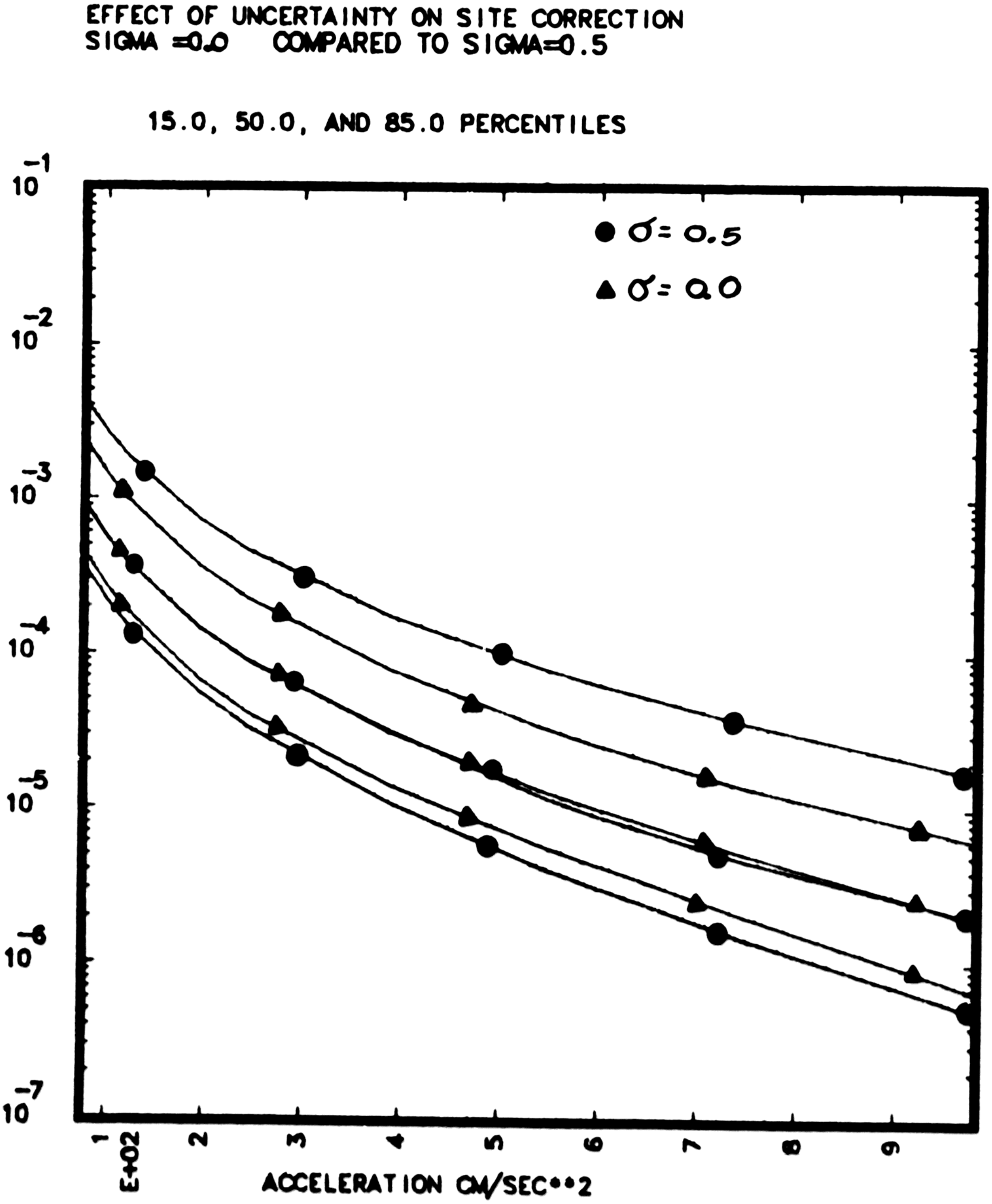
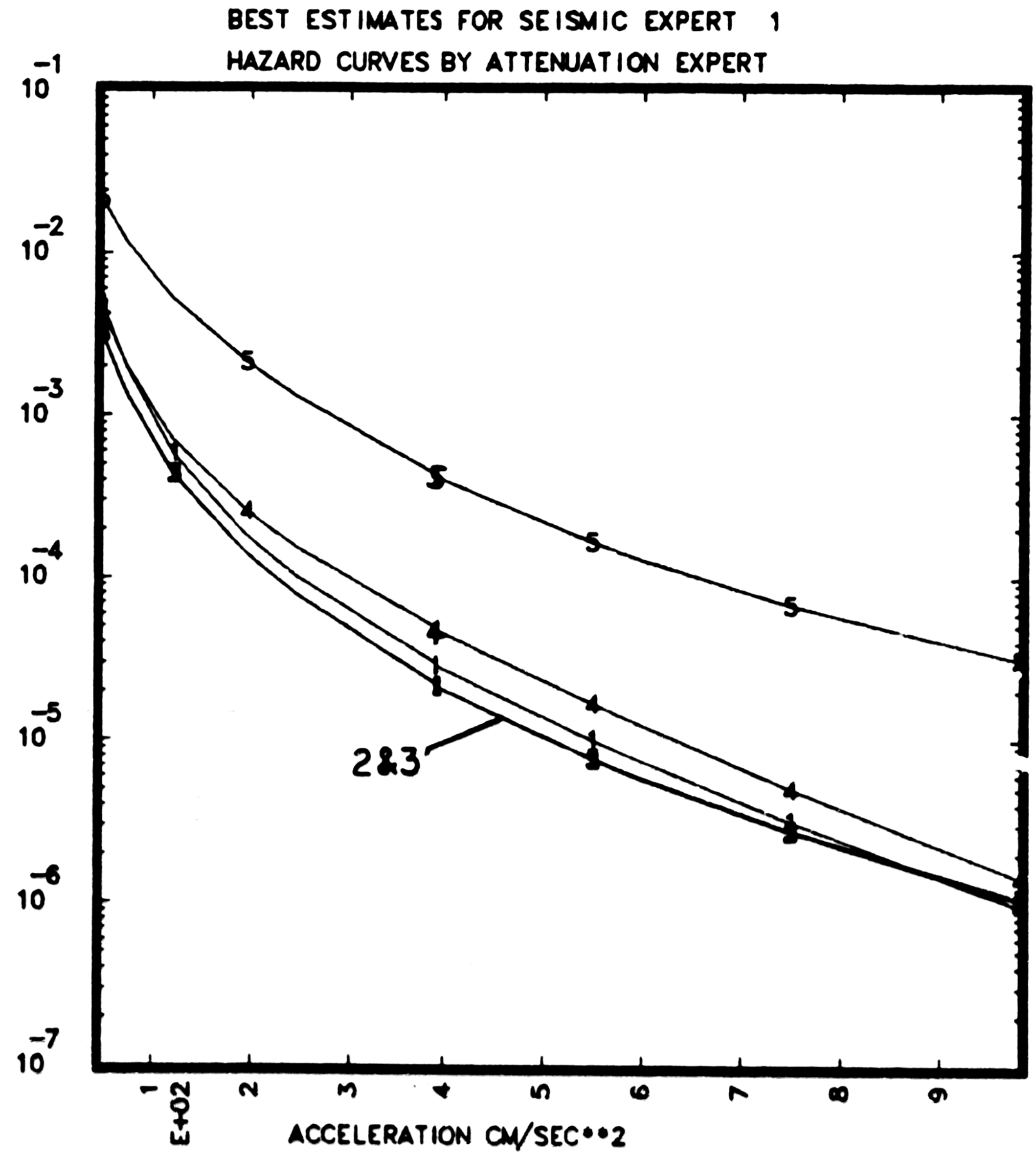

EFFECT OF UNCERTAINTY ON SITE CORRECTION
SIGMA =0.0 COMPARED TO SIGMA=0.5
15.0, 50.0, AND 85.0 PERCENTILES
σ= 0.5
σ= 0.0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
1
E+02
2
3
4
5
6
7
8
9
ACCELERATION CM/SEC**2

Figure 4.4. 3

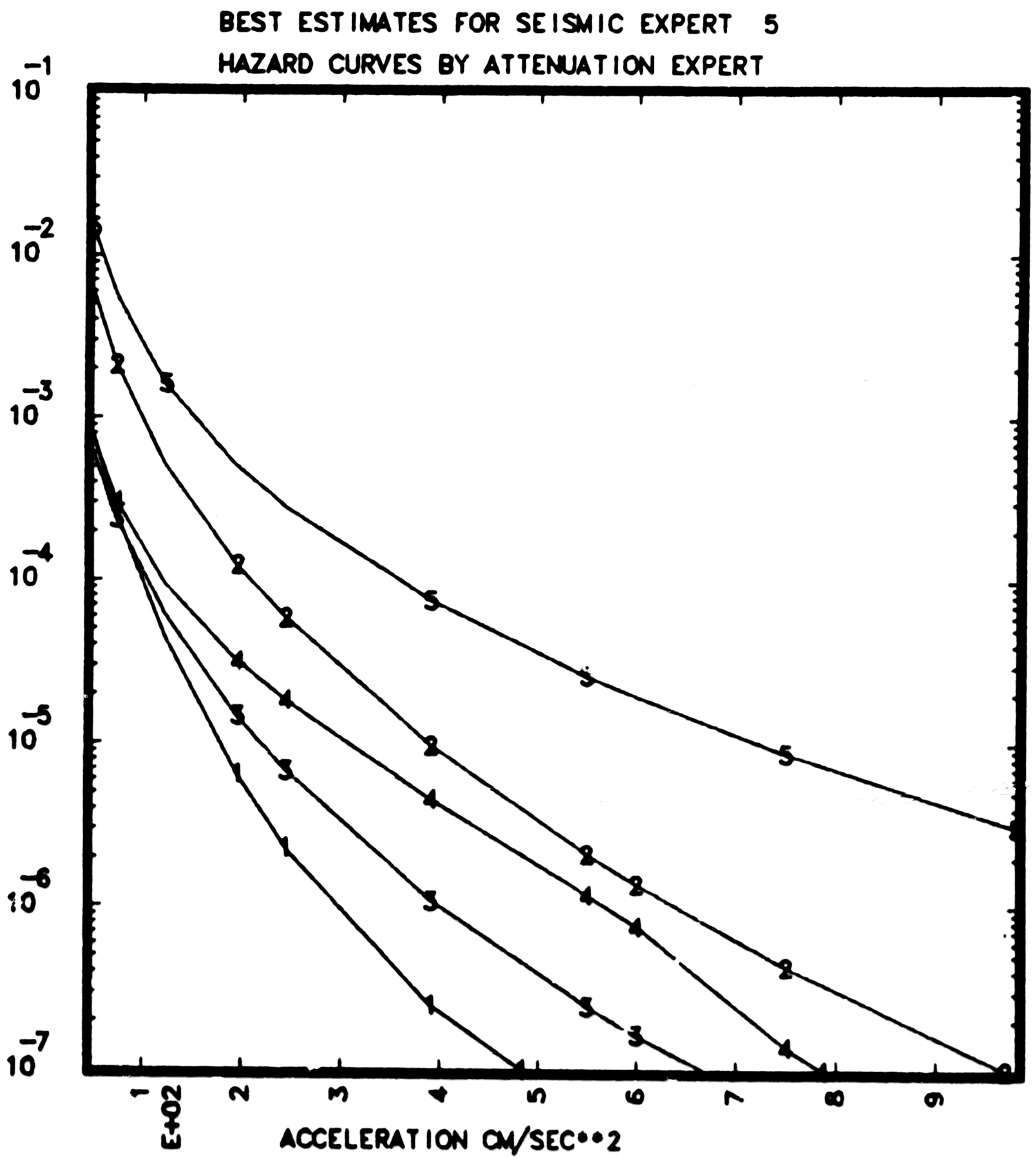
SENSITIVITY OF THE HAZARD TO THE GM MODELS
ALL OTHER PARAMETERS FIXED AT BEST ESTIMATE VALUES



BRAIDWOOD

Figure 4.4.4a

SENSITIVITY OF THE HAZARD TO THE GM MODELS
ALL OTHER PARAMETERS FIXED AT BEST ESTIMATE VALUES



BRAIDWOOD

Figure 4.4.4b

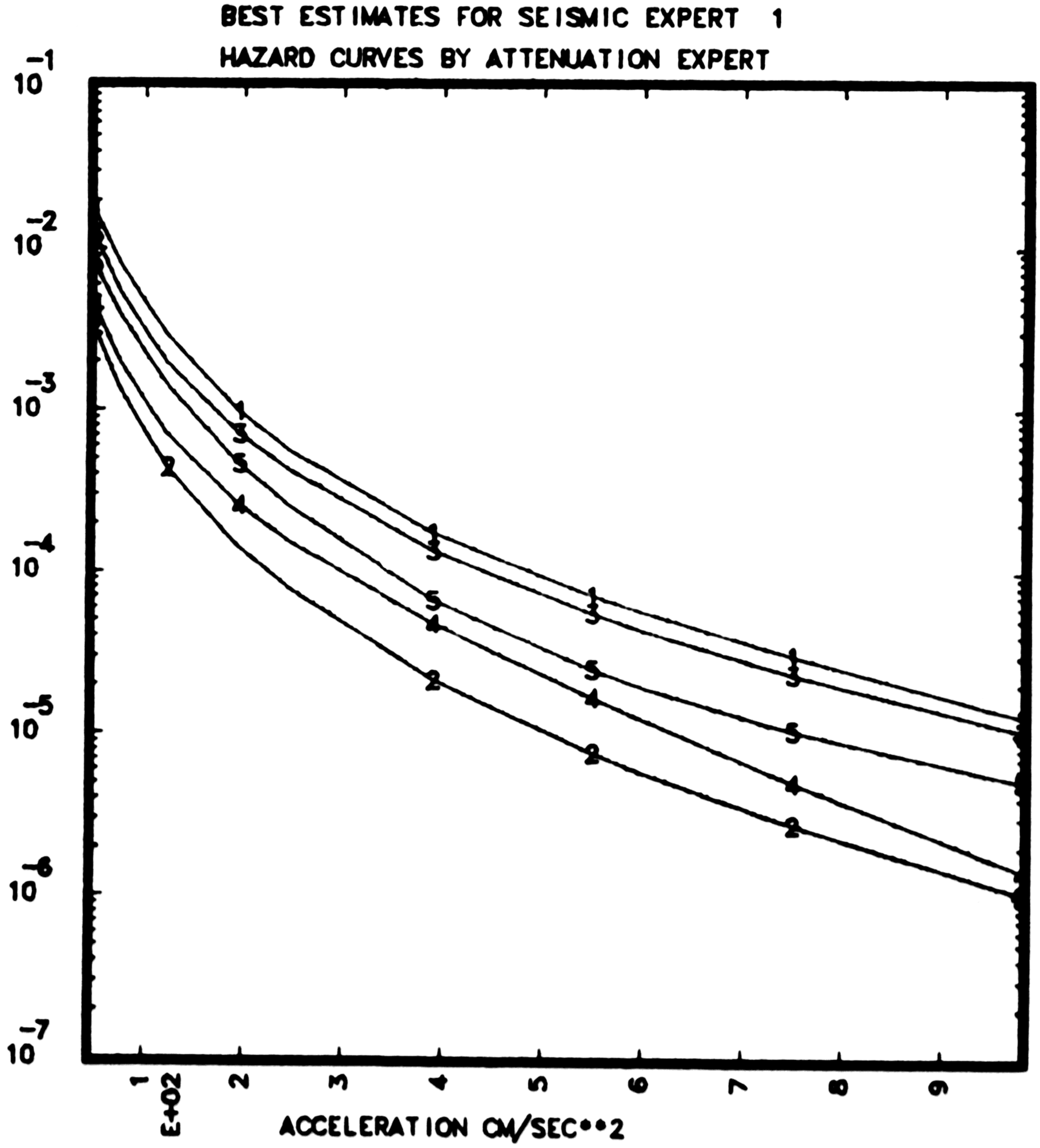
other experts because Expert 5's BE site correction for the Braidwood site is a factor of 1.9 compared to a factor of 1.0 for the other experts. Figure 4.4.5 gives the BEHC for Seismicity Expert 1 for the case where Braidwood is treated as a shallow sand site. In this case, the site correction factor causes ground motion experts' 1, 3 and 5 BE models to be different from one another.

It is now seen that Ground Motion Expert 5's model no longer results in the highest BEHC. Figures 4.4.6a and b provide some interesting insights. Figure 4.4.6a displays the CPHCs that were obtained when all the seismicity parameters were varied and a single GM model (#8) was used (Fig. 4.1.1.b) and on CPHCs that were obtained by fixing the seismicity parameters at their BE values but using all of the GM models. The 15th and 85th percentile bounds are much wider for the case where all the GM models are used with no uncertainty for the seismicity parameters as compared to the case when the seismicity parameters are fully simulated but only one GM model is used. The median curves are close together. Figure 4.4.6b displays compare the CPHC for the case when a complete simulation is performed and the case where the seismicity parameters are held at their BE values but a full simulation is performed where all the GM models vary. There is very little difference between the two sets of curves.

The comparison on Fig. 4.4.6a can be a little misleading because the GM model used (#8) is the BE model selected by Expert 4 and similar to the models selected by Expert 1. If GM model #14 (Expert 5's BE model) had been the model used instead of #8, there would be a substantial difference between the median CPHC in Fig. 4.4.6a and the median CPHC for the case of the fixed GM model. The results show that if one Ground Motion Panel Expert should change his mind or if one Ground Motion Panel Expert's models were given very low weight or a new expert added, the median CPHC would not change significantly. A similar conclusion was reached by a different approach in Bernreuter et al. (1984). This is an important conclusion.

The effect of the correction for the site's local soil conditions is illustratd on Fig. 4.4.7. The CPHC for Braidwood is displayed assuming three different site categories; 1) rock, 2) deep soil and, 3) shallow sand. The effect of the site correction is seen to be significant. The larger uncertainty bounds arise from the simulation of site correction factor for the categorical correction. Note that the deep soil case was chosen as the base case thus that the categorical correction factor is unity with no uncertainty. The categorical correction method was used 46% of the time (see Table 3.4.2). Figures 4.4.8a and b show the sensitivity of the CPUHS to the site's soil category. Figure 4.4.8a displays the CPUHSs combined over all experts for the 10,000 year return period for the Millstone site. In one case the site is assumed to belong to the rock category and in the other case, the site is considered to be in the shallow sand category. Figure 4.4.8b compares the combined over all experts 10,000 year return period CPUHS for the Braidwood site for the three site conditions mentioned above for that site.

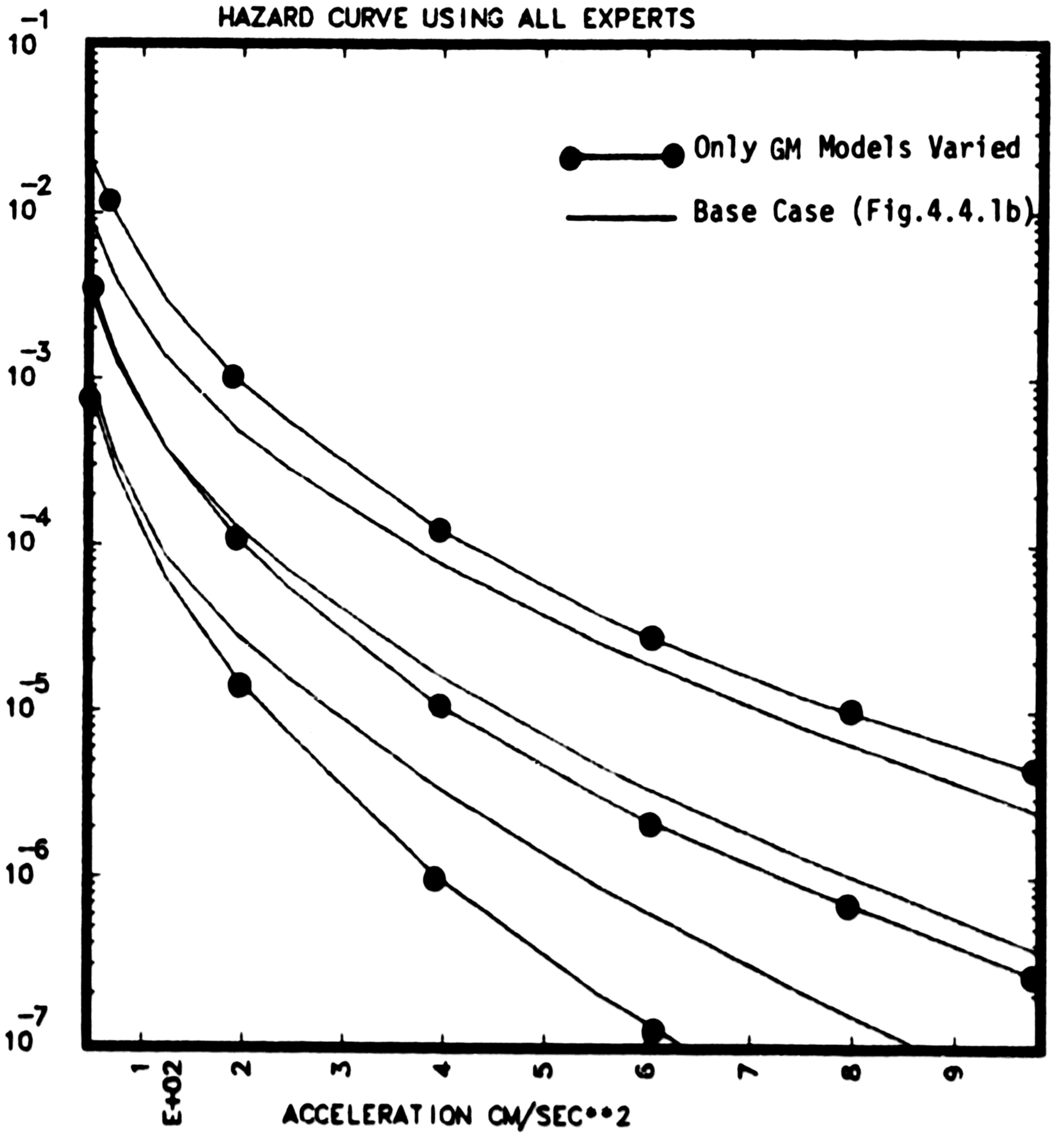
BEHC TREATING THE SITE AS A SHALLOW SOIL SITE
GROUND MOTION EXPERTS 1,3 AND 5 AFFECTED BY CHANGE



BRAIDWOOD

Figure 4.4.5

COMPARISON OF 'BASE CASE' CPHC FIG. 4.4.1.B TO THE CASE
WHERE ONLY THE GM MODELS ARE SIMULATED ALL OTHER PARAMETERS AT BE VALUES
PERCENTILES = 15.0,50.0 AND 85.0

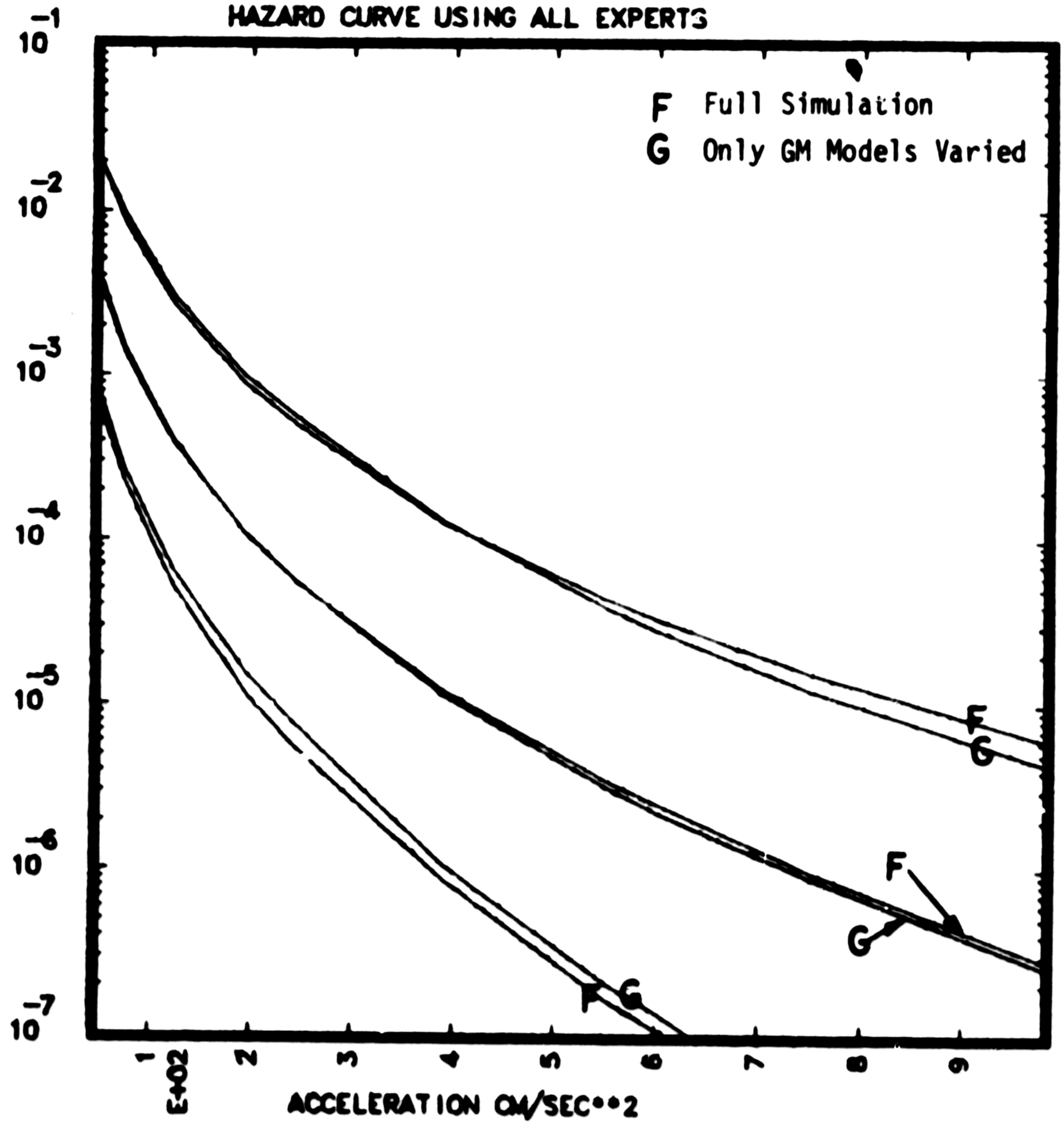


BRAIDWOOD

Figure 4.4.6a

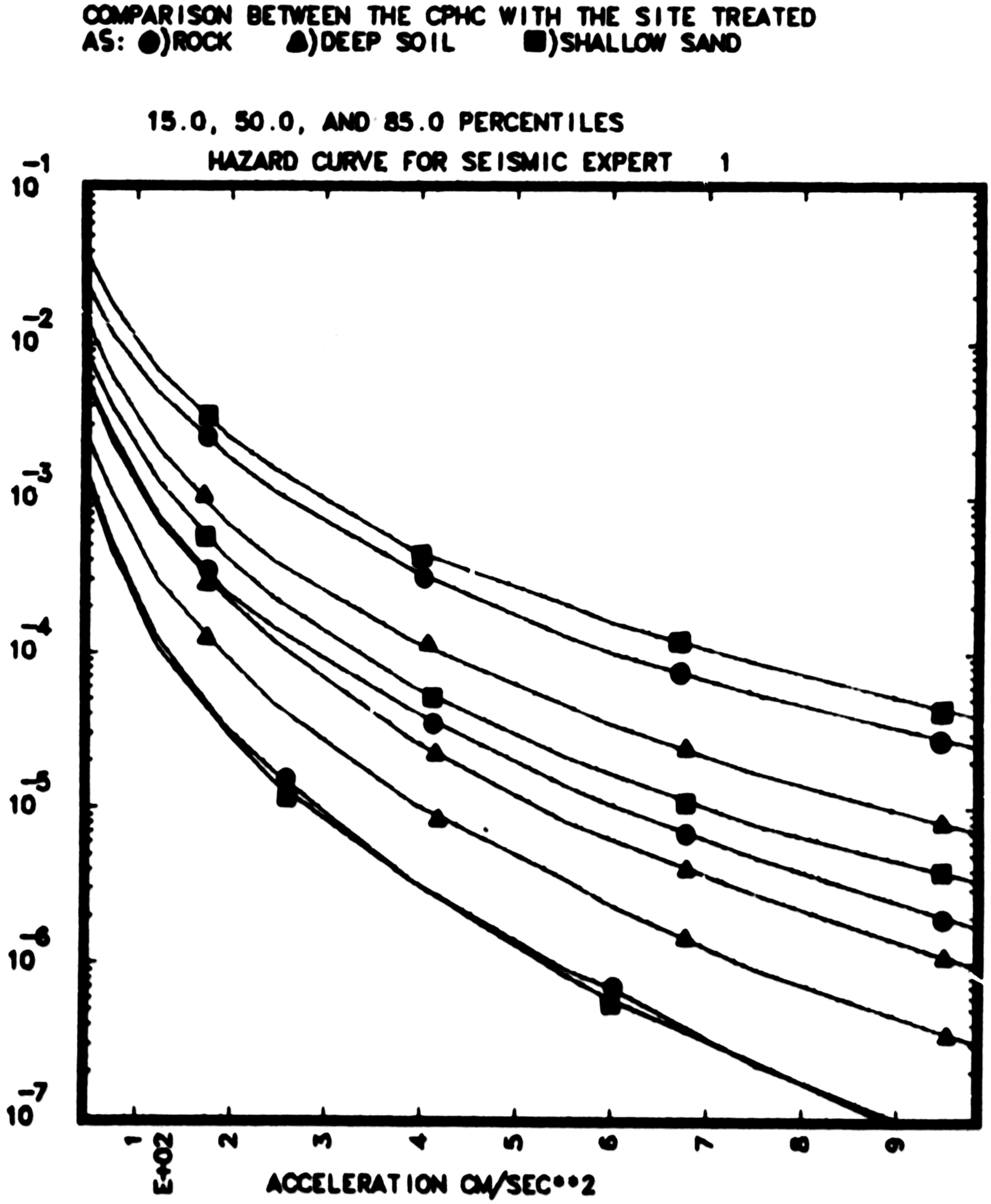
THE UNCERTAINTY INTRODUCED BY THE GM MODELS

COMPARISON OF THE FULL SIMULATION CASE TO THE CASE WITH ALL PARAMETERS HELD AT BE VALUES EXCEPT ALL GM MODELS USED-15.,50.&85. PERCENTILES



BRAIDWOOD

Figure 4.4.6b

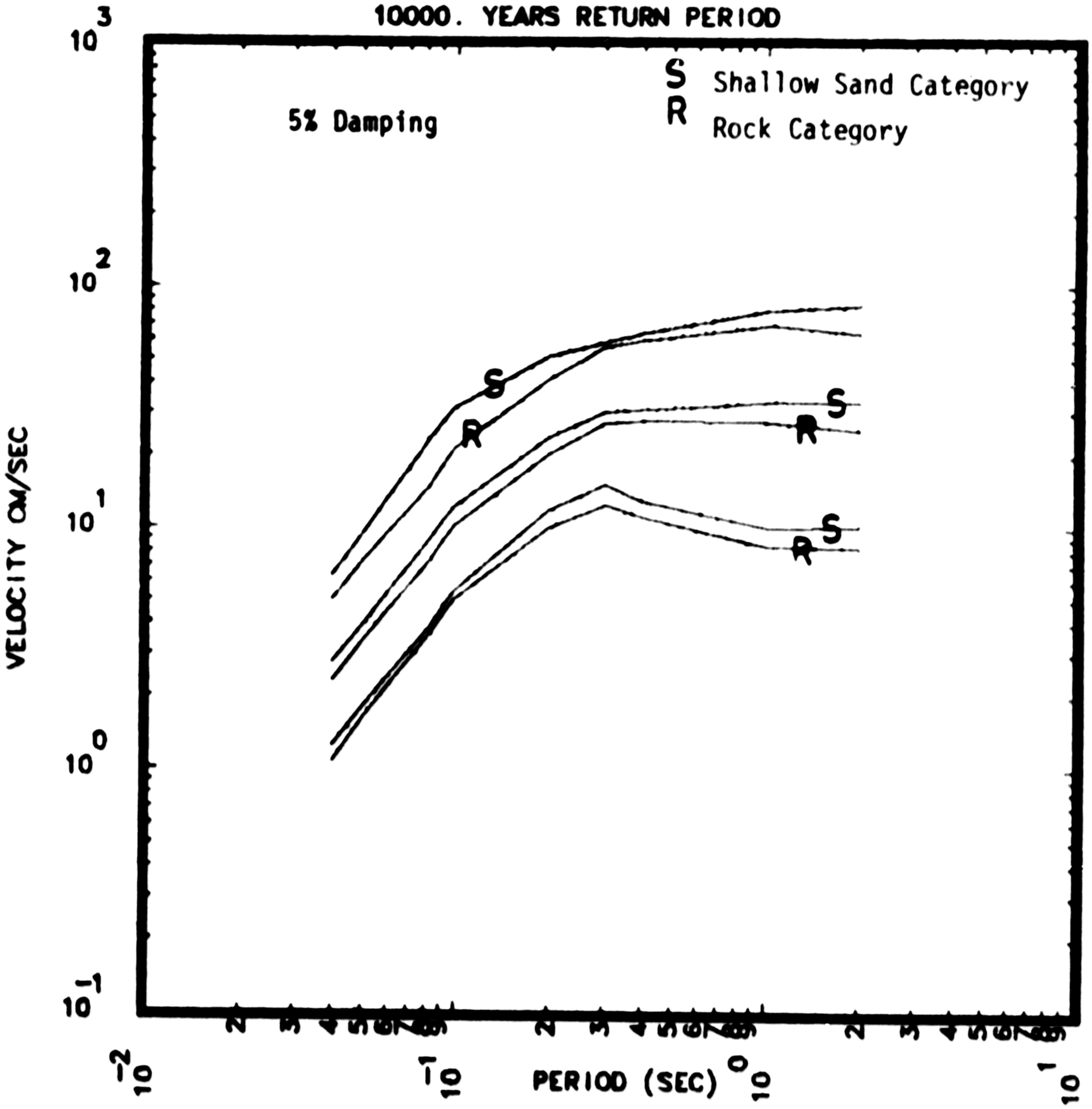


BRAIDWOOD

Figure 4.4.7

EFFECT OF SITE CORRECTION ON COMBINED CPUHS
SITE IN ROCK CATEGORY COMPARED TO SHALLOW SAND CATEGORY

PERCENTILES = 15.0,50.0 AND 85.0



MILLSTONE

Figure 4.4.8a

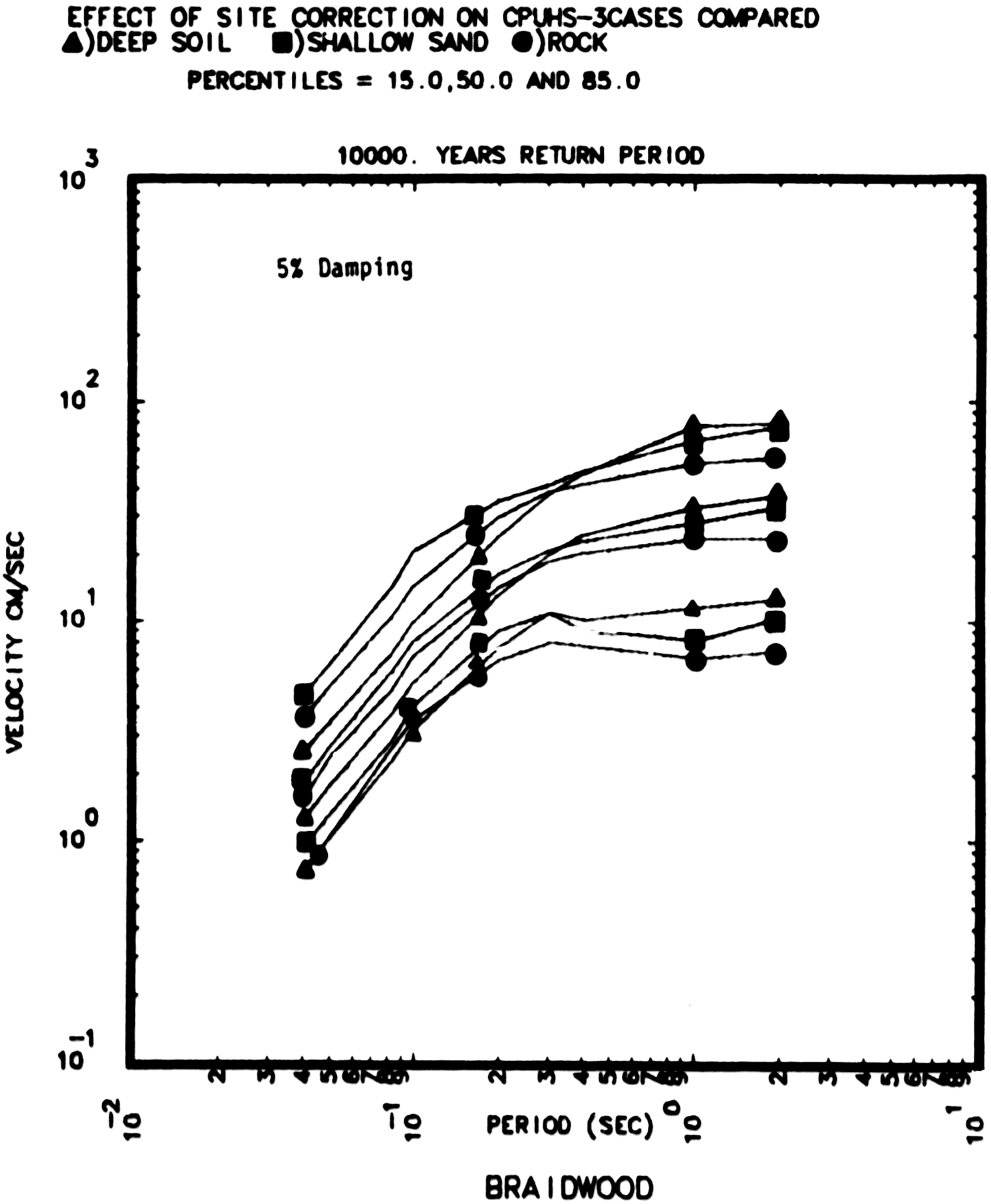

EFFECT OF SITE CORRECTION ON CPUHS-3CASES COMPARED
▲)DEEP SOIL ■)SHALLOW SAND ●)ROCK
PERCENTILES = 15.0,50.0 AND 85.0
10000. YEARS RETURN PERIOD
5% Damping
VELOCITY CM/SEC
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-1}
10^{0}
10^{1}
PERIOD (SEC)
BRAIDWOOD

figure 4.4.8b

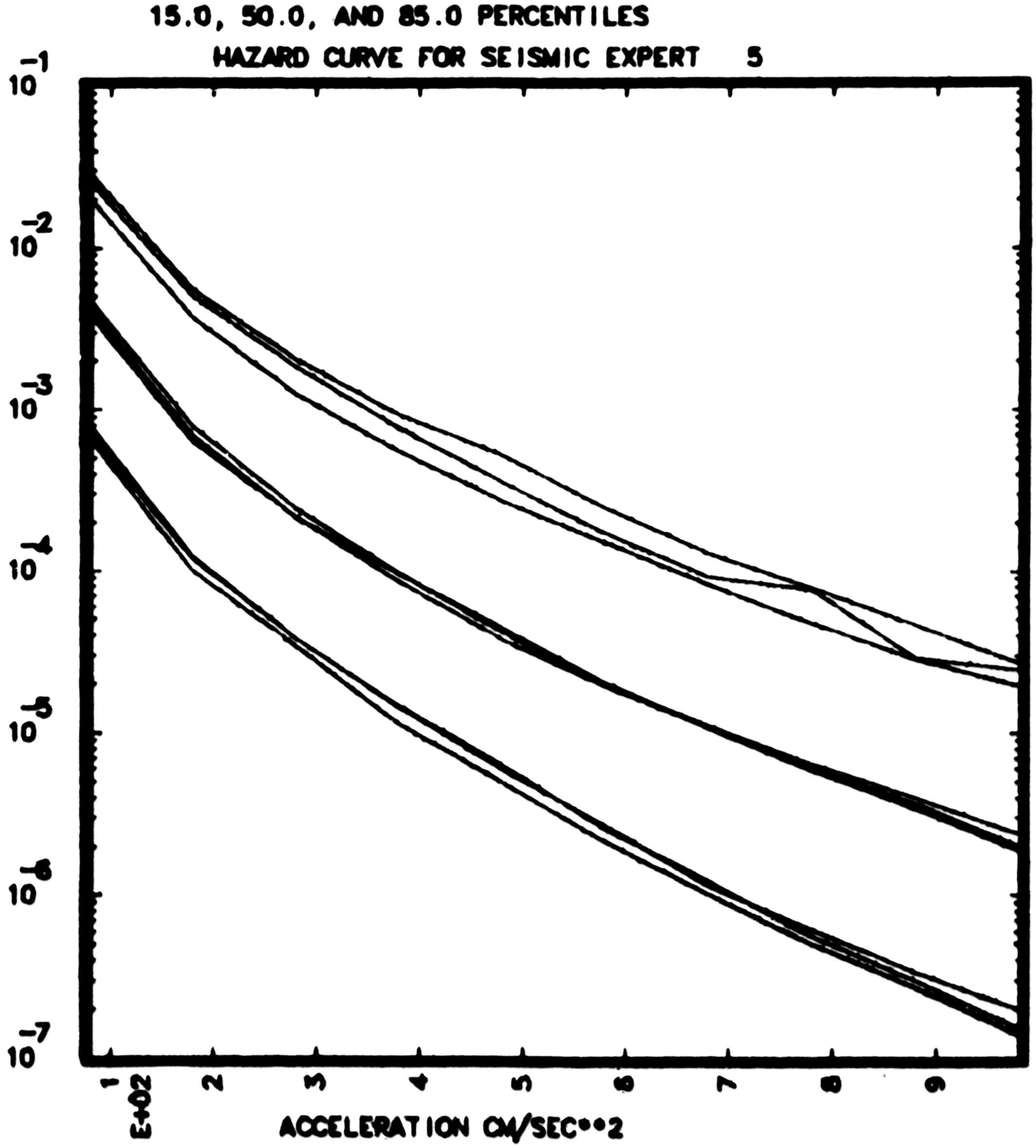
It is evident from Figs. 4.4.7 and 4.4.8 that site correction has a significant impact upon the computed seismic hazard at a site. The shape of the 15th percentile CPUHS shown in Fig. 4.4.8b is common to most of the results obtained for the ten sites. The behavior of these spectra for periods above 0.3 sec is influenced by several contradictory effects. One of them is the shape of the site correction factors, as described in Section 3 (see Figs. 3.4.1-3.4.3). Another effect is the result of the very different shape of some of the spectra at low magnitude, as shown in Fig. 3.4.9a (i.e, curves 1 and 3 of Fig. 3.4.9a for M=4.5). Another peculiarity of the CPUHS is in the irregular shape around 0.07 secs. period. This phenomenon is also due to the existence of a discontinuity in the shape of some undesirable of the spectra at that period (see Fig. 3.4.9a).

4.5 Other Models and Sampling Uncertainties

In our methodology discussed in Section 2 and Appendix C, propagation of the uncertainties in the input parameters (maps, a-, b- values etc.) are based on simulation methods. That is, each input parameter is treated as a random variable with either a continuous or discrete probability distribution. Here we want to examine the sensitivity of the results to the distributions used and the uncertainty introduced by the random selection of simulated values for each of the input parameters based on their assumed distributions and a random seed. Because of the random seed, each set of simulated values is different. In our analysis the maps and ground motion models have discrete distributions. The parameters of the earthquake recurrence model have continuous distributions. In the results reported on in Bernreuter et al. (1984), the simulated values for modeling the uncertainty in the values for a-, b- value and the sigma for the ground motion models were drawn from lognormal distributions with the values provided by the Seismicity Panel members being the 95 percentile confidence bounds. Examination of the responses of the panel members indicated that in many cases a lognormal distribution would not fit the bounds very well and was a poor model. The triangular distribution appeared to be a more desirable model and consequently the lognormal model was replaced by a trianglular distribution. The triangular distribution would always fit the bounds and the modes provided by the experts, would not require any added information or new assumptions and would not lead to anomalies which could have some effect on the final results.

In the cases where a particular expert's uncertainty in some parameter is large, we found that the results are moderately sensitive to the assumed form for the distribution, the random seed and number of simulations for that particular expert. However, when the results are combined over all experts these factors are insignificant compared to the sensitivity of the results to the other uncertainties. Figures 4.5.1a and b show the sensitivity introduced by the random seed. Figure 4.5.1a shows three sets of CPHC obtained from three different sequences of 200 simulations for seismicity Expert 5 for the Millstone site. Only one Ground Motion model (#8) was used. This particular expert and site were selected because they represent "worse case" conditions. It is observed from this figure that there is reasonable

COMPARISON OF THREE SETS OF CPHC OBTAINED FROM THREE
DIFFERENT RANDOM SIMULATIONS (200 SIM. EACH SET)



MILLSTONE

Figure 4.5.1a

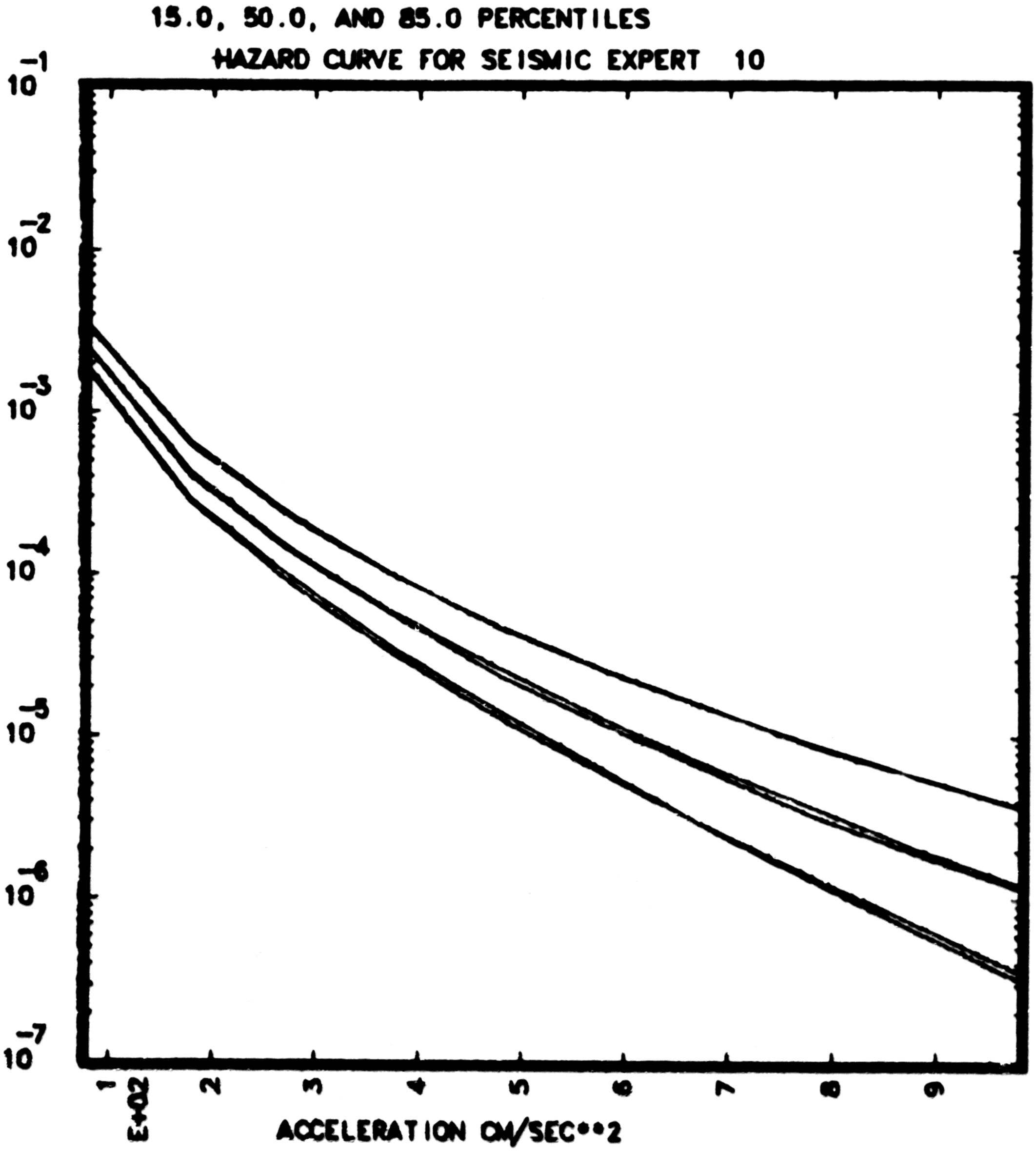
agreement between the different 15th and 50th percentile CPHC, however, differences between the 85th percentile CPHC are much more significant. Figure 4.5.1b shows a similar comparison between two sets of CPHC for Expert 10 at the Millstone site. In this case the agreement between each set is much better at all three percentiles. For the zones contributing most to the seismic hazard at the Millstone site, Expert 10's bounds on the input parameters are smaller than Expert 5's bounds. Typically the sensitivity of the CPHC is directly related to a particular expert's uncertainty. The smaller the uncertainty, the better CPHC agree between different sets of random simulations. Also, the smaller the number of simulations required to get reasonably stable estimates for the various CPHC.

Figure 4.5.2 shows a comparison between two sets of simulations for Expert 5 using a lognormal distribution for the simulation of the a- and b- values. The agreement between the 15th and 50th percentile CPHC are about the same as for the case of the triangular distributions used to develop the CPHC shown on Fig. 4.5.1. However, the 85th percentile CPHC are in better agreement for the lognormal distribution cases than for the triangular distribution cases. On Fig. 4.5.3 a comparison is made between two of the sets of CPHC from Fig. 4.5.1a and the two sets for the lognormal distribution shown in Fig. 4.5.2. It is observed that there is a significant difference between the 50th percentile CPHC for the two distributions. The major contributor to this difference in the 50th percentile CPHC between the triangular and lognormal distributions comes from the distortion introduced by attempting to fit a lognormal distribution to the parameters provided by the expert.

Figure 4.5.4 shows the influence of the number of simulations needed to define the individual seismicity experts' CPHC. As noted, above, the set of conditions represent a worst case. For this set of runs, a full simulation was performed using 10, 20 and 50 simulations per ground motion expert for a total of 50, 100 and 250 simulations per seismicity expert. The figure shows that at least 20 simulations per ground motion expert are required. There appears to be little difference between the 20 simulation cases and the 50 simulation cases. However, to ensure that the CPHC were adequately defined for each seismicity and ground motion expert our analysis for the CPHC are based on 50 simulations per ground motion expert for a total of 250 simulations per seismicity expert per site. The combined CPHC for each site is based on 2750 simulations (250 X 11 seismicity experts). The CPUHS curves are based on 30 simulations per ground motion expert for a total of 150 simulations per seismicity expert per site and the combined CPUHSs are based on 1650 simulations per site (150 X 11 seismicity experts).

In questionnaire 5 the experts were asked to select between having no correlation, partial correlation and full negative correlation between the simulated a- and b-values. Six experts selected partial correlation, four selected no correlation and one expert selected full negative correlation (Table 3.3.1). Figure 4.5.5 shows that there is very little difference between using partial correlation and no correlation. For the case of full negative correlation, as shown in Fig. 4.5.5, there is a significant reduction in the uncertainty bounds and a significant reduction in the 50th percentile CPHC as compared to the other two models for simulation of the a- and b-values.

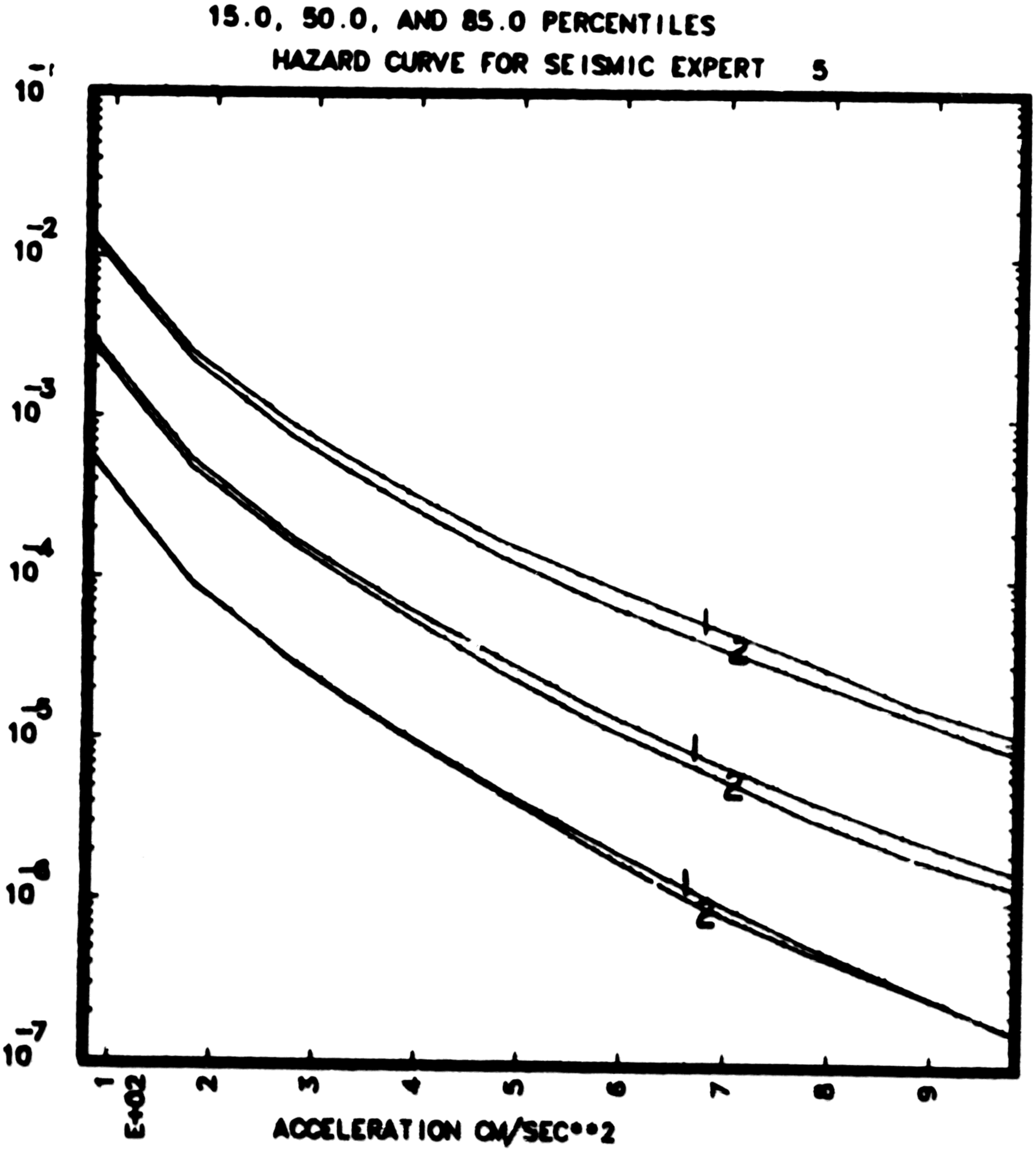
COMPARISON OF TWO SETS OF CPHC OBTAINED FROM TWO DIFFERENT RANDOM SIMULATIONS (200 SIM. EACH CASE)



MILLSTONE

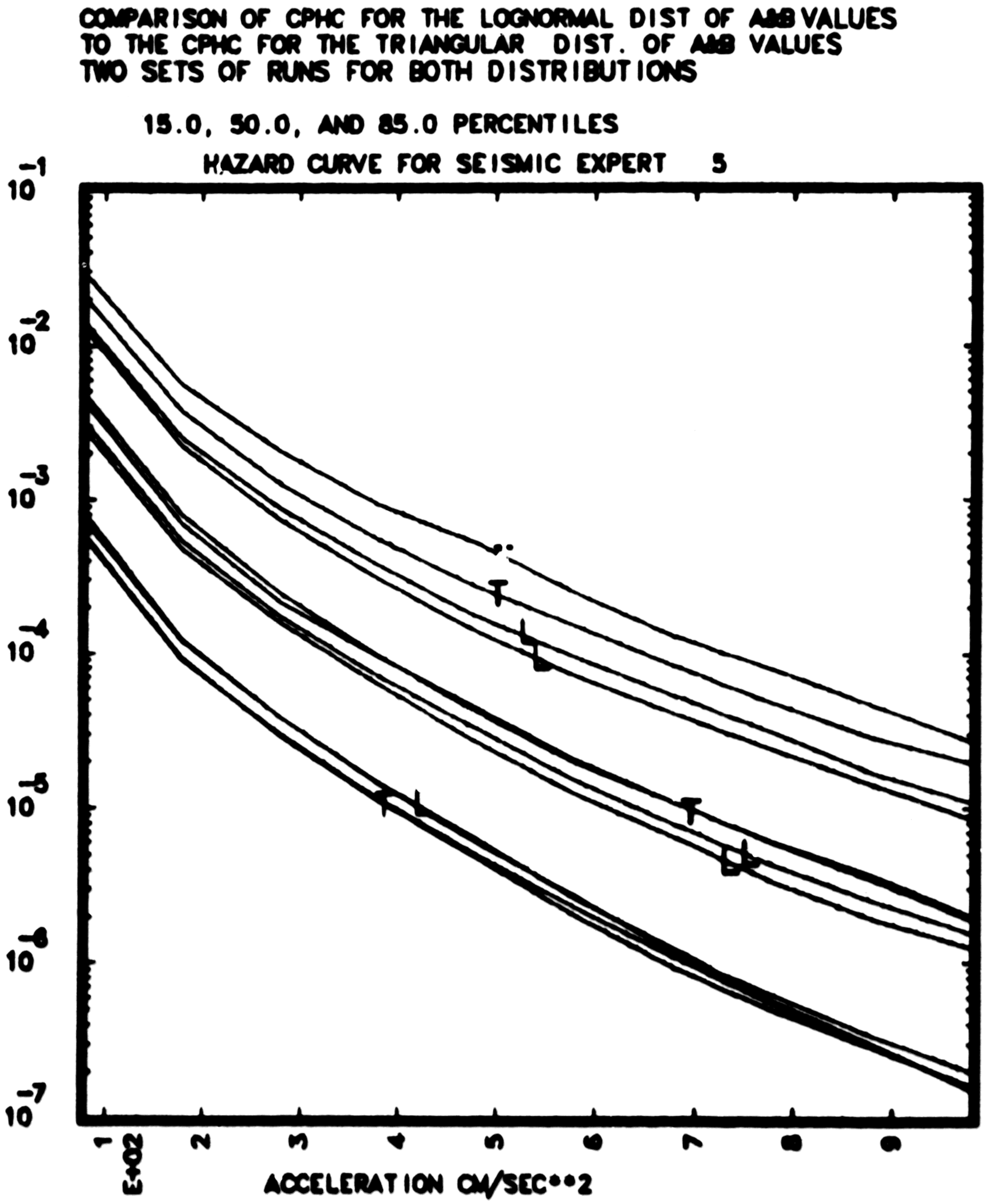
Figure 4.5.1b

COMPARISON OF TWO SETS OF CPHC FOR CASE OF LOGNORMAL
DIST. FOR A&B VALUES (200 SIM EACH CASE)



MILLSTONE

Figure 4.5.2



MILLSTONE

Figure 4.5.3

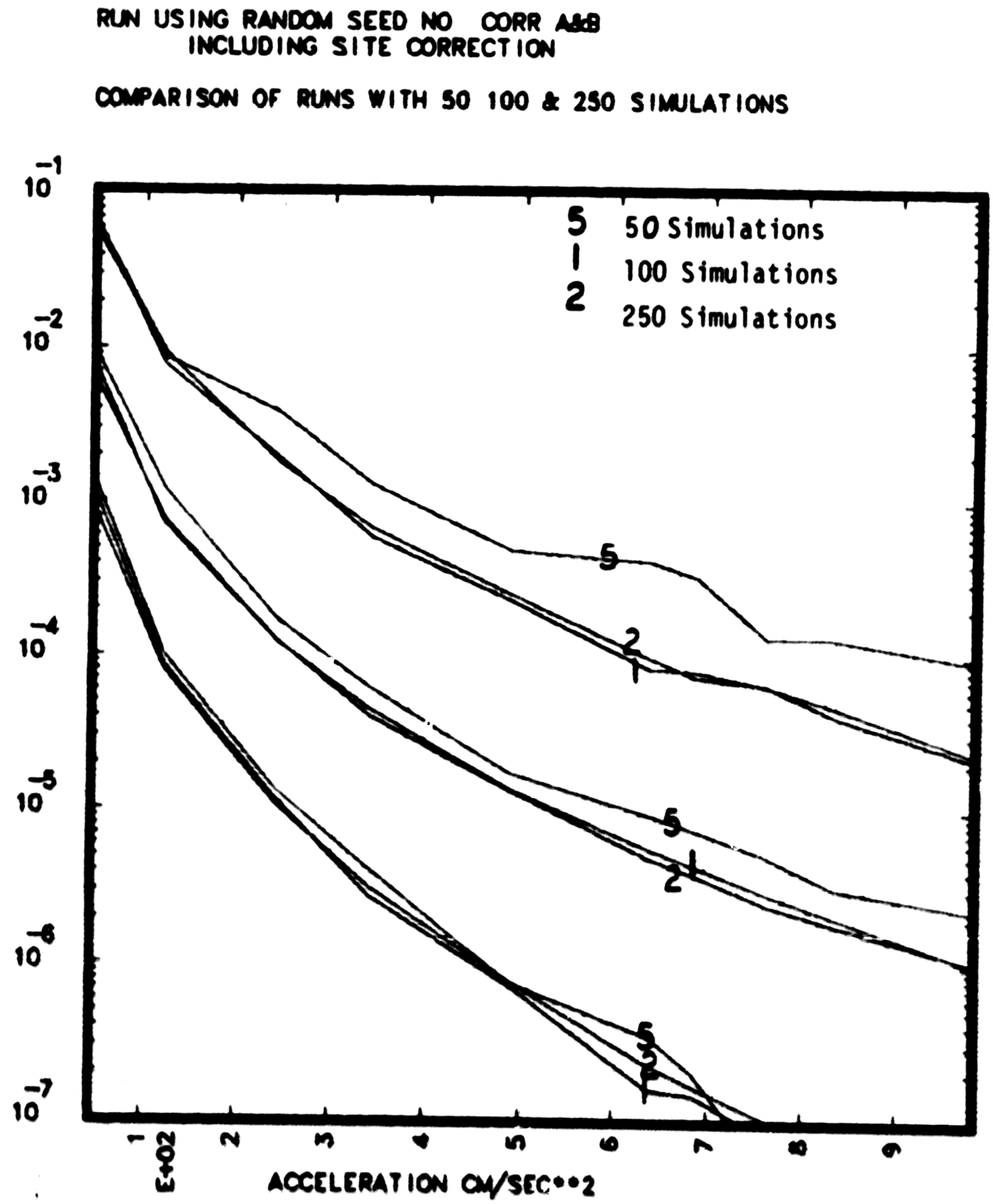

RUN USING RANDOM SEED NO CORR A&B
INCLUDING SITE CORRECTION
COMPARISON OF RUNS WITH 50 100 & 250 SIMULATIONS
5 50 Simulations
1 100 Simulations
2 250 Simulations
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
1 E+02
2
3
4
5
6
7
8
9
ACCELERATION CM/SEC**2

Figure 4.5.4

COMPARISON OF NO/PARTIAL/FULL A&B CORRELATION
NO SITE CORRECTION OR TRUNCATION -ONLY MODEL*8 USE

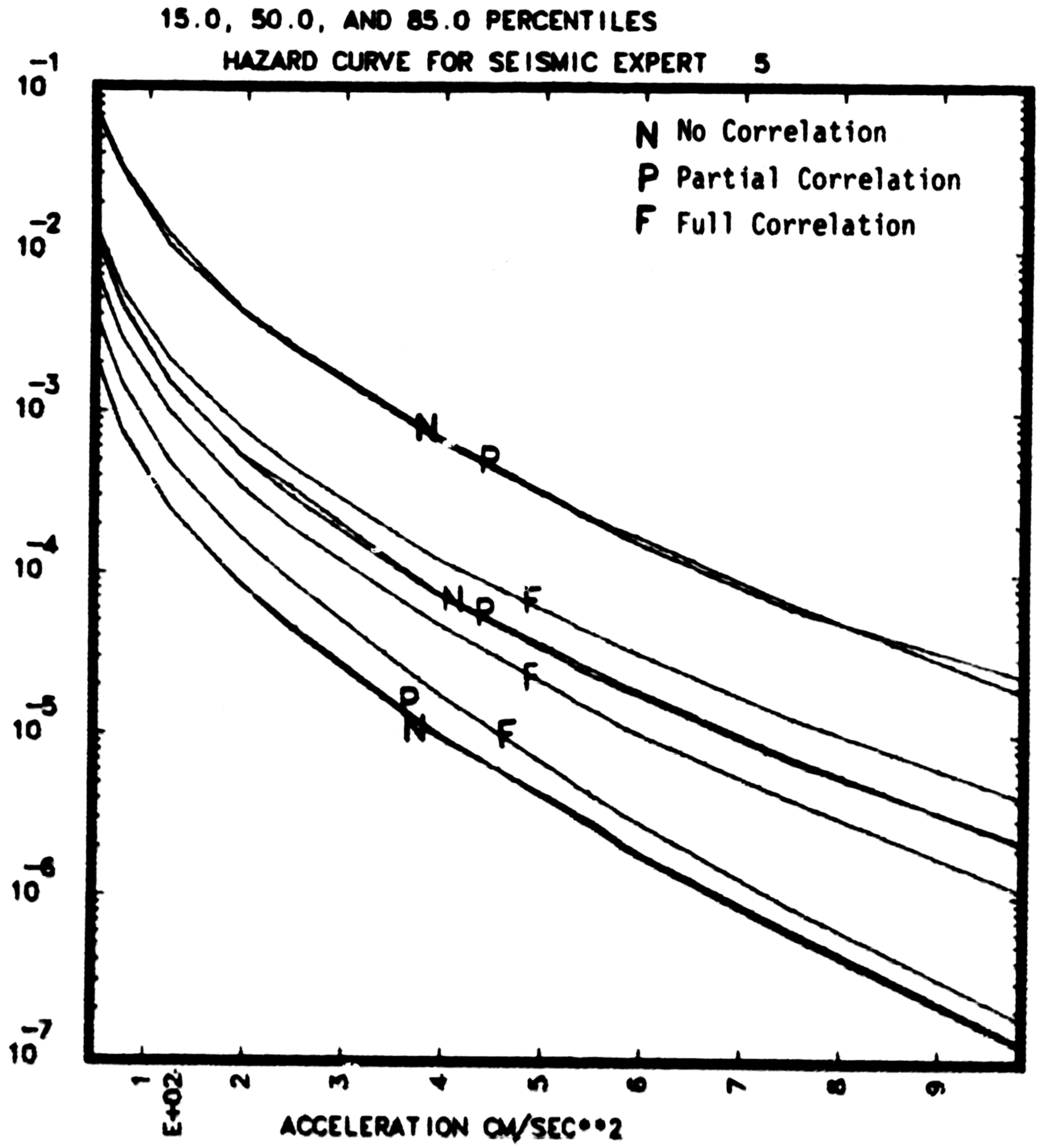


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Figure 4.5.5

SECTION 5 RESULTS FOR TEN SITES

5.1 Introduction

The results of the seismic hazard analyses, performed for the ten sites described in Sec. 3.5 (locations shown in Fig. 3.5.1, regions shown in Fig. 2.4), are presented and discussed in this section. The information necessary to develop a seismic hazard at a site consits of the following:

- o Seismic source modeling (zonation). This is done through the zonation described in Sec. 3.2.
- o Source seismicity. Described in Sec. 3.3.
- o Recurrence modeling. Described in Section 3.3 and discussed in Questionnaire 3, of Volume 2.
- o Attenuation of ground motion from source. The ground motion modeling is discussed in Sec. 3.4.

From these general input and using the methodology described in Appendix C, a peak ground motion parameter is characterized for a site. Part of the ground motion characterization is the frequency content of the ground motion parameter. The possible models for evaluating frequency content are discussed in Questionnaire 4 and 6 of Volume 2.

Several factors make this seismic hazard characterization unique. One is the manner in which expert judgement is incorporated into the analysis; another is this method's consideration of random as well as model uncertainty in the zonation maps and in the ground motion models; and a third is that distributions of zonation, seismicity parameters, and ground motion models for each expert are used.

The seismic hazard is quantified in terms of peak ground acceleration (PGA) on best estimate hazard curves (BEHC), and constant percentile hazard curves (CPHC). The uniform hazard spectrum is developed for each frequency so the spectral amplitude has the same probability of being exceeded. The uniform hazard spectra for each site are developed as a function of the period for the best estimate uniform hazard spectra (BEUHS) and constant percentile uniform hazard spectra (CPUHS). Refer to Table 4.1.1 for plot symbols.

The results for the four sites used in the sensitivity study, discussed in Sec. 4, are presented in greater detail than the results for the other six sites. The greater detail illustrates the sensitivity of the hazard curve to changes in various parameters. This provides insights as to which factors contribute most to the uncertainty in estimating the seismic hazard at a particular site. This also shows justification for the smaller number of simulations chosen for spectral ordinate than for PGA.

A summary of the zones which contribute most to the seismic hazard at a site is presented in table form for each site. A complete summary for all sites is presented as Table A3 of Appendix A. The tables indicate those zones which contribute most for each seismicity expert and the approximate percent of contribution of that zone to the BEHC. Because contribution of a given zone can change with increasing PGA, the tables give zone contribution for low PGA proportion and high PGA proportion. The zone numbers are keyed to the maps and seismicity data files for each expert given in Appendix A.

5.2 Braidwood

5.2.1 Zonation Effects

The Braidwood site is a rock site (Category I) located in the north central (NC) region of the EUS. The experts' zonation maps are located in Appendix A. As can be seen from these zonation maps, most experts placed a zone which contained the site within the central stable region. The seismicity parameters for these zones are summarized in Table 5.2.1. Looking at this table, one can see that Experts 3, 5, 7, and 13 located the site in the CZ. For these experts, the upper magnitude cutoff in the CZ is not low by comparison with the other zones. As a result, the contribution of the CZ for Experts 5, 7, and 13 is dominant in the BEHC at low and high PGA as indicated in Table 5.2.2. For Expert 3, zone 14 is small but only 25 km away from the site and has an upper magnitude cutoff that is comparable to the CZ upper magnitude cutoff (6.8 vs. 7.3 respectively). Thus, zone 14 dominates the BEHC at low PGA and the CZ of Expert 3 dominates the BEHC at high PGA, with some effect from the New Madrid area. Table 5.2.2 shows that for the other experts the effect of the sparse zonation in the NC region makes the zone to which the site belongs the dominant zone at both low and high PGA.

5.2.2 PGA Hazard Curves

The BEHC combined over all experts is shown on Fig. 5.2.1. The BEHC per individual seismicity expert combined over all ground motion experts is shown on Fig. 5.2.2, where the number on the curves are the expert's numbers and the letters A,B,C and D stand for experts 10,11,12 and 13.

Examination of the different experts' curves of Fig 5.2.2 indicates several features. For example, if the BEHC for Experts 1 and 11 are compared, it can be seen that Expert 11's BEHC is about a factor of 4 higher than Expert 1's BEHC. Looking at Table 5.2.1, it appears that the main difference between the models of Expert 11 and Expert 1 is the rate of seismicity in the zone which contains the Braidwood site. The activity is about a factor of 4 higher for Expert 11 than for Expert 1. This follows with what is found in the sensitivity analysis.

The problem is more complex when significantly different b-values are involved. For example, from Table 5.2.1, a comparison of the normalized a-values between Expert 13 and Expert 11 suggest about a factor of 5 difference between their respective BEHC; however, as can be seen from Fig. 5.2.2, there is about a factor of 15 difference at low PGA and about a factor of 75 at high PGA. For different b-values, we need to compare the number of earthquakes greater than or equal to the magnitude range contributing to the loading at any given level. At PGA values of approximately 100 cm/s^2, this is for magnitude 3.75 and greater. The ratio of the number of events greater than m_{bLg} = 3.75 is about 25, i.e., earthquakes greater than m_{bLg} = 3.75 per unit of area in the zone that contains the Braidwood site are 25 times more frequent in Expert 11's zone 10 than in the CZ of Expert 13. This suggests that the BEHC for Expert 11 is "high" compared to BEHC of Expert 13. Table 5.2.2 shows that Expert 13's model has significant contributions from several other zones where Expert 11 has almost all loading contribution coming from one zone. At high PGA, the CZ of Expert 13 contributes most significantly to the hazard. The ratio of the number of earthquakes greater or equal to magnitude 6.0 between Expert 11 and Expert 13 is about 69. This may suggest that Expert 13's BEHC is low (at high PGA) compared to Expert 11's BEHC. A look at Table 5.2.1 shows that Expert 11 has a larger upper magnitude cutoff than Expert 13. This, along with some contribution of loading from other zones, accounts for the larger differences factor found in the BEHC.

The BEHC for Experts 7 and 10 are interesting because they cross each other. The reason for this is that at low PGA Expert 7's CZ contributes most of the loading but the Expert's zones 5 and 6 also contribute significantly. At high PGA most of the loading comes only from the CZ which contains the Braidwood site. The rate of activity in Expert 7's CZ is the same as that for zones 5 and 6, but the upper magnitude cutoff is larger for zones 5 and 6. Table 5.2.2 indicates that a number of zones contribute to Expert 10's BEHC at low PGA as with Expert 7, at high PGA most of the loading comes from Expert 10's zone 26 which contains the Braidwood site. The rate of activity in Expert 10's zone 26 is less than that for the experts' other zones which contribute at low PGA, but has a higher upper magnitude cutoff than the CZ which is the only other contributor at high PGA.

The shape of the BEHC at high PGA levels is controlled to a large extent by the upper magnitude cutoff. Figure 5.2.2 indicates that Experts 2, 3, 4, 5, 6, 11, 12, and 13 have similar shaped curves, while the curves of Experts 1, 7, and 10 tend to be "flatter." This flatter shape is associated with higher upper magnitude cutoffs. Then looking at host zone upper magnitude cutoffs, the BEHC for Experts 2 and 3 should have this "flatter" effect. But other zones with higher upper magnitude cutoffs make contributions which keep this "flattening" from occurring.

The sparsity of the zonation, as mentioned previously, makes the analysis very sensitive to the choice of Ground Motion models. As a result, the dispersion of the BEHC for the seismicity experts is great. In particular, the BE ground motion model of ground motion Expert 5 is always a high outlier. This condition is seen in Fig. 5.2.2 where the spread at low PGA encompasses a factor of about 13, but at high PGA a factor as high as approximately 88. Expert 13's results represent the lowest values and Expert 11's results the highest. The BEHC combined over all seismicity experts in Fig. 5.2.1 is near the middle of the cluster of curves in Fig. 5.2.2. The uncertainty analysis leads to a large dispersion in the hazard as shown in Fig. 5.2.3 (a factor of 25 to 30 at low PGA and 200 to 300 on the hazard at high PGA between the 15th and the 85th percentile curves). The BEHC lies significantly above the 50th percentile curve (a factor of about 2 at low PGA and about 10 at high PGA); it lies roughly in the vicinity of the 65th to 75th percentile curve from a visual inspection of Fig. 5.2.3.

5.2.3 Uniform Hazard Spectra

The BEUHS curves combined for all experts is shown in Fig. 5.2.4. The 500 year BEUHS for each seismicity expert combined over the five ground motion experts is shown on Fig. 5.2.5. The curves show a spread that is fairly uniform. The range of the pseudo-velocity results is a factor of 5 at all periods from .04 sec. to 2 sec. The BEUHS for Experts 2, 5, and 6 tend to turn upward at periods above approximately .3 seconds. The phenomenon occurs, too a much smaller extent, for Experts 3 and 4. It is caused by the interplay of the New Madrid zone (see Table 5.2.2) with a high magnitude or intensity cutoff with the other dominant zones when the ground motion model of Ground Motion Expert 5 is used (model#14 in Table B-1). Although this ground motion model carries only one-fifth weight, due to the combination method, it leads to high estimates at high magnitudes for longer periods. After combination over all ground motion experts, some zonation models will present these turns upward at long periods. When combined over all experts, the BEUHS has only a slight turn upward as can be seen in Fig. 5.2.4. The BEUHS curve of seismicity Experts 3 and 4 from Figs. 5.2.5 and 5.2.6 are the closest to the perspective final BEUHS of Fig. 5.2.4. In spite of the apparent diversity of opinions among seismicity experts for the zonation around the Braidwood site, the uncertainty in the UHS is only slightly greater than the average for the other sites. The outliers are removed by plotting only the CPUHS for the 15th, 50th, and 85th percentiles in Figs. 5.2.7, 5.2.8, and 5.2.9 for return periods of 500, 1000 and 10,000 years.

It has to be noted that the short period asymptote of the spectra does not necessarily match the hazard results obtained when the variable of interest is the PGA. The mismatch observed in this study is due to the following two reasons:

1. The levels confidence assigned by the Ground Motion Experts to the PGA models and the corresponding Spectra Models are different.

2. Some of the PGA models of attenuation do not have corresponding spectra models, and some of the spectra models do not have the corresponding PGA models.

This is a drawback in the ground motion models modeling which is due to the fact that there has been more research done on PGA models so far than on spectra models. As a result, there are classes of PGA models to which the experts assigned high levels of confidence, which do not have PGV or spectra counterparts. The experts chose to retain these PGA models in spite of the lack of corresponding spectra, and they chose their levels of confidence accordingly.

TABLE 5.2.1

Zones in Central Stable Region Containing the Braidwood Site

Expert No.	Zone No.	Prob of Exist	Area (10^5 km^2)	M_{LB}	M_{BE}	M_{UB}	a_N	b
1	19	0.7	2.4	6.1	6.5	7.0	2.6	0.93
2	21	0.5	0.5	5.5	6.0	6.5	2.8	0.92
3	14(1)	0.5	0.5	5.0	6.0	6.8	2.1	0.67
4	6(2)	0.75	0.6	5.8	6.0	6.2	2.8	0.90
6	23(3)	0.7	1.1	5.5	6.0	6.5	3.1	1.0
10	26	0.9	2.5	5.8	6.0	6.5	2.8	0.94
11	10	0.9	2.3	6.0	6.5	6.8	3.2	0.90
12	10	0.65	0.5	5.0	5.3	5.3	2.9	0.95
3	CZ(1)	1.0	92.6	6.0	6.5	7.3	2.6	1.10
5	CZ	1.0	65.0	5.3*	5.8*	6.3*	2.4	0.92
7	CZ	1.0	56.7	6.2	6.7	7.2	2.1	0.90
13	CZ(15)	1.0	60.6	6.0	6.3	6.5	2.5	1.09

*The expert's values were MMI = VII, VIII and IX. They were transformed to magnitudes by using the relationship recommended by the expert $M = \frac{1}{2}(I+3.5)$

+ This notation indicates that the CZ was also identified as zone 15 by the expert

(1) Site is in Expert 3's control zone, zone 14 is about 25 km away.
(2) Site is at edge of boundary of zone 6 for Expert 4.
(3) Site is at edge of boundary of zone 23 for Expert 6.

M = Upper Magnitude Cutoff
BE = Best Estimate, LB = Lower Bound, UB = Upper Bound
a_N = logarithm of the best estimate of the a-value normalized to areas of 10^5 km^2.

TABLE 5.2.2

Zonal Dominance In The
BEHC At Low and High PGA

SITE: Braidwood
SITE CLASSIFICATION: Rock
REGIONAL LOCATION: North Central

Seis-micity Expert	Expert's Host Zone		Contribution to the Hazard									
			Low PGA (.05g)					High PGA (1.0g)				
1	19	Zone	19	11	9	10	CZ	19	9	11		
		Contribution	.63	.22	.06	.05	.03	.95	.03	.02		
2	21	Zone	21	18	20	CZ		21	CZ	18		
		Contribution	.57	.18	.12	.12		.63	.24	.13		
3	CZ(1)	Zone	14	CZ	16	17	15	CZ	16	15	14	17
		Contribution	.58	.21	.09	.08	.03	.90	.03	.03	.02	.02
4	6	Zone	6	4	5	3	CZ	6	4	CZ		
		Contribution	.80	.11	.06	.01	.01	.91	.05	.03		
5	CZ(2)	Zone	CZ	15	14	12	6	CZ	15			
		Contribution	.57	.23	.10	.08	.02	.70	.30			
6	23	Zone	23	17	CZ	16		23	CZ	17		
		Contribution	.57	.32	.09	.01		.59	.28	.12		
7	CZ(2)	Zone	CZ	5	6	7	11	CZ	6			
		Contribution	.85	.07	.06	.01	.01	.96	.04			
10	26	Zone	26	CZ	12A	13		26	CZ			
		Contribution	.69	.21	.05	.04		.91	.09			
11	10	Zone	10	CZ	11			10				
		Contribution	.96	.03	.01			1.00				
12	10	Zone	10	CZ	11	12		10	CZ	12		
		Contribution	.59	.32	.05	.04		.89	.10	.01		
13	CZ (15+16+17)	Zone	CZ	6	5	7	8	CZ	5			
		Contribution	.81	.10	.06	.02	.01	.99	.01			

NOTE: Contributions may not add up to 1.00.

The notation CZ (2) means that the CZ is also called zone 2 by the expert.

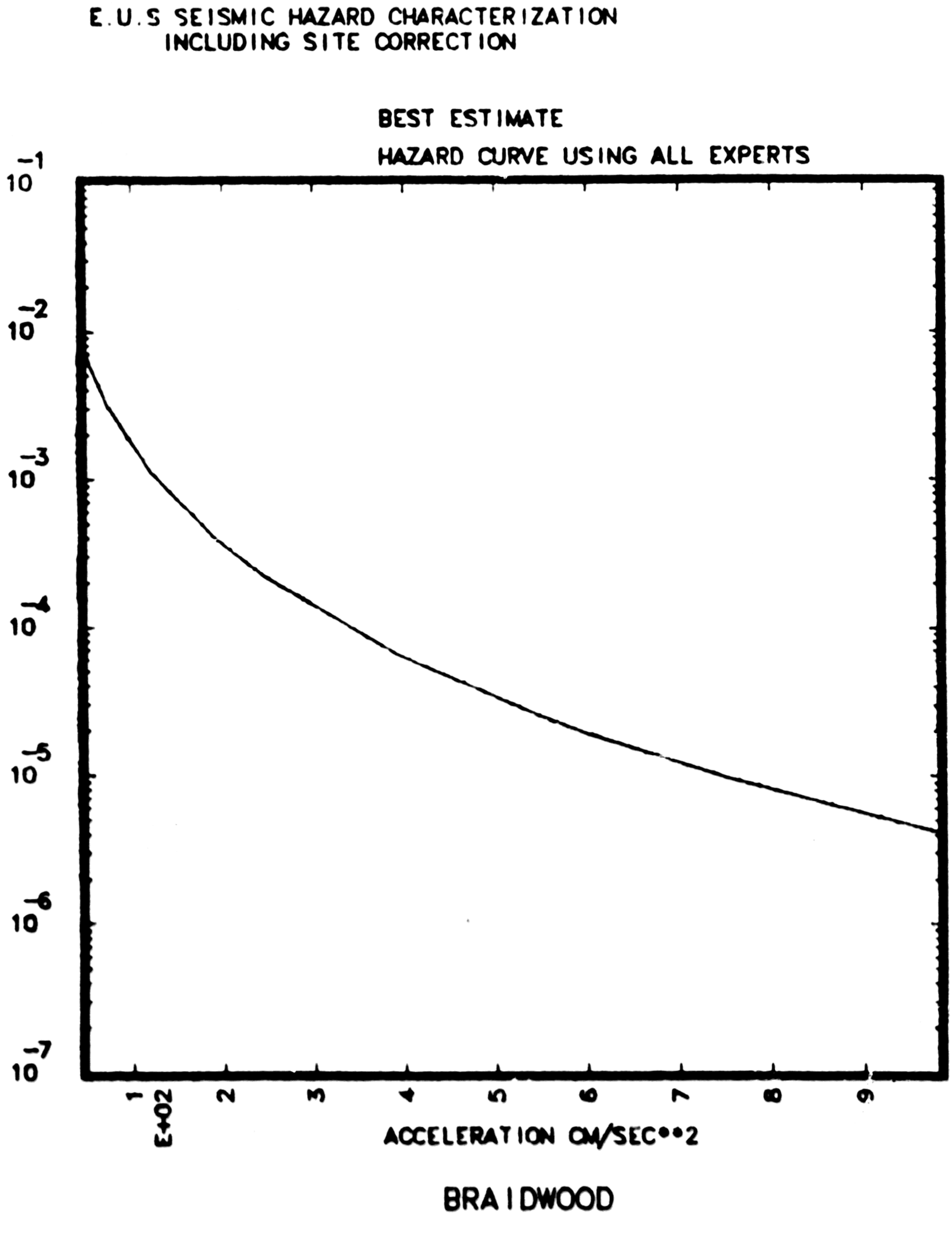


Figure 5.2.1 BEHC Combined Over All Experts

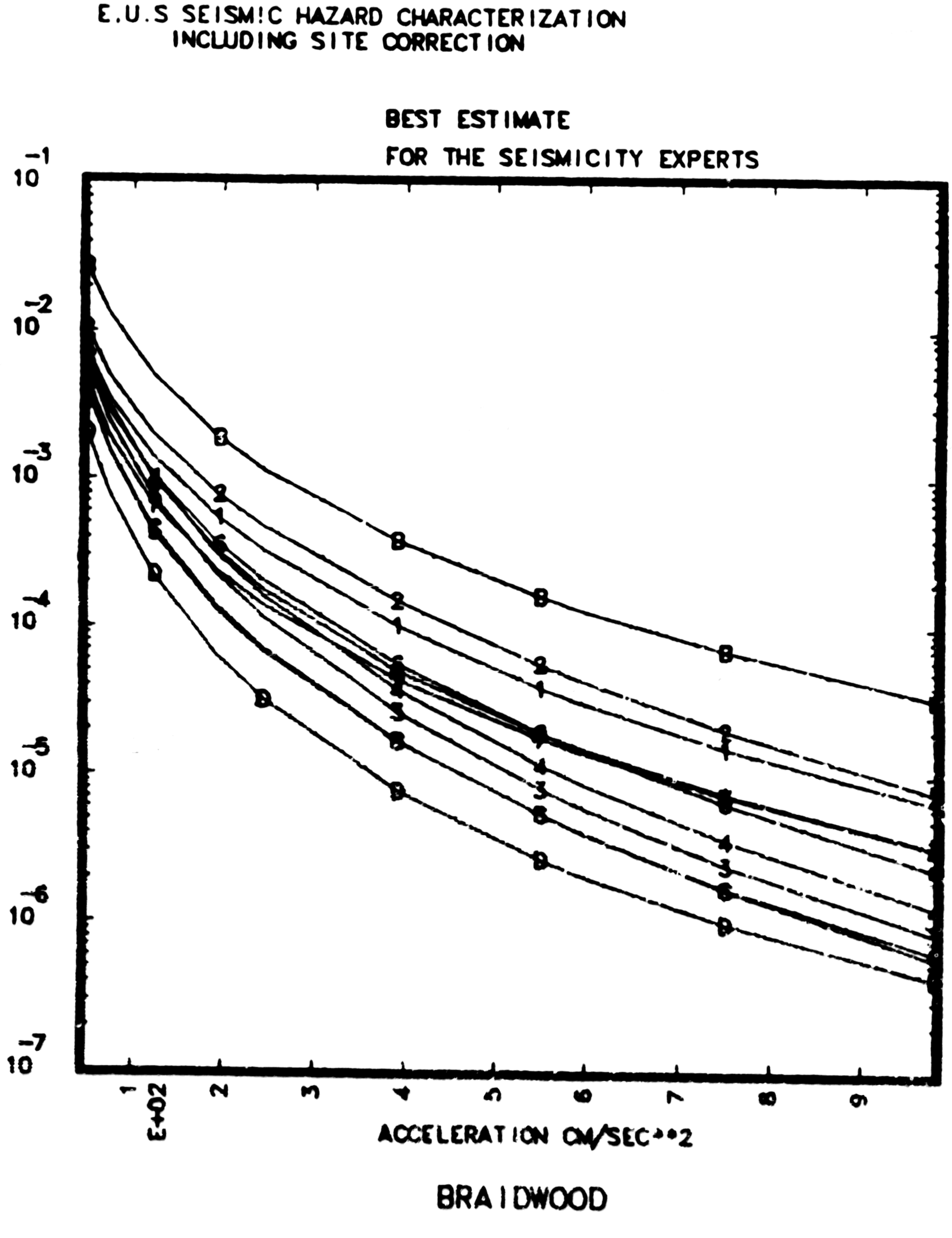


Figure 5.2.2 BEHC per Seismicity Expert Combined Over All Ground Motion Experts

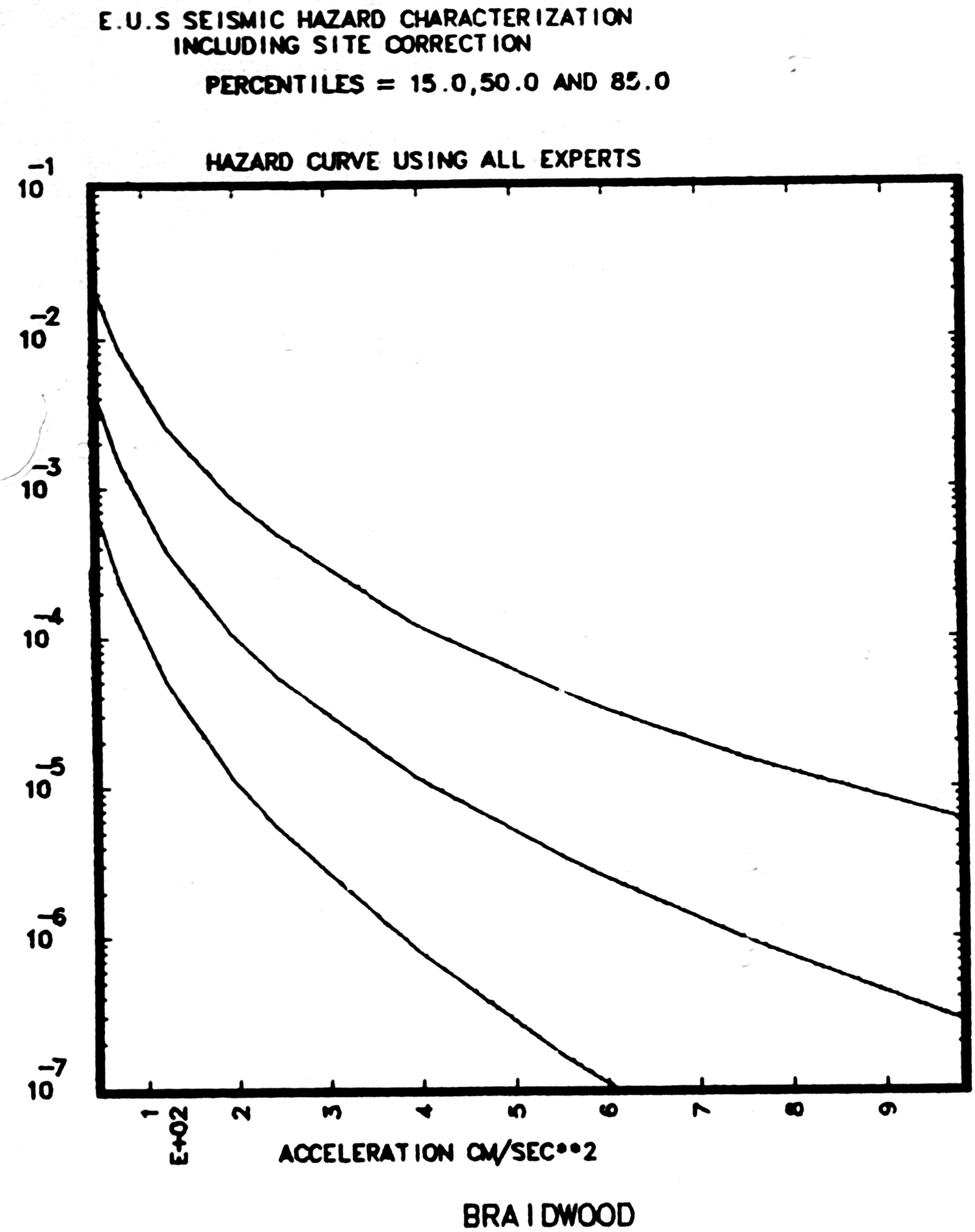


Figure 5.2.3 Constant Percentile Hazard Curves (CPHC) Over All Experts

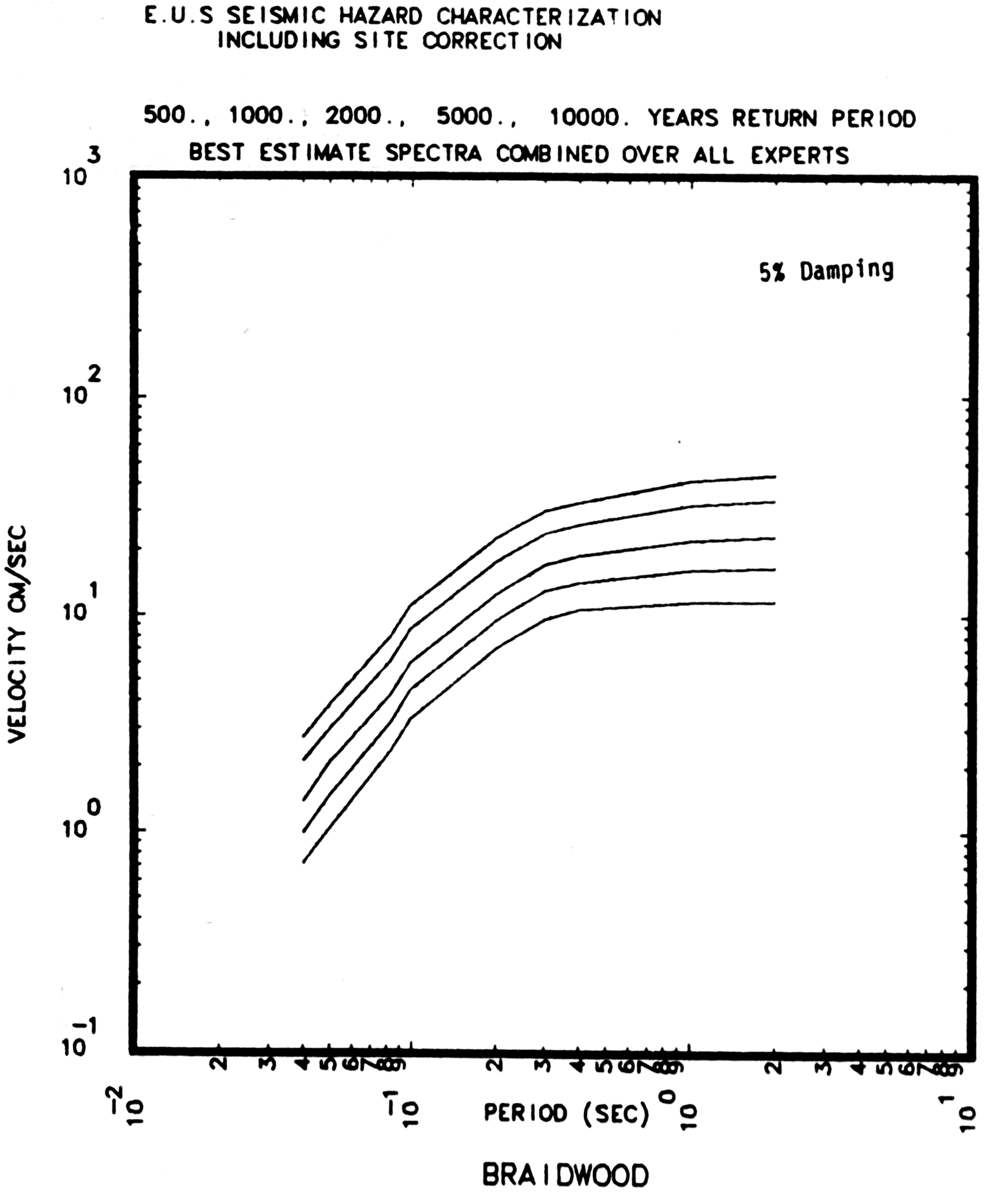


Figure 5.2.4 Best Estimate Uniform Hazard Spectra (BEUHS) Curves Over All Experts

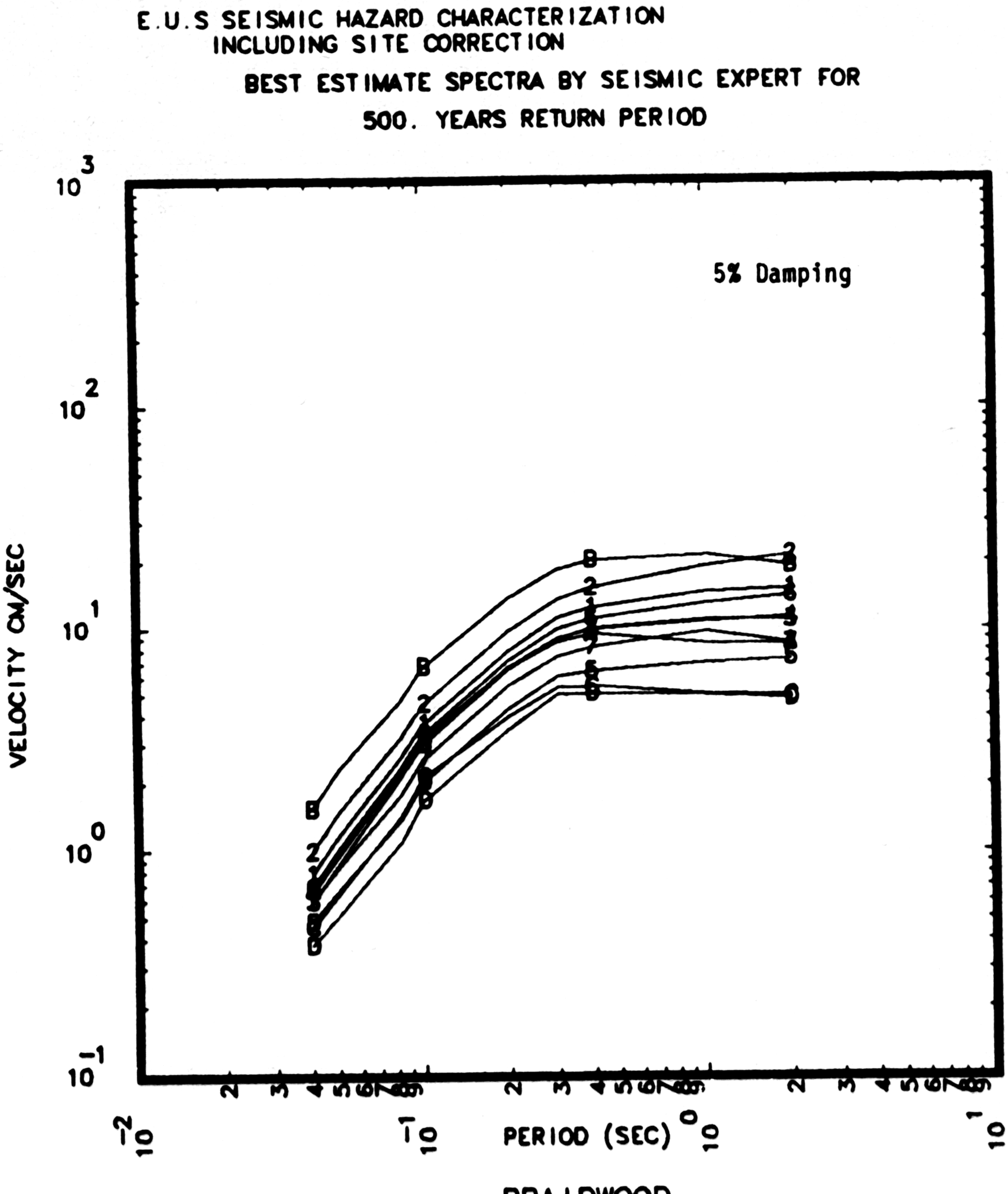


Figure 5.2.5 500 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

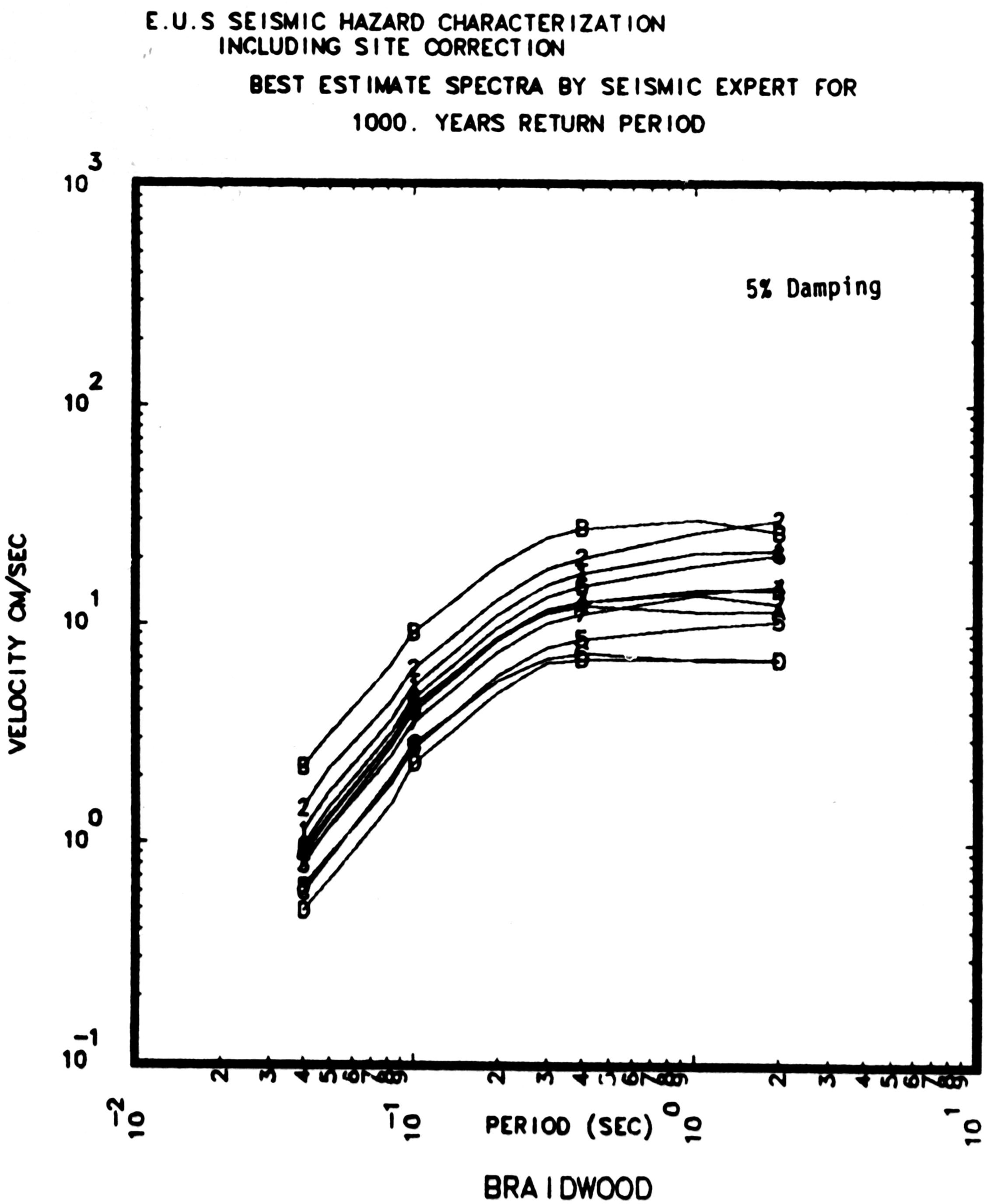


Figure 5.2.6 1,000 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

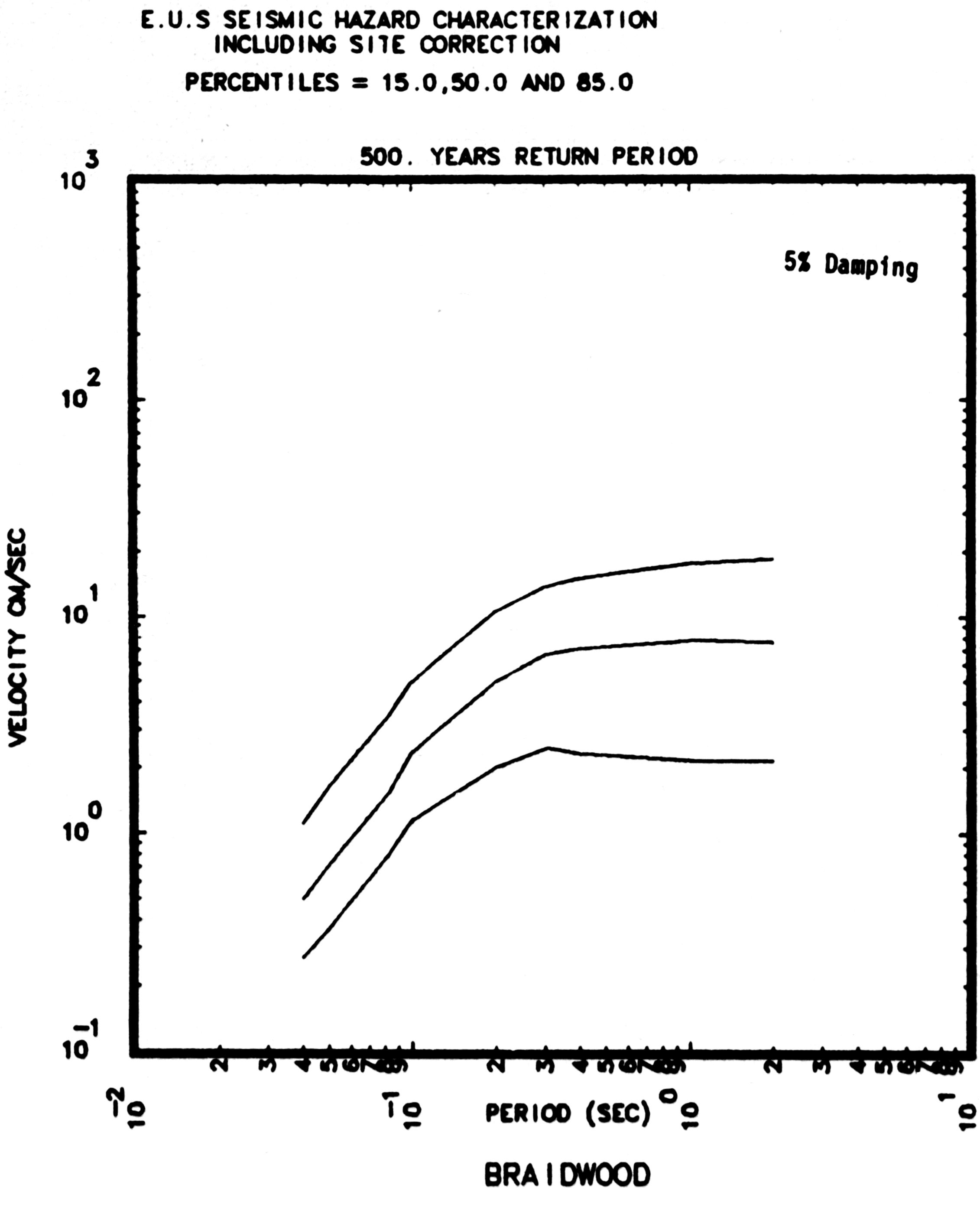


Figure 5.2.7 500 Year Return Period CPUHS Over All Experts

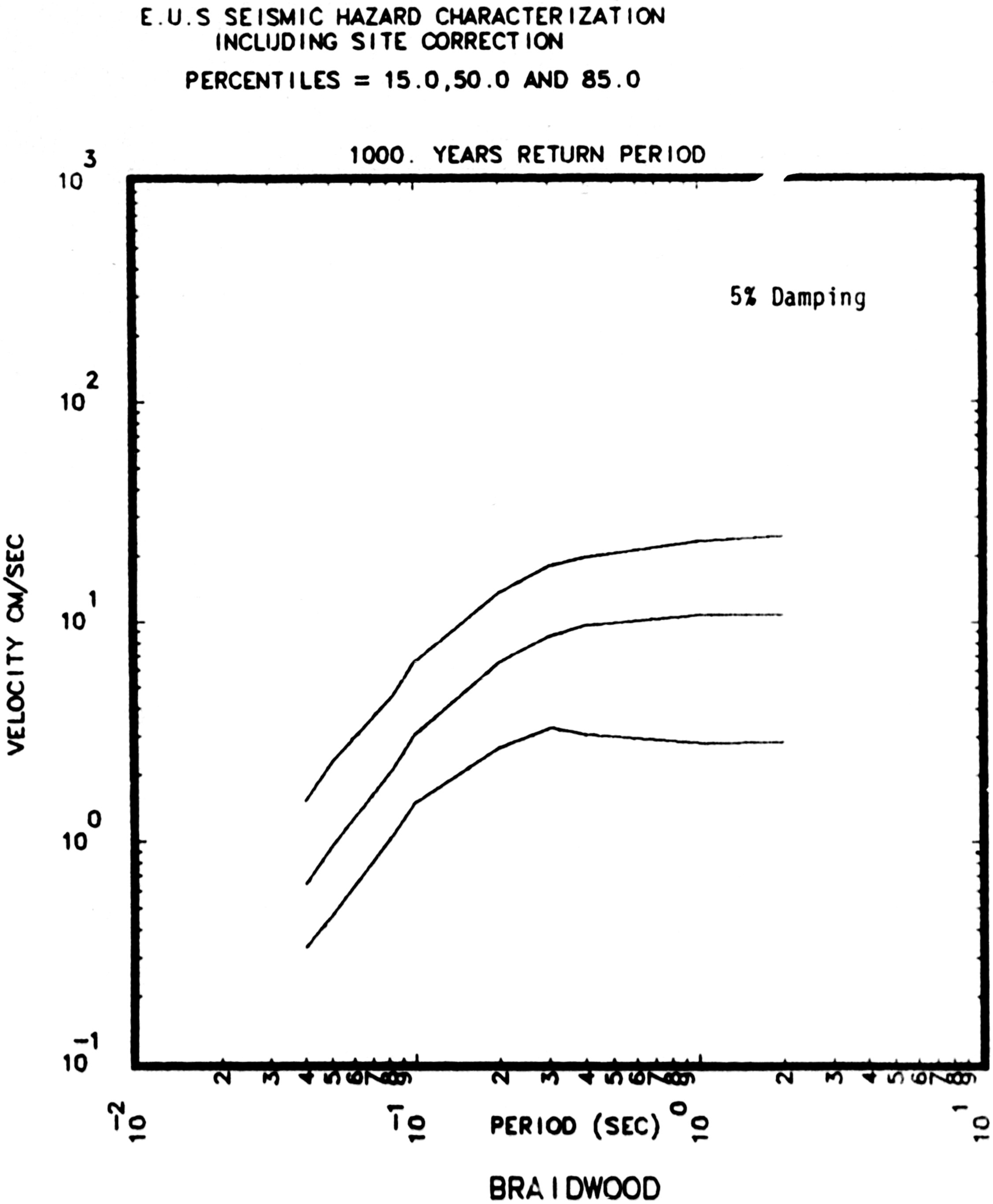


Figure 5.2.8 1,000 Year Return Period CPUHS Over All Experts

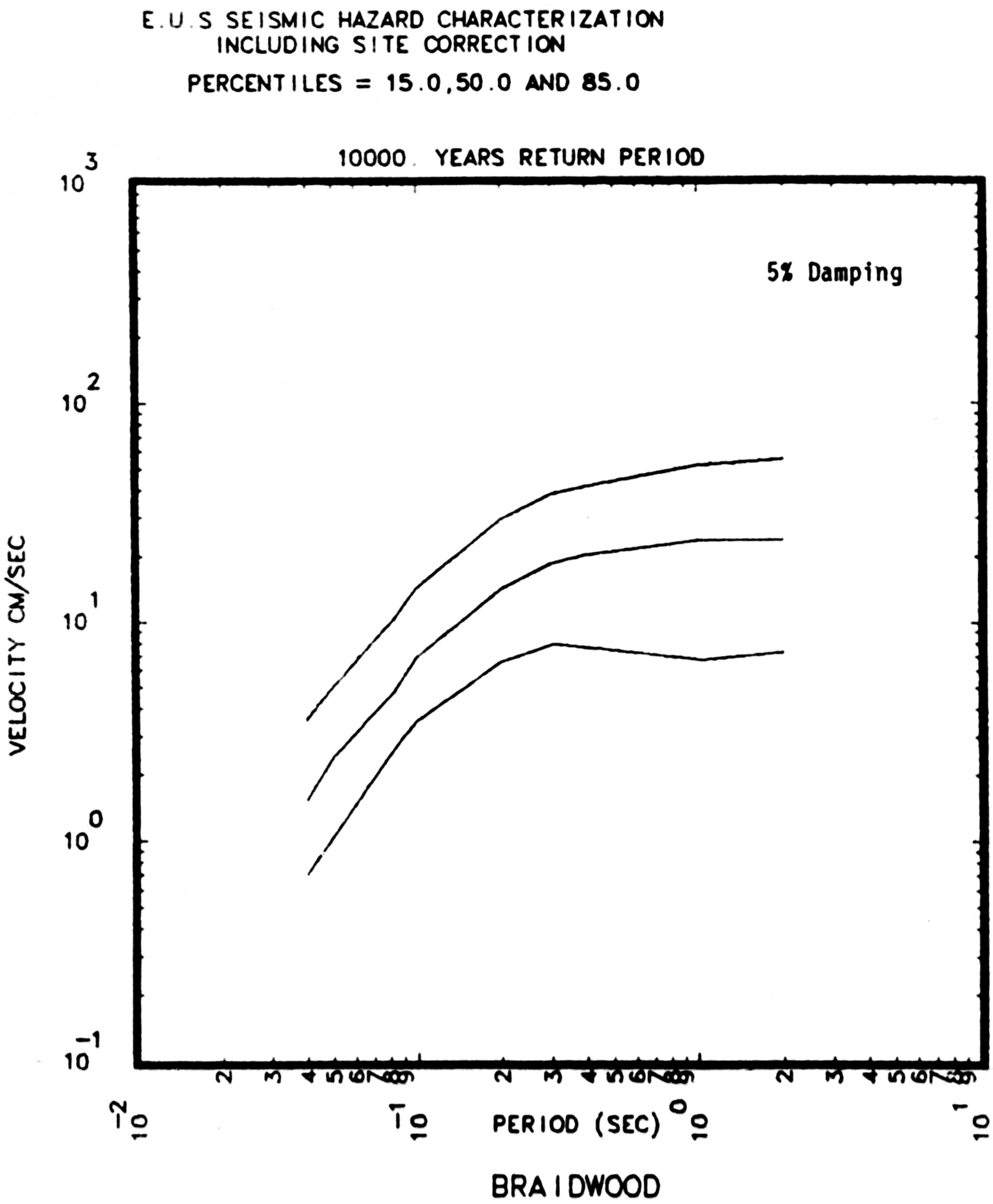


Figure 5.2.9 10,000 Year Return Period CPUHS Over All Experts

5.3 Shearon Harris

5.3.1 Zonation Effects

The Shearon Harris site is a rock site (Category I) located in the southeast region (SE) of the EUS. For Experts 2, 3, 6, 7, and 13, the site falls into the CZ, and for the other experts it belongs to another specified zone. Since the upper magnitude cutoff for the CZ is relatively high for the five experts mentioned above, in the same range of values as for the zones in which the site falls for the other experts, the hazard curves at high PGA values behave similarly for all experts. The zonal dominance of each seismicity expert is summarized in Table 5.3.1.

5.3.2 PGA Hazard Curves

The BEHC combined over all experts is shown on Fig. 5.3.1; the BEHC per individual seismicity expert is presented in Fig. 5.3.2. Looking at this latter figure, it can be seen that the hazard curves per Seismicity Expert do indeed behave in a similar fashion. Some variation does seem to occur in the BEHC for Experts 2, 3, 7, and 10. Experts 3, 7, and 10 have curves which are slightly more concave than the others. Table 5.3.1 shows that at low PGA values, for these experts, several of their zones make significant contributions to the hazard. Combine this with the fact that these experts also have high upper magnitude cutoffs for all zones which contribute significantly to the hazard. This varies from Expert 12 who has zonal contributions similar to Expert 10. A look at Table A3 of Appendix A shows the differences between the upper magnitude cutoffs for the two experts and the relevant zones. The upper magnitude cutoffs for Expert 12 are lower than those for Expert 10. Expert 2's curve has slightly less curvature than the other hazard curves. Table 5.3.1 indicates that this is due to the fact that at high PGA a zone other than the host zone makes a significant contribution to the hazard, and the zone which contributes the most to the hazard at high PGA is not the zone which contributes the most at low PGA. The difference in the upper magnitude cutoffs for Expert 2's CZ and zone 30 is slight compared to Expert 6's upper magnitude cutoffs for zone 1C and the CZ. This similarity in upper magnitude cutoff in the two zones of Expert 2 keeps the curve "flatter" by comparison. Experts 3 and 13 have very similar CZ in terms of seismicity and upper magnitude cutoff, thus their hazard curves converge at high PGA, but Expert 13 has a nearby zone (zone 9) which has more activity than the nearby zone (zone 10) of Expert 3, thus the zone 9 of Expert 13 dominates sightly at low PGA, and gives higher mid-range values for Expert 13's curve. The spread between the BEHC of Fig. 5.3.2 (on the order of a factor of 5 at low PGA and a factor of 20 at high PGA) reflects the diversity of expert opinions in the estimate of the BE parameters.

The site is located relatively close to zones of high seismicty (BE) and high magnitude cutoffs (BE), and there is a complex effect of contribution from those zones and the combined ground models. For example, the relative location of Expert 2's BEHC is controlled by ground motion Expert 5's BE model. When only ground motion model #7 is used, Expert 2's BEHC is the lowest (at high PGA) hazard curve for the Shearon Harris site. With the inclusion of BE ground motion model #27, Expert 2's BEHC is one of the highest. This effect is also apparent in Table 5.3.1. The changing dominance from one zone to another between low and high PGA indicates that the dominance is due to a change in ground motion model.

The BEHC over all experts, shown in Fig. 5.3.1, falls close to the middle of the cluster of BEHC by seismicity expert of Fig. 5.3.2 to refute the existence of outliers.

The CPHC is shown in Fig. 5.3.3 for all seismicity and ground motion experts combined for the 15th, 50th, and 85th percentiles. The spread between the 15th and 85th percentile curves is a factor of about 28 at low PGA and a factor of about 150 at high PGA levels. Again the large spread is due to the diversity of expert opinion on the zonation, seismicity, and ground motion modeling for analysis of sites located in the southeastern United States. Furthermore, a large discrepancy between the BEHC on Fig. 5.3.1 and the 50th percentile HC on Fig. 5.3.3 emphasizes the fact that the distributions of most of the parameters dominant in the uncertainty are highly skewed. It also underlines the difference between arithmetic averaging of the curves (as performed in the BE cases) and the geometric averaging performed in the interpolation process designed to determine the CPHC.

5.3.3 Uniform Hazard Spectra

The BEUHS curves on Fig. 5.3.4 are combined over all experts for the five return periods selected, and they exhibit a shape close to the Newmark-Hall spectrum shape. The curves diverge slightly as the period increases. An examination of Figs. 5.3.5 and 5.3.6 shows that the divergence is essentially due to one outlying curve, with slight influence of two other outlying curves. Expert 2 appears to provide the highest hazard for the spectral velocity in terms of BEUHS. It is noted that Expert 2 also provided one of the highest hazards for the PGA in terms of BEHC. Expert 2 contributes most to the slight divergence of the BEUHS as the period increases (See BEHC discussion). Experts 3 and 12 do contribute some to the divergence. Expert 3, which had the lowest HC in Fig. 5.3.2 is the lowest on Figs. 5.3.5 and 5.3.6 only at short periods. At longer periods the BEUHS for Expert 12 is lower than that of Expert 3. This is a consequence of the role that different zones play in association with the BE ground motions and various levels of upper magnitude cutoffs and distances.

The CPUHS for the 500, 1,000, and 10,000 year return periods, combined over all experts, are presented in Figs. 5.3.7, 5.3.8, and 5.3.9 for the 15th, 50th and 85th percentiles. The 85th percentile CPUHC is on the average a factor 2 to 3 times higher than the 50th percentile. The 15th percentile curve is an average 2 to 3 times smaller than the median, except at periods longer than .3 secs where the site correction introduces more uncertainty, as described in Section 4.4. This is a somewhat moderate to low dispersion by comparison with the results obtained for other sites evaluated.

TABLE 5.3.1

Zonal Dominance In The
BEHC At Low and High PGA

SITE: Shearon Harris
SITE CLASSIFICATION: Rock
REGIONAL LOCATION: Southeast

Seismicity Expert	Expert's Host Zone		Contribution to the Hazard: Low PGA (.05g)						High PGA (1.0g)			
1	3	Zone	3	1	2	4			3	1		
		Contribution	.85	.07	.06	.02			.99	.01		
2	CZ	Zone	30	CZ	27	29	18		CZ	30		
		Contribution	.62	.17	.11	.09	.01		.84	.16		
3	CZ(1)	Zone	CZ	10	11	8	9	16	CZ	10	11	
		Contribution	.40	.28	.15	.12	.05	.01	.95	.03	.01	
4	11	Zone	10	11	9	26	8	CZ	11	10		
		Contribution	.52	.38	.04	.03	.02	.01	.93	.07		
5	10	Zone	10	9	8	11	6		10	9		
		Contribution	.64	.28	.05	.02	.01		.91	.09		
6	CZ(1)	Zone	10	8	CZ	9	17	7	CZ	10	8	9
		Contribution	.34	.30	.24	.08	.03	.01	.86	.12	.02	.01
7	CZ(2)	Zone	CZ	8	9	10	7		CZ	10		
		Contribution	.39	.21	.18	.13	.10		.97	.03		
10	4	Zone	4	28	15	28A	5		4			
		Contribution	.71	.12	.08	.08	.01		1.00			
11	7	Zone	7	8	6	CZ	5		7	8		
		Contribution	.80	.13	.03	.01	.01		.76	.24		
12	3	Zone	3	15	14	5	2		3	14		
		Contribution	.71	.13	.12	.02	.01		.98	.02		
13	CZ	Zone	9	CZ	8				CZ	9		
	(15+16+17)	Contribution	.51	.35	.13				.92	.08		

NOTE: Contributions may not add up to 1.00.

The notation CZ(2) means that the CZ was also called zone 2 by the expert.

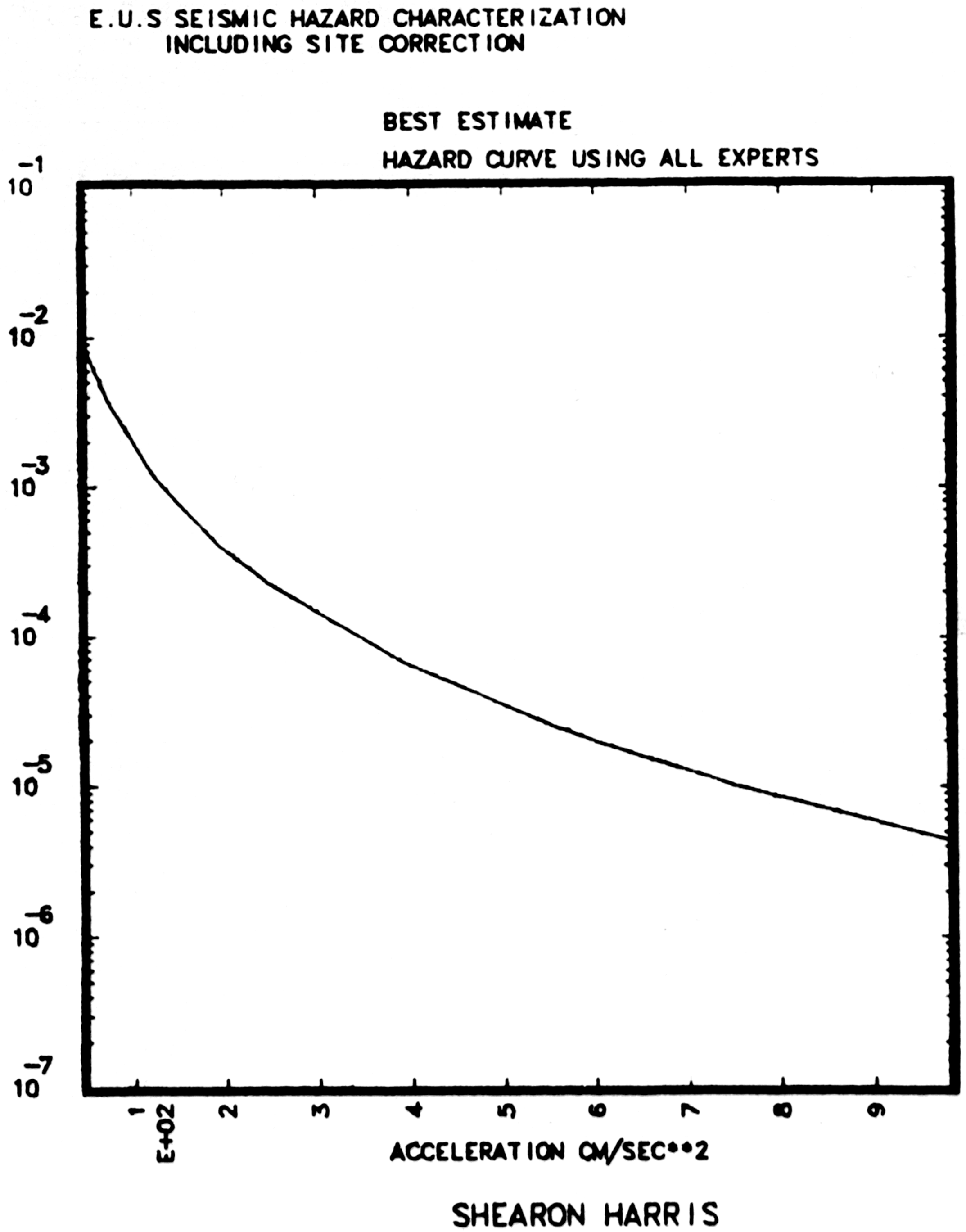


Figure 5.3.1 BEHC Combined Over All Experts

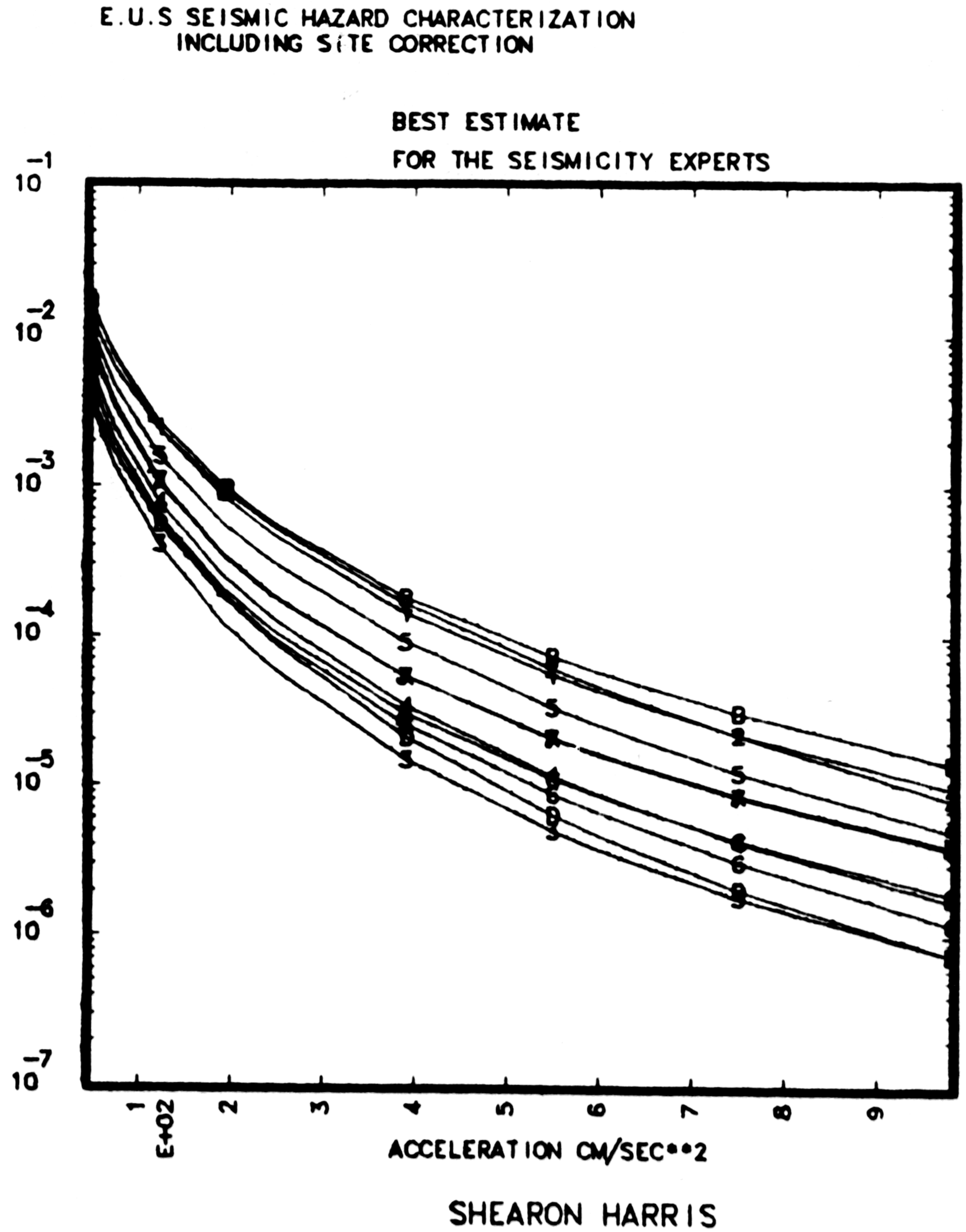


Figure 5.3.2 BEHC per Seismicity Expert Combined Over All Ground Motion Experts

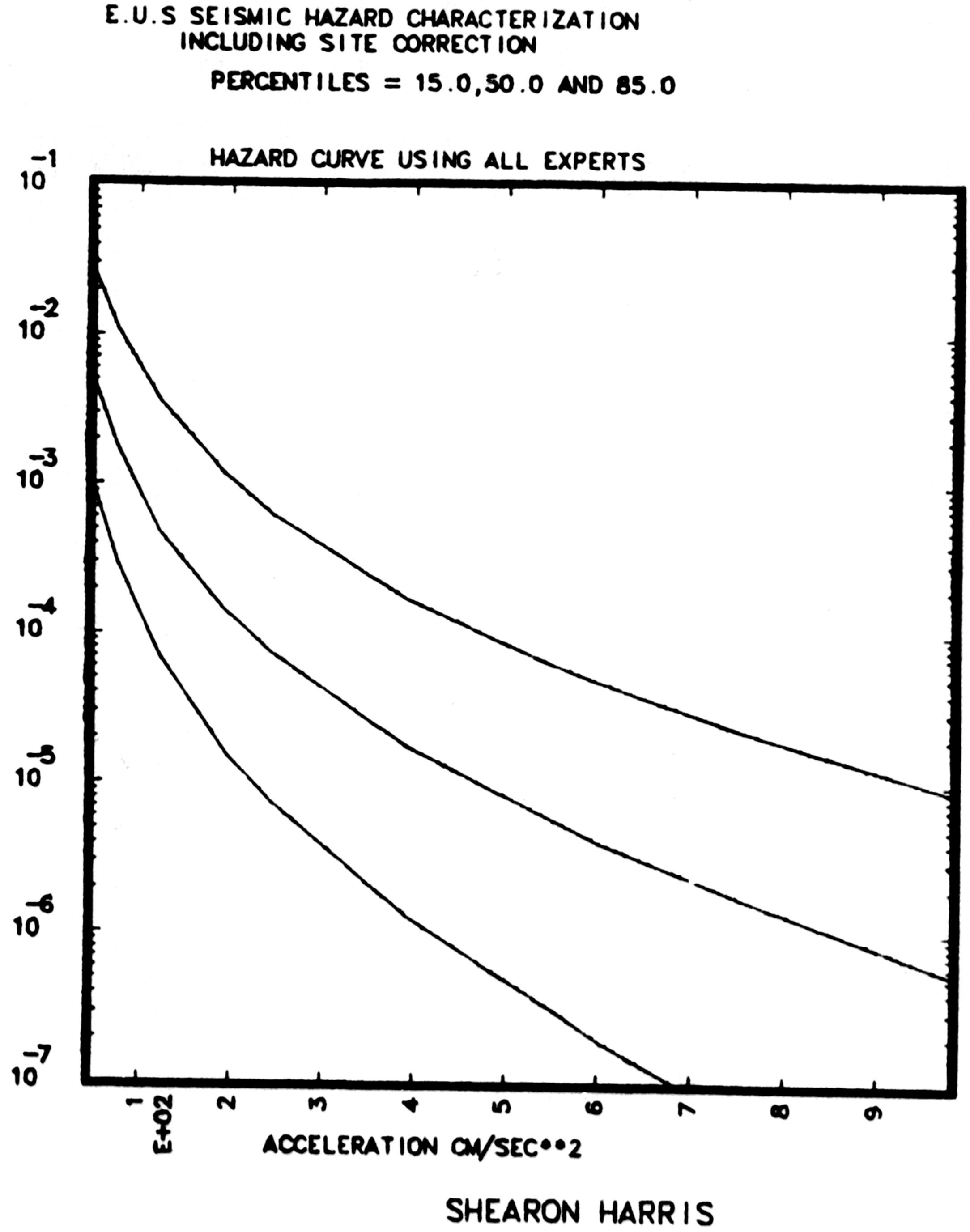


Figure 5.3.3 Constant Percentile Hazard Curves (CPHC) Over All Experts

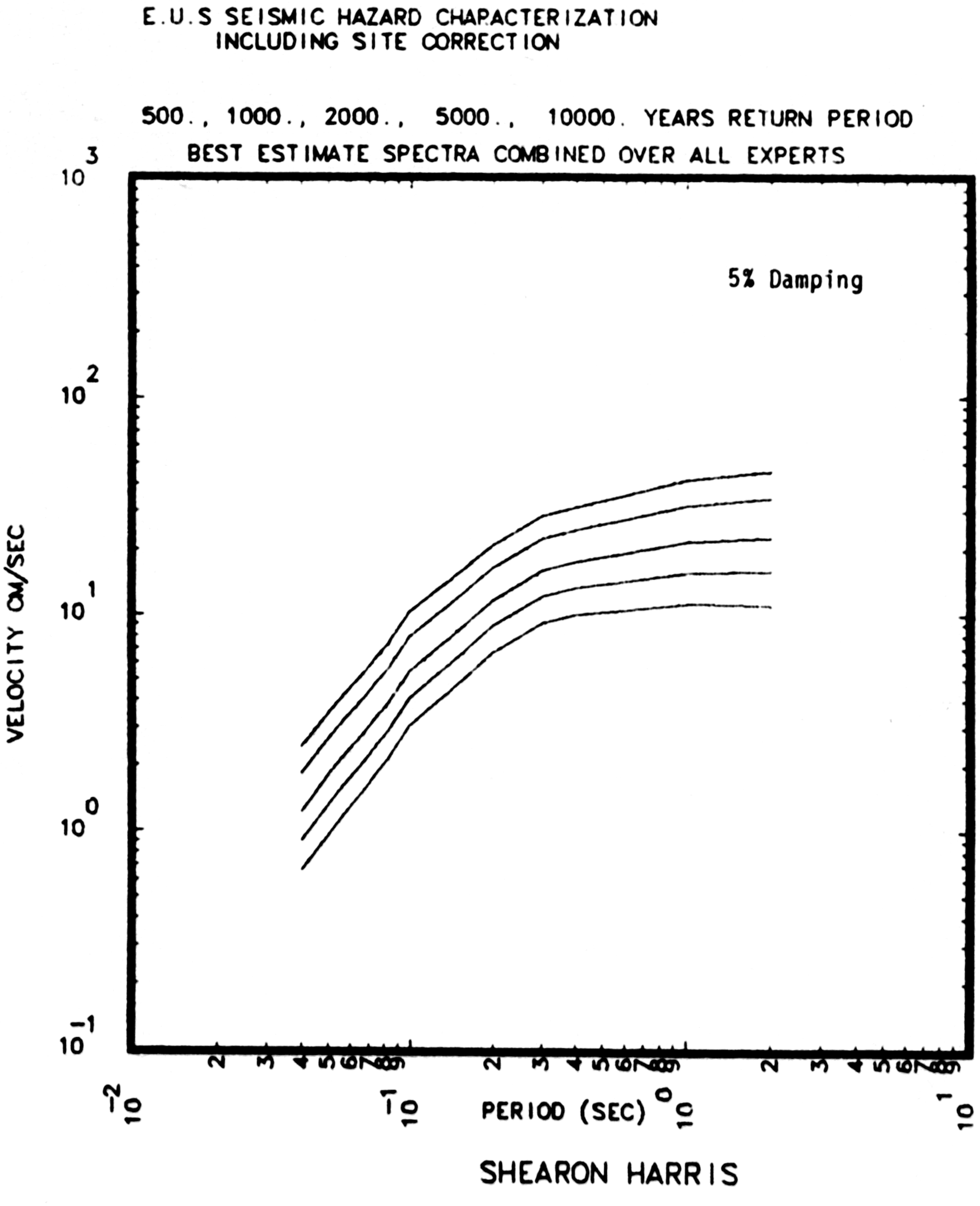


Figure 5.3.4 Best Estimate Uniform Hazard Spectra (BEUHS) Curves Over All Experts

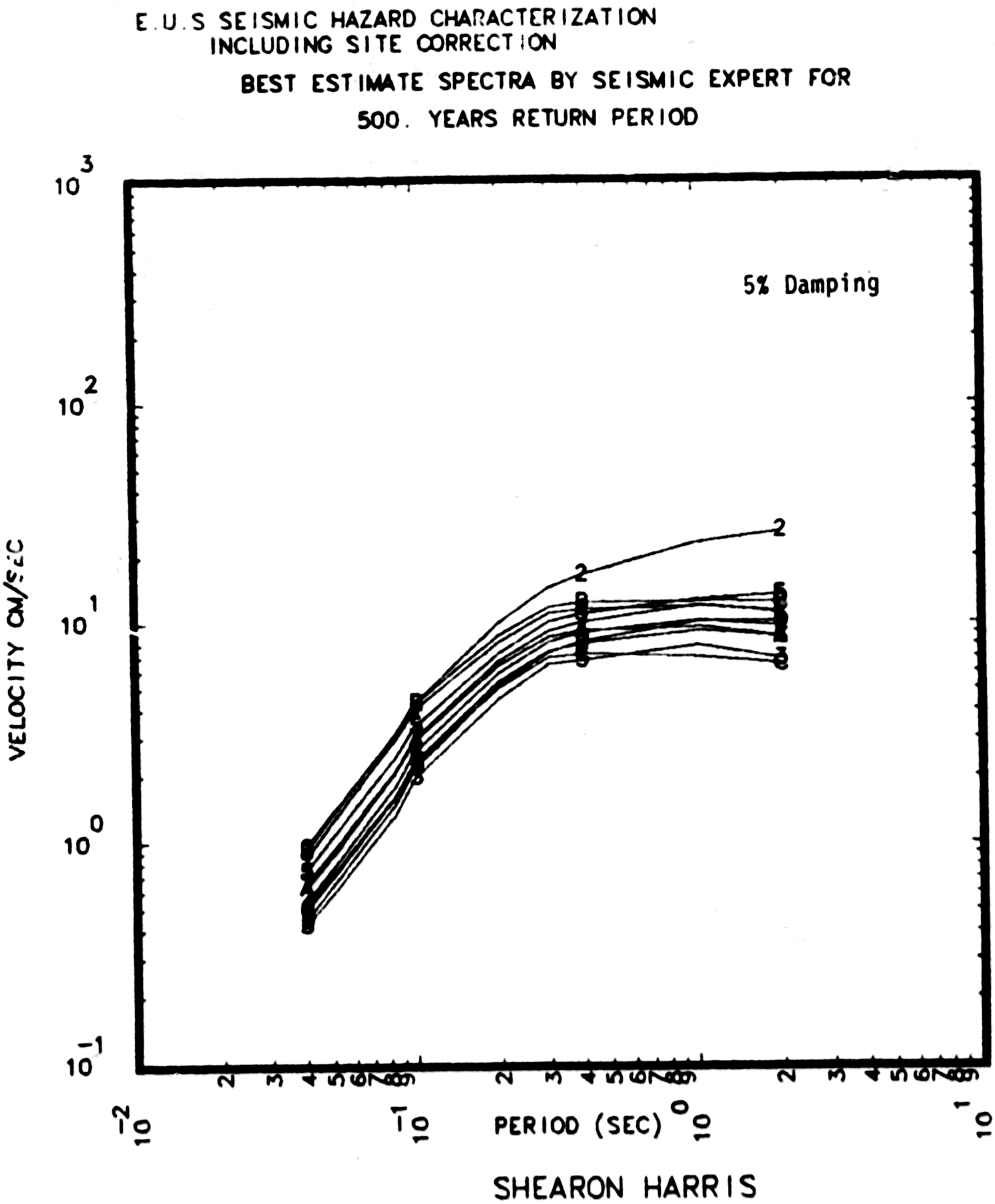


Figure 5.3.5 500 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

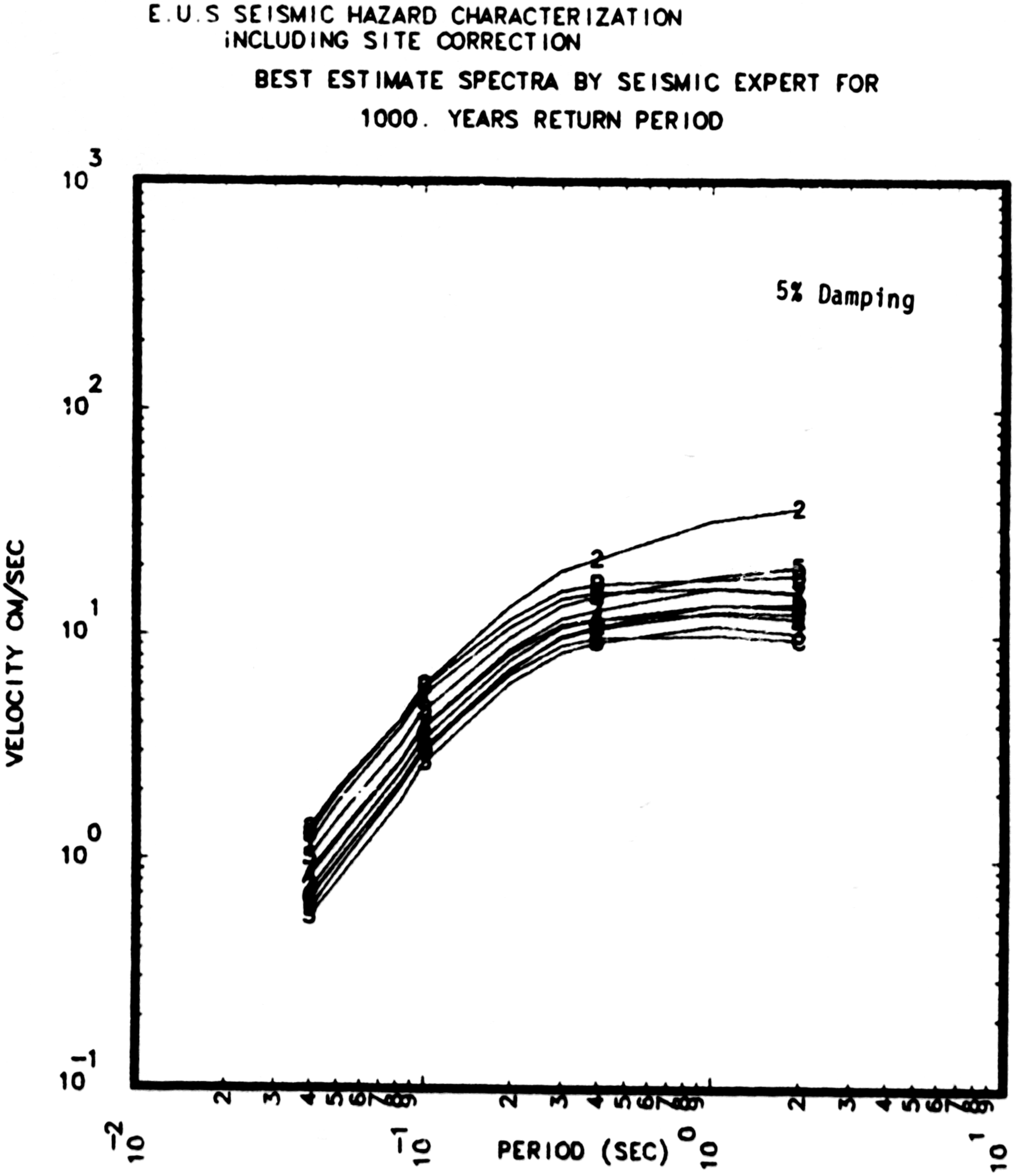


Figure 5.3.6 1,000 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

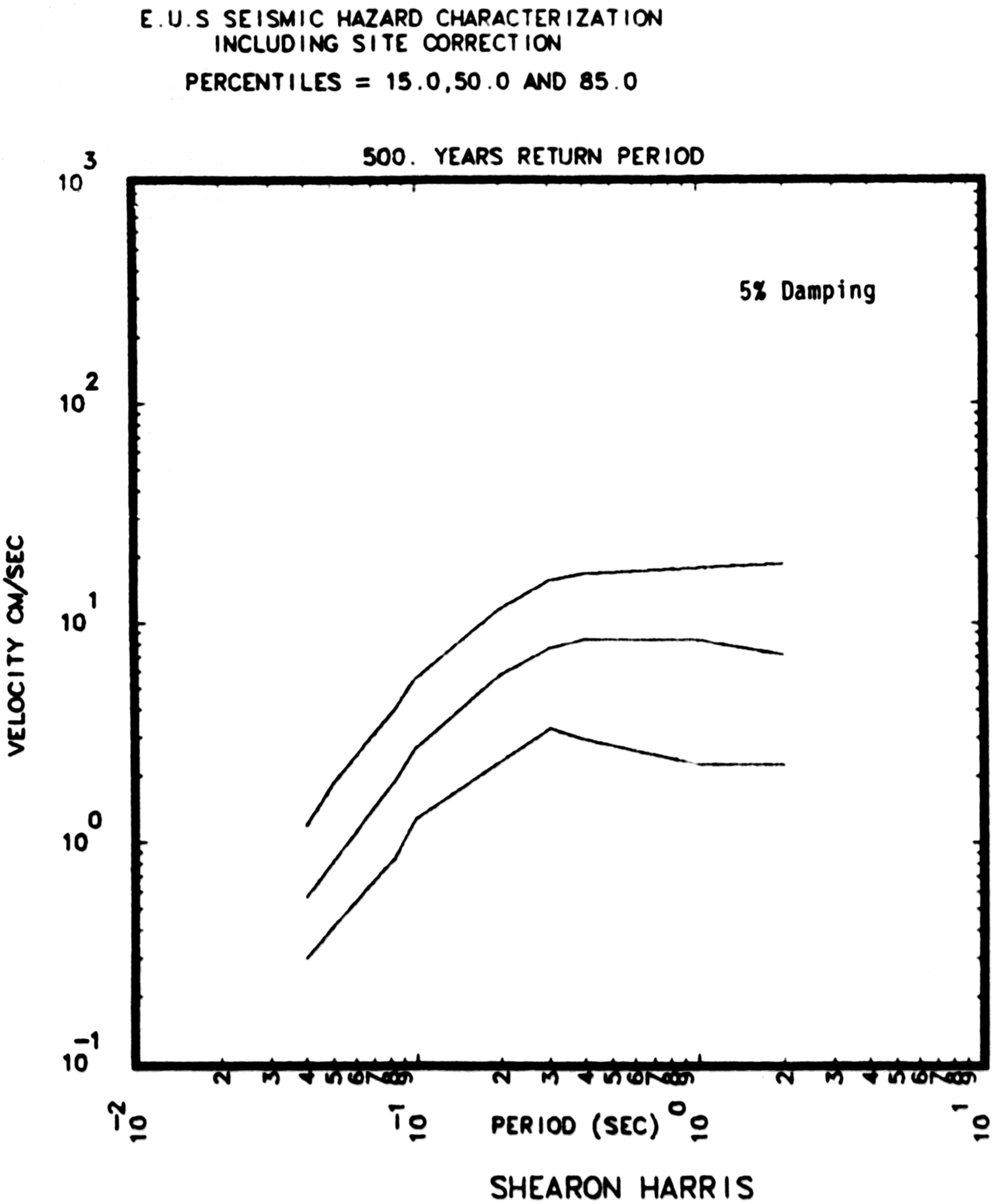


Figure 5.3.7 500 Year Return Period CPUHS Over All Experts

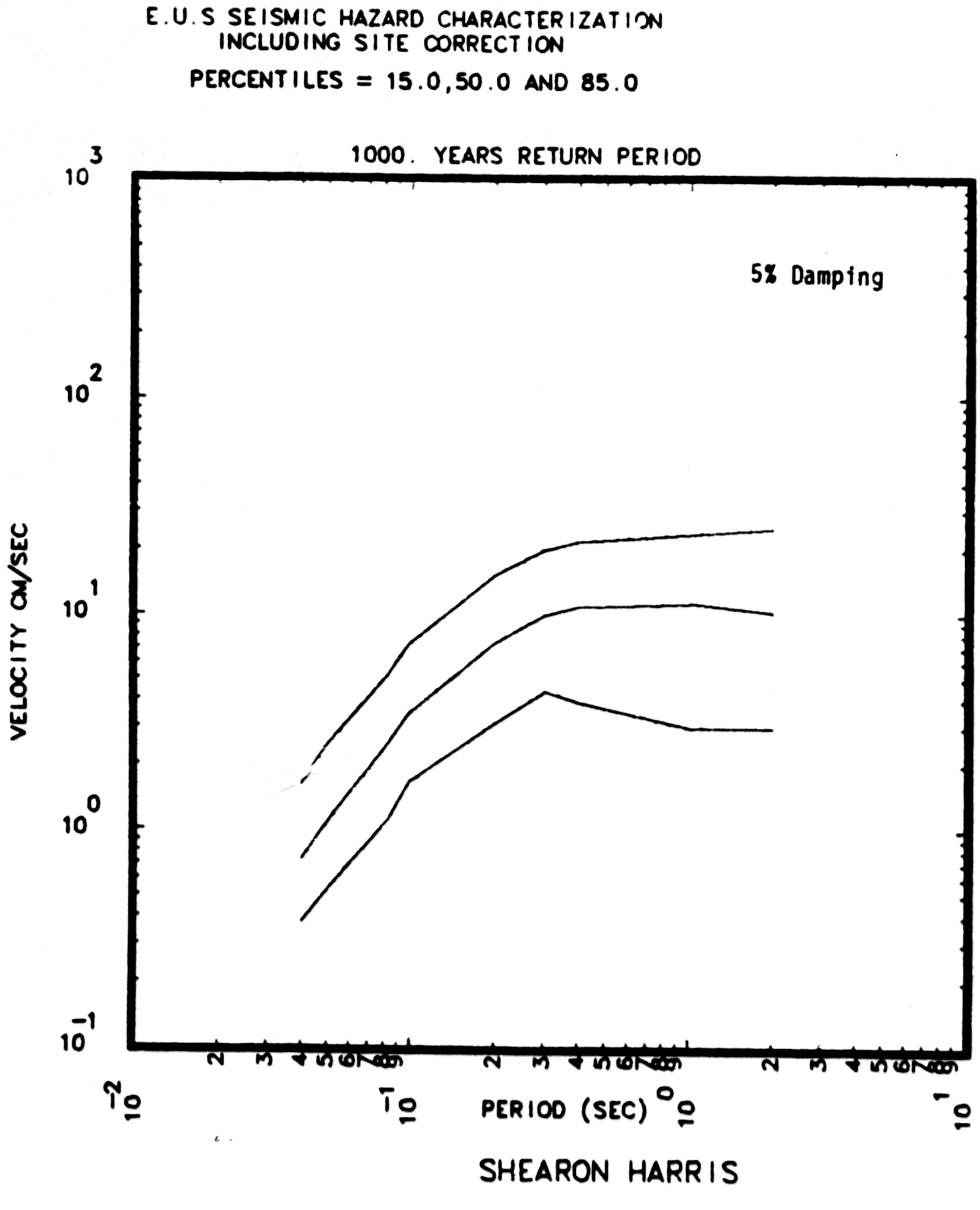


Figure 5.3.8 1,000 Year Return Period CPUHS Over All Experts

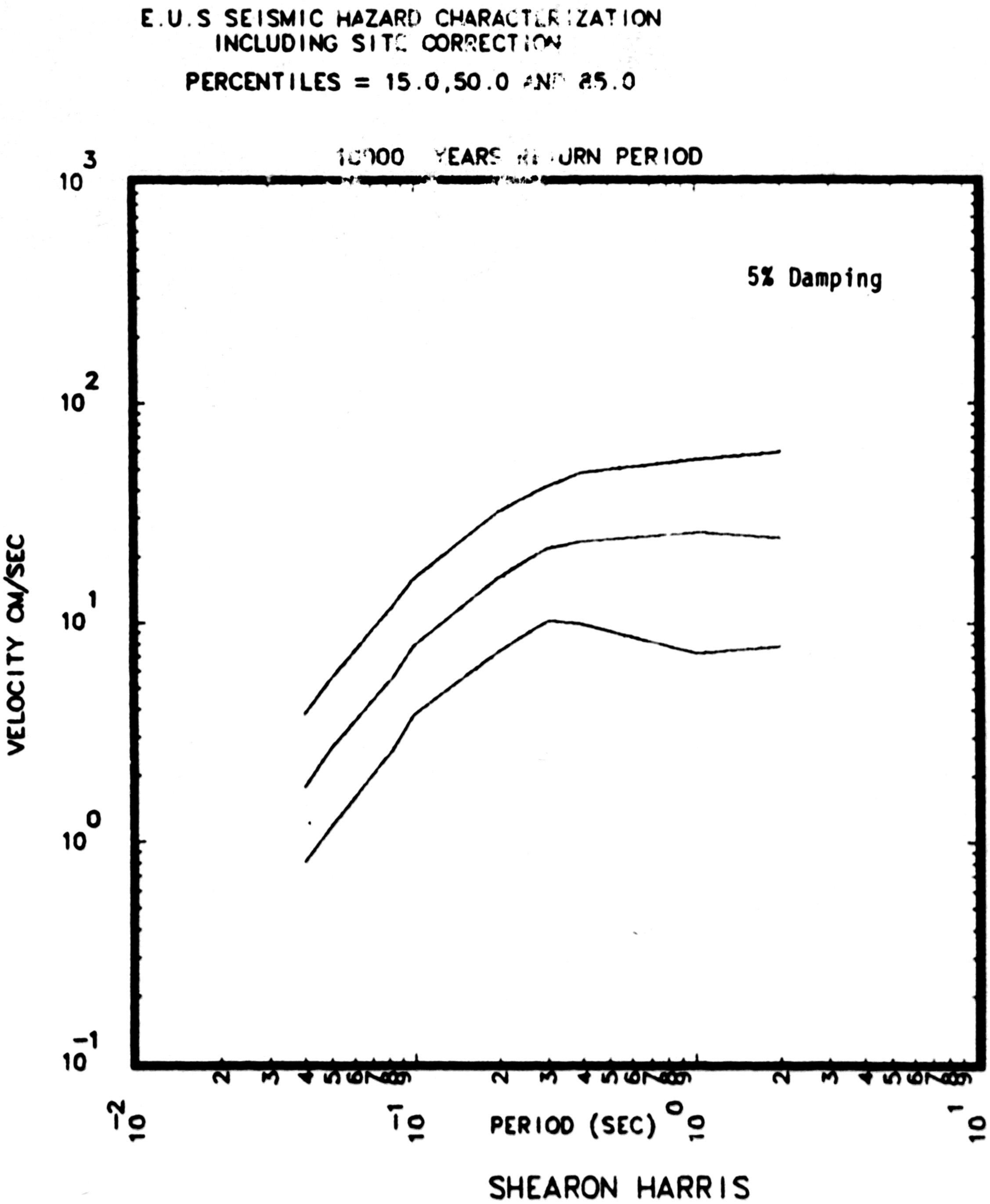


Figure 5.3.9 10,000 Year Return Period CPUHS Over All Experts

5.4 River Bend

5.4.1 Zonation Effects

The River Bend site is classified as a deep soil site (Category III) located approximately at the boundary between the two regions defined as southeast and south central of the EUS. Since for all the seismicity experts the New Madrid area appears to be the dominant area after the CZ, it was decided to consider this site as located in the south central (SC) region. In actuality, the CZ is the dominant zone in the BE calculations shown in Table 5.4.1 for all experts except Experts 1, 4, 11, and 12, and Expert 5 at low PGA. For these experts, however, the dominant zones are also large zones similar to a CZ.

5.4.2 PGA Hazard Curves

The BEHC combined over all experts is shown on Fig. 5.4.1. The BEHC per seismicity expert is shown on Fig. 5.4.2. The curves in general are all the same shape except for Experts 2, 4, and 5 which have a similar shape, for different reasons. For Expert 2, the CZ which contains the site has a relatively large upper magnitude cutoff (7.5) when compared to Experts 4 and 5 whose zone 25 and CZ respectively contain the site and have low upper magnitude cutoffs (5.5 and I = 6.0 respectively). For Experts 2, 4, and 5, it is the zone in which the site is located which governs the shape of the curve at high PGA. At low PGA for Expert 2 the CZ in which the site is located governs the shape of the curve but zone 18 contributes significantly. At low PGA, Expert 2's curve has the same general shape as the majority of the curves. This can also be said about Experts 5's curve. That, at low PGA, it has the same general shape as the majority of other curves. At low PGA, Expert 5's curve is governed by zone 11 which is a large nearby zone which has a significant upper magnitude intensity cutoff, along with contribution from Expert 5's zone 15 (New Madrid area). For Expert 4, the low PGA part of the curve differs greatly from the other curves. At low PGA, Expert 4's curve is governed almost equally by zone 4 (New Madrid area) which has a high upper magnitude cutoff (7.5) and zone 25.
Excluding the hazard curve for Expert 4, which appears to be an outlier, the hazard curves for Experts 1 and 12 are the upper and lower bound on the hazard, respectively. The spread between Experts 1 and 12 BEHC is a factor of 10 at low PGA and a factor of about 28 at high PGA. If Expert 4 is included, at high PGA, the factor is 50.

The combined BEHC over all experts shows the relatively low hazard associated with this site. The BEHC for Expert 10 in Fig. 5.4.2 appears to be the closest to the BEHC of all experts combined, which is on Fig. 5.4.1.

The uncertainty in the hazard curves, shown by the CPHC in Fig. 5.4.3, is typical of the moderate uncertainty found at most sites. The 50th percentile curve is close to the BEHC at low PGA values, but diverges toward upper values at high PGA to reach a factor of about 3 times higher hazard at the 1 g level.

5.4.3 Uniform Hazard Spectrum

The BEUHS shown in Fig. 5.4.4 have an atypical shape for the various return periods. Figures 5.4.5 and 5.4.6 show the BEUHS per seismicity expert combined over all ground motion experts for two different return periods. The BEUHS curves of Experts 2, 4, and 5 appear to be the most responsible for the atypical shape of the BEUHS combined over all experts. It is the zonation and seismicity parameters of these experts along with the effect of Ground Motion Expert 5's model which produces the atypical shape. However, the relative agreement of the experts leads to a narrow band (at low periods a factor of 2 to 3 and at high periods a factor of 4 to 5). Because the simulations for Experts 2, 4, and 5 include many other models, this leads to more typical spectral shapes; the effect seen on the BEUHS over all experts does not appear in the uncertainty analysis. In this case, the sample simulations which create the effect mentioned above do not appear to be inside of the 15th to 85th percentile interval. However, the uncertainty introduced by the site correction method appears at periods longer than .3 sec as described in Section 4.4, in Figures 5.4.7 to 5.4.9. The uncertainty in the CPUHS is moderate for this site; a factor of 2 at low periods and 6 at high periods between the 15th percentile curve and the 85th percentile curve.

TABLE 5.4.1

Zonal Dominance In The
BEHC At Low and High PGA

SITE: River Bend
SITE CLASSIFICATION: Generic Deep Soil
REGIONAL LOCATION: South Central

Seismicity Expert	Expert's Host Zone		Contribution to the Hazard: Low PGA (.05g)						High PGA (1.0g)		
1	1	Zone	1	9	10	5			1	9	
		Contribution	.85	.10	.03	.02			.99	.01	
2	CZ	Zone	CZ	18					CZ	18	
		Contribution	.64	.35					.92	.08	
3	CZ(1)	Zone	CZ	15	17	16			CZ		
		Contribution	.80	.13	.04	.02			1.00		
4	25	Zone	4	25	3				25	4	CZ
		Contribution	.50	.49	.01				.79	.13	.08
5	CZ(2)	Zone	11	CZ	15				CZ	15	11
		Contribution	.50	.32	.18				.87	.12	.01
6	CZ(1)	Zone	CZ	17	22	9			CZ	17	
		Contribution	.73	.25	.01	.01			.99	.01	
7	CZ(2)	Zone	CZ	1	6	5	30		CZ	6	
		Contribution	.67	.19	.10	.03	.01		.99	.01	
10	CZ(19)	Zone	CZ	12	29				CZ		
		Contribution	.86	.13	.01				1.00		
11	14	Zone	14	11	15	8	CZ	16	14	CZ	
		Contribution	.80	.11	.03	.02	.02	.02	.93	.06	
12	6	Zone	6	12	2				6	12	
		Contribution	.72	.25	.03				.94	.06	
13	CZ	Zone	CZ	5	8				CZ		
	(15+16+17)	Contribution	.79	.19	.01				1.00		

NOTE: Contributions may not add up to 1.00.
The notation CZ (2) means that the CZ was also called zone by the expert.

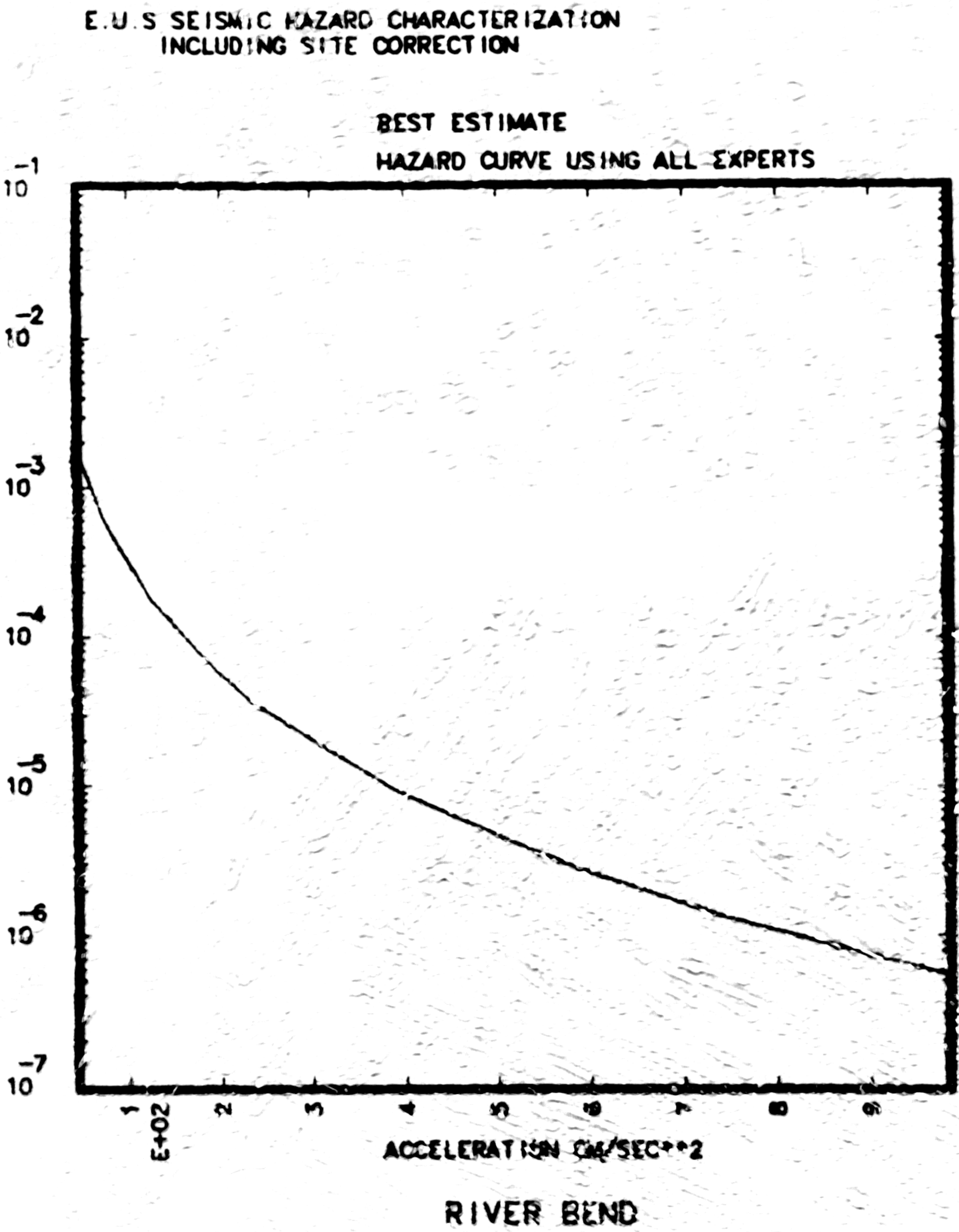


Figure 5.4.1 BEHC Combined Over All Experts

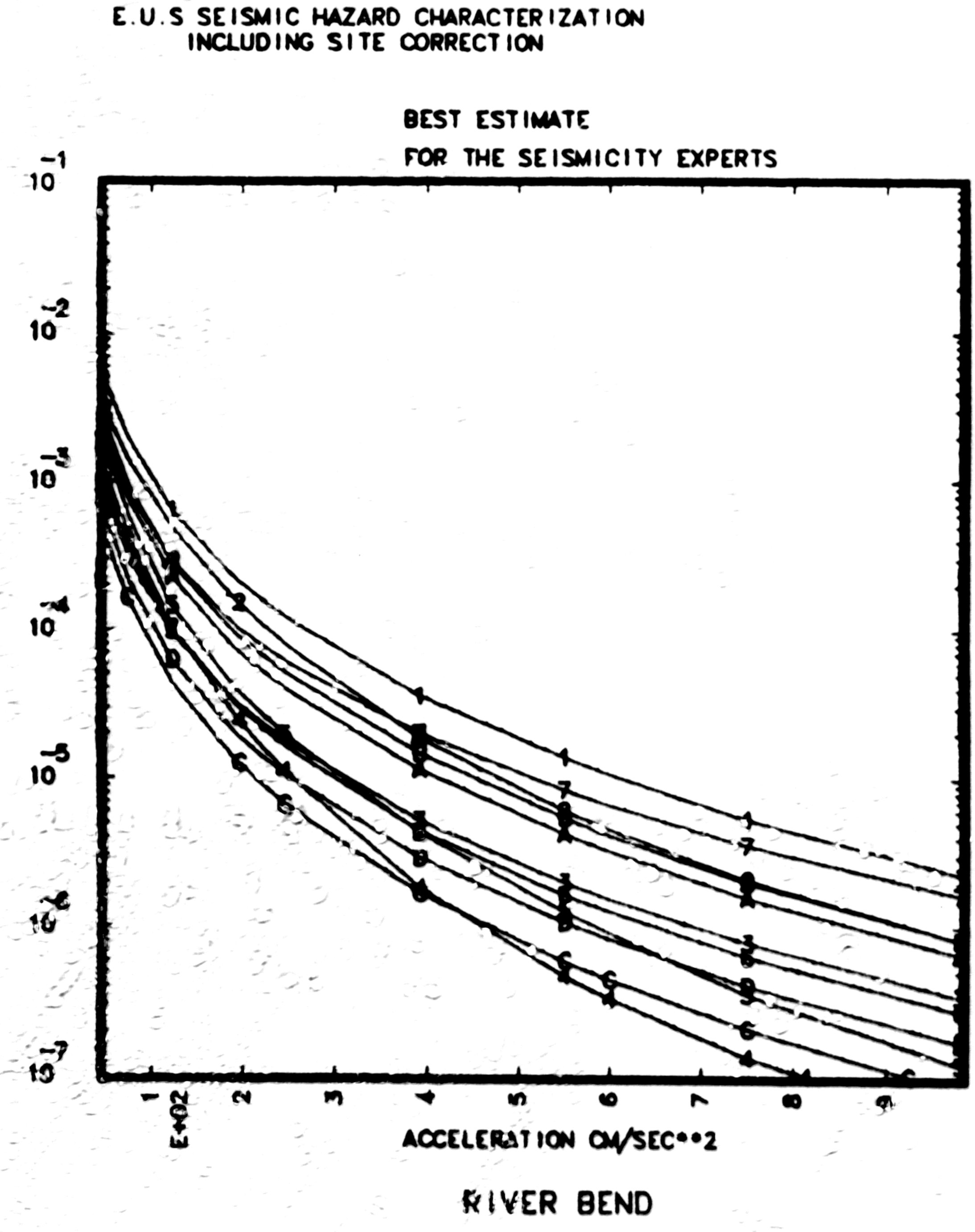


Figure 5.4.2 BEHC per Seismicity Expert Combined Over All Ground Motion Experts

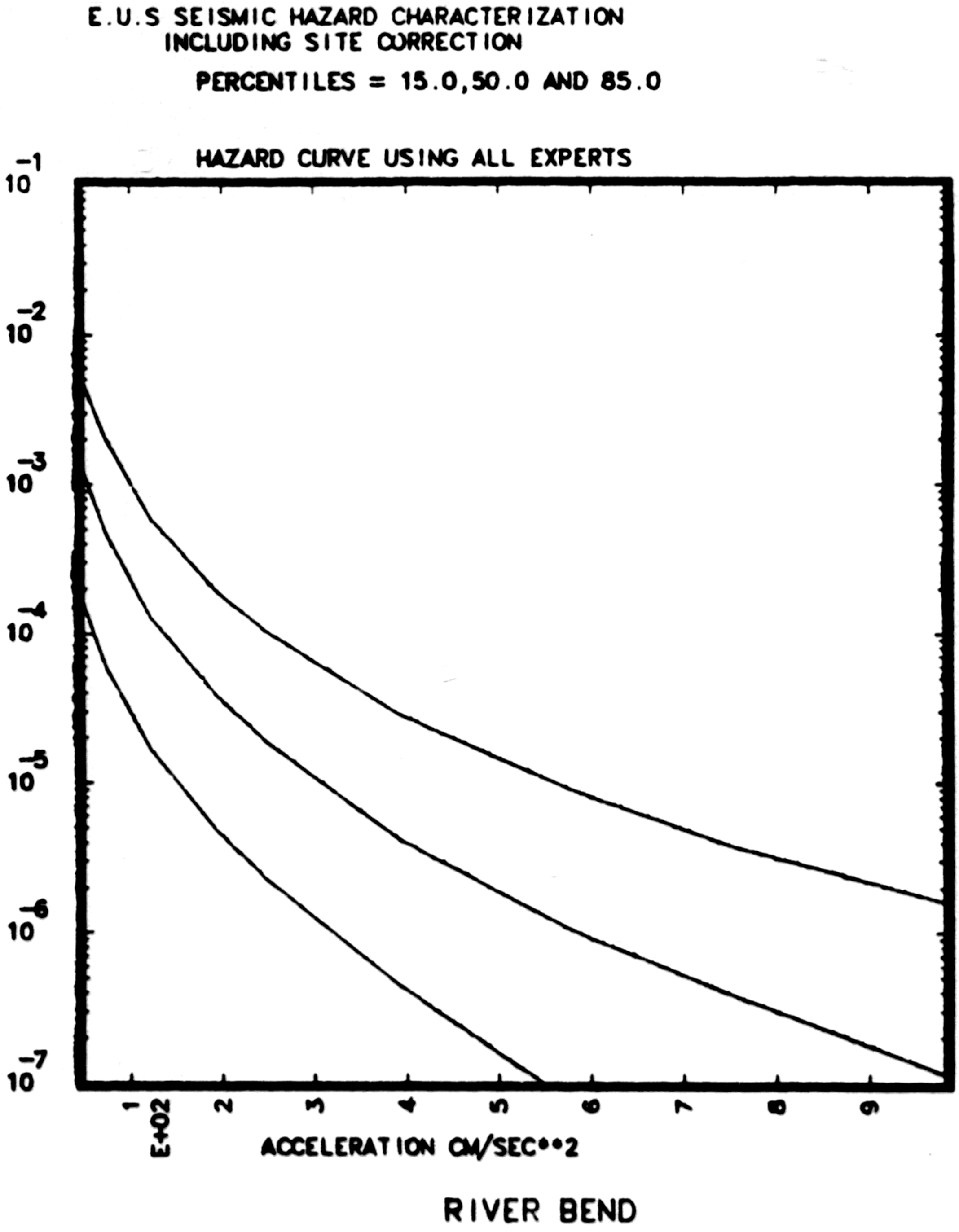


Figure 5.4.3 Constant Percentile Hazard Curves (CPHC) Over All Experts

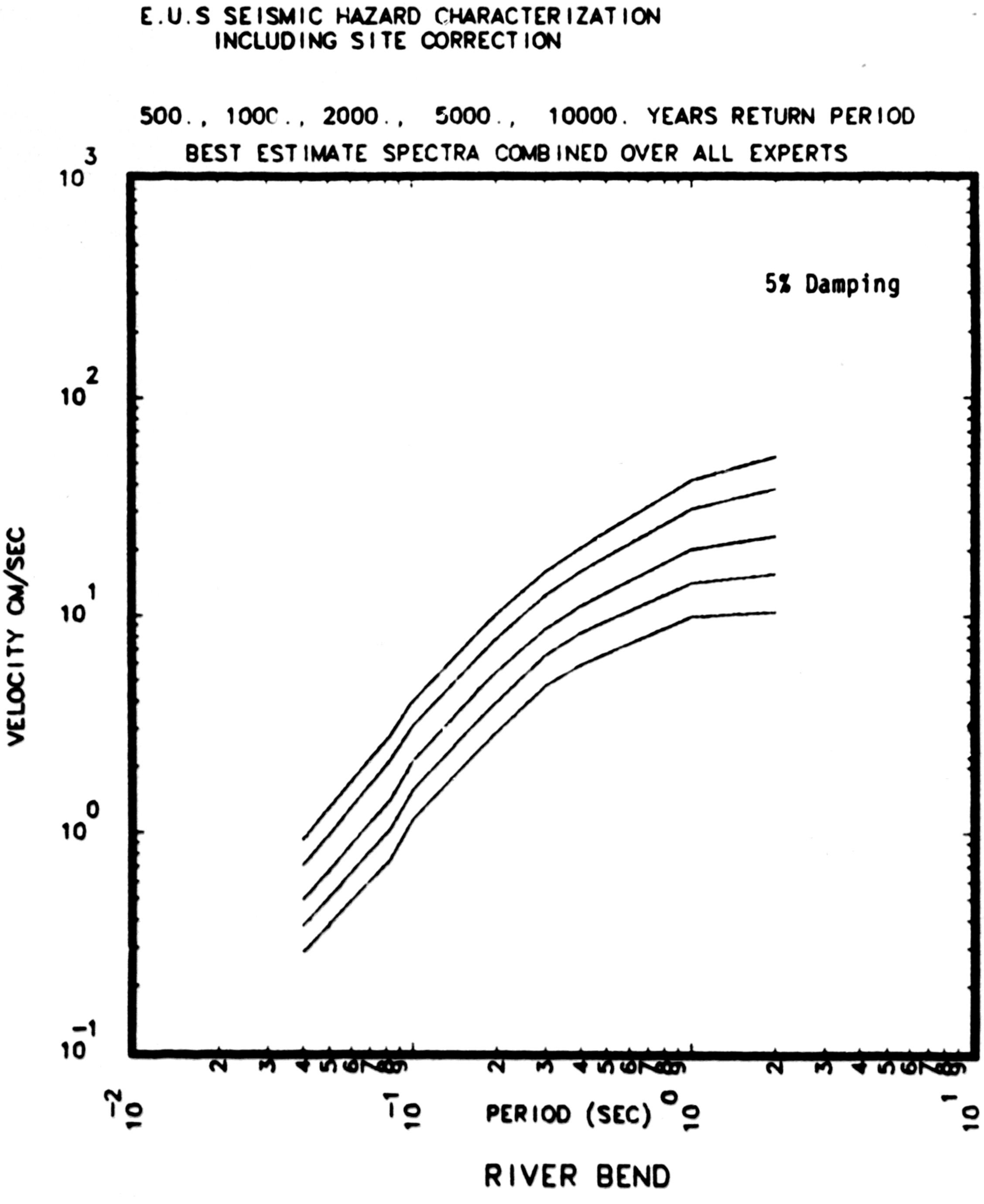


Figure 5.4.4 Best Estimate Uniform Hazard Spectra (BEUHS) Curves Over All Experts

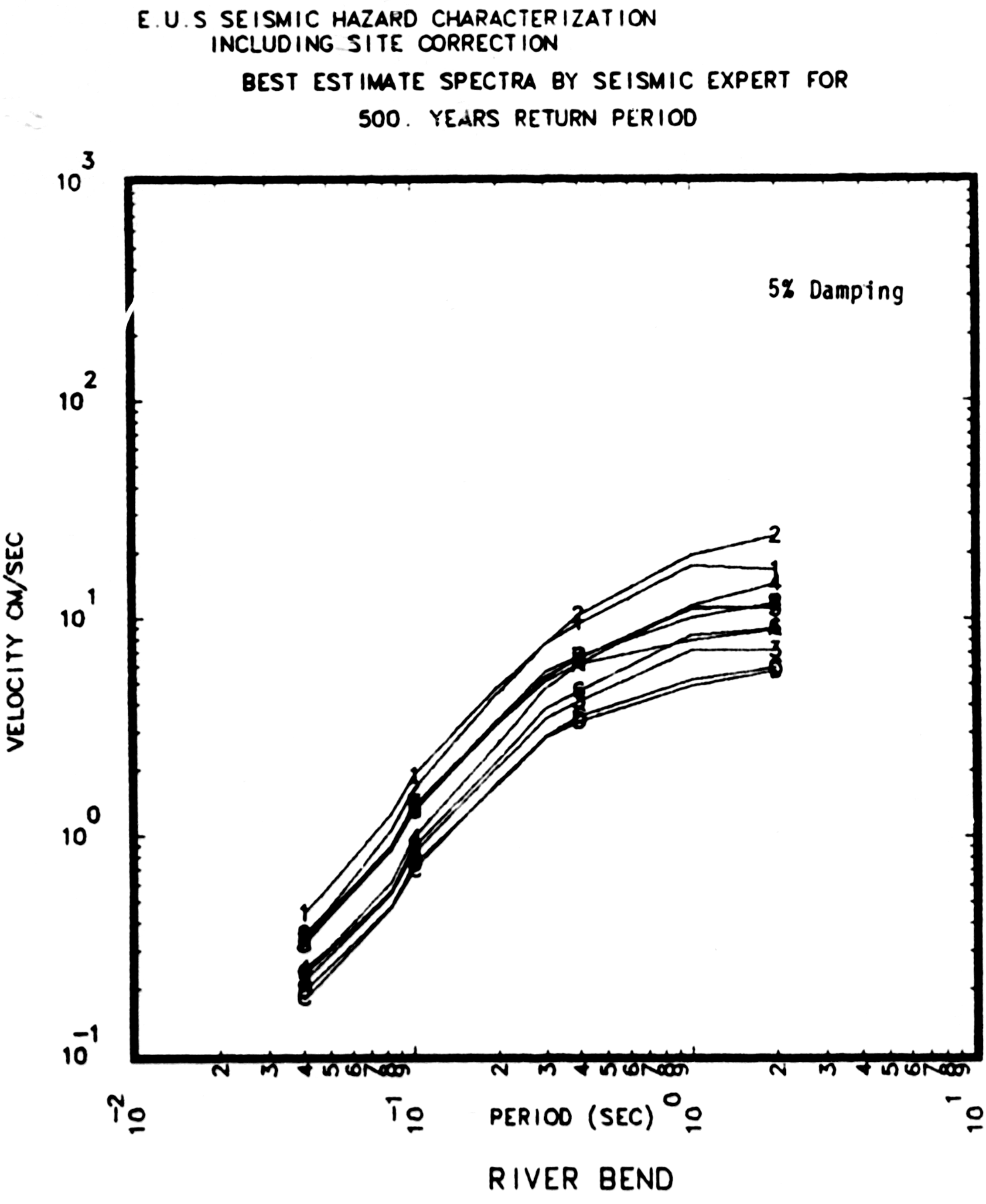


Figure 5.4.5 500 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

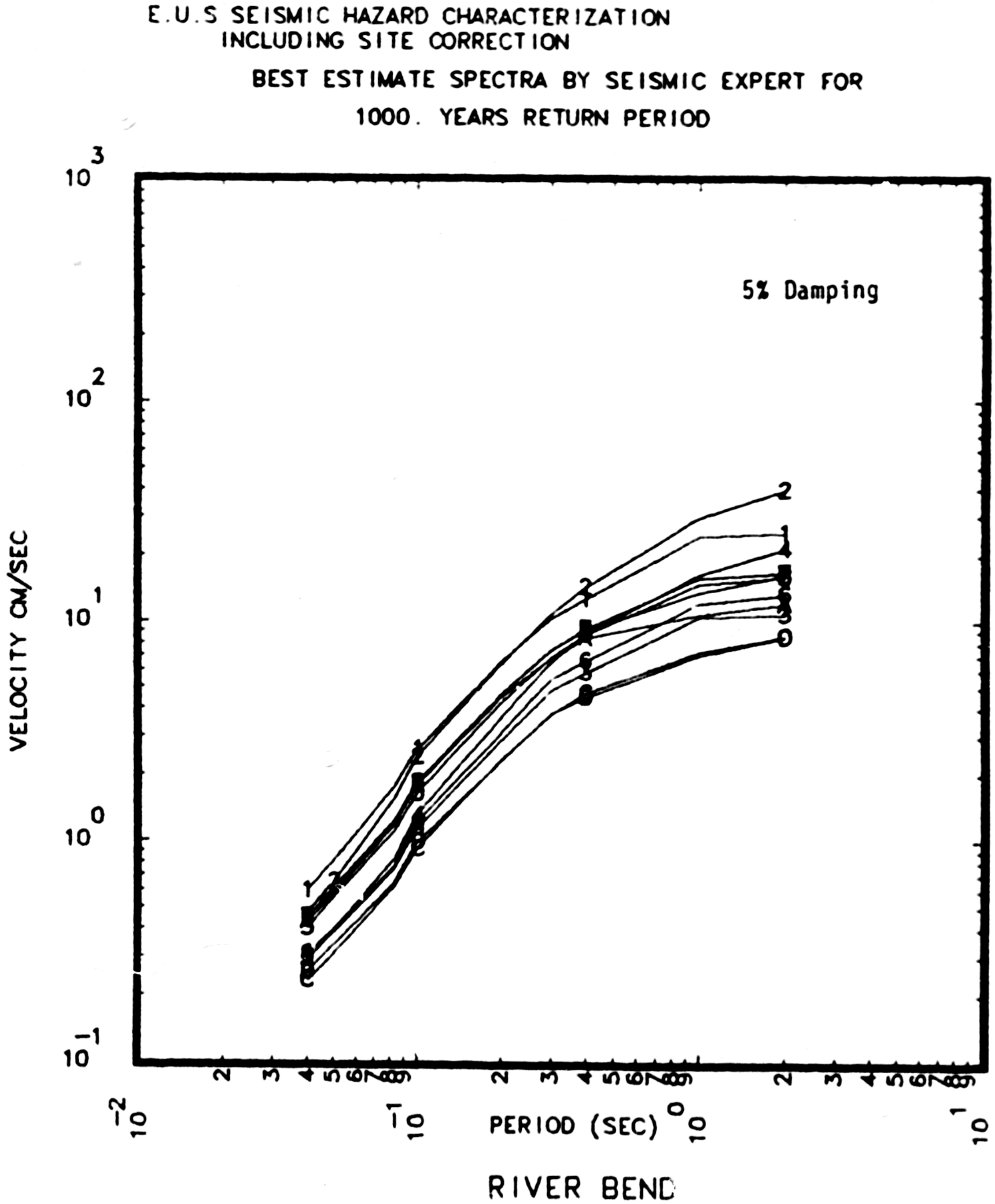


Figure 5.4.6 1,000 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

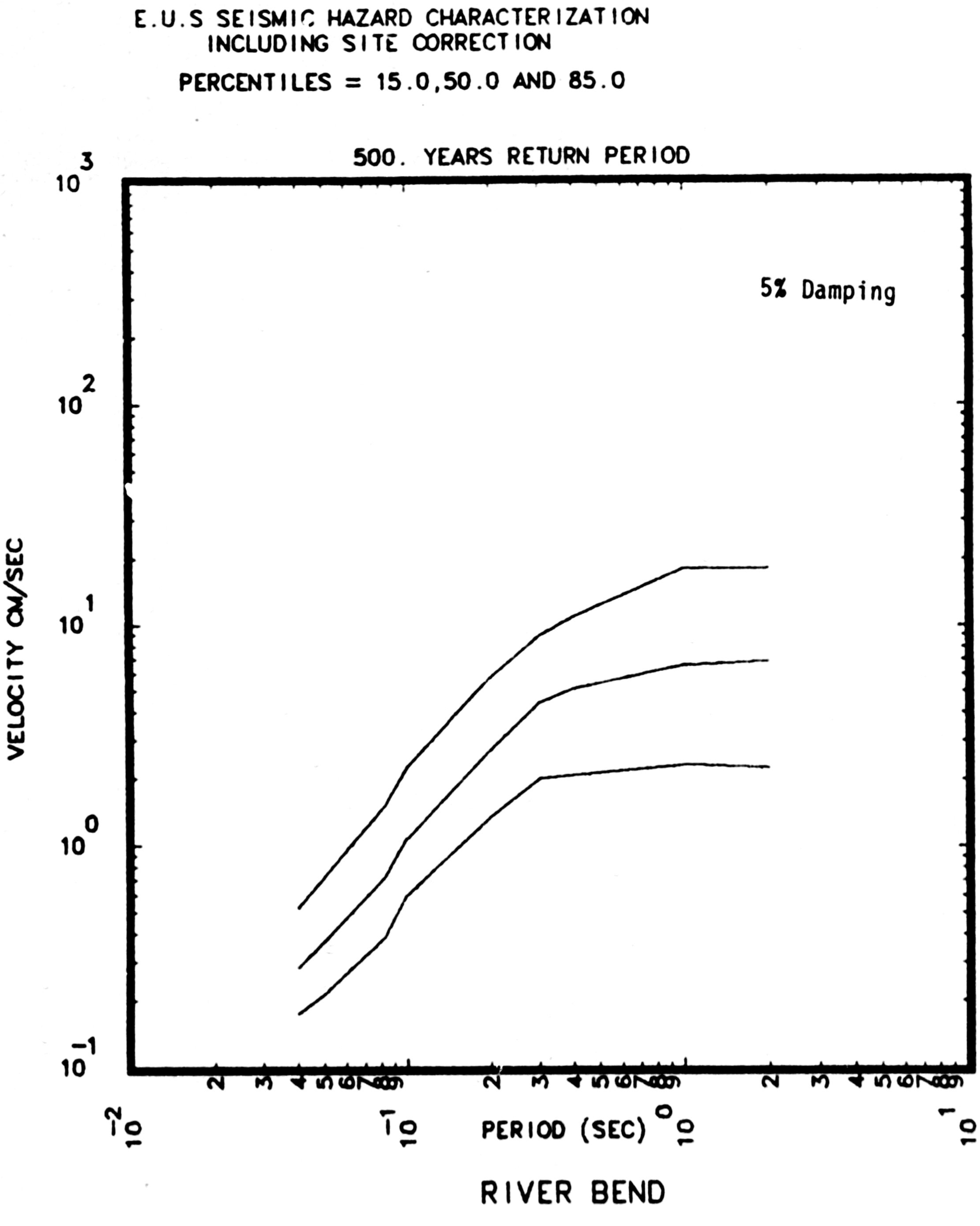


Figure 5.4.7 500 Year Return Period CPUHS Over All Experts

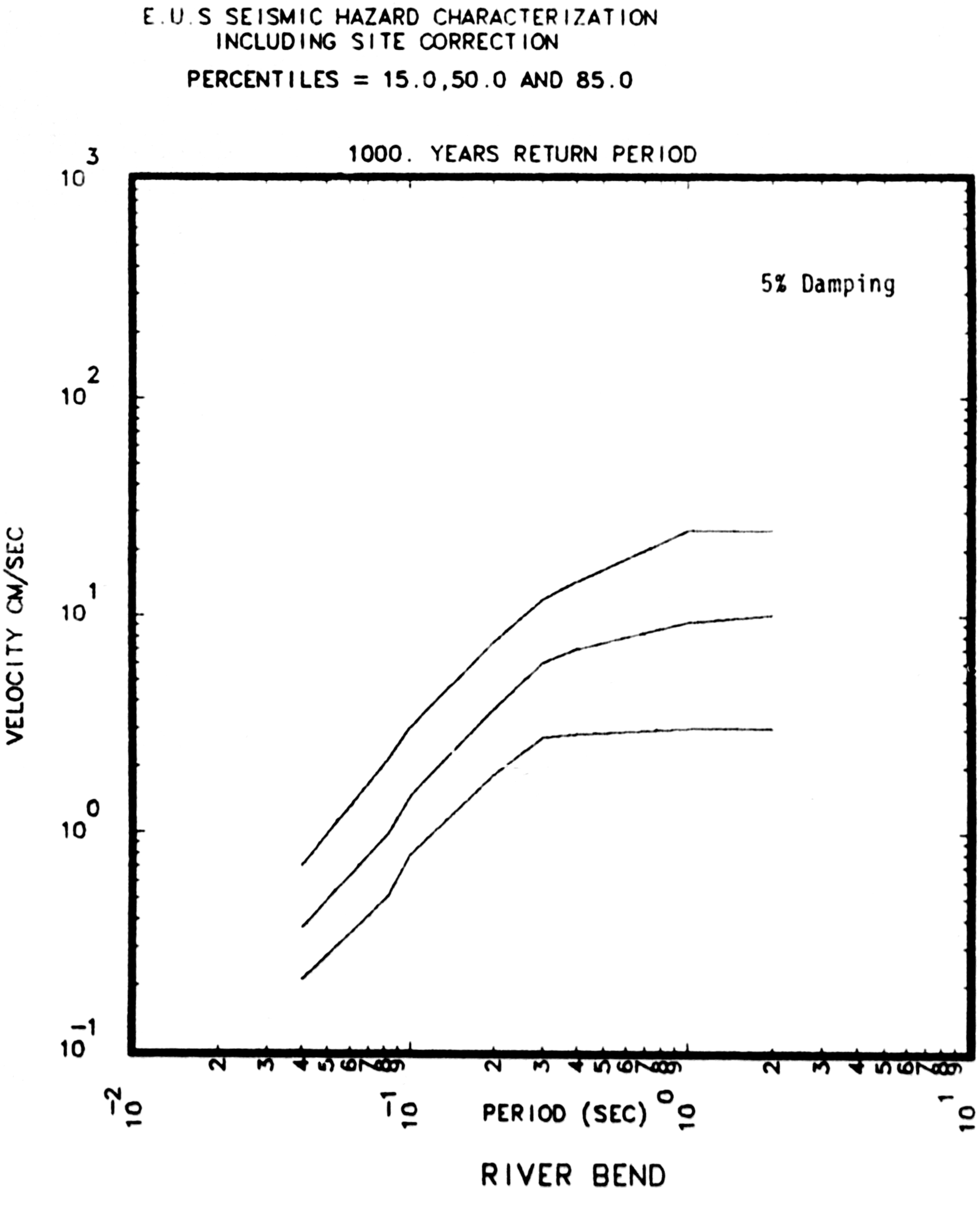


Figure 5.4.8 1,000 Year Return Period CPUHS Over All Experts

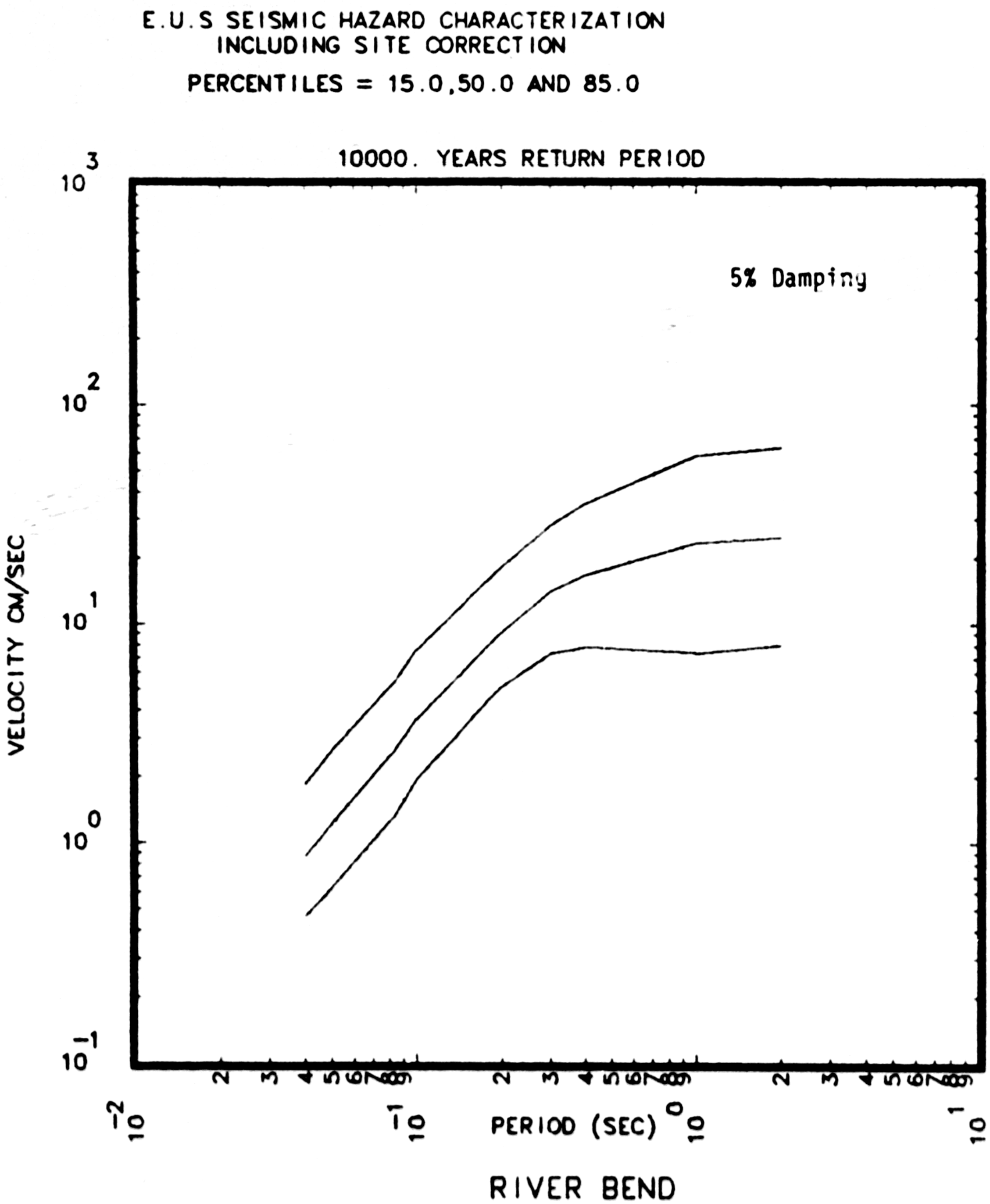


Figure 5.4.9 10,000 Year Return Period CPUHS Over All Experts

5.5 Millstone

5.5.1 Zonation Effects

The Millstone site is a rock site (Category I) located in the southeast portion of the northeast (NE) region of the EUS. None of the experts, in their best estimate zonation, located this site on the CZ. The scale of zonation is generally smaller for the northeast than for other regions in the experts' best estimate maps. Thus the distribution of the zonation maps is expected to have a wider uncertainty. However, the seismicity of this region is well-constrained, in part because earthquake catalogues for New England have a longer time period of complete recording than for other regions. Thus the seismicity models are expected to have less uncertainty than for the rest of the EUS and the uncertainty in the analysis for this site is not expected to be much larger than for other sites. Zonal dominance at low and high PGA is summarized on Table 5.5.1.

5.5.2 PGA Hazard Curves

The BEHC combined over all experts is shown in Fig. 5.5.1. The BEHC per seismicity expert is shown in Fig. 5.5.2. The diversity of opinion among seismicity experts is a factor of 5 on the hazard at low PGA and a factor of 17 on the hazard at high PGA. This level of diversity compares well with the diversity at the other sites. In the best estimate curves of Fig. 5.5.2, there appears to be four clusters of curves different from each other by a factor of approximately 1.5 to 3.5 on the hazard values. The BEHC combined over all experts falls in the upper middle cluster.

Figure 5.5.3 shows that the uncertainty analysis is moderate to high on the hazard. The uncertainty at low PGA appears to be moderate with a factor of about 20 between the 15th and the 85th percentile curves. The uncertainty is high at high PGA values with a factor of about 350 on the hazard between the 15th and the 85th percentile.

5.5.3 Uniform Hazard Spectra

The BEUHS combined over all experts is displayed in Fig. 5.5.4. The BEUHS per seismicity expert for a 500 year return period and a 1,000 year return period are shown on Figs. 5.5.5 and 5.5.6 respectively. Looking at these figures, it can be seen that the band of curves is fairly narrow with some slight differences at 1 sec.. This is an indication of good agreement between experts in zonation and spectral ground motion models for the ranges of magnitudes considered. This agreement between experts is also manifested by the uniform shape of the BEUHS (Fig. 5.5.4). In Fig. 5.5.5, the ratio between the highest curves (Experts 6 and 7) and the lowest curves (Experts 4 and 13) is approximately equal to 2.5, with the BEUHS combined over all experts falling roughly in the middle. Figures 5.5.7, 5.5.8, and 5.5.9 show the CPUHS curves combined over all experts for a 500 year, 1,000 year, and 10,000 year return period. These curves show that the 50th and 85th percentile curves have similar shapes to the BEUHS of Fig. 5.5.4. The 15th percentile curves have a slightly different shape resulting in a lower pseudo-velocity in the upper range of .3 to 2 seconds. This is due to the uncertainty introduced by the site correction (See Section 4.4). Except in that period range, the uncertainty is moderate and comparable with results obtained for other sites. The ratio between the 15th and the 85th percentile curves is approximately 4 at .04 sec. period, 6.5 at .3 sec. period, 7 at .4 sec. period, and 8.5 at 2 sec. period for the 500 year return period curves.

The BEUHS is practically equal to the 50th percentile curve at short periods and higher by a factor of about 1.3 at long periods for the 500 and 1,000 year return period curves of Figs. 5.5.7 and 5.5.8. For the 10,000 year return period curve (Fig. 5.5.9) the BEUHS curve of Fig. 5.5.4 is a factor of 1.3 higher at both short and long periods.

TABLE 5.5.1

Zonal Dominance In The
BEHC At Low and High PGA

SITE: Millstone
SITE CLASSIFICATION: Rock
REGIONAL LOCATION: Northeast

Seismicity Expert	Expert's Host Zone		Contribution to the Hazard								
			Low PGA (.05g)						High PGA (1.0g)		
1	22	Zone	22	1	20	4	21		22	1	
		Contribution	.85	.06	.05	.03	.02		.98	.02	
2	31	Zone	31	32	28	CZ			31	32	CZ
		Contribution	.90	.05	.03	.03			.99	.01	.01
3	7	Zone	7	6	1	3	4		7	1	6
		Contribution	.78	.16	.04	.01	.01		.95	.03	.02
4	23	Zone	23	18	16	11	20	19	23		
		Contribution	.79	.10	.03	.02	.02	.02	1.00		
5	1	Zone	1	6	8	3			1		
		Contribution	.92	.06	.02	.01			1.00		
6	4	Zone	4	3	7	5			4		
		Contribution	.95	.02	.01	.01			1.00		
7	24	Zone	24	15	13	CZ	19	26	24	CZ	15
		Contribution	.52	.36	.05	.03	.02	.01	.98	.01	.01
10	2	Zone	2	4	22	23	CZ	6	2	4	CZ
		Contribution	.56	.23	.07	.04	.02	.02	.68	.26	.05
11	1	Zone	1	5	CZ	3	4	2	1	5	CZ
		Contribution	.72	.12	.09	.04	.02	.01	.98	.01	.01
12	3	Zone	3	18	16	17	4		3		
		Contribution	.87	.05	.04	.02	.01		1.00		
13	10	Zone	10	12	11	CZ			10	CZ	
		Contribution	.95	.02	.02	.02			.99	.01	

NOTE: Contributions may not add up to 1.00.

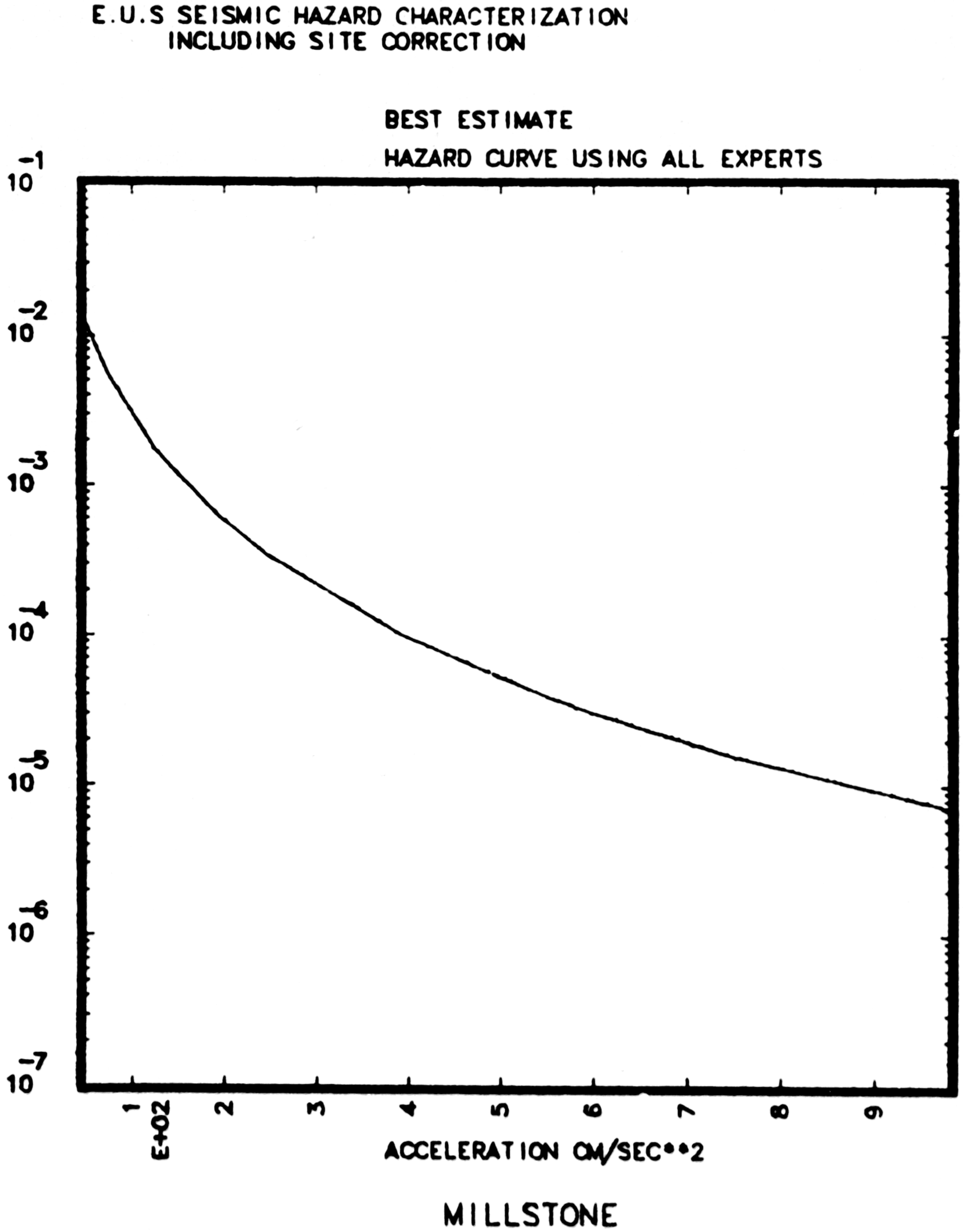


Figure 5.5.1 BEHC Combined Over All Experts

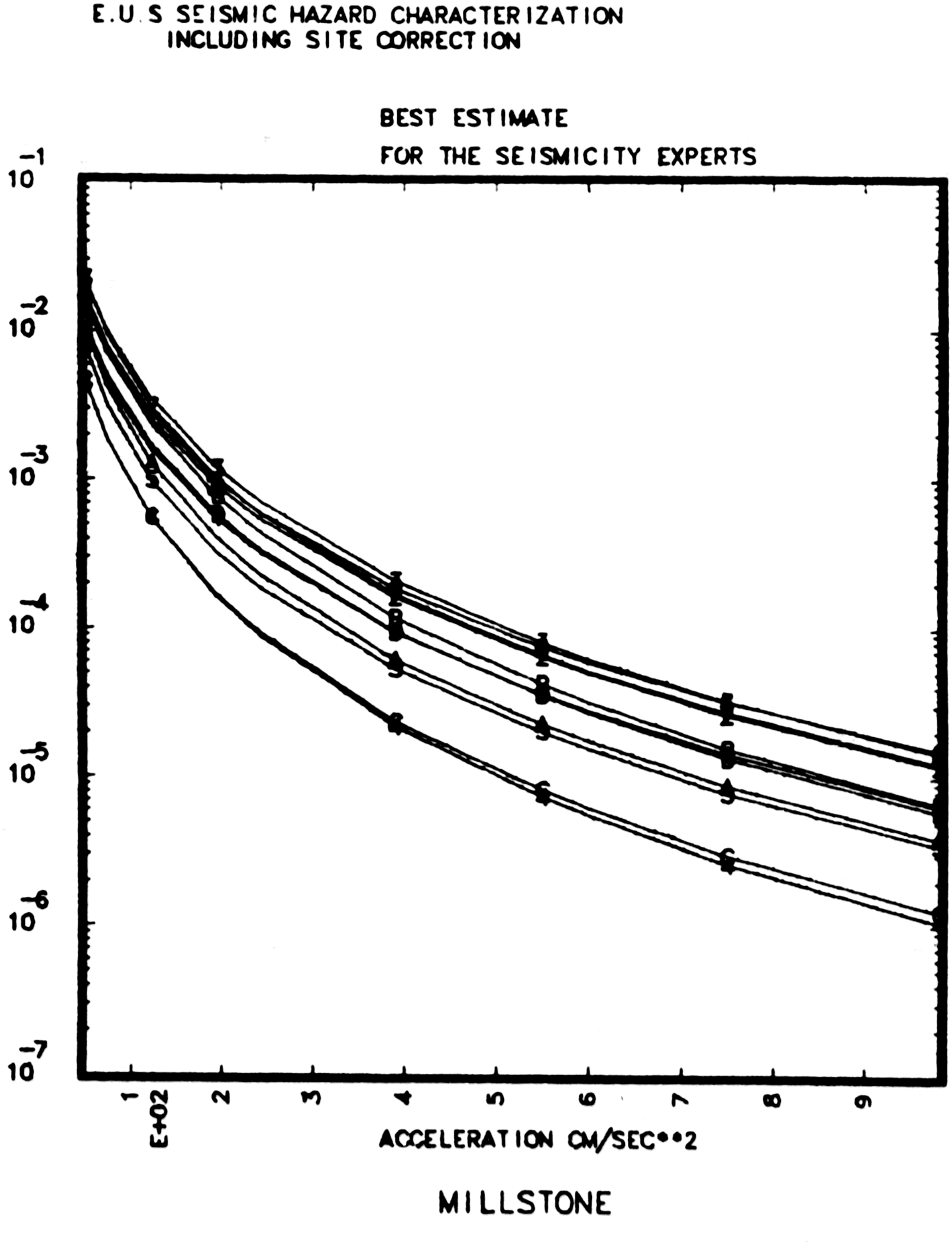


Figure 5.5.2 BEHC per Seismicity Expert Combined Over All Ground Motion Experts

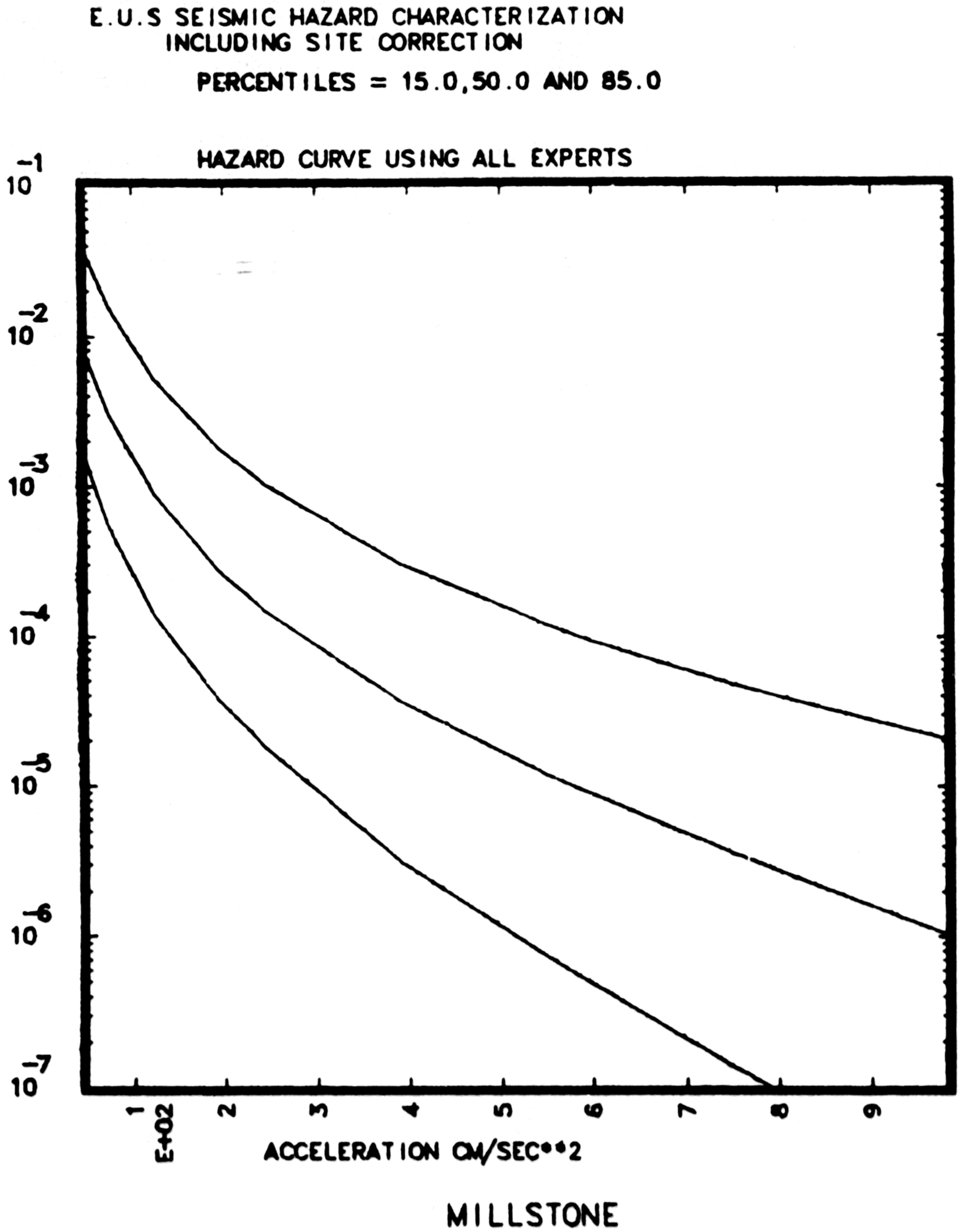


Figure 5.5.3 Constant Percentile Hazard Curves (CPHC) Over All Experts

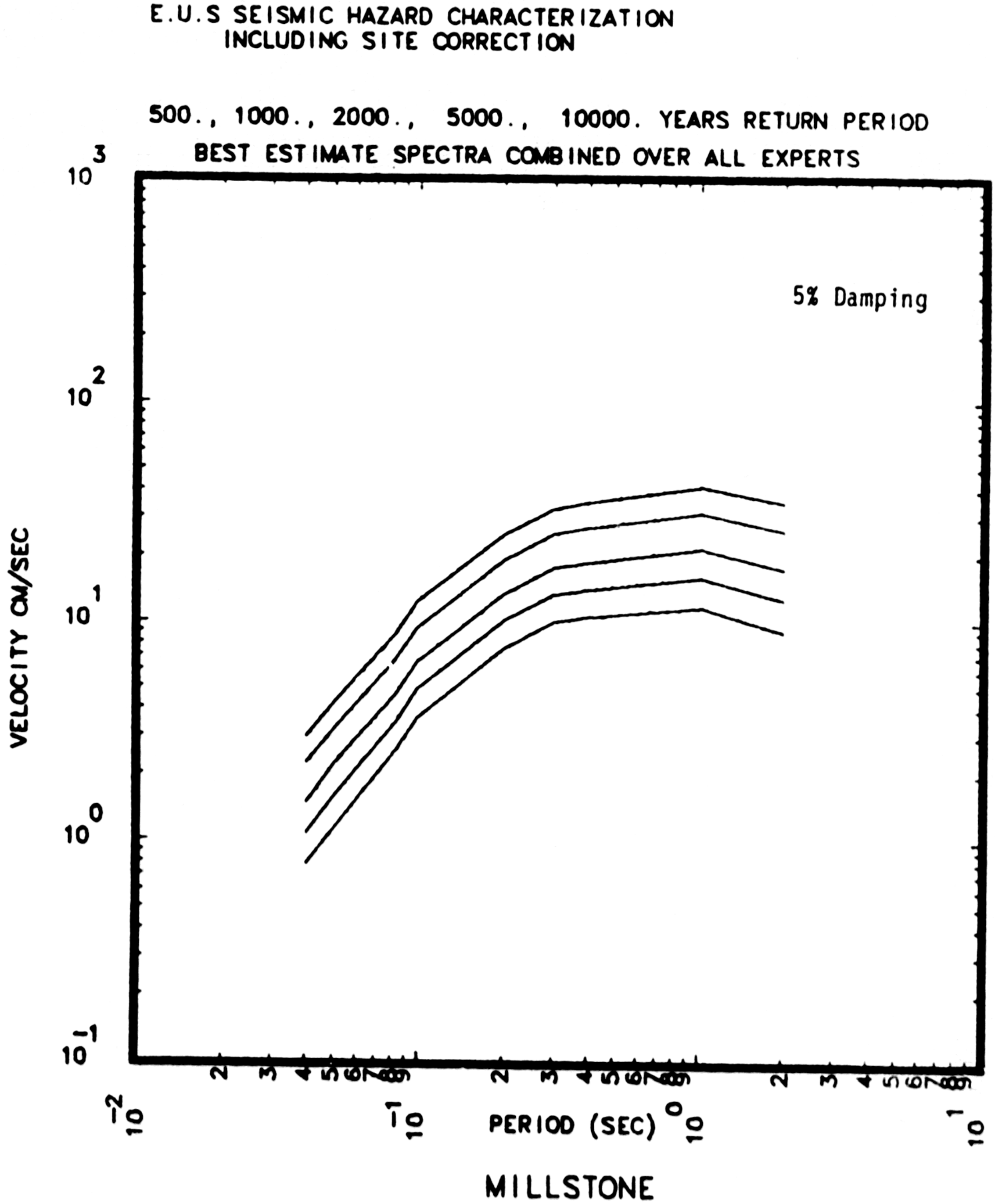


Figure 5.5.4 Best Estimate Uniform Hazard Spectra (BEUHS) Curves Over All Experts

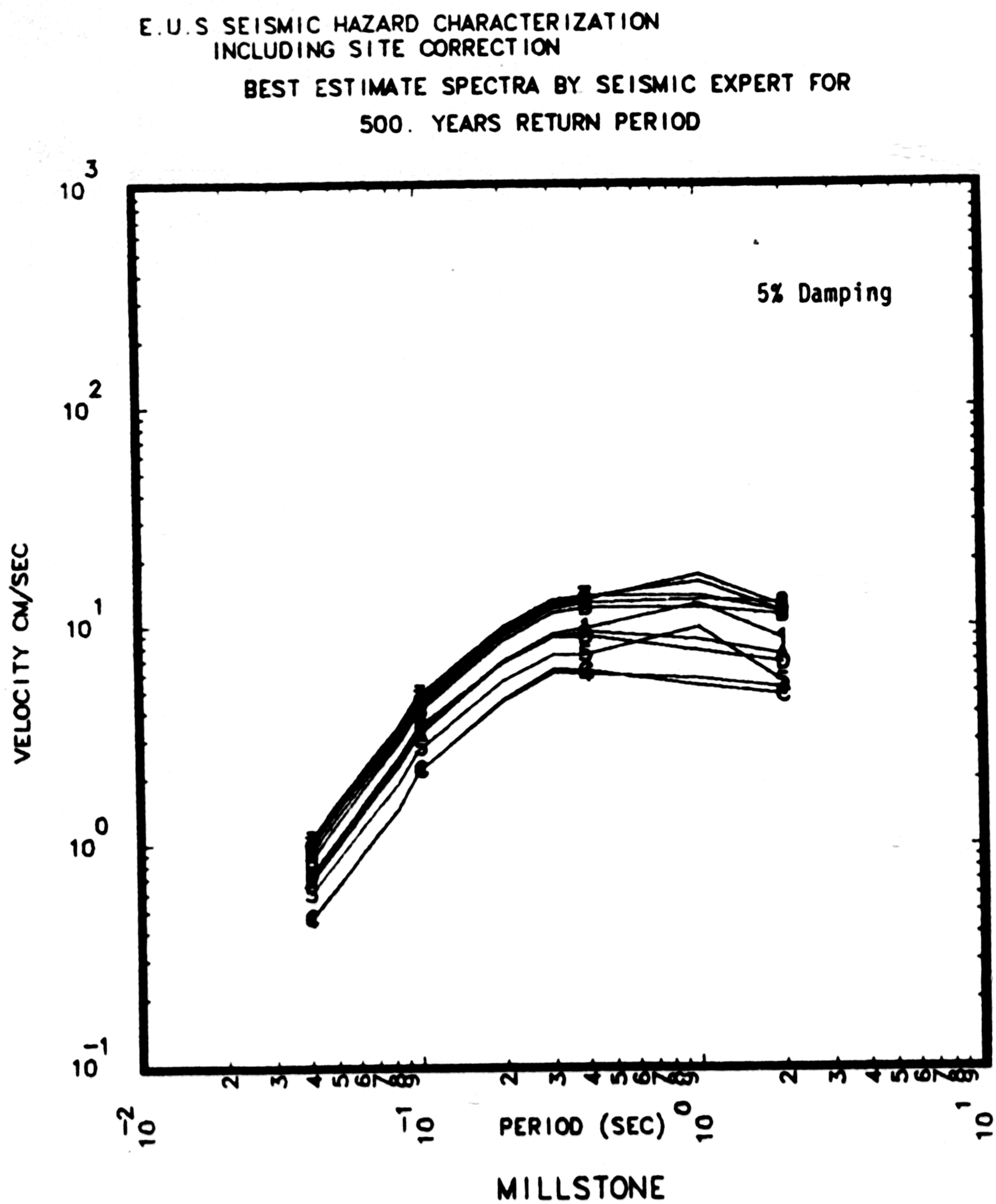


Figure 5.5.5 500 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

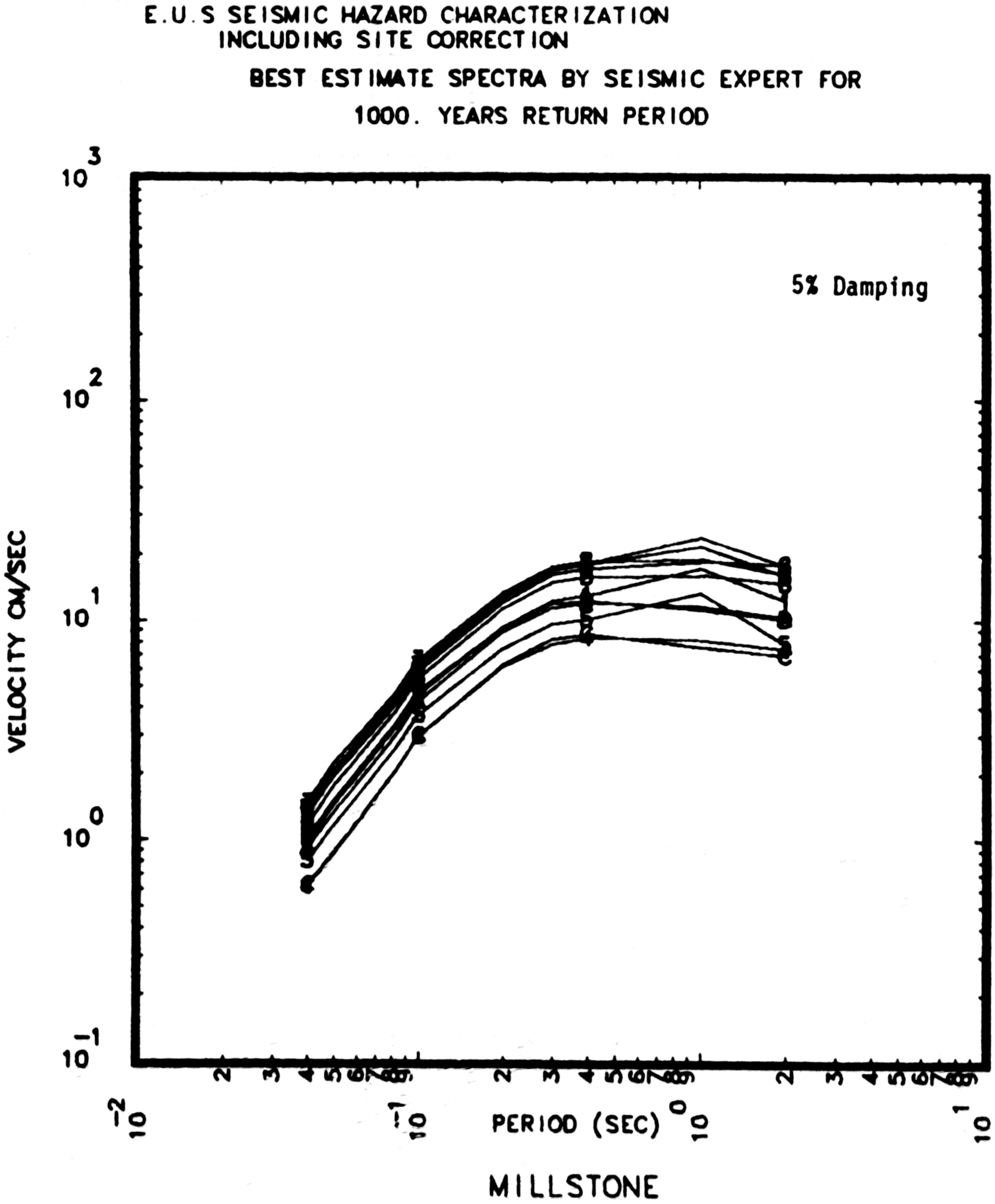


Figure 5.5.6 1,000 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

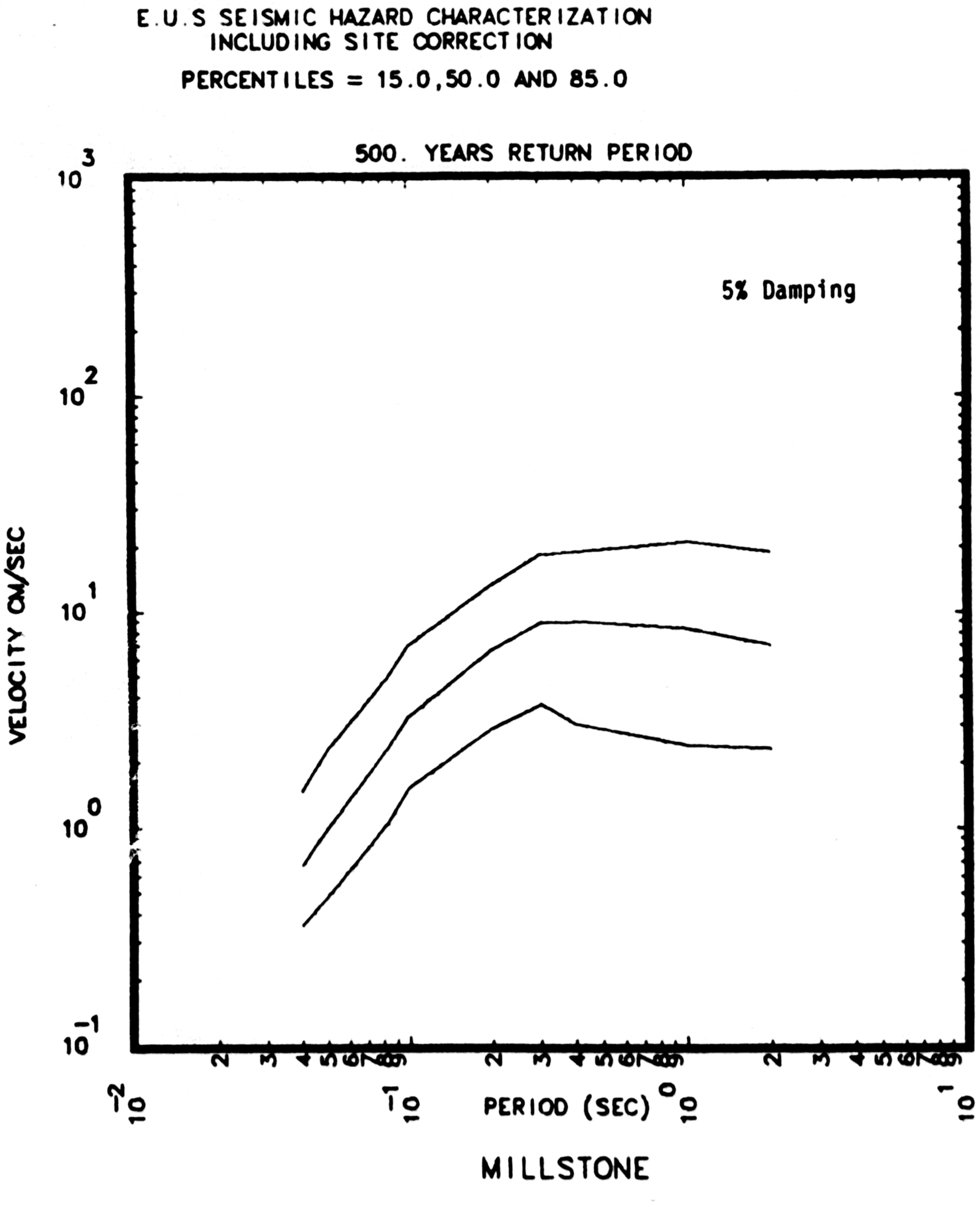


Figure 5.5.7 500 Year Return Period CPUHS Over All Experts

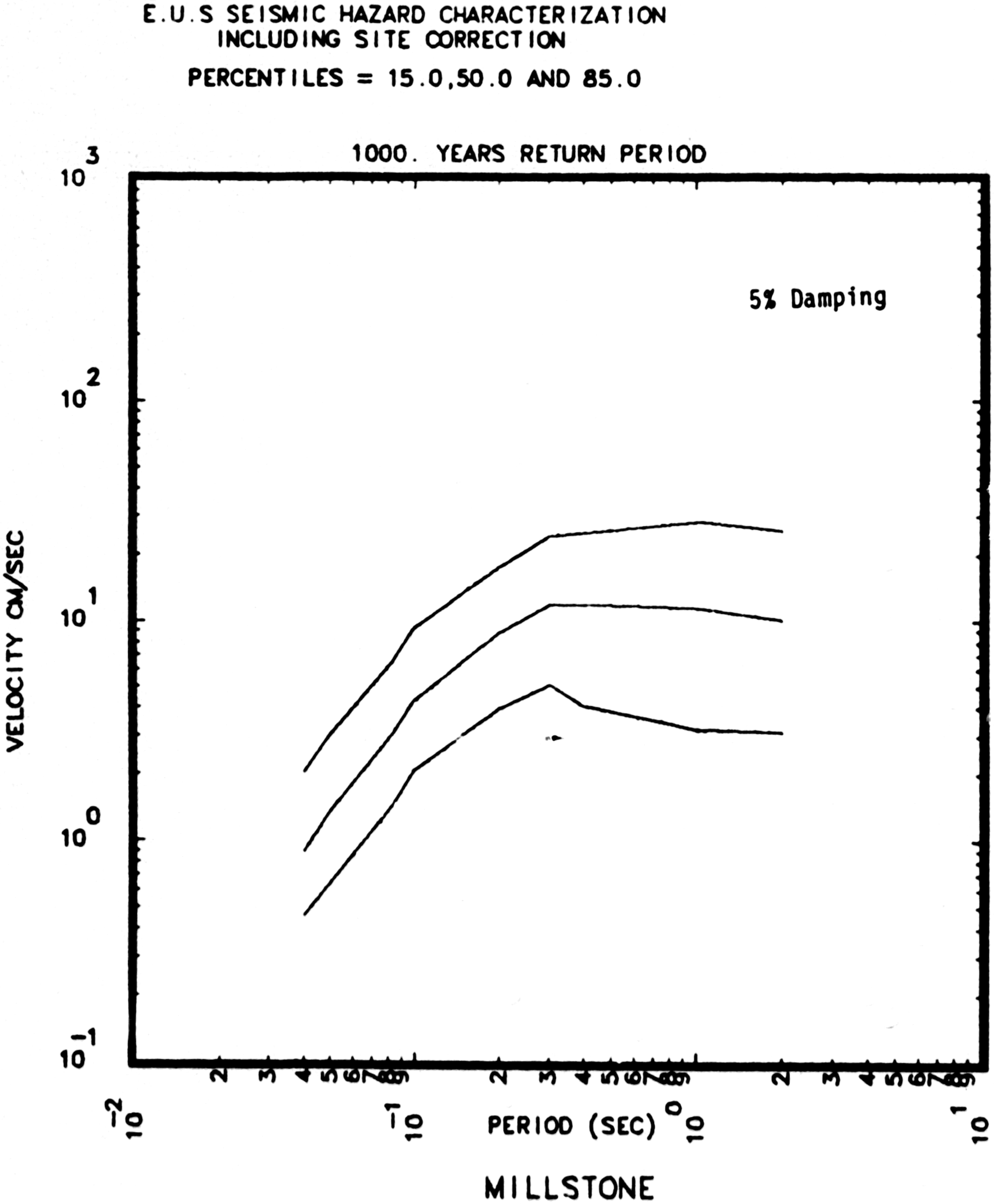


Figure 5.5.8 1,000 Year Return Period CPUHS Over All Experts

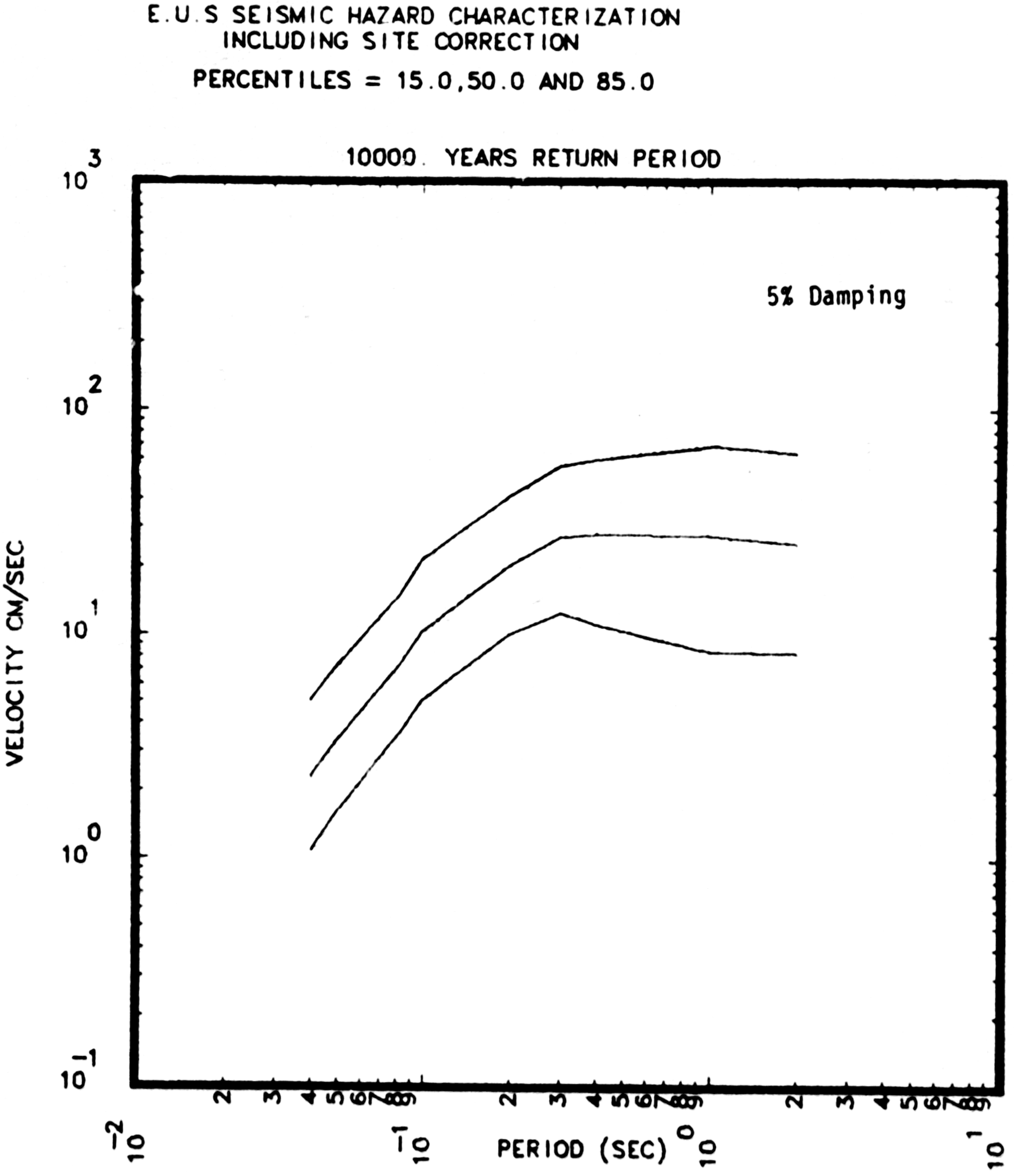


Figure 5.5.9 10,000 Year Return Period CPUHS Over All Experts

5.6 Limerick

5.6.1 Zonation Effects

The Limerick site is a rock site (Category I) located at the boundary point where the northeast, north central, and southeast regions meet in the EUS. For the analysis, the site is located in the northern part of the southeast region. Only seismicity Expert 13 placed the site in the CZ, but the best estimate upper magnitude cutoff is relatively low (6.3) as well as the a-value normalized to the zone size (2.4). Zonal dominances on the BEHC at low and high PGA values are summarized in Table 5.6.1.

5.6.2 PGA Hazard Curves

The BEHC combined over all experts is presented in Fig. 5.6.1. The BEHC per individual seismicity expert is shown on Fig. 5.6.2. The spread (factor of about 18 at low PGA and a factor of about 58 at high PGA values) on the curves indicates the high diversity of opinions between the experts. The BEHC for Expert 13 is spaced further from the other curves. This is due, as mentioned above, to the fact that Expert 13 placed the site in the CZ which has relatively low seismicity. Even though this curve lies outside the general cluster of results for the other experts, the shape of the curve is similar to all the other curves except for Expert 3. Expert 3's curve is more convex than the other curves. This is due to the relatively high upper magnitude cutoff combined with average a-values for the dominant zone (zone 6). It is interesting to note that the BEHC combined over all experts falls approximately on the BEHC of Expert 3.

The CPHC combined over all experts are presented in Fig. 5.6.3. The diversity between experts in the zonation maps for this part of the EUS is also evident in the CPHC of Fig. 5.6.3. The 15th to 50th and 50th to 85th percentile curves vary by approximately one order of magnitude at 500 cm/sec^2, slightly less at low acceleration levels, and higher around 1 g. The 50th percentile BEHC in Fig. 5.6.3 is significantly lower (approximately half an order of magnitude in the value of the probability) than the BEHC of Fig. 5.6.1. This is a manifestation of the skewness of the probability distributions of the parameters in the dominant zones, including the distribution of zonation maps and ground motion models. It is also due, in part, to the fact that the combination over all experts is an arithmetic averaging process; whereas, the constant percentile curves are obtained by interpolations of a distribution on a logarithmic scale.

5.6.3 Uniform Hazard Spectra

The BEUHS combined over all seismicity experts for the five return periods selected are presented in Fig. 5.6.4. The general shape of the spectra is close to the Newmark-Hall model with some visible effect of the Trifunac-Anderson model. The BEUHS per seismicity expert for 500 year and 1,000 year return periods are shown in Figs. 5.6.5 and 5.6.6. The dispersion among seismicity experts appears to be low (typically less than one order of magnitude of velocity) and uniform (a factor of 5 separates the high and low BEUHS of Experts 6 and 13 at both the short period (.04 seconds) and long period (2 seconds) end of the curves) in width. Figures 5.6.5 and 5.6.6 show that the BEUHS for Experts 4, 12, and 13 lie below the curves for the rest of the experts. This is due to the fact that each of these experts placed the site in comparatively large zones which have relatively low seismicity. Input from Experts 2, 6, and 11 led to the highest results in both PGA and spectra. This is because these experts place the site in moderate sized zones which have relatively high seismicity.

The CPUHS curves for a 500 year return period, 1,000 year return period, and 10,000 year return period are shown in Figs. 5.6.7, 5.6.8, and 5.6.9 respectively. The 50th percentile CPUHS for these return periods falls below the BEUHS curves for these return periods by a factor of 1 to 1.5 at the low period (.04 sec.) end of the spectra and by a factor of 1.5 to 2 at the high period (2 sec.) end of the spectra. The 50th and 85th percentile curves in Figs. 5.6.7, 5.6.8, and 5.6.9 have the same general shape as the BEUHS of Figs. 5.6.4. The 15th percentile curves drop off for periods greater than .3 sec. This is an indication of more uncertainty at the higher periods, due in part to the uncertainty in the site correction factor, as described in Section 4.4.

TABLE 5.6.1

Zonal Dominance In The
BEHC At Low and High PGA

SITE: Limerick
SITE CLASSIFICATION: Rock
REGIONAL LOCATION: Southeast

Seismicity Expert	Expert's Host Zone		Contribution to the Hazard: Low PGA (.05g)						High PGA (1.0g)		
1	4	Zone	4	20	1				4		
		Contribution	.96	.01	.01				1.00		
2	28	Zone	28	31	32	CZ	30	27	28		
		Contribution	.93	.02	.02	.01	.01	.01	1.00		
3	6	Zone	6	7	1	8	3	4	6	1	
		Contribution	.76	.09	.08	.04	.01	.01	.94	.06	
4	11	Zone	11	12	16	10	8	19	11	12	
		Contribution	.66	.22	.05	.01	.01	.01	.99	.01	
5	1	Zone	1	6	9	8	CZ		1		
		Contribution	.83	.14	.01	.01	.01		1.00		
6	7	Zone	7	4	5	8	3		7	4	
		Contribution	.85	.12	.01	.01	.01		.99	.01	
7	13	Zone	13	CZ	29	7	24	12	CZ	13	
		Contribution	.57	.20	.13	.05	.02	.01	.97	.02	
10	4	Zone	5	4	CZ	6	7		4	5	CZ
		Contribution	.61	.33	.02	.01	.01		.66	.33	.02
11	5	Zone	5	CZ	3	4	8		5	CZ	
		Contribution	.92	.03	.01	.01	.01		.99	.01	
12	3	Zone	3	4	17A	18	15A	5	3		
		Contribution	.47	.45	.02	.02	.02	.01	1.00		
13	CZ	Zone	CZ	10	11	12	9	8	CZ		
	(15+16+17)	Contribution	.68	.22	.03	.03	.02	.02	1.00		

NOTE: Contributions may not add up to 1.00.

The notation CZ (15+16+17) means that the CZ was also made of zones named 15,16 and 17 by the expert.

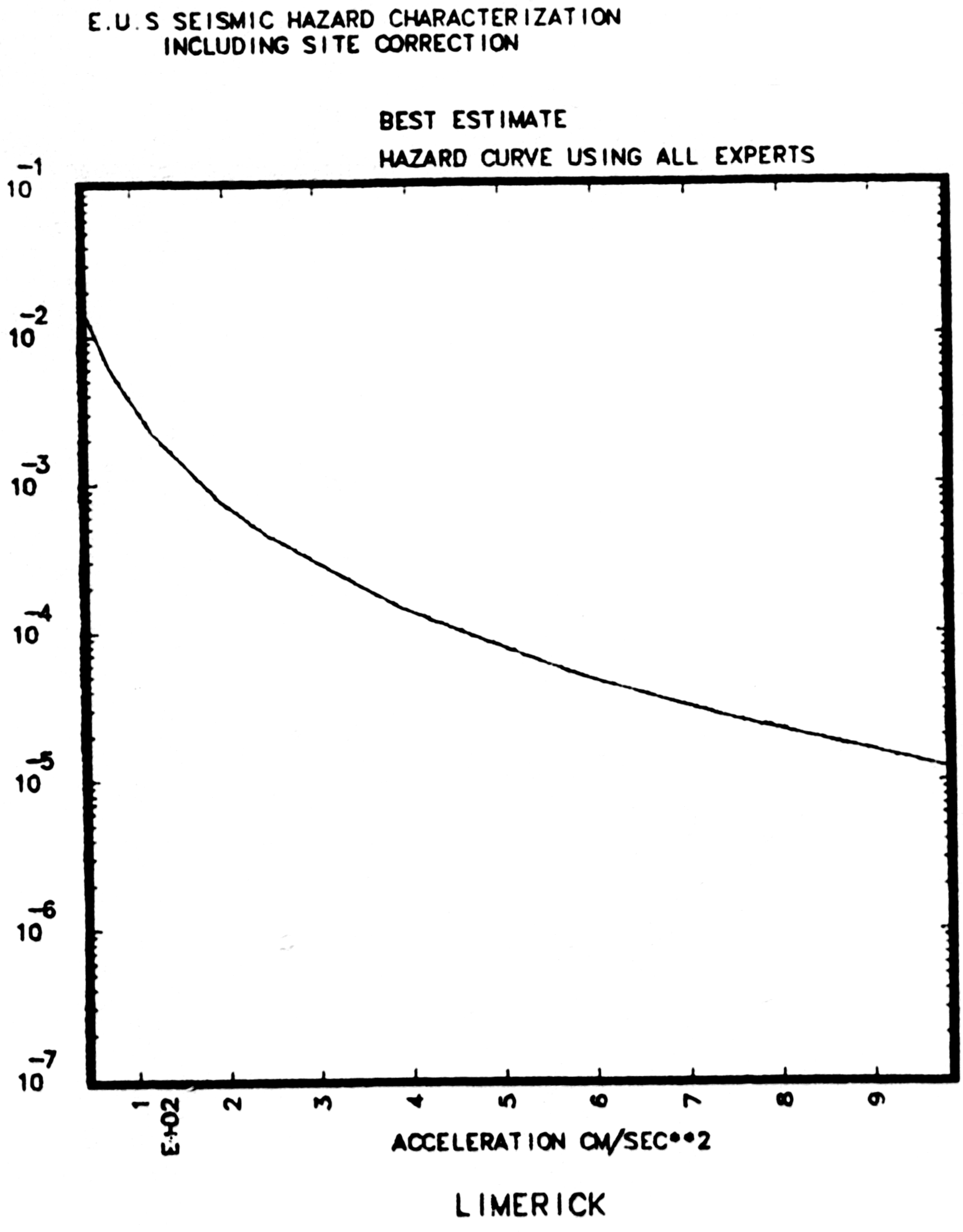


Figure 5.6.1 BEHC Combined Over All Experts

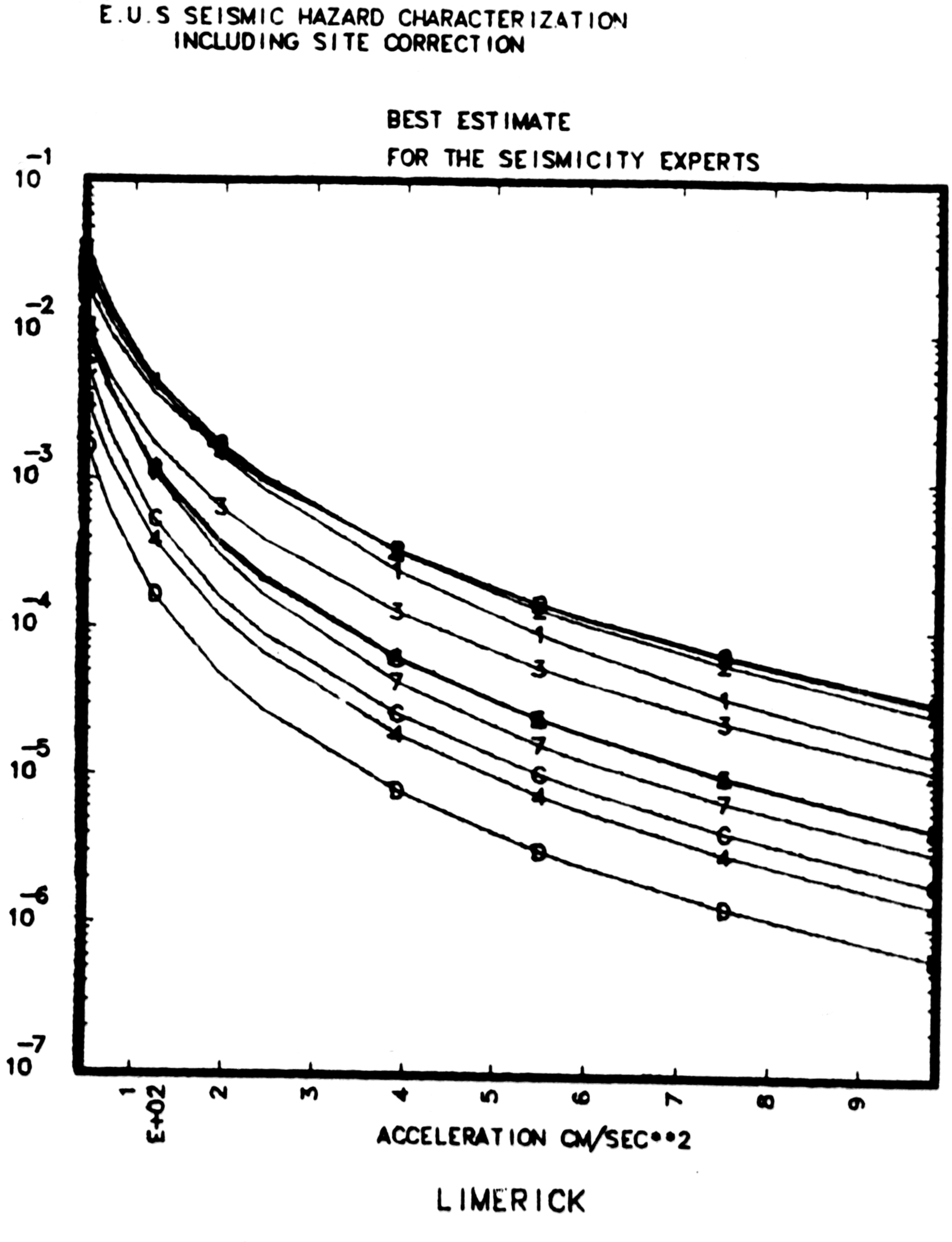


Figure 5.6.2 BEHC per Seismicity Expert Combined Over All Ground Motion Experts

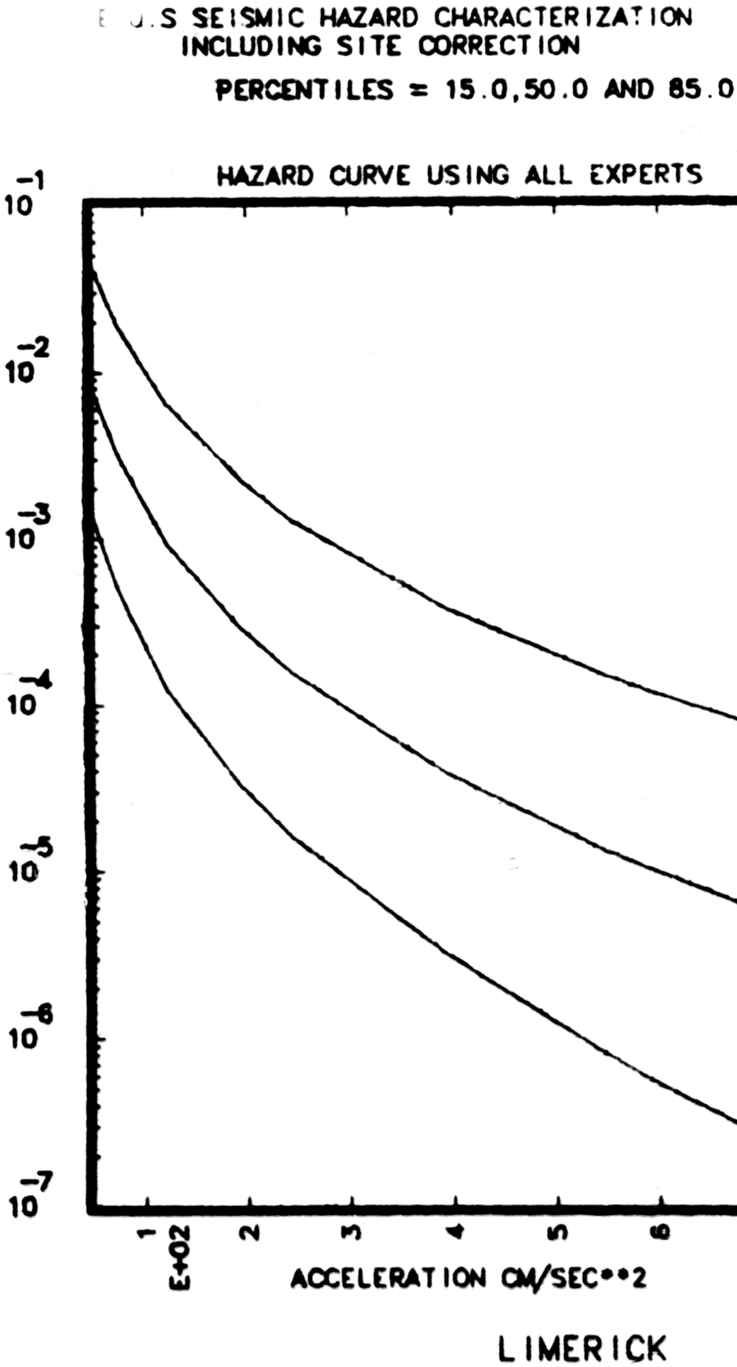


Figure 5.6.3 Constant Percentile Hazard Curves (CPHC) Over All Experts

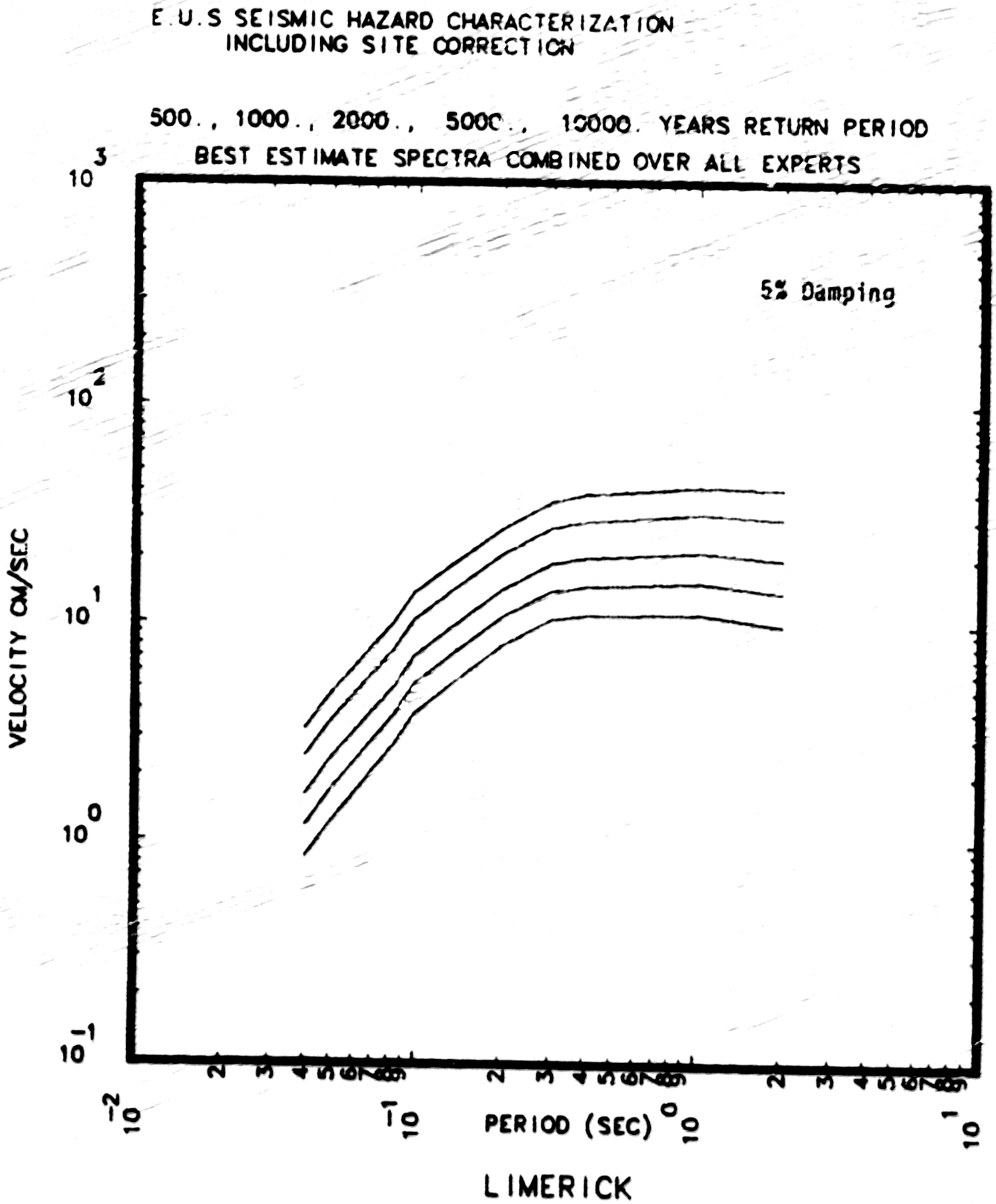


Figure 5.6.4 **Best Estimate Uniform Hazard Spectra (BEUHS) Curves Over All Experts**

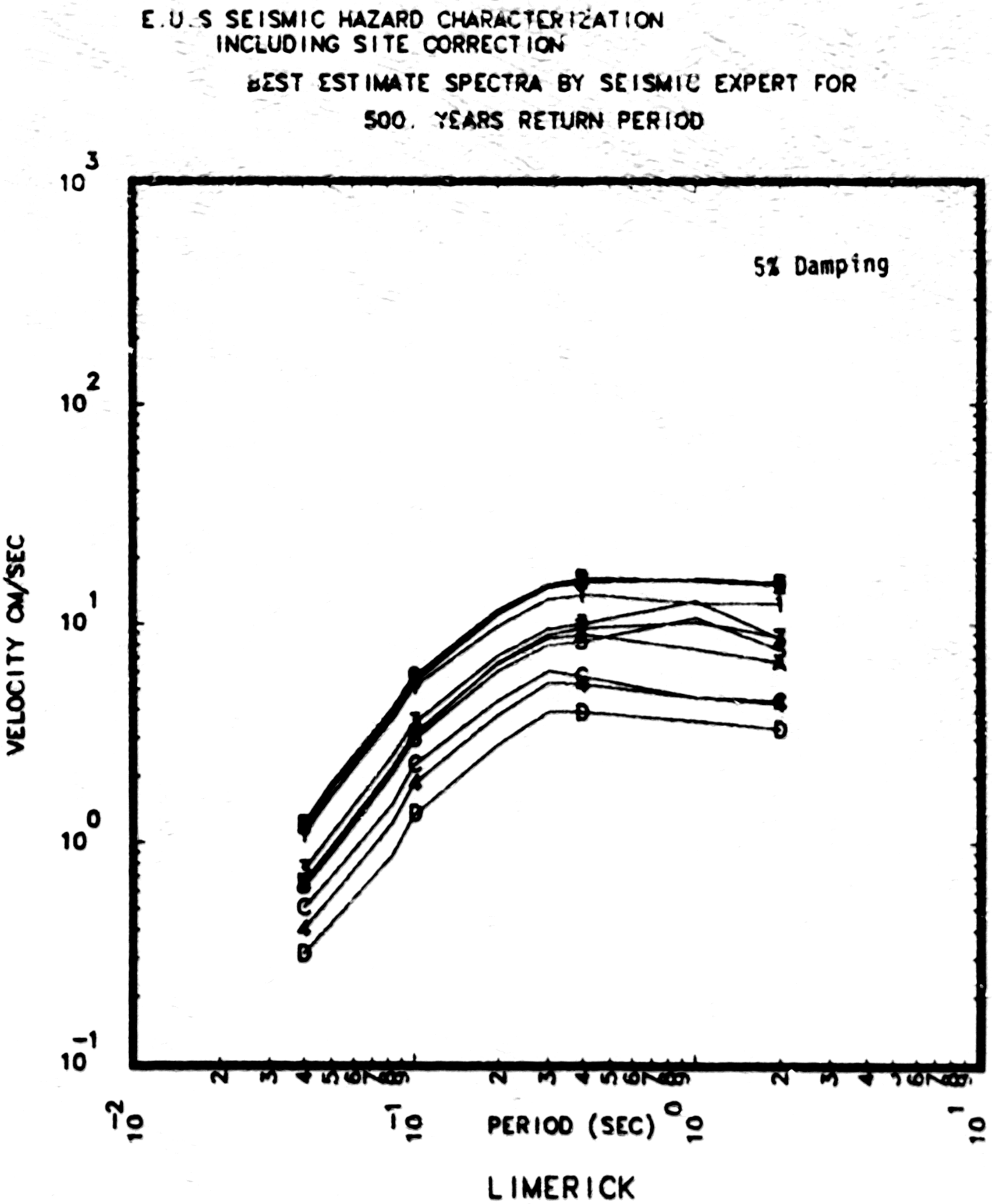


Figure 5.6.5 500 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

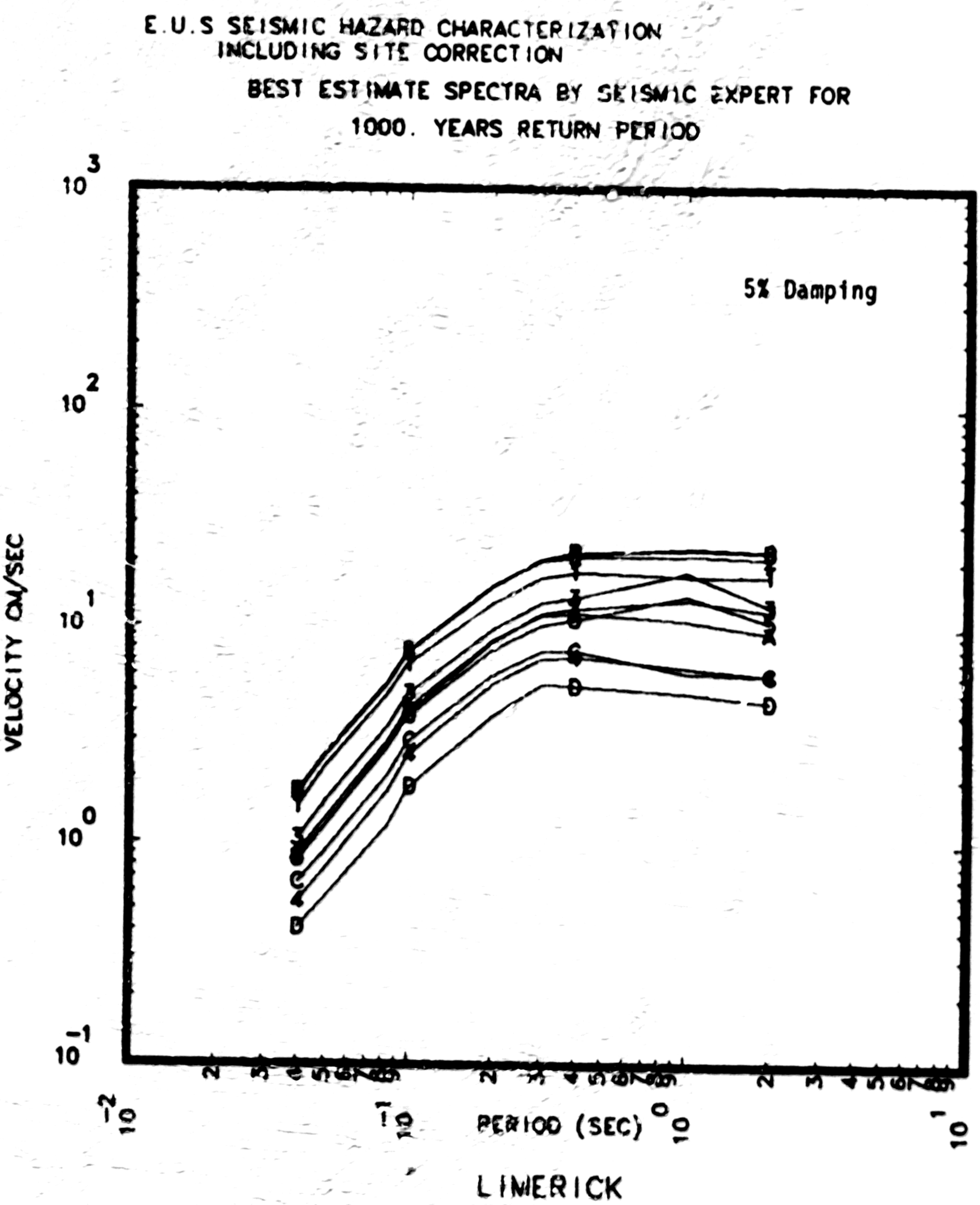


Figure 5.6.6 1,000 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

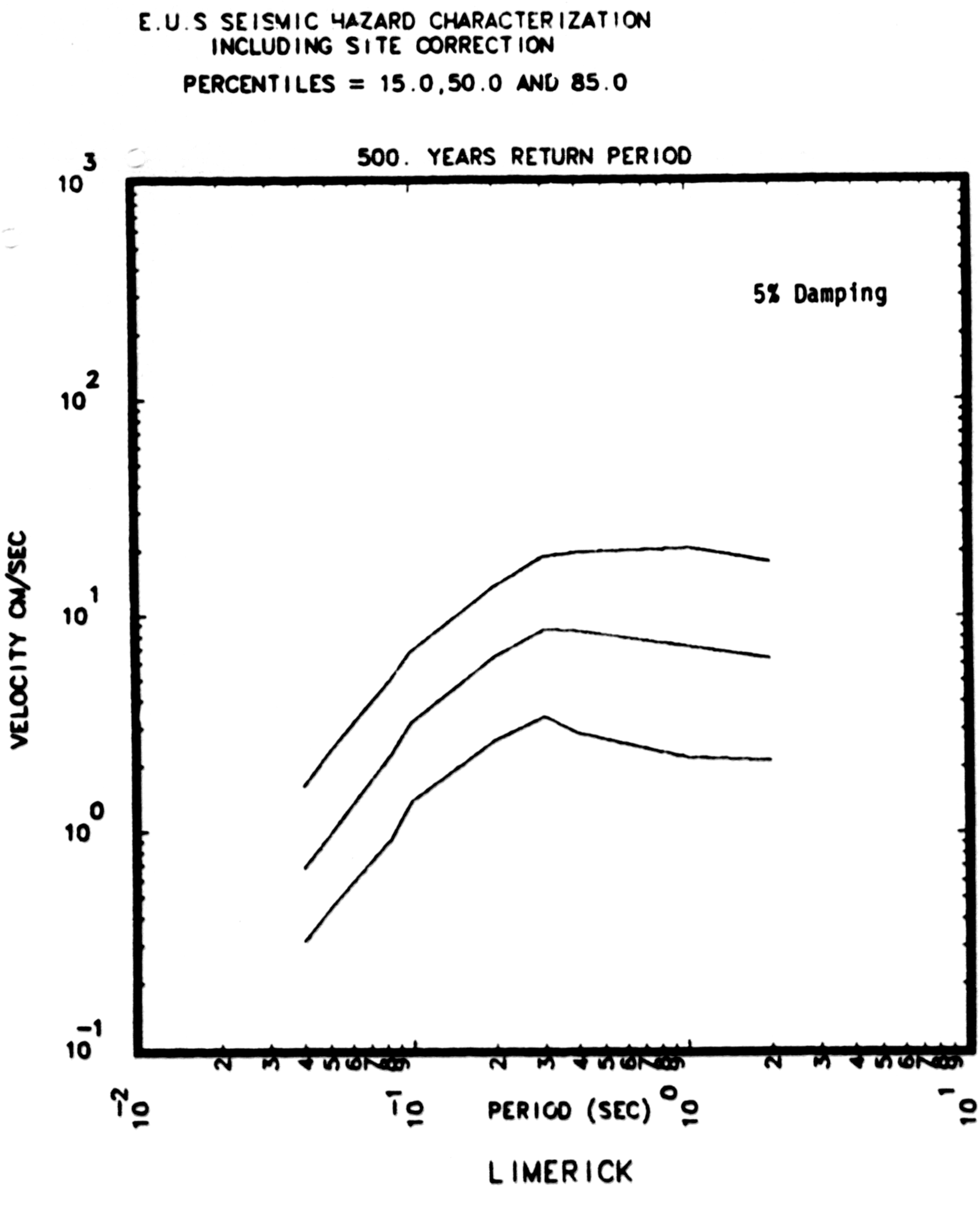


Figure 5.6.7 500 Year Return Period CPUHS Over All Experts

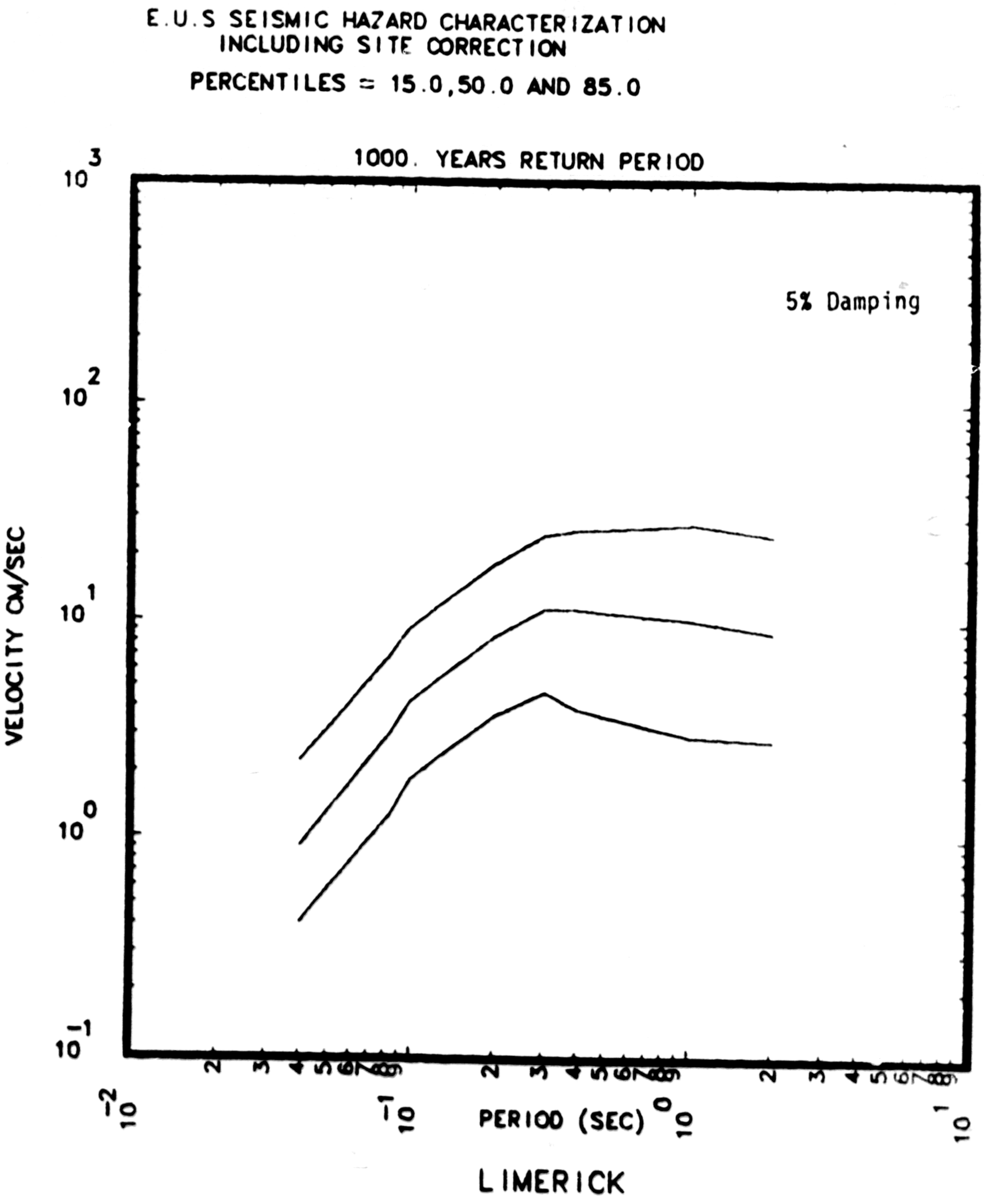


Figure 5.6.8 1,000 Year Return Period CPUHS Over All Experts

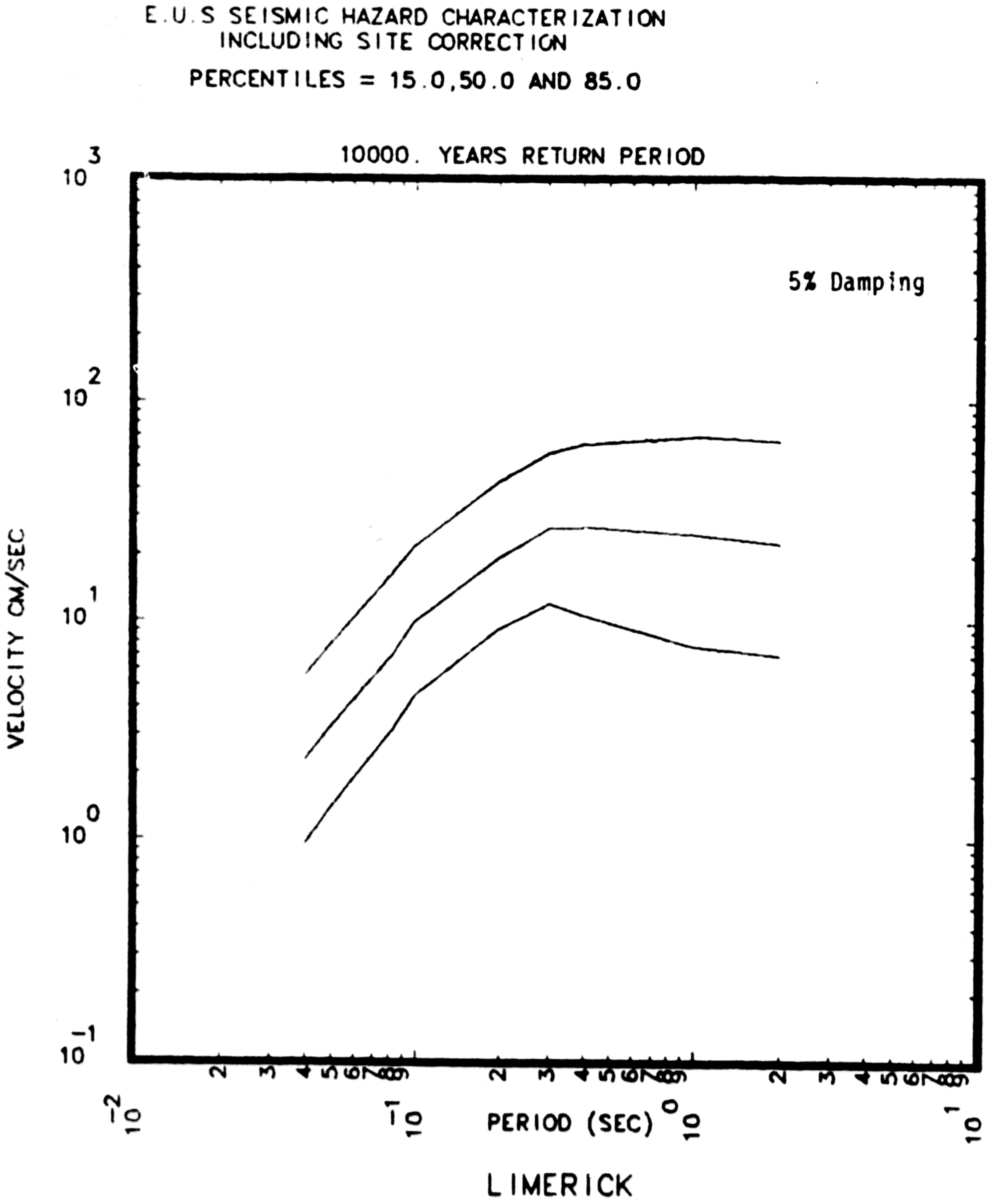


Figure 5.6.9 10,000 Year Return Period CPUHS Over All Experts

5.7 La Crosse

5.7.1 Zonation Effects

The La Crosse site is a shallow soil site (Category IIb) located in the middle of the north central region of the EUS. All seismicity experts (except Experts 4 and 7) placed the site in the CZ. Therefore, the hazard at this site depends primarily on the seismicity parameters of the CZ which for most experts has a low upper magnitude cutoff. Zonal dominance in the BEHC at low and high PGA values is summarized in Table 5.7.1.

5.7.2 PGA Hazard Curves

The BEHC combined over all experts is shown in Fig. 5.7.1. The BEHC per seismicity expert combined over all ground motion experts are shown in Fig. 5.7.2. Despite the fact that the hazard at this site is strongly dominated by the CZ, the curves fall close to one another except the high (Expert 11) and low (Expert 5) curves which fall significantly above and below the curves of the other experts. The effect of ground motion Expert 5 along with the zonation and seismicity of Expert 11 results in Expert 11's high curve. Expert 5 is low, primarily because the upper magnitude cutoff of his CZ is low (5.0). The CPHC are presented in Fig. 5.7.3. The CPHC exhibits a rather large spread. This spread is due in part to the large uncertainty in the CZ parameters. It is also due to the large distribution of the zonation maps. Since the site in all but two cases is located in a large dominant zone, any alternate map generates results which are significantly different from the best estimate. The 50th percentile hazard curve falls on Expert 7's curve, while the BEHC combined over all experts falls in about the middle of the cluster of individual seismicity expert hazard curves. Both the BEHC combined over all experts and the CPHC combined over all experts have the same general shape as the individual seismicity expert hazard curves (except Experts 2 and 12).

5.7.3 Uniform Hazard Spectra

The BEUHS combined over all experts for the five return periods selected are presented in Fig. 5.7.4. The BEUHS per seismicity expert for a 500 year return period and 1,000 year return period are shown in Figs. 5.7.5 and 5.7.6 respectively. The final combined spectra do not flatten out at long periods. This is due to the curves of Experts 1, 2, 4, 5, 6, and 7 which do not flatten out at long periods because of the relatively high upper magnitude cutoffs used by these experts in the dominant zone or significant zone. It is noted that even though these experts have curves with this high upper magnitude phenomenon, the spread in results between seismicity experts is small.

The CPUHS combined over all experts for a 500 year return period, 1,000 year return period, and 10,000 year return period are shown in Figs. 5.7.7, 5.7.8, and 5.7.9 respectively. As with some of the CPUHS for other sites, a greater degree of uncertainty exists at longer periods (periods above .3 sec.) due to the uncertainty in the site correction (See Section 4.4). It coincides with the difference in curve shapes between seismicity experts seen in Figs. 5.7.5 and 5.7.6. Moreover, the median spectra fall substancially below the BEUHS, but they both have the same shape. As with the PGA hazard curves, the differences and spread are due to the uncertainty in the parameters of the CZ.

TABLE 5.7.1

Zonal Dominance In The
BEHC At Low and High PGA

SITE: La Crosse
SITE CLASSIFICATION: Shallow Soil
REGIONAL LOCATION: North Central

Seismicity Expert	Expert's Host Zone		Contribution to the Hazard							
			Low PGA (.05g)					High PGA (1.0g)		
1	CZ(15)	Zone	CZ	9	11	10	19	CZ	9	
		Contribution	.79	.08	.07	.04	.02	.98	.01	
2	CZ	Zone	CZ	18	21	20		CZ	18	
		Contribution	.80	.16	.02	.01		.98	.02	
3	CZ(1)	Zone	CZ	14	17	15	16	CZ		
		Contribution	.57	.35	.04	.03	.02	1.00		
4	6	Zone	6	4	CZ	5		6	CZ	
		Contribution	.82	.10	.06	.01		.73	.27	
5	CZ(2)	Zone	CZ	15	13	14	12	CZ	15	
		Contribution	.74	.19	.03	.02	.02	.96	.04	
6	CZ(1)	Zone	CZ	23	17			CZ		
		Contribution	.63	.22	.15			1.00		
7	3	Zone	3	CZ	6	4	5	3	CZ	6
		Contribution	.76	.12	.07	.04	.02	.75	.23	.02
10	CZ(19)	Zone	CZ	26	12	32		CZ		
		Contribution	.93	.03	.03	.01		1.00		
11	CZ(0)	Zone	CZ	10	11			CZ		
		Contribution	.89	.10	.01			1.00		
12	CZ(1)	Zone	CZ	10	12	20	11	CZ		
		Contribution	.88	.05	.04	.02	.01	1.00		
13	CZ (15+16+17)	Zone	CZ	5	6			CZ		
		Contribution	.93	.06	.01			1.00		

NOTE: Contributions may not add up to 1.00.

The notation CZ (2) means that the CZ was also named zone 2 by the expert.

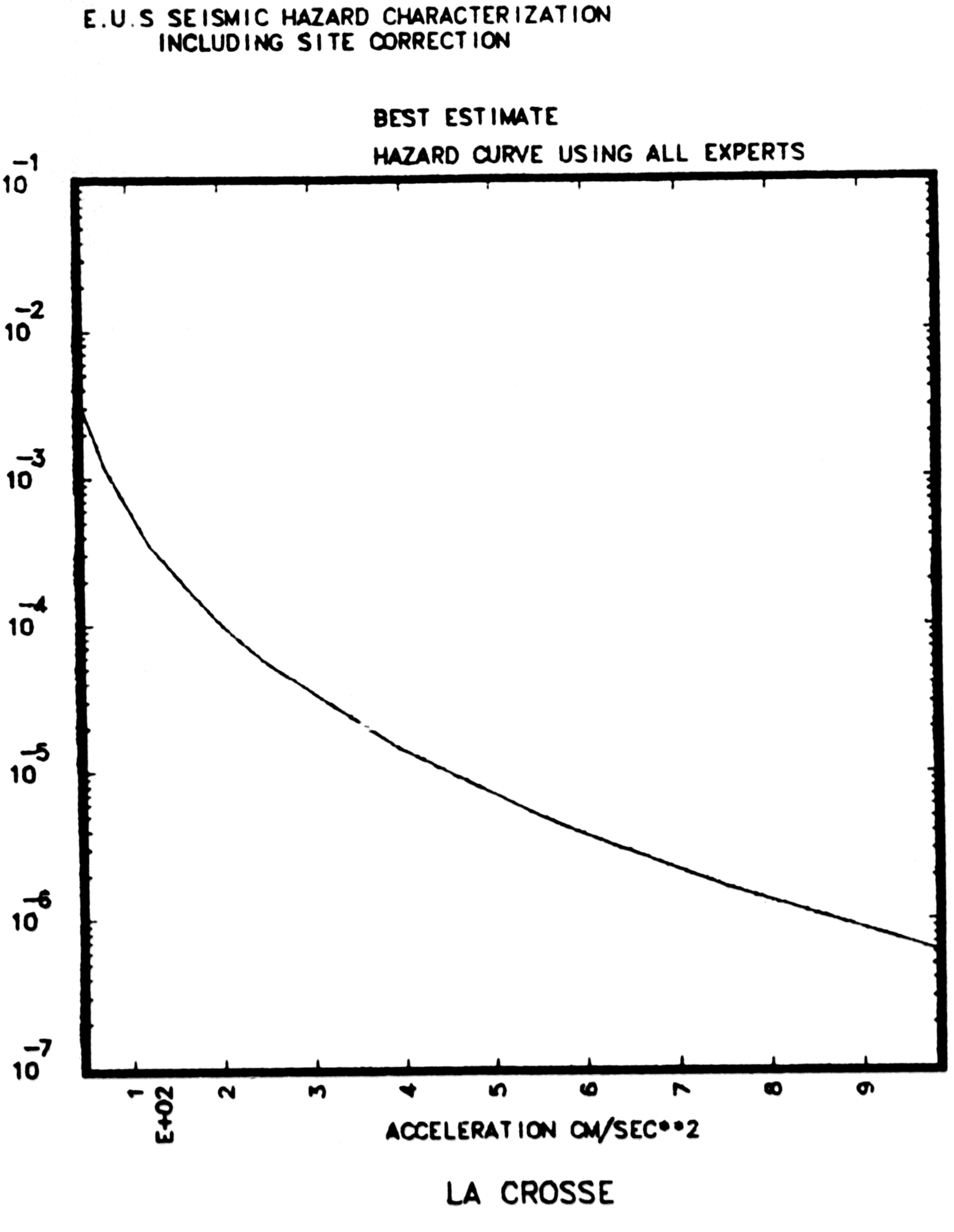


Figure 5.7.1 BEHC Combined Over All Experts

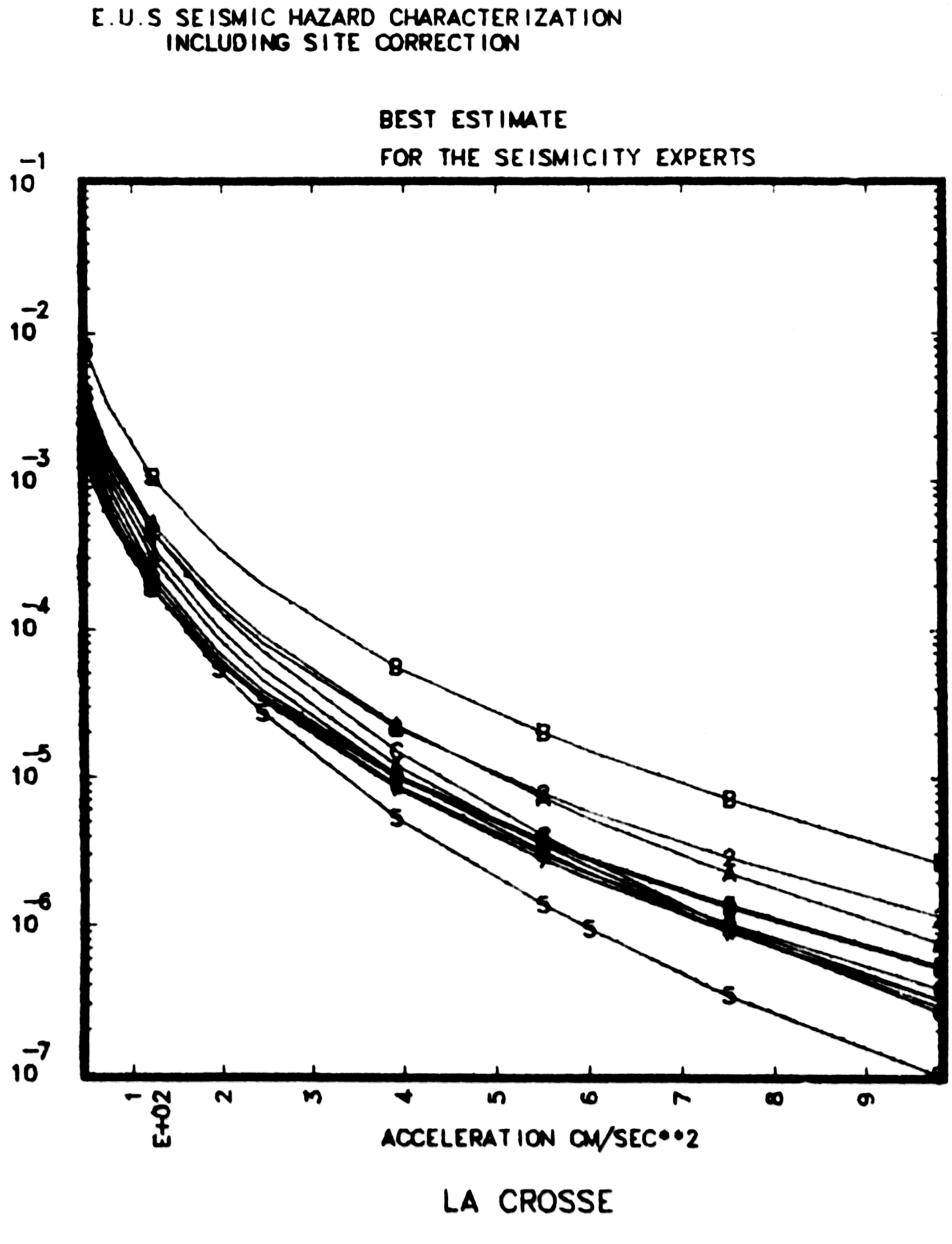


Figure 5.7.2 BEHC per Seismicity Expert Combined Over All Ground Motion Experts

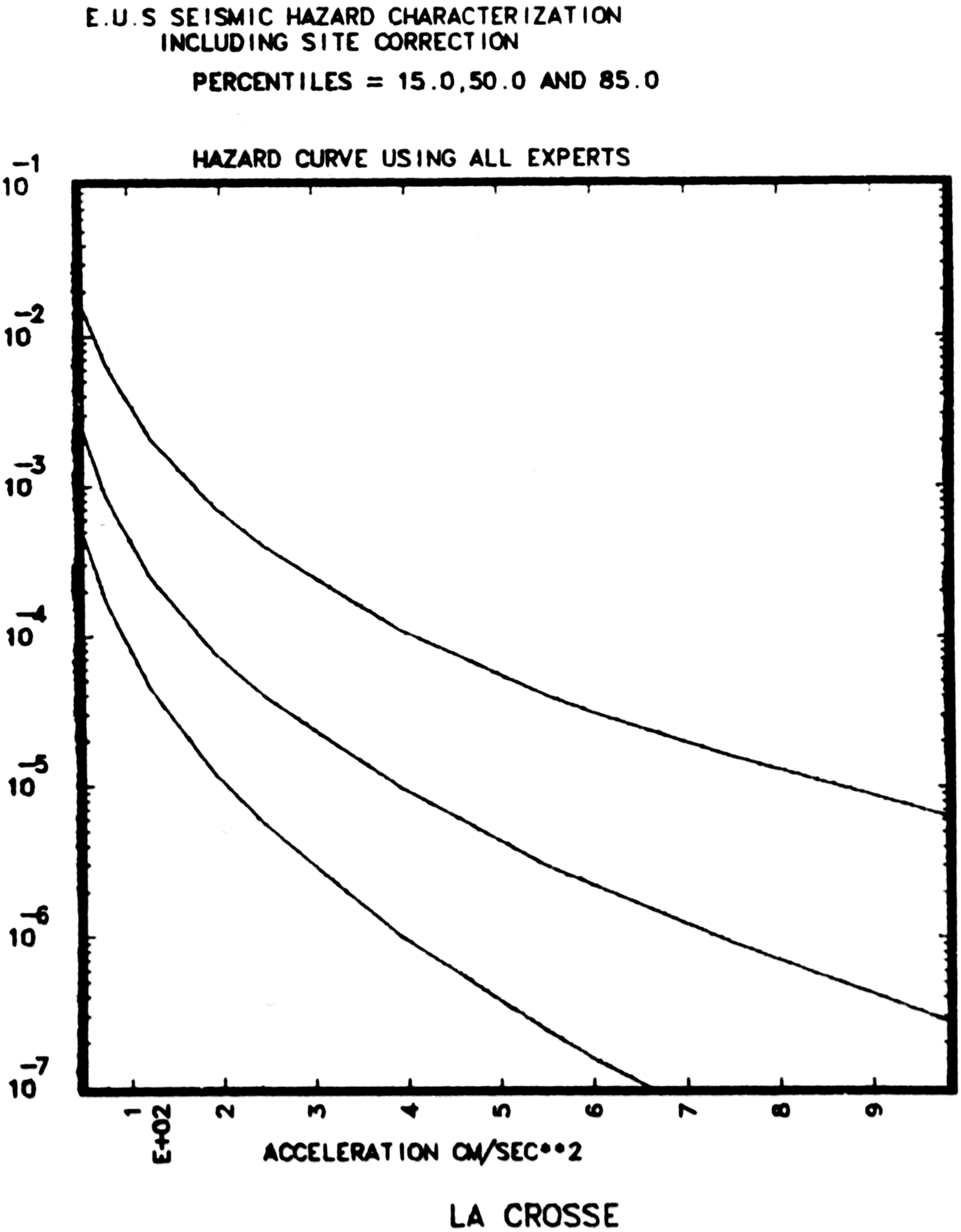


Figure 5.7.3 Constant Percentile Hazard Curves (CPHC) Over All Experts

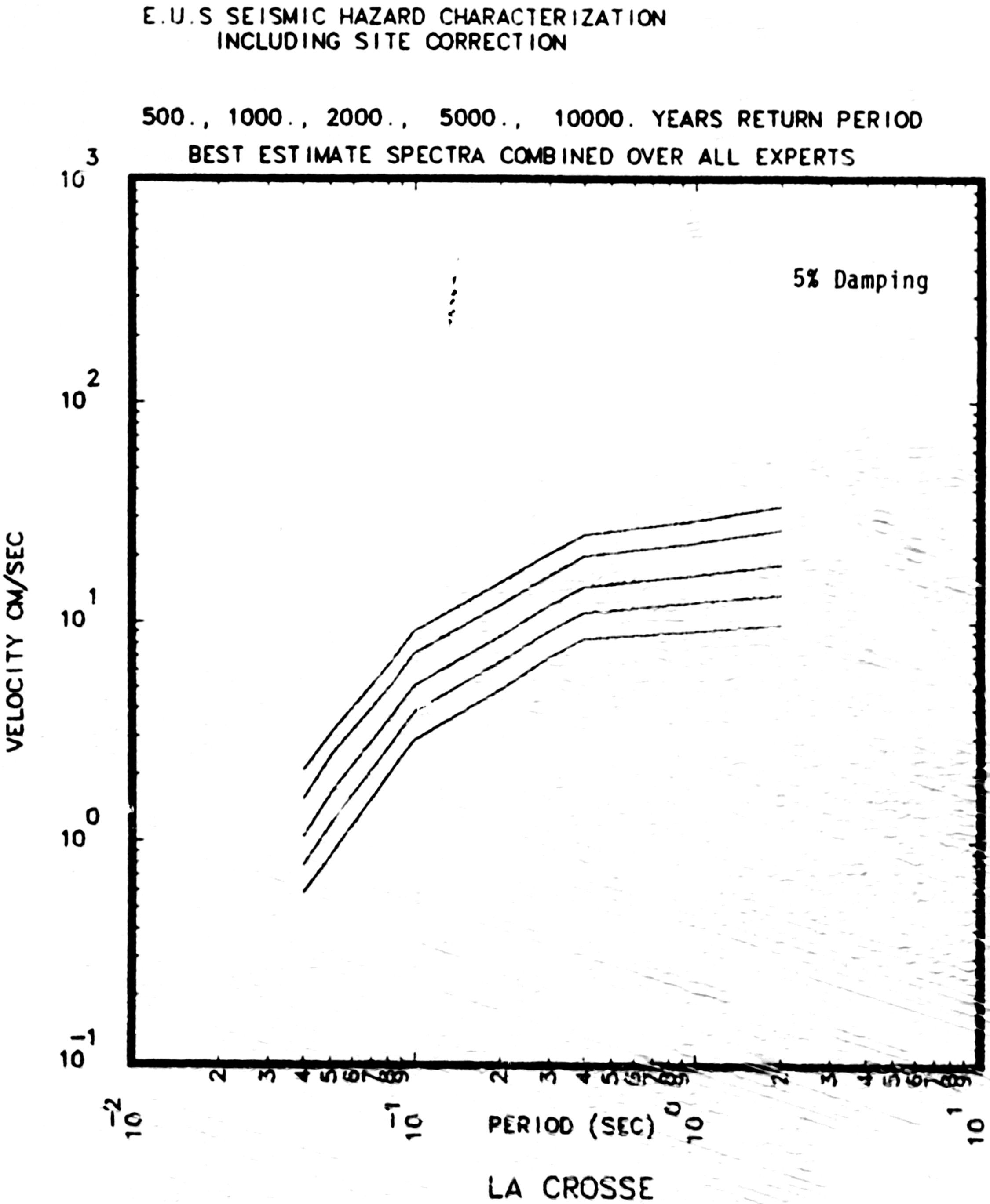


Figure 5.7.4 Best Estimate Uniform Hazard Spectra (BEUHS) Curves Over All Experts

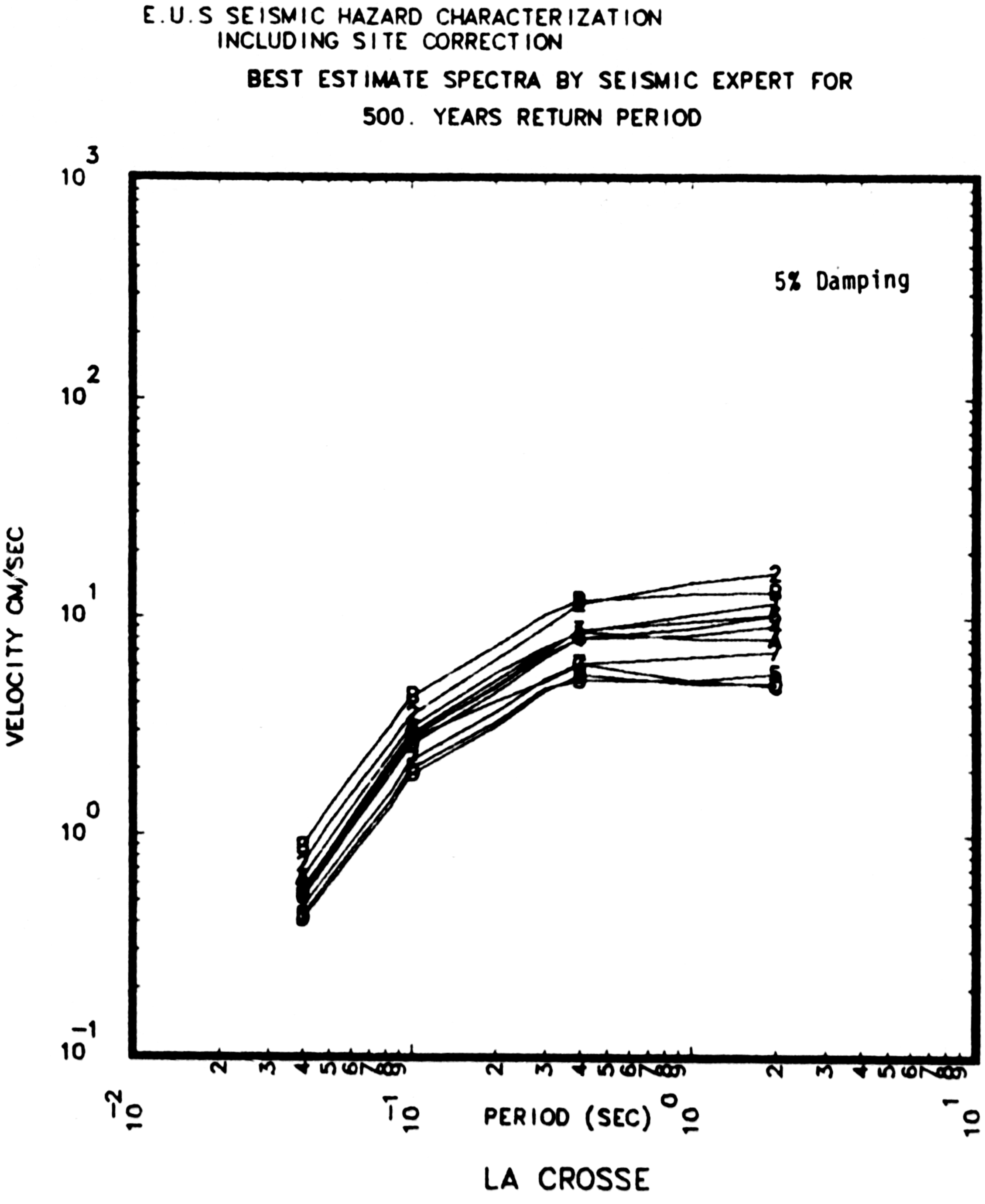


Figure 5.7.5 500 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

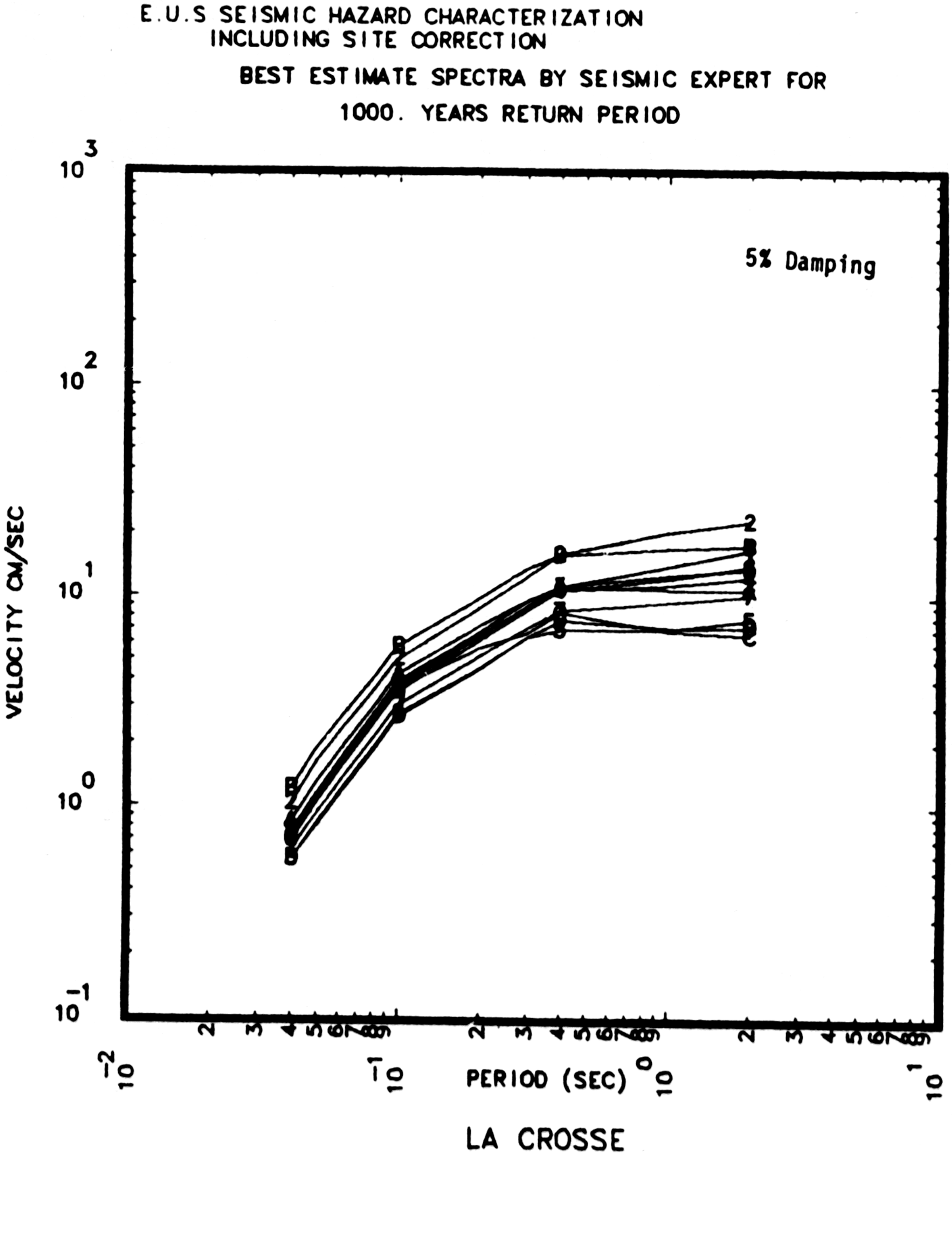


Figure 5.7.6 1,000 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

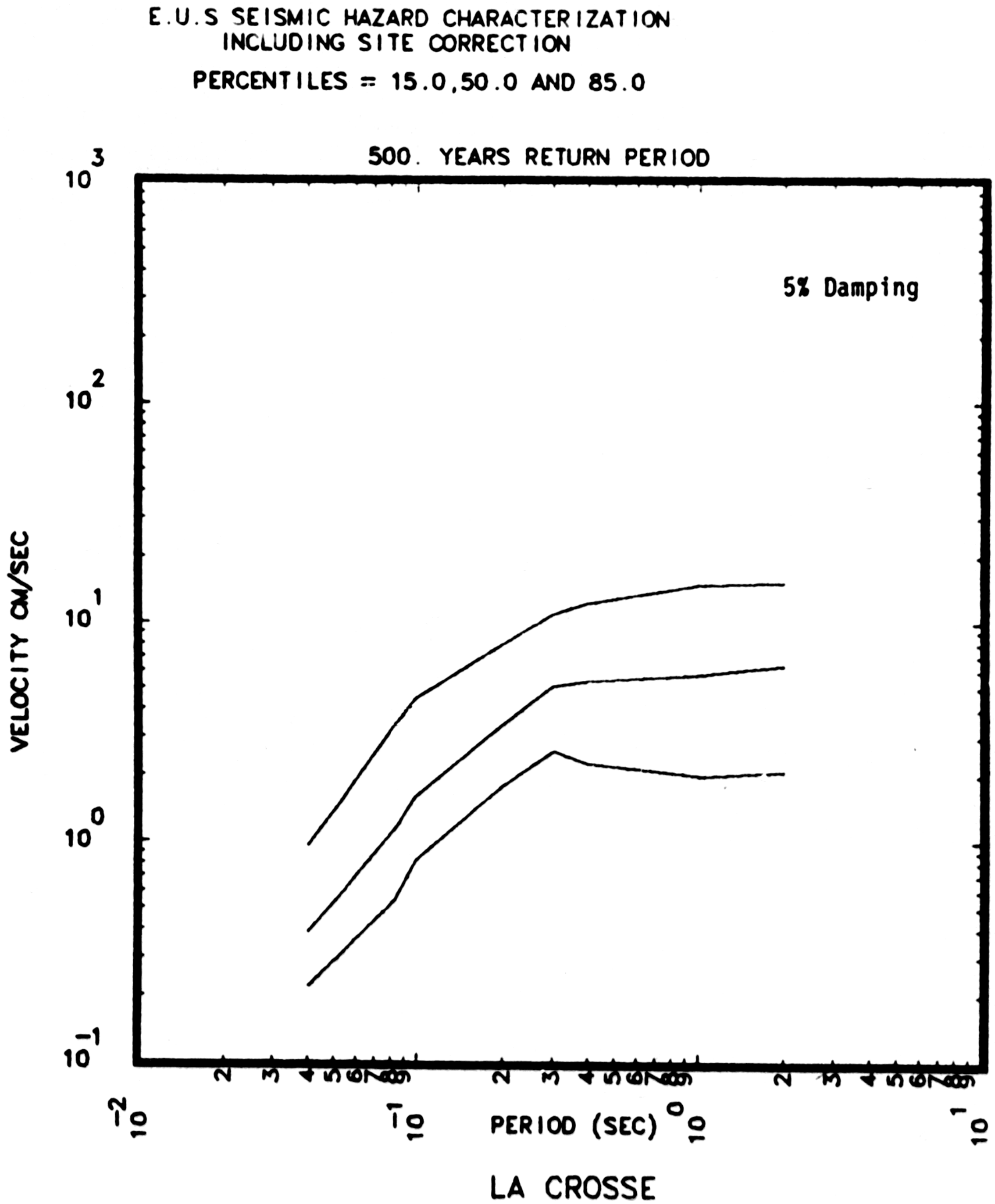


Figure 5.7.7 500 Year Return Period CPUHS Over All Experts

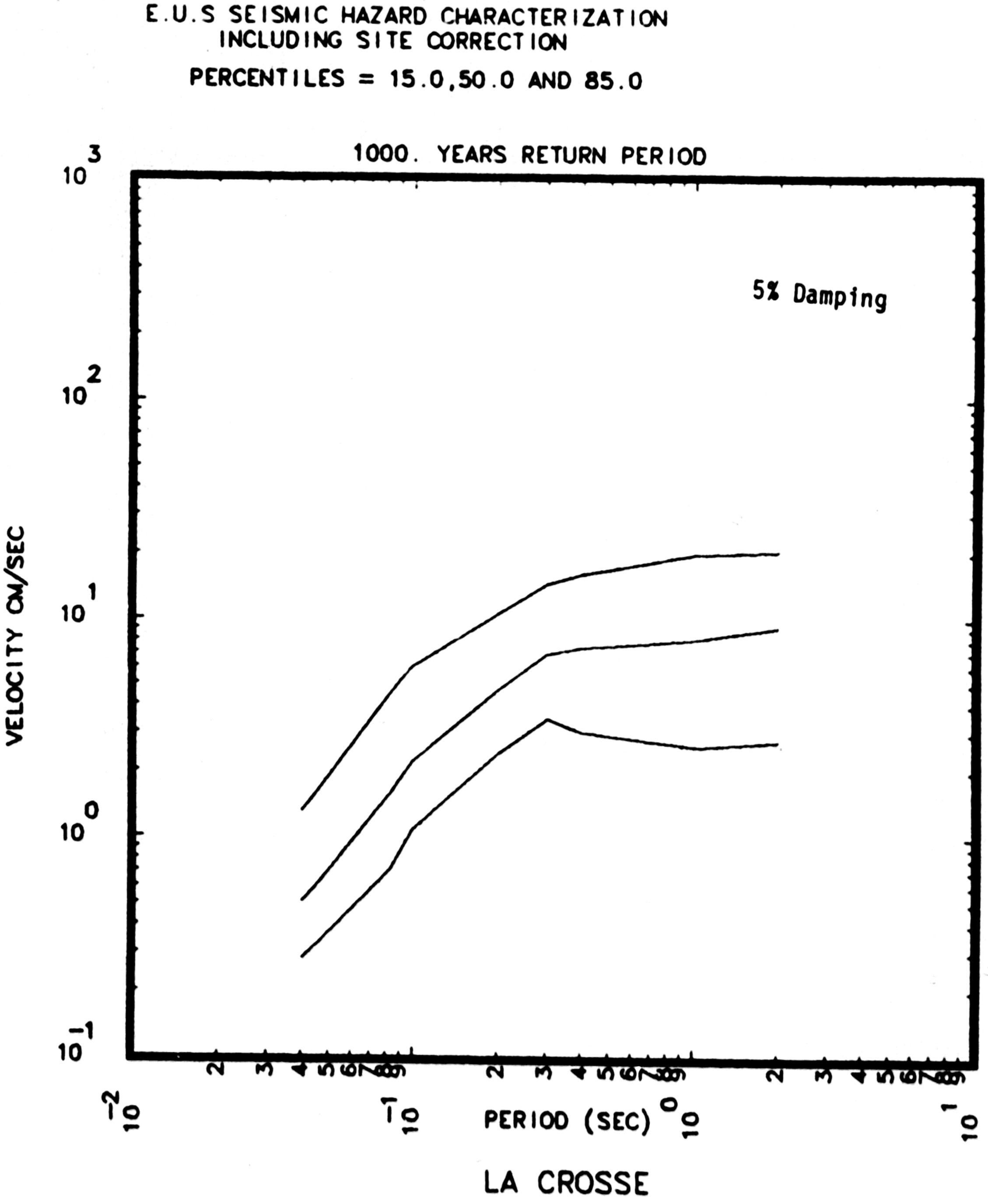


Figure 5.7.8 1,000 Year Return Period CPUHS Over All Experts

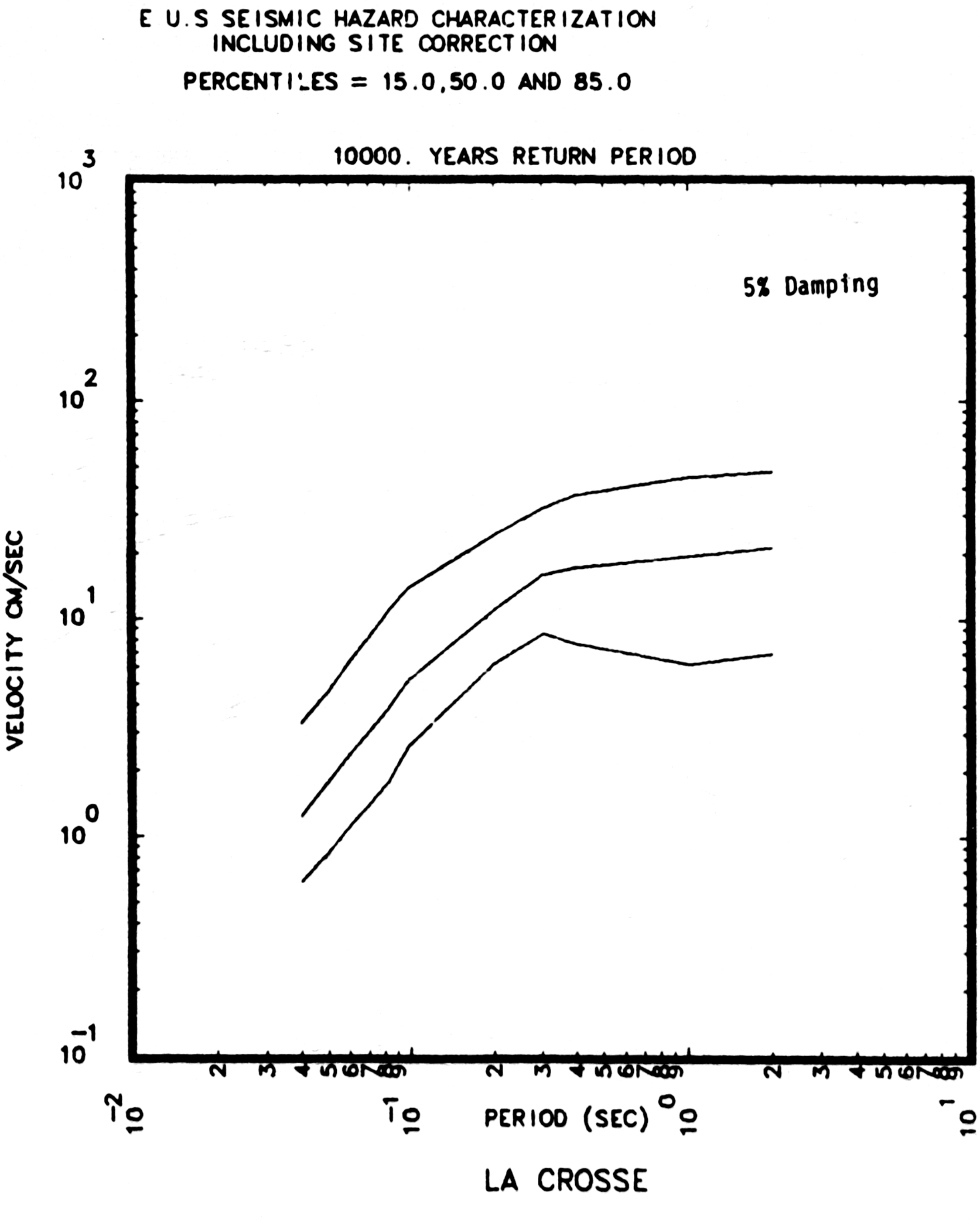


Figure 5.7.9 10,000 Year Return Period CPUHS Over All Experts

5.8 Wolf Creek

5.8.1 Zonation Effects

The Wolf Creek site is a rock site (Category I) located at the northern end of the south central region of the EUS. For all the seismicity experts, but Expert 2, the site falls in the CZ. The diversity of the zonation between experts in the south central region is an important factor in the spread of hazard curves. For two of the experts (Experts 4 and 10) the combination of zonation and ground motion models shifts the zonal dominance from one zone to another between low to high PGA values. For Expert 10, the shift is between zone 32 (a nearby zone) at low PGA values to the CZ at high PGA values. For Expert 4, the site is located in the CZ, but at low PGA values zone 1 (a nearby zone) is dominant. At high PGA values, the CZ is dominant. The zonal dominances at low and high PGA values are summarized in Table 5.8.1.

5.8.2 PGA Hazard Curves

The BEHC combined over all experts is shown in Fig. 5.8.1. The BEHC per seismicity expert combined over all ground motion experts is shown in Fig. 5.8.2. The BEHC combined over all experts falls on the BEHC for Expert 10. This curve is in the middle of the cluster of BEHC for individual seismicity experts. In general, two shapes of hazard curves are seen in Fig. 5.8.2. Experts 2, 5, 7, 10, 11, and 13 have curves which have less curvature than Experts 1, 3, 4, 6, and 12. The flatter curves are obtained in those cases where the upper magnitude cutoff and seismicity for the dominant nearby zones is higher than for the other experts. The spread of the curves appears to be moderate (a factor of 8 at low PGA values and a factor of 24 at high PGA values). Expert 2's curve lies significantly above the curves for the rest of the experts. This is due to the high upper magnitude cutoffs for all of this expert's dominant zones (6.0 for zone 15, 7.8 for zone 18, 7.3 for the CZ, 6.0 for zone 5, 6.5 for zone 20, and 5.8 for zone 6). As discussed in Sec. 5.2, the large upper magnitude cutoffs in the New Madrid zone, combined with the ground motion Expert 5's BE ground motion model (#14 in Table B-1), leads to higher hazard than the other ground motion models. The effect of ground motion model #14 on rock sites is also shown in Fig. 4.4.4a and 4.4.4b.

The large dispersion in the hazard results is shown in Fig. 5.8.3. The difference in hazard between the 15th and 50th percentile curves or between the 50th and 85th percentile curves is about one-and-a-half order of magnitude at low PGA values and about two-and-a-half orders of magnitude at high PGA values. The BEHC combined over all experts and the CPHC combined over all experts are similar in shape. The discrepancy between the BEHC and the 50th percentile hazard curve is a factor of about 2.5 at low PGA values (the BEHC lies above the 50th percentile hazard curve). Most of this uncertainty comes from the high hazard which results from ground motion Expert 5's model in conjunction with the New Madrid zone. The difference is also due to the fact that the BEHC is based on an arithmetical average as opposed to the CPHC which is obtained by interpolations on a logarithmic scale. Another factor which contributes to the discrepancy between the BEHC and the 50th percentile hazard curve is the skewness of the probability distributions of the dominant parameters.

5.8.3 Uniform Hazard Spectra

The BEUHS combined over all experts for the five return periods specified is presented in Fig. 5.8.4. The curves exhibit a shape very close to the Newmark-Hall spectrum shape. The BEUHS per seismicity expert for the 500 year return period and the 1,000 year return period are shown in Figs. 5.8.5 and 5.8.6 respectively. These two figures show that the slight divergence of the combined BEUHS as the period increases is due mainly to Expert 2. As discussed above, Expert 2 has high upper magnitude cutoffs for all the dominant zones. As with PGA hazard, Expert 2 lies significantly above and Expert 13 significantly below the cluster of BEUHS for the rest of the experts. The dispersion in the BEUHS among the other nine experts is small. The BEUHS combined over all experts for the 500 year return period lies in the middle of the spread of BEUHS per seismicity expert for the same return period. This can also be said for the 1,000 year return period curves.

The CPUHS combined over all experts for the 500 year return period, the 1,000 year return period, and 10,000 year return period are presented in Figs. 5.8.7, 5.8.8, and 5.8.9 respectively. The CPUHS have shapes slightly closer to a Newmark-Hall spectrum shape. The spread between the 15th and 50th percentile and the 50th and 85th percentile is moderate at low periods and high at long periods. Comparison of the BEUHS to the CPUHS shows that the BEUHS is a factor of about 1.5 higher at short period (.04 sec.) and a factor of about 2 higher at long periods (2 sec.). As indicated above, this discrepancy is due to the skewness of the probability distributions of the dominant parameters.

TABLE 5.8.1

Zonal Dominance In The
BEHC At Low and High PGA

SITE: Wolf Creek
SITE CLASSIFICATION: Rock
REGIONAL LOCATION: South Central

Seis-micity Expert	Expert's Host Zone		Contribution to the Hazard: Low PGA (.05g)						High PGA (1.0g)		
1	CZ(15)	Zone	CZ	14	9	10	5	11	CZ	9	10
		Contribution	.50	.22	.11	.09	.05	.02	.85	.12	.02
2	15	Zone	15	18	CZ	5	20	6	15	18	CZ
		Contribution	.63	.19	.08	.06	.01	.01	.84	.11	.06
3	CZ(1)	Zone	CZ	17	15	16	18		CZ	15	17
		Contribution	.75	.12	.09	.03	.01		.97	.02	.01
4	CZ	Zone	1	4	CZ	3	5		CZ	4	1
		Contribution	.71	.22	.04	.02	.01		.82	.12	.06
5	CZ(2)	Zone	CZ	15	17	14			CZ	15	
		Contribution	.68	.19	.11	.02			.85	.15	
6	CZ(1)	Zone	CZ	25	17	22			CZ	17	25
		Contribution	.44	.28	.24	.04			.81	.08	.01
7	CZ(2)	Zone	CZ	30	6	5			CZ	6	
		Contribution	.80	.08	.07	.05			.97	.03	
10	CZ(19)	Zone	32	CZ	12	29	13		CZ	32	
		Contribution	.50	.38	.08	.03	.01		.96	.04	
11	CZ	Zone	CZ	17	10	15	11		CZ		
		Contribution	.68	.18	.04	.04	.04		1.00		
12	CZ(1)	Zone	CZ	9	12	11			CZ	12	9
		Contribution	.59	.32	.06	.03			.94	.03	.02
13	CZ	Zone	CZ	5	1	6	3		CZ	5	
	(15+16+17)	Contribution	.81	.15	.02	.01	.01		.99	.01	

NOTE: Contributions may not add up to 1.00.
The Notation CZ (2) means that the CZ was also called zone 2 by the expert.

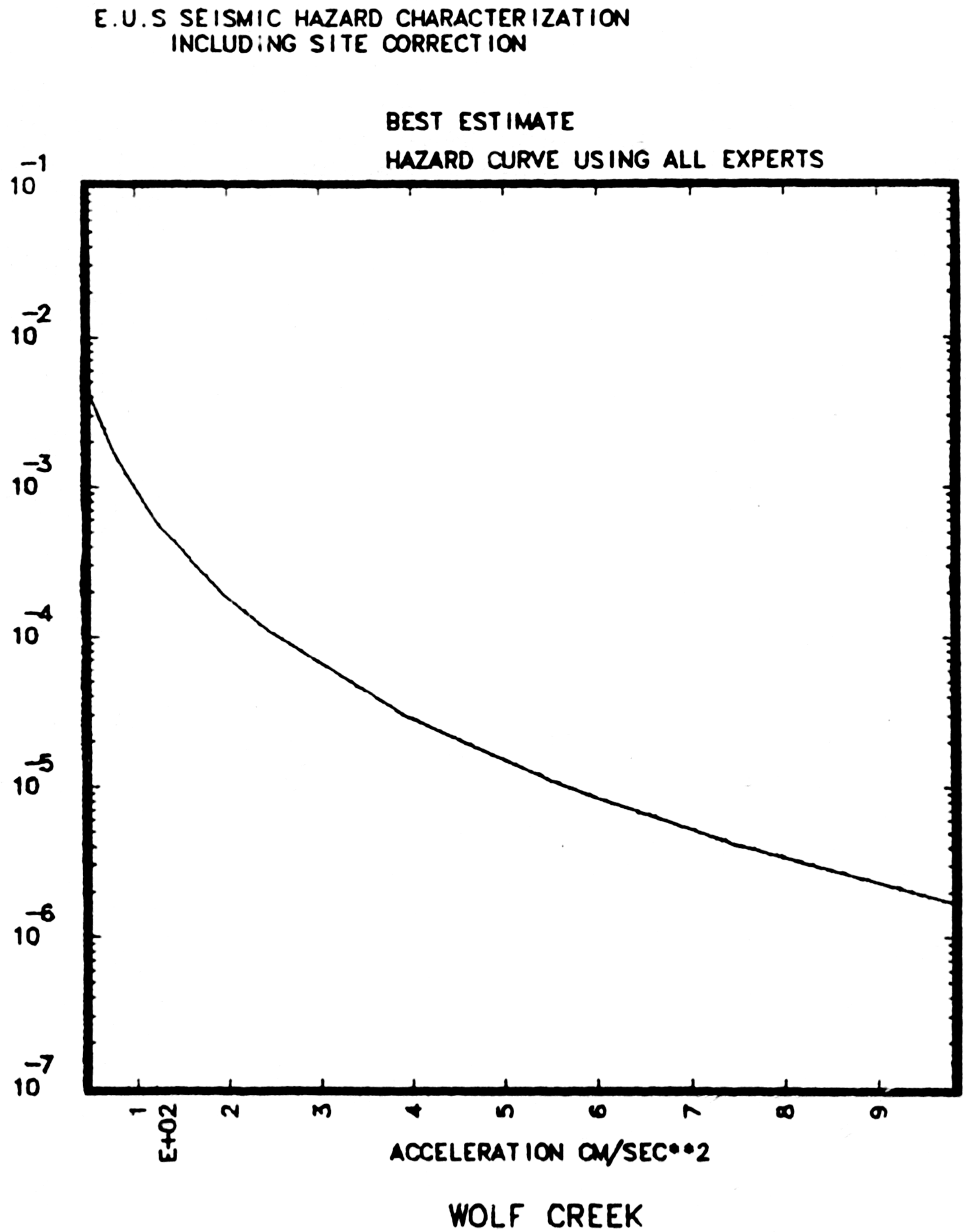
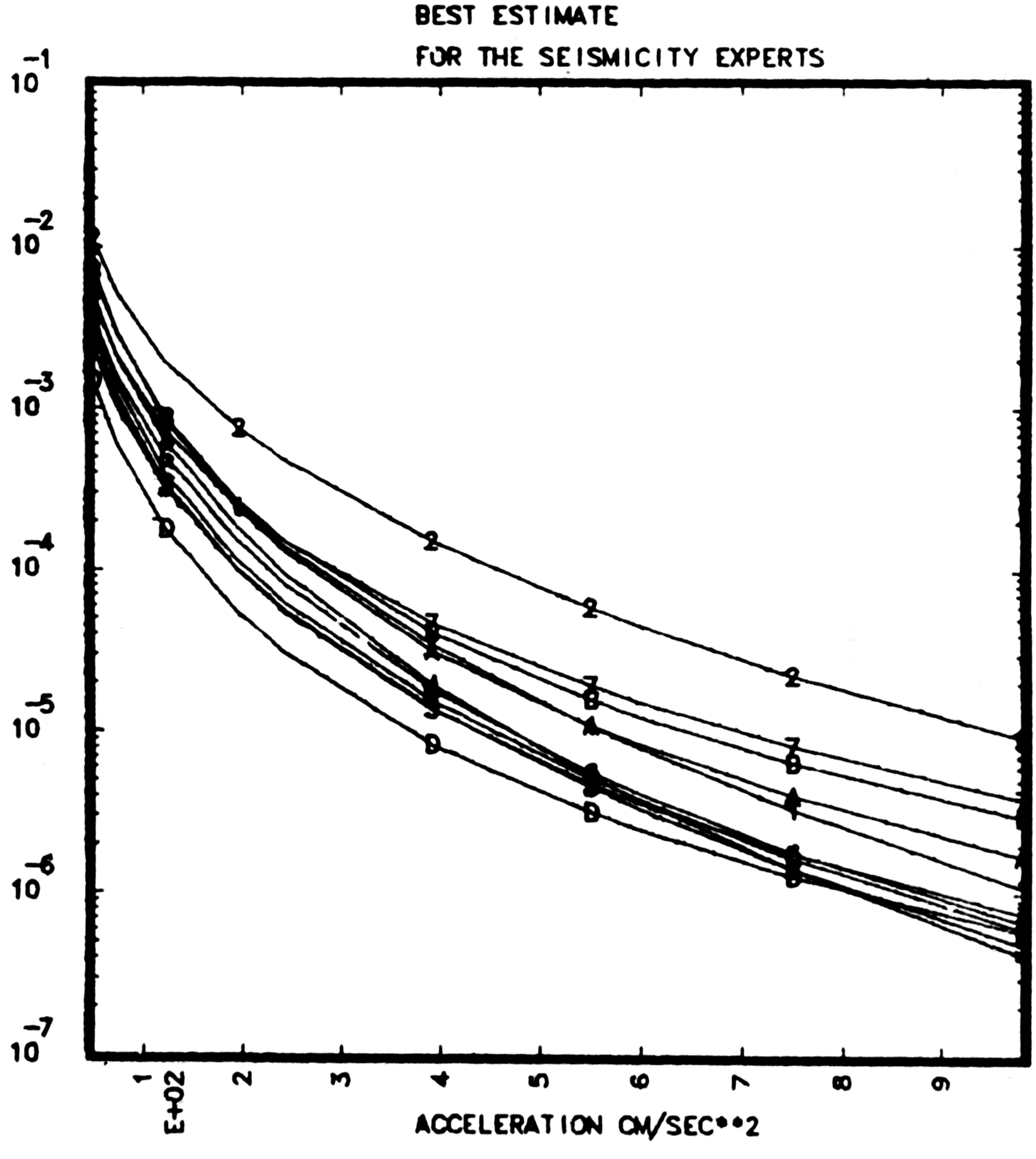


Figure 5.8.1 BEHC Combined Over All Experts

E.U.S SEISMIC HAZARD CHARACTERIZATION
INCLUDING SITE CORRECTION



WOLF CREEK

Figure 5.8.2 BEHC per Seismicity Expert Combined Over All Ground Motion Experts

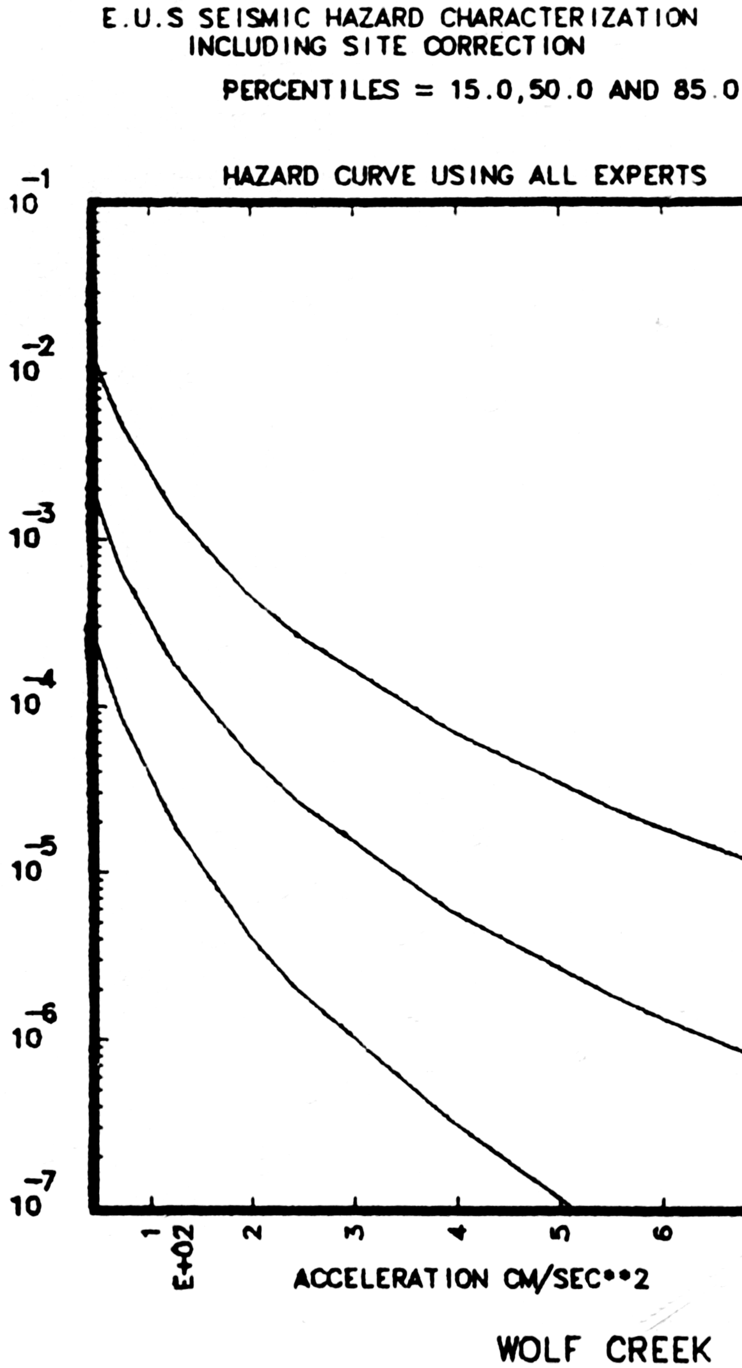


Figure 5.8.3 Constant Percentile Hazard Curves (CPHC) Over All Experts

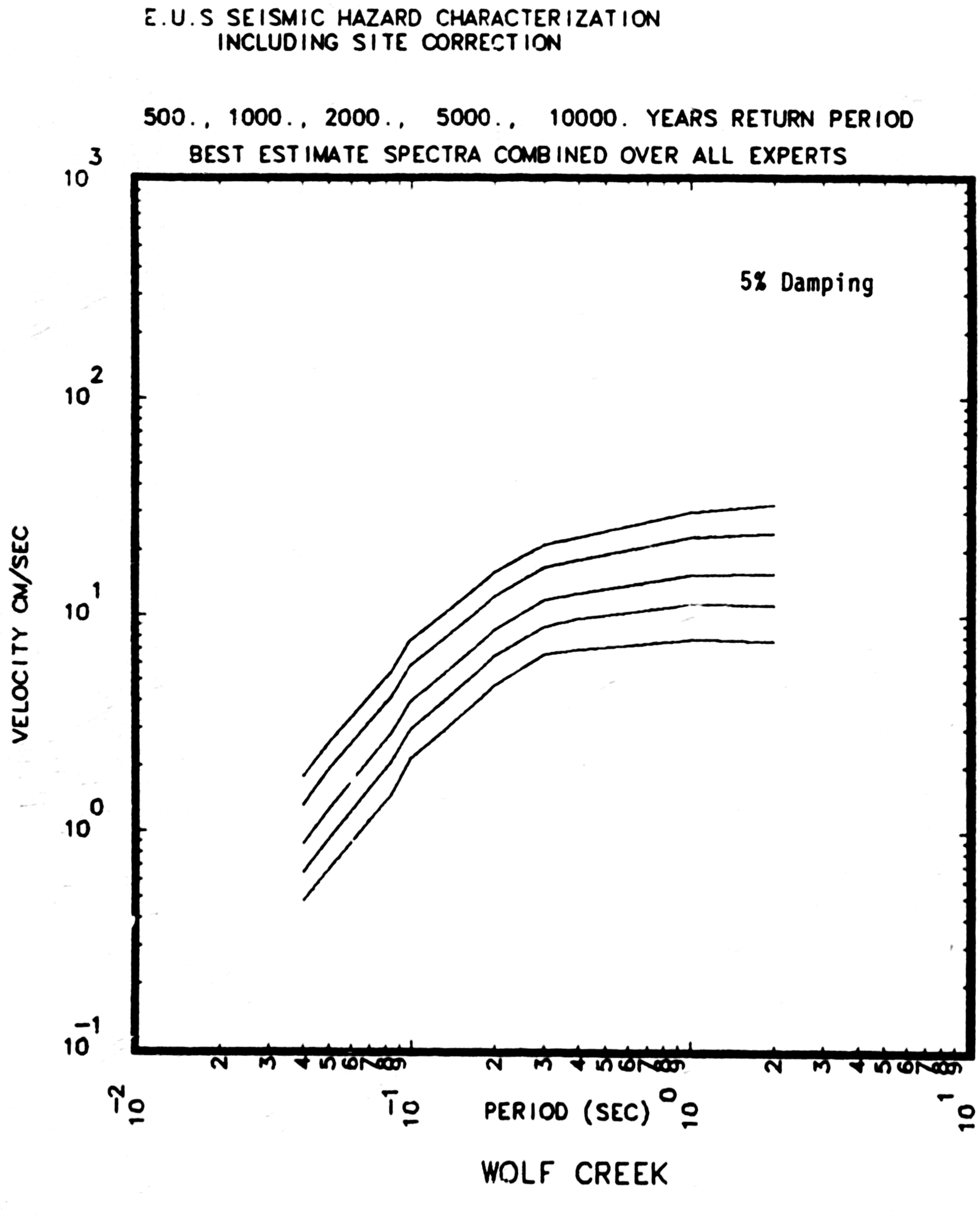


Figure 5.8.4 Best Estimate Uniform Hazard Spectra (BEUHS) Curves Over All Experts

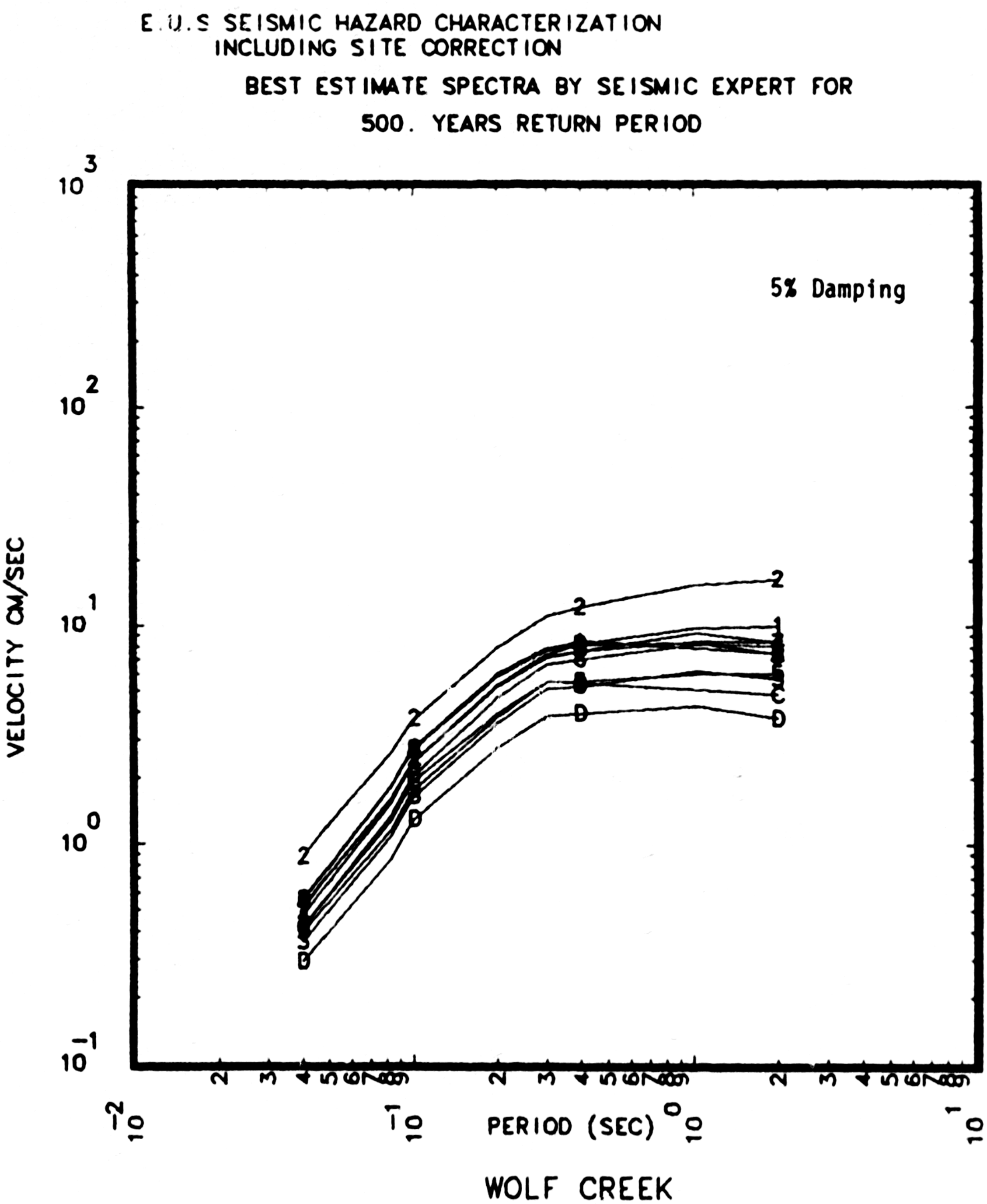


Figure 5.8.5 500 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

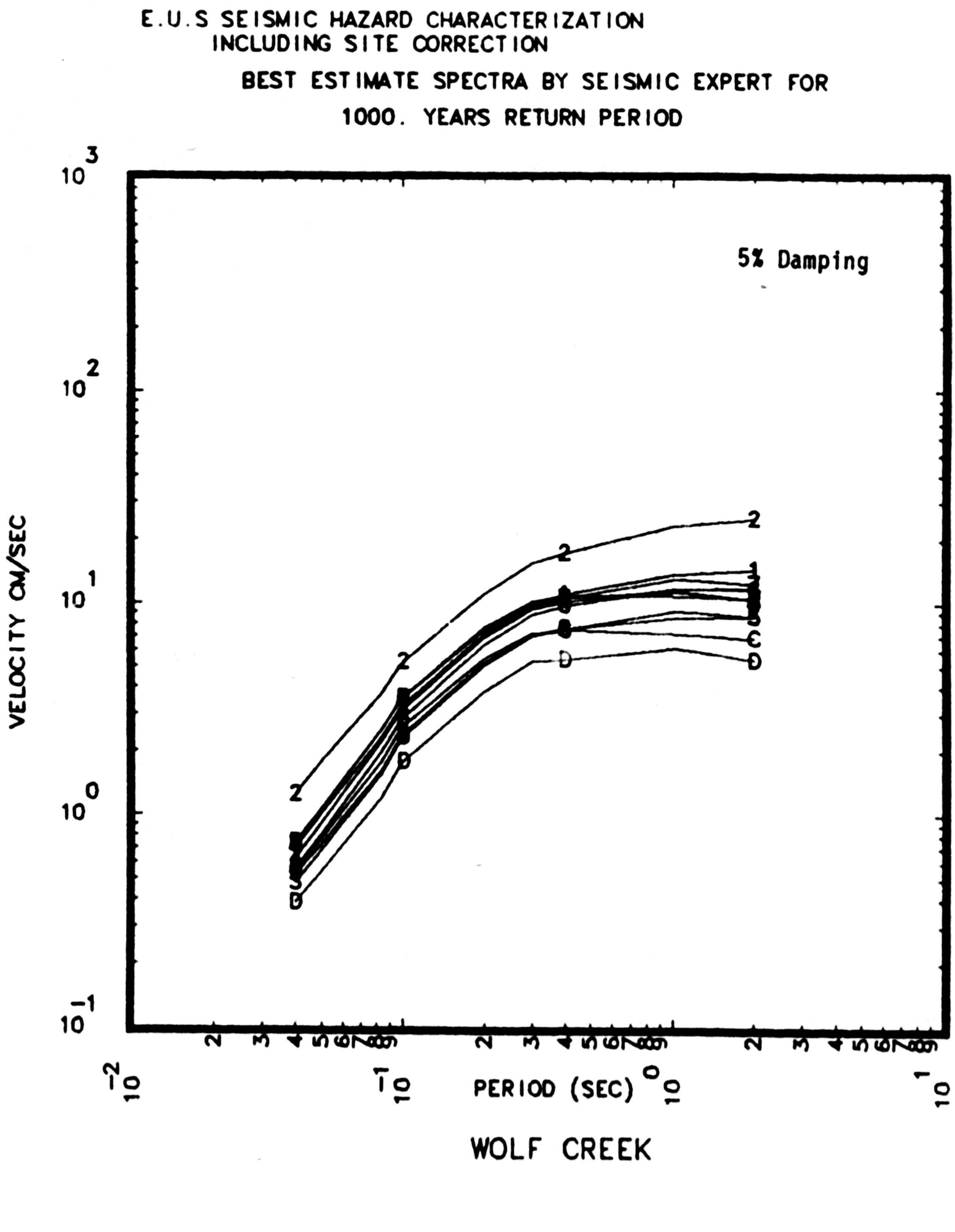


Figure 5.8.6 1,000 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

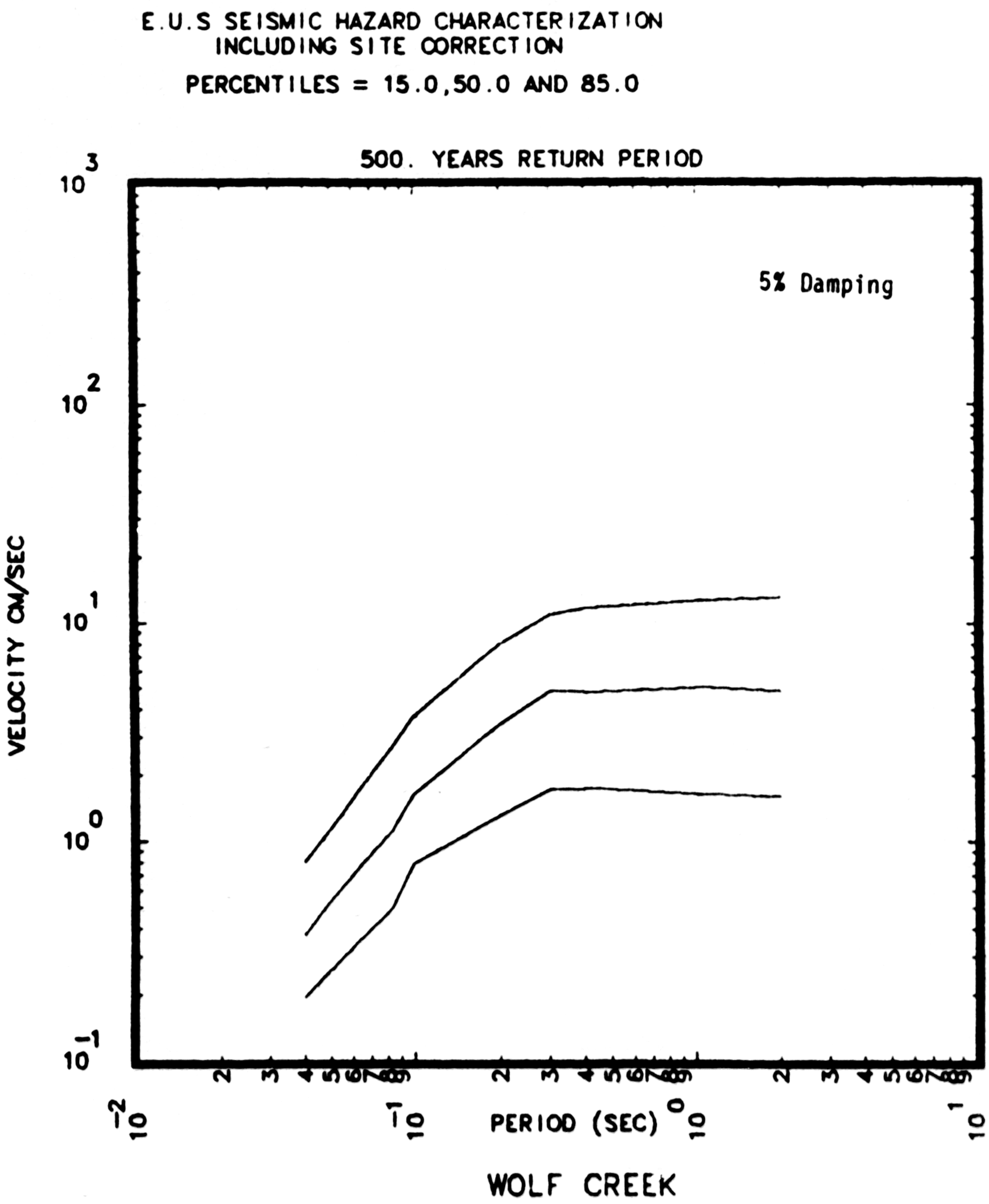


Figure 5.8.7 500 Year Return Period CPUHS Over All Experts

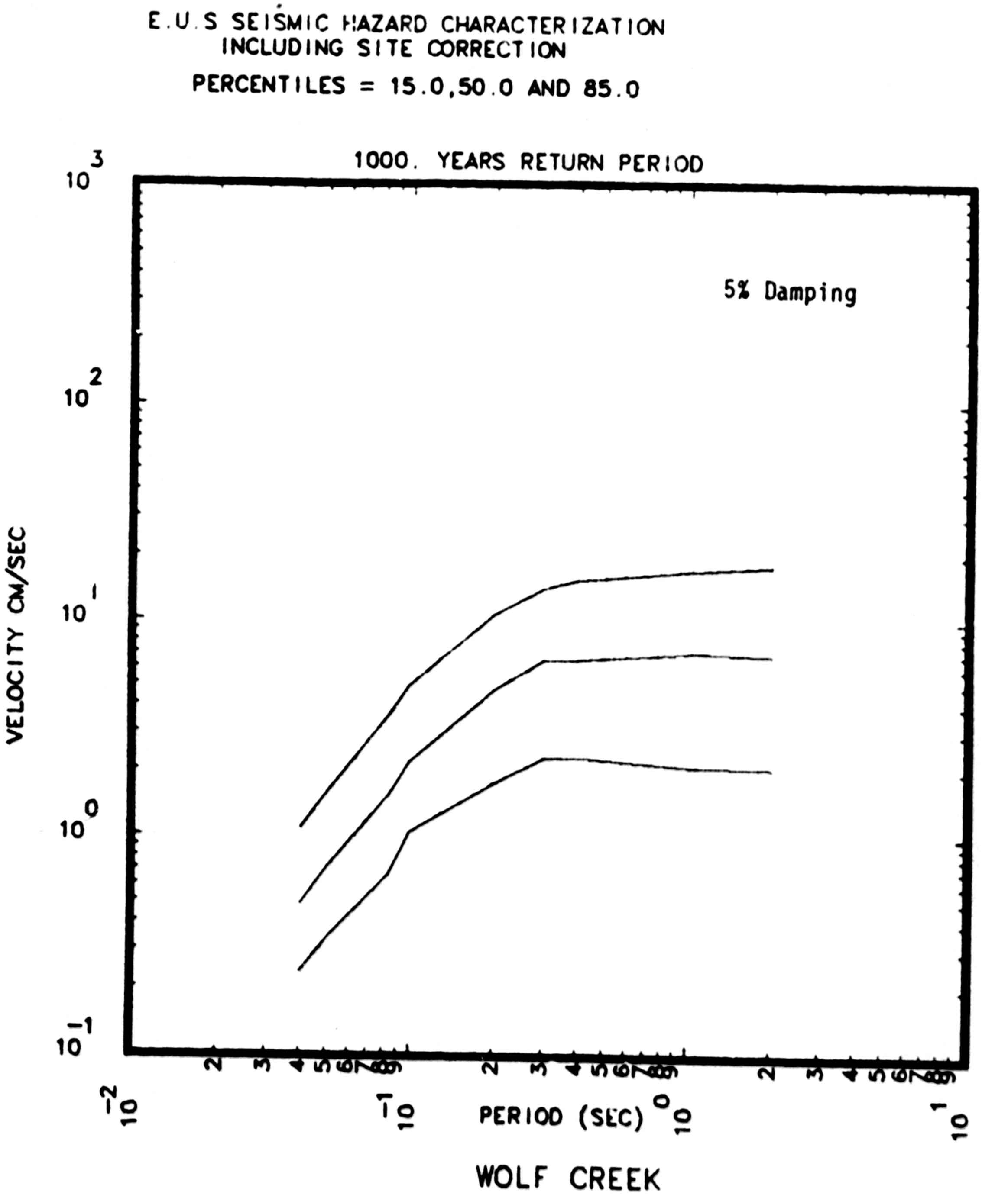


Figure 5.8.8 1,000 Year Return Period CPUHS Over All Experts

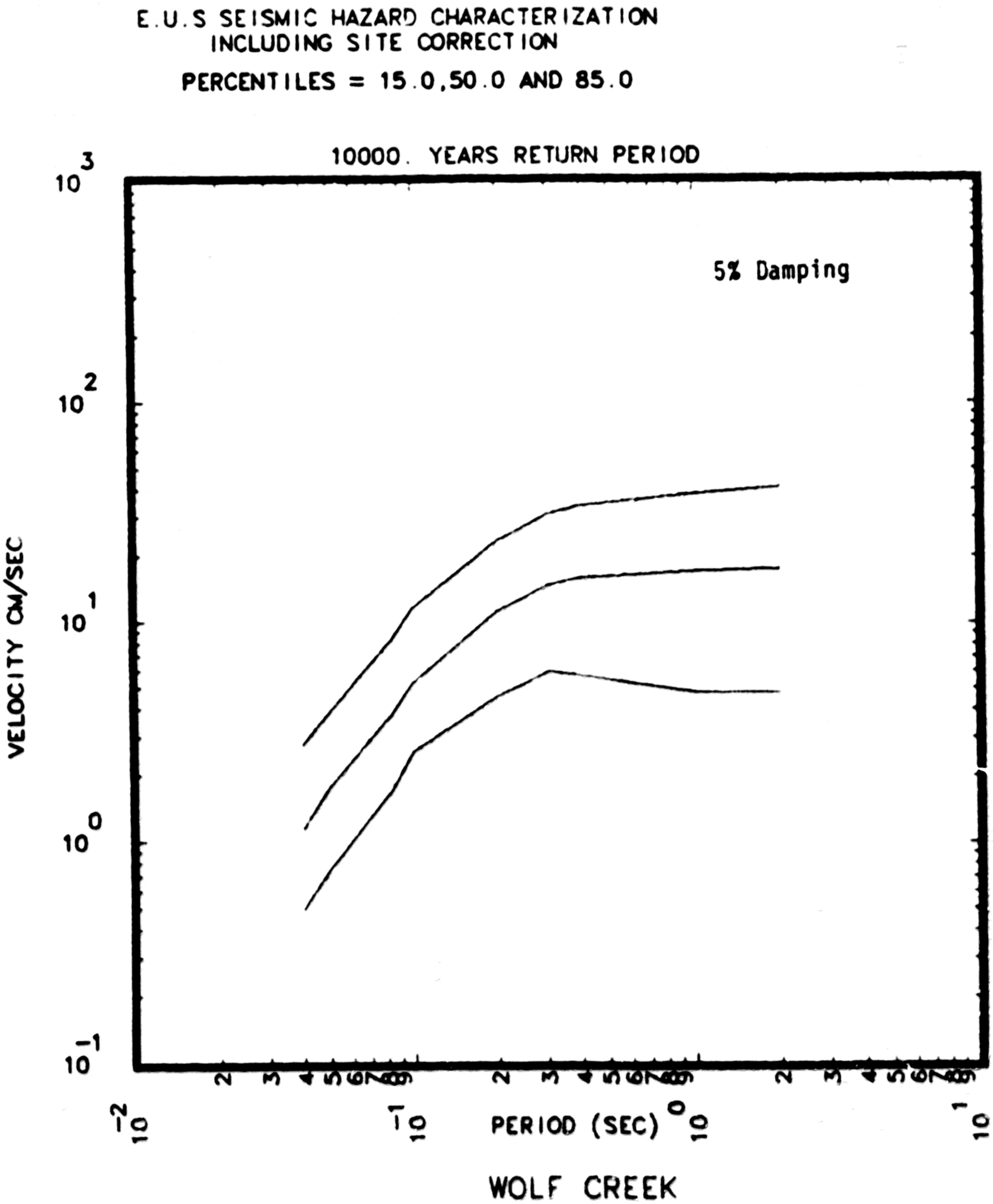


Figure 5.8.9 10,000 Year Return Period CPUHS Over All Experts

5.9 Watts Bar

5.9.1 Zonation Effects

The Watts Bar site is a rock site (Category I) located on the western edge of the southeast region near the boundary with the south central region of the EUS. All seismicity experts have placed this site in a specified zone other than the CZ. The zonal dominances at low and high PGA values are summarized in Table 5.9.1. For all seismicity experts, the site host zone is also the most dominant zone at low and high PGA values. This is consistent with the recent seismicity observed in that region, i.e., the presence of hot spots of seismicity in the Northeast Tennessee in the last two-three years.

5.9.2 PGA Hazard Curves

The BEHC combined over all experts is shown in Fig. 5.9.1. The BEHC per seismicity expert combined over all ground motion experts is presented in Fig. 5.9.2. Figure 5.9.2 shows a cluster of curves, and the curves for Experts 4 is substantially below the cluster. The BEHC combined over all experts lies close to the BEHC of Expert 13. Leaving curve 4 aside, the spread of the rest of the curves is uniform and relatively low (a factor of 3). The spread, using all the curves, is a factor of about 3.5 at low PGA values and a factor of about 6 at high PGA values. Since most experts have similar views for the zonation in the region and similar upper magnitude or intensity cutoffs for the dominant region, the difference comes from diversity in the values of the seismicity parameters.

The CPHC combined over all experts is presented in Fig. 5.9.3. Comparison of the combined BEHC with the 50th percentile hazard curve shows that the BEHC is about a factor of 1.5 higher at low PGA values and a factor of about 3 higher at high PGA values. The spread between the 15th and 50th percentile or the 50th and 85th percentile is lower at low PGA and increases with increasing PGA. This indicates some of the distributions of the seismicity and upper magnitude bounds of the dominant zones are highly skewed.

5.9.3 Uniform Hazard Spectra

The BEUHS combined over all experts for the five return periods selected is presented in Fig. 5.9.4. Figures 5.9.5 and 5.9.6 present the BEUHS per seismicity expert for the 500 year and 1,000 year return periods. The curves of Fig. 5.9.4 exhibit a shape close to the Newmark-Hall spectrum shape with some divergence at long periods. Figures 5.9.5 and 5.9.6 show this divergence is due to the curves of Experts 2 and 12. The arithmetic averaging technique used to combine the BEUHS results does not show this dispersion at long periods. The CPUHS for a 500 year return period, 1,000 year return period, and 10,000 year return period are shown in Figs. 5.9.7, 5.9.8, and 5.9.9 respectively. The spread in the CPUHS is low, at all periods, if we consider the median and 85th percentile curves. The spread between the median and the 15th suddenly increases for periods longer than .3 secs. This phenomenon, described in Section 4.4, is due to the uncertainty in the site correction.

TABLE 5.9.1

Zonal Dominance In The
BEHC At Low and High PGA

SITE: Watts Bar
SITE CLASSIFICATION: Rock
REGIONAL LOCATION: South Central

Seis-micity Expert	Expert's Host Zone		Contribution to the Hazard: Low PGA (.05g)						High PGA (1.0g)		
1	4	Zone	4	9	10	3	15	11	4	9	
		Contribution	.90	.05	.02	.01	.01	.01	.95	.05	
2	27	Zone	27	18	30	20	CZ	29	27	18	
		Contribution	.71	.20	.05	.03	.01	.01	.89	.11	
3	8	Zone	8	1	15	16	11	17	8	1	15
		Contribution	.80	.07	.05	.03	.02	.02	.94	.05	.01
4	8	Zone	8	4	9	10	CZ	5	8	4	CZ
		Contribution	.62	.27	.04	.03	.02	.01	.85	.10	.05
5	11	Zone	11	15	9	14	CZ		11	15	
		Contribution	.89	.07	.03	.01	.01		.95	.05	
6	9	Zone	9	17	10				9	17	
		Contribution	.88	.09	.02				.99	.01	
7	7	Zone	7	6	5	8	CZ	10	7	6	
		Contribution	.92	.03	.02	.02	.01	.01	.98	.02	
10	28	Zone	28	26	12	13	19	28A	28	26	
		Contribution	.75	.13	.08	.02	.01	.01	.98	.02	
11	6	Zone	6	CZ	10	11	8		6		
		Contribution	.89	.04	.02	.02	.01		1.00		
12	2	Zone	2	12	1	11	3		2	12	
		Contribution	.87	.04	.03	.03	.02		.99	.01	
13	8	Zone	8	5	9	CZ	6		8		
		Contribution	.80	.04	.02	.02	.01		.99		

NOTE: Contributions may not add up to 1.00.

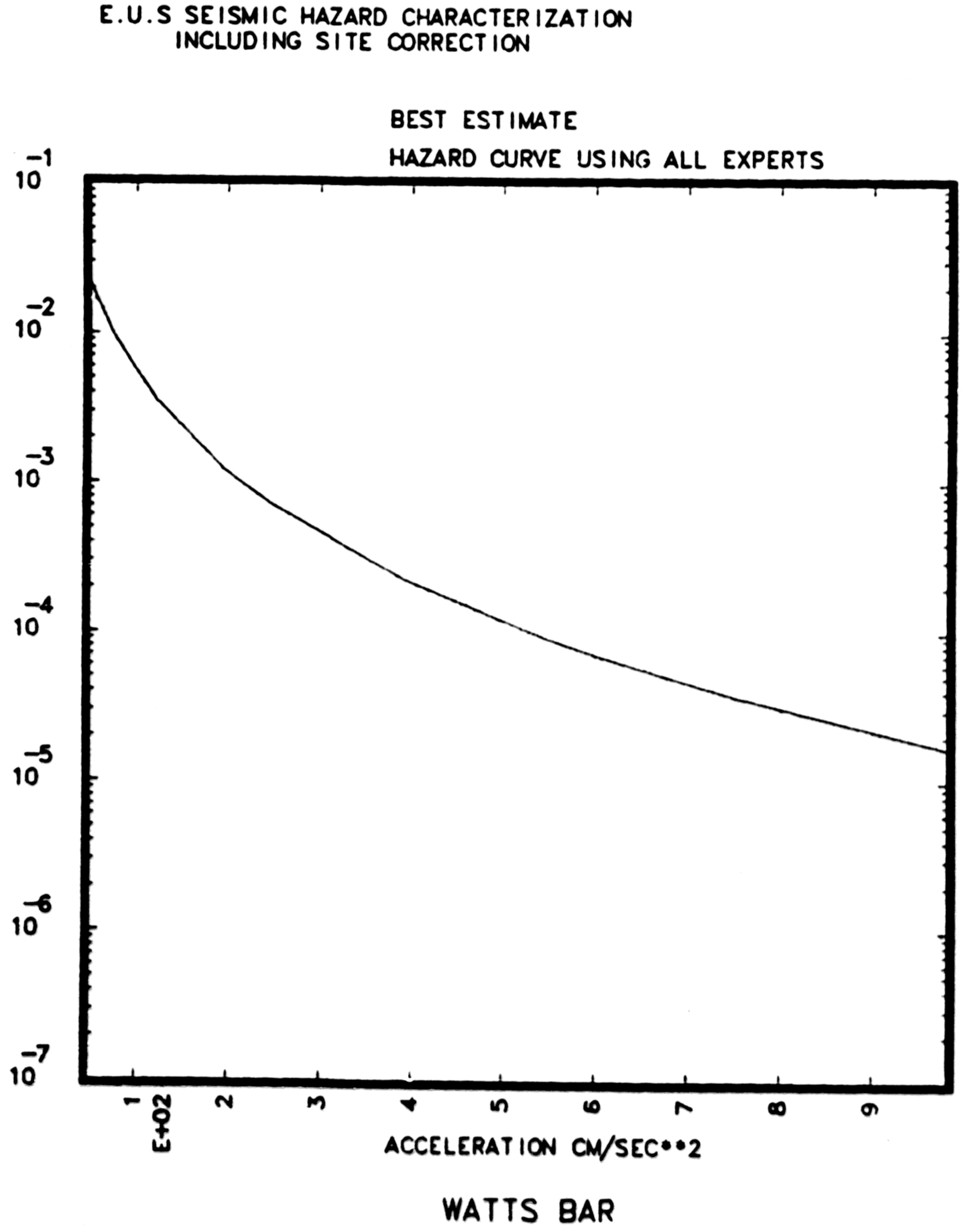
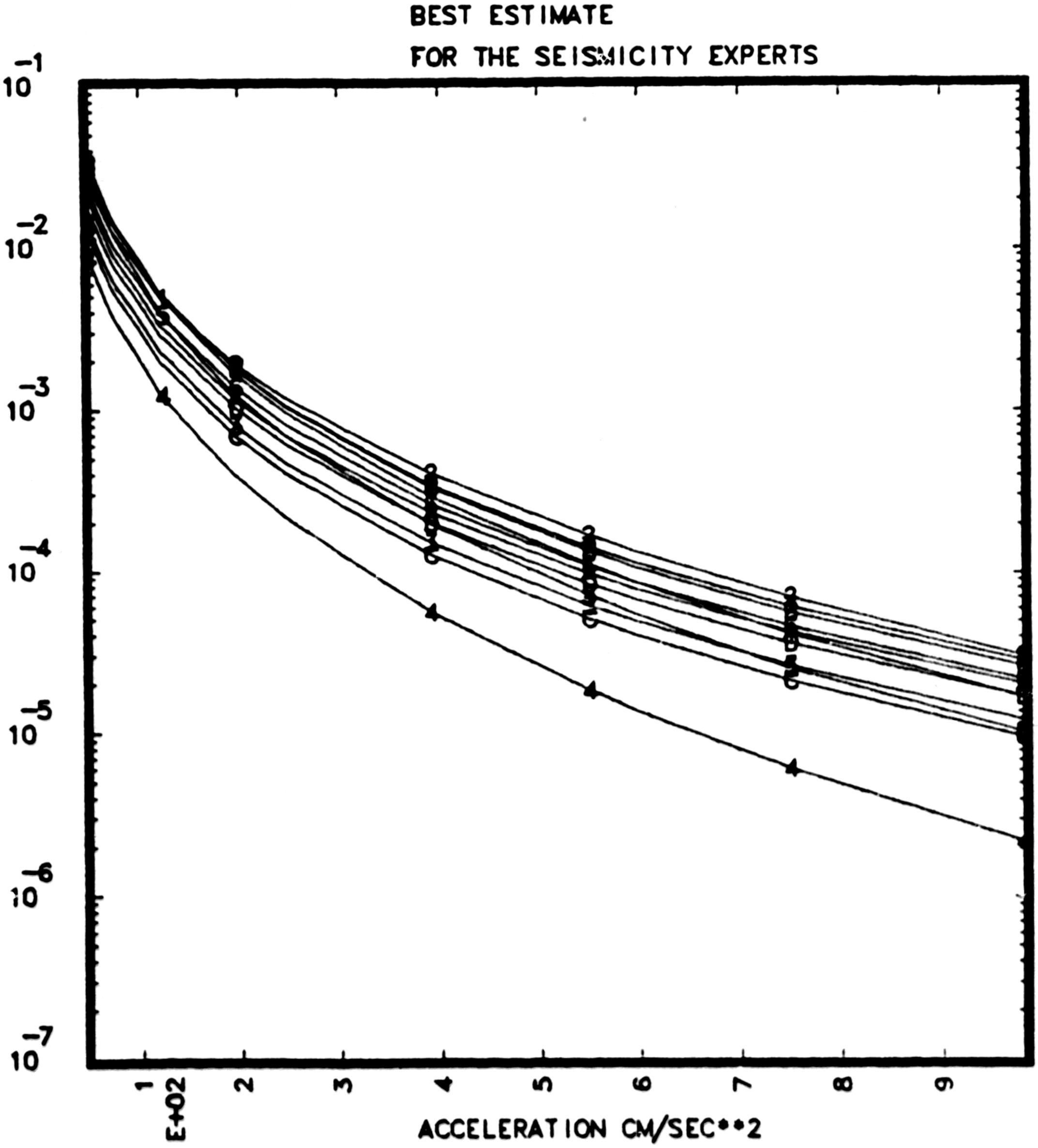


Figure 5.9.1 BEHC Combined Over All Experts

E.U.S SEISMIC HAZARD CHARACTERIZATION
INCLUDING SITE CORRECTION



WATTS BAR

Figure 5.9.2 BEHC per Seismicity Expert Combined Over All Ground Motion Experts

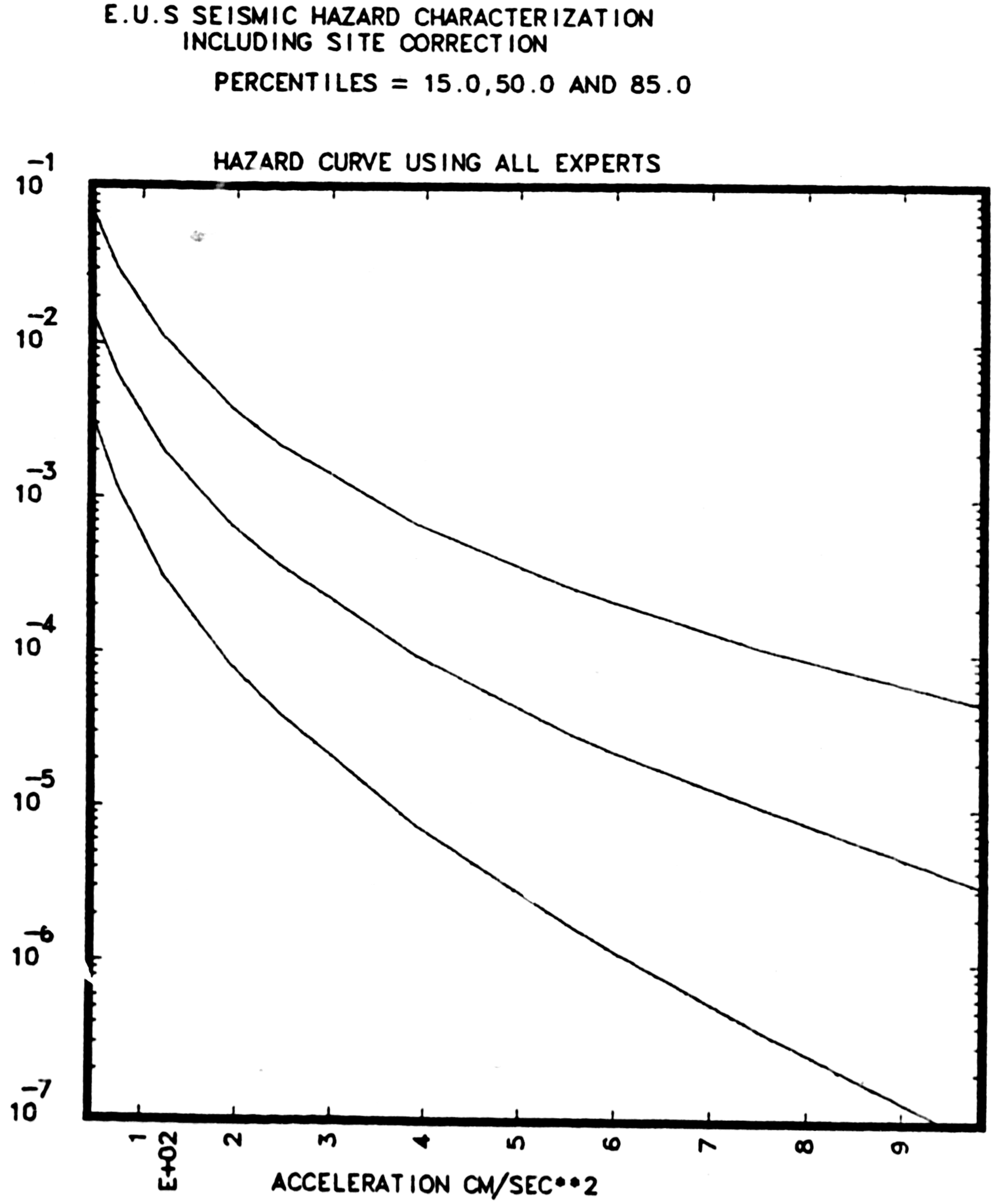


Figure 5.9.3 Constant Percentile Hazard Curves (CPHC) Over All Experts

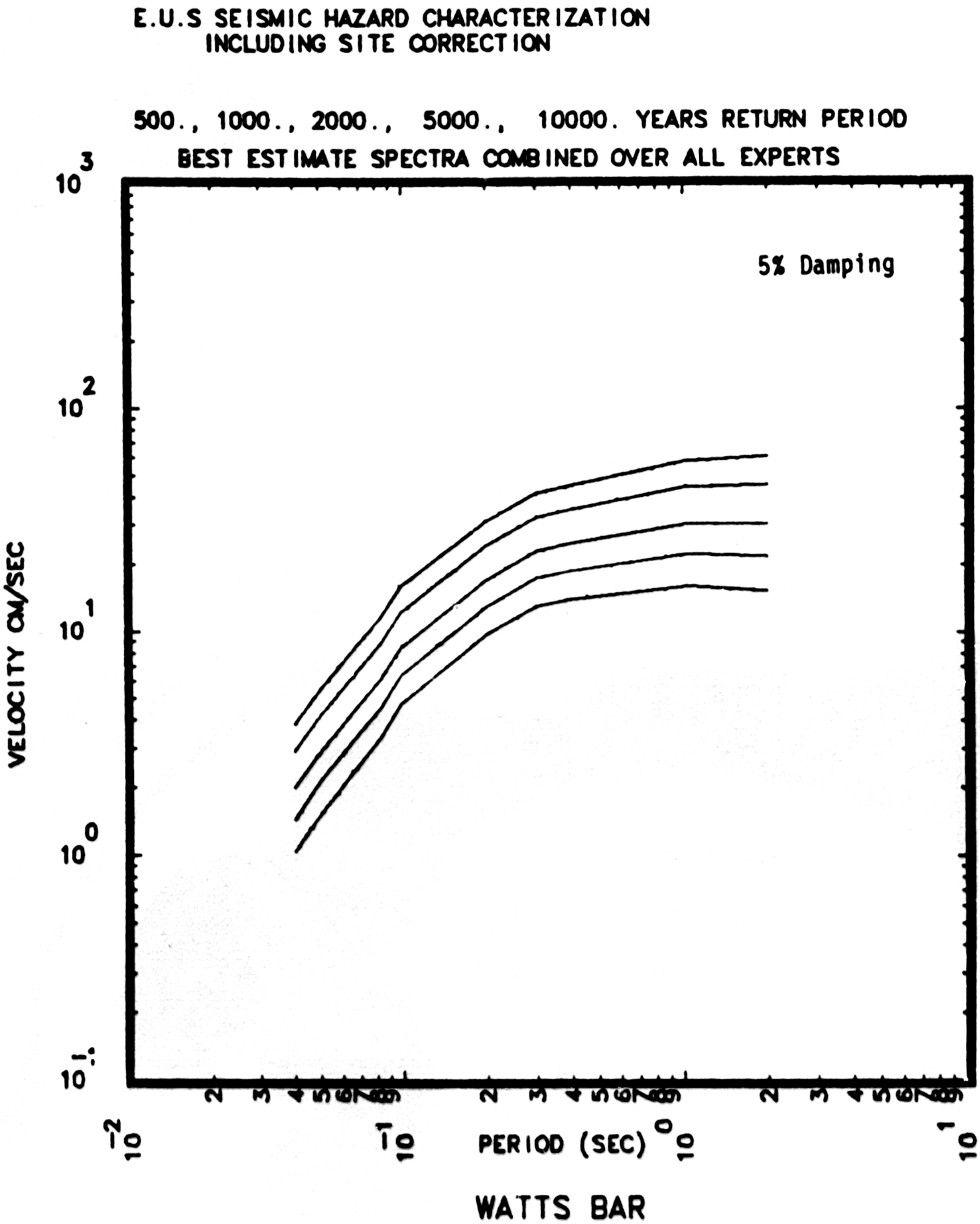


Figure 5.9.4 Best Estimate Uniform Hazard Spectra (BEUHS) Curves Over All Experts

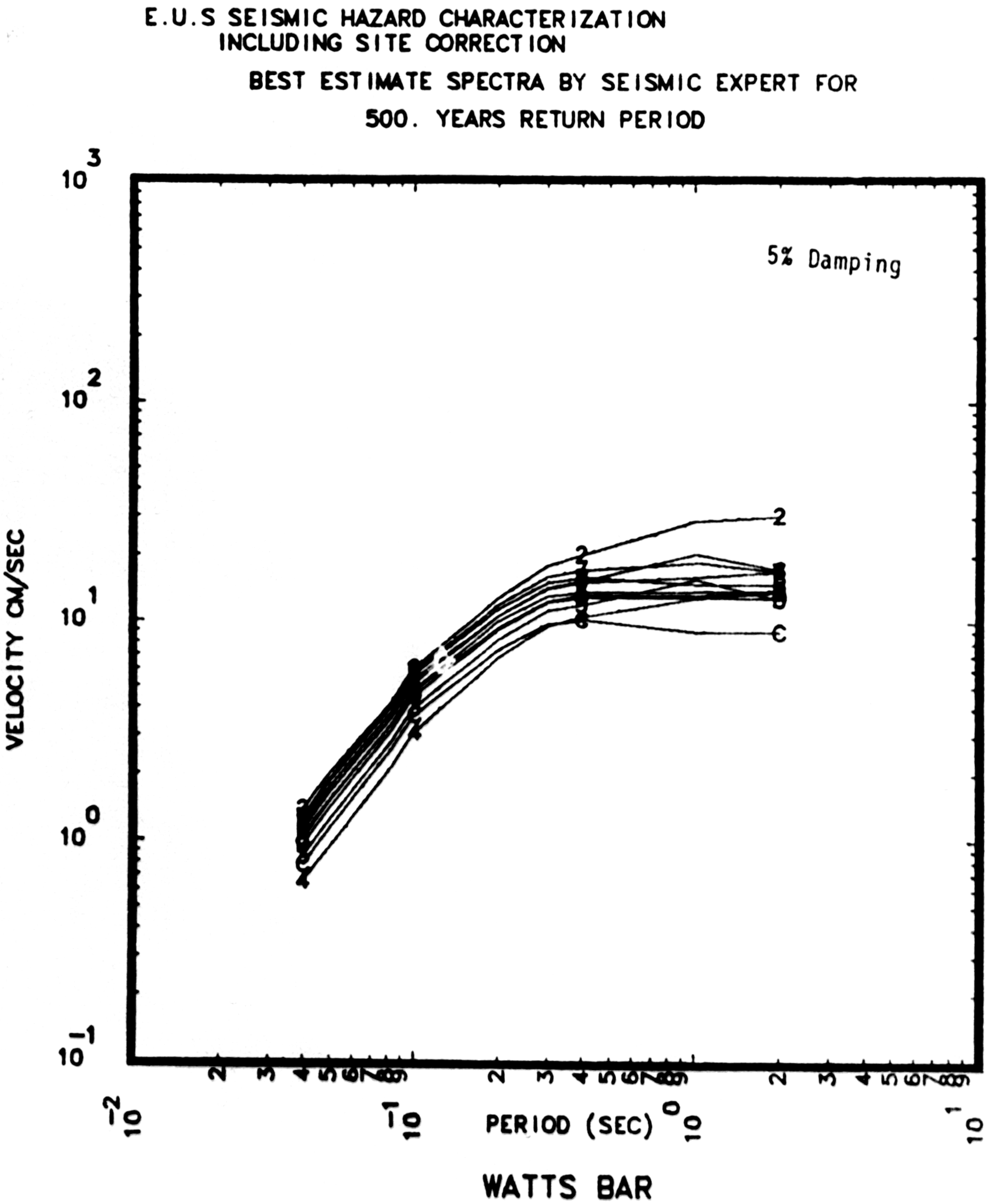


Figure 5.9.5 **500 Year Return Period BEUHS** per Seismicity **Expert Combined Over All** Ground Motion Experts

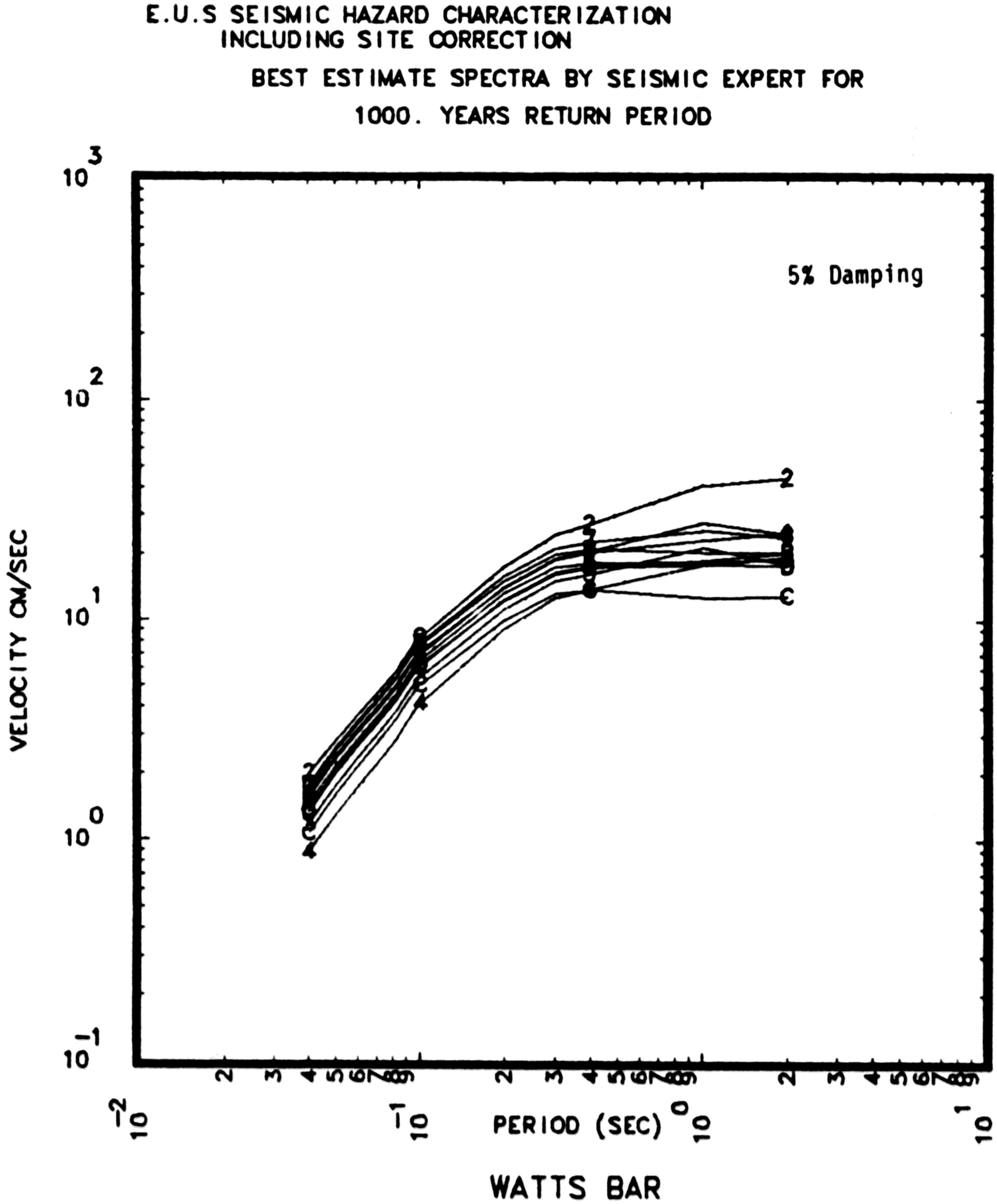


Figure 5.9.6 1,000 Year Return Period BEUHS Per Seismicity Expert Combined Over All Ground Motion Experts

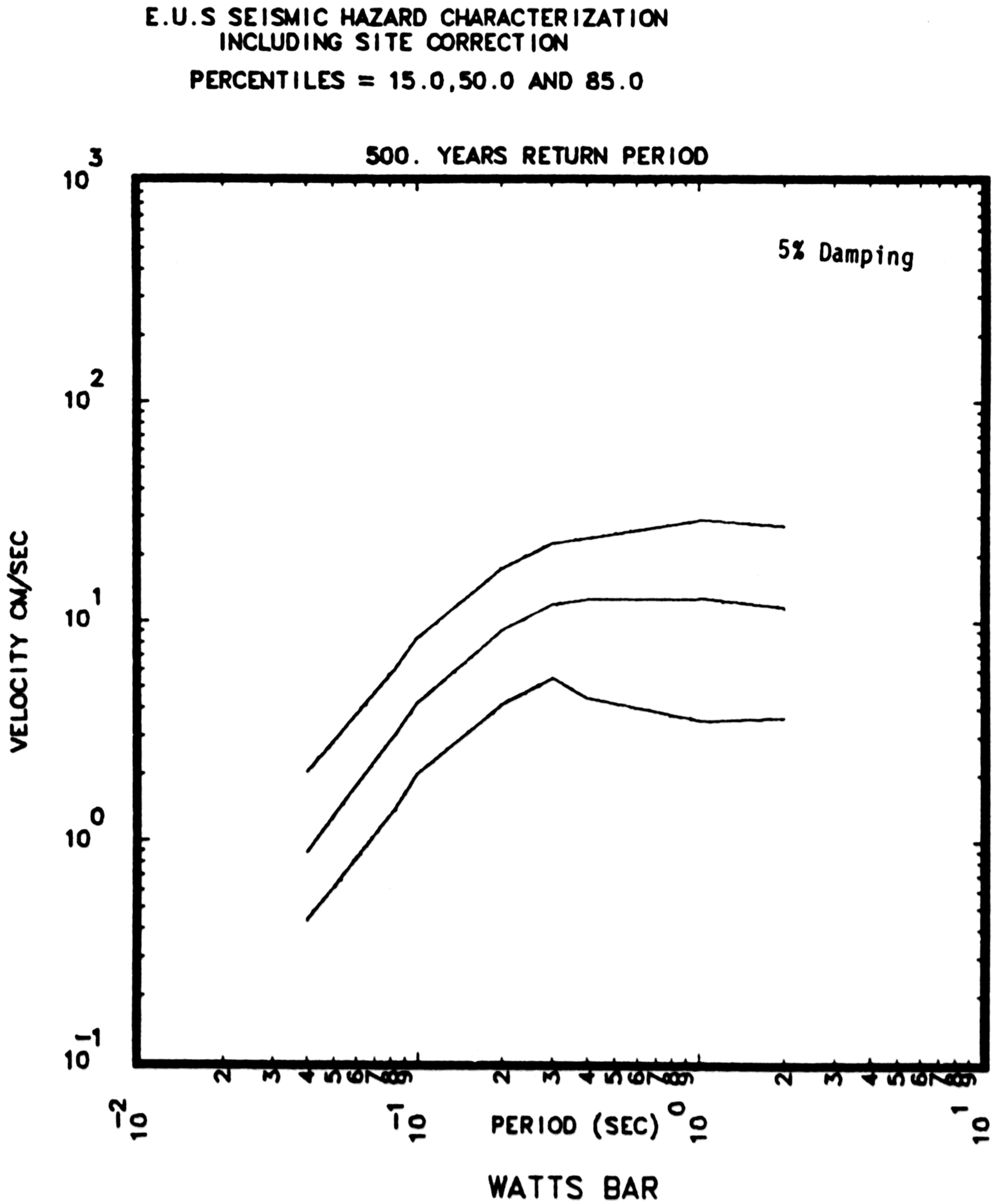


Figure 5.9.7 500 Year Return Period CPUHS Over All Experts

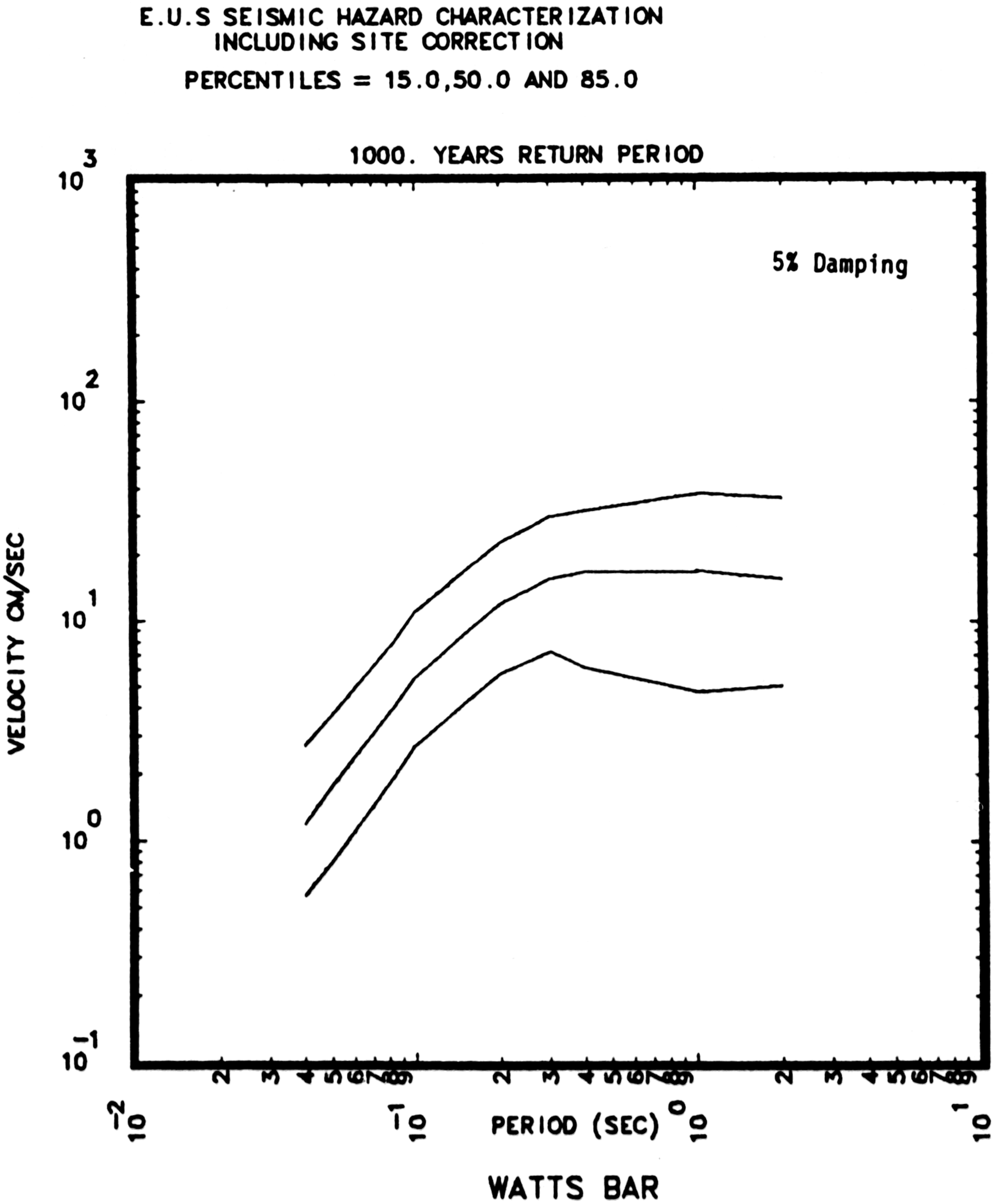


Figure 5.9.8 1,000 Year Return Period CPUHS Over All Experts

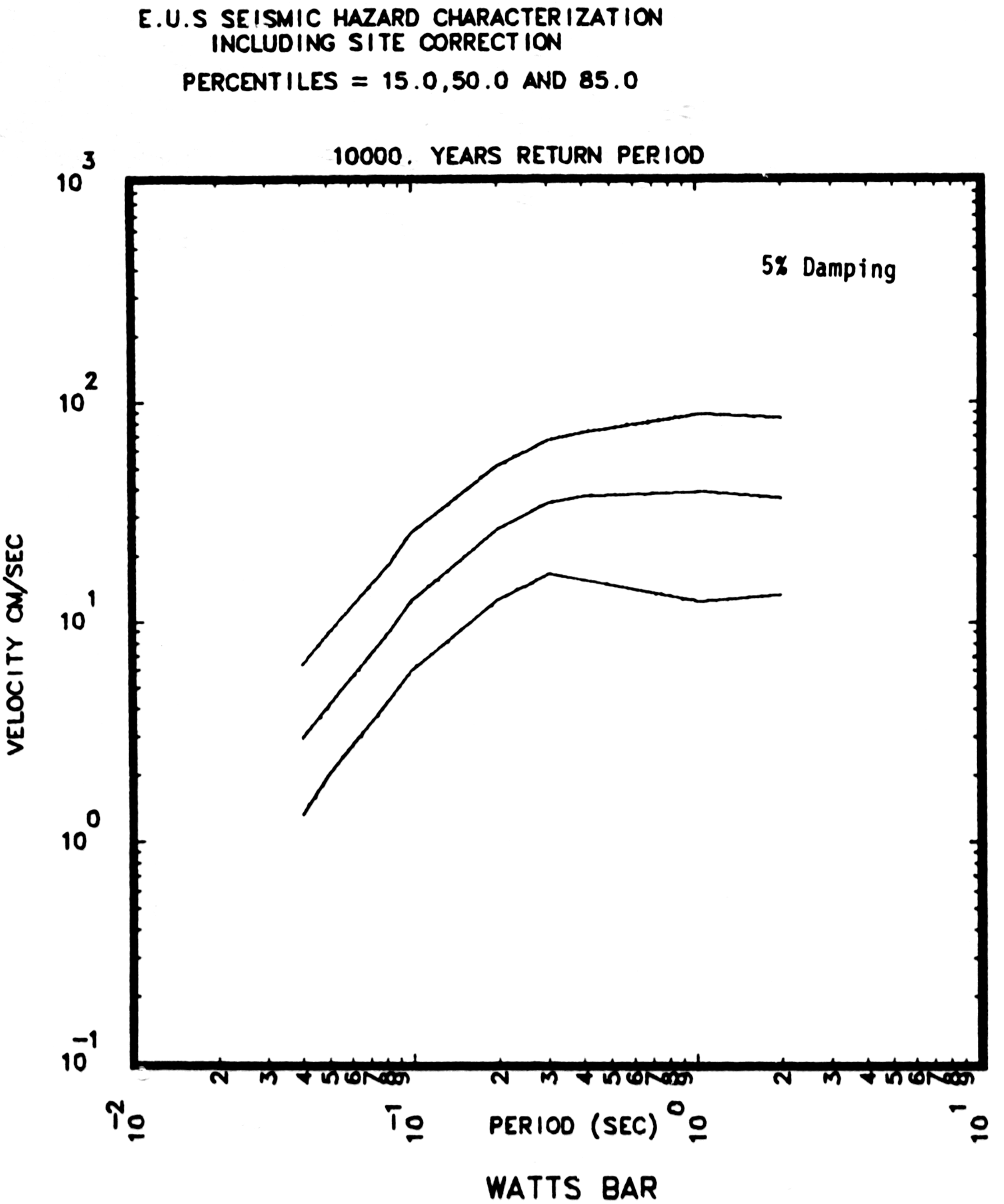


Figure 5.9.9 10,000 Year Return Period CPUHS Over All Expert

5.10 Vogtle

5.10.1 Zonation Effects

The Vogtle site is a deep soil site (Category III) located in the southeast region of the EUS. The site is located in the CZ only for one of the seismicity experts (Expert 13). Expert 13 divided the CZ into three zones (zone 15, 16 and 17). The site falls in seismic Expert 13's CZ 17. All experts except Expert 11 have a zone near the site which is associated with the Charleston area. Expert 11 and Expert 6 have a large zone with high seismicity which contains the site and the Charleston area. Zonal dominance in the BEHC at low and high PGA values is summarized in Table 5.10.1. At low PGA, the effect of the Charleston area is predominant on the hazard at the site. The site is located in the coastal plains in 7 out of 11 cases, and in 2 of the remaining cases (Experts 6 and 11) the site is located in large coastal zones containing the Charleston area. Consequently, the hazard is dominated by the coastal plains for the high PGA levels, since the zones associated with the Charleston area do not have very high upper magnitude cutoffs relative to the surrounding zones.

5.10.2 PGA Hazard Curve

The BEHC combined over all experts is shown in Fig. 5.10.1. The BEHC per seismicity expert is shown in Fig. 5.10.2. Two general curve shapes are noted on Fig. 5.10.2, the more convex shape which the majority of the curves have and the flatter curves of Experts 2, 3, 4, and 13. For Experts 4, 5, and 13, this curve shape is due to the fact that at high PGA values a zone which has little dominance at low PGA values is now significant. The shape of Expert 2's curve is due in part to this shift of zonal dominance and in part to a greater influence of seismicity parameters. For Experts 2, 5, 12, and 13, the nearby Charleston zone with higher magnitude/intensity cutoff dominates at low PGA; at high PGA values, the larger zone in which the site is located dominates. The larger zone also has a high magnitude/intensity cutoff. For the rest of the experts, the zone in which the site is located dominates at both low and high intensity values. The spread exhibited by the seismicity experts is rather large, especially at high PGA values (a factor of 10 to 15 at low PGA values and a factor of 55 to 60 at high PGA values). The BEHC of Expert 12 is significantly lower than the other experts. This is due in part to the relatively low seismicity and low magnitude cutoffs attributed to the site's host zone and the surrounding zones.

The CPHC is presented in Fig. 5.10.3. The dispersion in the hazard estimates is moderate and similar to that observed for other sites. The BEHC is higher than the 50th percentile hazard curve by a factor of 1.5 to 2.5 at low PGA values and a factor of 7 to 8 at high PGA values.

5.10.3 Uniform Hazard Spectra

The BEUHS combined over all experts for the return periods selected are presented on Fig. 5.10.4. The BEUHS per seismicity expert for a 500 year return period and a 1,000 year return period are shown in Figs. 5.10.5 and 5.10.6 respectively. The curves are clumped together, except for Experts 2 and 12. The curves of Experts 2 and 12 are clearly outliers for this site. The CPUHS for a 500 year return period, 1,000 year return period, and 10,000 year return period are shown in Figs. 5.10.7, 5.10.8, and 5.10.9 respectively. The uncertainty analysis leads to 15th to 50th, and 50th to 85th intervals in the same range as the ones obtained for typical sites (i.e. moderate values). Instead, much smaller values are obtained by removing the outliers. However, the uncertainty increases at periods longer than .3 sec. This phenomenon is due to the technique used for the site correction and is described in Section 4.4. At low periods, the BEUHS lies close to the 50th percentile UHS. As the period increases the BEUHS approaches the 85th percentile UHS.

TABLE 5.10.1

Zonal Dominance In The
BEHC At Low and High PGA

SITE: Vogtle
SITE CLASSIFICATION: Generic Deep Soil
REGIONAL LOCATION: Southeast

Seismicity Expert	Expert's Host Zone		Contribution to the Hazard								
			Low PGA (.05g)					High PGA (1.0g)			
1	1	Zone	1	2*	3	9	4	1	2*		
		Contribution	.45	.37	.14	.03	.01	.98	.02		
2	29	Zone	30*	29	18	27		29	30*		
		Contribution	.62	.34	.03	.01		.84	.15		
3	10*	Zone	10*	11	CZ	8	15	10*	CZ		
		Contribution	.85	.09	.04	.01	.01	.98	.02		
4	10*	Zone	10*	9	4	25		10*	25	9	
		Contribution	.85	.11	.03	.01		.84	.15	.01	
5	8-10	Zone	9*	10	8	15		8	9*	10	CZ
		Contribution	.76	.17	.06	.01		.57	.32	.09	.02
6	10*	Zone	10*	17	9			10*			
		Contribution	.97	.01	.01			1.00			
7	8	Zone	8	10*	CZ	7	6	8	CZ	10*	
		Contribution	.66	.26	.06	.01	.01	.90	.06	.03	
10	4	Zone	4	15*	28	12	CZ	4	15*		
		Contribution	.50	.30	.18	.02	.01	.99	.01		
11	8*	Zone	8*	7	CZ	6	11	8*	CZ		
		Contribution	.65	.31	.01	.01	.01	.97	.03		
12	5	Zone	14*	5	3	12		5	14*		
		Contribution	.45	.44	.09	.02		.85	.15		
13	CZ	Zone	9*	CZ	8	5		CZ	9*	15	
	(15+16+17)	Contribution	.92	.06	.02	.01		.78	.19	.03	

NOTE: Contributions may not add up to 1.00.
The notation CZ (15+16+17) means that the CZ was made of zones 15,16 and 17.
* means that the zone contains the Charleston Area.

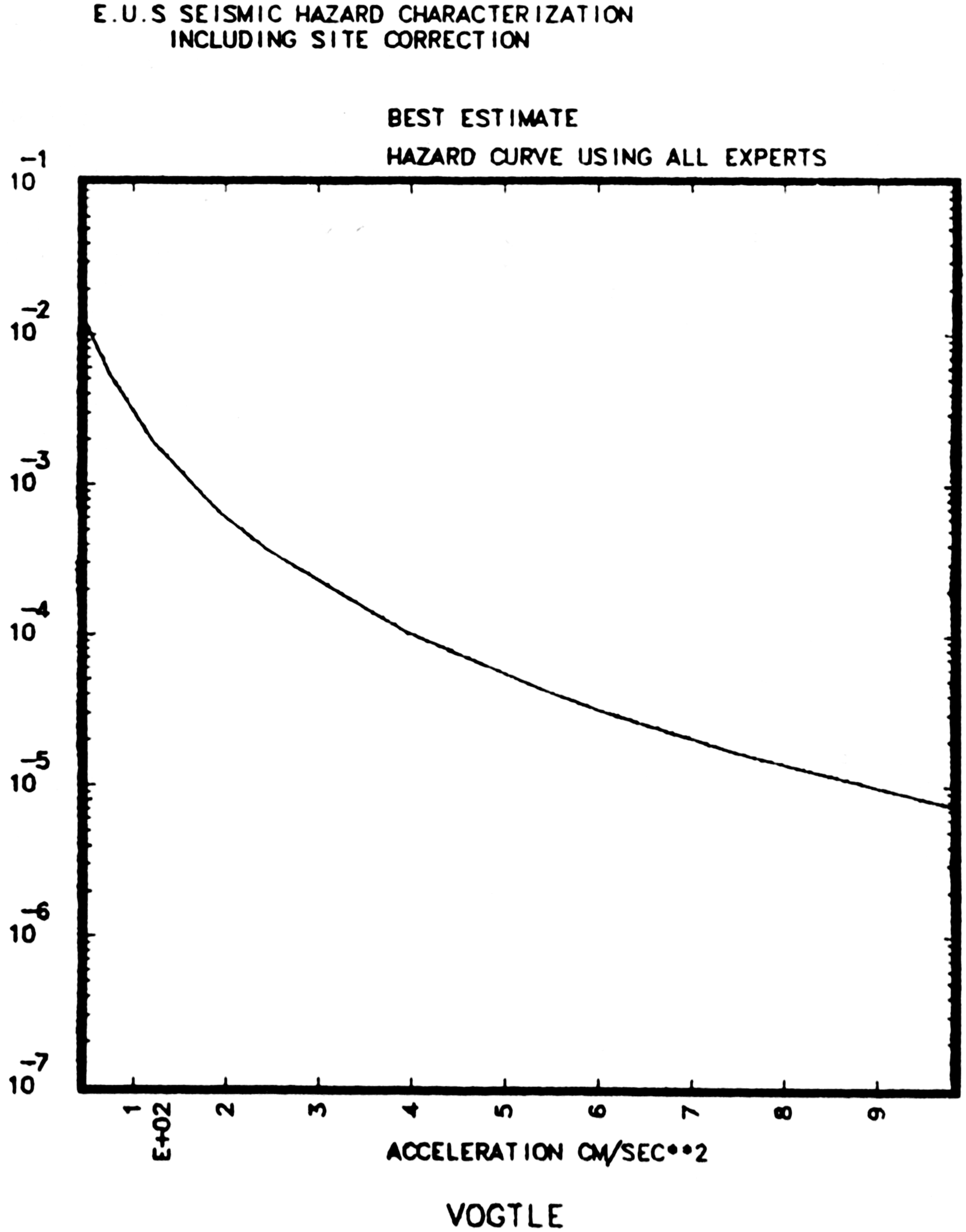


Figure 5.10.1 BEHC Combined Over All Experts

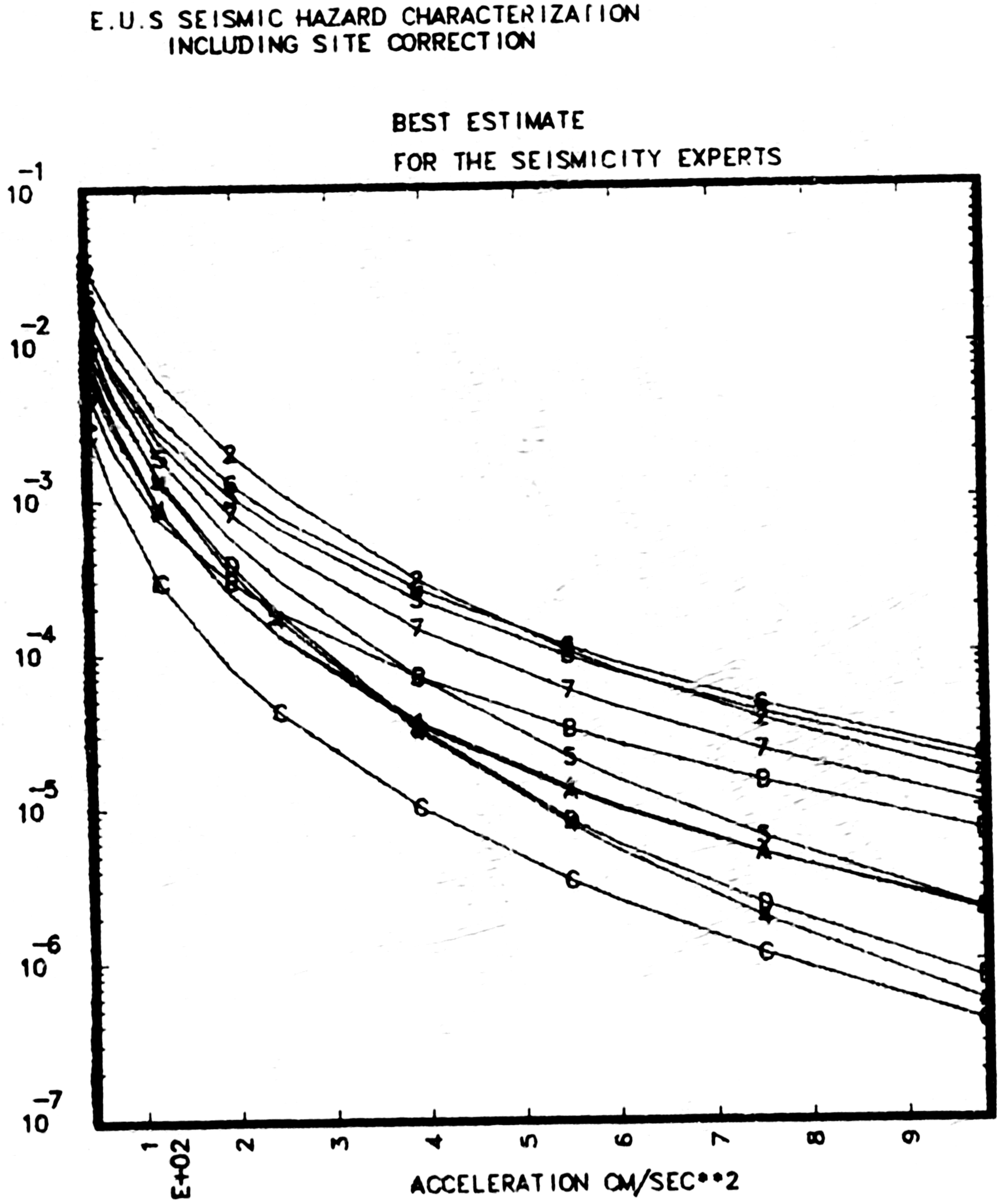


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Figure 5.10.2 BEHC per Seismicity Expert Combined Over All Ground Motion Experts

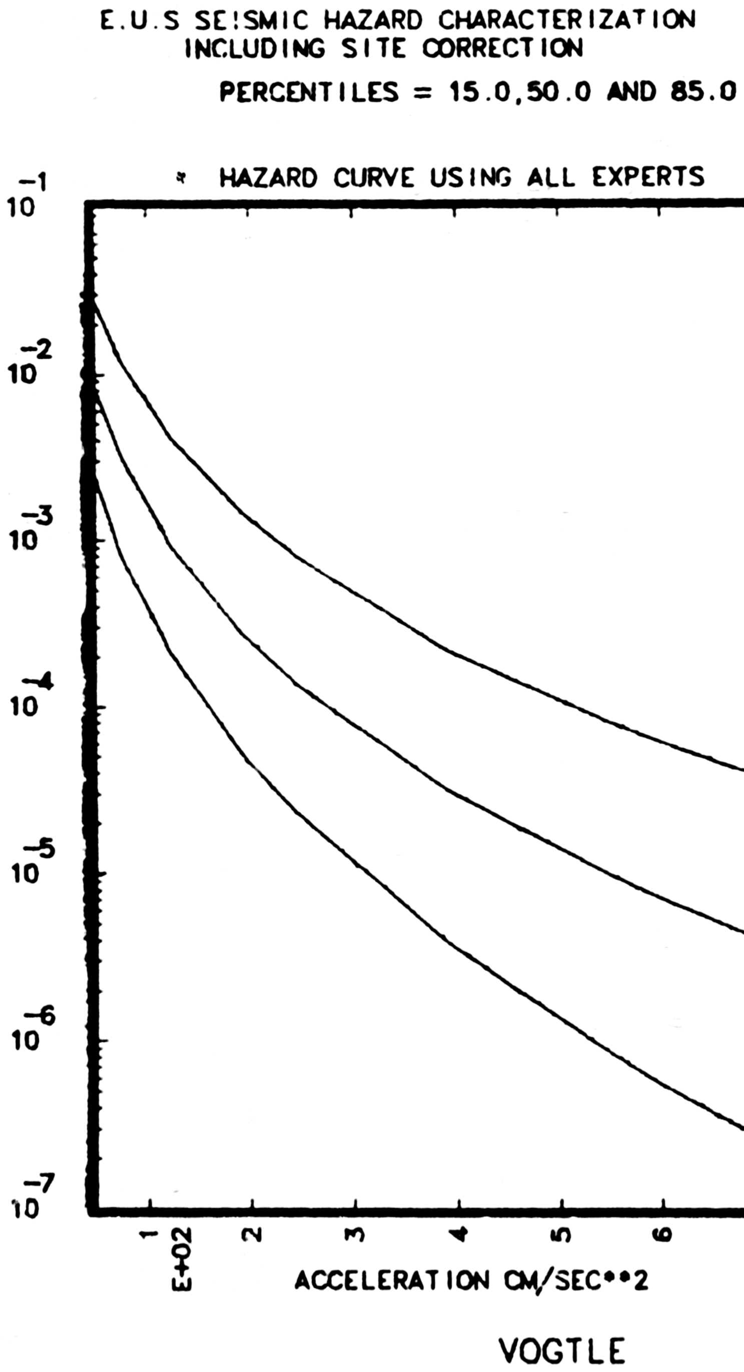

Figure 5.10.3 Constant Percentile Hazard Curves (CPHC) Over All Experts

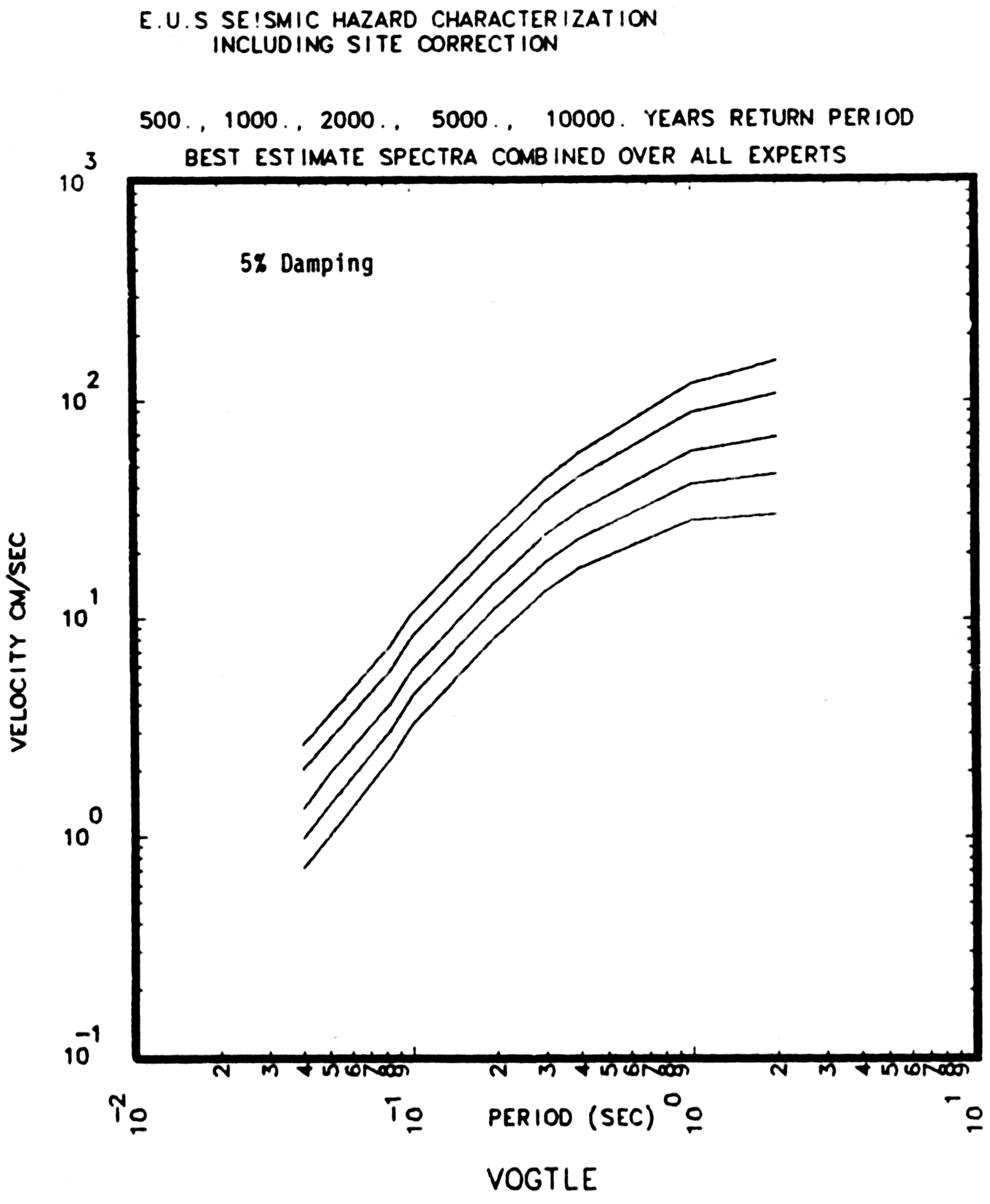

Figure 5.10.4 Best Estimate Uniform Hazard Spectra (BEUHS) Curves Over All Experts

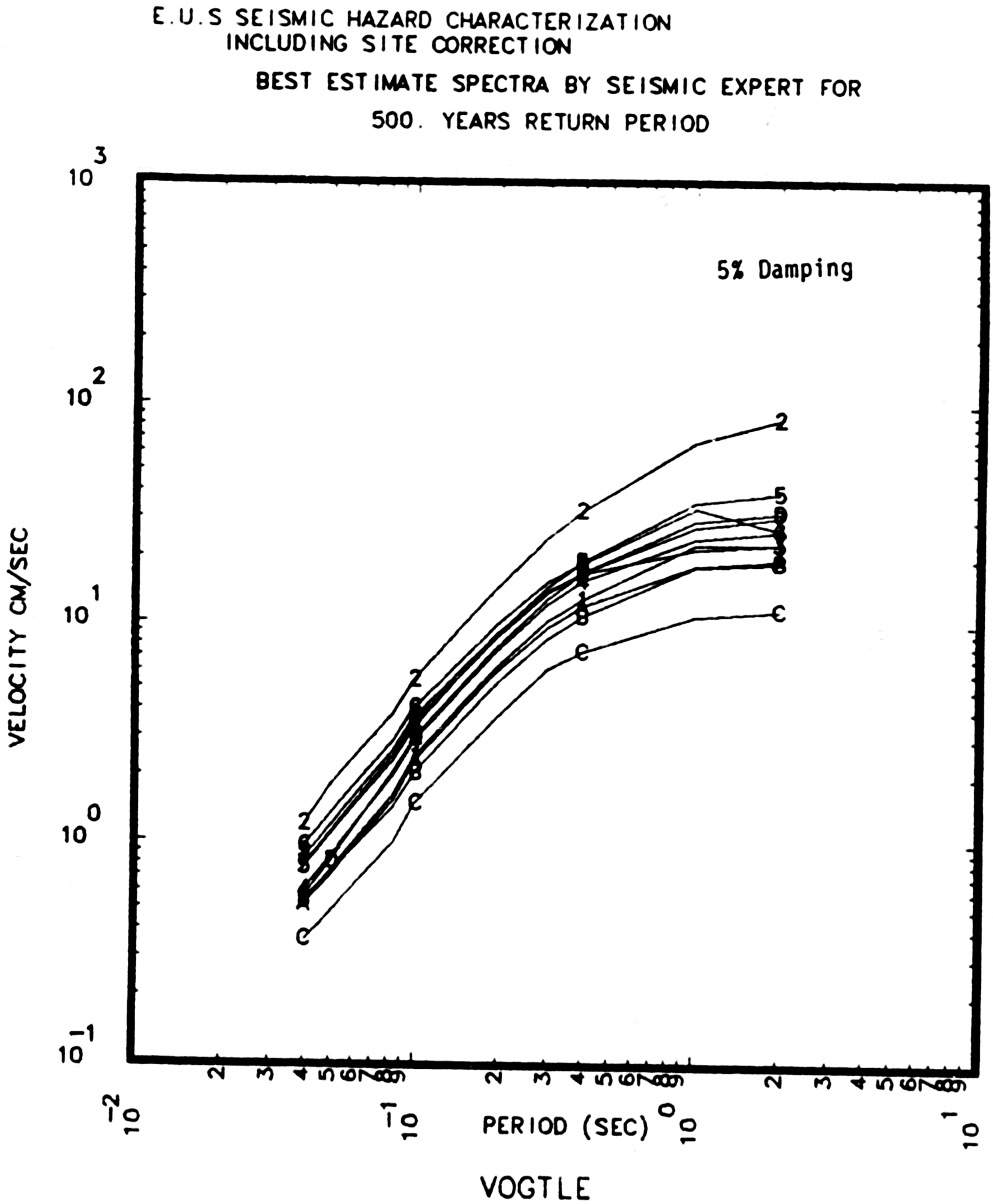

Figure 5.10.5 500 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

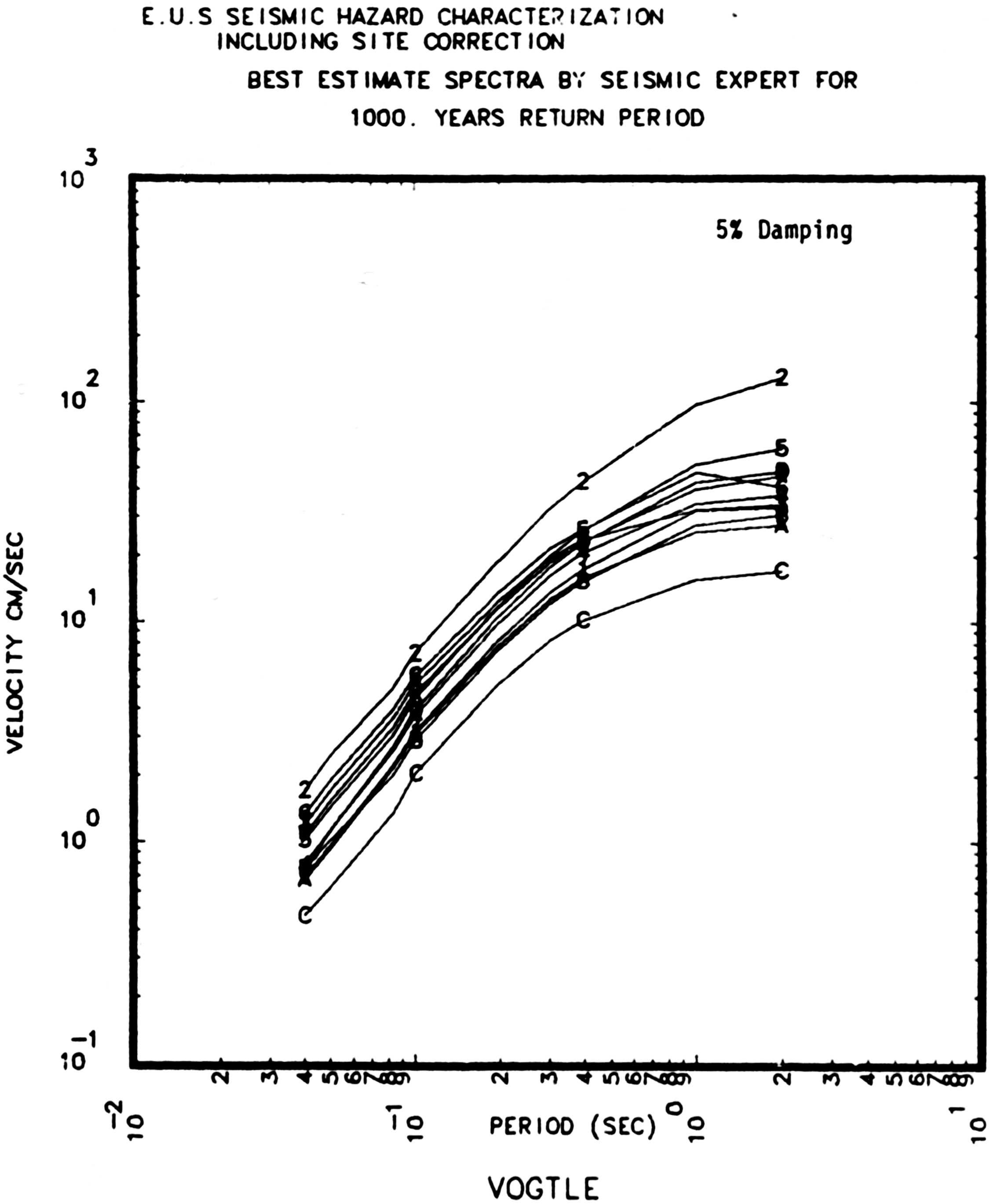

Figure 5.10.6 1,000 Year Return Period BEUHS per Seismicity Expert Combined Over All Ground Motion Experts

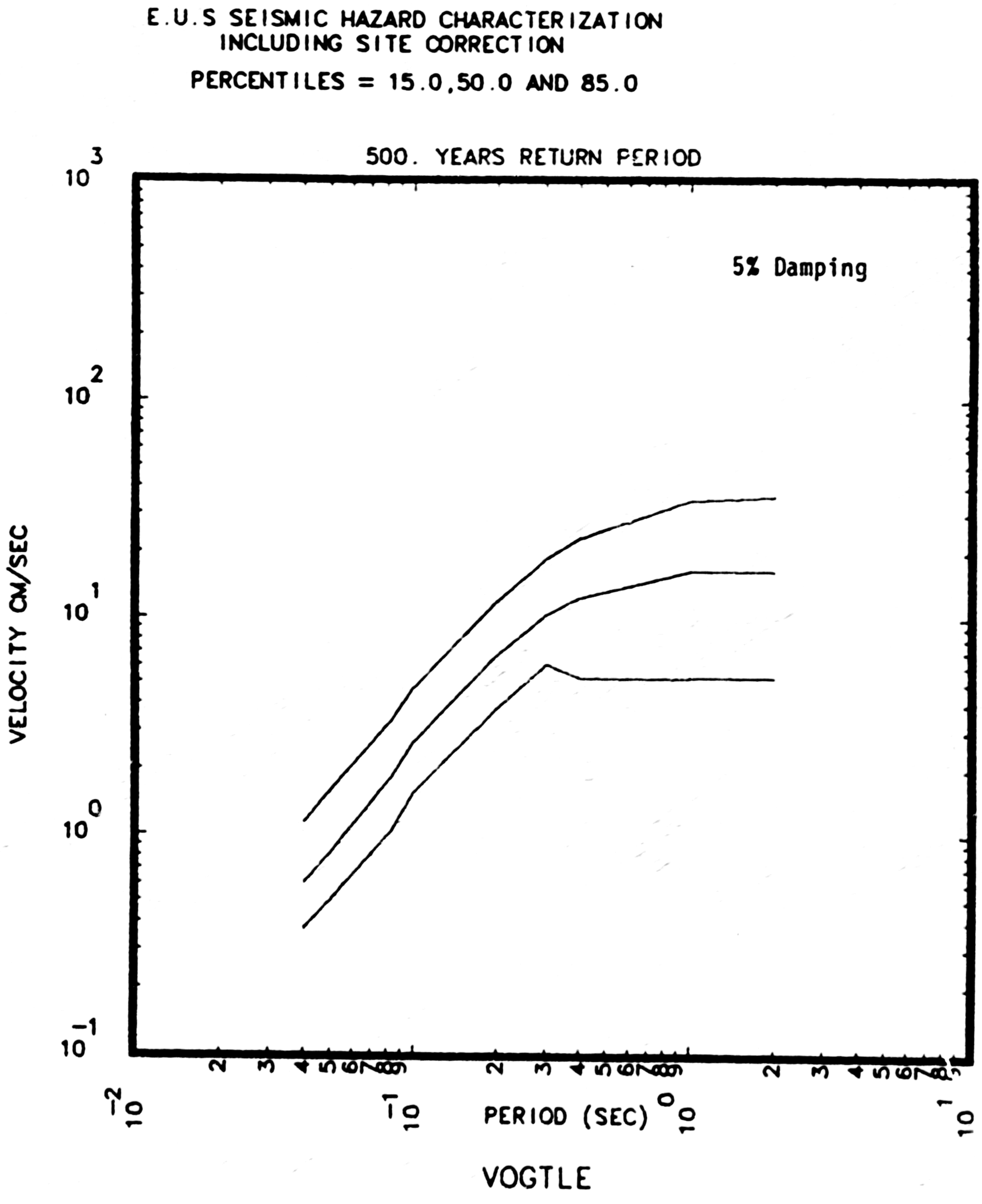

Figure 5.10.7 500 Year Return Period CPUHS Over All Experts

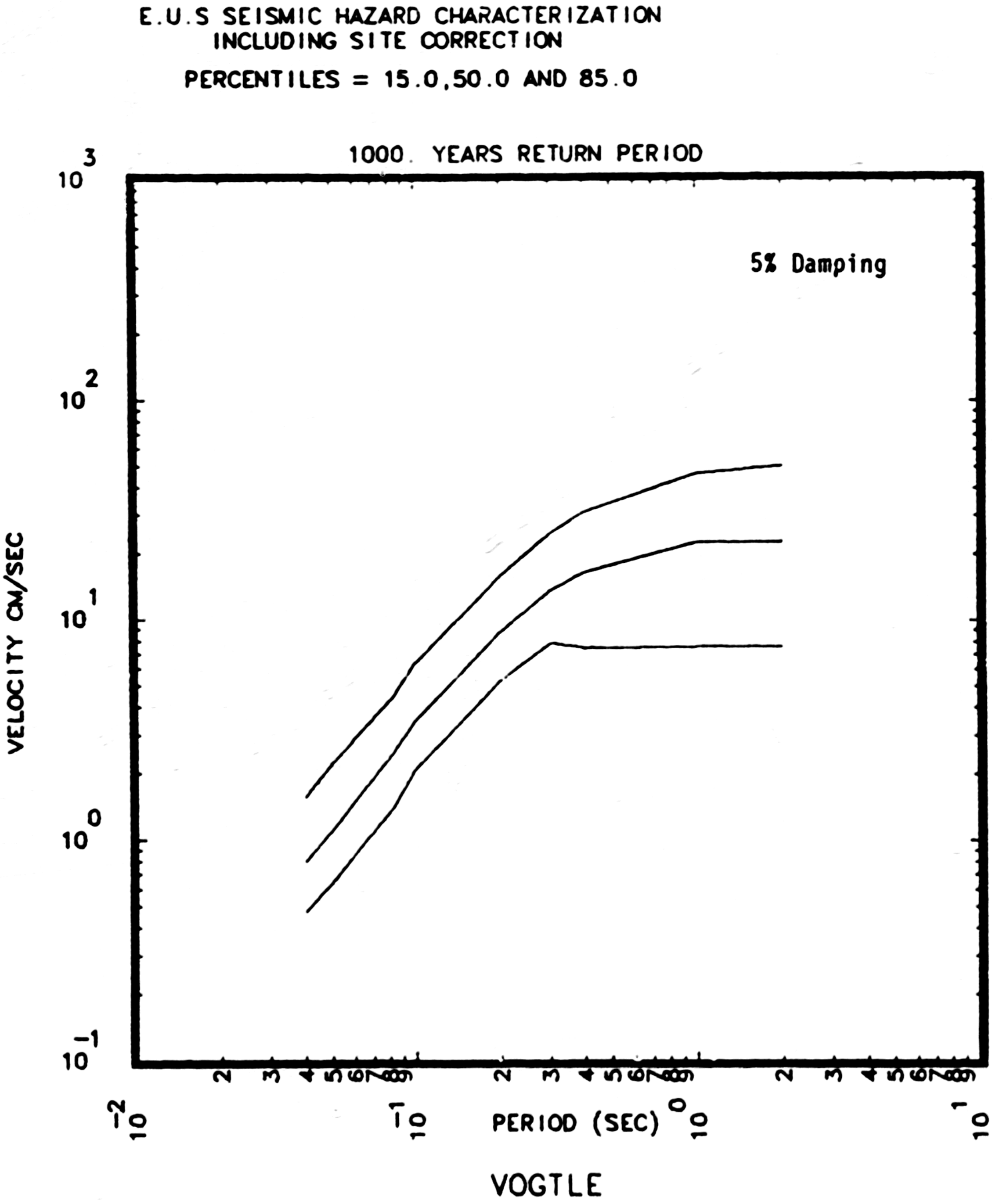

Figure 5.10.8 1,000 Year Return Period CPUHS Over All Experts

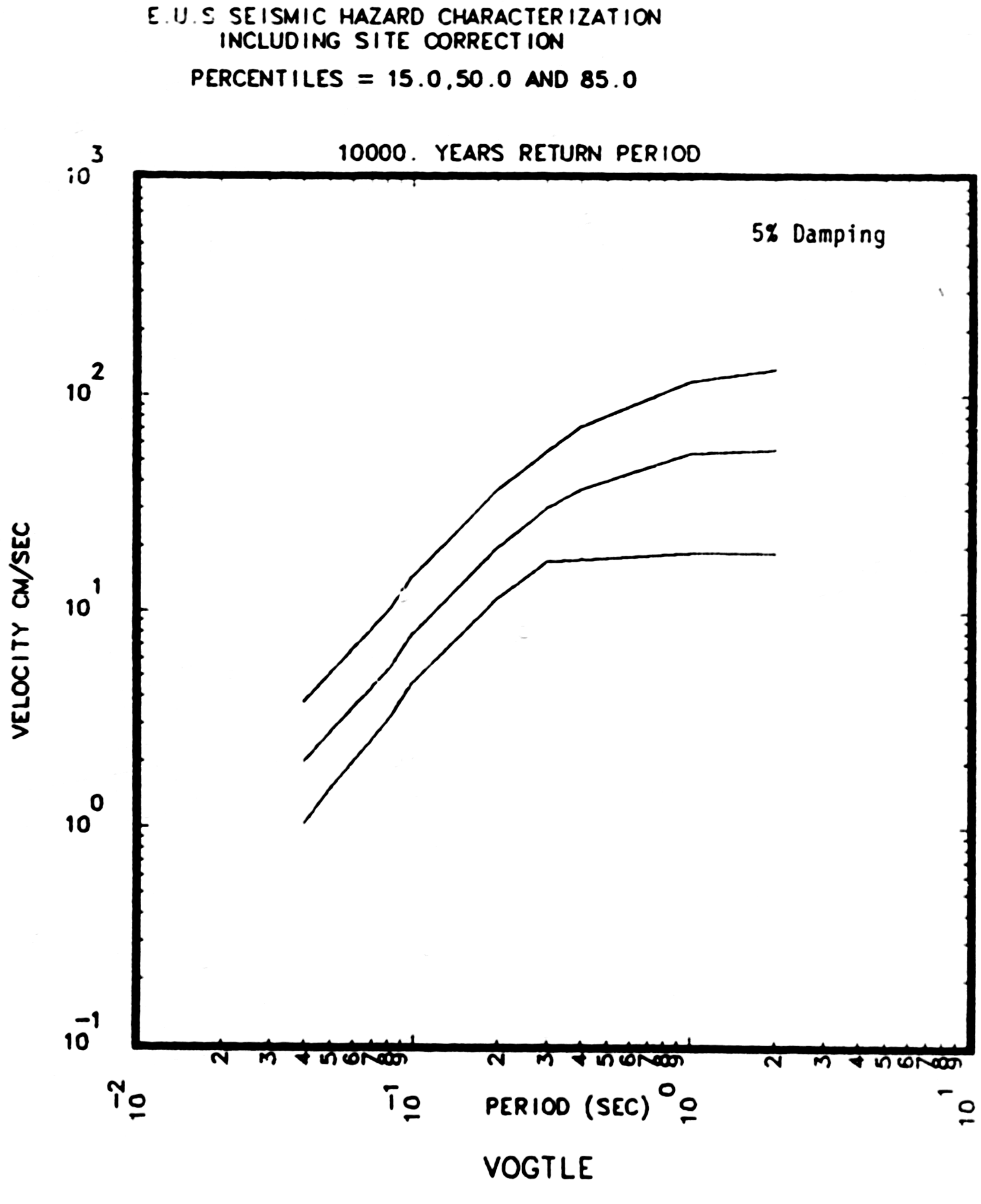

Figure 5.10.9 10,000 Year Return Period CPUHS Over All Experts