214 8C 6

UCRL-ID-105148

Seismic Hazard Characterization of the BNL - HFBR Site (Upton, New York)

Jean B. Savy

October, 1990

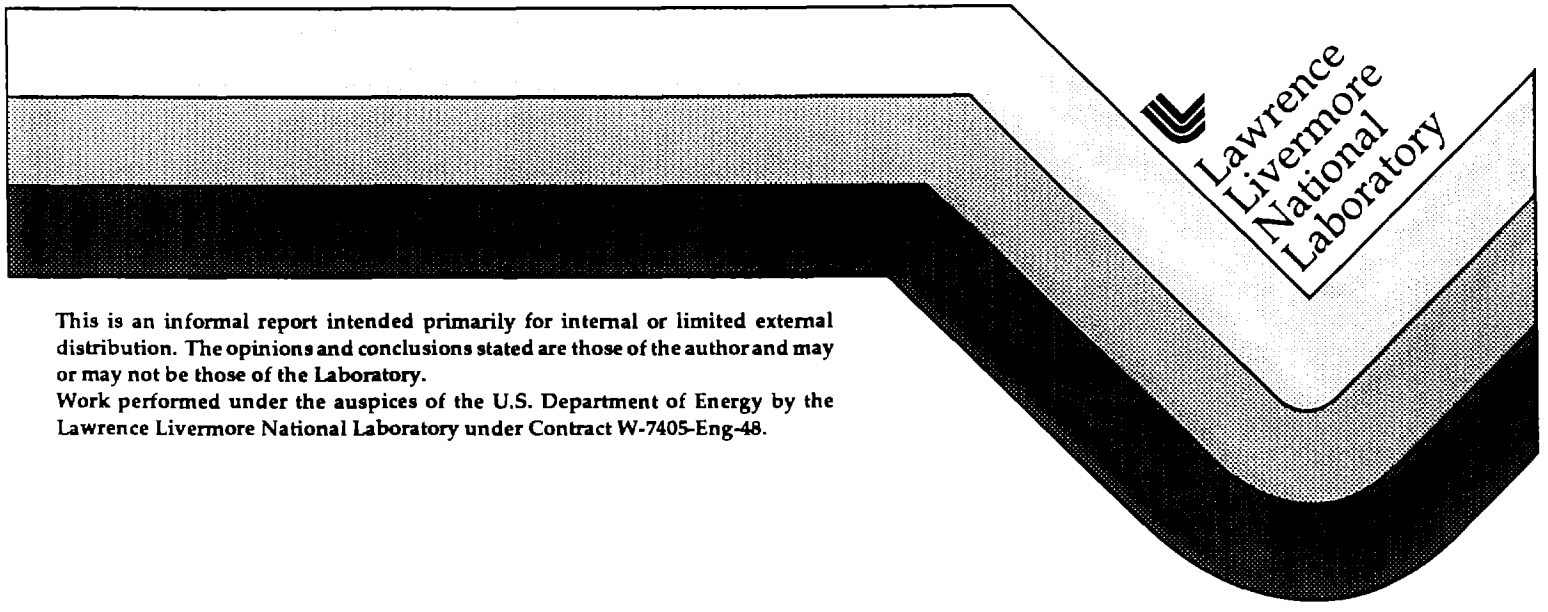

Table of Contents

List of Tables

List of Figures

ACKNOWLEDGEMENTS

This work was performed by the Lawrence Livermore National Laboratory (LLNL) for the Department of Energy/Brookhaven National laboratory (BNL) under purchase order 459470. Mr. Charles Hofmayer was the Project Manager, Mr. Jean B. Savy was the LLNL Project Leader.

1.0 INTRODUCTION

In an effort to develop estimates of the seismic hazard at the HFBR, the Lawrence Livermore National Laboratory, through DOE/BNL was asked to provide such estimates by using its latest methodology and data banks.

The scope of this study is to perform for the HFBR site the same kind of calculation as performed for the Nuclear Regulatory Commission (NRC), using the same methods and data, as those used for all the active Nuclear Power Plant (NPP) sites located east of the Rocky Mountains.

The study for NRC was specifically designed to provide a set of tools with which the hazard at all the plant sites in the Eastern United States (EUS) could be estimated. However, it must be noted that the very specific characteristics of each plant site are only accounted for in a generic fashion. For example, the local site corrections used eight different site categories rather than any site specific factors. In addition, the models of seismicity developed did not concentrate on any specific site locations, but were provided for the entire EUS. similarly, the ground motion models used in the analysis did not concentrate on small regions, rather, they were separated in four different groups of models applicable to the four areas in the EUS, namely the North East, the South East, North Central, and South Central EUS. A complete description of the methodology and of the data used here is presented in detail in Bernreuter et al., 1988, Volumes 1, 6, and 7, provided in Appendix C of this letter report. The results provided by the NRC/LLNL methods with the present data banks are accurate enough that they can be used in screening techniques and for preliminary types of analyses. If a detailed site specific analysis were deemed necessary at a site, a careful revisiting and possibly updating of each of the links in the chain of analyses leading to the final data base would be appropriate.

The parameters of interest in the present study are:

1. The peak ground acceleration, considered to be at the site location in the free field.
2. The pseudo velocity response spectrum of the free field motion for 5% critical damping and at five frequencies (1Hz, 2.5Hz, 5.0Hz, 10.0Hz, and 25Hz).

In Bernreuter et al. (1988), it was found that the results were very sensitive to the choice ground motion model.

To provide an understanding in the behavior of the model with respect to the ground motion input, an additional set of results is given for the case when the Trifunac-Anderson ground motion attenuation model is removed from the data bank.

2.0 METHODOLOGY

The hazard model used here is based on the now well accepted model developed by C.A. Cornell (1968).

The important aspects of the NRC/LLNL methodology consist of:

- Using many experts' opinions to include the knowledge uncertainty, as well as the physical uncertainty which is already included in the hazard model itself.

- Propagating all uncertainties, in the seismicity modeling and ground motion modeling, through the use of a Monte Carlo simulation process.

The details of the methodology, including the hazard model and the process of elicitation of the experts' opinion, are given in Bernreuter et al. (1985), Vol. 1 and 2 and Bernreuter et al., Vol. 1, 6, and 7 (given in Appendix C). In particular Volume 7 details all the questionnaires used in the experts' opinion elicitations.

3.0 INPUT DATA

The input data used for this HFBR study, is exhaustively described in Bernreuter et al. (1988), Vol. 1. The minimum magnitude of the earthquakes contributions to the hazard in the base case, is magnitude 5.0, and all five ground motion experts inputs are used.

4.0 SEISMIC HAZARD ESTIMATES AT THE HFBR SITE

4.1 Site Description

The HFBR site is part of the Brookhaven National Laboratory in Upton, New York. The coordinates of the site provided to LLNL in a transmitted fax on 4/17/90 (in a memo from P. Tichler to J. Tichler and H. Bernstein, dated 7/28/88) and used in this analysis are:

- Latitude: 40.8701° N (decimal)
- Longitude: 72.8751° W (decimal)

Formally, the site characteristics were described in the statement of work as follows:

> "The HFBR Site is situated at BLN on a 200 foot thick layer of dense glacial deposits of gravels, sands and clays. Below

this morainal deposit exists additional series of dense sediments about 1,200 foot thick. Bedrock is at a depth of about 1,400 feet. The site can be classified as a deep soil site (category 8)." [Referring to LLNL site categories described in Bernreuter et al., 1985.]

Following a later request by BNL staff, the site characteristics was assumed to be either a deep soil, as defined in Bernreuter et al., Vol. 1, 1988, or a rock site.

4.2 Dominant Zonal Contributions

The dominant zonal contribution tables (Tables 1.1 and 1.2) are an attempt at identifying which of the seismic zones given by the seismicity experts (S-experts) contribute the most to creating the seismic hazard at the HFBR site. The percentages given in these tables are the ratios of the hazard provided by a zone, to the total hazard at the site, given only for the four highest contributing zones. (See Bernreuter et al. 1988, Vol. 1, Appendix C).

However, one needs to be careful in interpreting the results presented in Tables 1.1 and 1.2, since the calculations are made only with the best estimate hazard curves (BEHC) and not with the constant percentile hazard curves (CPHC).

The BEHC for a given S-expert is obtained by setting each of the uncertain parameters equal to what each expert has defined as the most likely value of the parameter (zonation, seismicity parameters) and the most likely models of the ground motion experts (G-experts). Thus, the table of zonal contributions is only indicative of the relative contributions but it does not always represent accurately the relative contributions when all possible alternatives, and all uncertainties are included.

In these tables, the percentage values have been rounded-off to the nearest integer value and only the five zones contributing the most have been reported. Thus, the sum of all the percentages for a given S-expert, either at low PGA levels (0.125g) or high levels (0.56g) do not necessarily add up to unity. The zone indexes refer to the indexes for each of the zones in the maps given in the Appendix B.

Table 1.1
Seismic Hazard at the Brookhaven HFBR Site
Most Important Zones per S-expert

Site Soil Category: Rock Site

S-expert Index	Host Zone Index		Zones contributing most significantly, and their percentage of contribution									
			At Low PGA (0.125g)					At High PGA (.56g)				
1	1	Zone ID	22	20	1	21	4	1	22	20	4	21
		%	29	26	18	13	13	49	34	8	5	4
2	31	Zone ID	31	32	28	CZ		31	32	28	CZ	
		%	58	20	17	4		83	10	4	4	
3	4	Zone ID	4	5	3	2	CZ	4	CZ			
		%	83	7	4	3	1	98	1			
4	CZ	Zone ID	18	16	11	23	19	11	23	16	18	CZ
		%	25	23	14	12	10	42	17	16	12	9
5	1	Zone ID	1	6	8	3	4	1	3			
		%	75	16	4	4	1	99	1			
6	6	Zone ID	6	7	3	5	CZ	6	7	5		
		%	81	8	6	4	1	97	2	1		
7	29	Zone ID	29	14	19	13	17	29	14	24	13	19
		%	33	28	9	8	7	64	27	4	2	2
10	4	Zone ID	4	2	CZ	22	5	4	CZ	2	22	
		%	51	10	7	6	6	96	2	1	1	
11	CZ	Zone ID	5	3	CZ	1	4	5	CZ	1	3	
		%	36	27	17	12	7	57	26	7	6	
12	32	Zone ID	32	31	34	33	37	32				
		%	79	9	7	2	2	99				
13	10	Zone ID	10	CZ	12	11		10	CZ			
		%	88	6	4	2		98	2			

Notes:
* CZ = Complementary Zone
* The Zone ID's in this table refer to the zones identified in the zonation maps in Appendix B.
* The S-experts ' numbering do not include the indexes 8 and 9. A total of 11 S-experts only were used in this analysis, as well as in the inital NRC study (see Appendix C) for details.

Table 1.2
Seismic Hazard at the Brookhaven HFBR Site
Most Important Zones per S-expert

Site Soil Category: Deep Soil Site

S-expert Index	Host Zone Index		Zones contributing most significantly, and their percentage of contribution								
			At Low PGA (0.125g)					At High PGA (.56g)			
1	1	Zone ID	1	22	20	21	4	1	22	20	4
		%	44	29	14	7	7	84	14	1	1
2	31	Zone ID	31	32	28	CZ		31	CZ	32	
		%	80	10	7	3		95	3	2	
3	4	Zone ID	4	5	CZ			4			
		%	96	2	1			100			
4	CZ	Zone ID	11	16	18	23	CZ	11	CZ	23	
		%	27	19	19	15	7	46	45	7	
5	1	Zone ID	1	3	6			1			
		%	96	1	1			100			
6	6	Zone ID	6	7	3	5		6			
		%	95	3	1	1		100			
7	29	Zone ID	29	14	13	19	17	29	14		
		%	60	26	3	3	2	90	8		
10	4	Zone ID	4	CZ	2	22		4	CZ		
		%	86	4	3	2		97	3		
11	CZ	Zone ID	5	CZ	3	1	4	CZ	5	1	
		%	39	33	13	10	4	55	41	3	
12	32	Zone ID	32	34	31			32			
		%	96	1	1			100			
13	10	Zone ID	10	CZ	12			10	CZ		
		%	96	3	1			99	1		

Notes:
* **CZ = Complementary Zone**
* **The Zone ID's in this table refer to the zones identified in the zonation maps in Appendix B.**
* **The S-experts ' numbering do not include the indexes 8 and 9. A total of 11 S-experts only were used in this analysis, as well as in the inital NRC study (see Appendix C) for details.**

4.3 Hazard Estimates with all Seismic and Ground Motion Experts

4.3.1 Hazard Estimates Assuming the HFBR to be a Rock Site

The results are first presented for a site at the location of the HFBR facility assuming that the characteristics are those of a rock site. The results are surface free field. Figure 1R represents an arithmetic mean hazard curve of the Peak Ground Acceleration (PGA); Fig. 2R gives the 5th, 15th, 25th, 35th, 45th, 50th, 65th, 75th, 85th and 95th percentile hazard curves, including all types of uncertainties and expert variabilities; Fig. 3R gives the arithmetic average 1,000, 10,000 and 100,000 year 5 percent damping Uniform Hazard Velocity response spectra; Fig. 4R gives the 5 percentiles (5, 15, 50, 85 and 95), 1,000 year, 5 percent Damped Velocity response spectra; Fig. 5R gives the same information as Fig. 4R for 10,000-year return period and Fig. 6R the same as Fig. 4R for 100,000-year return period.

4.3.2 Hazard Estimates Assuming the HFBR to be a Deep Soil Site

Figures 1S to 6S give the same results as Figures 1R to 6R for deep soil site.

4.4 Sensitivity Analysis

The results presented in this section correspond to exactly the same cases treated in section 4.3. the only difference is that only the ground motion models from four of the five G-experts were used. In this case, the Trifunac-Anderson ground motion model was not considered. Figures 7R to 12R show the results of using four G-experts' input and considering the site to be a rock site. Figures 7S to 12S show the same results for the deep soil case.

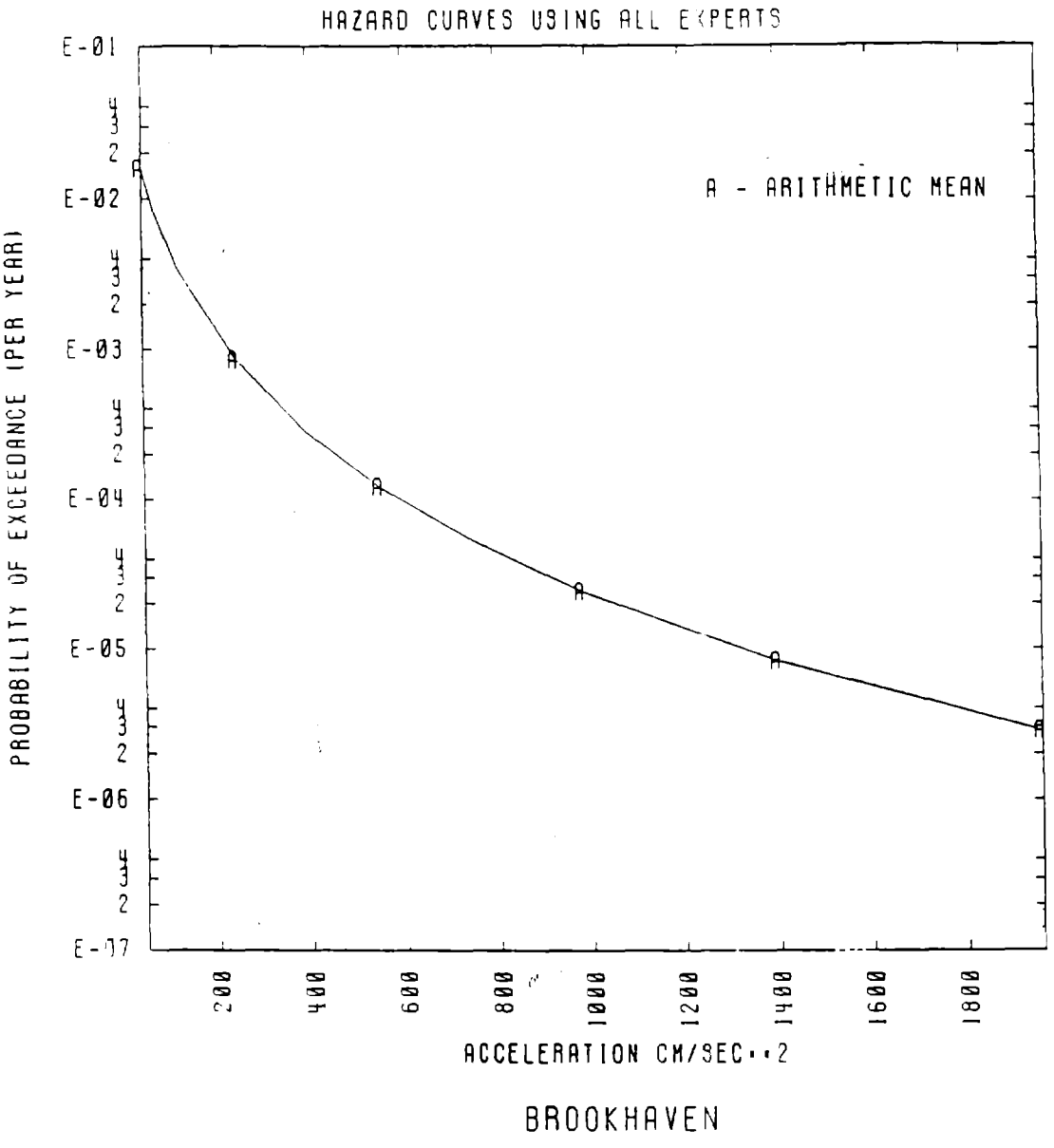

Figure 1R **Arithmetic average hazard curves (Minimum contributing magnitude = 5.0) of the PGA for the BNL-HFBR rock site characteristics and with five ground motion experts' input.**

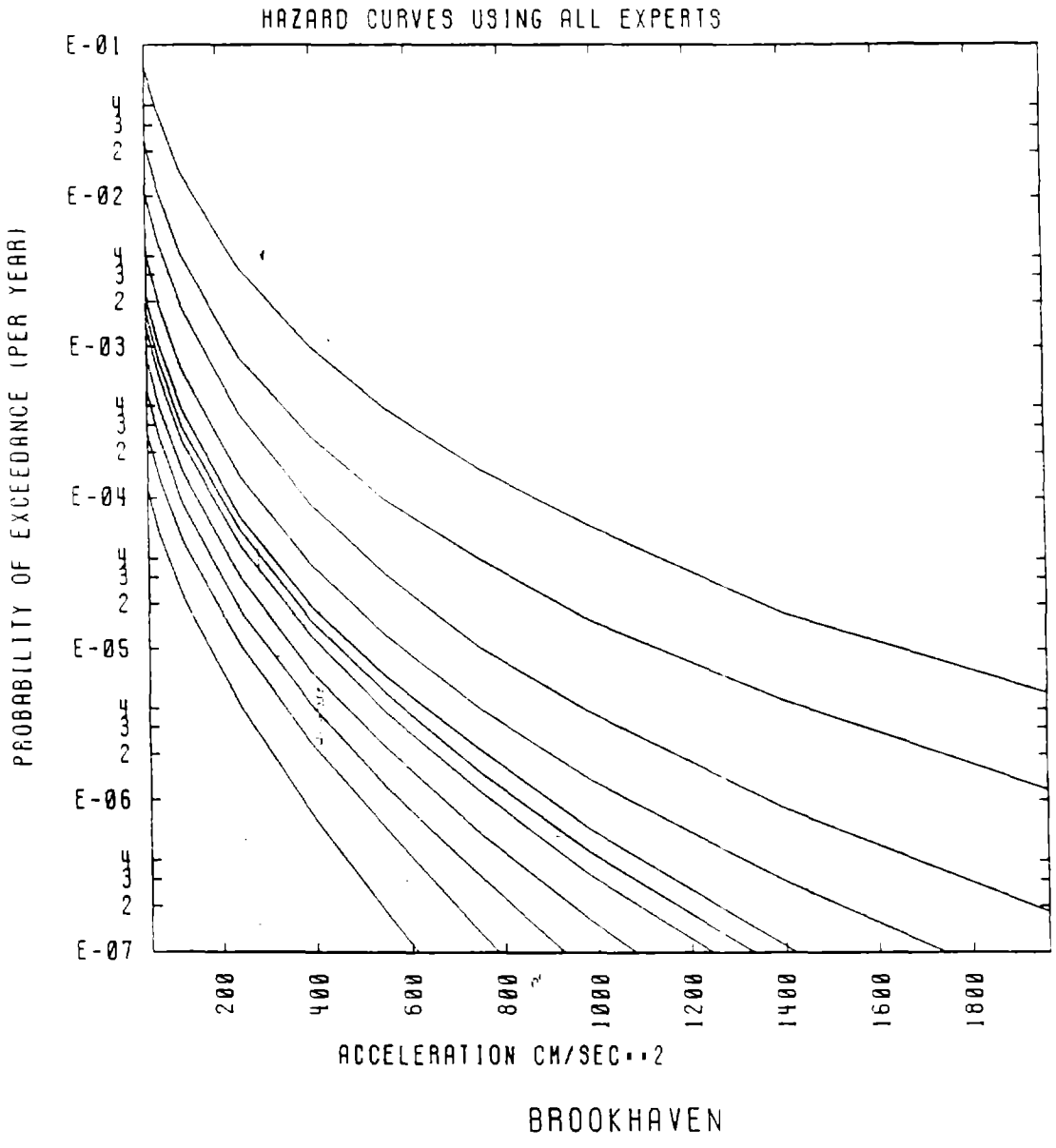

Figure 2R 5, 15, 50, 85 and 95 percent constant percentile hazard curves (Minimum contributing magnitude = 5.0) of the PGA for the BNL-HFBR site, under the assumption of rock site characteristics and with five ground motion experts' input.

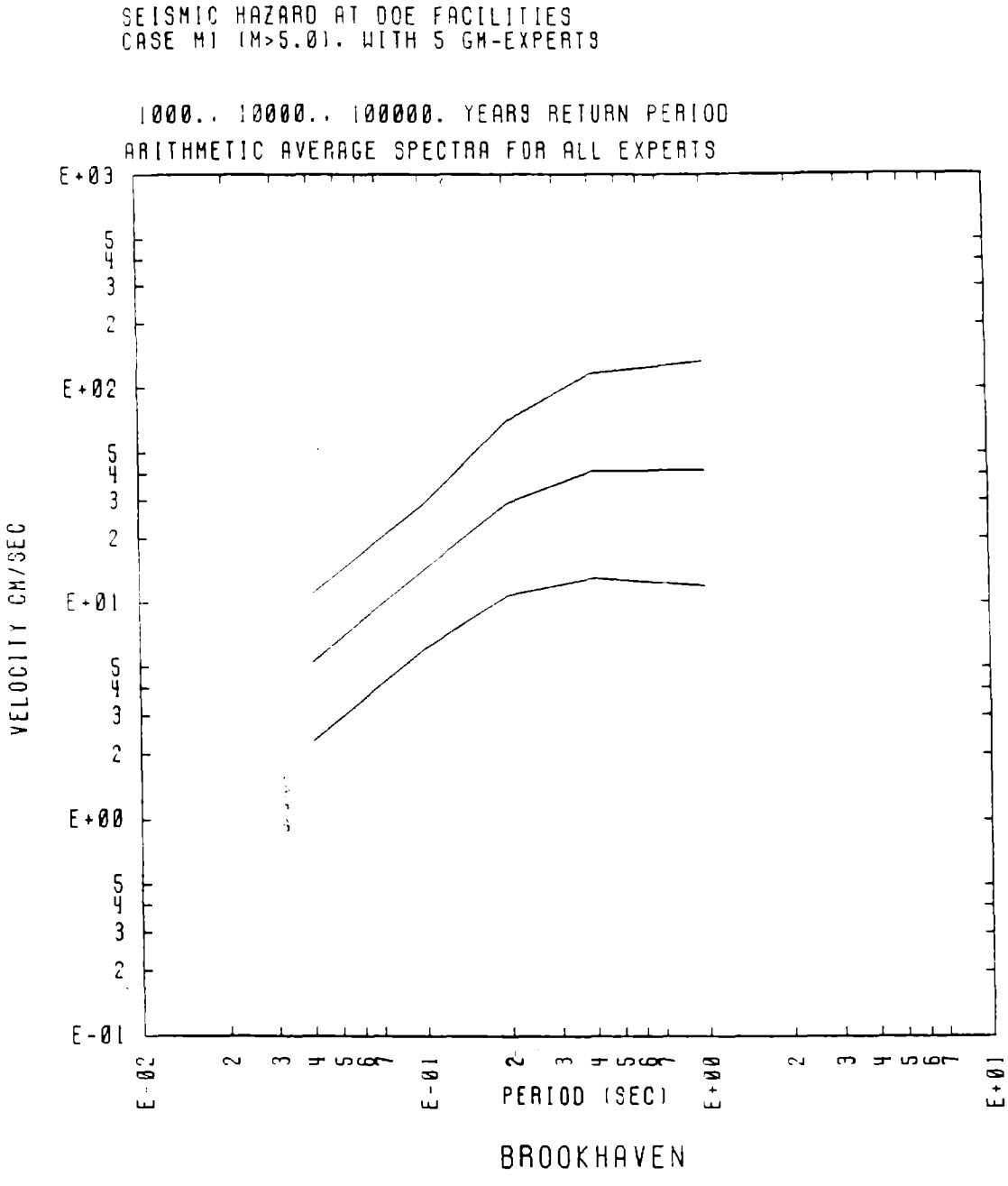

Figure 3R **Arithmetic average Uniform Hazard Spectra for three return periods (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of rock site characteristics, and with five ground motion experts' input.**

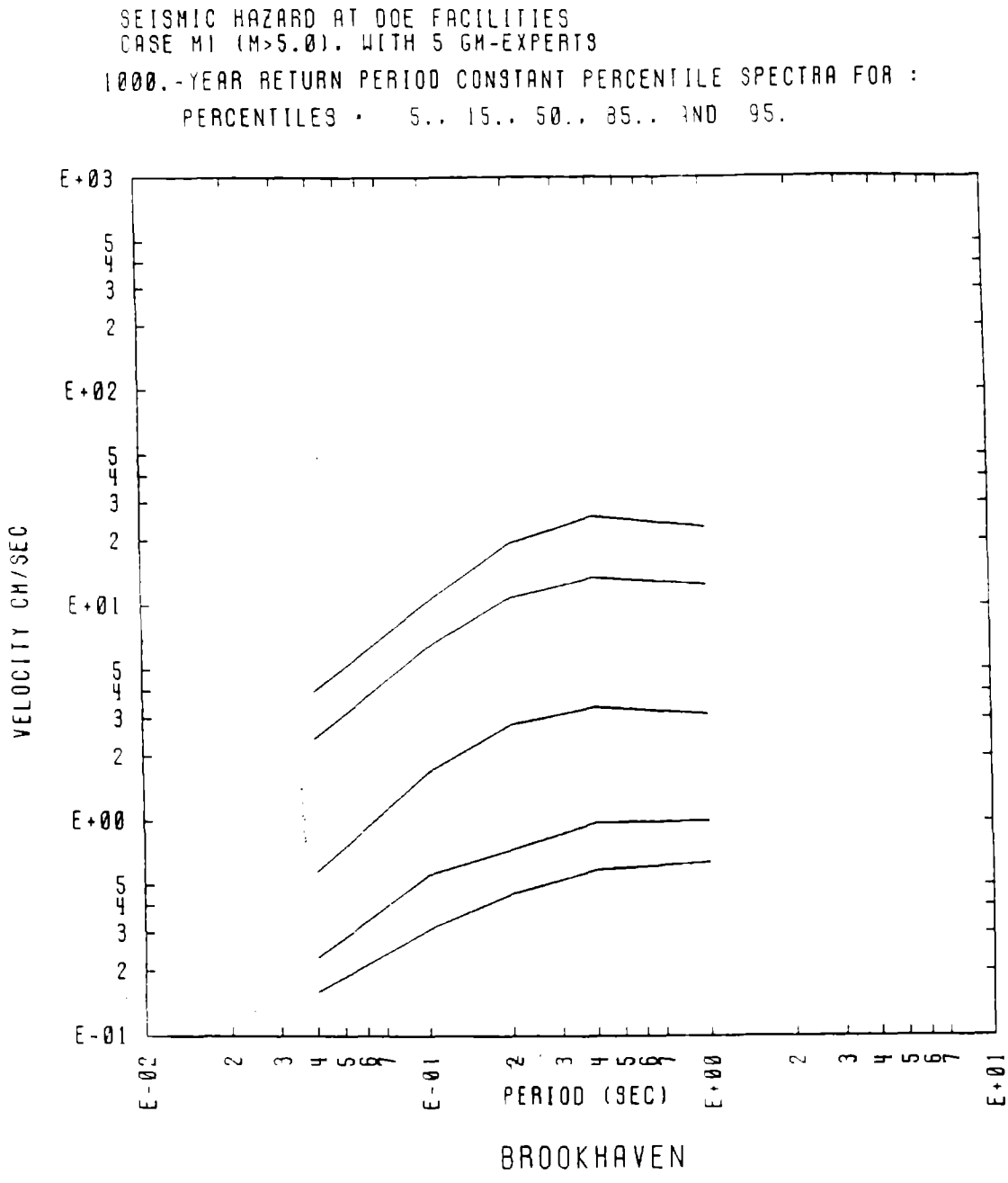

Figure 4R 5, 15, 50, 85 and 95 percent constant percentile 1,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the HFBR site, under the assumption of rock site characteristics, and with five ground motion experts' input.

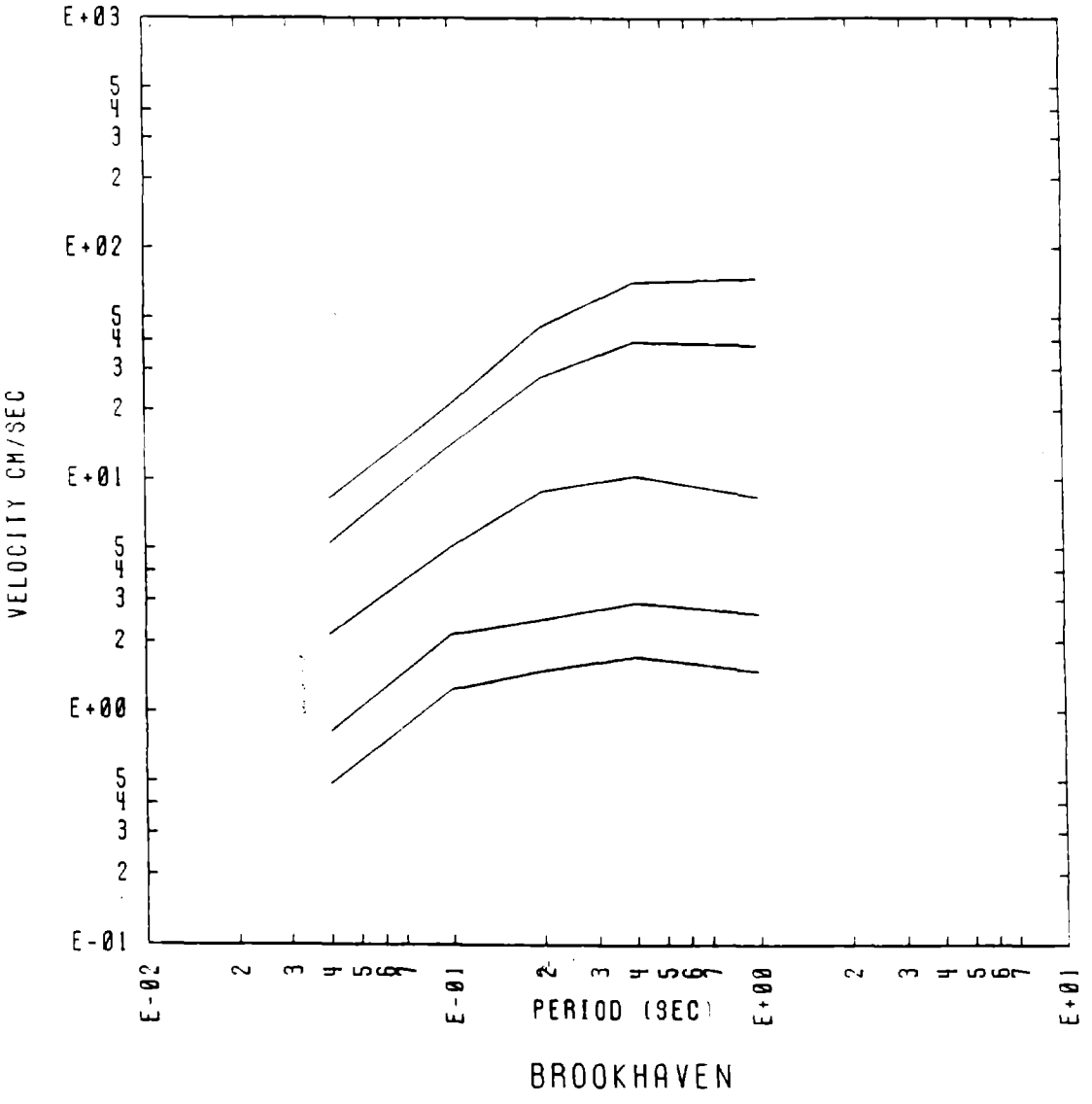

Figure 5R **5, 15, 50, 85 and 95 percent constant percentile 10,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of rock site characteristics, and with five ground motion experts' input.**

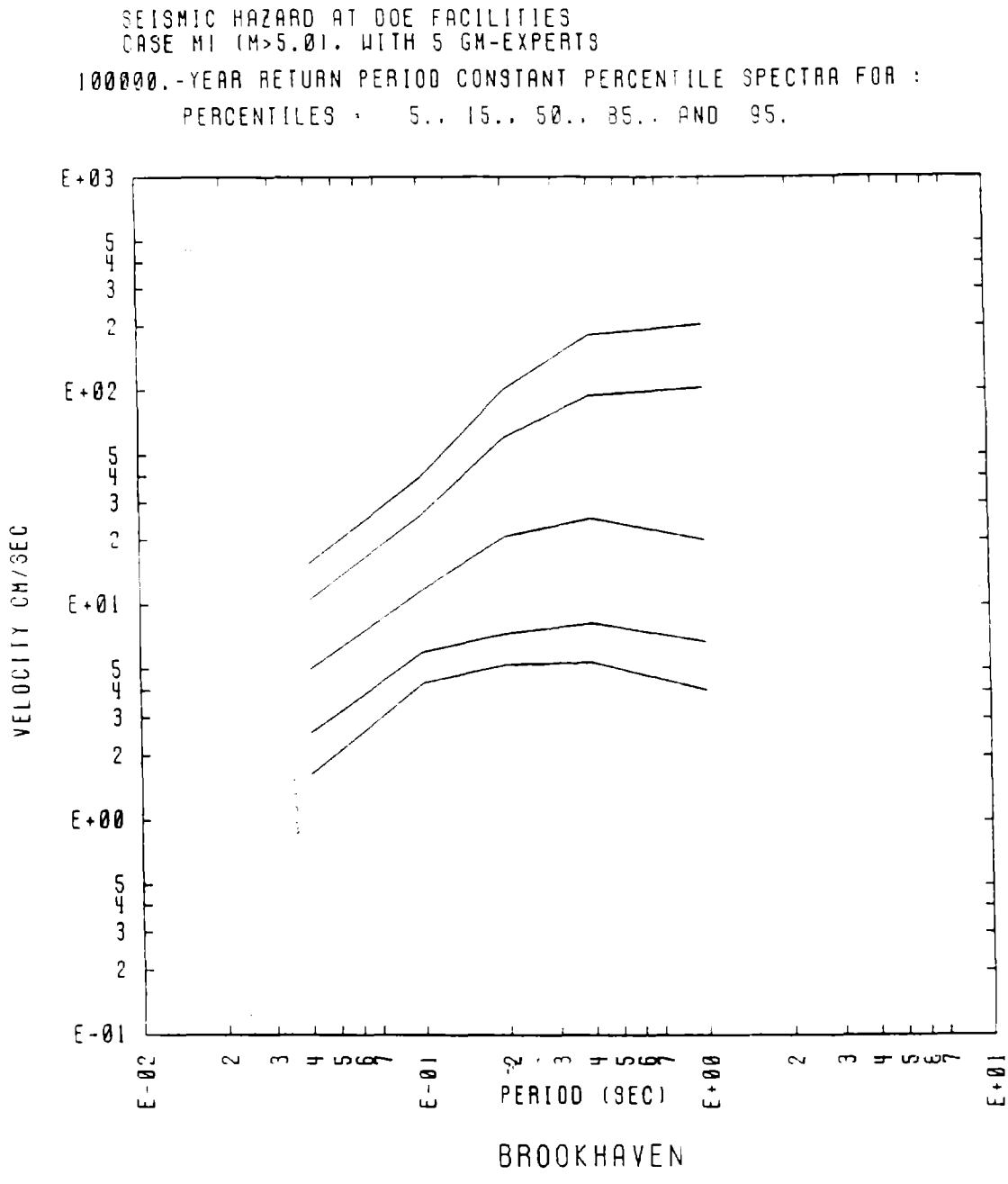

Figure 6R **5, 15, 50, 85 and 95 percent constant percentile 100,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of rock site characteristics and with five ground motion experts' input.**

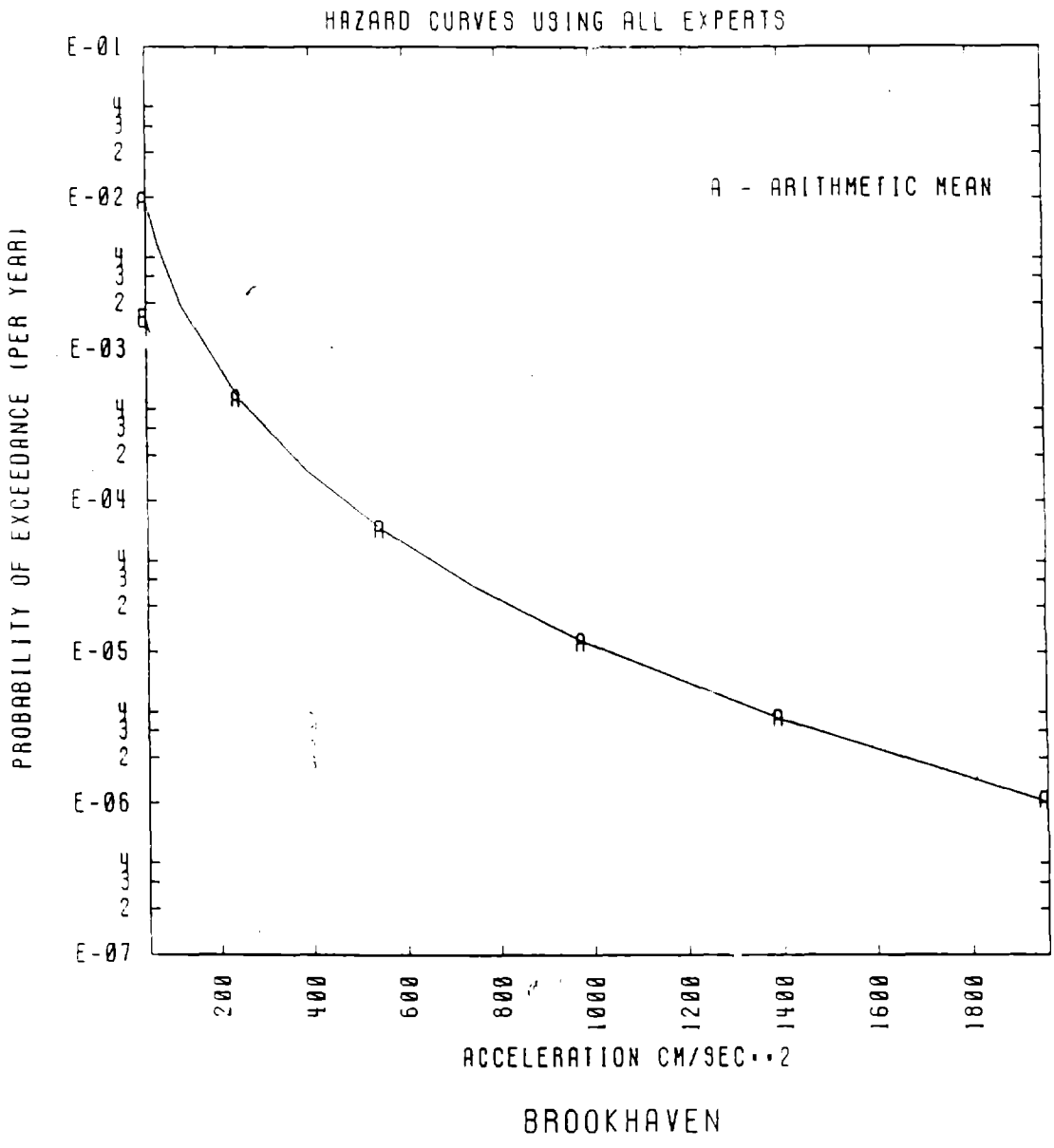

Figure 1S **Arithmetic average hazard curves (Minimum contributing magnitude = 5.0) of the PGA for the BNL-HFBR site, under the assumption of deep soil site characteristics and with five ground motion experts' input.**

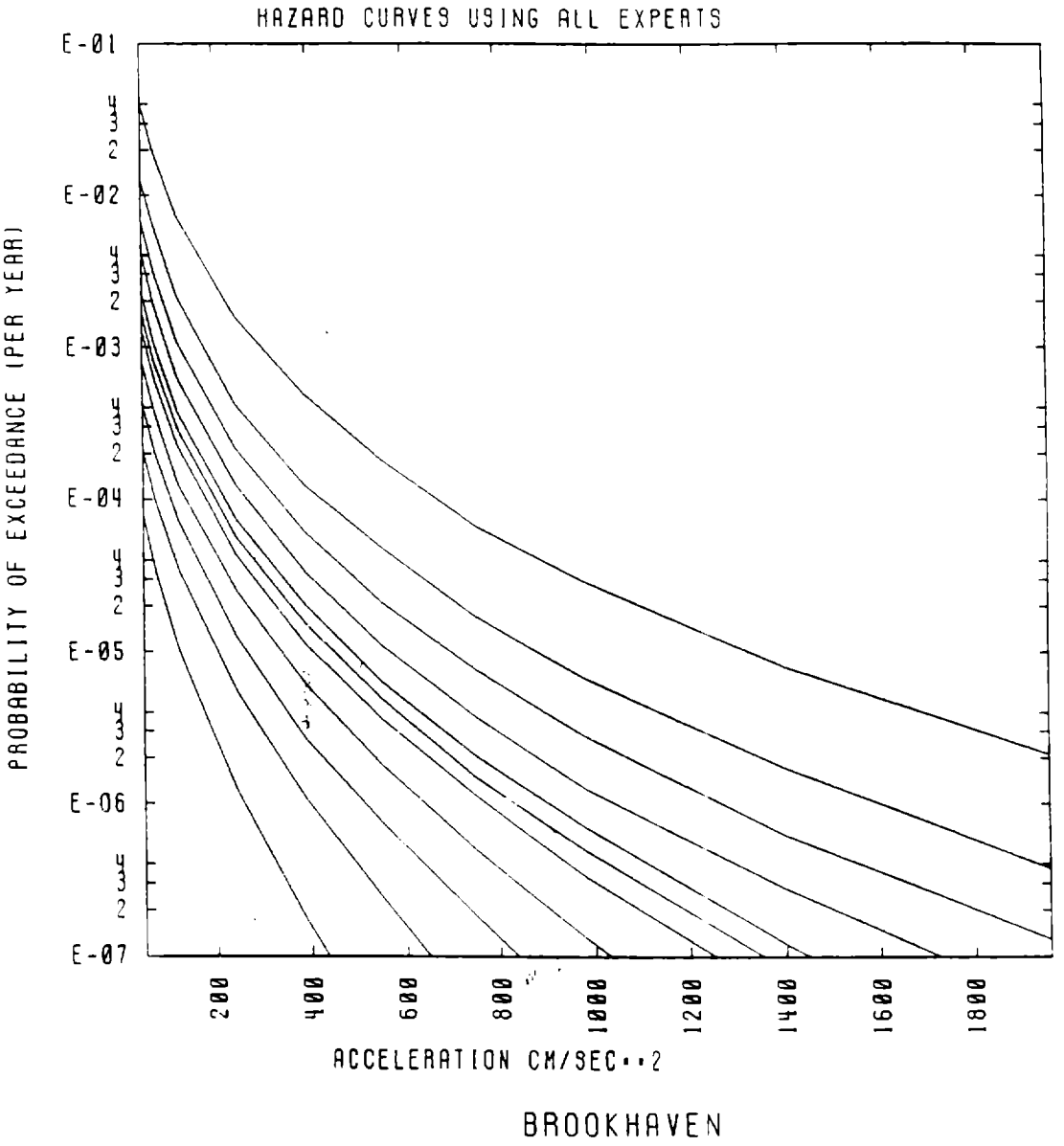

Figure 2S **5, 15, 50, 85, 95 percent constant percentile hazard curves (Minimum contributing magnitude = 5.0) of the PGA for the BNL-HFBR site, under the assumption of deep soil site characteristics and with five ground motion experts' input.**

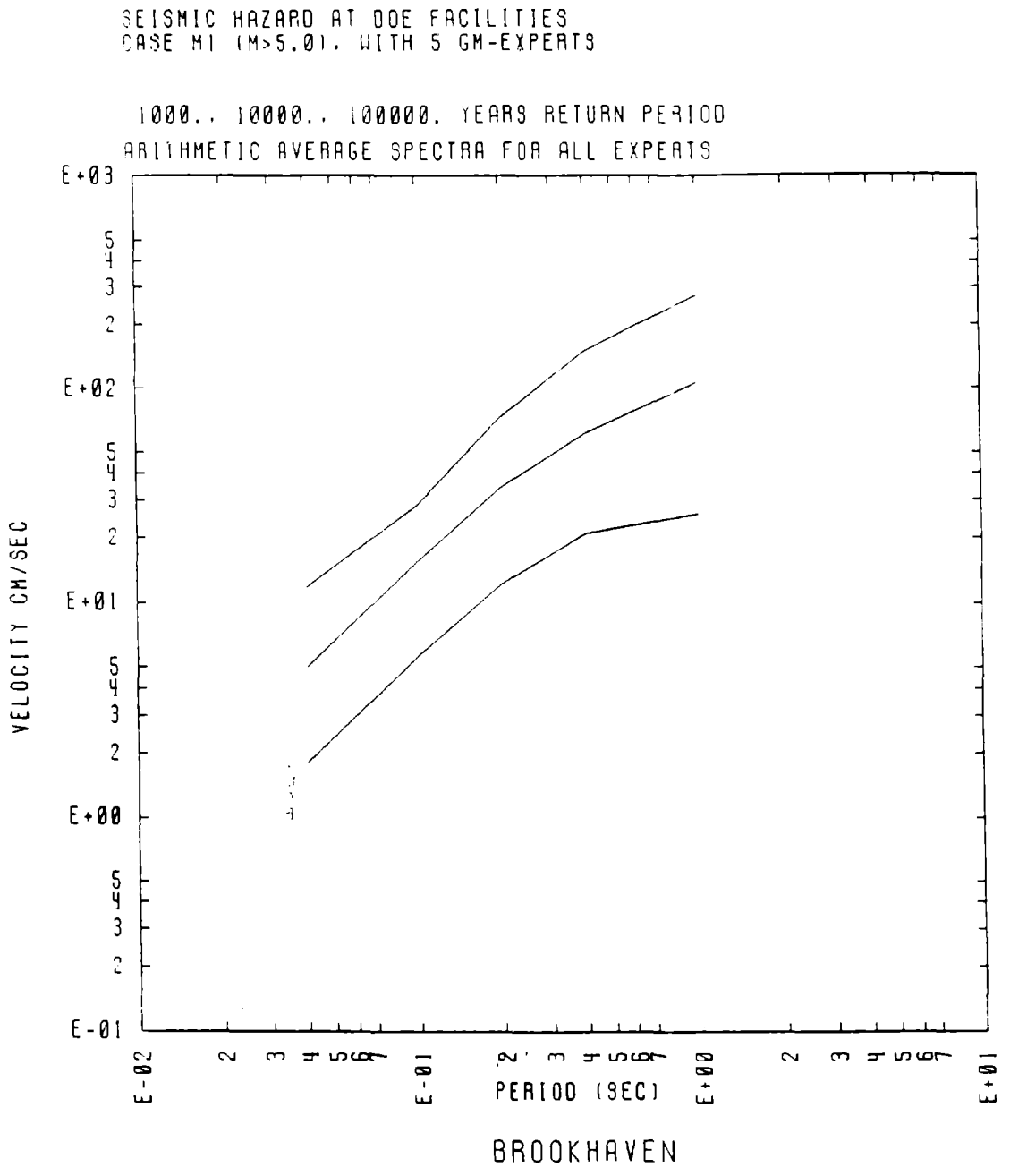

Figure 3S **Arithmetic average Uniform Hazard Spectra for three return periods (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of deep soil site characteristics, and with five ground motion experts' input.**

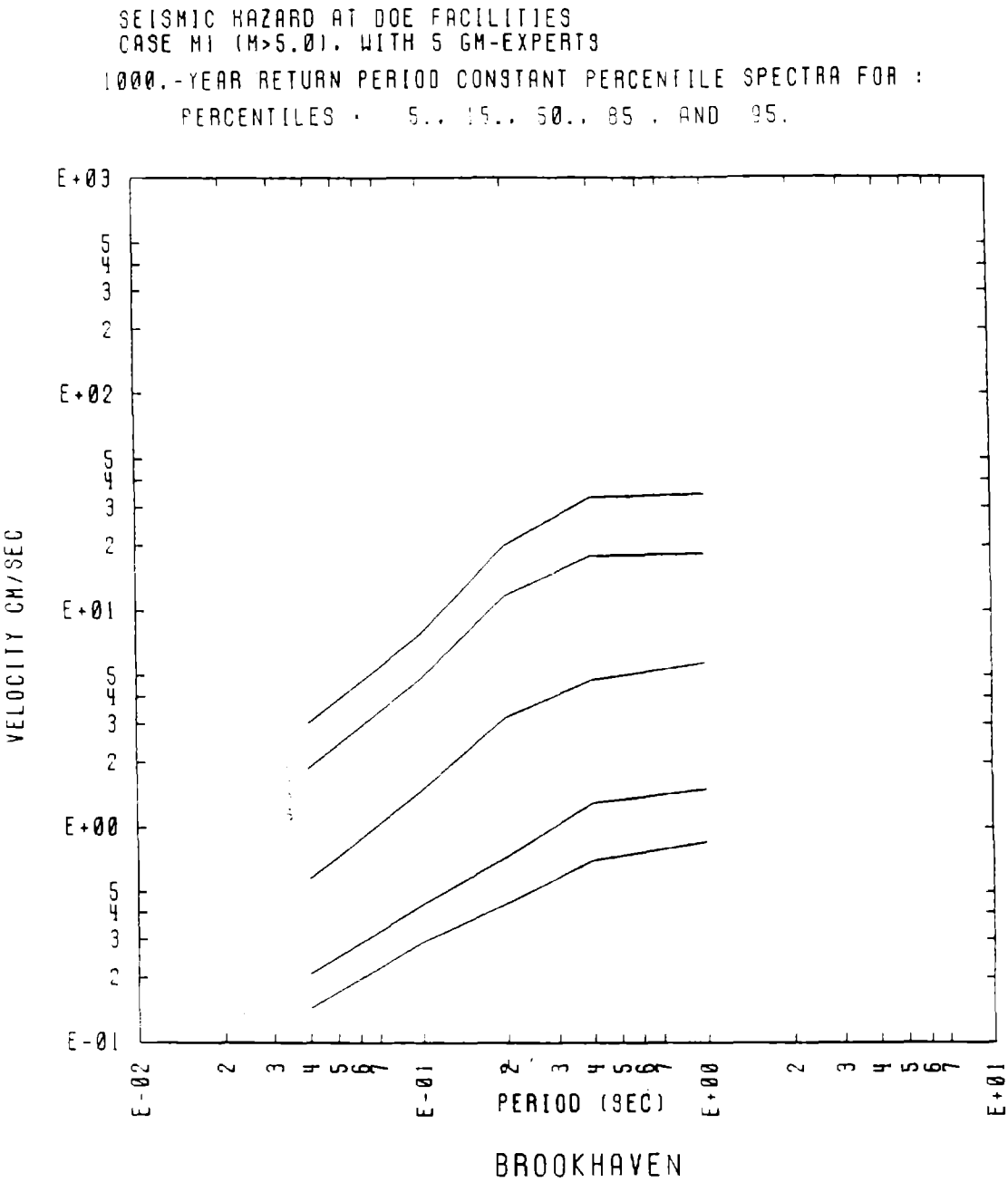

Figure 4S **5, 15, 50, 85, 95 percent constant percentile 1,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the HFBR site, under the assumption of deep soil site characteristics, and with five ground motion experts' input.**

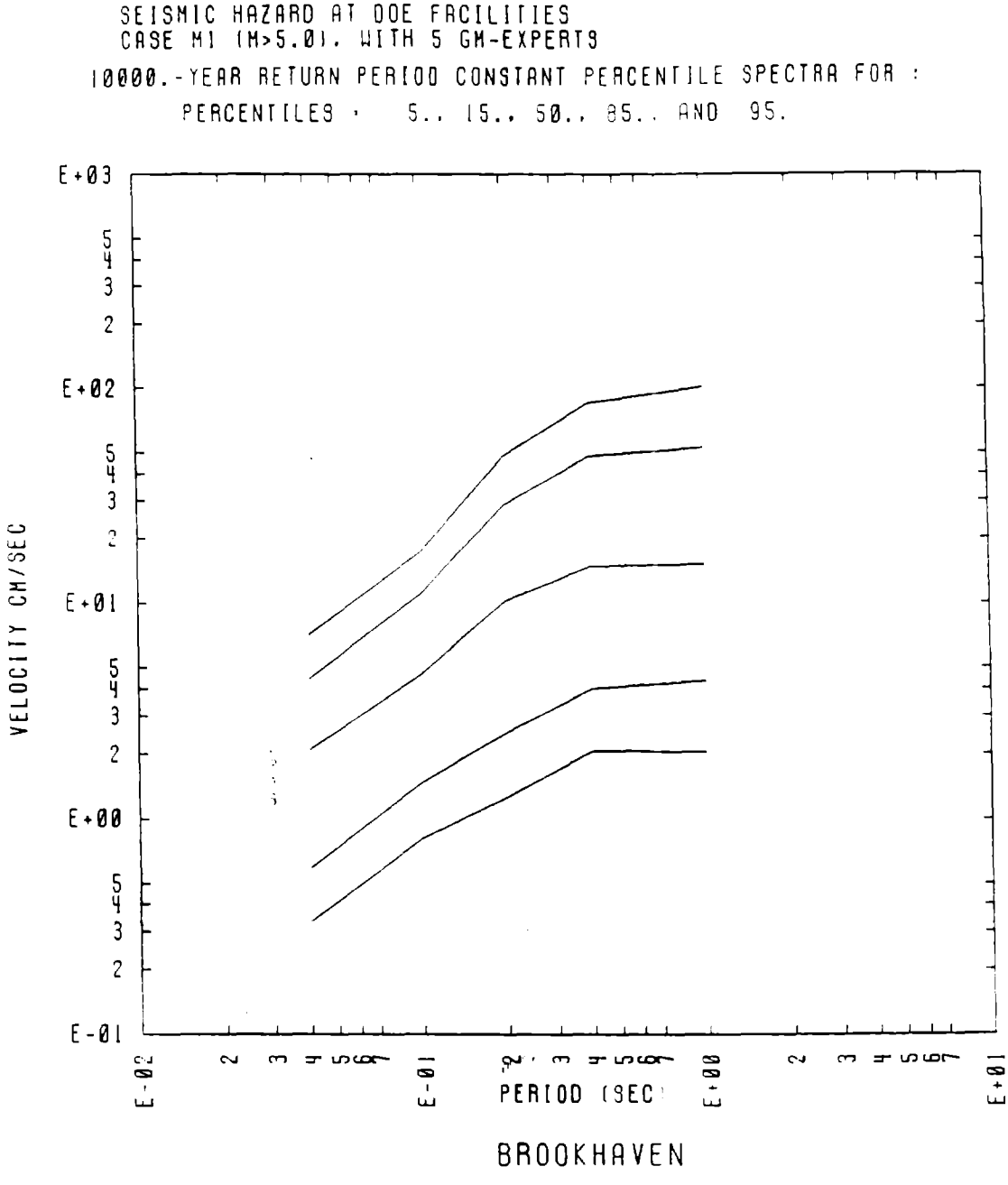

Figure 5S **5, 15, 50, 85 and 95 percent constant percentile 10,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of deep soil site characteristics, and with five ground motion experts' input.**

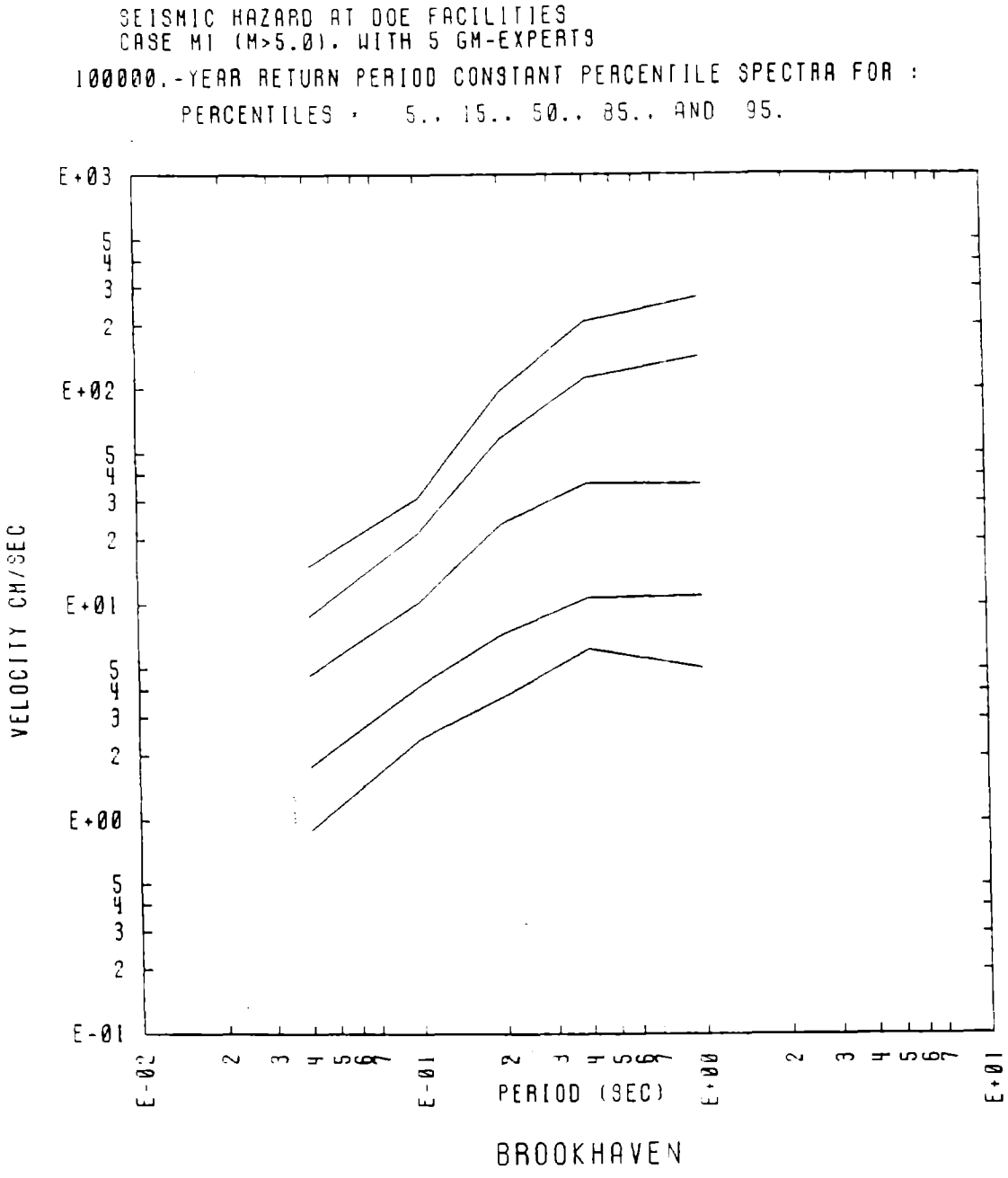

Figure 6S **5, 15, 50, 85 and 95 percent constant percentile 100,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of deep soil site characteristics, and with five ground motion experts' input.**

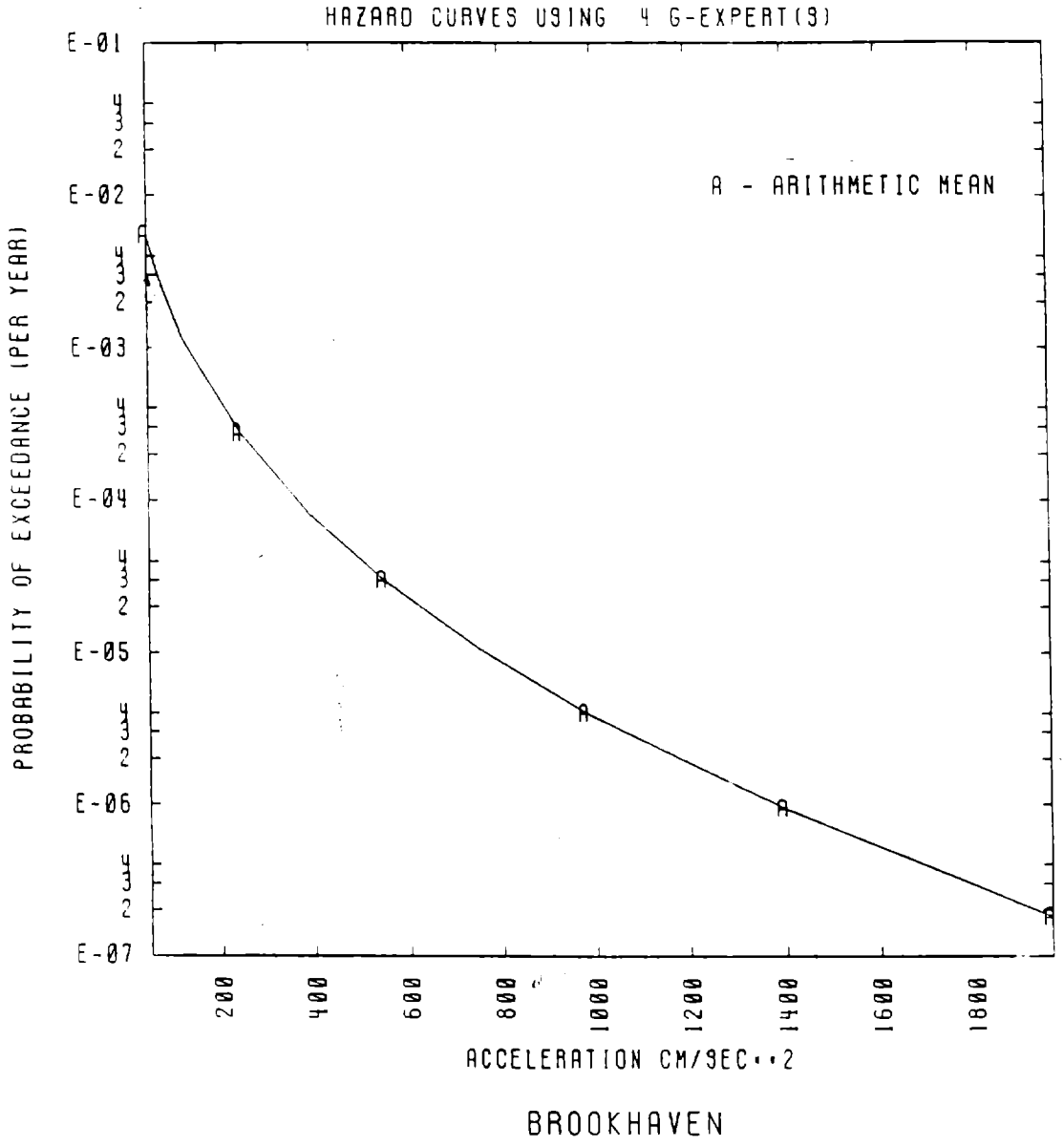

Figure 7R **Arithmetic average hazard curves (Minimum contributing magnitude = 5.0) of the PGA for the BNL-HFBR site, under the assumption of rock site characteristics, and with four ground motion experts' input.**

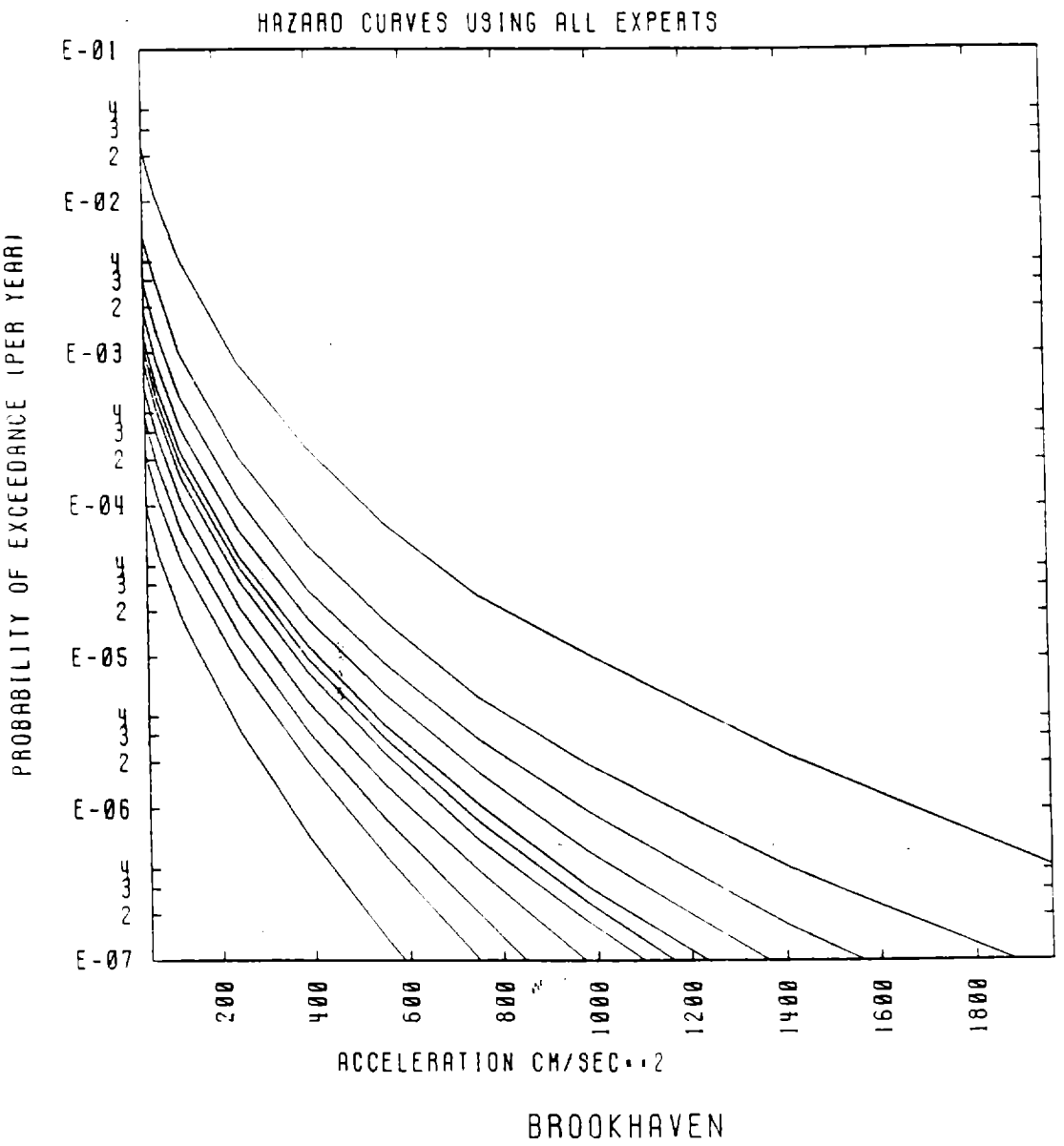

Figure 8R **5, 15, 50, 85 and 95 percent constant percentile hazard curves (Minimum contributing magnitude = 5.0) of the PGA for the BNL-HFBR site, under the assumption of rock site characteristics and with four ground motion experts' input.**

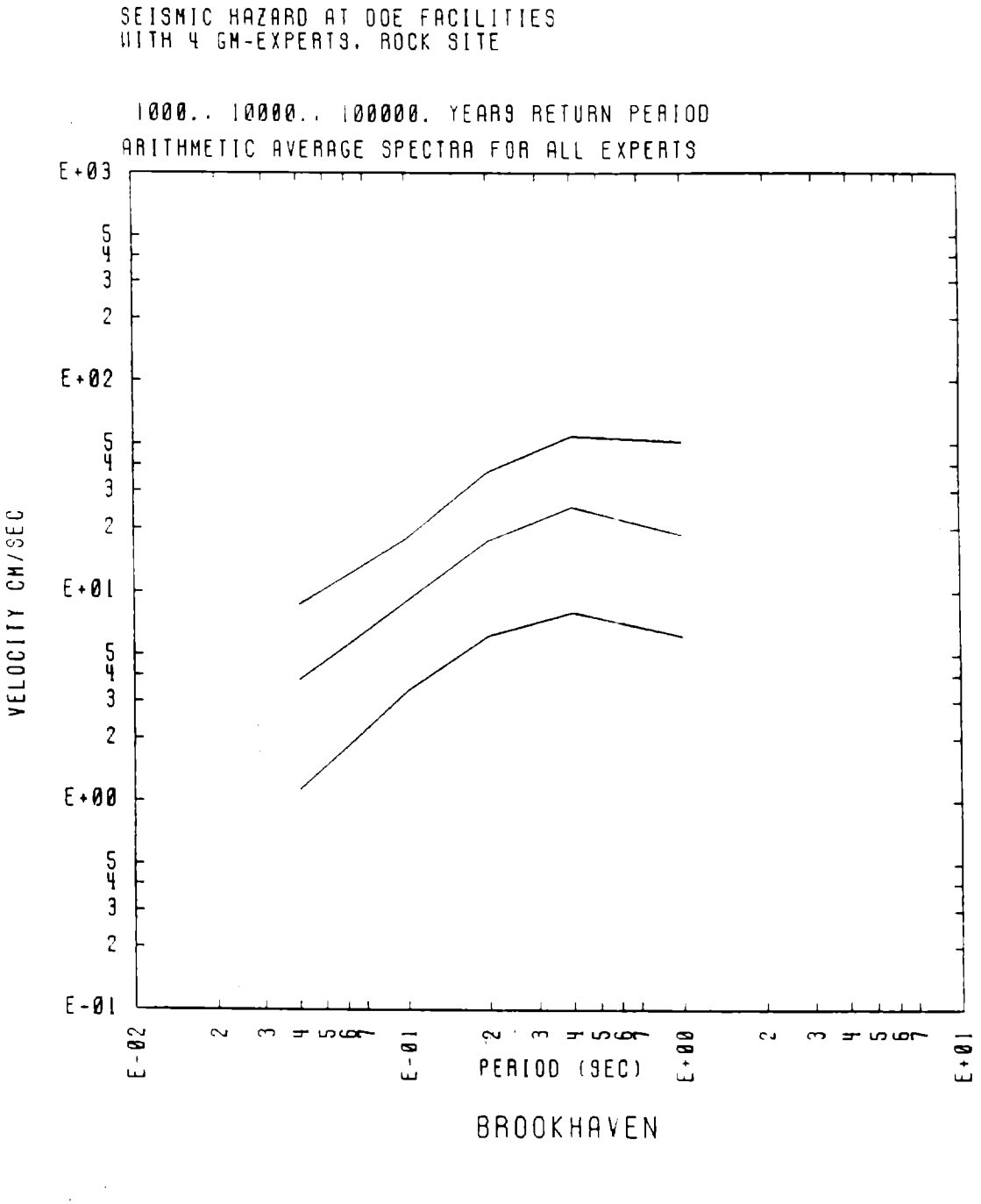

Figure 9R **Arithmetic average Uniform Hazard Spectra for three return periods (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of rock site characteristics, and with four ground motion experts' input.**

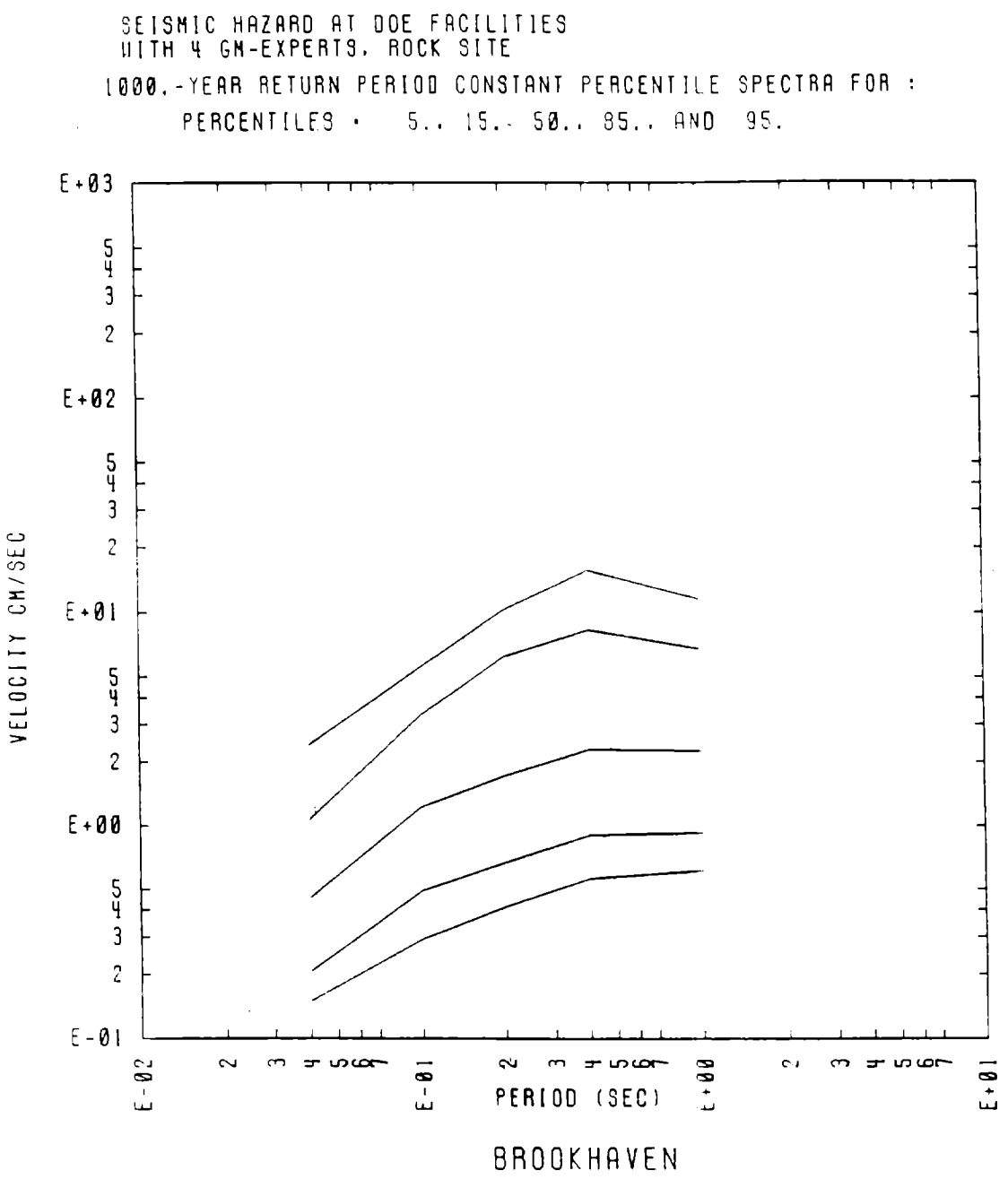

Figure 10R 5, 15, 50, 85 and 95 percent constant percentile 1,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of rock site characteristics, and with four ground motion experts' input.

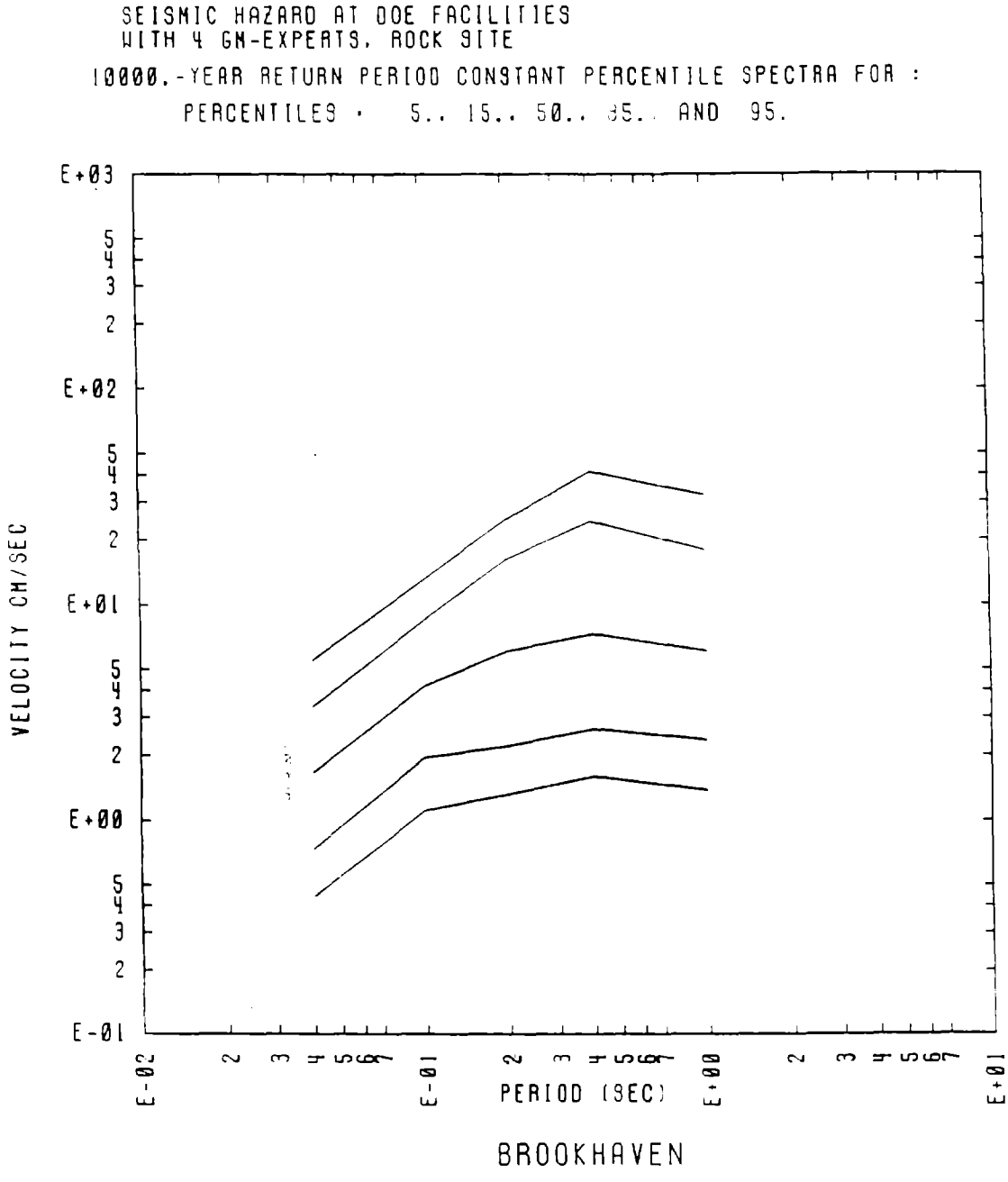

Figure 11R 5, 15, 50, 85 and 95 percent constant percentile 10,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of rock site characteristics, and with four ground motion experts' input.

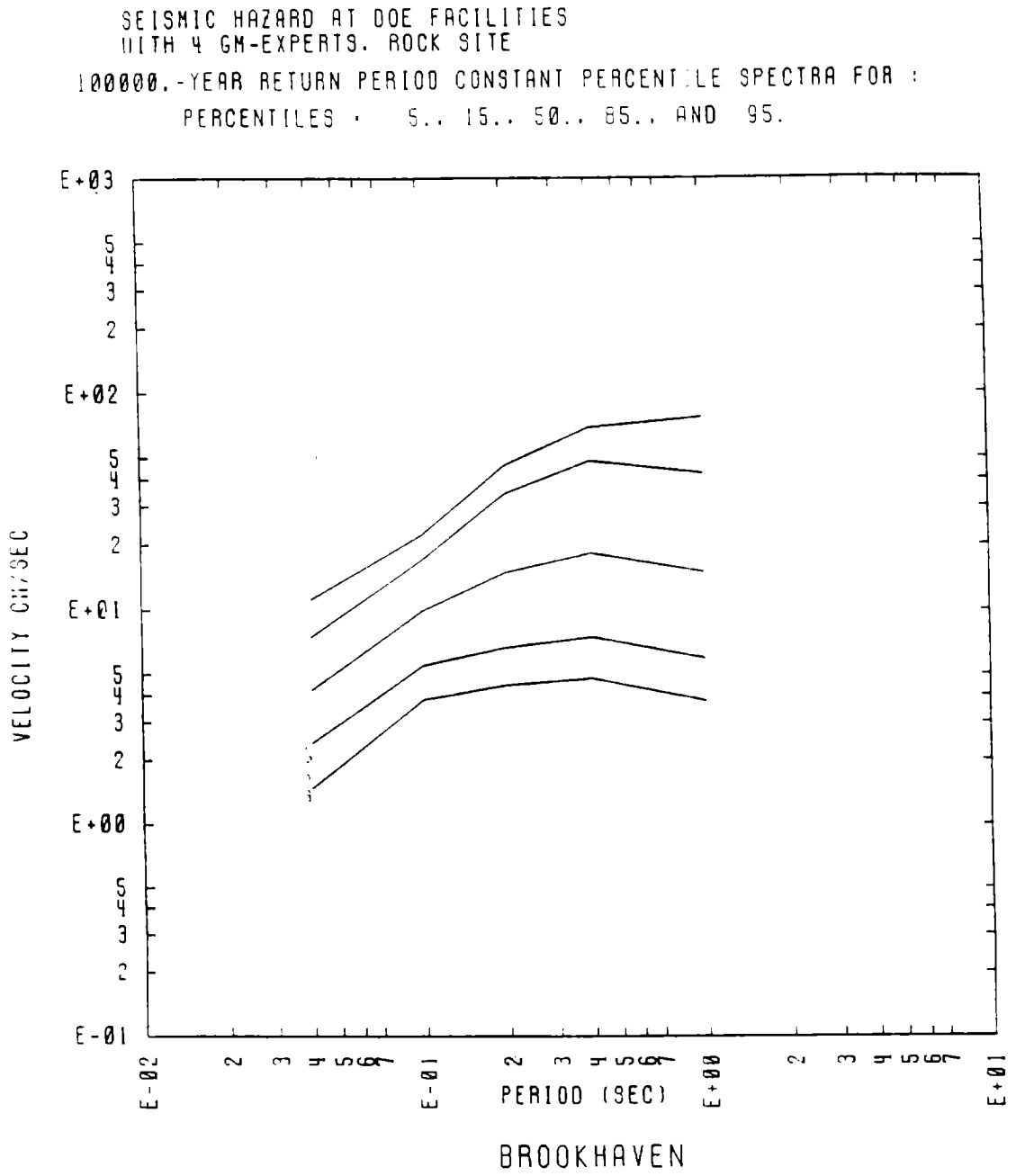

Figure 12R **5, 15, 50, 85 and 95 percent constant percentile 100,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of rock site characteristics, and with four ground motion experts' input.**

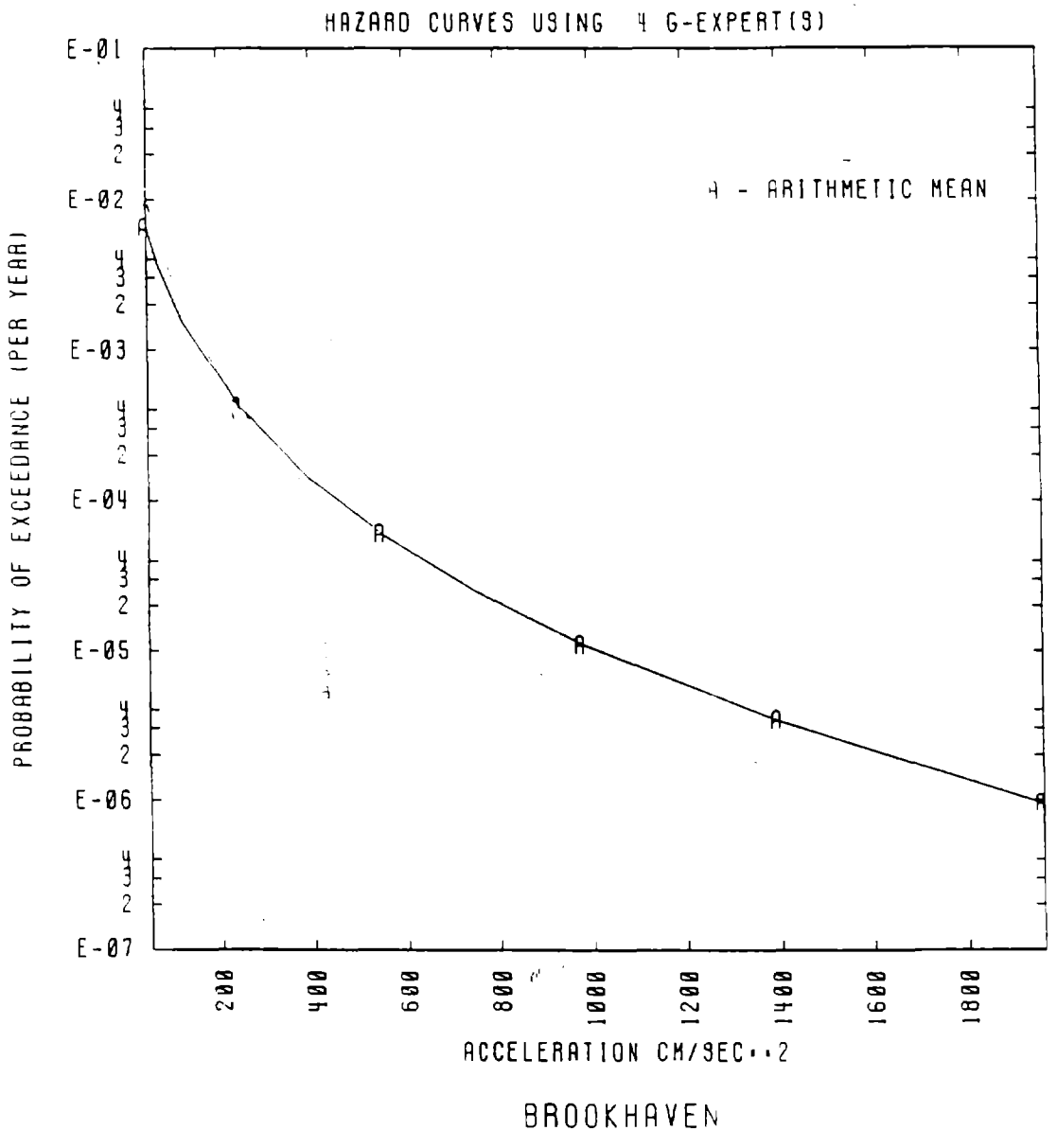

Figure 7S **Arithmetic average hazard curves (Minimum contributing magnitude = 5.0) of the PGA for the BNL-HFBR site, under the assumption of deep soil site characteristics and with four ground motion experts' input.**

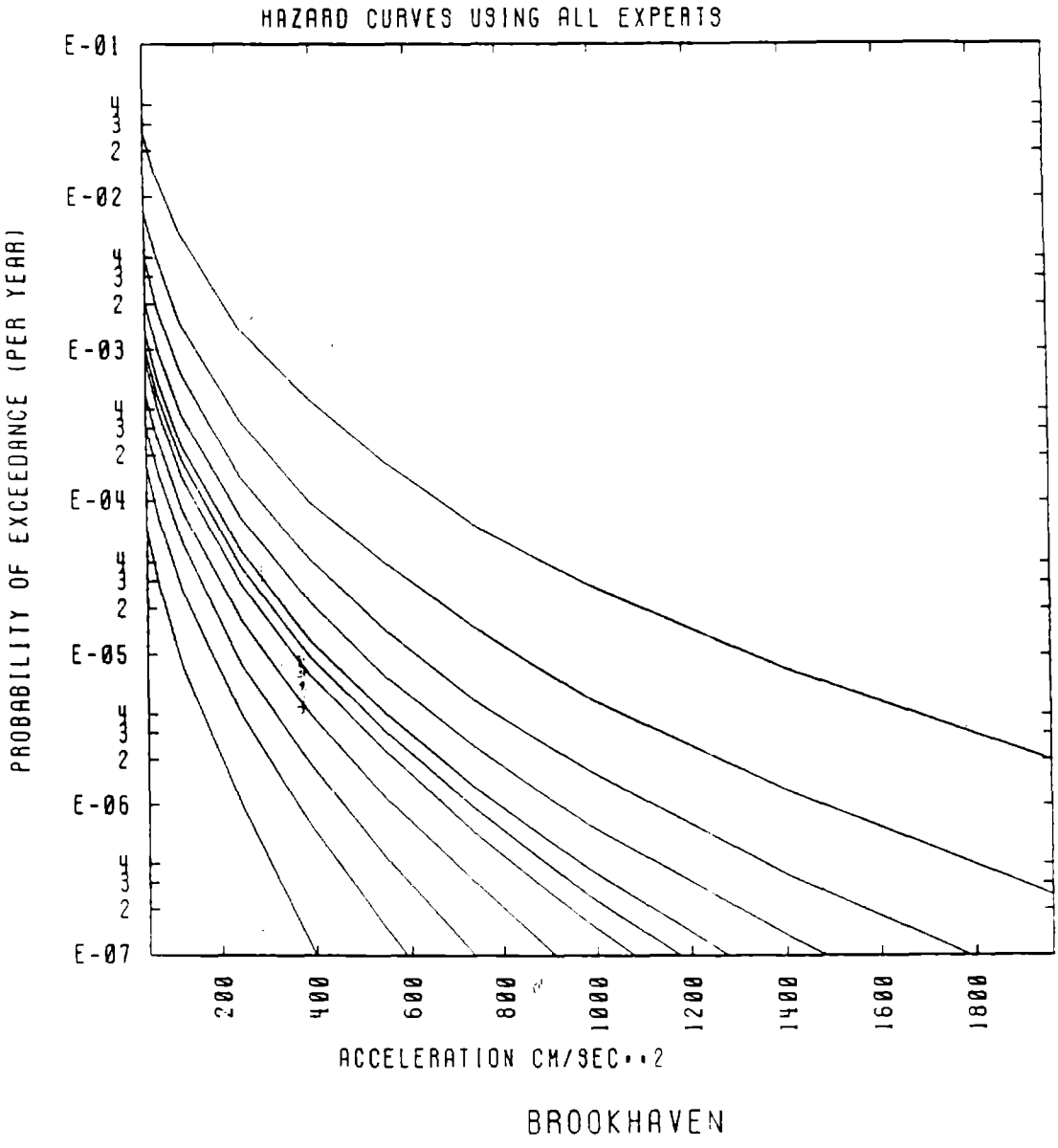

Figure 8S 5, 15, 50, 85 and 95 percent constant percentile hazard curves (Minimum contributing magnitude = 5.0) of the PGA for the BNL-HFBR site, under the assumption of deep soil site characteristics and with four ground motion experts' input.

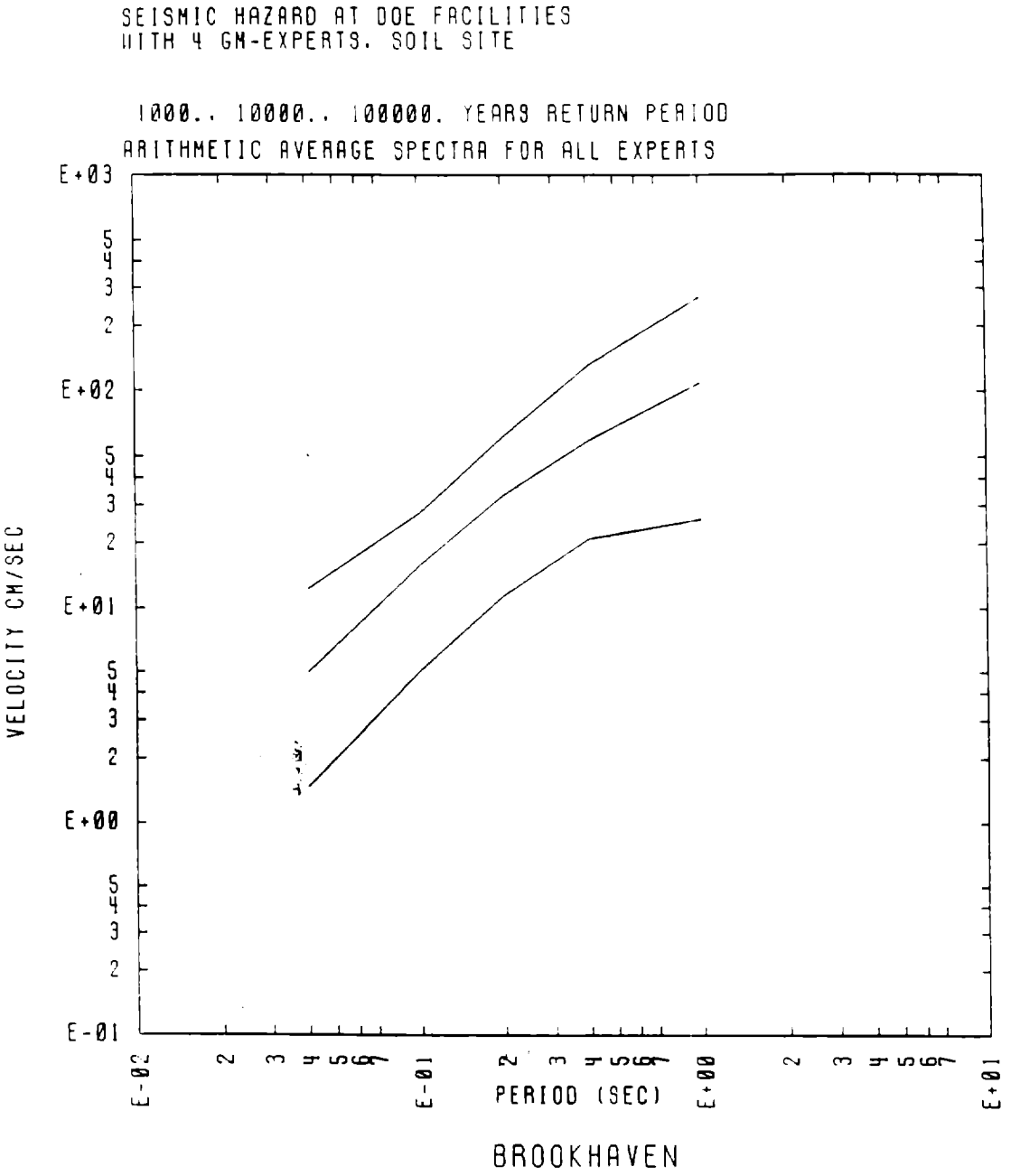

Figure 9S **Arithmetic average Uniform Hazard Spectra for three return periods (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of deep soil site characteristics, and with four ground motion experts' input.**

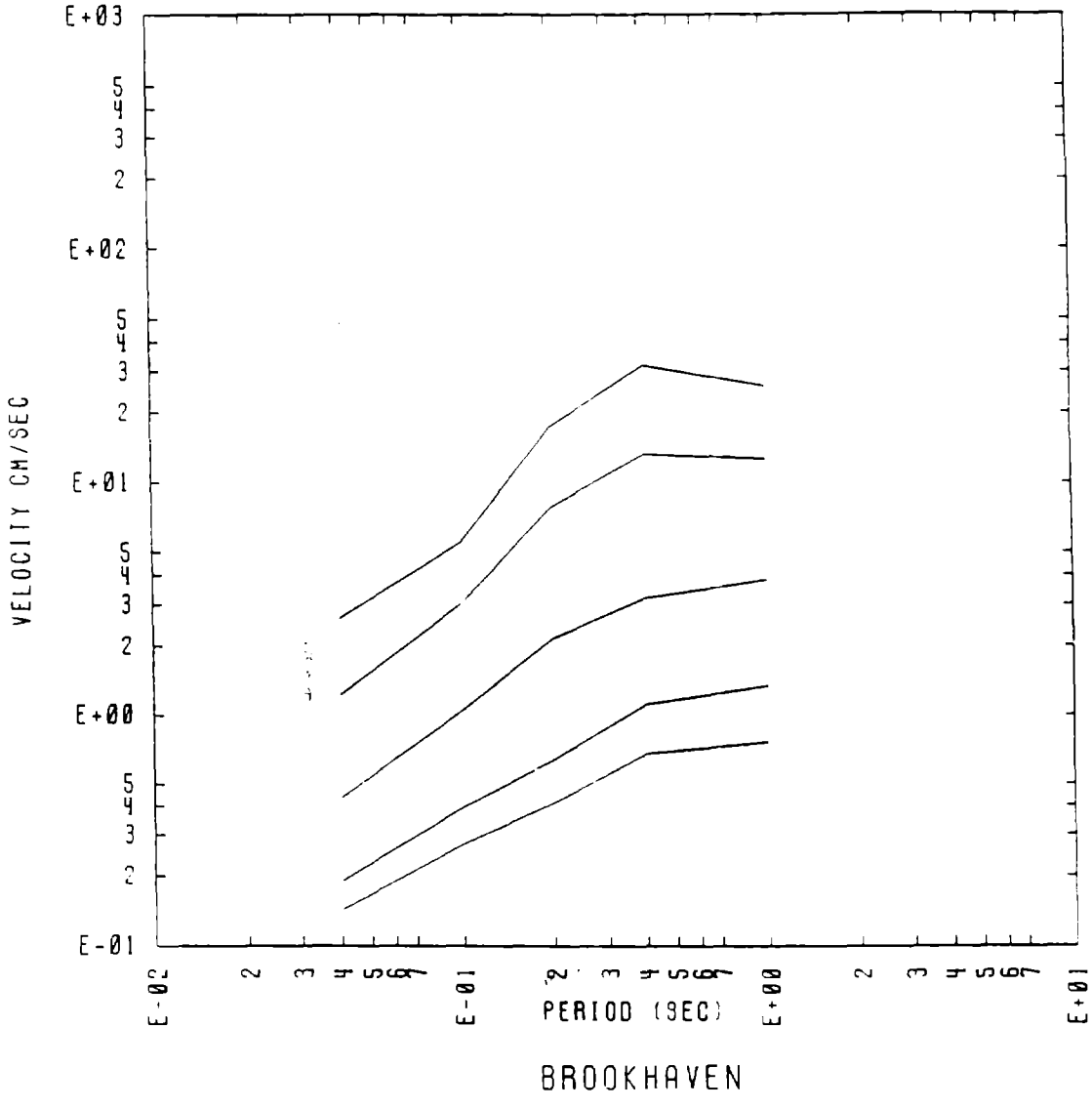

Figure 10S 5, 15, 50, 85 and 95 percent constant percentile 1,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of deep soil site characteristics, and with four ground motion experts' input.

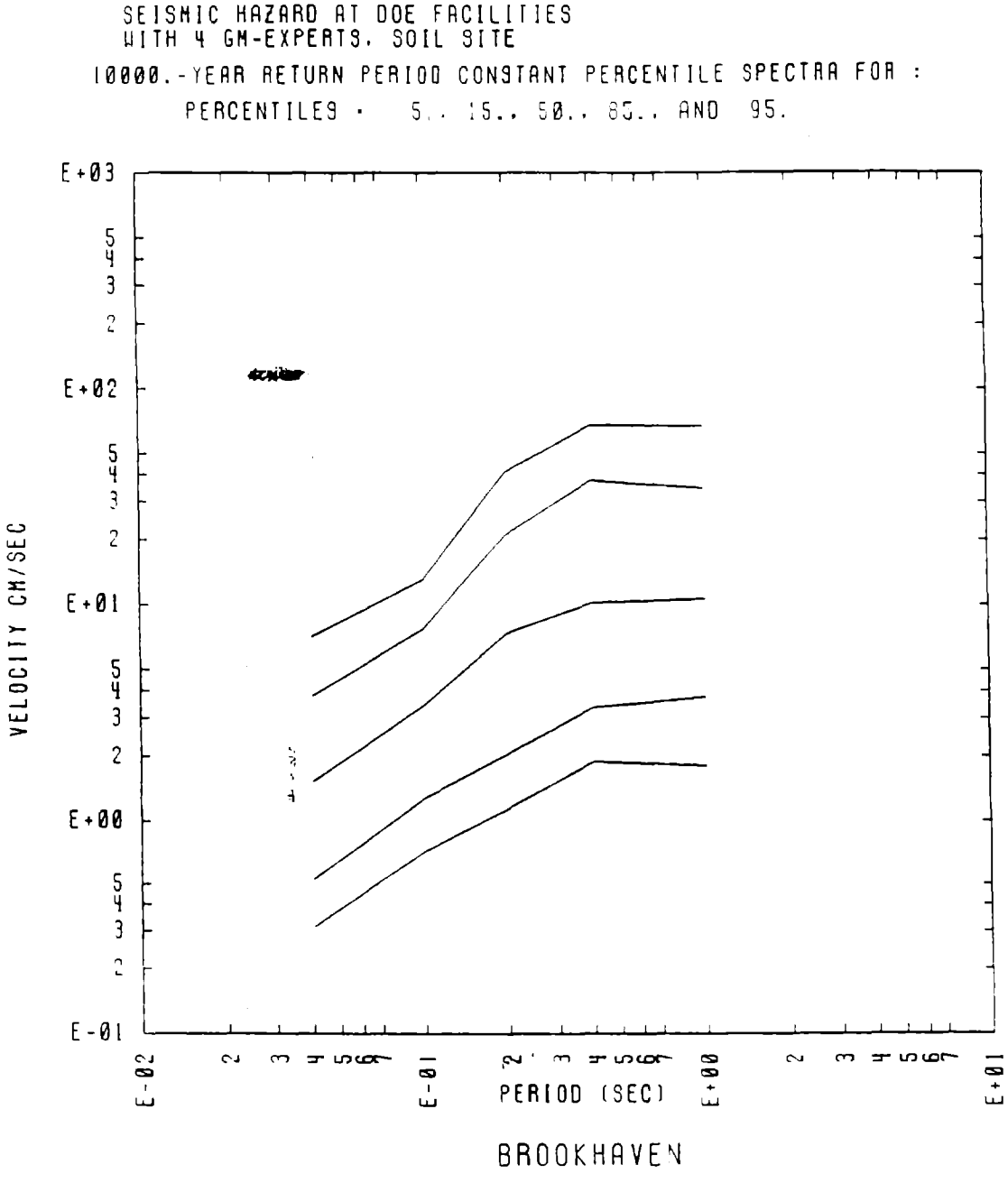

Figure 11S 5, 15, 50, 85 and 95 percent constant percentile 10,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of deep soil site characteristics, and with four ground motion experts' input.

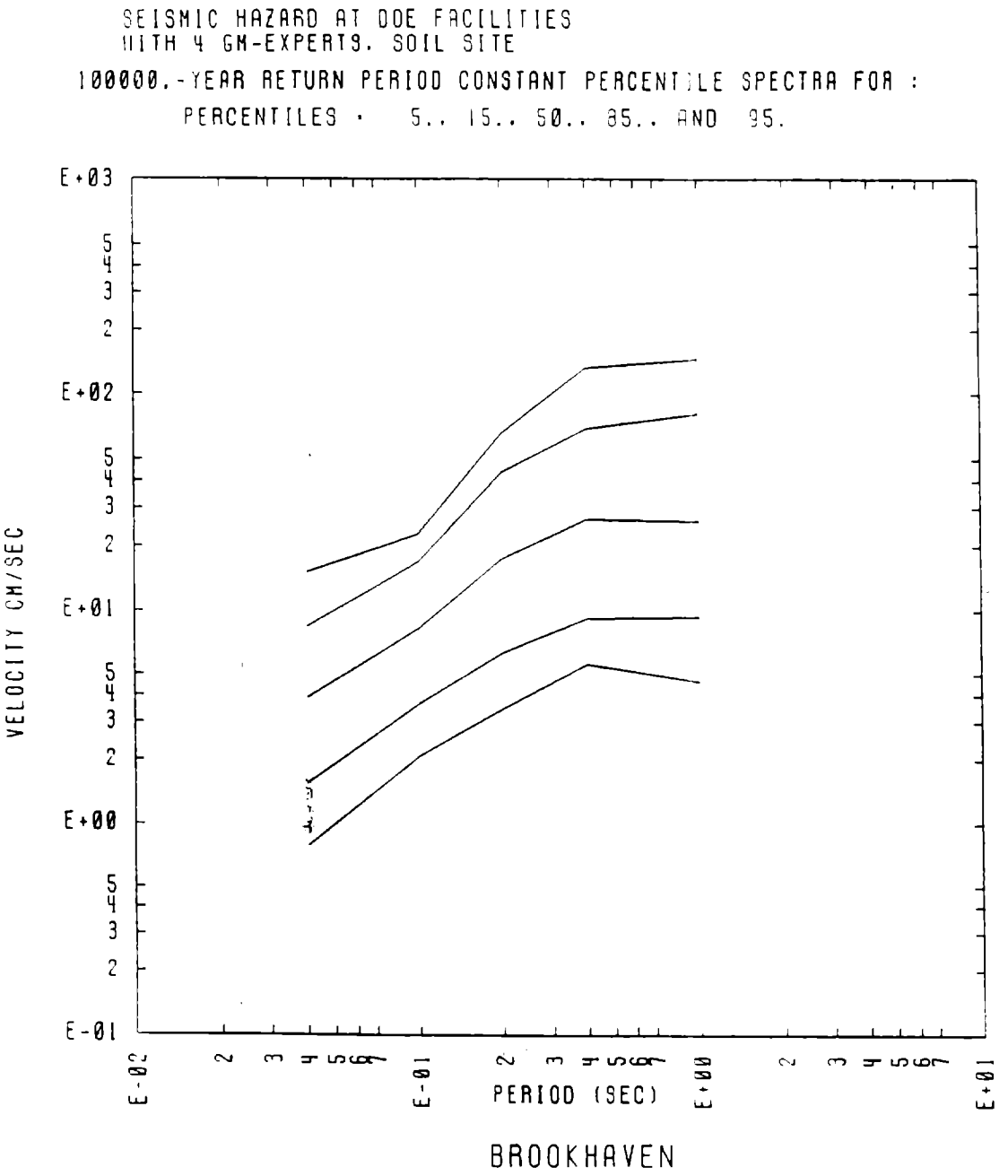

Figure 12S 5, 15, 50, 85 and 95 percent constant percentile 100,000 year return period Uniform Hazard Spectra (Minimum contributing magnitude = 5.0) for the BNL-HFBR site, under the assumption of deep soil site characteristics and with four ground motion experts' input.

APPENDIX A

REFERENCES

Bernreuter, D.L., J. B. Savy, R.W. Mensing, J.C. Chen, and B.C. Davis, *Seismic Hazard Characterization of the Eastern United States*, Volumes 1 and 2, UCID-20412, April, 1985.

Bernreuter, D.L., J.B. Savy, R.W. Mensing, and J.C. Chen, *Seismic Hazard Characterization of 69 Nuclear Plant Sites East of the Rocky Mountains*, Volumes 1 through 8, NUREG/CR-5250, and UCID-21517, November 1988.

APPENDIX B

Seismic zonation maps for each of the eleven seismicity experts (S-experts) who provided input to develop the data base used in the analysis of the Savannah River site.

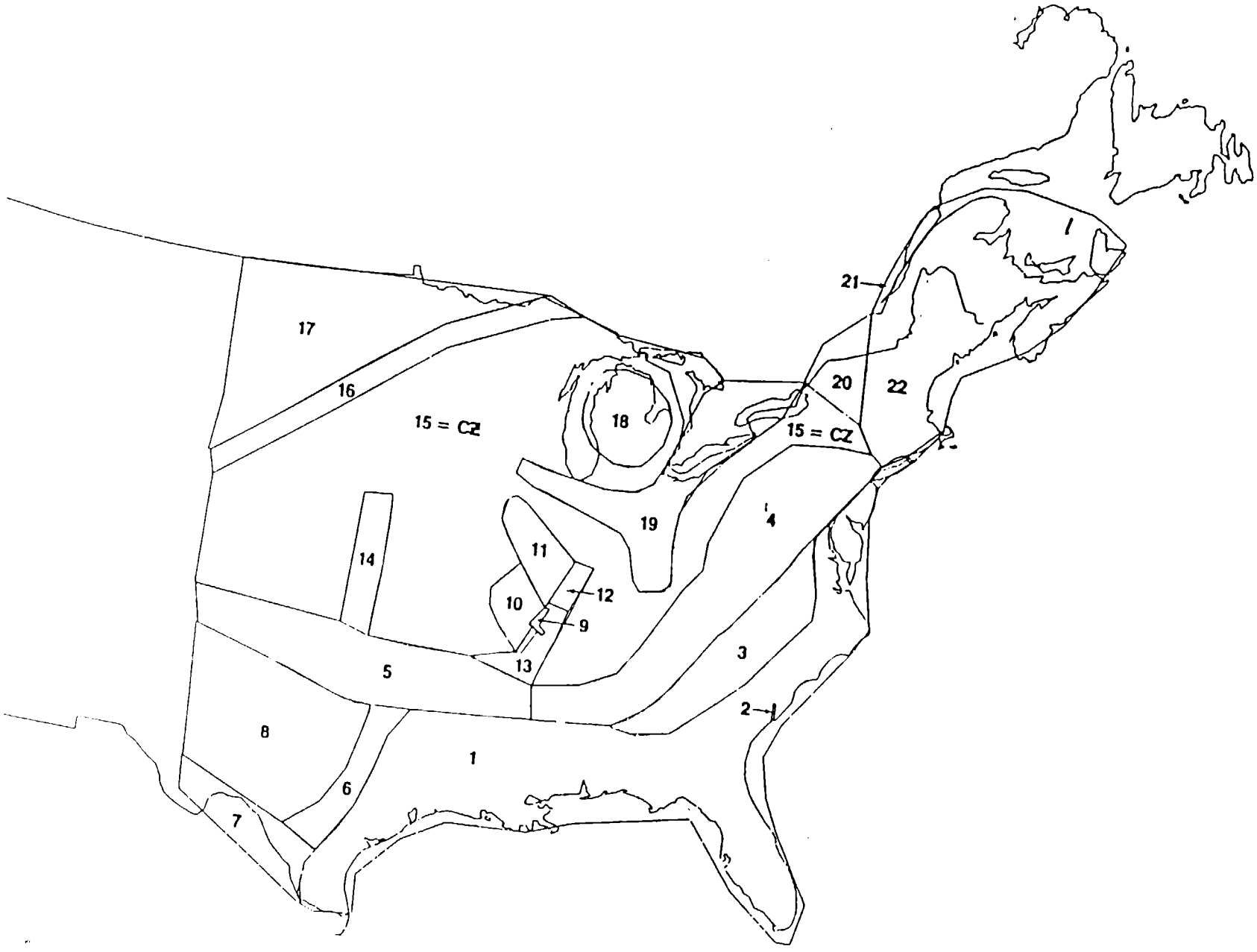

Figure B1.1 Seismic zonation base map for Expert 1.

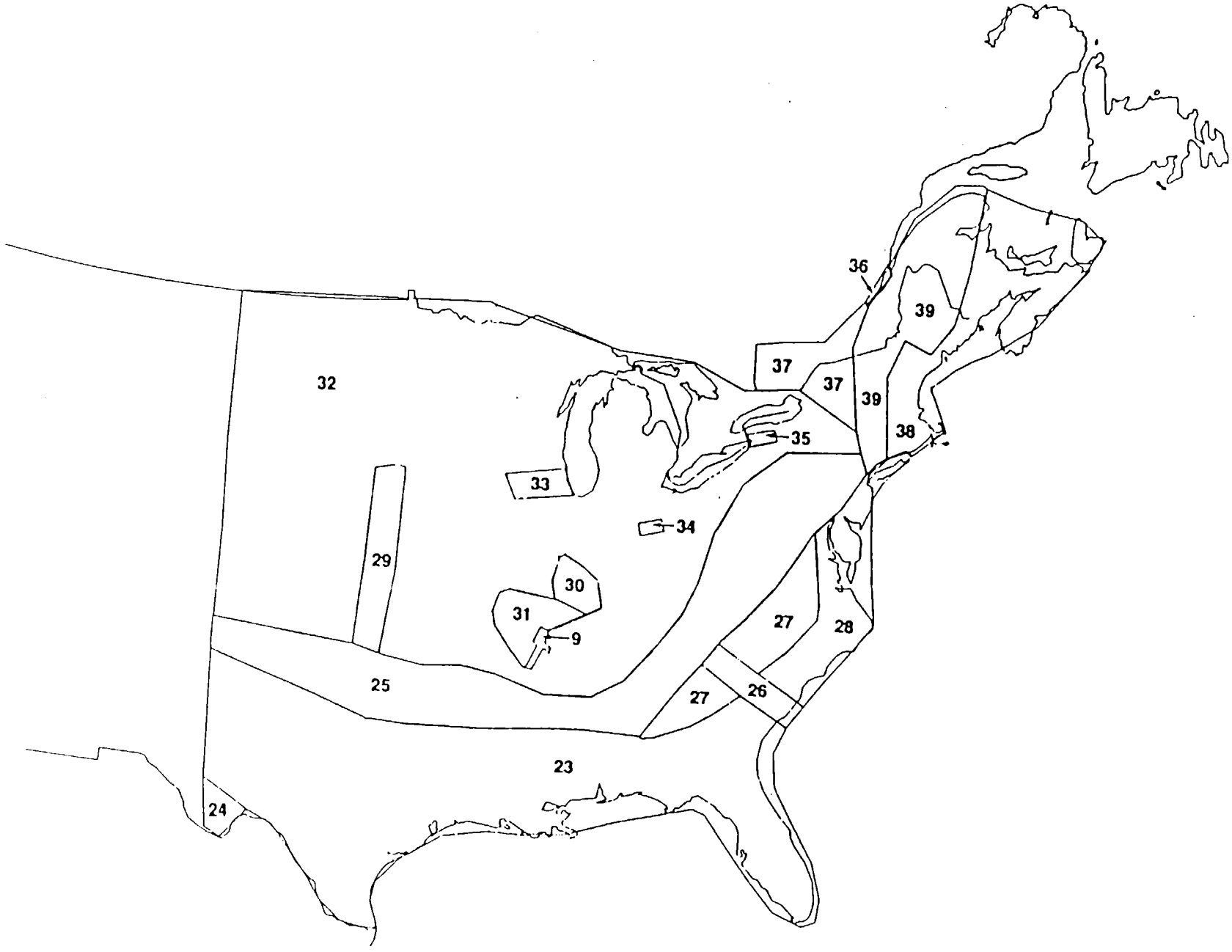

Figure B1.2 Map of alternative seismic zonation to Expert 1's base map.

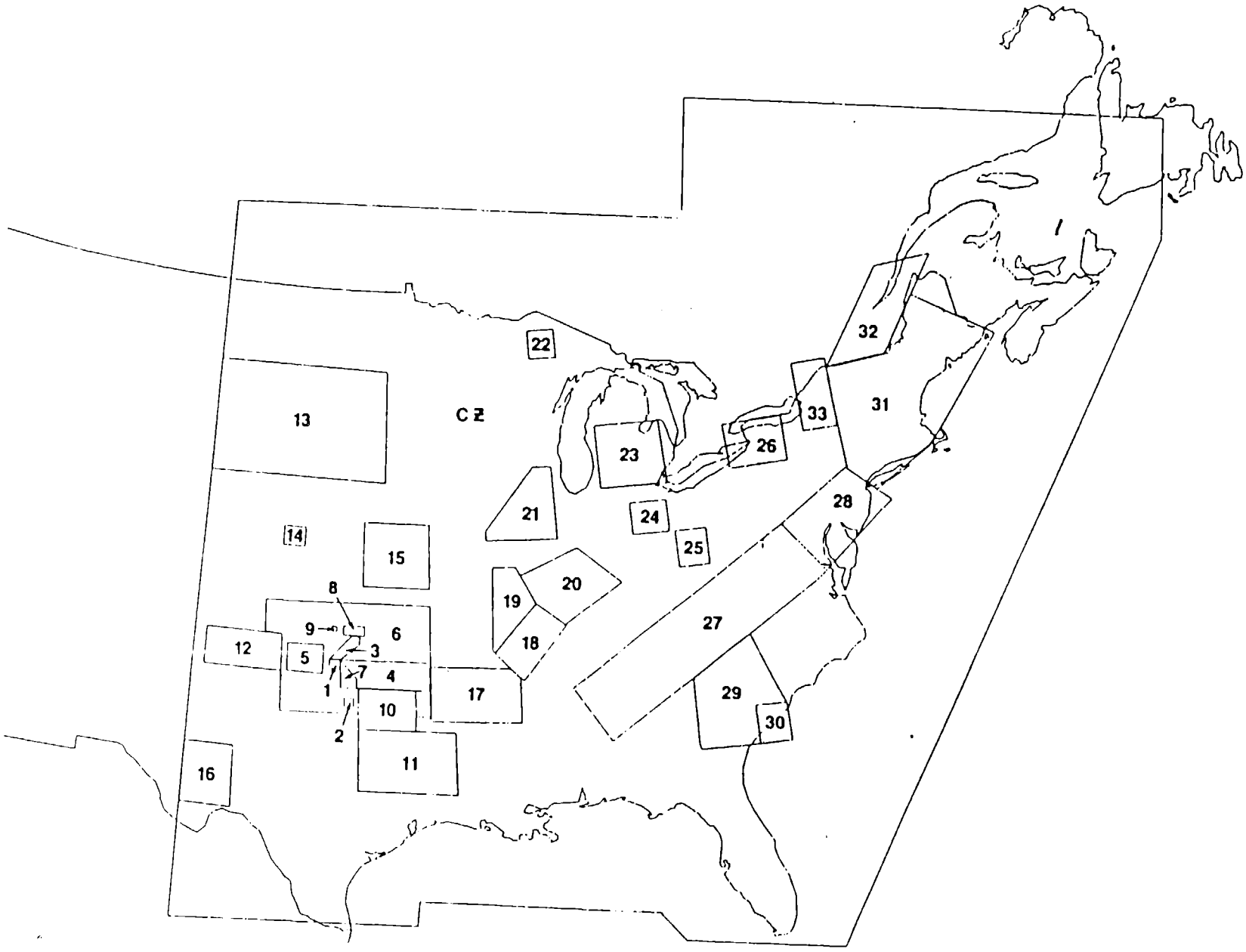

Figure B2.1 Seismic zonation base map for Expert 2.

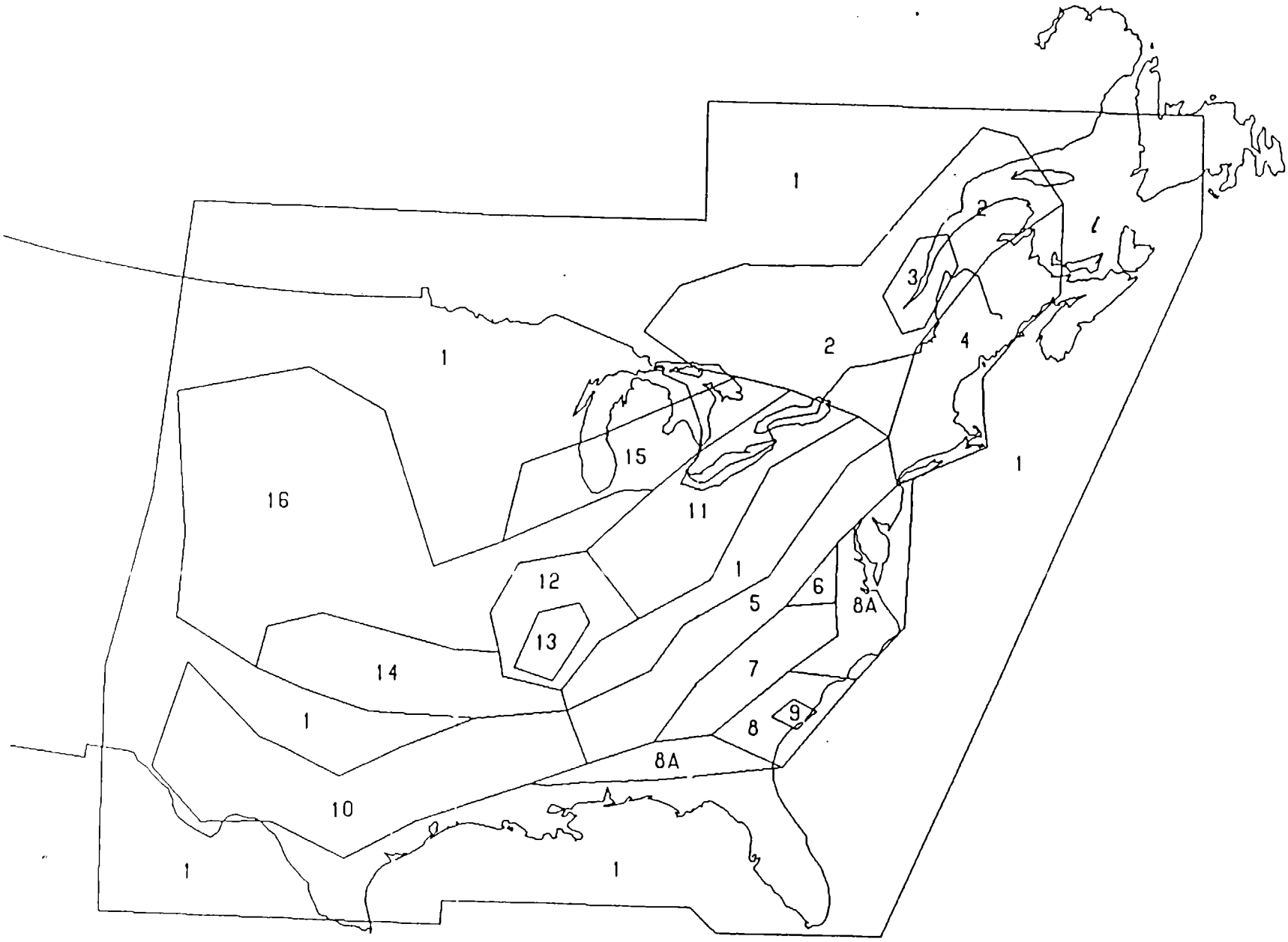

Figure B3.1 Seismic zonation base map for Expert 3.

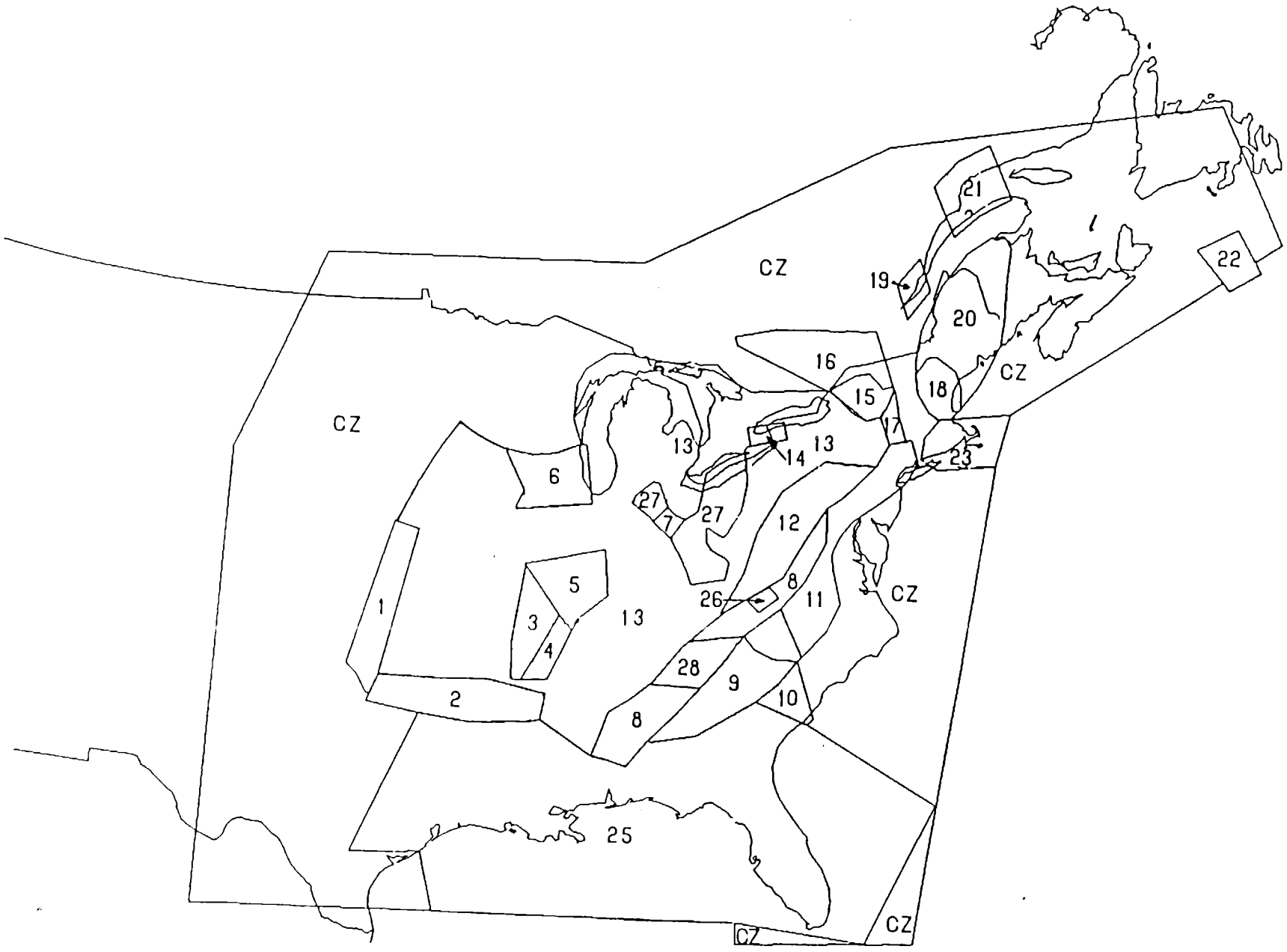

Figure B4.1 Seismic zonation base map for Expert 4.

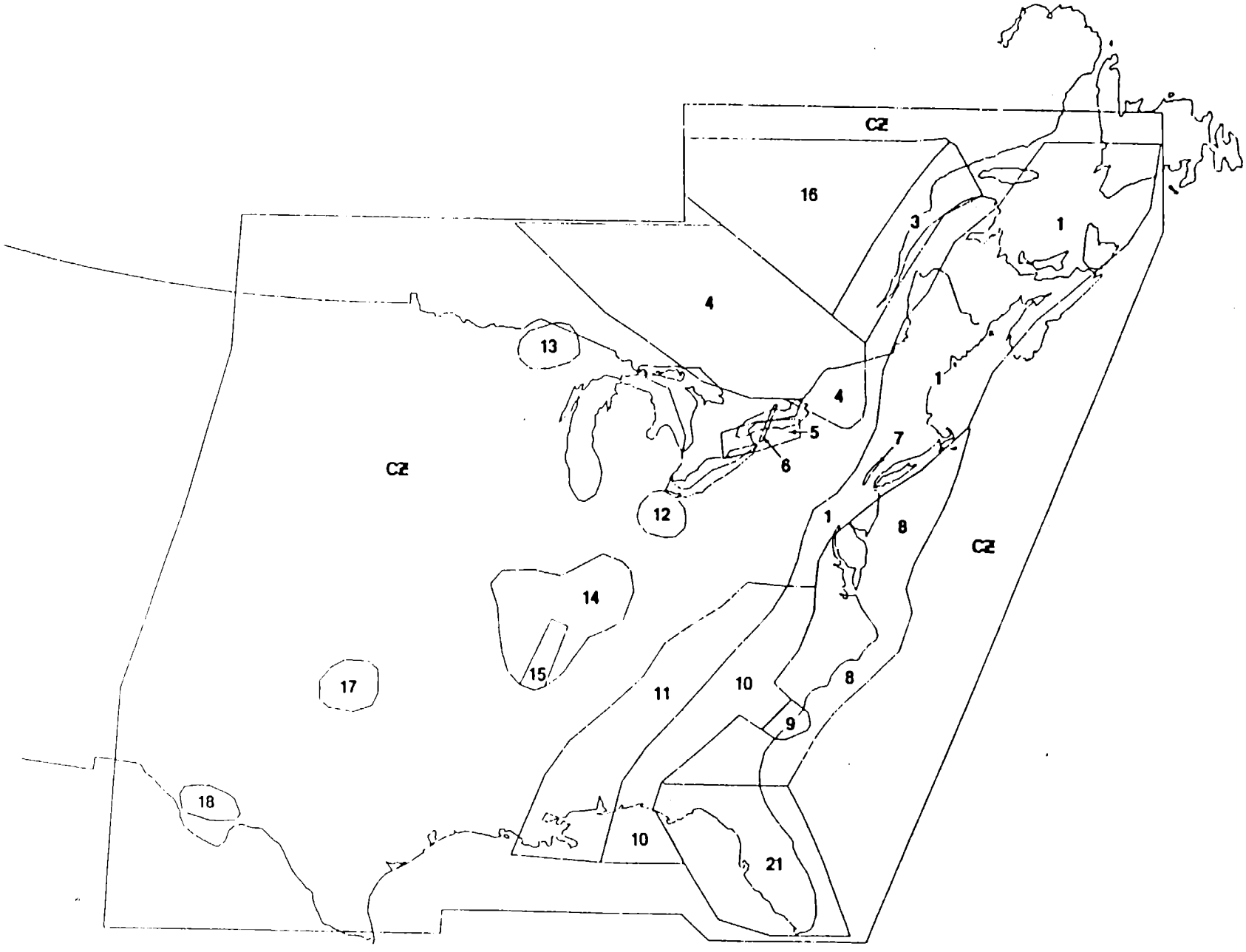

Figure B5.1 Seismic zonation base map for Expert 5

Figure B5.2 Map of alternative seismic zonations to Expert 5's base map.

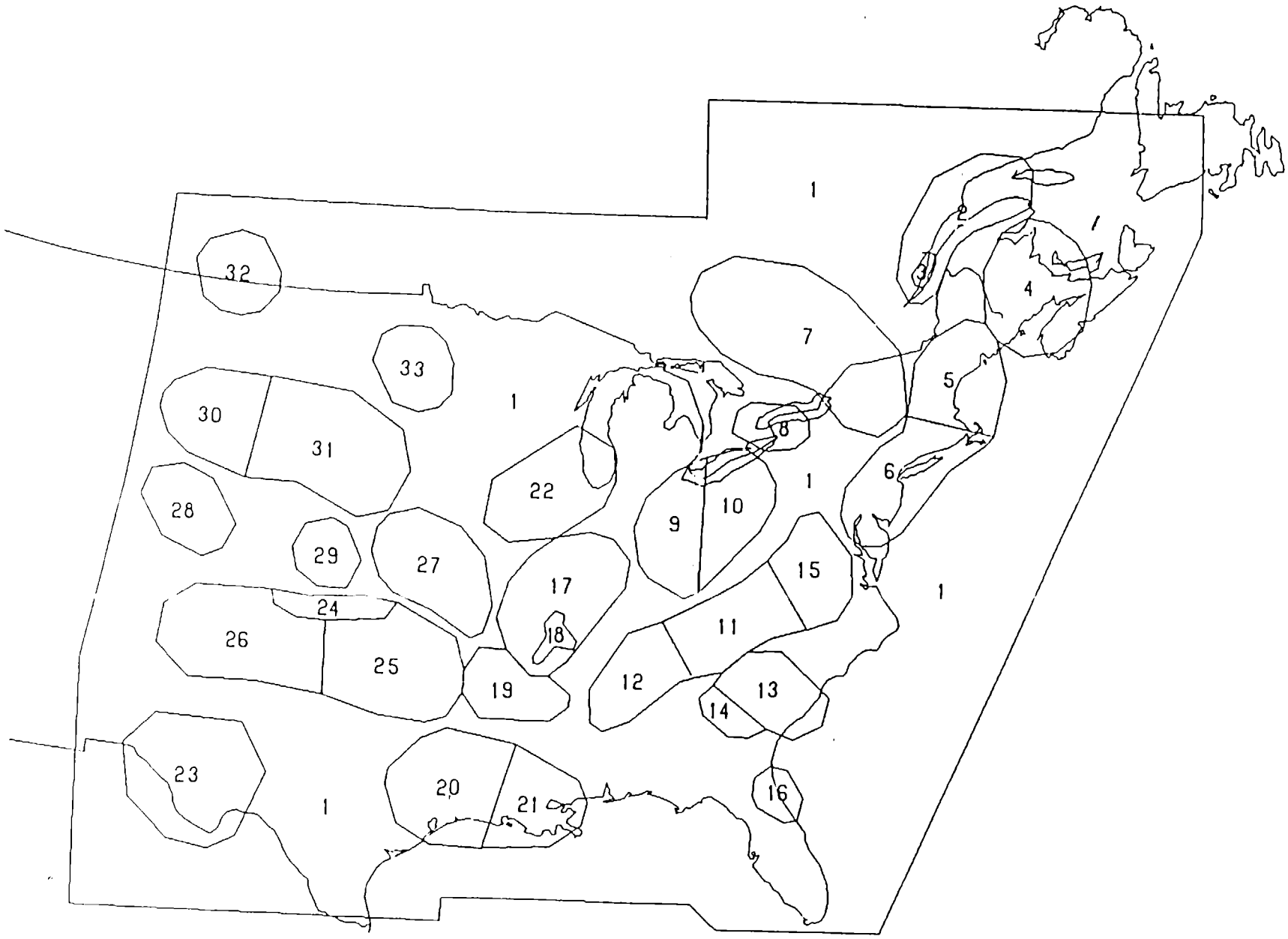

Figure B6.1 Seismic zonation base map for Expert 6

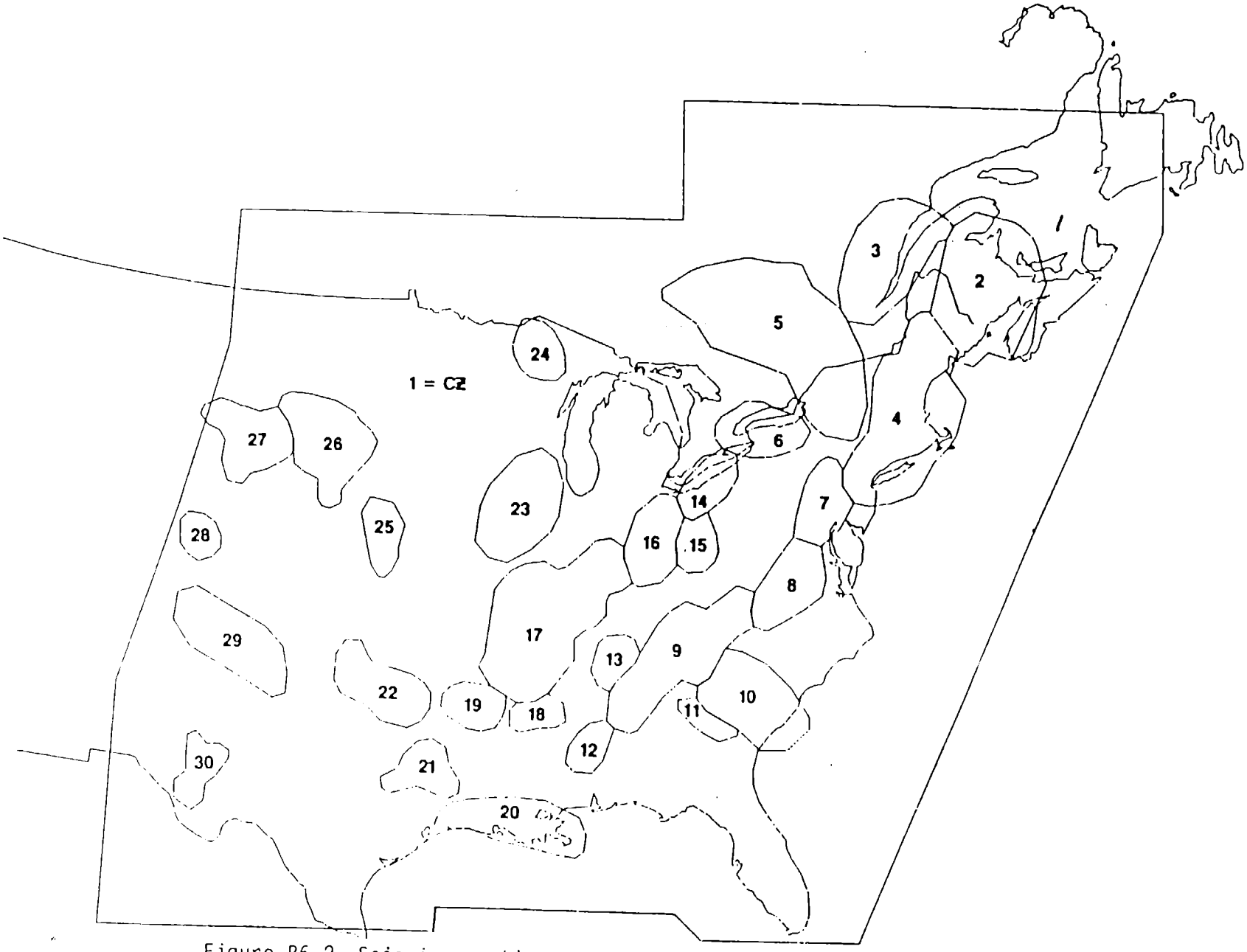

Figure B6.2 Seismic zonation map alternative 1 to Expert 6's base map.

Figure B6.3 Seismic zonation map alternative 2 to Expert 6's base map.

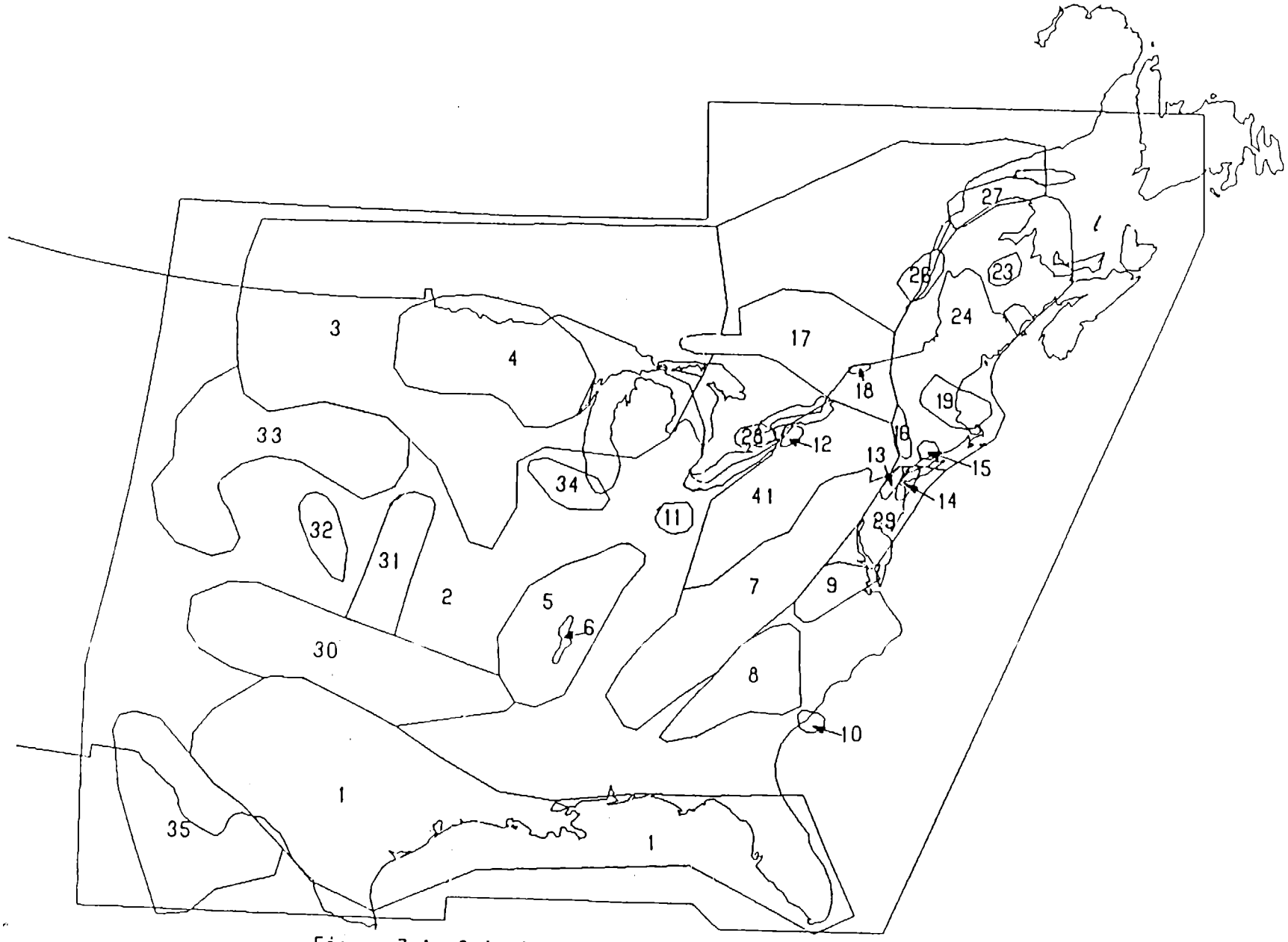

Figure 7.1 Seismic zonation base map for Expert 7.

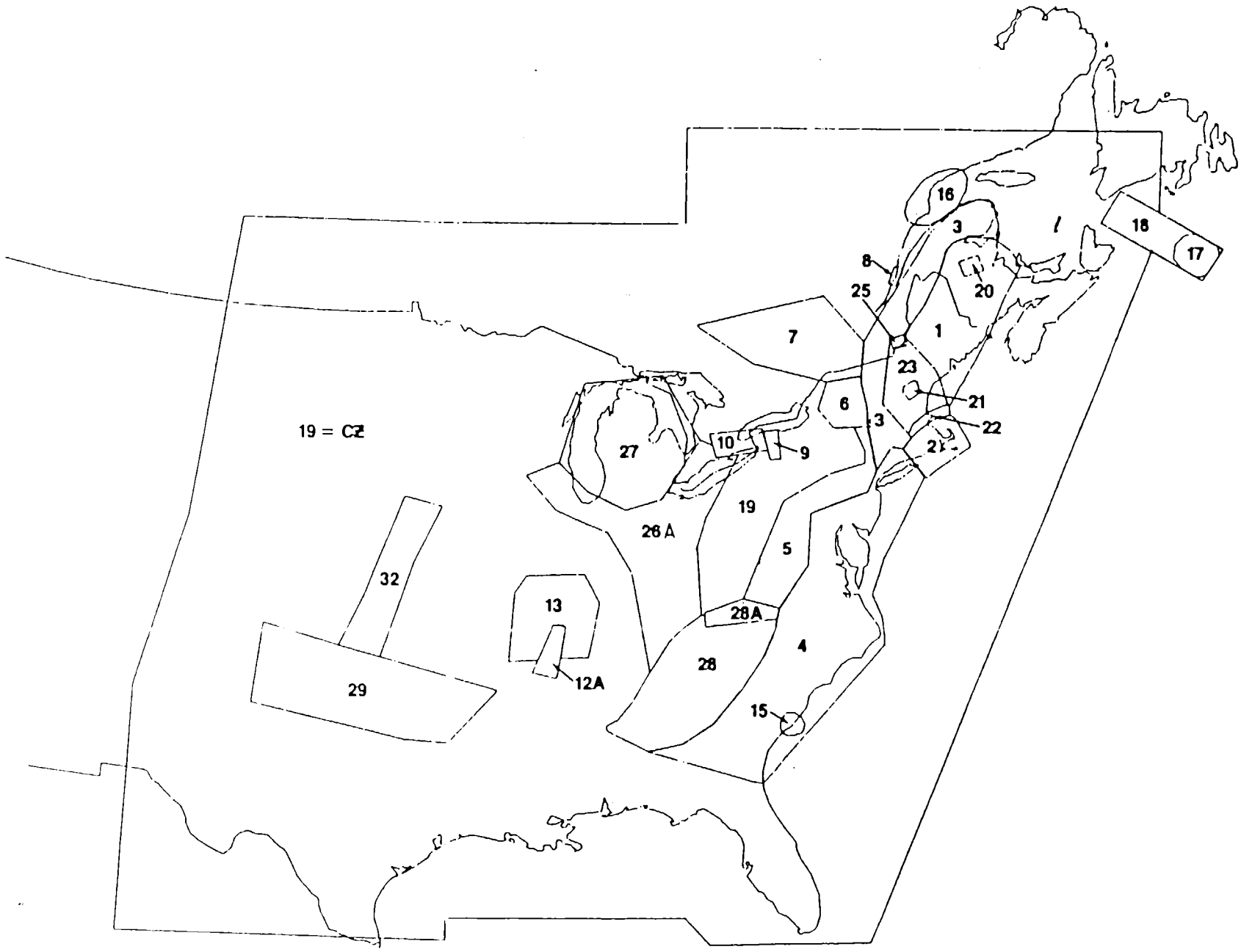

Figure B10.1 Seismic zonation base map for Expert 10.

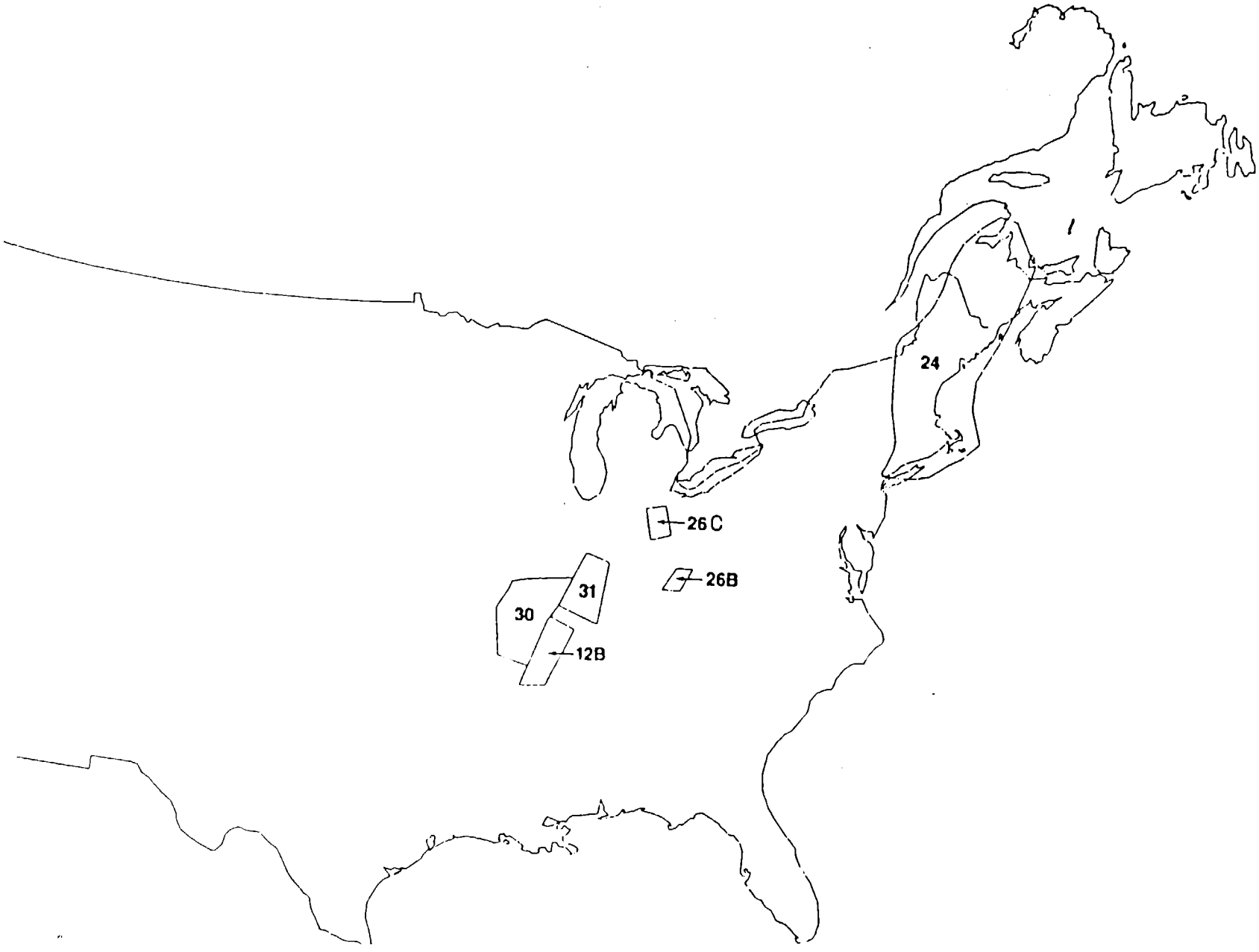

Figure B10.2 Map of alternative seismic zonations to Expert 10's base map.

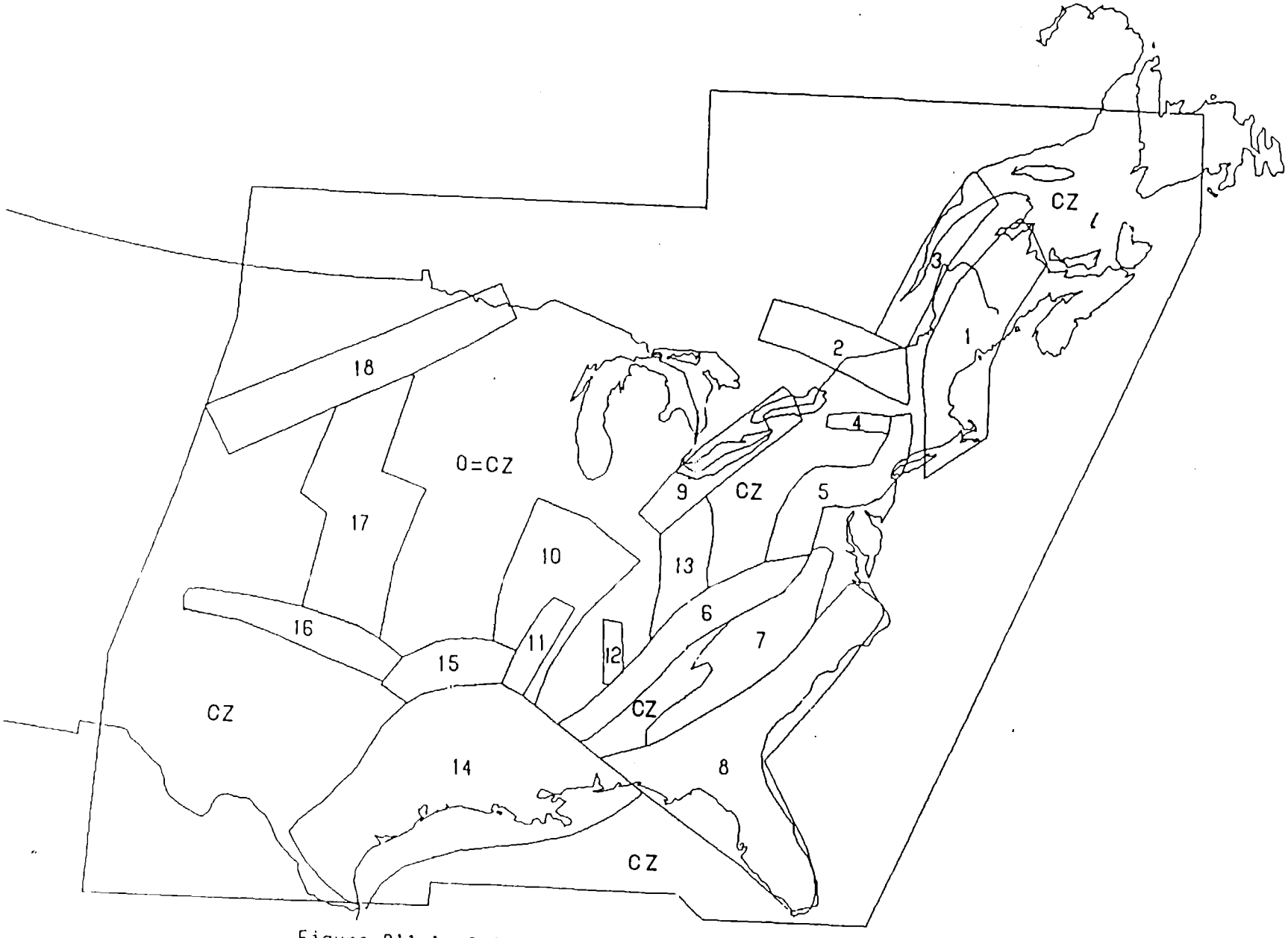

Figure B11.1 Seismic zonation base map for Expert 11.

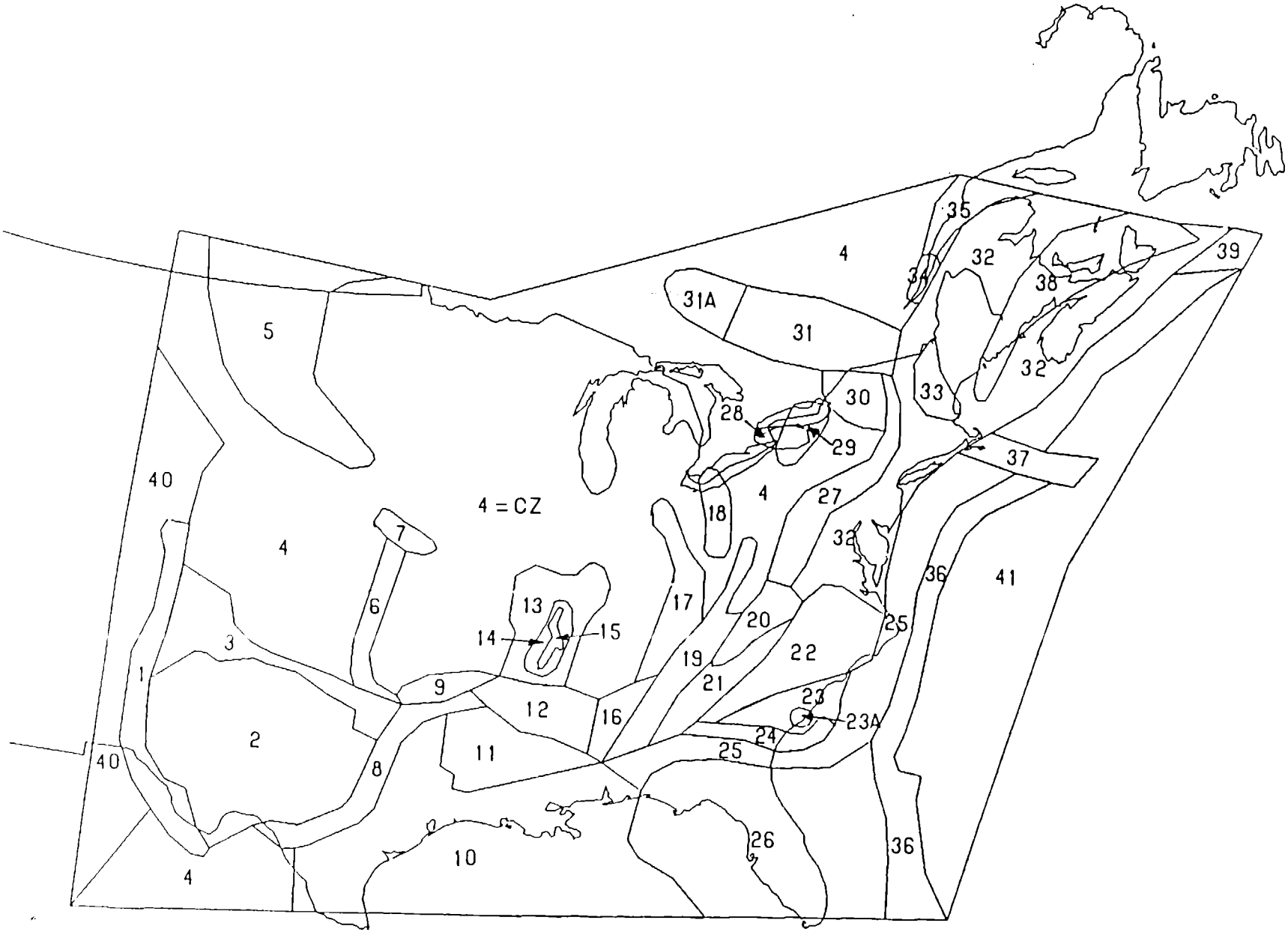

Figure B12.1 Seismic zonation base map for Expert 12.

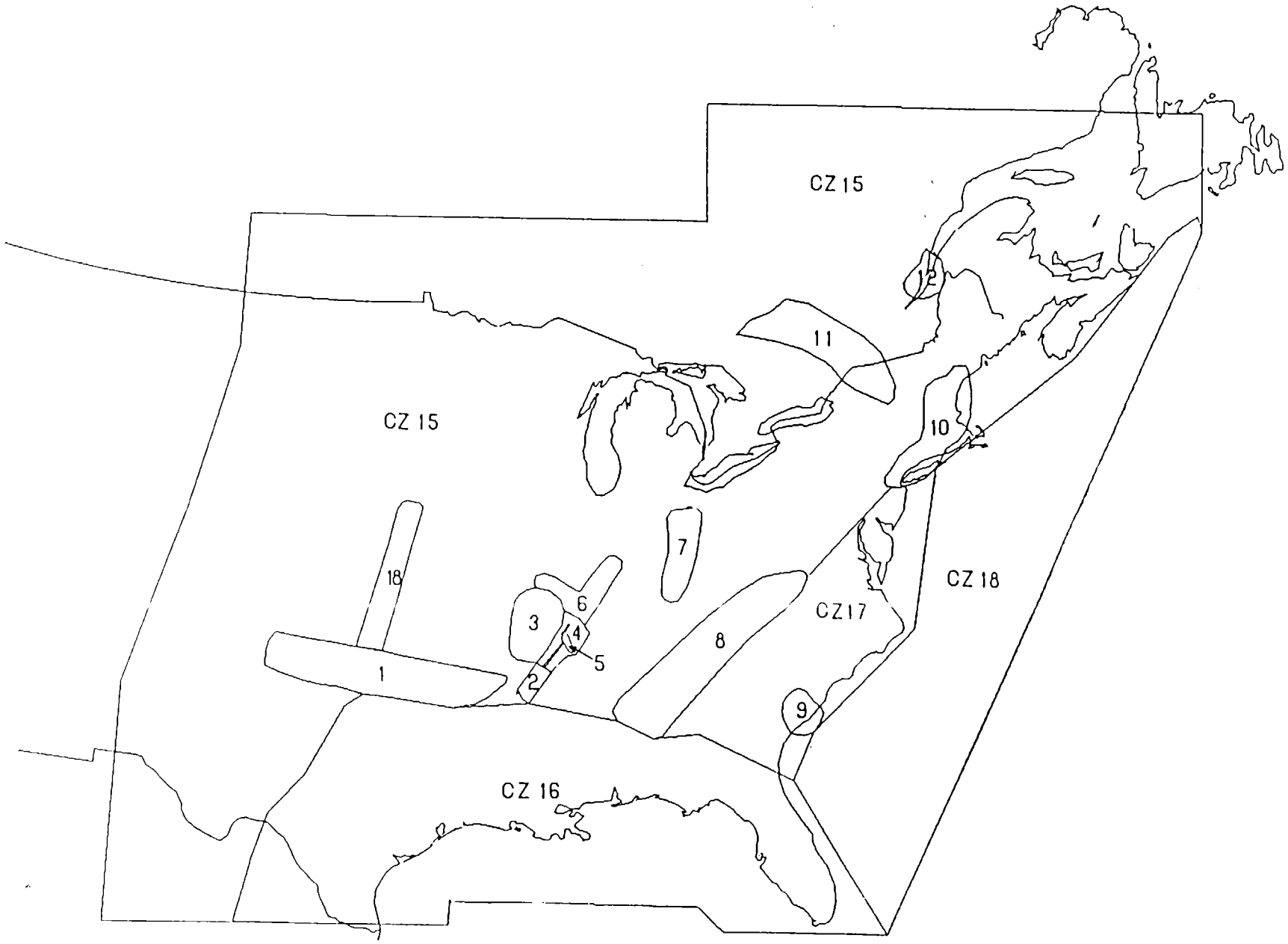

Figure B13.1 Seismic zonation base map for Expert 13.

Figure B13.2 Map of alternative seismic zonations to Expert 13's base map.