

RECURRENCE FREQUENCY OF THE OPERATING BASIS EARTHQUAKE
AT THE
ENRICO FERMI-2 NUCLEAR PLANT SITE

DRAFT REPORT

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1.0 INTRODUCTION

The Operating Basis Earthquake (OBE) for the Enrico Fermi Power Plant, Unit 2, is characterized as a horizontal ground surface (rock foundation) acceleration of 0.08g (EF-2 FSAR, Amendment 3, June, 1976). The frequency of occurrence of the OBE was estimated by interpreting the historical levels of seismic loading at the site resulting from earthquake activity known for the Central U.S. region. This procedure is not considered to be a formal probabilistic seismic hazard assessment, since hypothetical activity is not considered. However, this historical analysis does yield useful results for the recurrence frequency of low amplitude ground motion.

2.0 ATTENUATION MODELS

The foundation material at the EF-2 site is rock (Paleozoic dolomite). The observation at near epicentral distances is that seismic intensities are lower by one or more intensity units (MM scale) at localities situated on rock or sound foundation materials than at adjacent localities underlain by alluvial materials. On the other hand, it is also observed that peak ground motion parameters can be larger on firm foundation materials than on softer materials for the same seismic intensity. To account for these observations, attenuation models are developed using the following assumptions; first, seismic intensity attenuation on rock is

characterized by a median value; second, the ground motion for that intensity is characterized as the median to median +1 standard deviation values.

Equation 1 is the form of the intensity attenuation model that predicts the median intensity at a distance (R in km) from an earthquake with size defined by m_b -magnitude.

$$I(R) = 2.53 + 1.20 m_b - 0.0027R - 1.84 \log R \quad (1)$$

Ground motion parameters are determined from the site intensity by using the correlations of Nuttli (1979) and McGuire (1977). Equations (2) and (3) are relations of sustained (3 cycle) acceleration and velocity determined from the data presented by Nuttli (1979).

$$\log A_s = 0.326 + .214 I_{MM} \quad (2)$$

$$\sigma \log A_s = 0.32$$

$$\log V_s = -1.210 + .289 I_{MM} \quad (3)$$

$$\sigma \log V_s = 0.36$$

Equations (4) and (5) are correlations of peak acceleration and velocity to intensity observed on firm foundation materials (McGuire, 1977).

$$\log A_p = -.361 + .370 I_{MM} \quad (4)$$

$$\sigma \log A_p = .33$$

$$\log V_p = -1.75 + .413 I_{MM} \quad (5)$$

$$\sigma \log V_p = .33$$

Substitution of Equation (1) into Equations 2 through 5 results in the set of attenuation models used to calculate the

historical seismic loading of the rock foundation at the EF-2 site.

3.0 GROUND MOTION RESULTS

The ground motions at the EF-2 site were computed using earthquake activity located in the region bounded by 36° to 47° N latitude and 77° to 90° W longitude. This broad region was used so that all of the major activity in the central region would be included. Events documented with only epicentral intensities (I_0) were converted to m_b magnitudes using Equation (6).

$$m_b = 0.5 I_0 + 1.75 \quad (6)$$

Table 1 lists earthquakes which resulted in estimated intensities of II or greater at the site, and also the corresponding median plus standard deviation sustained acceleration and velocity determined using Equations (1), (2), and (3). The data in Table 1 were sorted to determine the number of exceedances of various intensity levels during the period 1776-1976; these results are plotted in Figure 1. Similarly, the number of exceedances of sustained acceleration and sustained velocity, using the median plus standard deviation and the median correlations of Nuttli (1979), are shown in Figures 2 and 3. Finally, in a parallel manner, results using the McGuire (1977) conversions for peak motions on firm site conditions are shown in Figures 4 and 5.

Also plotted in Figures 2 through 5 are the maximum historical, horizontal ground motions in comparison to the OBE

ground motion levels. The OBE acceleration is 0.08g, while the velocity is taken to be in the range of 5 to 7 cm/sec at frequencies in the vicinity of 1 Hz. This ground velocity range is determined from the 11.5 cm/sec level of the OBE response spectrum at 5% of critical damping at the frequency of 1 Hz., by dividing by the median and 84th percentile response spectrum amplification factors of 1.65 and 2.3, respectively (Newmark and Hall, 1978).

4.0 CONCLUSION

On the basis of the results of this historical analysis, it is concluded that the return frequency of the OBE at the EF-2 site is, as a minimum, on the order of 100 to 300 years.

REFERENCES

- McGuire, R. K., 1977, The Use of Intensity Data in Seismic-Hazard Analysis, Proceedings of the 6th World Conference on Earthquake Engineering, New Delhi, Vol. 2, p. 353-358.
- Newmark, N. M. and Hall, W. J., 1978, Development of Criteria for Seismic Review of Selected Nuclear Power Plants, NUREG/CR-0098, prepared for U.S. Nuclear Regulatory Commission.
- Nuttli, O. W., 1979, State-of-the-Art for Assessing Earthquake Hazards in the United States, Report 16 - The Relation of Sustained Maximum Ground Acceleration and Velocity to Earthquake Intensity and Magnitude, U.S. Army Engineer Waterways Experiment Station Miscellaneous Paper S-73-1, Report 16.

TABLE

Table 1

EARTHQUAKE CATALOG FOR FERNI2 SITE
COORDINATES 41.9600N 83.2580W

YR	HOUR	MIN	SEC	LAT.	LONG.	INT	MAGNITUDE MB MN ML	DISTANCE KM.	MMI	ACC(G)	PEAK GROUND MOTION VEL(CM/S)	SOURCE
1775	14			40.000N	82.000W	6	0.0 0.0 0.0	241.7	3.2	0.022	1.18	NU
18040820	2010			42.000N	87.800W	-6	0.0 0.0 0.0	374.7	2.5	0.015	0.74	DO
18111216	0500			45.600N	89.600W	12	0.0 0.0 0.0	806.7	4.3	0.038	2.48	EH
19120123	15			36.600N	89.500W	12	0.0 0.0 0.0	805.7	4.3	0.038	2.48	NU
19170207	0945			45.600N	89.600W	12	0.0 0.0 0.0	806.7	4.3	0.038	2.48	NU
19270807	0330			39.300N	85.800W	5	0.0 0.0 0.0	460.0	2.1	0.013	0.57	EH
19270807	0500			39.300N	85.800W	5	0.0 0.0 0.0	460.0	2.1	0.013	0.57	EH
19330204				42.300N	85.600W	6	0.0 0.0 0.0	196.4	3.5	0.025	1.43	NU
19450708				41.500N	81.700W	4	0.0 0.0 0.0	139.7	2.7	0.017	0.86	NU 2
19520409	1445			38.500N	89.000W	-8	0.0 0.0 0.0	619.8	2.6	0.016	0.81	NU1
19490910				43.200N	79.850W	5	0.0 0.0 0.0	310.6	2.2	0.013	0.61	EP
19541001				41.500N	81.700W	4	0.0 0.0 0.0	138.7	2.7	0.017	0.86	WG 2
19530213	10			43.100N	79.400W	5	0.0 0.0 0.0	339.9	2.1	0.012	0.55	EP 2
19570228	0140			41.800N	80.600W	-5	0.0 0.0 0.0	220.3	2.7	0.017	0.87	WG 2
19571008	1000			38.700N	89.200W	7	0.0 0.0 0.0	619.3	2.0	0.012	0.54	NU1
19571023	2015			43.200N	78.800W	5	0.0 0.0 0.0	404.7	2.3	0.014	0.67	EP 2
19590410	1130			41.670N	81.250W	4	0.0 0.0 0.0	169.1	2.5	0.015	0.73	EO12
19730705	1430			43.000N	79.500W	6	0.0 0.0 0.0	328.5	2.7	0.017	0.84	EP 2
19750618	0743			40.200N	84.000W	7	0.0 0.0 0.0	205.0	4.0	0.033	2.05	EP
197806				40.400N	84.200W	-4	0.0 0.0 0.0	190.2	2.3	0.014	0.65	EO12
19770817	1650			42.300N	83.300W	-5	0.0 0.0 0.0	37.9	4.6	0.044	3.05	NU
19410420				41.590N	85.830W	4	0.0 0.0 0.0	217.0	2.1	0.013	0.59	DO
19810209	19			40.400N	84.200W	5	0.0 0.0 0.0	190.2	2.9	0.019	0.99	EH1
19830204	1000			42.300N	85.600W	6	0.0 0.0 0.0	196.4	3.5	0.025	1.43	EH
19840919	1914			40.700N	84.100W	6	0.0 0.0 0.0	156.5	3.8	0.029	1.73	EH
19850110	1030			41.100N	81.450W	4	0.0 0.0 0.0	178.0	2.4	0.015	0.70	WG 2
1992				40.390N	84.170W	4	0.0 0.0 0.0	190.2	2.3	0.014	0.65	BS12
19851011	1108			37.000N	89.400W	9	0.0 0.0 0.0	761.5	2.7	0.017	0.84	NU1
19950315	07			40.330N	84.170W	4	0.0 0.0 0.0	196.3	2.3	0.014	0.64	DO
19970531	1858			37.300N	80.700W	8	0.0 0.0 0.0	561.6	2.9	0.018	0.95	PO

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Table 1 (cont.)

EARTHQUAKE CATALOG FOR FERH2 SITE
COORDINATES 41.9500N 83.2580W

YR	MO	HR	SEC	LAT.	LONG.	INT	MAGNITUDE MB MN ML	DISTANCE KM.	PEAK GROUND MOTION MMI ACC(G)	VEL(CM/S)	SOURCE
1899	04	30	0205	38.500N	87.000W	-7	0.0 0.0 0.0	472.3	2.6	0.016	0.82 NU
1900	05	17	0200	39.300N	82.500W	5	0.0 0.0 0.0	302.1	2.3	0.014	0.63 EH
1900	05	14	0200	40.350N	81.450W	-5	0.0 0.0 0.0	234.0	2.6	0.017	0.82 DO
1900	04	23	0212	40.700N	83.600W	5	0.0 0.0 0.0	142.7	3.3	0.023	1.25 DO
1900	05	25	1412	42.500N	89.000W	7	0.0 0.0 0.0	475.5	2.6	0.016	0.81 NU
1900	07	19	0414	40.200N	90.000W	7	0.0 0.0 0.0	596.8	2.1	0.013	0.58 EH
1900	09	27	0345	39.500N	87.400W	7	0.0 0.0 0.0	442.6	2.8	0.018	0.89 DO
1910	01	02	1521	41.500N	88.500W	6	0.0 0.0 0.0	437.1	2.2	0.013	0.61 EH
1910	03	27	1252	43.200N	79.700W	5	0.0 0.0 0.0	321.6	2.1	0.013	0.59 SH
1910	02	22		42.850N	84.150W	4	0.0 0.0 0.0	124.4	2.8	0.018	0.94 DO
1920	03	27	0406	39.500N	83.900W	5	0.0 0.0 0.0	278.3	2.4	0.015	0.69 NU
1920	04	27	0305	38.300N	87.600W	-7	0.0 0.0 0.0	548.4	2.3	0.014	0.66 NU1
1920	10	28	1000	41.670N	83.580W	4	0.0 0.0 0.0	41.8	3.9	0.031	1.94 DO
1920	11	05	1453	39.100N	82.100W	-7	0.0 0.0 0.0	332.1	3.3	0.023	1.27 EH
1920	12	17	0430	40.750N	82.500W	4	0.0 0.0 0.0	148.4	2.6	0.017	0.82 DO
1920	09	09	2000	41.500N	82.000W	5	0.0 0.0 0.0	116.0	3.5	0.026	1.47 EH
1920	03	08	0905	40.350N	84.180W	5	0.0 0.0 0.0	191.5	2.9	0.019	0.98 EP
1920	08	12	112448	42.870N	78.350W	8	0.0 5.2 5.8	414.5	2.8	0.018	0.93 FP12
1930	05	26	2145	40.500N	84.000W	4	0.0 0.0 0.0	173.5	2.4	0.015	0.72 EP
1930	06	27	0723	40.500N	84.000W	4	0.0 0.0 0.0	173.5	2.4	0.015	0.72 NU
1930	07	11	0015	40.700N	83.200W	4	0.0 0.0 0.0	139.9	2.7	0.017	0.35 EB
1930	09	20		40.390N	84.170W	6	0.0 0.0 0.0	150.2	3.5	0.026	1.47 BB1
1930	09	30	2040	40.300N	84.300W	7	0.0 0.0 0.0	203.8	4.0	0.033	2.06 EH
1930	10			40.390N	84.170W	-4	0.0 0.0 0.0	190.2	2.3	0.014	0.65 BB1
1931	05	10	0830	41.320N	84.040W	5	0.0 0.0 0.0	96.2	3.7	0.028	1.68 BB1
1931	09	20	2305	40.530N	84.260W	7	0.0 0.0 0.0	179.4	4.2	0.036	2.31 EH
1932	01	22		41.080N	81.500W	4	0.0 0.0 0.0	175.7	2.4	0.015	0.71 BB12
1933	02	23	0320	40.300N	84.200W	4	0.0 0.0 0.0	200.4	2.3	0.014	0.63 NU 2
1934	10	29	2007	42.000N	80.200W	5	0.0 0.0 0.0	252.3	2.5	0.016	0.76 EH
1935	11	01	060340	46.780N	79.070W	7	0.0 6.2 6.2	629.8	3.1	0.021	1.13 FP 2

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Table 1 (cont.)

EARTHQUAKE CATALOG FOR FERM12 SITE
COORDINATES 41.9600N 83.2580W

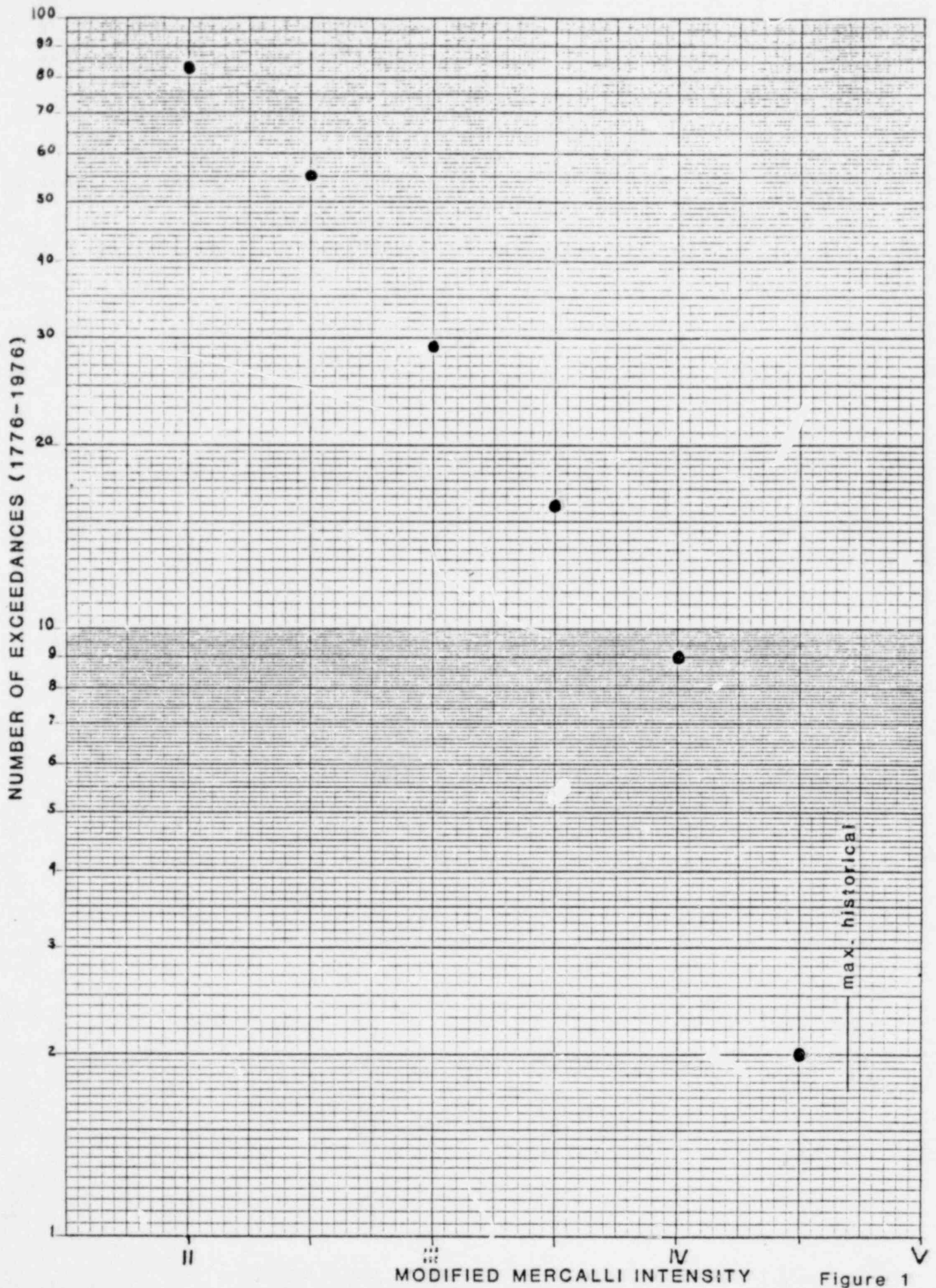
YR	MO	DA	HR	MIN	SEC	LAT.	LONG.	INT	MR	HN	ML	MAGNITUDE	DISTANCE KM.	HMI	ACC(G)	PEAK GROUND MOTION VEL(CM/S)	SOURCE
1936	01	31	1930			41.200N	83.200W	4	0.0	0.0	0.0		84.5	3.3	0.022	1.23	NU 2
1937	03	01	144736			40.500N	84.340W	7	0.0	0.0	0.0		185.5	4.2	0.035	2.24	NU1
1937	03	03	0950			40.700N	84.060W	5	0.0	0.0	0.0		152.9	3.2	0.022	1.19	BB1
1937	03	09	0545			40.470N	84.280W	-9	0.0	0.0	0.0		186.1	4.7	0.047	3.33	DD1
1937	05	02	1703			40.700N	84.060W	4	0.0	0.0	0.0		152.9	2.6	0.016	0.80	DD 2
1949	01	12	0522			41.600N	87.000W	5	0.0	0.0	0.0		312.2	2.2	0.013	0.61	DD
1932	03	13	1510			42.400N	83.200W	4	3.8	0.0	2.4		49.1	3.8	0.030	1.83	NU12
1940	08	16	0430			40.900N	82.300W	4	0.0	0.0	0.0		142.1	2.7	0.017	0.84	NU 2
1943	03	09	042534			41.610N	81.330W	5	0.0	0.0	0.0		164.2	3.1	0.021	1.12	EP12
1947	08	10	0147			42.000N	85.000W	6	0.0	0.0	4.8		143.8	3.2	0.022	1.22	EH1
1951	12	03	0702			41.650N	81.410W	4	0.0	0.0	0.0		156.7	2.6	0.016	0.78	WG 2
1952	05	20	0933			39.700N	82.200W	6	0.0	0.0	5.0		266.1	2.6	0.016	0.79	EH1
1953	06	12	0445			41.670N	83.550W	4	0.0	0.0	0.0		40.2	4.0	0.032	1.58	EP1
1955	05	23	180923			41.310N	81.400W	-5	0.0	0.0	0.0		169.2	3.1	0.021	1.09	WG 2
1955	05	29	011533			41.310N	81.400W	4	0.0	0.0	4.3		159.2	2.6	0.016	0.79	WG12
1958	01	27	1103			40.450N	84.220W	5	0.0	0.0	0.0		185.9	3.0	0.019	1.01	DD
1957	05	09	112509			42.920N	81.320W	0	0.0	3.8	4.2		191.2	2.4	0.015	0.69	EP12
1961	02	22	0845			41.200N	83.400W	5	0.0	0.0	4.3		55.2	3.4	0.024	1.32	EH1
1966	01	01	132338			42.800N	79.200W	6	4.7	0.0	0.0		424.9	2.2	0.013	0.61	US12
1967	02	02	0530			42.710N	84.540W	4	0.0	0.0	0.0		135.5	2.7	0.017	0.89	US1
1947	04	08	054032.3			39.555N	82.489W	5	4.5	0.0	0.0		274.7	2.7	0.017	0.85	NO
1956	11	09	170141.1			38.000N	88.500W	7	0.0	5.5	0.0		626.0	2.3	0.014	0.45	US1
1976	02	02	211402.0			41.960N	82.670W	0	0.0	3.4	0.0		48.5	3.4	0.024	1.34	PD

THIS CATALOG LISTS 83 EARTHQUAKES

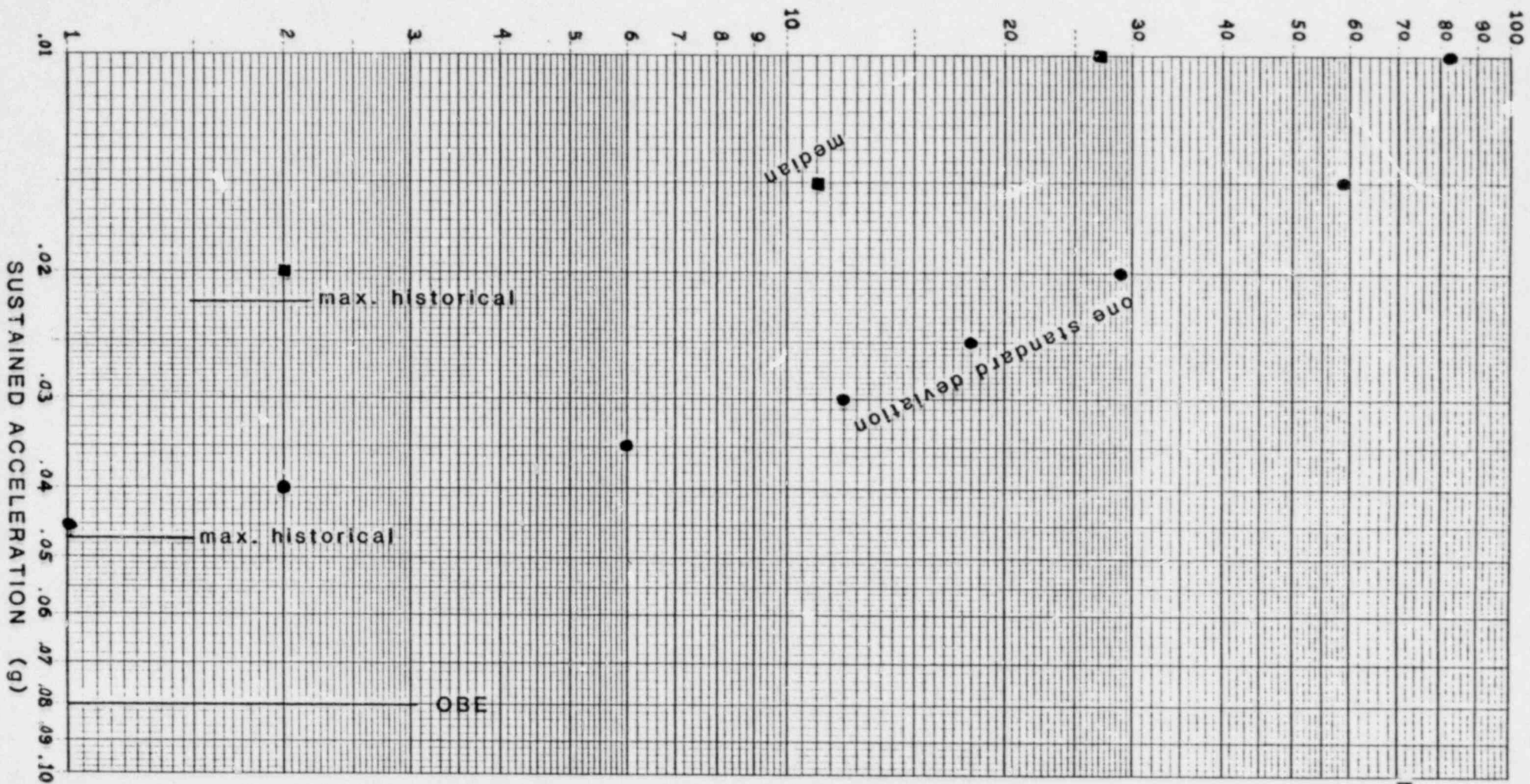
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FIGURES



NUMBER OF EXCEEDANCES (1776-1976)



NUTTLI (1979)

Figure 2

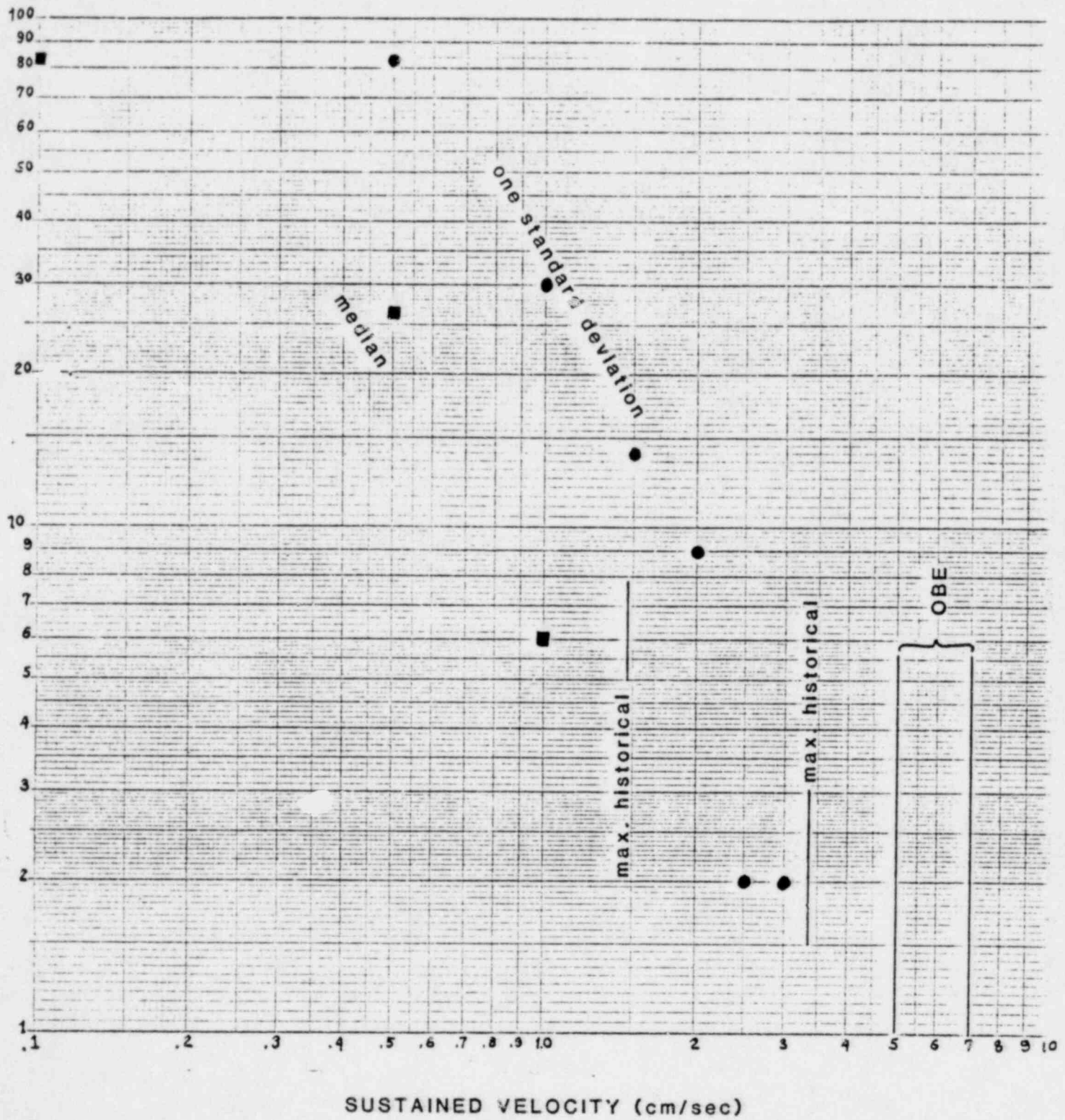
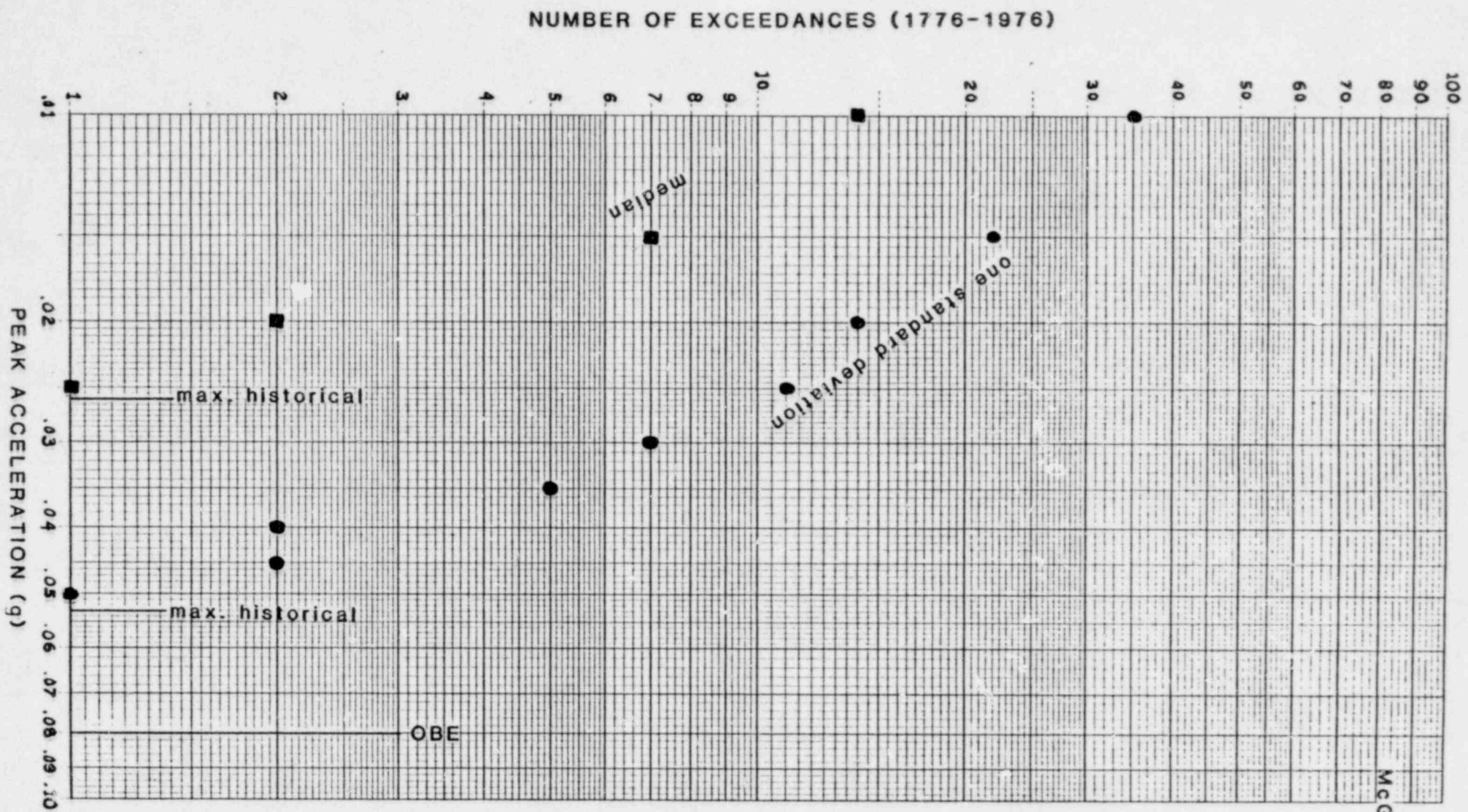


Figure 3



McGUIRE (1977)

Figure 4

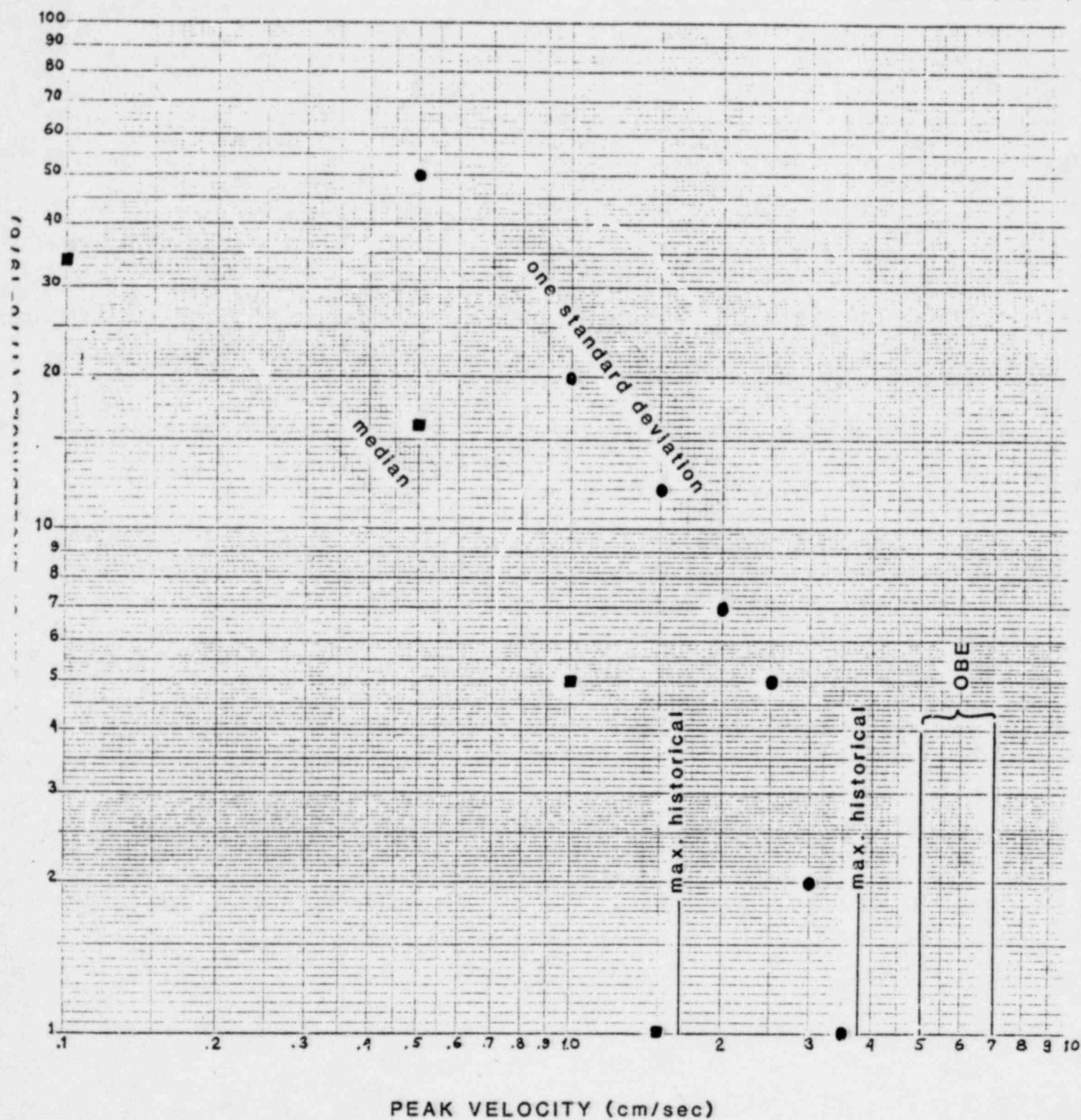


Figure 5