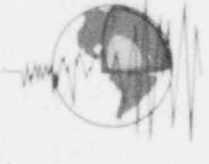
SIXTH QUARTERLY REPORT
CEI SEISMIC MONITORING NETWORK
JANUARY 1 THROUGH MARCH 31, 1988

Prepared for

CLEVELAND ELECTRIC ILLUMINATING COMPANY

APRIL 1988



Weston Geophysical CORPORATION

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

In accordance with its agreement with the U.S. Nuclear Regulatory Commission, Cleveland Electric Illuminating [CEI] continues to monitor the seismic activity in a restricted region of Northeastern Ohio, encompassing the site of the Perry Nuclear Power Plant, two deep injection wells operated by CALHIO, and the epicentral area of the January 31, 1986 earthquake. This sixth Quarterly Report covers the period from January 1 to March 31, 1988. An update of the injection data is also provided in Appendix A.

2.0 SEISMIC NETWORK

During this period, the Automated Seismic Telemetering and Recording System [AUTOSTAR], fully described in the third Quarterly Report, has performed in a very reliable manner. The downtime was minimal, less than five percent; usually caused by noise on one of the five telephone lines. Figure 1 shows the station locations around the area of interest.

3.0 OBSERVED SEISMICITY

3.1 Epicentral Area of January 31, 1986

There was no earthquake activity within the epicentral area during the present quarter. The last event occurred on February 12, 1987.

3.2 The Corridor Between the January 31, 1986 Epicenter and the Injection Wells

During this quarter, only three microearthquakes [M_c = 1.8, 0.5, and 0.5] triggered the digital system. These events occurred on January 16, 17, and February 5, 1988, respectively. A close examination of the analog seismograms reveals five other smaller events, all with coda magnitudes less than 0. Two of them, apparently foreshocks,

occurred within an hour before the M_c = 1.8 January 16 microearthquake. The other three followed the first aftershock of January 17, within twelve hours. These events are too small to be independently located using phase arrival times. In view of their close occurrences in time and the apparent similarity of the S-P interval at the closest station, about 0.5 sec, a common origin with the main shock of January 16, 1988 is currently assumed.

Figures 2, 3, and 4 show the 15 seismic signals recorded for each of the three events that triggered. The calculated locations are plotted on Figure 5. Table 1 presents an updated list of the location parameters of all events located in the corridor since 1986; Figure 6 illustrates the cumulative seismicity observed in the area of interest, including the January 31, 1986 sequence.

3.3 Other Events Recorded by AUTOSTAR

During the period covered, AUTOSTAR triggered on several local and regional quarry blasts. It also recorded on March 31, at $16^h\ 30^m$, a small earthquake with an approximate magnitude $M_c = 2.8 \pm 0.2$. Ten good phase arrival times were provided by CEI to John Carroll Observatory. A preliminary location obtained by Rev. W. Ott, S.J., places the epicenter at 41° 18.88 and 81° 02.88, in the vicinity of Nelson, Ohio, approximately 40 Km south of the January 31, 1986 epicenter. An uncertainty of several kilometers should be attached to the location to account for a model and configuration bias.

4.0 DISCUSSION

The seismicity observed during this quarter is consistent with the previous rate and spatial distribution. The occurrences are sporadic instead of regularly spaced, but the long term average of one event per month [$\pm$ 0.1] is maintained and the activity was centered at the northern end of the epicentral cluster.

An interesting sequence of microshocks was observed on January 16 and 17. Within 15 hours, seven microearthquakes occurred; the two largest ones, M_c = 1.8 and 0.5 were recorded digitally; the five others with estimated M_c = -0.6 could only be seen on the analog seismograms of the two closest stations, FORD and SCH at epicentral distances of 2.5 and 3.8 km. It must be stressed that these extremely small events, with a coda of about 3 sec, are almost at the limit, if not beyond, of what can be identified with confidence as seismic.

The January 16, 1988 event is the largest [M_c = 1.8] to occur within the array. On May 1, 1987, an event with M_c = 1.3 had been located no more than one half kilometer away to the east of the January 16, 1988 microearthquake [see Figure 6]. This May 1, 1987 event, illustrated on Figure 8 of the Third Quarterly Report, had also one foreshock [M_c = -.6], in the preceeding minute, and was followed by two small events on May 2, 1987. In the discussion of these four events, it was then suggested that they could well be from the same origin, although individual locations had been calculated at that time, given that additional MEQ-800 data were available. Considering that the January 16, main shock and January 17, 1988 principal aftershock, both recorded digitally, yield almost identical epicentral solutions, it now seems more likely that all four events of May 1 and 2, 1987 were parts of a single sequence and from the same source, about half kilometer to the east of the recent January 1988 events. It is felt that mixing digital data with MEQ-800 data and their individual time correction and poorer resolution, may have caused the apparent epicentral scatter for the May 1987 events.

The occurrence of these two similar and closely located sequences, within eight months, suggests a common mechanism, whatever it might be, purely tectonic or possibly induced. At this time, we can only notice that the January 1988 sequence occurred approximately four days after injection at the Calhio well number 1 had resumed, while in May 1987, the sequence occurred several days after injection at the same

well had stopped. This difference does not rule out the possible influence of injection, since both variations in pressure, positive or negative, can result in induced activity.

As suggested in previous reports, it is only through reliable data, patiently accumulated over a reasonable time period, that a true understanding of these complex problems will be reached.

5.0 CONCLUSION

During this quarter, three microearthquakes were digitally recorded by AUTOSTAR. The January 16, 1988 event is the largest (Mc=1.8) to occur within the array. The availability of analog seismograms has made it possible to identify the occurrence of a small seismic sequence associated with this event which is similar to one recorded in May last year. The identification of interesting characteristics of these two sequences suggests that gradual progress in the understanding of this localized microactivity is being realized. The nature of the seismic activity, tectonic or induced, is still under evaluation.

TABLE

TABLE 1

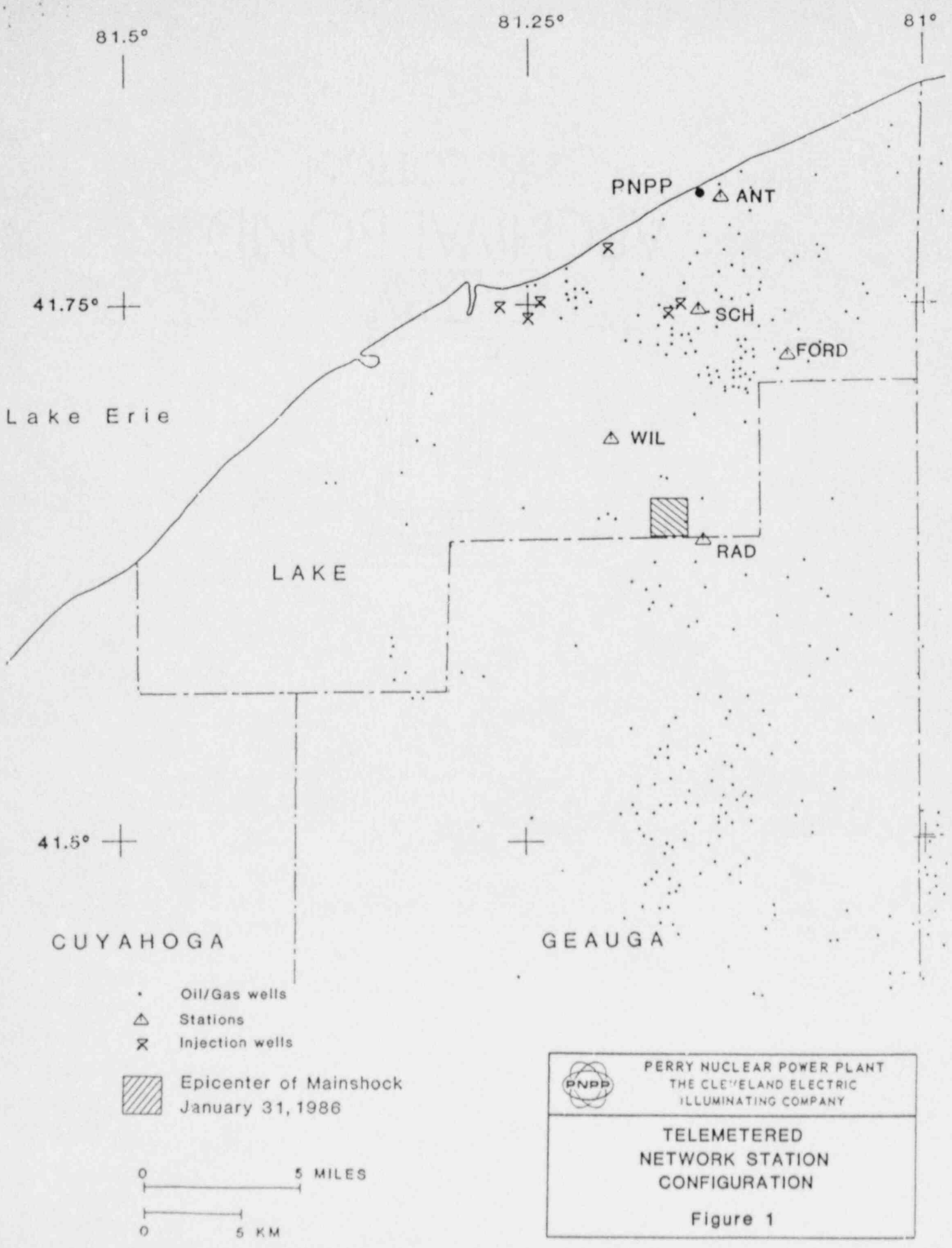
MICROEARTHQUAKES IN THE CORRIDOR BETWEEN THE INJECTION WELLS AND THE MAIN SHOCK

YEAR	MO	DY	HRMISEC	LAT.N	LONG.W	D	RMS	EH	EZ	NP	NS	GAP	MC	SO
1986	03	12	085526.6	41.7272	81.1707	2.0	0.06	0.7	0.4	10	6	216	-.3	GS
1986	09	28	103604.2	41.7247	81.1091	2.3	0.04	0.3	0.4	11	6	174	.3	WG
1986	10	20	105944.7	41.7587	81.1453	3.0	0.07	1.7	2.0	6	4	337	-.6	WG
1986	10	27	122555.5	41.7435	81.0944	2.9	0.07	2.7	1.5	6	3	221	-.2	WG
1986	11	03	085449.6	41.7098	81.1292	1.8	0.06	0.5	0.5	7	5	145	.3	WG
1986	12	01	050317.5	41.7120	81.1195	2.1	0.07	0.6	5.8	7	5	188	-.2	WG
1986	12	24	093733.9	41.7487	81.2392	1.0	0.04	8.5	6.7	6	3	306	.3	WG
1987	01	02	024114.8	41.7472	81.1027	2.0	0.06	0.3	0.5	10	6	174	.6	WG
1987	01	28	235829.8	41.7299	81.0974	2.1	0.03	0.4	0.7	8	5	199	-.7	WG
1987	02	23	214556.4	41.7284	81.1197	2.0	0.03	0.1	0.3	10	7	100	.5	WG
1987	02	28	204644.5	41.7451	81.0932	2.4	0.07	1.0	1.7	7	4	239	-.4	WG
1987	05	01	211332.3	41.7466	81.0872	1.9	0.06	0.3	0.2	7	4	196	-.6	WG
1987	05	01	211352.1	41.7466	81.0921	2.4	0.08	0.2	0.8	15	9	100	1.3	WG
1987	05	02	183307.7	41.7475	81.0932	2.0	0.02	0.1	3.0	6	4	174	-.6	WG
1987	05	02	202526.5	41.7424	81.0889	2.7	0.08	0.3	0.6	14	8	115	.4	WG
1987	07	08	034835.2	41.7392	81.1037	2.7	0.07	0.7	1.1	8	5	166	-.2	WG
1987	08	15	052637.7	41.6994	81.1472	2.8	0.06	0.2	1.0	10	6	133	-.1	WG
1987	10	10	000610.4	41.7430	81.1030	1.9	0.04	0.3	0.2	7	5	166	-.6	WG
1987	10	14	195924.8	41.8250	81.1318	3.4	0.04	1.6	0.7	6	3	190	-.7	WG
1987	11	22	024918.9	41.6989	81.1447	2.2	0.04	0.2	3.8	9	5	120	-.1	WG
1988	01	16	222403.	41.747	81.098						2		-.5	WG*
1988	01	16	223010.	41.747	81.098						3		-.6	WG*
1988	01	16	231704.4	41.7474	81.0991	2.0	0.05	0.5	0.3	9	5	185	1.8	WG
1988	01	17	024821.7	41.7467	81.0997	1.9	0.06	0.5	0.3	10	5	180	0.5	WG
1988	01	17	092236.	41.747	81.098						3		-.6	WG*
1988	01	17	092400.	41.747	81.098						2		-.6	WG*
1988	01	17	131551.	41.747	81.098						2		-.6	WG*
1988	02	05	155837.0	41.7351	81.0907	2.0	0.04	0.4	0.2	10	5	195	0.5	WG

REVISED 04-20-88

* LOCATION INFERRED

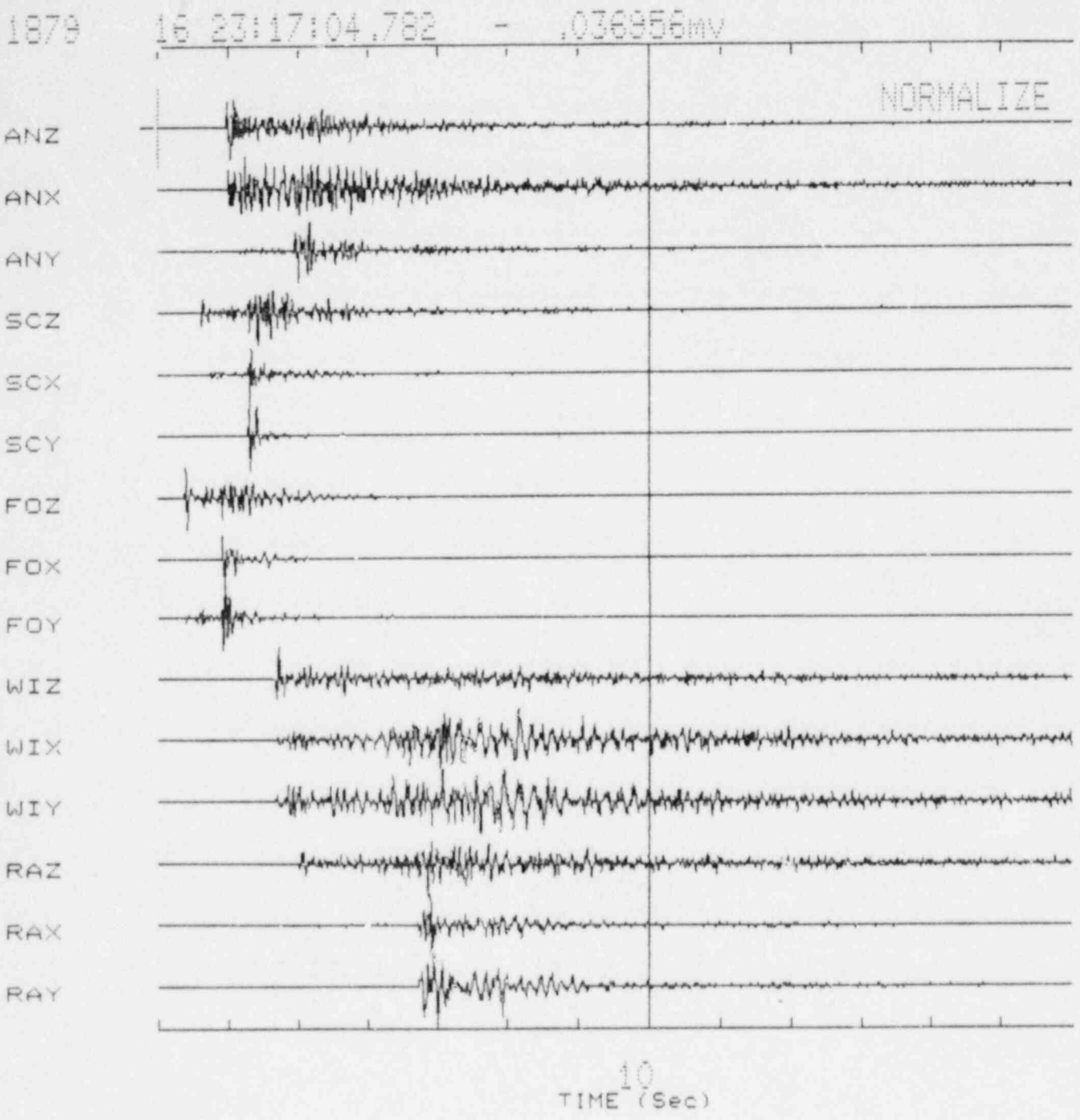
FIGURES



PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

TELEMETERED
NETWORK STATION
CONFIGURATION

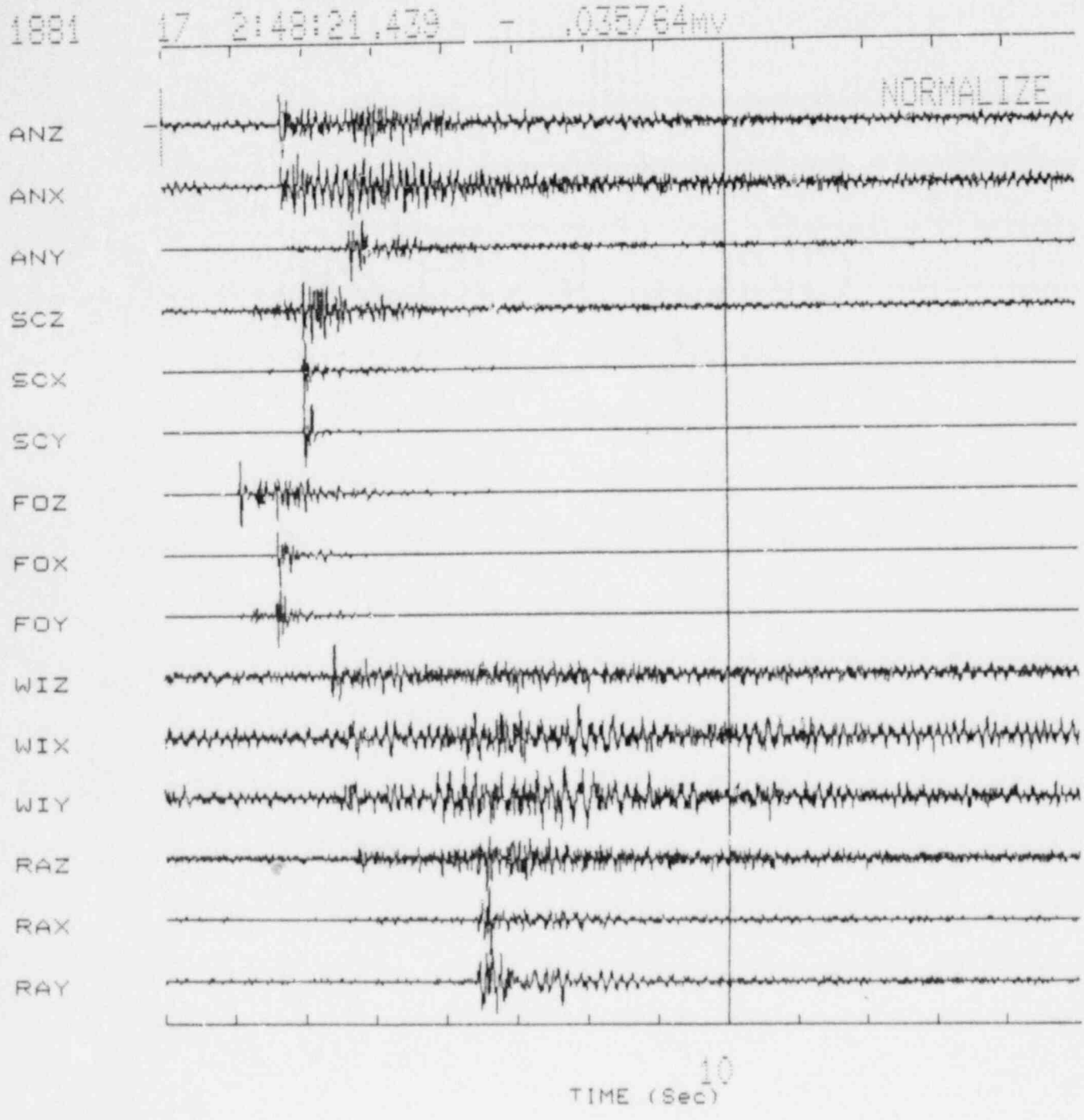
Figure 1



PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

RECORDED SIGNALS
FOR THE JANUARY 16, 1988
MICROEARTHQUAKE

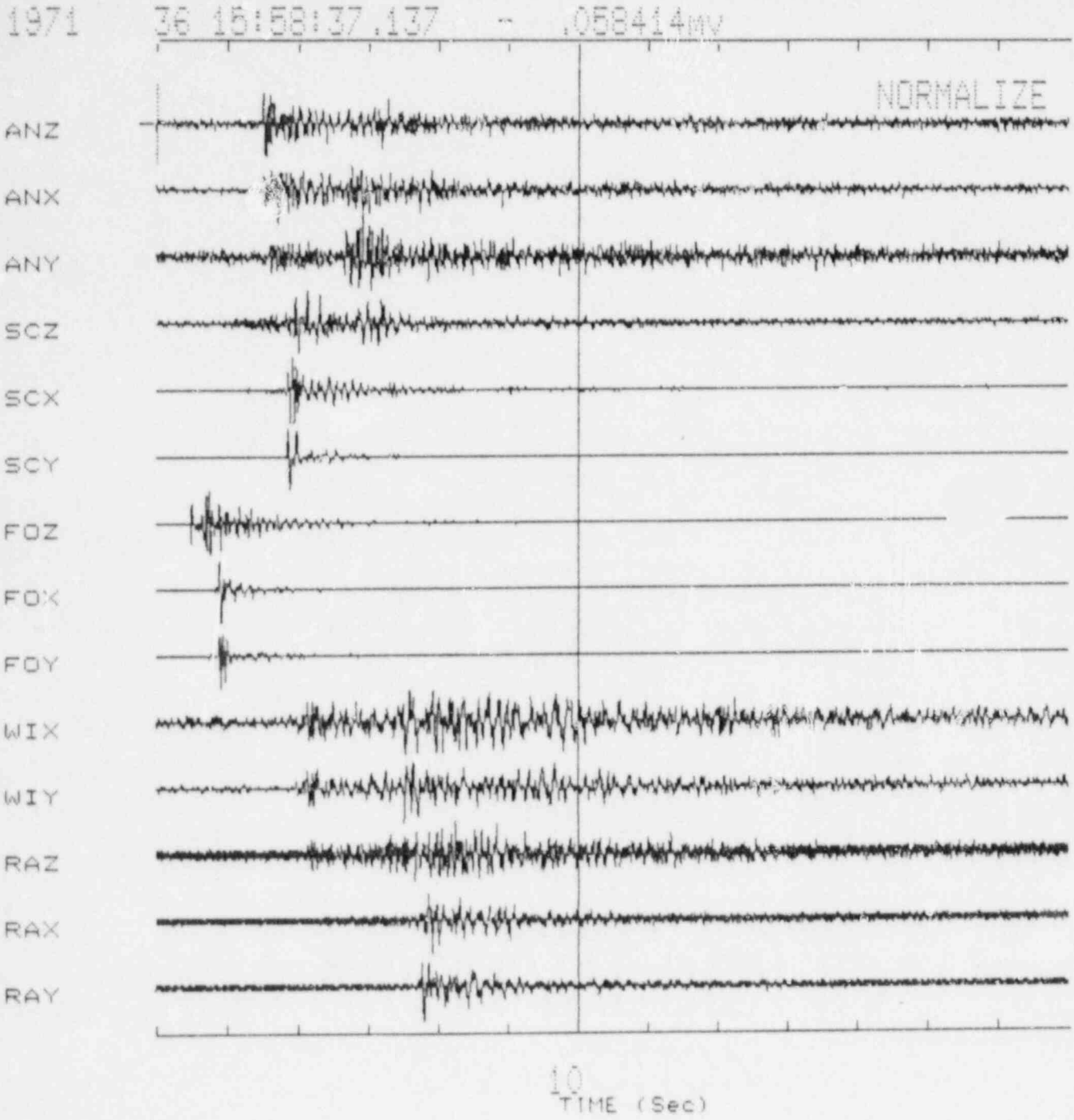
Figure 2



PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

RECORDED SIGNALS
FOR THE JANUARY 17, 1988
MICROEARTHQUAKE

Figure 3

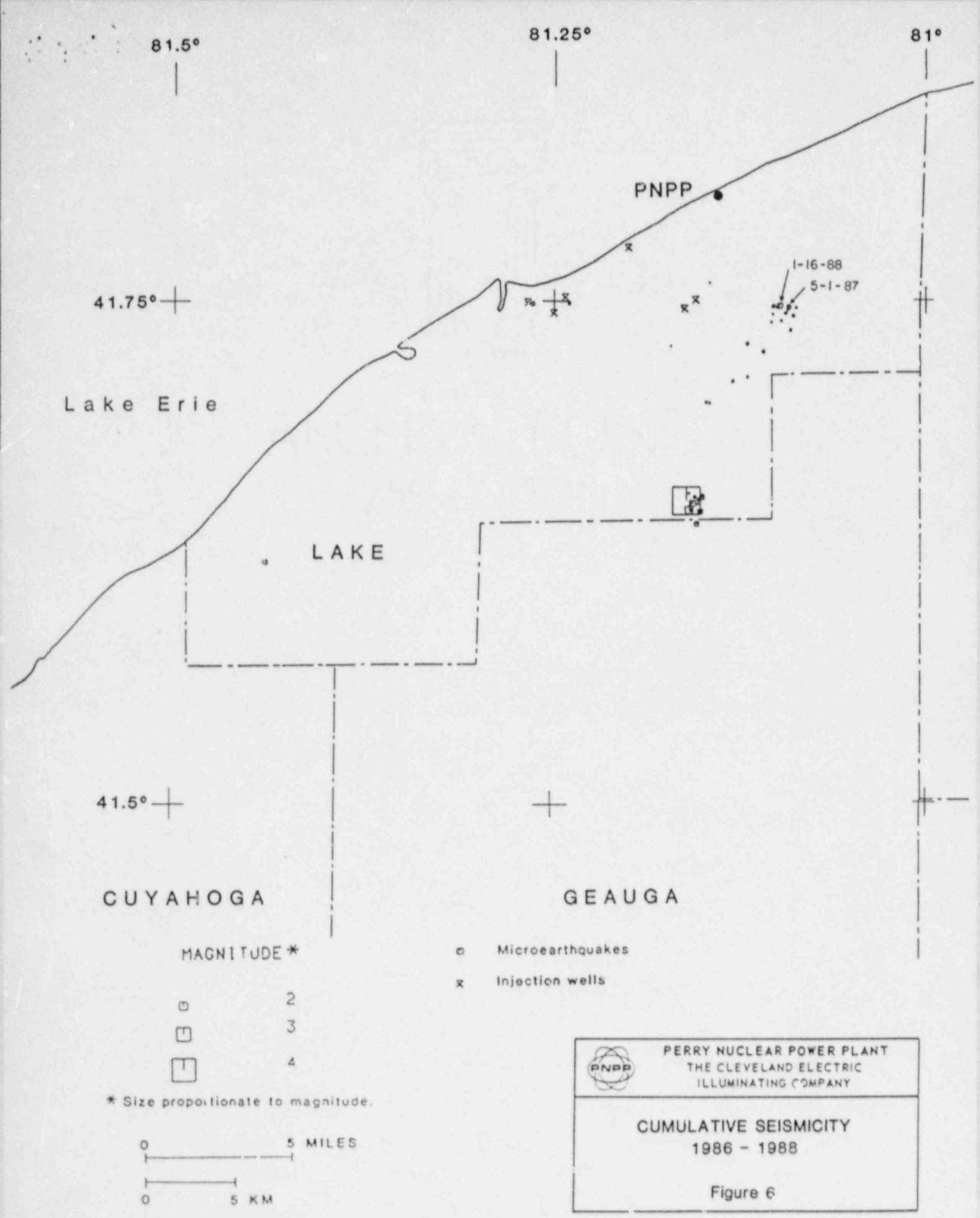


PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

RECORDED SIGNALS
FOR THE FEBRUARY 5, 1988
MICROEARTHQUAKE

Figure 4

81.5°
81.25°
81°
PNPP
41.75°
Lake Erie
LAKE
CUYAHOGA
GEAUGA
MAGNITUDE *
2
3
4
Microearthquakes
Injection wells
* Size proportionate to magnitude.
Epicenter of Mainshock
January 31, 1986
0
5 MILES
0
5 KM
PNPP
PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY
SEISMICITY FOR THE PERIOD
JANUARY 1 - MARCH 31, 1988
Figure 5



PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
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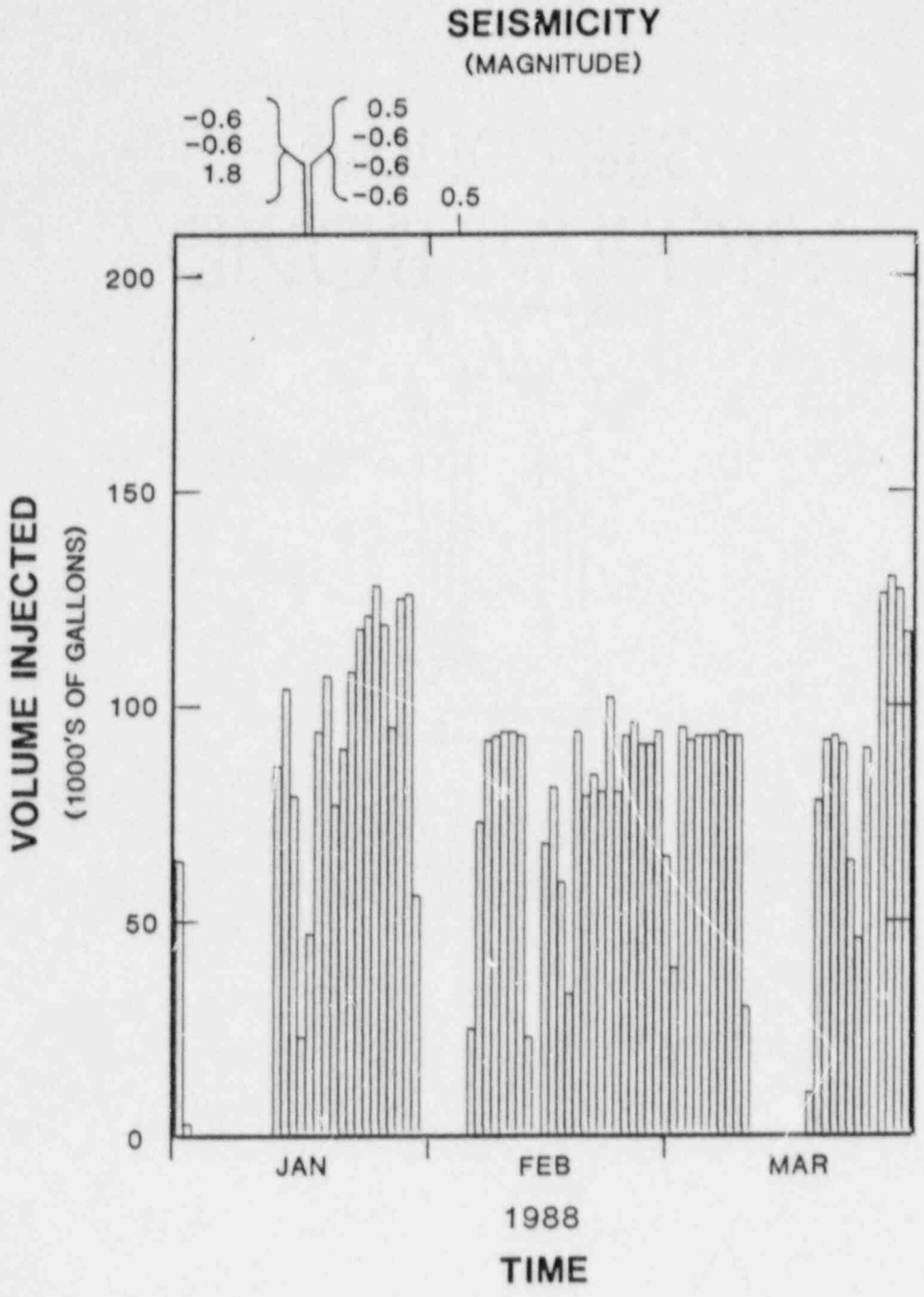
CUMULATIVE SEISMICITY
1986 - 1988

Figure 6

APPENDIX A

FIGURE 1A



Solid lines represent data from Calhio well #1

Dashed lines represent data from Calhio well #2

Injection well volume data from Calhio Chemical

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

DAILY INJECTION VOLUME
AND OBSERVED SEISMICITY
1988

Figure A1