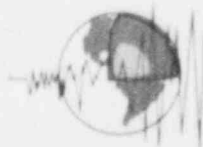


FOURTH QUARTERLY REPORT
CEI SEISMIC MONITORING NETWORK
JULY 16 THROUGH OCTOBER 15, 1987

Prepared for
CLEVELAND ELECTRIC ILLUMINATING COMPANY

DECEMBER 1987



Weston Geophysical
CORPORATION

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APPENDIX 1 CALHIO INJECTION WELL DATA

1.0 INTRODUCTION

As agreed with the U.S. Nuclear Regulatory Commission, Cleveland Electric Illuminating [CEI] continues to monitor the seismic activity in an area of northeastern Ohio that includes the Perry Nuclear Power Plant, two deep injection wells operated by CALHIO, and the epicentral region of the January 31, 1986 earthquake. This fourth quarterly report, prepared by Weston Geophysical for CEI, covers the period from July 16 through October 15, 1987. It also provides in an appendix, the injection data collected from March 1986 to September 1987.

2.0 SEISMIC NETWORK

During the last quarter, the Automated Seismic Telemetering and Recording System [AUTOSTAR] has been in operation, and was in the last stage of testing. Figure 1 shows the station locations around the area of interest. Hardware and software problems were resolved, allowing removal of the supporting portable MEQ-800 instruments and Weston Geophysical's on-site seismologist at the end of October. A more detailed description of AUTOSTAR was included in the third quarterly report.

3.0 OBSERVED SEISMICITY DURING THE QUARTER

3.1 Epicentral Area of January 31, 1986

No activity was detected in this area by either the John Carroll University network or CEI Net. Close cooperation between CEI and John Carroll University continues.

3.2 Injection Wells - January, 1986 Epicenter Corridor

Three microearthquakes were detected and located during the quarter within the corridor. Their coda magnitudes are respectively, -0.1, -0.6, -0.7, based on average durations of 5, 3, and 2 seconds. Only the first event, on August 15, triggered AUTOSTAR; the second one was

visible on some of AUTOSTAR's analog records and MEQ-800 records, all vertical components; the third event was recorded only on three MEQ-800's at a time when AUTOSTAR's helicorders were being serviced. The last extremely small event is not well recorded and has a somewhat unstable solution.

Figure 2 shows the locations of the three microevents of this quarter. Figure 3 presents the updated seismicity recorded since January 31, 1986 between longitudes 81.0W and 81.5W. Table 1 gives location parameters of all events in or near the corridor.

3.3 Other Events Recorded by AUTOSTAR

During the last quarter, AUTOSTAR recorded local quarry blasts, all originating outside its aperture. It also triggered on several of the larger aftershocks of the July 13, 1986 Ashtabula earthquakes. These data files have not been examined or analyzed.

4.0 DISCUSSIONS

The microearthquakes recorded in the wells-main shock corridor are extremely small, judging by their durations. It is not clear, at this time, how valid is the downward extrapolation of the coda magnitude formula currently used:

$$M_c = 2.2 \log D - 1.1,$$

where D is duration in seconds. At short distances, it is quite conservative compared to other relationships.

The AUTOSTAR digital data, particularly when examining the two horizontal components, is superior to the single vertical analog records produced by MEQ-800s. The comparison of both types confirms the difficulty in identifying the S-phase from MEQ-800 vertical seismograms. This is particularly true when the S-P interval is on the

order of one second. For this reason, CEI anticipates collecting more reliable hypocenters obtained from AUTOSTAR data before evaluating the spatial distribution of the activity. All events previously tabulated are totally or partly based MEQ-800 data.

5.0 CONCLUSIONS

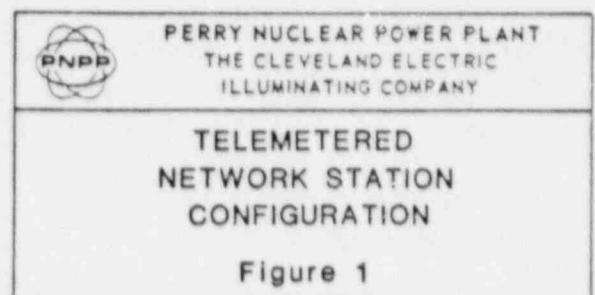
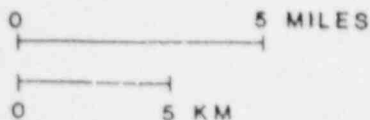
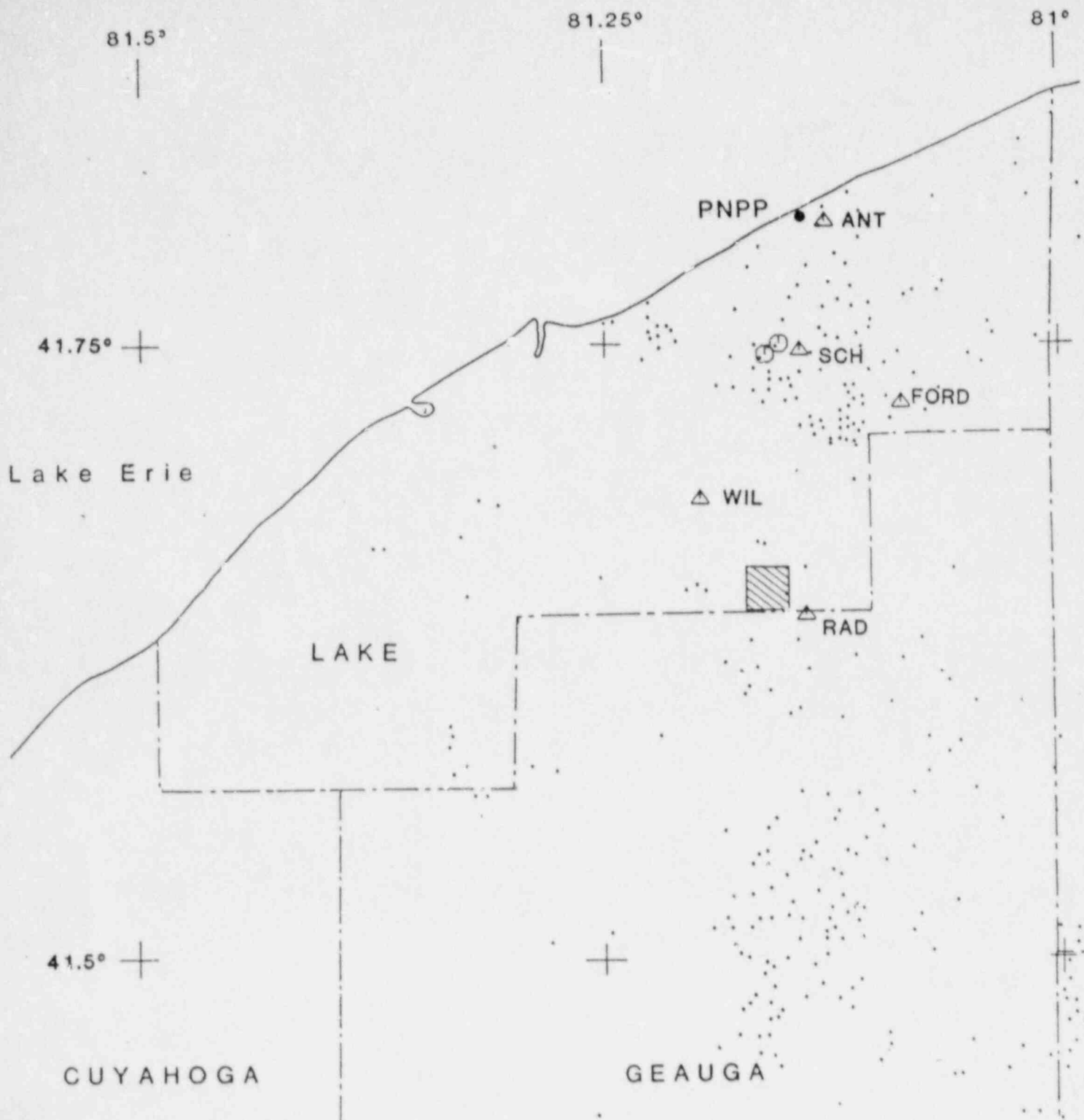
During the last quarter, from July 16 to October 15, the seismicity in the corridor has been very low, encompassing only three small events with negative magnitudes. No relationship between well operation and occurrence of microseismicity has yet been established. AUTOSTAR has been declared fully operational during the period and the digital files from this system are of excellent quality even for small events.

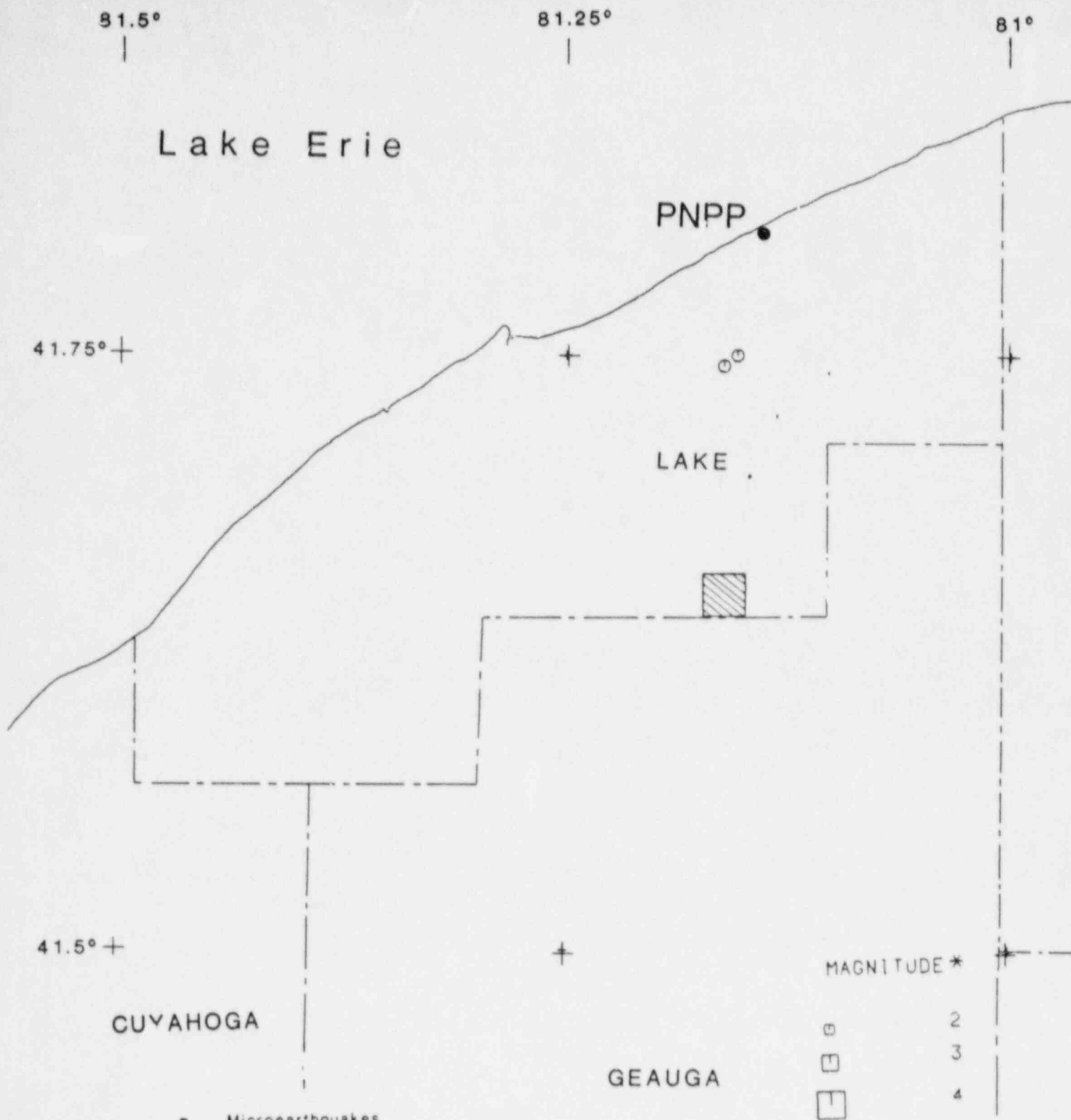
TABLE 1

MICROEARTHQUAKES IN THE INJECTION WELLS - MAIN SHOCK CORRIDOR

YEAR	MO	DY	HRMISEC	LAT.N	LONG.W	D	RMS	EH	EZ	NP	NS	GAP	MC	SD
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	41.7597	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	138	-.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	41.7399	81.0974	2.1	0.03	0.4	0.7	8	5	199	-.7	WG
1987	02	23	114556.4	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	41.7292	81.1037	2.7	0.07	0.7	1.1	8	5	166	-.2	WG
1987	08	15	052637.7	41.6594	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	41.7250	81.1318	3.4	0.04	1.6	0.7	6	3	190	-.7	WG

REVISED 10-15-87





○ Microearthquakes

○ Injection wells

▨ Epicenter of Mainshock
January 31, 1986

* Size proportionate to magnitude.

0 5 MILES

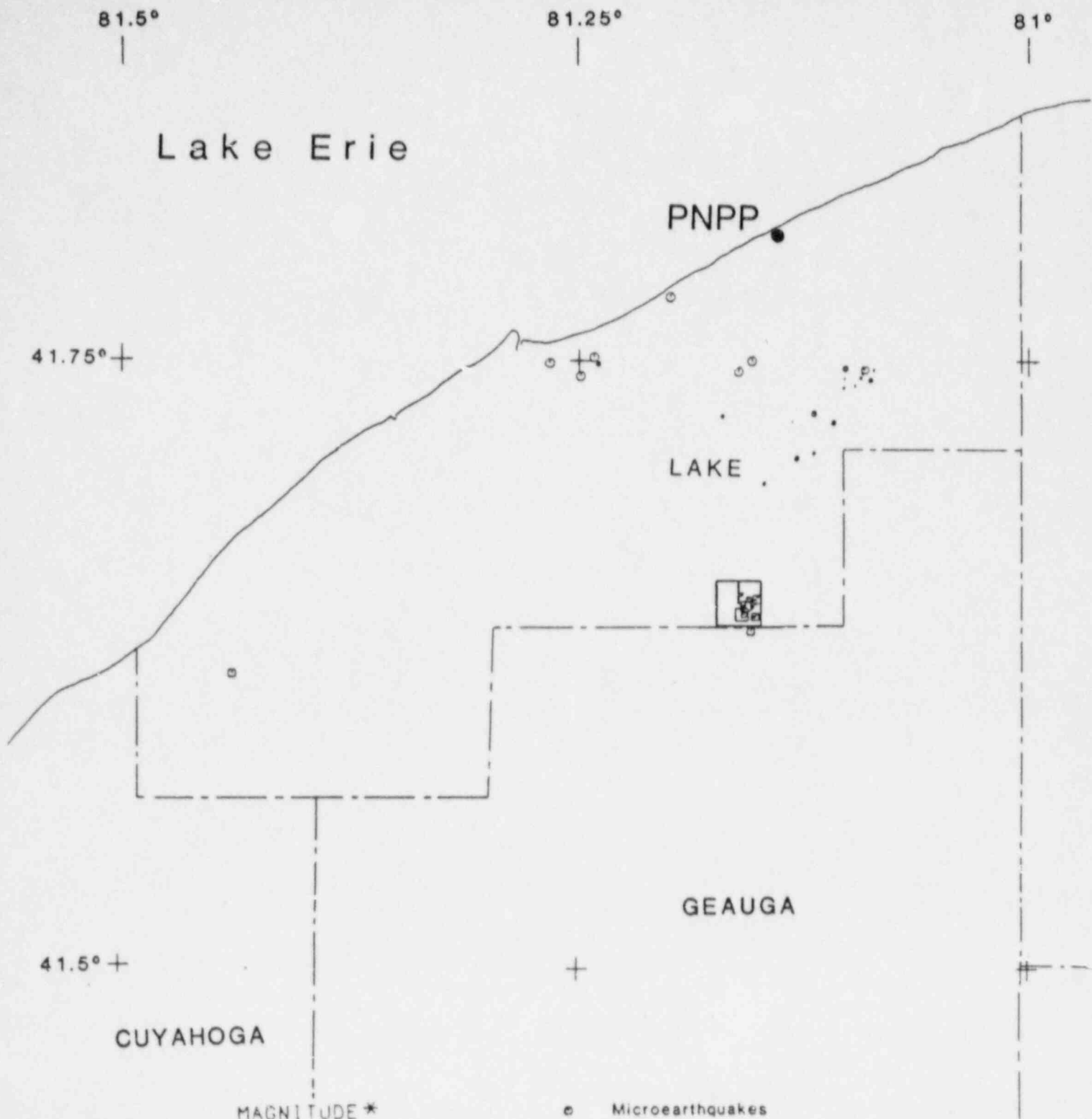
0 5 KM



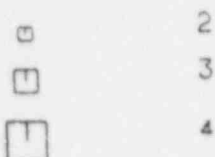
PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

SEISMICITY FOR THE PERIOD
JULY 16 - OCTOBER 15, 1987

Figure 2

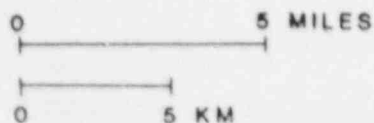


MAGNITUDE *



* Size proportionate to magnitude.

- Microearthquakes
- Injection wells



	PERRY NUCLEAR POWER PLANT THE CLEVELAND ELECTRIC ILLUMINATING COMPANY
	CUMULATIVE SEISMICITY
Figure 3	

APPENDIX I

CALHIO INJECTION WELL DATA

CALHIO INJECTION WELL DATA

Two deep injection wells operated by CALHIO Chemicals, Inc., are located in the corridor between the Perry Nuclear Power Plant and the January 31, 1986 epicentral region. Both wells are used for disposal of waste products from the manufacture of agricultural fungicide. The operator of these two wells [CALHIO] has provided CEI with daily injection volumes, as reported to the Ohio Environmental Protection Agency. Daily injection volume records for 19 months, from March 1986 through September 1987, were collected and examined for correlation with seismic activity.

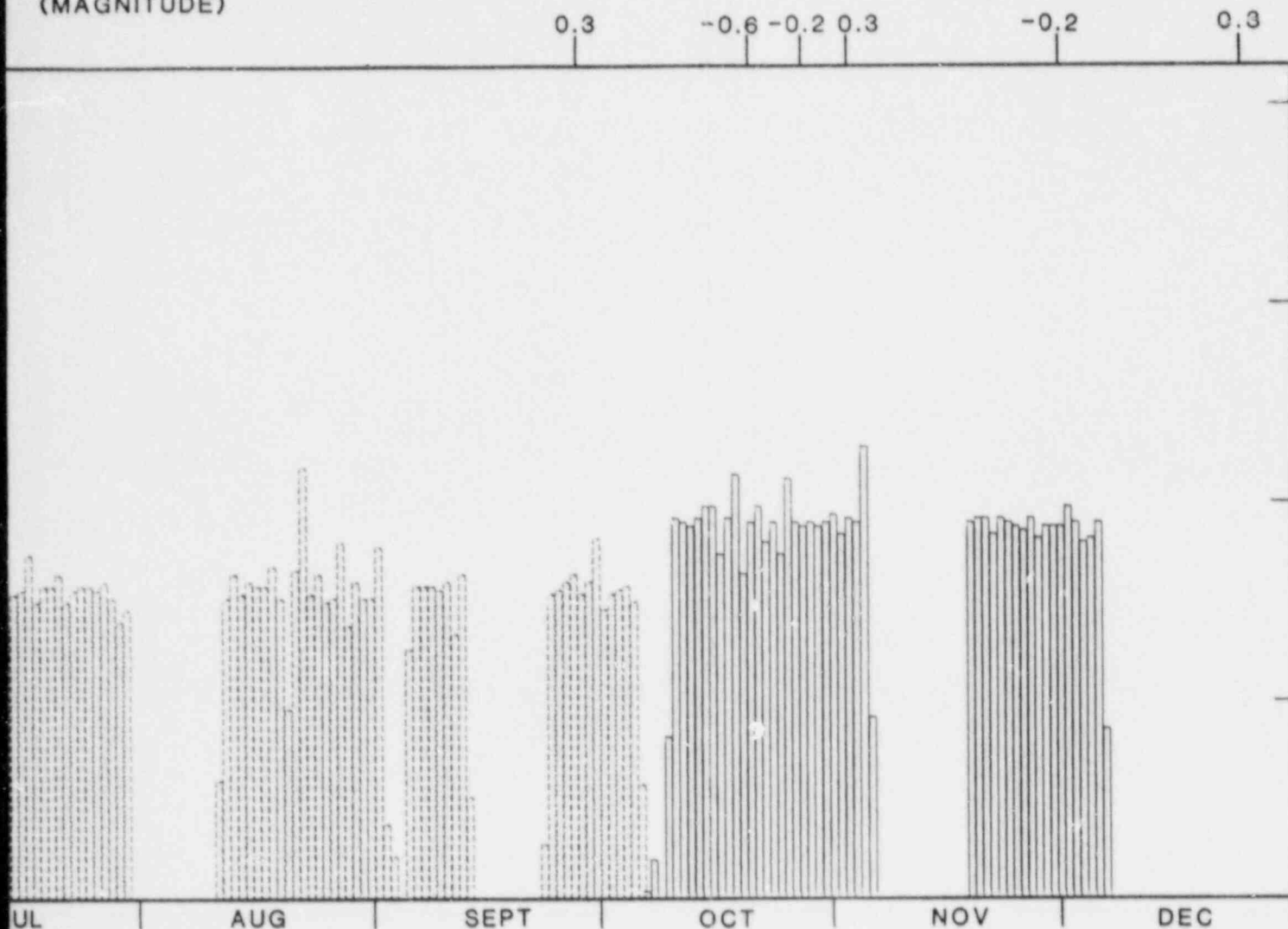
Data from the CALHIO wells, plotted in Figures A1 and A2, show a fairly regular pattern of daily injection volumes. Increases in injection volume occur during periods of heavy or prolonged rainfall, i.e. June 1986 and June-July 1987. Hiatuses in injection lasting from two to fourteen days occur when wells are shut down for filter replacement. From July through September 1986, Well #1 underwent regular maintenance and testing. During this time Well #2 was used for injection.

Seismicity, as shown in Figures A1 and A2, is varied in both magnitude and frequency. Seventeen events during the nineteen months range in magnitude from -0.7 to 1.3. Injection data for the entire quarter is not yet available.

Figure A1 shows a lack of observable seismicity from April through September 1986. The events which show a magnitude of less than 0.0 represent extremely small releases of energy and are therefore located with less confidence.

The available data presented in this report show no apparent correlation between seismicity and fluid injection. The temporal paucity of events and the uncertainties associated with the smaller events preclude a detailed mathematical correlation at this time. Further analysis using data acquired from the new digital network is necessary to accurately assess any possible correlation between seismicity and fluid injection.

SEISMICITY (MAGNITUDE)



1986

TIME

TI
APERTURE
CARD

Also Available On
Aperture Card

8801210383-01

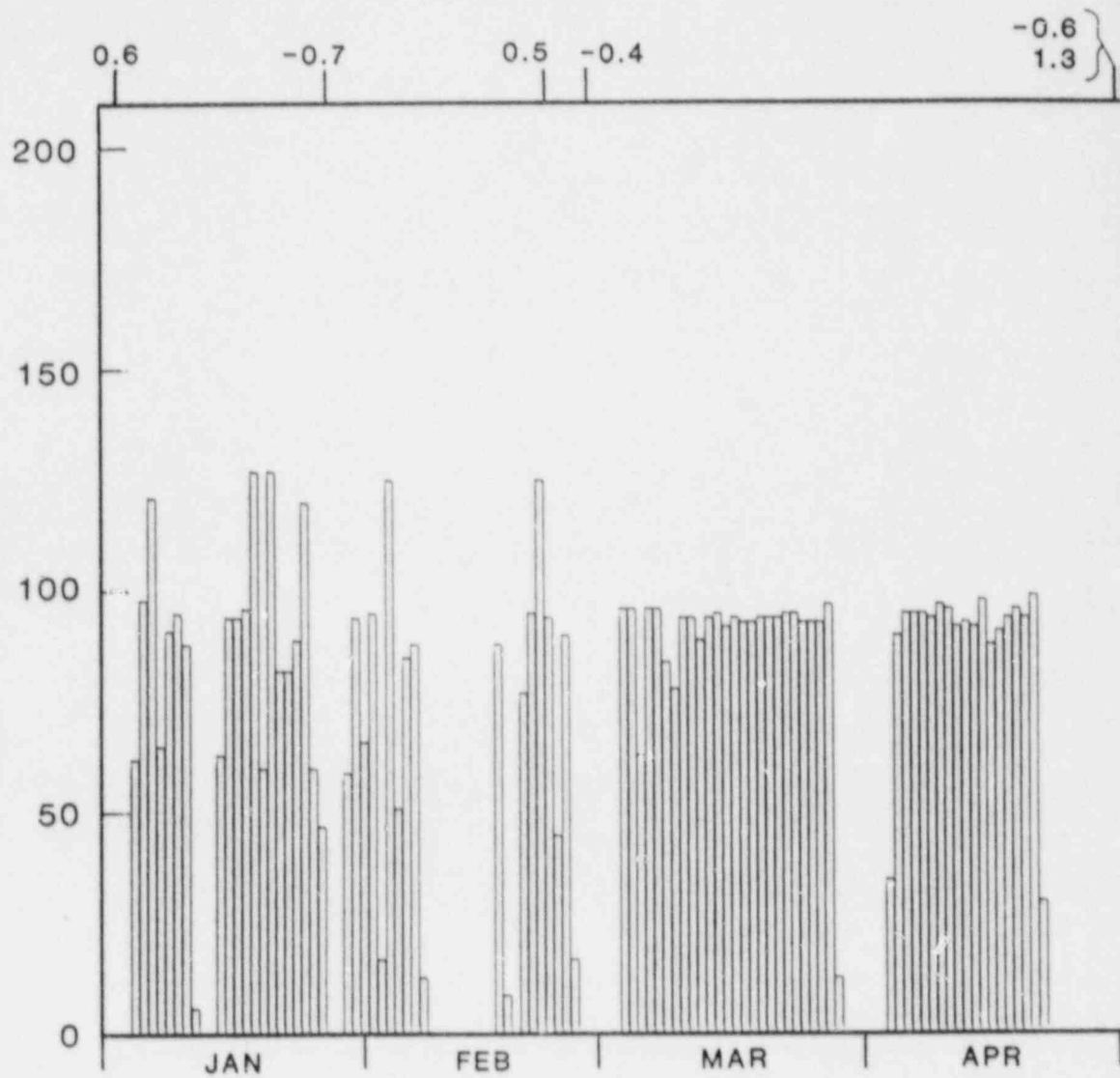


PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

DAILY INJECTION VOLUME
AND OBSERVED SEISMICITY
1986

Figure A1

VOLUME INJECTED
(1000'S OF GALLONS)

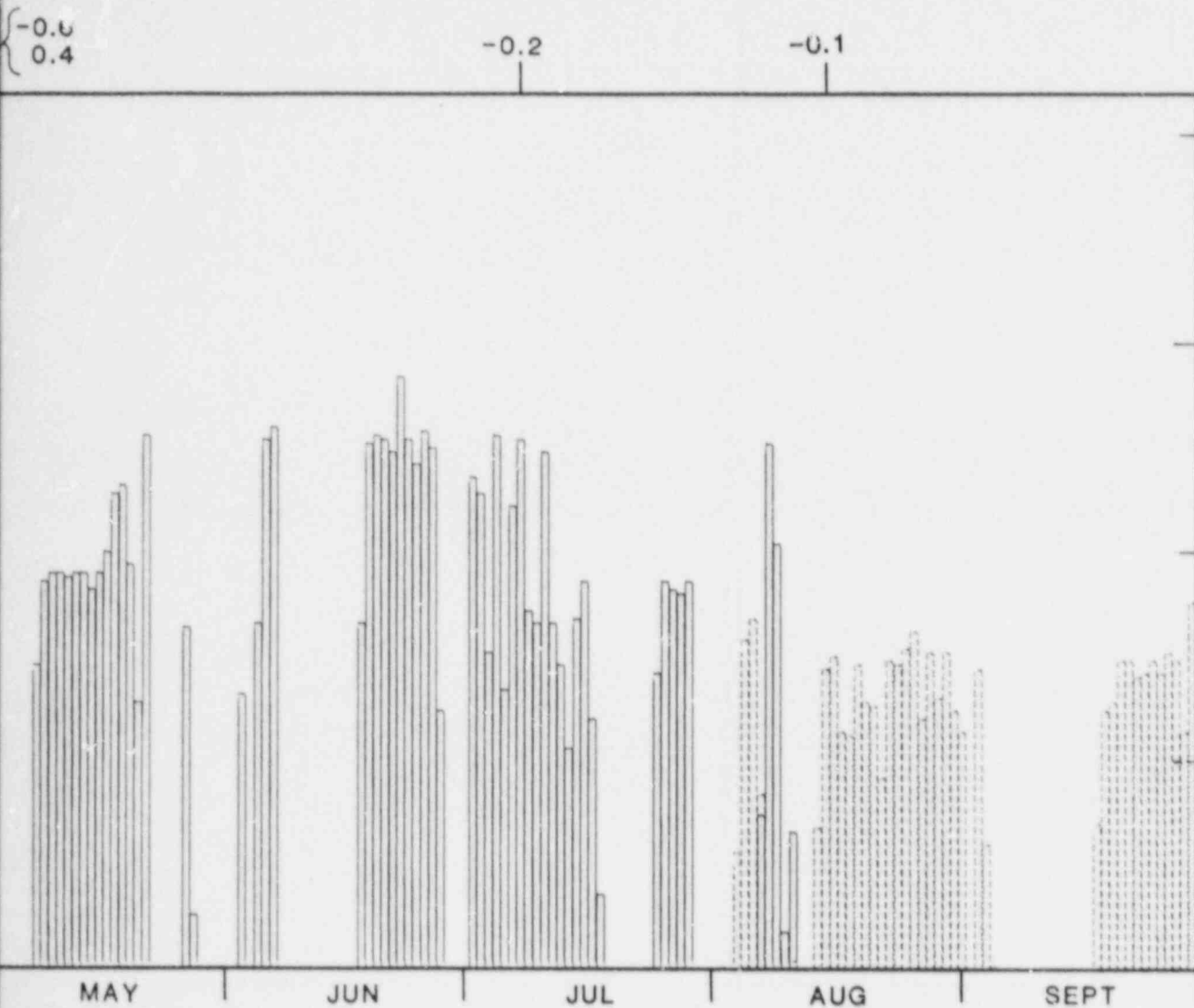


Solid lines represent data from Calhio well #1

Dashed lines represent data from Calhio well #2

Injection well volume data from Calhio Chemical

SEISMICITY (MAGNITUDE)



MAY
1987

JUN

JUL

AUG

SEPT

TIME

TI
APERTURE
CARD

Also Available On
Aperture Card

8801210383-02



PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

DAILY INJECTION VOLUME
AND OBSERVED SEISMICITY
1987

Figure A2