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Michael D. Lyster
Vice President - Nuclear

December 17, 1990
PY-CEI/NRR-1279 L

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D. C. 20555

Perry Nuclear Power Plant
Docket No. 50-440
Seismic Monitoring
Report Number 15

Gentlemen:

Enclosed for your information is Seismic Monitoring Report Number 15 for the CEI operated Micro-Net, which is monitoring an area in the vicinity of two waste injection wells, operated by ICI Americas (formally Calhio), located 3 miles south of the Perry Nuclear Power Plant site. This report provides data and event analysis for the period between July 1, 1990 and September 30, 1990. Appendix A of the report provides the volumetric data from the two ICI Americas injection wells for the same period. Results of seismic monitoring for this reporting period are summarized below.

Monitoring Results

During this reporting period, one micro earthquake (Mc= 1.5, calculated focal depth = 4.5 km) was detected in the epicentral area of the January 31, 1986 Leroy earthquake. This event is not considered an aftershock of the January 31, 1986 main shock. Another micro earthquake (Mc= -0.2) was detected within or near the aperture of the Micro-Net. Neither of these events have altered our interpretations on local seismicity.

Also, during this reporting period, one microearthquake was detected near Fairport Harbor, Ohio, and six micro earthquakes were detected near Ashtabula, Ohio. These seven events are located, outside the Micro-Net aperture, near operating injection wells.

Future Actions

As previously noted, CEI is evaluating the long term need for continued operation of the seismic network. Considerable data has been accumulated and reported through Quarterly Reports submitted to the Staff. Several mini-studies have been conducted to analyze collected data and refine the understanding of local microseismicity. In the near future, we will apprise you of our plans for continued operation of the seismic network.

Please contact us, should you have any questions.

Sincerely,

Frank R Stead for
Michael D. Lyster

MDL:AHL:njc

Enclosure

cc: USNRC Project Manager
USNRC Resident Inspector Office
USNRC Region III
R. Rothman

FOURTEENTH QUARTERLY REPORT
CEI SEISMIC MONITORING NETWORK
JANUARY 1 THROUGH JUNE 30, 1990

Prepared for
CLEVELAND ELECTRIC ILLUMINATING COMPANY

AUGUST 1990

Weston Geophysical
CORPORATION

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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 locale of the Perry Nuclear Power Plant, two deep injection wells operated by CALHIO (ICA Americas, Inc.), and the epicentral area of the January 31, 1986 earthquake. This fourteenth Quarterly Report covers the monitoring period from January 1, 1990, to June 30, 1990. In addition, Appendix A provides the volumetric data from the two Calhio wells for the same period. Appendix B summarizes research completed on the possible influence of gas wells on microseismic activity.

2.0 SEISMIC NETWORK

During the first six months of 1990, the Automated Seismic Telemetering and Recording System (AUTOSTAR) and the Geneva station performed quite reliably with a total uptime percentage of 94.8%. Most of the downtime was caused by telephone line problems.

3.0 OBSERVED SEISMICITY

3.1 Epicentral Area of the January 31, 1986 Earthquake

There was no microearthquake activity detected during this period. The last event reported occurred on December 28, 1988.

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

During this period of six months, five small microearthquakes were detected by AUTOSTAR within the aperture of the CEI network or near it. The location parameters for these events are listed on Table 1 and the epicenters are presented on Figure 1. Locations of the stations and injection wells are included on the same figure for orienting the reader. Figure 2 presents the cumulative seismicity observed in the area since the January 31, 1986 earthquake.

3.3 Other Events Recorded by AUTOSTAR

On January 1, 1990, the CEI and JCU networks detected a microearthquake (M_c=2.2) originating in the vicinity of Ashtabula. Trial epicentral solutions suggest a location fairly similar to that of other events that have occurred periodically since July 1987 close to a deep injection well.

On May 26, the two networks detected an event (M_c=1.3) located in the vicinity of Fairport Harbor, not far from an injection well. The location parameters of this event are given on Table 1 and the epicenter has been included in Figures 1 and 2.

Finally on June 4, both networks recorded an event well outside their aperture, 200 km away, in the vicinity of Fostoria, Ohio. Phase arrival times were given to the University of Michigan which operates the Anna seismic network. Observed coda lengths of 120 sec from the CEI net suggest a magnitude Mc close to 3.0, substantially larger than 2.25 reported by the University of Michigan.

4.0 DISCUSSION

4.1 Epicentral Area of the January 31, 1986 Earthquake

The eighteen month absence of microseismic activity in the Leroy area is not surprising since it previously occurred in 1987 and 1988. The periodic absence of microseismic activity is a characteristic of northeastern seismicity patterns.

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

The activity in the corridor has been very low, as in the last four years. The average rate of one event per month continues to hold. With the use of the coda length magnitude defined as:

$$M_c = 2.21 \log \text{Duration (sec)} - 1.71,$$

it can be seen that the observed events were extremely small, with a duration varying from 5 to 8 seconds. At this low level of the activity, it is unwise to infer a definite tectonic significance. In addition, one is never sure that the recorded tremors are natural and not related to extraneous man influence.

The relative shallowness of all the events forming a cluster observed at the center of the network aperture compared to the deeper hypocenters of the Leroy seismic source as well as the persisting seismic gap between these two areas suggest the existence of two distinct seismic regimes. This minimizes the likelihood of the Calhio wells having a causal influence on the Leroy earthquake.

4.3 Other Events Recorded by AUTOSTAR

The repeated occurrences of small events in the immediate vicinity of deep injection wells, either at Fairport Harbor or Ashtabula, and even within the array, increase the probability of some causal relationship regardless of the absence of a strict demonstration. This spatial proximity of microevents to injection wells is observed too often to be considered a random coincidence.

5.0 CONCLUSIONS

The CEI network has operated quite reliably during the first six months of 1990. This is partly attributed to the fact that the telephone company has made progress in resolving problems that persistently affected one station of the network.

No activity was observed in the Leroy area where the January 31, 1986 earthquake originally occurred. Only five small events, with magnitude M_c=0.3 or less, were located within or near the CEI network aperture. Further away, one event occurred near Ashtabula and one other near Fairport Harbor; deep injection wells are operated in both areas.

CEI continues to believe that the Leroy earthquake was not causally related to the Calhio injection wells, a question raised four years ago by the USGS and USNRC.

6.0 ACKNOWLEDGEMENT

CEI and Weston Geophysical are grateful to Rev. W.R. Ott, S.J. of the John Carroll University Seismological Observatory for contributing data from his network. Considering the small aperture of CEI's network, the additional data are critical to the locationing of several events.

TABLE

TABLE 1

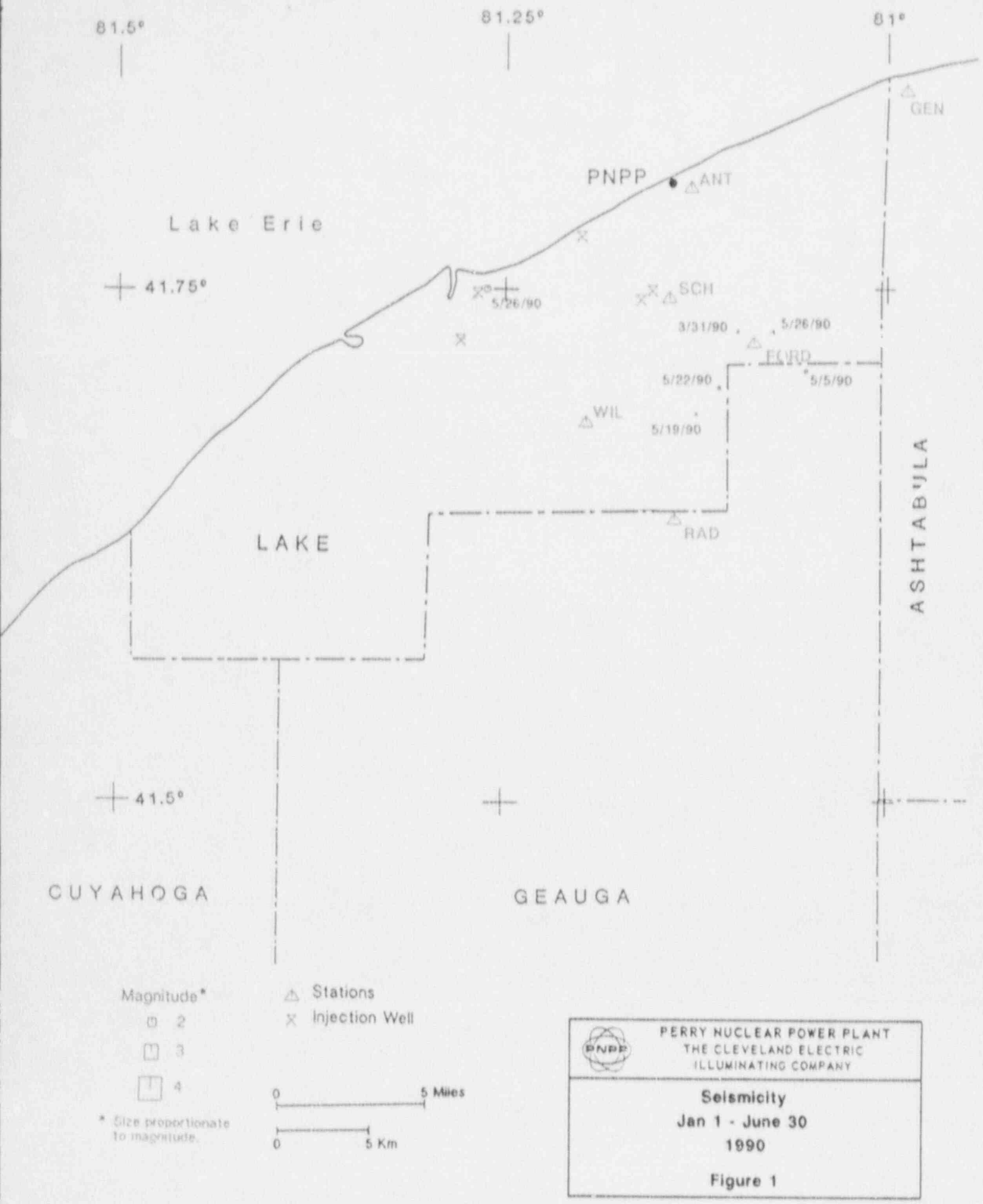
MICROEARTHQUAKE INSIDE THE MICRONET APERTURE OR IN THE IMMEDIATE VICINITY

1990

NO.	YEAR	MODY	HRMNSEC	LAT.N	LONG.W	D	RMS	EH	EZ	N	NS	GAP	MC	SO	TR.NO
1.	1990	0331	025526.6	41.7303	81.1001	2.0	0.05	0.3	0.6	9	5	134	-.2	WG	4938
2.	1990	0505	212924.0	41.7111	81.0556	2.1	0.03	0.2	1.5	13	8	194	.2	WG	5086
3.	1990	0519	222828.5	41.6901	81.1269	2.1	0.05	0.2	12.0	8	5	153	-.2	WG	5153
4.	1990	0522	140632.2	41.7026	81.1119	2.2	0.05	0.3	3.9	9	5	162	.3	WG	5159
5.	1990	0526	095118.9	41.7498	81.2624	2.4	0.04	0.2	3.8	13	8	186	1.3	WG	5197
6.	1990	0526	120735.4	41.7300	81.0774	2.3	0.03	0.2	0.2	10	5	236	.1	WG	5198

JLL 02,1990

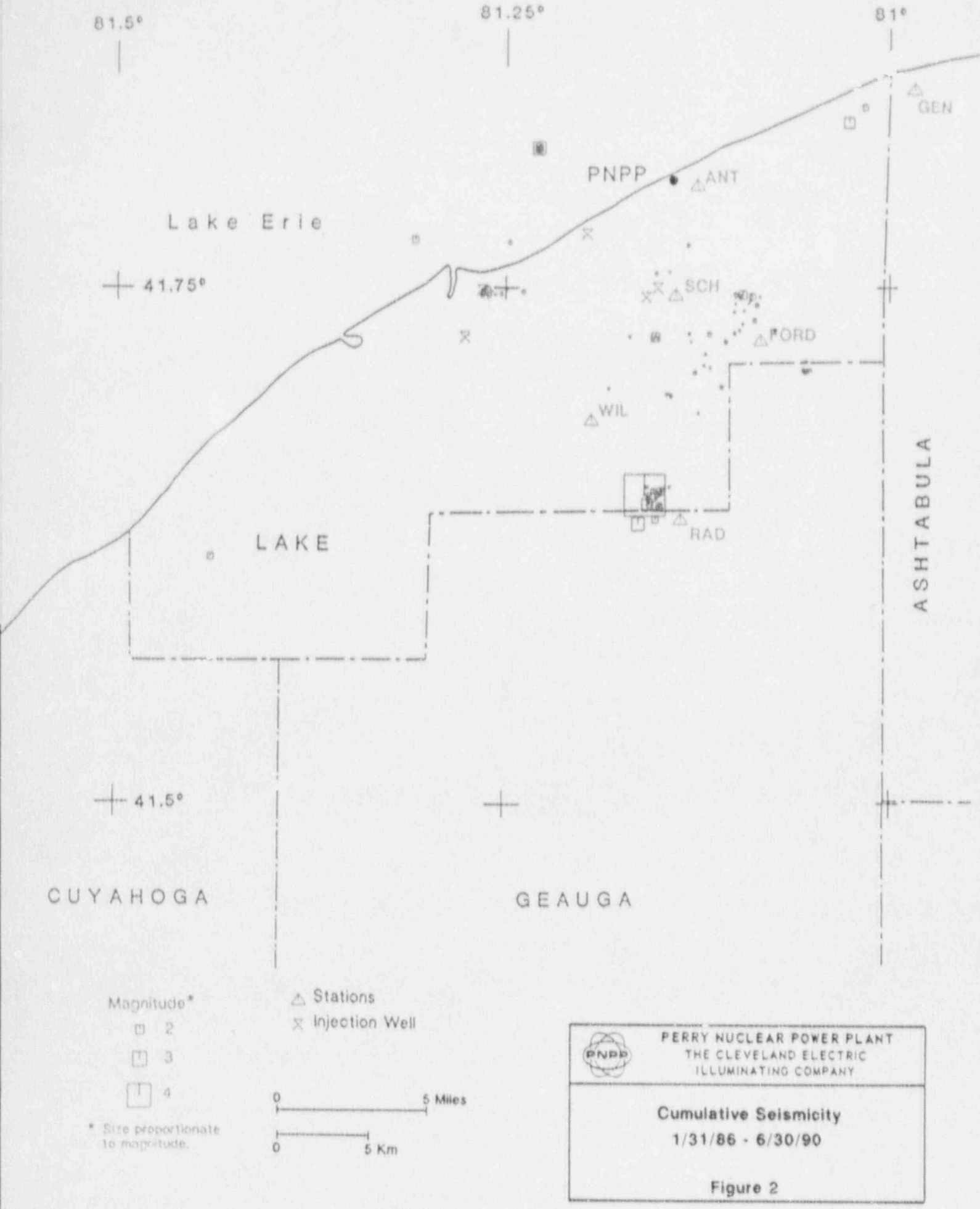
FIGURES



PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

Seismicity
Jan 1 - June 30
1990

Figure 1



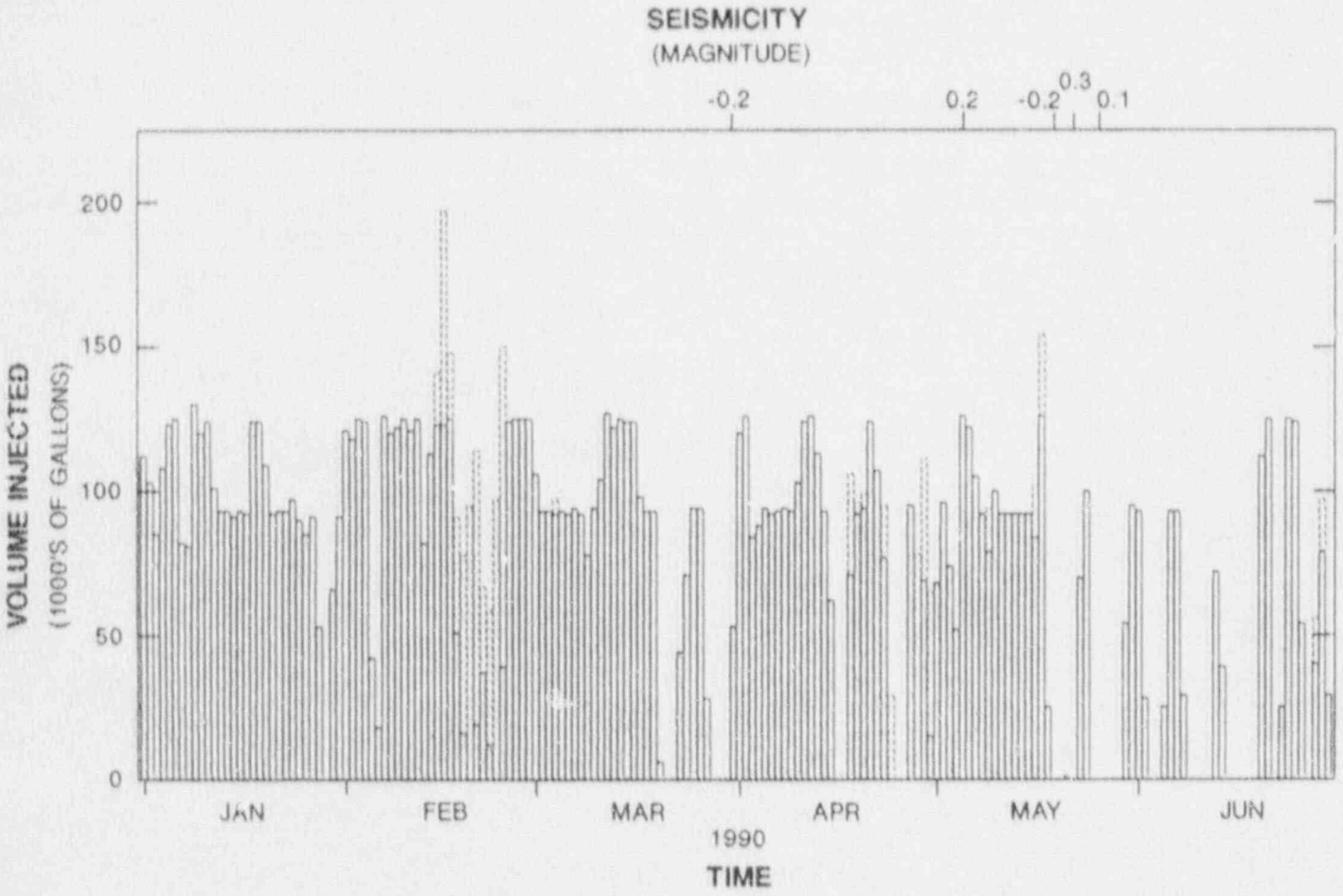
PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

Cumulative Seismicity
1/31/86 - 6/30/90

Figure 2

APENDIX A

CALHIO PRESSURE AND VOLUMETRIC INJECTION DATA



Solid lines repres. Well #1

Dashed lines represent Well #2

Data provided by ICI Americas, Perry, Ohio

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

Daily Injection Volume and Observed Seismicity 1990

Figure A-1

APPENDIX B

GAS WELL INVESTIGATIONS

APPENDIX B

GAS WELL INVESTIGATIONS

1.0 INTRODUCTION

The purpose of this investigation is to assess the potential association of microearthquake activity with gas well operations in the vicinity of the CEI seismic network in northeastern Ohio. The origin of microseismicity, recorded by the small aperture network, still remains undetermined with several potential sources under consideration. The shallow occurrence of the microevents, in an area of oil and gas field operations, suggested that the potential for induced seismicity should be evaluated. The precipitating event of the investigation was the recording of four seismic events in a previously aseismic area near Dewey Road, Madison Township, where gas well drilling operations had been recently initiated.

The occurrence of induced seismicity has been related in a number of locations around the world to high pressure waste injection wells, hard rock mining, reservoir impoundment loading, and water injection for enhanced petroleum recovery, (Healy et al., 1968; Raleigh et al., 1972; Sampson, 1976; Evans and Steeples, 1987; Pennington et al., 1986). Induced, or more appropriately, triggered earthquakes are typically small and non-destructive; however, several events exceeding magnitude 5.0 are noted, for example, events recorded at the Rocky Mountain Arsenal waste injection facility near Denver, Colorado. Seismic events occurring in association with oil and gas field operations have generally a lower magnitude (less than 3.0Mb). A typical occurrence of such activity is reported in the Gobles oil field in southwestern Ontario, in a geological environment similar to that of northeastern Ohio (Mereu et al., 1986). Although the occurrence of triggered seismicity is apparently more characteristic of high pressure injection or large-scale formation flooding for enhanced petroleum recovery, the potential for some relationship with simple gas extraction could not be ignored, particularly in light of the activity in the Gobles oil field just across Lake Erie.

Several aspects of gas well installation and operation with the potential for triggering microseismicity or generating seismic noise were evaluated. Amoung these were drilling activities, hydrofracturing, and Initial Gas Production.

2.0 METHODS OF INVESTIGATION

Available information on gas well drilling, testing, installation and operation was compiled from the Ohio Geological Survey and operators/producers. Evaluation and assessment of the information was conducted and comparisons made with the chronological and spatial occurrence of seismic events.

Available information on gas wells related to drilling, installation, development and production, relevant to recorded microseismic events included:

- Drilling dates
- Hydrofracture dates
- Hydrofracture data
- Production dates
- Initial Production (IP)

This information was obtained from well completion and production records, geophysical well logs, and well summary cards. Hydrofracture data sheets were obtained from well operators for 5 wells in the Dewey Road area of Madison Township. Well operators are reluctant to reveal information on hydrofracturing; therefore, detailed data on rock breakdown pressures and initial shut in pressures (ISIP) were not widely available.

Because of the proximity of four isolated seismic events to recently drilled gas wells (909, 952, 958, 962, and 968) in the Dewey Road area, the initial evaluation of the data base concentrated in some detail on this area. An aerial reconnaissance flight by CEI and Weston personnel confirmed the existence of recent gas well drilling operations in the general vicinity of Dewey Road. Dates of well drilling, completion, hydrofracturing and initial production were compiled for comparison with the seismic event chronology (Tables 1 and 2). These data on gas well production were also plotted on maps of the area to evaluate potentially anomalous patterns for comparison with seismicity trends (Figures 1-4).

Of the four microearthquakes observed in the Dewey area (Table 2) the last three are almost equivalent to a point source (Figure 1). The first one, on October 22, 1988 is plotted slightly to the north. A re-examination of the data suggests that this epicenter could well be with the other three, considering that it has a larger location uncertainty resulting from the fact that digital playback of the data was not possible for that event. Readings were thus made from the analog traces, with a reduced accuracy.

A similar though more general assessment of gas well and formation data was undertaken, encompassing the cluster of microseismicity observed in eastern Lake County.

3.0 RESULTS OF INVESTIGATION

Dewey Road

The aerial reconnaissance and subsequent office verification of the gas well drilling activities near Dewey Road revealed that several wells were in fact drilled close to the time of the recorded seismic activity. Data on the location, drilling, completion and hydrofracturing of the five identified wells (Table 1, Figures 1-4),shows the wells to be located approximately 1 mile northeast of the seismic events. Comparison of Tables 1 and 2 indicate that there is no exact correlation of the dates of the seismic events with dates of drilling and hydrofracturing. It should be pointed out that three wells located in the immediate vicinity of the seismic events were installed in January of 1985 (Figures 5 and 6). Although a spatial correlation is apparent, there is obviously no temporal relationship of the seismicity with well drilling dates.

Initial gas production values are obtained by measuring gas volume produced by a well over a finite time interval, typically 2-6 hours. This value is extrapolated to a 24 hour rate expressed in units of mcf or 1000 cubic feet per day. The accuracy of the reported figures may be somewhat questionable as the operators have some leeway in terms of the testing interval, which could allow for optimistic production projections, depending on the operators intentions. Despite this, the regional patterns of initial gas production are not likely to be significantly affected by this factor, because the range of observed IP values (0-6000mcf) is much greater than that which might be reasonably attributed to operator "adjustment".

IP values in the Dewey Road area range from 50 down to 15 mcf, on the low end of the regionally reported values. There is no relationship apparent of IP from the 5 recently drilled wells or any older wells in the area with the pattern of seismicity. No anomalously high IP values were found for the area.

Eastern Lake County

Evaluation of a large data base for a broader area comprising eastern Lake County included plotting of well completion dates and IP values. Large scale working figures are provided in an enclosed map pocket. No specific correspondence of well completion dates with the dates of the microseismic events was observed. Generally, wells in the vicinity of the seismicity have completion dates in 1984 and 1985, prior to installation of the seismic net. Microseismicity was not recorded until installation of the seismic net in 1986.

IP values recorded in eastern Lake County range from 0 to 6000 mcf. Consistently higher values occur in some irregularly shaped areas, for example, a large area encircles South Madison immediately northeast of the cluster of microseismicity. A small zone of several wells with IP values of 2300-5000 mcf includes microevent 10-20-86. The main cluster of microseismic activity does not correspond to any particular IP values or patterns.

4.0 CONCLUSIONS

The following conclusions are based on evaluation of the results of the investigations completed to date.

Dewey Road

Evaluation of microseismicity and gas well drilling, completion and production activities in the Dewey Road area of South Madison shows no significant spatial or temporal correlations that would indicate an induced or triggered origin for the microseismicity. First, the recently drilled wells are located approximately 1 mile northeast of the microevents. Secondly, the dates of the well drilling and completion activities, with a potential to be directly or indirectly a cause of microseismicity, in particular hydrofracturing, do not correlate with the microevent chronology. Finally, indirect indicators such as Initial Production (IP) values for the wells in the area show no anomalous patterns or trends that might indicate a causal relationship with seismicity.

If the wells are somehow involved with the seismic activity, the mechanism is not apparent from the available data. The spatial and temporal relationships, if they occur, are consequently not directly observable but rather shifted or delayed by some unknown factor.

Eastern Lake County

A more general evaluation of the potential correlation of gas well activities in eastern Lake County with the larger cluster of microevents recorded since 1986, shows no significant spatial or temporal correlations. Although a wide range of IP values is reported (0–6000mcf), the location and patterns of anomalous lows and highs is unrelated to the patterns of seismic activity. In general, the dates of well completions do not correspond to the microevent chronology. However, it is

possible that microevents were occurring in the region prior to installation of the sensitive seismic network. In addition, no specific correlations of well completions and individual microevents was noted. The possibility of a delayed response to long term gas withdrawals and formation pressure declines was not assessed because the available production data is insufficient for that purpose. Nonetheless, such a possibility should not be ruled out.

It must be realized that this investigation was limited to searching for potential correlations between the microseismicity and gas wells from a relatively limited available data base. With the exception of the limited hydrofracture dates, which represented a potential direct cause of the microevents, the typical gas well data served only as a possible indicator of a linkage between the two activities. Given the results of the investigation, with no apparent evidence of spatial or temporal relationships, the probability of a causal linkage is reduced but not eliminated.

Unresolved key components of this problem are: 1) the depth uncertainty of the microseismicity and, 2) the lack of a detailed history of individual gas well production. If the events should prove to be occurring within the Clinton formation, then a much greater probability exists that gas well activities, as yet not fully understood, are a factor in the occurrence of microseismic events. As, yet, there is no understanding of the long term influence of gas depletion on the Clinton formation and whether such depletion might contribute to the generation of microseismicity.

References

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Raleigh, C.B., Healy, J.H., Bredehoeft, 1972, Faulting and crustal stress at Rangely Colorado, Geophys. Monograph Am Geophys. Union, vol. 16, p. 275-284.

Simpson, D.W. 1976 Seismicity changes associated with Reservior loading, Engineering Geology, vol. 10, no. 2-4, p 123-150.

Table 1

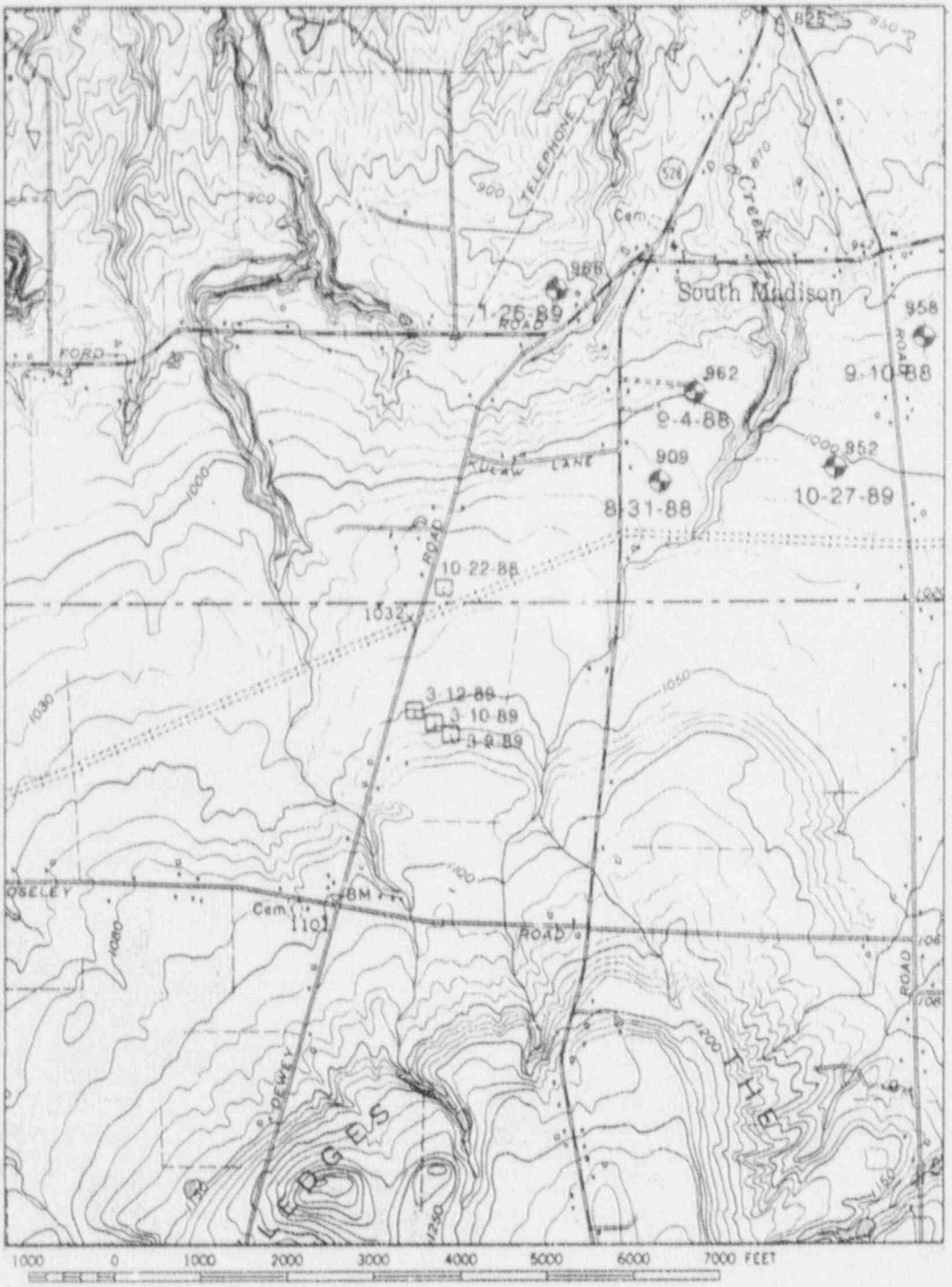
Dewey Road Gas Well Data

Well #	909	952	958	962	966
Date Drilling Commenced	8-29-88	10-19-89	9-6-88	9-2-88	1-21-89
Date Drilling Completed	8-31-88	10-27-89	9-10-88	9-4-88	1-26-89
Frac Date	9-8-88	10-29-89	9-17-88	9-12-88	2-1-89
Production Date (on-line)	2-1-89	12-7-89	11-30-88	2-1-89	5-18-89
Initial Production (IP)	50 mcf	25 mcf	50 mcf	50 mcf	15 mcf

Table 2

Dewey Road Microearthquakes

Date	Time	Lat°N	Long°W	D(Km)	M_c
1988, Oct. 22	201132.9	41.7150	81.0578	2.5	0.1
1989, March 9	033045.8	41.7105	81 0581	2.0	0.6
1989, March 10	165722.4	41.7107	81.0585	1.9	-.2
1989, March 12	192349.6	41.7113	81.0596	2.0	0.1



Basemap: U.S.G.S. 7.5 Minute Series (Topographic) Thompson, Ohio Quadrangle, 1970.

909 Gas Well

Microseismic Event

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
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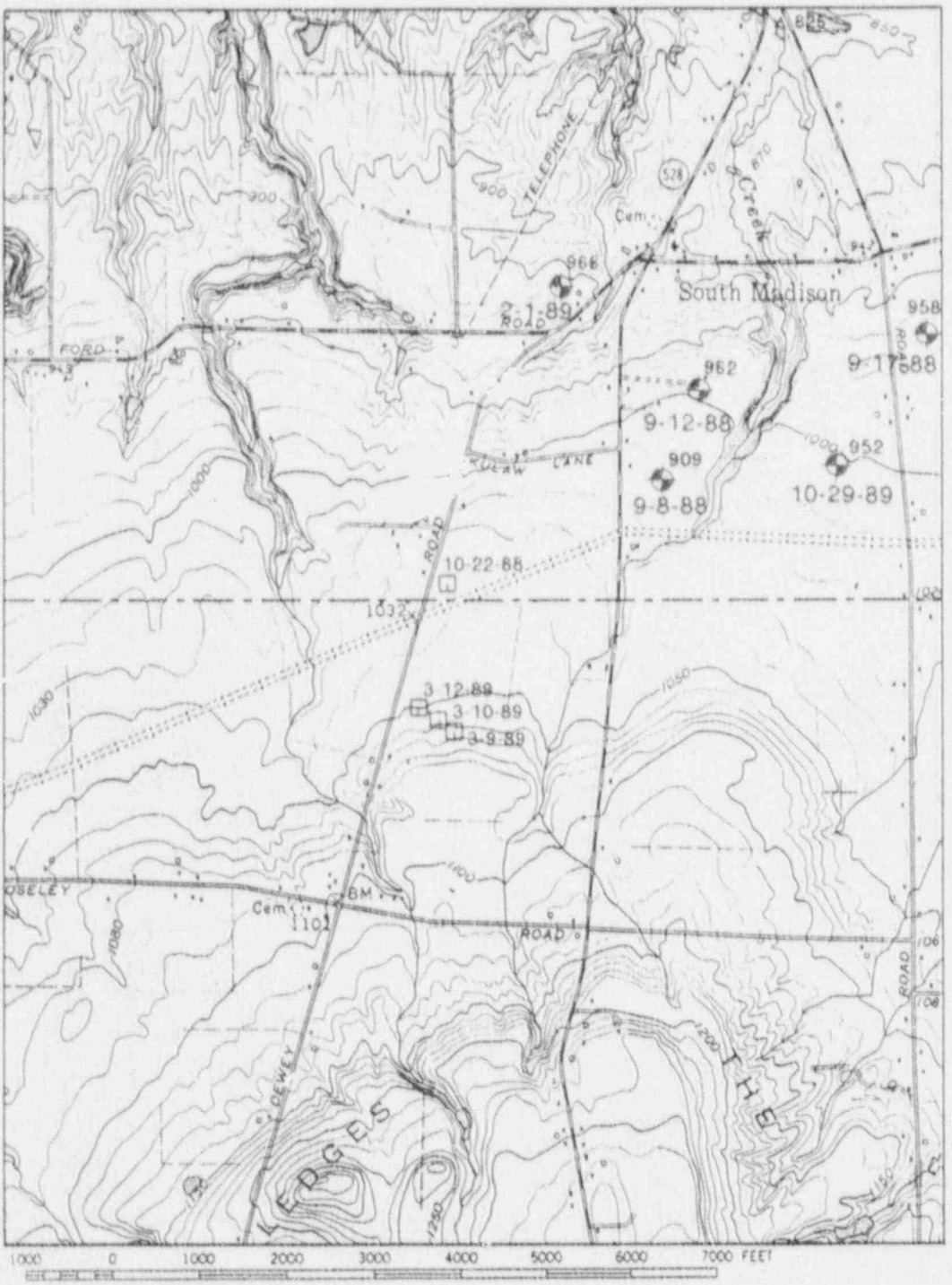
Dewey Road Gas Wells
Drilling Completion Dates

Figure B-1



Basemap: U.S.G.S. 7.5 Minute Series (Topographic) Thompson, Ohio Quadrangle, 1970.

909 Gas Well

Microseismic Event

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
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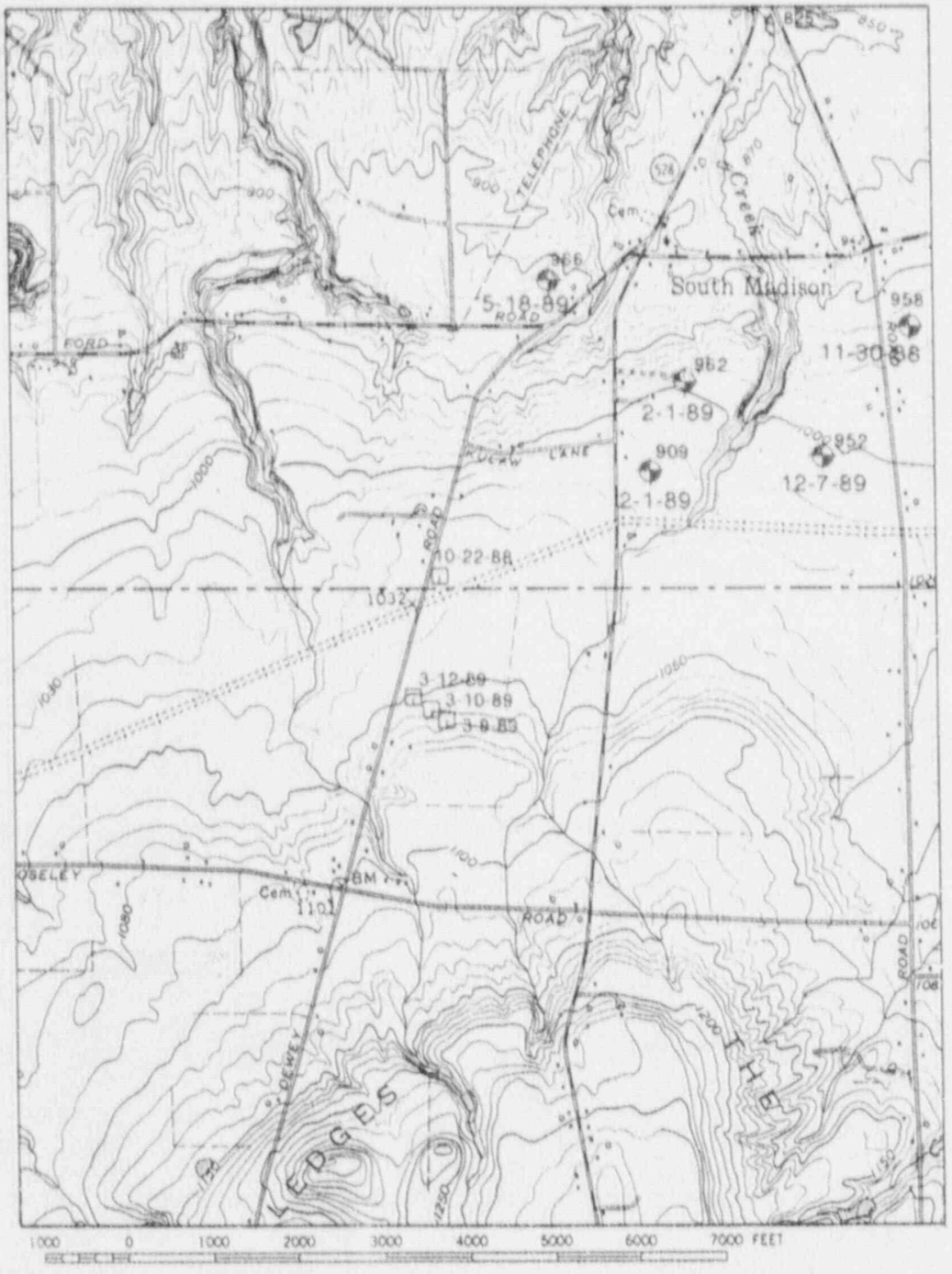
Dewey Road Gas Wells
Hydrofrac Dates

Figure B-2



Basemap: U.S.G.S. 7.5 Minute Series (Topographic) Thompson, Ohio Quadrangle, 1970.

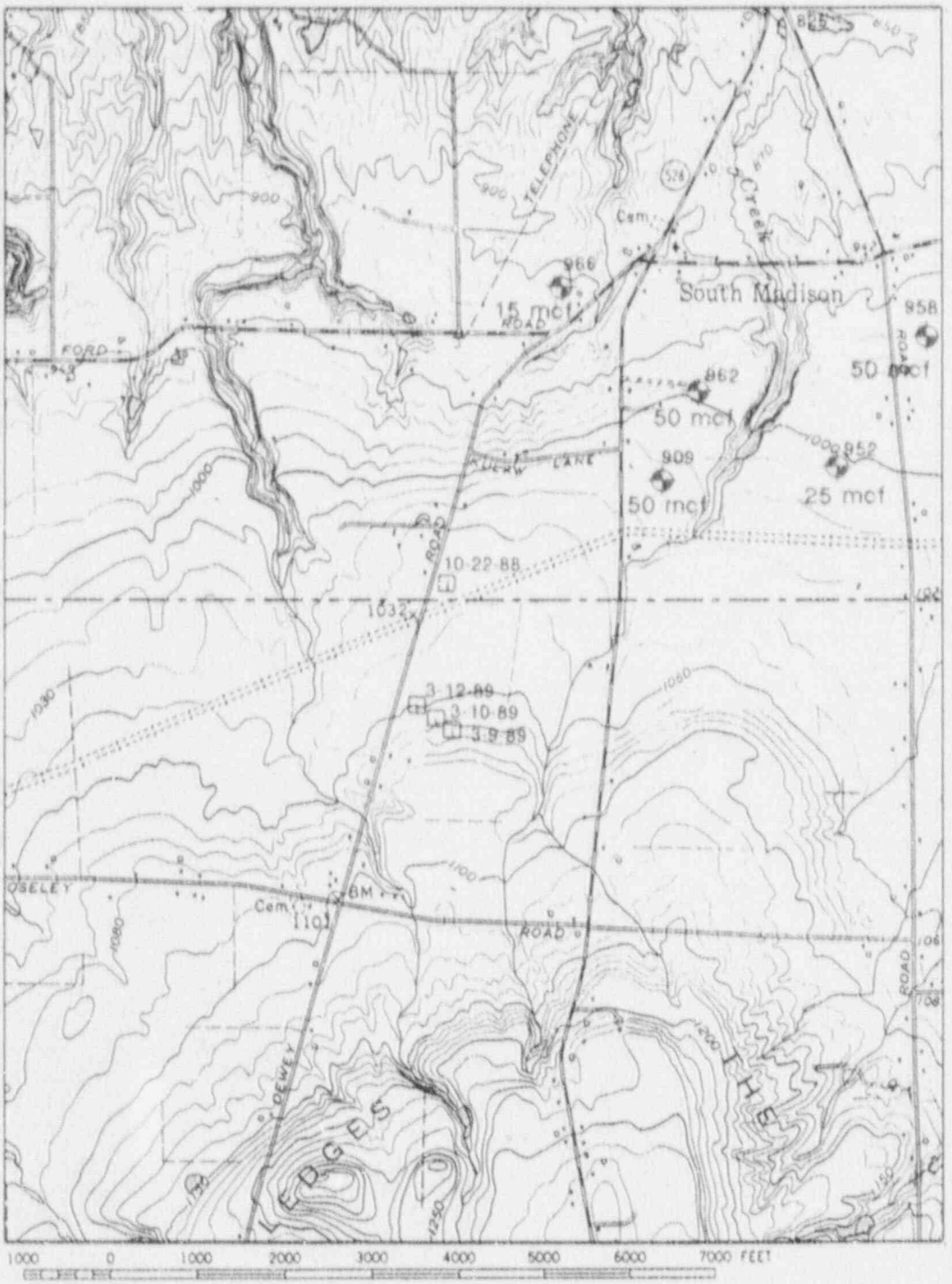
909 Gas Well

Microseismic Event

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

Dewey Road Gas Wells
Production Dates (on-line)

Figure B-3



Basemap: U.S.G.S. 7.5 Minute Series (Topographic) Thompson, Ohio Quadrangle, 1970.

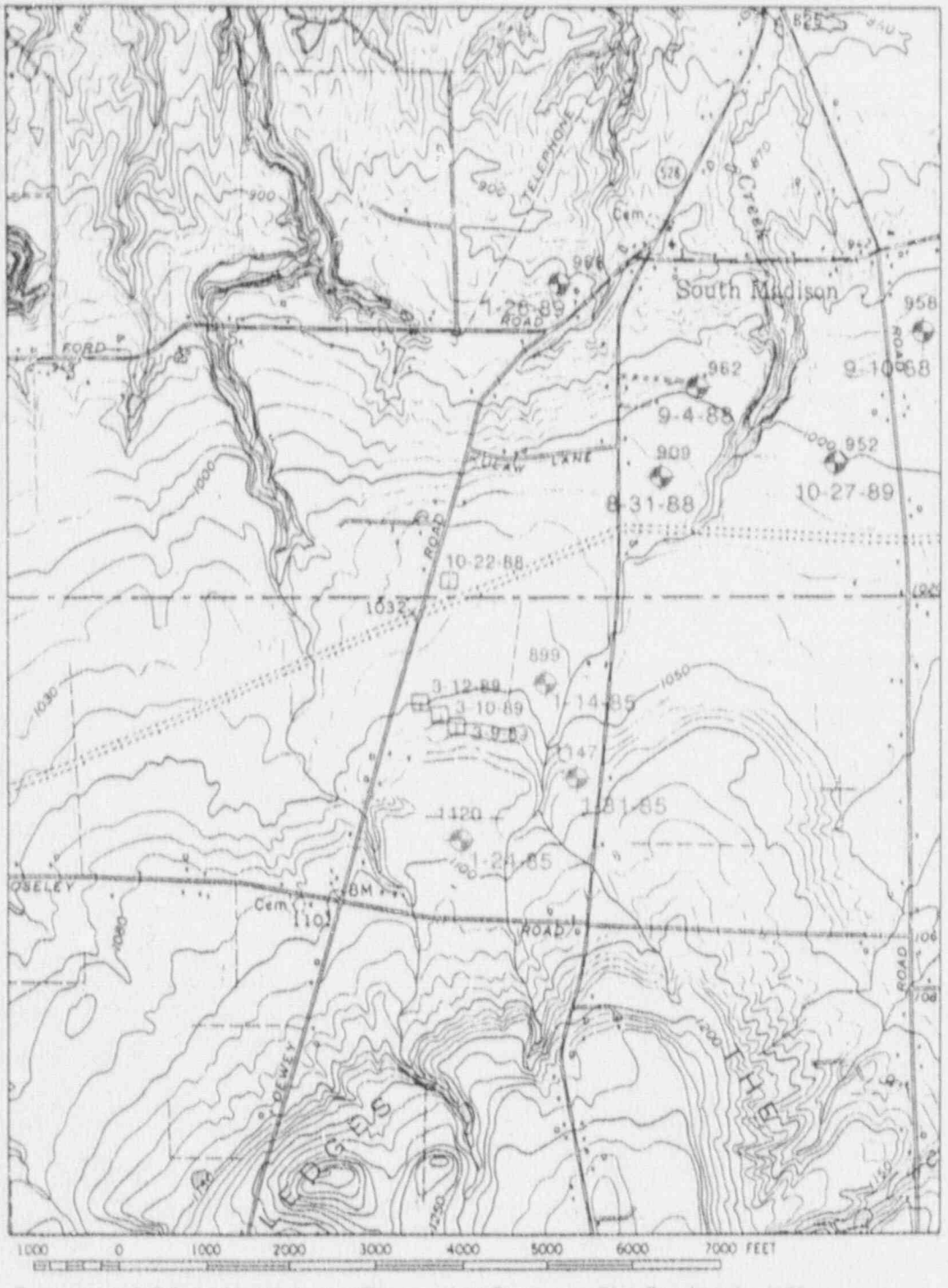
909 Gas Well

Microseismic Event

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

Dewey Road Gas Wells
Initial Gas Production (IP)

Figure B-4



Basemap: U.S.G.S. 7.5 Minute Series (Topographic) Thompson, Ohio Quadrangle, 1970.

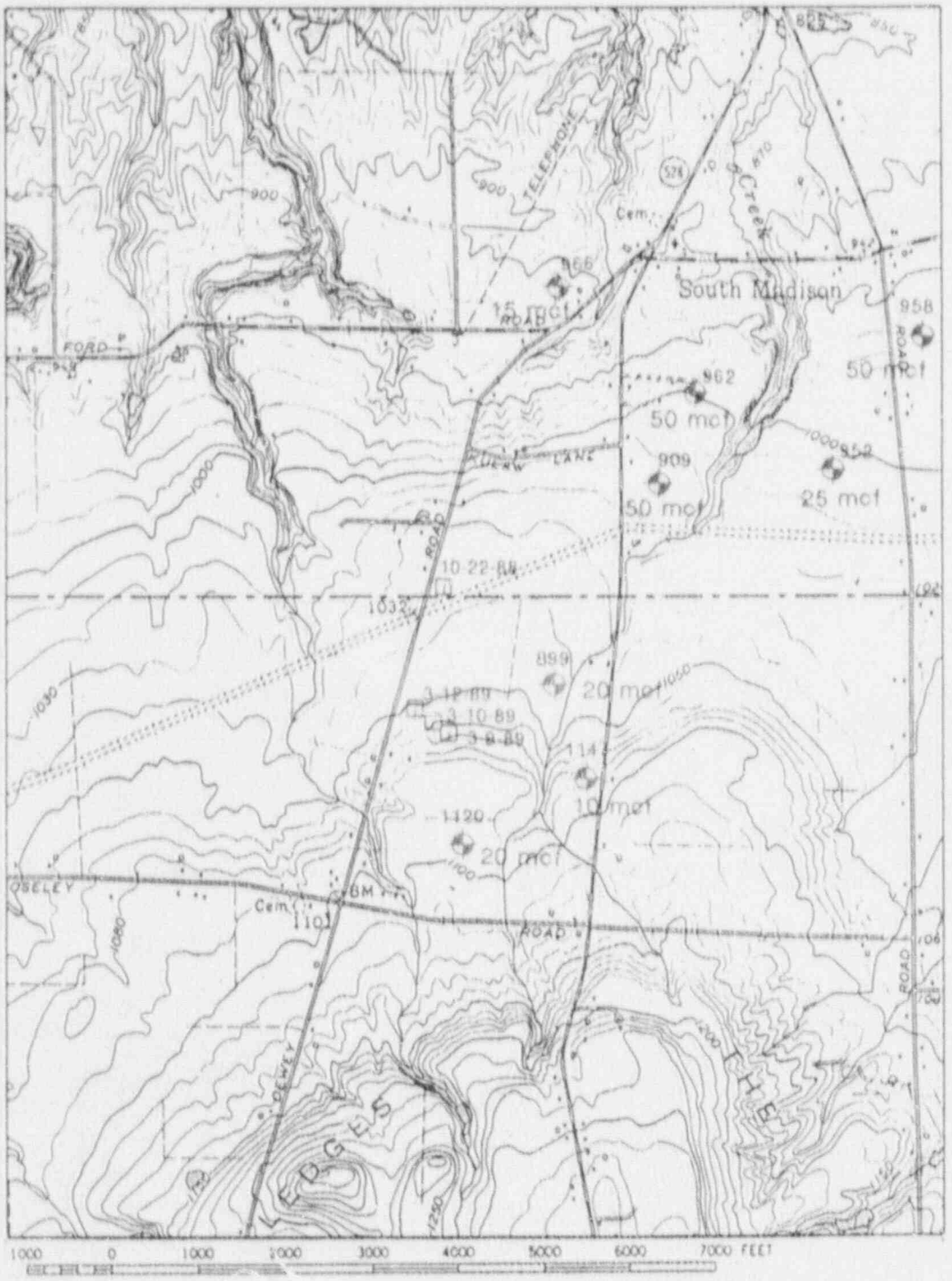
909 Gas Well

Microseismic Event

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

Additional Dewey Road Gas Wells
Drilling Completion Dates

Figure B-5



Basemap: U.S.G.S. 7.5 Minute Series (Topographic) Thompson, Ohio Quadrangle, 1970.

909 Gas Well

Microseismic Event

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

Additional Dewey Road Gas Wells
Initial Gas Production (IP)

Figure B-6

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Michael D. Lyster
Vice President - Nuclear

September 5, 1990
PY-CEI/NRR-1215 L

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D. C. 20555

Perry Nuclear Power Plant
Docket No. 50-440
Seismic Monitoring Report
Number 14

Gentlemen:

Enclosed for your information is Seismic Monitoring Report Number 14 for the CEI operated Micro-Net, which is monitoring an area in the vicinity of two waste injection wells located 3 miles south of the Perry Nuclear Plant site. This report provides data and event analysis for the period between January 1, 1990 and June 30, 1990. Since only one microevent was detected within the network aperture at the end of the 1st quarter 1990, it was decided to prepare a single report through June as enclosed. Appendix A of this report provides the volumetric data from the two Calhio (ICI America) injection wells for the same period.

Additionally, Appendix B of this report contains the findings of studies completed to assess the possible relationship between gas well production and induced seismicity in the vicinity of the CEI seismic network. This assessment of gas well influence provides additional information in our continuing effort to evaluate the nature of seismicity in the region. The results of this assessment attribute no definable influence of oil/gas operations on local seismicity, although it has occurred in other regions geologically similar.

Monitoring Results

During this reporting period, five microevents originating within the network were recorded. Three other events, originating outside the network were also recorded, one of which occurred in Northwestern Ohio, near Fostoria (M_c=3.0). None of these events have altered our interpretations on local seismicity.

Future Actions

For the immediate future CEI plans to continue operation of the local network and to complete ongoing analysis. When this analysis is complete and our assessment of the seismological activity concluded, we will provide a summary position and explore with the staff network decommissioning or reduction.

Sincerely,

Michael D. Lyster

MDL:AHL:njc

Enclosure

cc: NRR Project Manager
Sr. Resident Inspector
NRC Region III
R. Rothman