THIRTEENTH QUARTERLY REPORT
CEI SEISMIC MONITORING NETWORK
OCTOBER 1 THROUGH DECEMBER 31, 1989

Prepared for
CLEVELAND ELECTRIC ILLUMINATING COMPANY

MARCH 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 (ICI Americas, Inc.), and the epicentral area of the January 31, 1986 earthquake. This thirteenth Quarterly Report covers the monitoring period from October 1, 1989 to December 31, 1989; it also contains a review of four years of accumulated data. In addition, Appendix A provides the volumetric and pressure data from the two Calhio wells for the last four years.

2.0 SEISMIC NETWORK

During this quarter, the Automated Seismic Telemetering and Recording System (AUTOSTAR) and the GENeva station performed as reliably as usual, but nonetheless the total uptime percentage achieved (77.3%) was slightly reduced. The increased downtime, calculated in station-hour units, resulted when one remote station unit was sent back to the manufacturer to allow the reproduction and upgrade of some firmware. Instead of the expected one-week turn around, the unit was retained for sixty-three days, resulting in 11.5% downtime. The rest of the downtime was caused by telephone line problems, usually affecting station ANT.

In mid December, the high corner frequency of the system response was changed from 61 Hz to 37Hz. This modification was necessary to reduce the large amount of AC 60 Hz noise thereby improving the reading of initial phases of very small events.

3.0 OBSERVED SEISMICITY

3.1 Epicentral Area of the January 31, 1986 Earthquake

There was no microearthquake activity detected during this quarter. 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 quarter, AUTOSTAR detected one microearthquake with Mc= -0.3 within the network aperture. The standard location parameters of this October 2 event are listed on Table 1 and the epicenter is plotted on Figure 1. Station and injection well locations are also shown on the same figure. Figure 2 presents the cumulative seismicity since January 31, 1986.

3.3 Other Events Recorded by AUTOSTAR

Three other microearthquakes with Mc=0.4, 0.2, and 0.3 were detected by AUTOSTAR on October 19, December 6, and 21 respectively. The first two calculated epicenters, well outside the CEI network aperture, are located in the vicinity of Fairport Harbor near an injection well. The third event is located offshore in an area associated with salt mining and could be related to a cave-in or collapse or even blasting. CEI intends to inquire about such occurrences. Location parameters are listed on Table 2; the epicenters are shown on Figure 1.

4.0 DISCUSSION

The microseismicity observed in the area of interest during the fourth quarter is noticeably low, and does not call for any specific comment.

5.0 REVIEW OF DATA ACQUIRED THROUGH THE MONITORING PROGRAM

After several years into the monitoring program, it is appropriate to summarize the most important observations made in previous Quarterly Reports.

5.1 Epicentral Area of the January 31, 1986 Earthquake

The seismic activity in the January 31, 1986 epicentral area has been remarkably well behaved. The main shock with its magnitude 5.0 mblg had a relatively short aftershock sequence; by July 15, 1986 only fifteen events had been recorded. In 1987, there was an isolated Mc=1.8 event; three events occurred in 1988, two of

which were very small (Mc=0.1 and -0.2) and one more important Mc=2.8 on December 28. Other than the January 31, 1986 main shock, none of these events was felt by plant personnel or triggered the in-plant strong motion instrumentation. There were no events recorded in 1989. Such a temporal distribution of aftershocks is typical of moderate tectonic earthquakes in eastern U.S. and Canada. The aftershock sequence was not only constrained in time, but very tightly clustered in space, within an hypocentral ellipse approximately 2.5 x7x1 km.

The December 28, 1988 event was located at the southwestern end of the original hypocentral cluster; (see Quarterly Report #9 and Appendix B of Quarterly Report #10). Its focal depth of 5.8 km was in good agreement with the January 31, 1986 estimated depth, and the focal mechanism was very similar to the solutions obtained for the main shock and two composites of several aftershocks. An interesting feature of the December 28, 1988 event is the complete absence of aftershocks. This is in sharp contrast with another Mc=2.8 event which occurred on August 1, 1989 in Ashtabula, which had several aftershocks. In that same location, an earthquake sequence (main shock with Mc=3.6 and more than 50 aftershocks) occurred in July 1987, and was evaluated by Armbruster et al. (1987) as most probably induced by a nearby injection well. This August 1, 1989 event, also assumed to be induced, had at least thirteen aftershocks observable over a period of three days at CEI's Geneva station located about ten kilometers away. Most of the hypocenters calculated by Armbruster were shallow, just near the interface of the Paleozoic and Precambrian. Such differences in focal depth and number of aftershocks, observed between the two main shocks of January 31, 1986 at Leroy and July 13, 1987 at Ashtabula, suggest two different types of earthquakes: the natural tectonic events versus the induced ones. It supports CEI's current position that the Leroy 1986 event was not induced by the Calhio wells, ten kilometers away, but was purely tectonic.

To a large extent, these observational data now provide an answer to the original question asked by the N.R.C. in 1986, when the installation of a network covering the corridor between the Calhio wells and the epicentral area was requested: "Was the Leroy Event induced?"

At present, the Leroy activity is interpreted as caused by periodic strain releases at the corner of one of many small crustal blocks which typify the region. The concept of a small block is supported by the aftershock data of the Leroy event (WG 1986) which suggested that small events were occurring along two intersecting planes.

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

Two deep injection wells are located about 10 km north of the epicentral area of the January 31, 1986 earthquake and dispose of waste fluids at a depth of about 1.8 km. Although the distance separating the two wells and the Leroy main epicenter was relatively large compared to other classical cases of induced seismicity, several scientists including some from the USGS, (Nicholson, et. at 1988) raised the possibility that the Leroy earthquake had been caused or "triggered" by the fluid injection. Because there was a lack of supporting evidence, CEI was requested to monitor the corridor between the wells and the epicenter. Initially in 1986, this was accomplished by enlarging the coverage of the portable stations operated by Weston Geophysical during the aftershock program, and later through a telemetered network of five 3-component stations configured around the corridor, with a recording center at PNPP staffed by CEI personnel.

As time elapsed, very small events, with magnitude Mc usually less than zero, appeared rather infrequently, at the average rate of one per month. They occurred first to the southwest and to the north, then to the east and southeast of the two wells, all of them with similar shallow focal depth of about 2 km, roughly at the same interface of the Paleozoic and Precambrian rocks where injection takes place. The epicentral distribution evolved with time in a rather complex manner, giving the appearance of randomness. On Figure 3, all the events that have occurred in the general area of the wells have been plotted with a number that indicates the chronological order of occurrence shown on Table 1.

In 1986 and 1987, the microevents seemed to occur preferentially to the east of the wells, but with no clear progression in any direction, although a northeast trending cluster became apparent. Events larger than M = 1.0 were rare: one Mc = 1.3 on May 1, 1987 and one Mc = 1.8 on January 16, 1988, both at the same location. With 1988 and 1989, events began to occur to the north and also to the south of the wells, all very small except for one M = 1.9 about 2 1/2 km south of well #2. These recent events seemed to form other alignments, one trending northeast and passing through the wells and two others running east-west. Such a crisscross pattern of the seismic lineations suggests the possible existence of small blocks, which would be considered typical of the area.

As stated in QR #10, the relationship between the wells and the microseismicity remains unclear. As it can be seen in Appendix A, neither the pressure nor the volumetric injection data visually correlate with the seismic activity. A detailed examination of the volumetric throughput and well head pressure data has not provided any mathematical correlation between microevents and operating variations of the wells. Some of these events are so small that their nature becomes equivocal, possibly related to man-made activity. It still remains that a possible influence of the large volume of injected fluids on the fractured rocks constantly subjected to high compressive forces of the regional stress field cannot be ruled out at this time. The relative proximity of some of the events and similarity of their shallow focal depths with the injection depth are the two supporting elements of this hypothetical influence, the regional stresses being the primary source of the energy released. CEI considers that this low level activity presents no risk to PNPP.

An important observation made after four years of observations is the presence of an aseismic zone, which appeared early on and persisted, between the Leroy epicentral area and the cluster of microevents located east and south of the Calhio wells. Such a gap is currently interpreted as supporting the theory, maintained by CEI and later by Nicholson et. al. (1988), that the Leroy earthquake was not induced but simply natural, as also inferred in Section 5.1.

5.3 Other Events Recorded by AUTOSTAR

The seismicity discussed in Sections 5.1 and 5.2 is enclosed within AUTOSTAR's aperture and the associated location error is considered small. Because of its high sensitivity, the system also triggers on other seismic arrivals from sources outside the aperture. By sharing data with the larger aperture network of John Carroll University Observatory, several other epicenters have been located. The degree of confidence in the location varies with the size and location of the events. Figure 4 presents the station locations of both networks. Station GEN was installed in June 1989 and provides limited coverage of the Madison area since it has only a vertical component and an analog visual recorder, and is independent of AUTOSTAR.

The low level seismicity observed near Fairport Harbor (Table 2) is within the joint configuration, and as long as data are provided by the key stations MEN, SCH, and WIL, the epicentral accuracy remains fairly reliable. The large azimuthal gap

created by the Lake is probably biasing the solutions, but not by much since the distances to the stations are not large. It is possible that some of these events are causally related to the deep injection well present in the area.

Several events, the largest in June 1988 (Mc=2.7), have occurred offshore. Most likely, they are simply part of the tectonic background. The association with salt mining operations still remains hypothetical, and most likely would not apply to all events. Two other events of interest occurred on December 25, 1988 and August 11, 1989 in the vicinity of Madison-on-the-Lake. These isolated events, with Mc=2.4 and 1.2, are too far from the Calhio wells and the seismic cluster to be considered related to them. Being outside AUTOSTAR's aperture, no reliable focal depth could be obtained. At this time, these events are considered part of the natural seismic background. None of these events was felt by plant personnel or triggered the in-plant strong motion instrumentation.

Finally, CEI has attempted to verify whether gas production of recently drilled wells could account for some of the shallower microevents observed. Four recent events to the southeast of station FOR had led to this hypothesis. After reviewing data obtained from various sources, it is concluded that such causal relationship does not appear to exist. A detailed presentation of this investigation will be appended to a subsequent Quarterly Report.

6.0 CONCLUSIONS

This quarter has not been typical: less seismic activity than the average rate has been observed.

After four years of seismic monitoring, CEI has gathered valuable data and can address some of the questions raised in 1986. In the epicentral area of the Leroy January 31, 1986, the aftershock sequence has clearly come to an end. The data set suggests strongly that the event was purely tectonic, somewhat typical of other similar events observed in the Central Stable Province and also in the northeast.

A very low level of microseismic activity has been observed within five kilometers from the two CALHIO injection wells, but no causal relationship has been proven.

A detailed examination of the injection data with microevent occurrences has not provided any observable correlation between the two in the time domain. However, considering the relative proximity of some events to the wells, their shallow focal depth similar to the injection depth, and the fact that Armbruster et. al. (1987) reported induced seismicity at Ashtabula, and others at Fairport Harbor, it seems logical at this time not to rule out absolutely that induced seismicity could be responsible for some of these events. CEI considers such low level activity as presenting no risk for PNPP.

Other microearthquakes have been observed; they are infrequent and small. The explanation considered possible at this time is that of the regional seismic background.

7.0 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.

8.0 REFERENCES

Armbruster, J. G., Seeber, L., and Evans, K., 1987, The July 1987 Ashtabula earthquake ($m_b = 3.6$) sequence in northeastern Ohio and a deep fluid injection well; Seismological Research Letters, vol. 58, P.91.

Nicholson, C., Roeloffs, E. and R.L. Wesson, 1988, The Northeastern Ohio Earthquake of 31 January, 1986: Was it induced?, Bulletin of the Seismological Society of America, vol. 78, p. 188-217.

Weston Geophysical , 1987, Investigations of Confirmatory Seismological and Geological Issues - Northeastern Ohio Earthquake of January 31, 1986. Prepared for CEI.

TABLES

Table 1

MICROEARTHQUAKES INSIDE THE MICRONET APERTURE OR IN THE IMMEDIATE VICINITY (1986-1989)

NO.	YEAR	MODY	HRMISEC	LAT.N	LONG.W	D	RMS	EH	EZ	NP	NS	GAP	MC	SO	TR.NO.
1.	1986	0312	085526.6	41.7272	81.1707	2.0	0.06	0.7	0.4	10	6	216	-.3	GS	
2.	1986	0928	103604.2	41.7247	81.1091	2.3	0.04	0.3	0.4	11	6	174	.3	WG	
3.	1986	1020	105944.7	41.7587	81.1453	3.0	0.07	1.7	2.0	6	4	337	-.6	WG	
4.	1986	1027	122555.5	41.7435	81.0944	2.9	0.07	2.7	1.5	6	3	221	-.2	WG	
5.	1986	1103	085449.6	41.7098	81.1292	1.8	0.06	0.5	0.5	7	5	145	.3	WG	
6.	1986	1201	050317.5	41.7120	81.1195	2.1	0.07	0.6	5.8	7	5	188	-.2	WG	
7.	1987	0102	024114.8	41.7472	81.1027	2.0	0.06	0.3	0.5	10	6	174	.6	WG	
8.	1987	0128	235829.8	41.7399	81.0974	2.1	0.03	0.4	0.7	8	5	199	-.7	WG	
9.	1987	0223	114556.4	41.7284	81.1197	2.0	0.03	0.1	0.3	10	7	100	.5	WG	
10.	1987	0228	204644.5	41.7451	81.0932	2.4	0.07	1.0	1.7	7	4	239	-.4	WG	
11.	1987	0501	211332.3	41.7466	81.0872	1.9	0.06	0.3	0.2	7	4	196	-.6	WG	
12.	1987	0501	211352.1	41.7466	81.0921	2.4	0.08	0.2	0.8	15	9	100	1.3	WG	363
13.	1987	0502	183307.7	41.7475	81.0932	2.0	0.02	0.1	3.0	6	4	174	-.6	WG	
14.	1987	0502	202526.5	41.7424	81.0889	2.7	0.08	0.3	0.6	14	8	115	.4	WG	366
15.	1987	0708	034835.2	41.7392	81.1037	2.7	0.07	0.7	1.1	8	5	166	-.2	WG	
16.	1987	0815	052637.7	41.6994	81.1472	2.8	0.06	0.2	1.0	10	6	133	-.1	WG	1061
17.	1987	1010	000610.4	41.7430	81.1030	1.9	0.04	0.3	0.2	7	5	166	-.6	WG	
18.	1987	1014	195924.8	41.7250	81.1318	3.4	0.04	1.6	0.7	6	3	190	-.7	WG	
19.	1987	1122	024918.9	41.6989	81.1447	2.2	0.04	0.2	3.8	9	5	120	-.1	WG	1720
20.	1988	0116	222403.	*41.747	81.098						2		-.6	WG	
21.	1988	0116	223010.	*41.747	81.098						3		-.6	WG	
22.	1988	0116	231704.4	41.7474	81.0981	2.0	0.05	0.5	0.3	9	5	185	1.8	WG	1879
23.	1988	0117	024821.7	41.7467	81.0997	1.9	0.06	0.5	0.3	10	5	180	0.5	WG	1881
24.	1988	0117	092236.	*41.747	81.098						3		-.6	WG	
25.	1988	0117	092400.	*41.747	81.098						2		-.6	WG	
26.	1988	0117	131551.	*41.747	81.098						2		-.6	WG	
27.	1988	0205	155837.0	41.7351	81.0907	2.0	0.04	0.4	0.2	10	5	195	0.5	WG	1971
28.	1988	0820	005423.1	41.7026	81.1121	2.4	0.05	0.2	1.6	8	4	162	-.2	WG	3011
29.	1988	0927	154639.1	41.7716	81.1334	3.2	0.03	0.2	0.3	11	6	292	0.1	WG	3076
30.	1988	1022	201132.9	41.7150	81.0578	2.5	0.06	0.3	0.7	13	7	193	0.1	WG	3138
31.	1988	1031	063428.7	41.7290	81.1035	2.1	0.04	0.2	0.5	10	5	120	.0	WG	3412
32.	1988	1103	190335.4	41.7133	81.1232	2.1	0.05	0.2	7.9	9	5	126	-.2	WG	3437
33.	1988	1205	055514.9	41.7578	81.1538	2.4	0.06	0.5	0.7	7	4	279	0.0	WG	3525
34.	1989	0103	120244.5	41.7287	81.1328	2.1	0.06	0.2	11.0	8	5	226	-.1	WG	3623
35.	1989	0130	032527.0	41.7018	81.1846	2.0	0.04	0.4	18.2	10	6	182	-.2	WG	3661
36.	1989	0130	185020.8	41.7334	81.0983	2.0	0.04	0.2	0.4	11	5	155	-.2	WG	3663
37.	1989	0309	033045.8	41.7105	81.0581	2.0	0.04	0.2	15.1	13	8	187	0.6	WG	3719
38.	1989	0310	165722.4	41.7107	81.0585	1.9	0.04	0.2	0.1	10	6	186	-.2	WG	3725
39.	1989	0312	192349.6	41.7113	81.0596	2.0	0.04	0.2	13.2	13	8	185	0.1	WG	3729
40.	1989	0322	201335.9	41.7269	81.1545	2.1	0.03	0.1	1.4	16	9	119	1.9	WG	3770
41.	1989	0530	142039.6	41.7188	81.1223	2.1	0.04	0.1	3.0	7	4	115	-.4	WG	3953
42.	1989	0719	085451.1	41.7261	81.1542	2.1	0.05	0.1	2.0	16	8	161	.9	WG	4132
43.	1989	1002	071123.5	41.6981	81.1447	2.2	0.04	0.2	4.7	8	5	163	-.3	WG	4415

* Indicates location by inference

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Table 2

MICROEARTHQUAKES OUTSIDE THE CEI MICRONET APERTURE

YEARMODY	HRMISEC	LAT.N	LONG.W	D	RMS	EH	EZ	NP	NS	GAP	MC	LOCATION	TR.NO
19861224	093733.9	41.7487	81.2392	1.0	0.04	8.5	6.7	6	3	306	0.3	FAIRPORT H.	
19870228	113833.8	41.6200	81.4400	2.5	0.10	0.5	4.9	13	8	247	1.4	WILLOUGHBY	
19870618	103057.3	41.5146	80.3859	3.0	0.80	1.4	23.	13	7	345	2.7	NW. PA	725
19870713	054917.8*	41.9030	80.7380								3.6	ASHTABULA	805
19871219	115600.0	41.9030	80.7380								2.0	ASHTABULA	1807
19871225	082800.0	41.9030	80.7380								2.2	[illegible]BULA	1822
19871229	072226.9	41.7485	81.2640								1.2	FAIRPORT H.	1832
19880331	163000.	41.3140	81.0480								2.8	NELSON,OH	2599
19880420	165127.9	41.7738	81.3085	3.3	0.05	0.2	2.0	16	10	221	1.4	OFFSHORE	2652
19880627	044631.3	41.8180	81.2293	2.2	0.06	0.2	7.4	22	11	239	2.7	OFFSHORE	2812
19880627	044700.0	41.8180	81.2293								0.2	OFFSHORE	
19880627	044826.0	41.8180	81.2293								1.7	OFFSHORE	2813
19880627	065500.0	41.8180	81.2293								-.1	OFFSHORE	
19880627	072940.0	41.8180	81.2293								1.3	OFFSHORE	2814
19880627	082908.0	41.8180	81.2293								0.7	OFFSHORE	2815
19880722	160902.1	41.7575	81.2496	2.1	0.05	0.4	19.	10	5	274	-.1	FAIRPORT H.	2900
19880930	172556.9	41.7500	81.2500	1.9	0.02	2.8	2.2	6	4	306	0.1	FAIRPORT H.	3081
19881225	021124.9	41.8305	81.0296	1.1	0.03	1.0	0.8	13	9	299	2.4	MADISON	3610
19890325	233507.9	41.7468	81.2653	2.2	0.06	0.3	15.	14	9	115	0.3	FAIRPORT H.	3786
19890615	164751.6	41.7475	81.2570	2.0	0.04	0.3	17.	11	6	278	0.4	FAIRPORT H.	4023
19890721	052202.4	41.7485	81.2595	1.7	0.03	0.7	0.5	9	5	280	0.2	FAIRPORT H.	41[illegible]
19890801	161248.6	41.89	80.75								2.8	ASHTABULA	4170
19890801	165030.6	41.89	80.75								2.9	ASHTABULA	4171
19890802	004459.0	41.89	80.75								2.2	ASHTABULA	4175
19890803	040752.0	41.89	80.75								2.2	ASHTABULA	4185
19890811	115354.3	41.8378	81.0192	2.0	0.03	0.3	14.	9	5	320	1.2	MADISON H.	4211
19891019	224300.5	41.7462	81.2612	2.0	0.03	0.2	0.2	13	7	182	0.4	FAIRPORT H.	4458
19891206	123613.3	41.7476	81.2533	2.0	0.05	0.4	24.	10	6	276	0.2	FAIRPORT H.	4522
19891221	153915.4	41.7726	81.2477	2.2	0.04	0.6	20.	6	5	352	0.3	FAIRPORT H.	4600

* This event had more than 50 aftershocks. See Armbruster et al. 1987.

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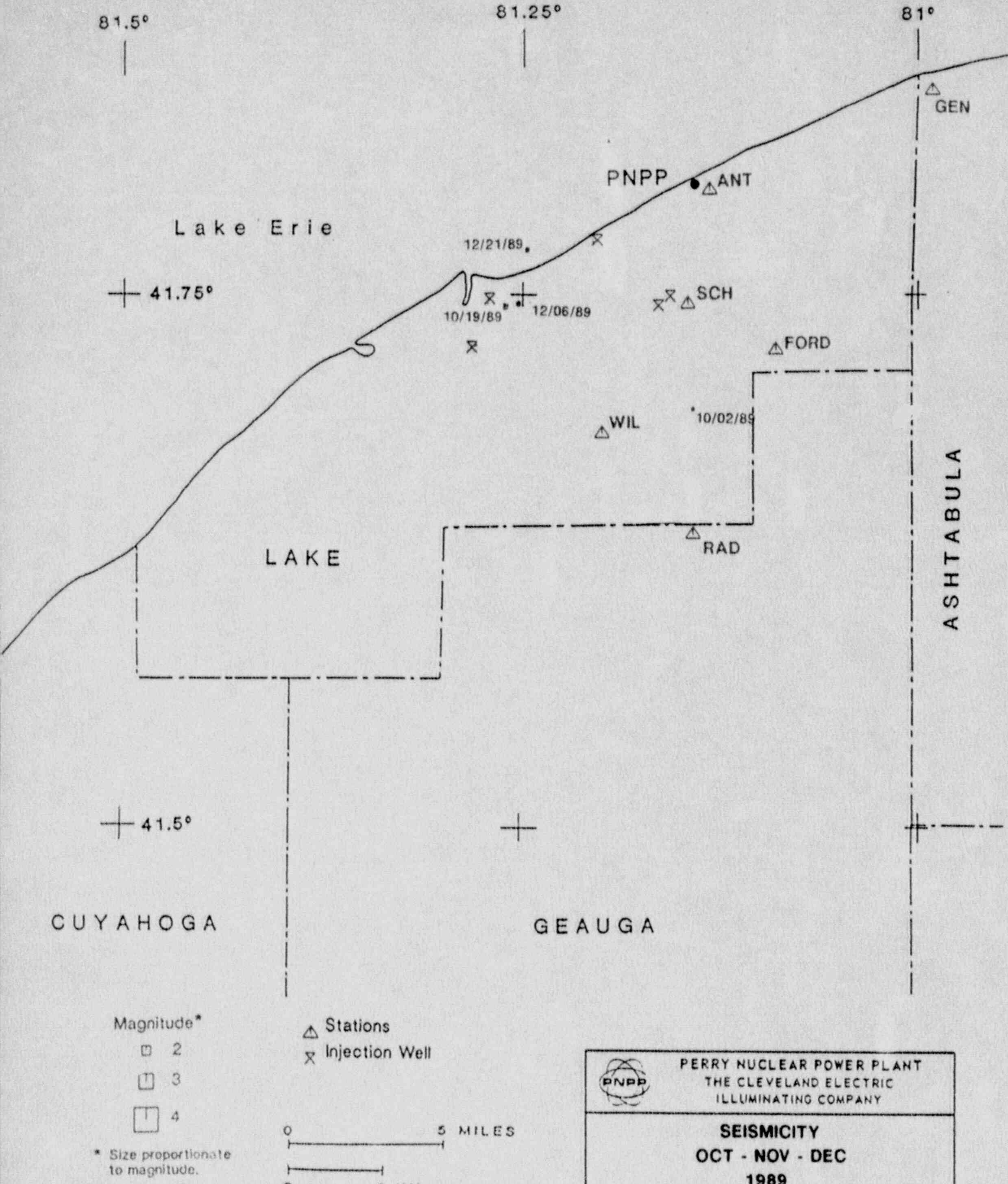
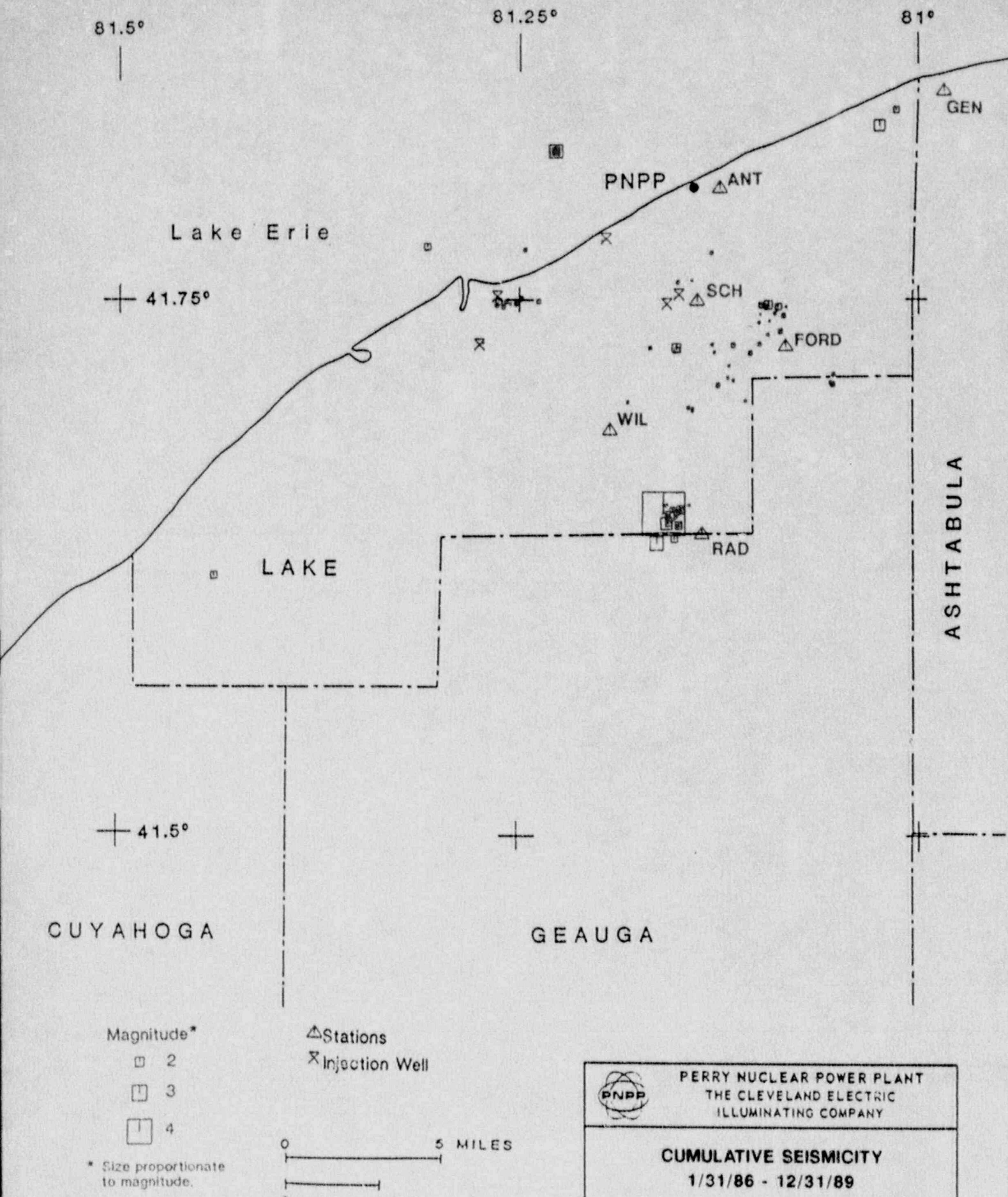
FIGURES



PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

SEISMICITY
OCT - NOV - DEC
1989

Figure 1



PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

CUMULATIVE SEISMICITY
1/31/86 - 12/31/89

Figure 2

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
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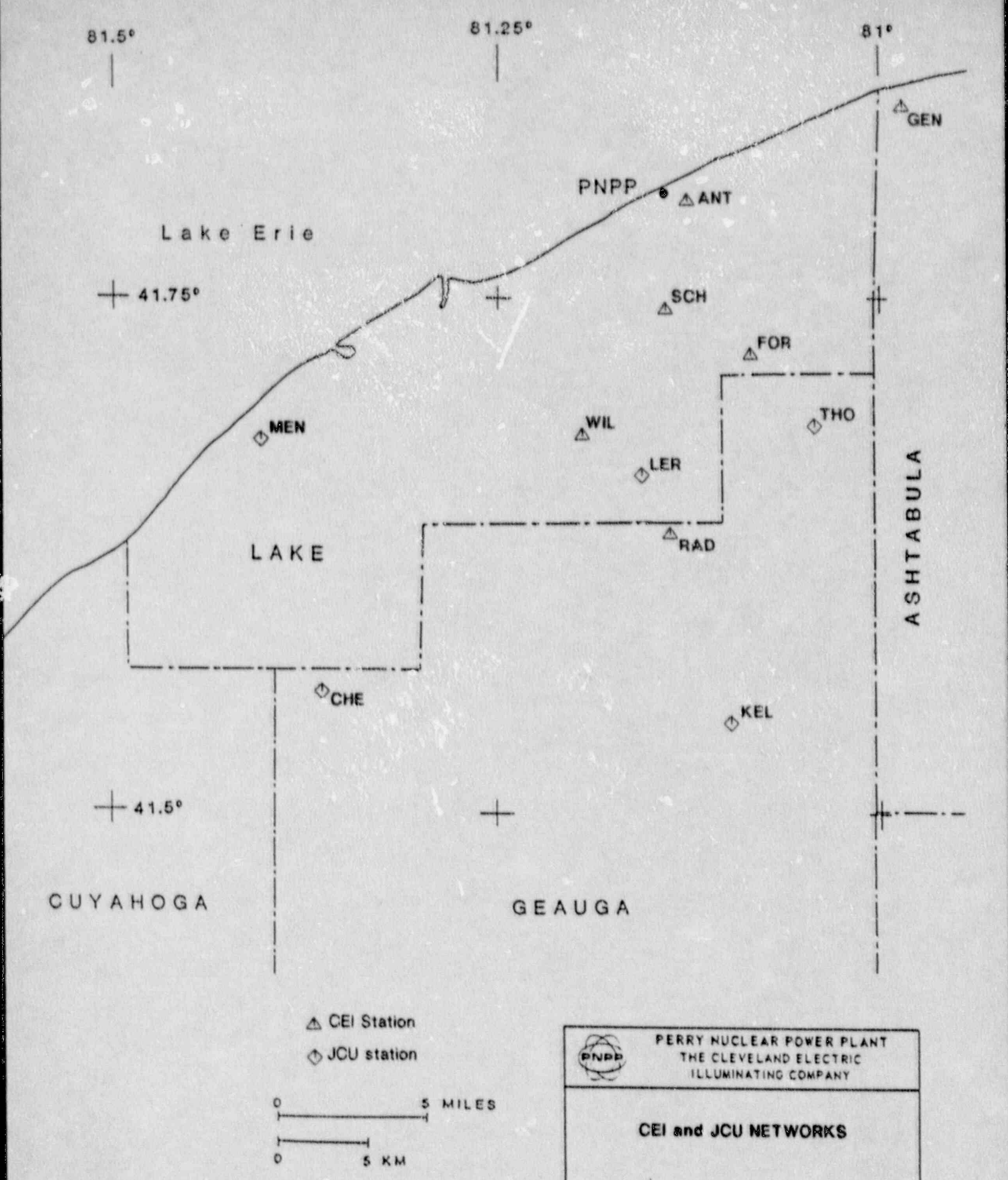
CHRONOLOGICAL ORDER OF MICROEVENT OCCURRENCES

Figure 3



PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
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CEI and JCU NETWORKS

Figure 4

APPENDIX A

APPENDIX A

CEI continues to investigate the possibility that deep fluid injection carried out by Calhio could induce local seismic activity. In this context, volumetric and pressure data have been examined versus observed seismicity. This Appendix presents in an improved format all the data collected for the years 1986 to 1989.

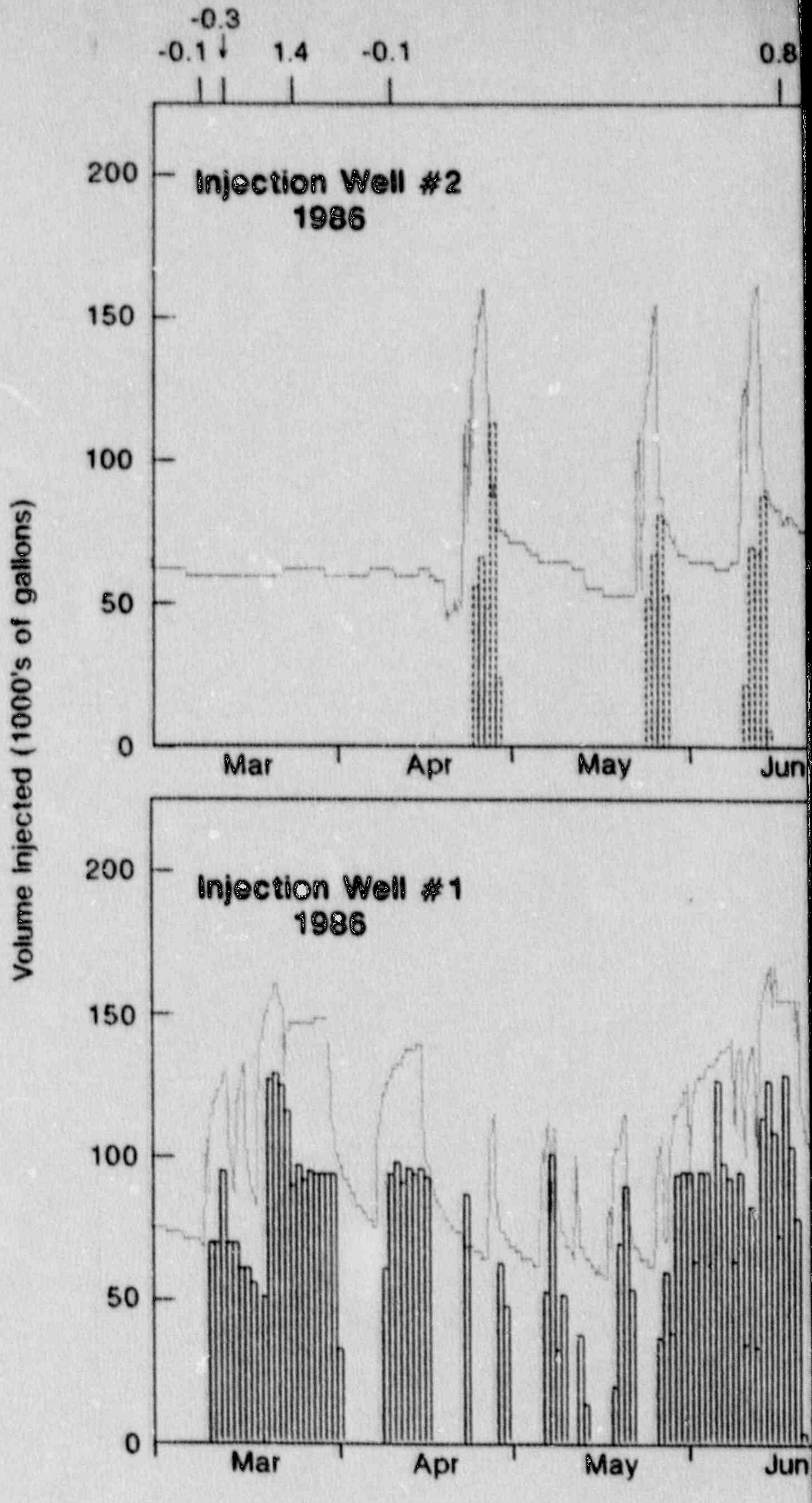
To illustrate their close relationship in time, both the pressure and volumetric data have been superposed on a single graph. By placing the data sets for wells 1 and 2 separately but on the same page (Figures 1a to 4a), the temporal distribution of either simultaneous or alternate usage of the two wells is clearly illustrated. On Figures 1b to 4b, the cumulative volumetric input for each day is shown with the two pressure histories. The observed seismicity in terms of Mc magnitude is presented on both sets of figures.

The following observations were made:

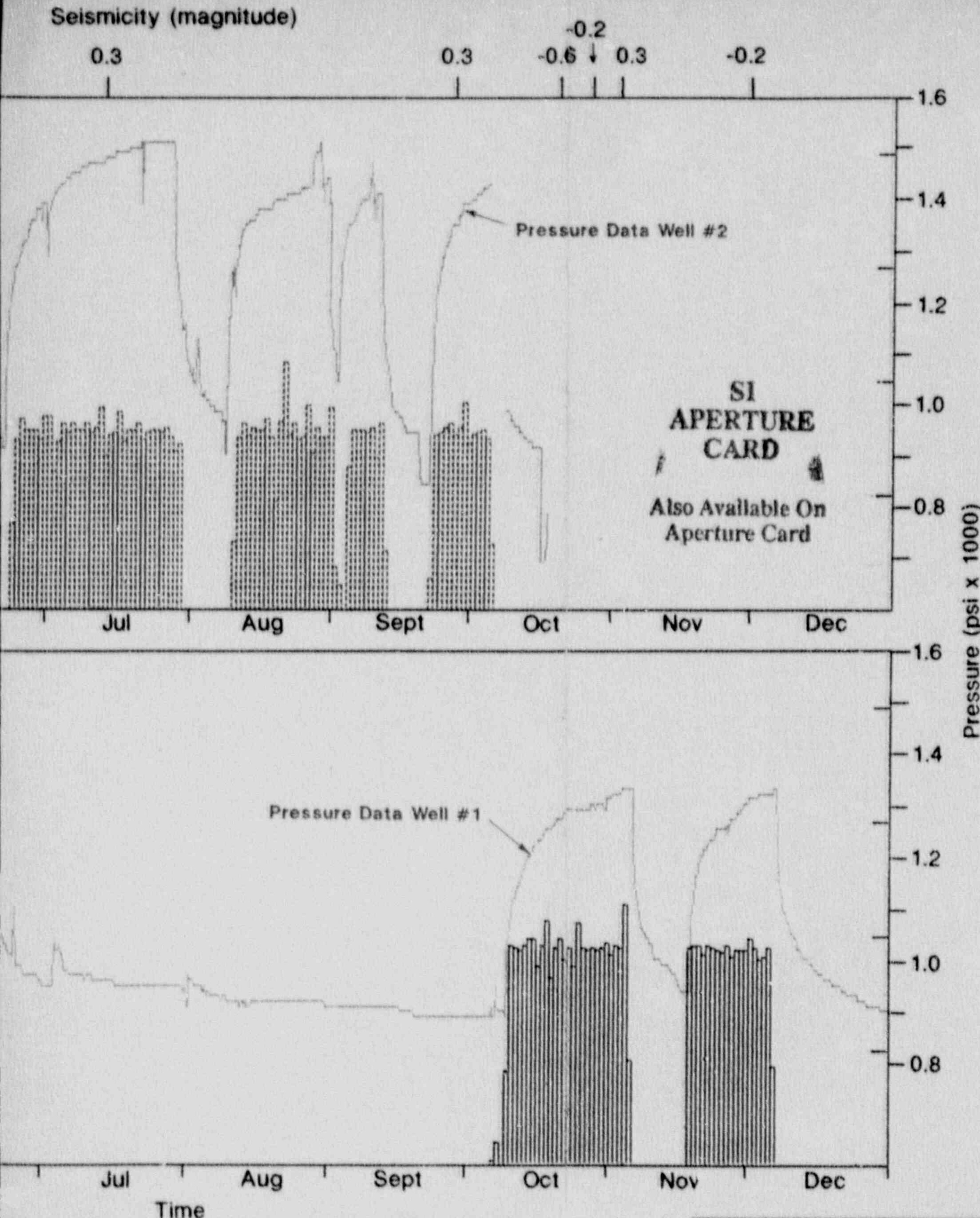
1. In general, the pressure read 4 times a day is in good agreement with the volumetric input reported once a day. Rises to maximal pressure are time dependent, i.e. several days are needed before full pressure is achieved.

2. For comparatively similar input volumes, well #1 requires a slightly lower maximal pressure than well #2.

3. As shown in Figures 1b to 4b the volumetric injection data constitute a monotonous function, almost continuous, with a relatively steady level or amplitude. By contrast, the function describing the seismic histogram is rather discontinuous and diverse in amplitude. No direct temporal correlation between injection volumes and seismic occurrences have yet been found, i.e. a one-to-one correspondence between injection periods and microearthquakes. This would imply that any influence, if it exists, is simply related to the reservoir action of the water injection in general rather than to single inputs.



Injection values provided by ICI AMERICAS, INC.

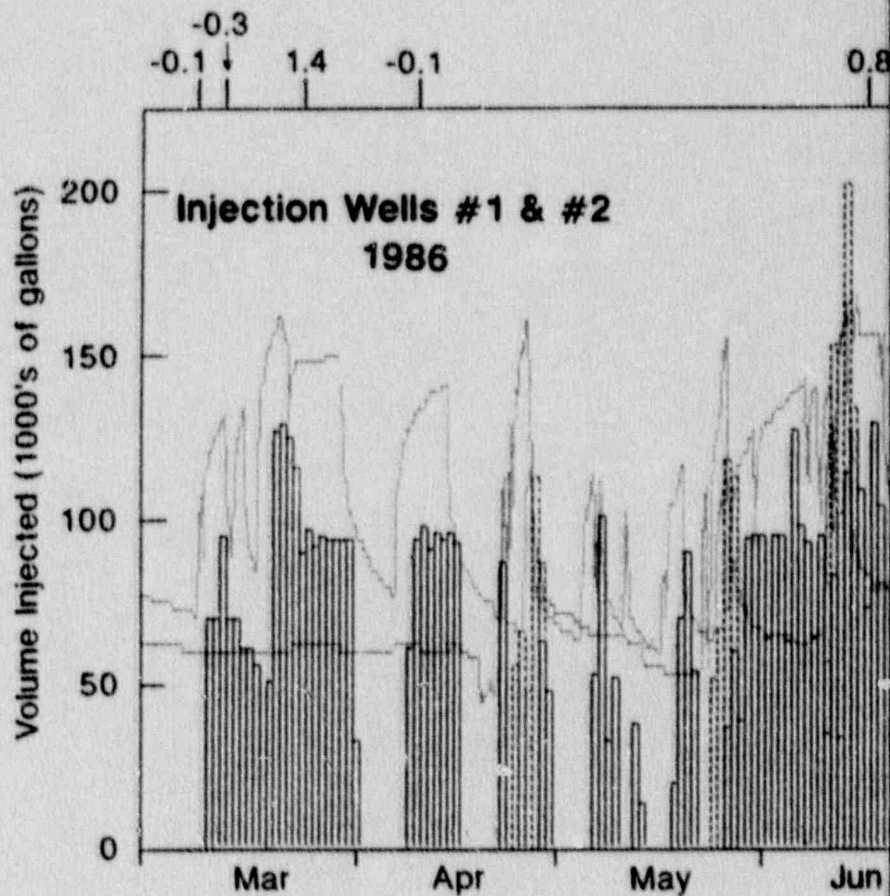


9004230314-01

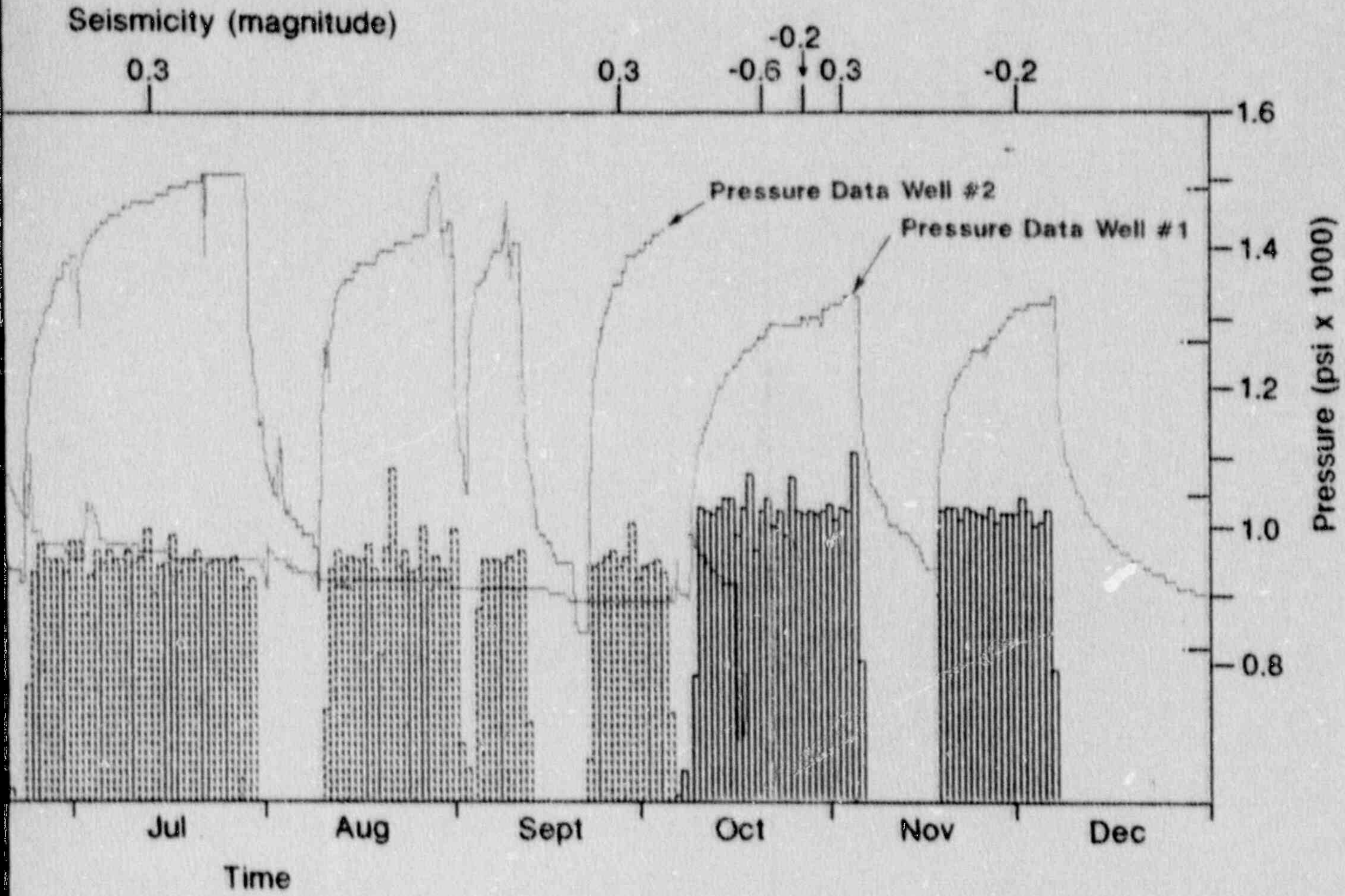
PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

INJECTION DATA AND SEISMICITY
WELLS #1 AND #2
1986

Figure A1a



Injection values provided by ICI AMERICAS, INC.



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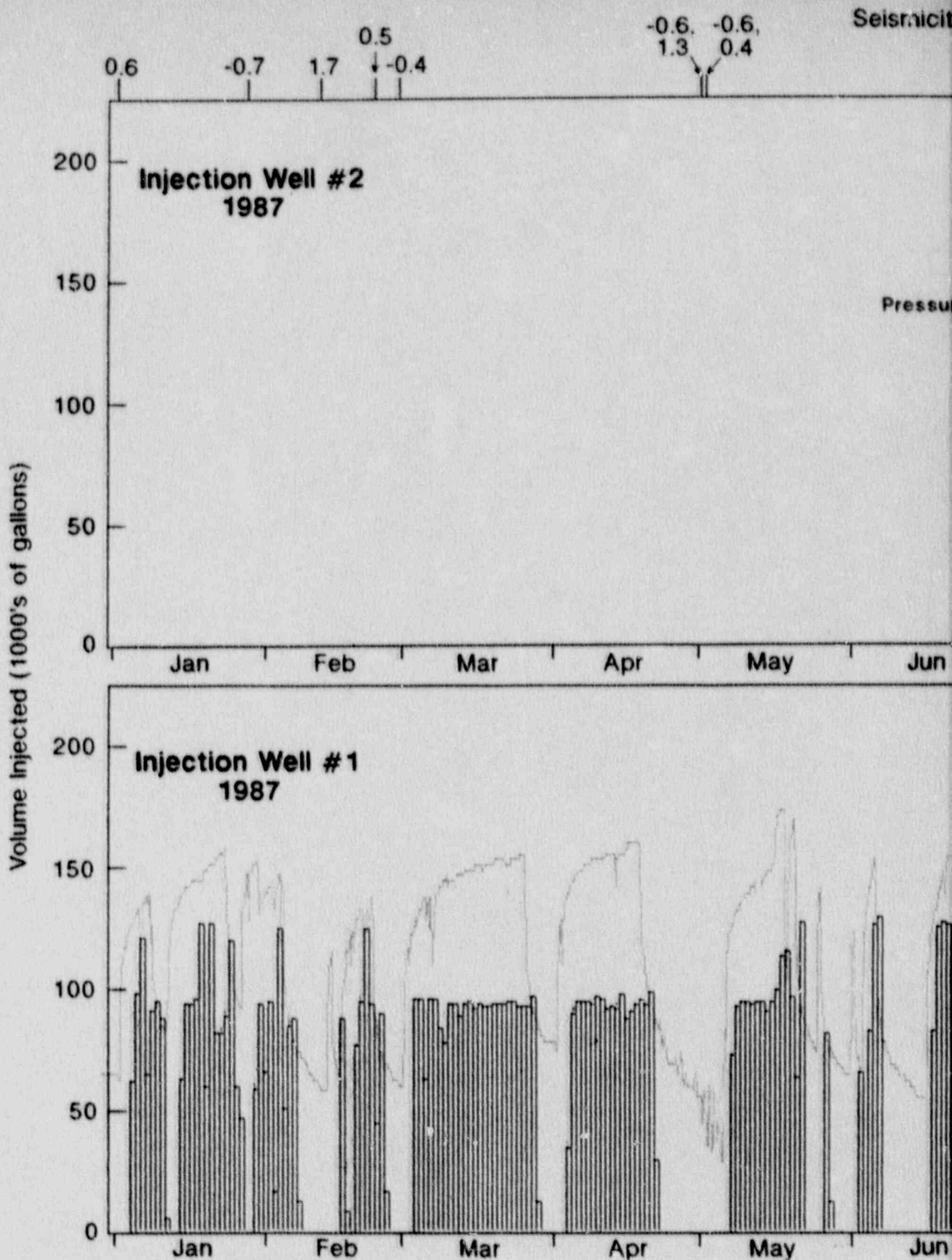
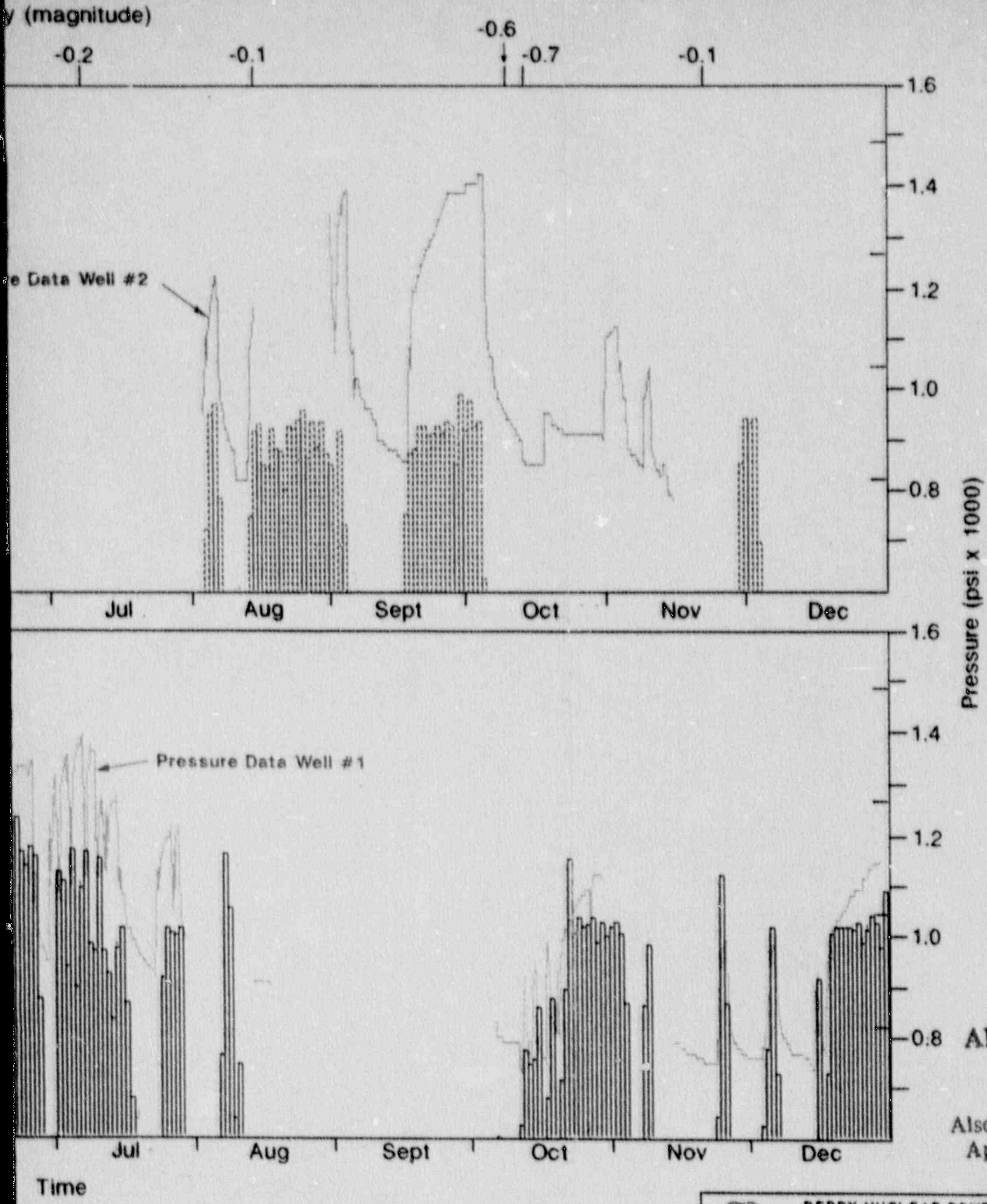
INJECTION DATA AND SEISMICITY WELLS #1 AND #2 SUPERPOSED 1986

Figure A1b



Injection values provided by ICI AMERICAS, INC.



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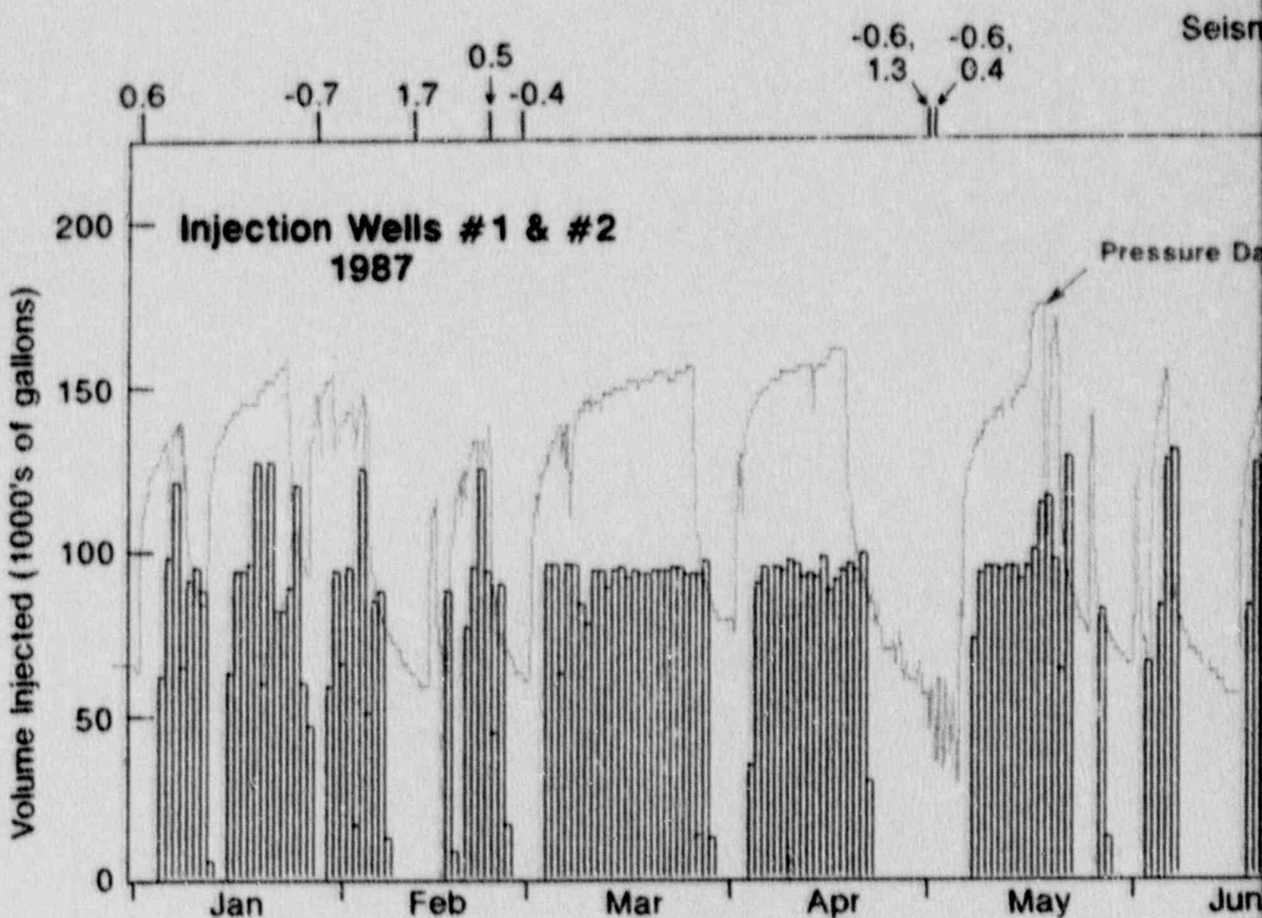
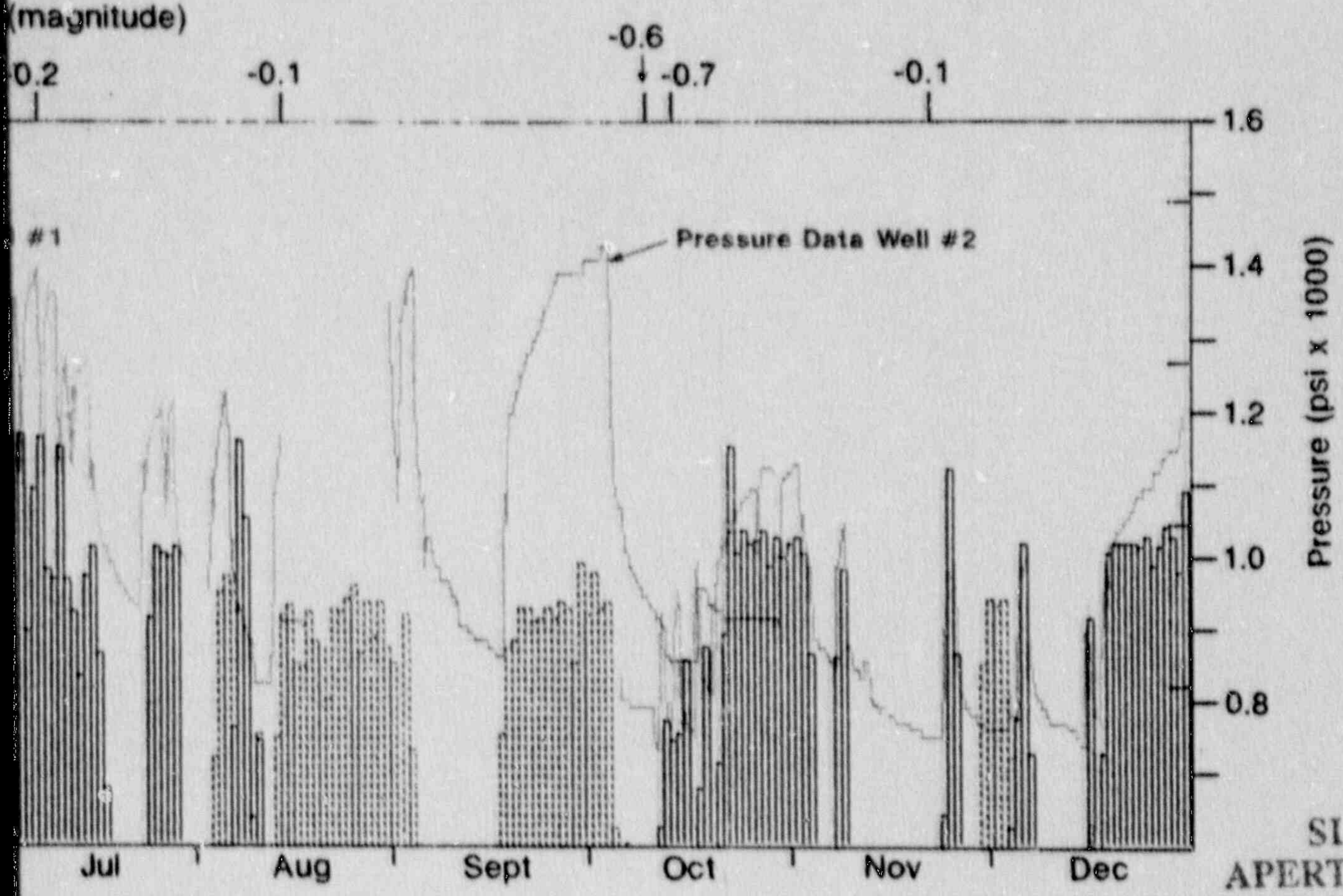
INJECTION DATA AND SEISMICITY
WELLS #1 AND #2
1987

Figure A2a

9004230314-03



Injection values provided by ICI AMERICAS, INC.



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PERRY NUCLEAR POWER PLANT
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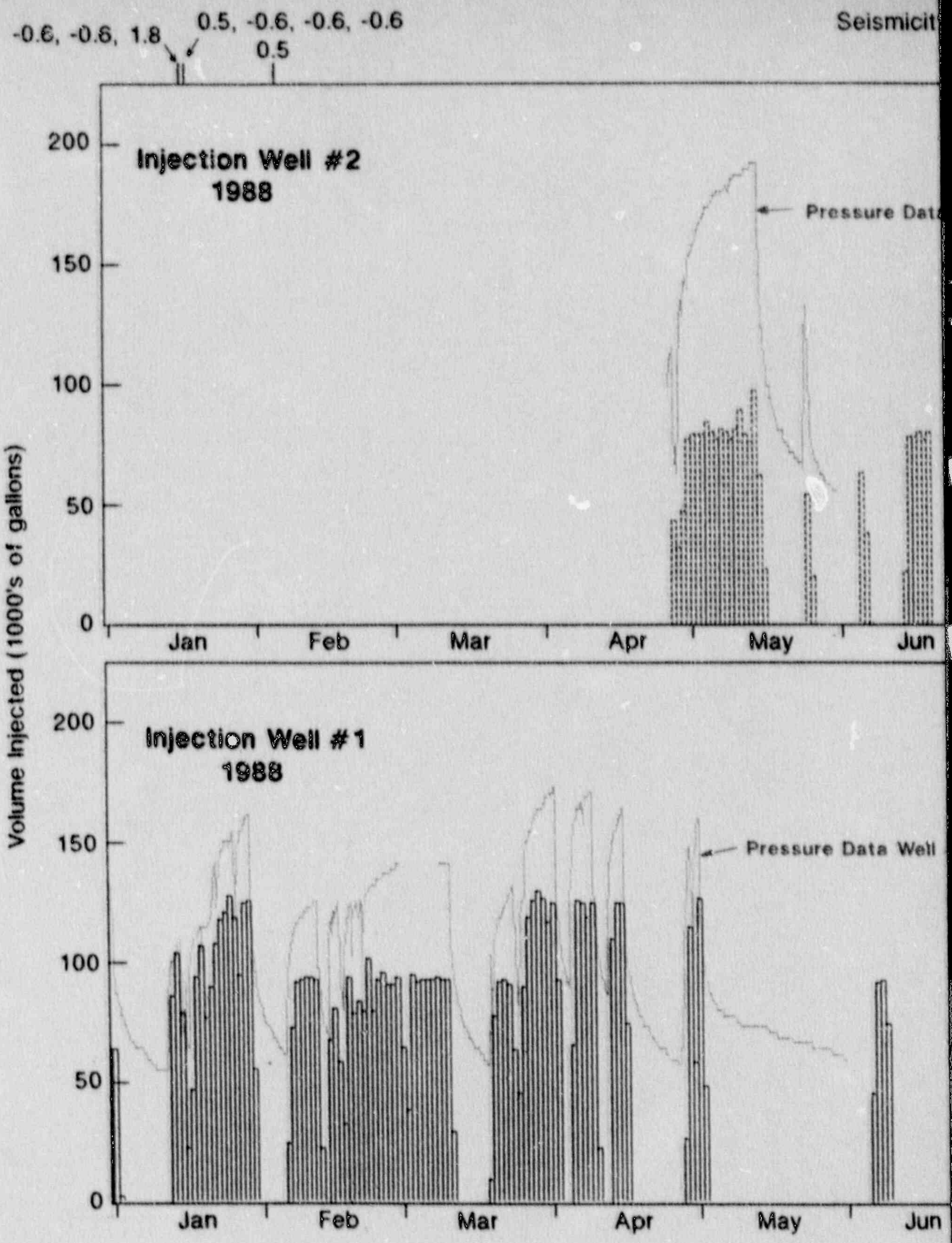
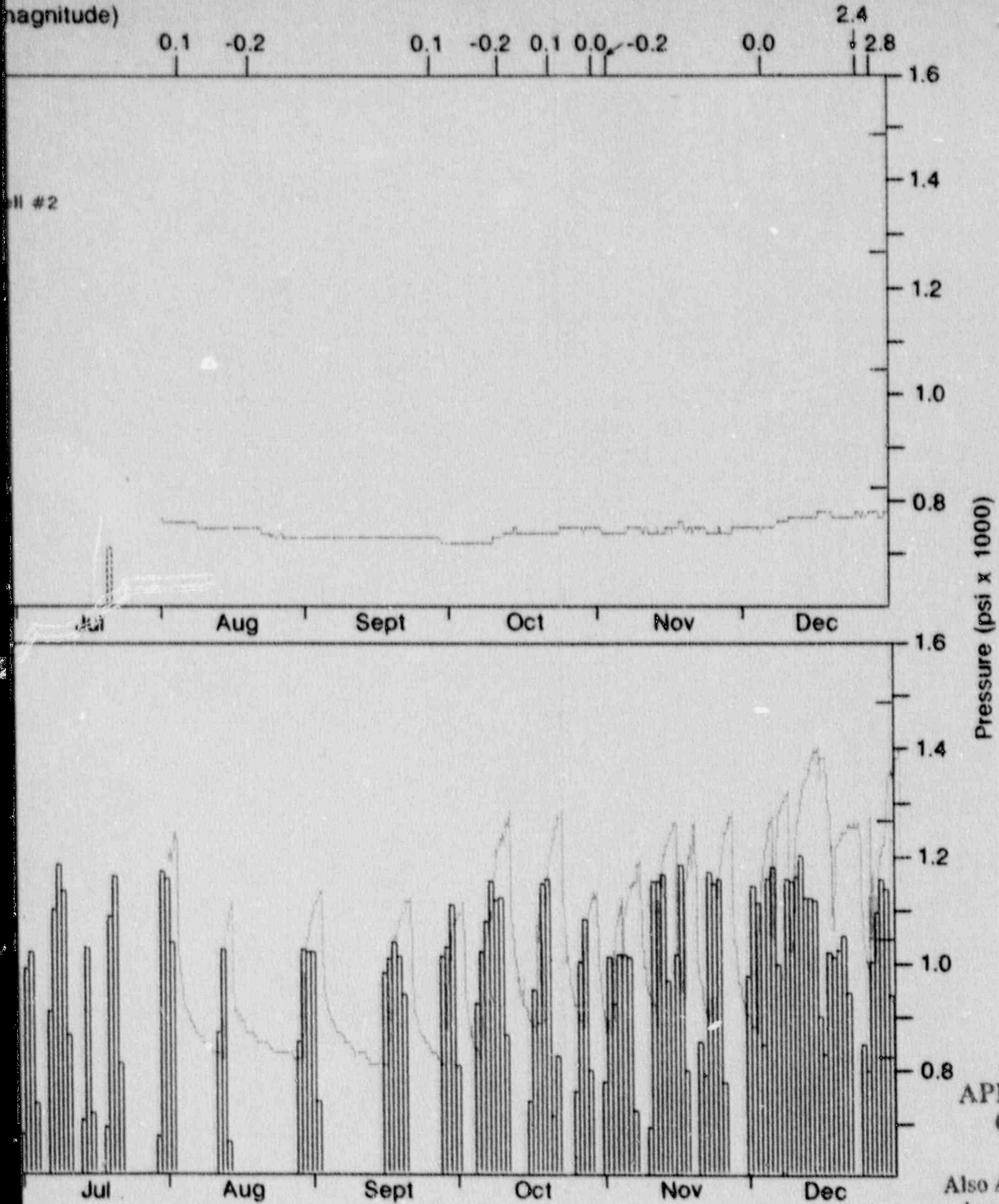
INJECTION DATA AND SEISMICITY
WELLS #1 AND #2 SUPERPOSED
1987

Figure A2b



Injection values provided by ICI AMERICAS, INC.



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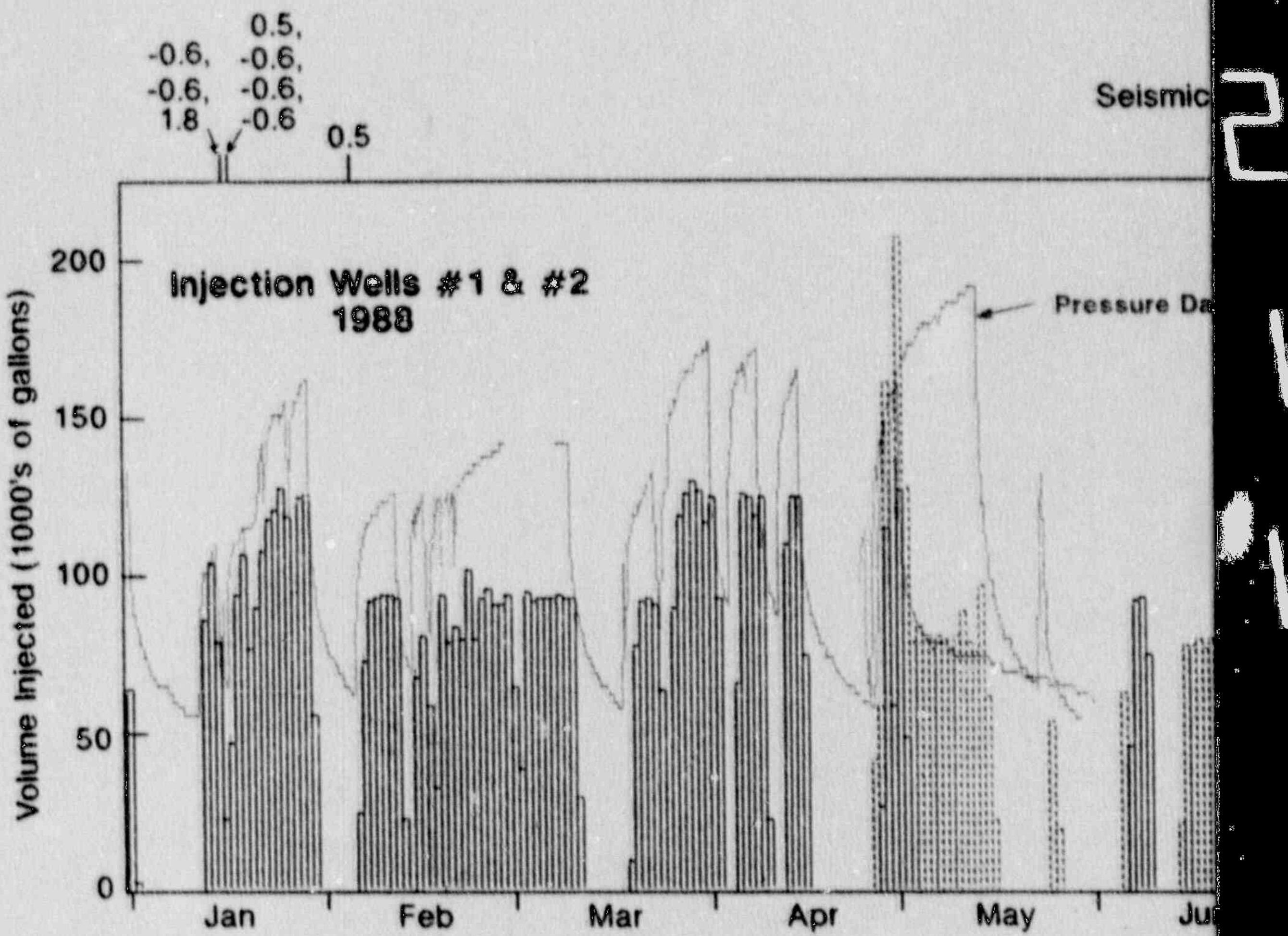
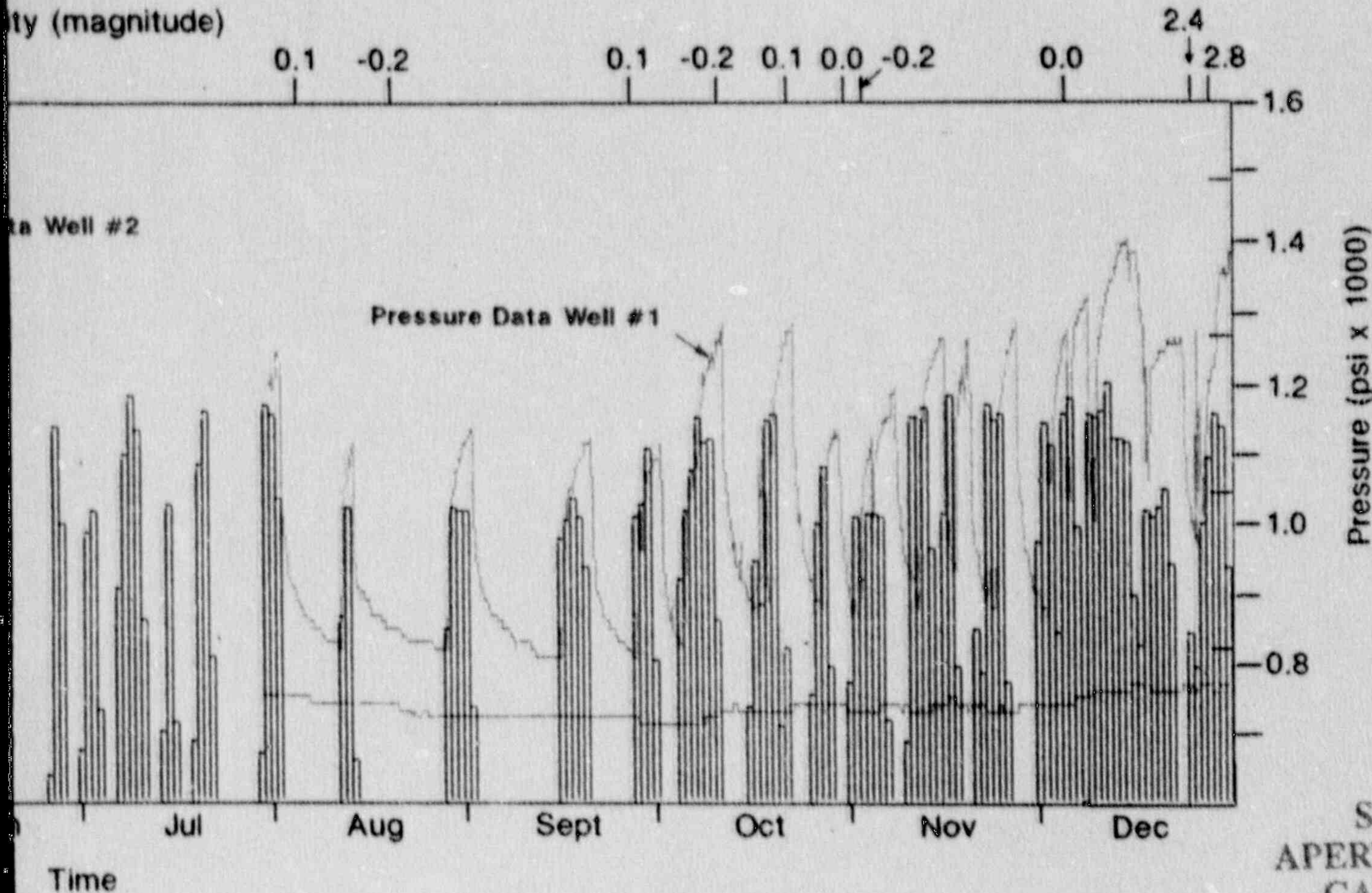
INJECTION DATA AND SEISMICITY
WELLS #1 AND #2
1988

Figure A3a

9004230314-05



Injection values provided by ICI AMERICAS, INC.



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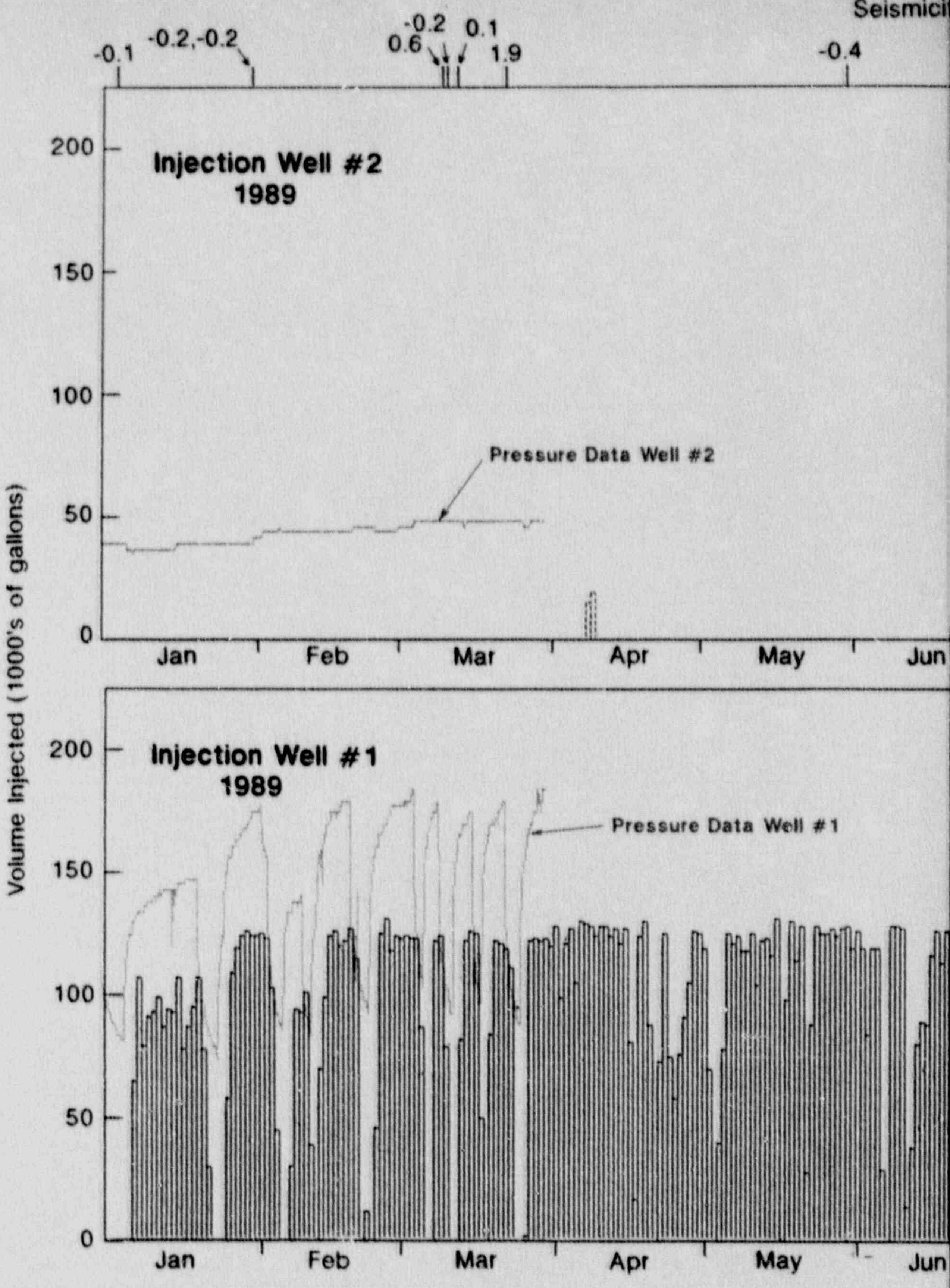
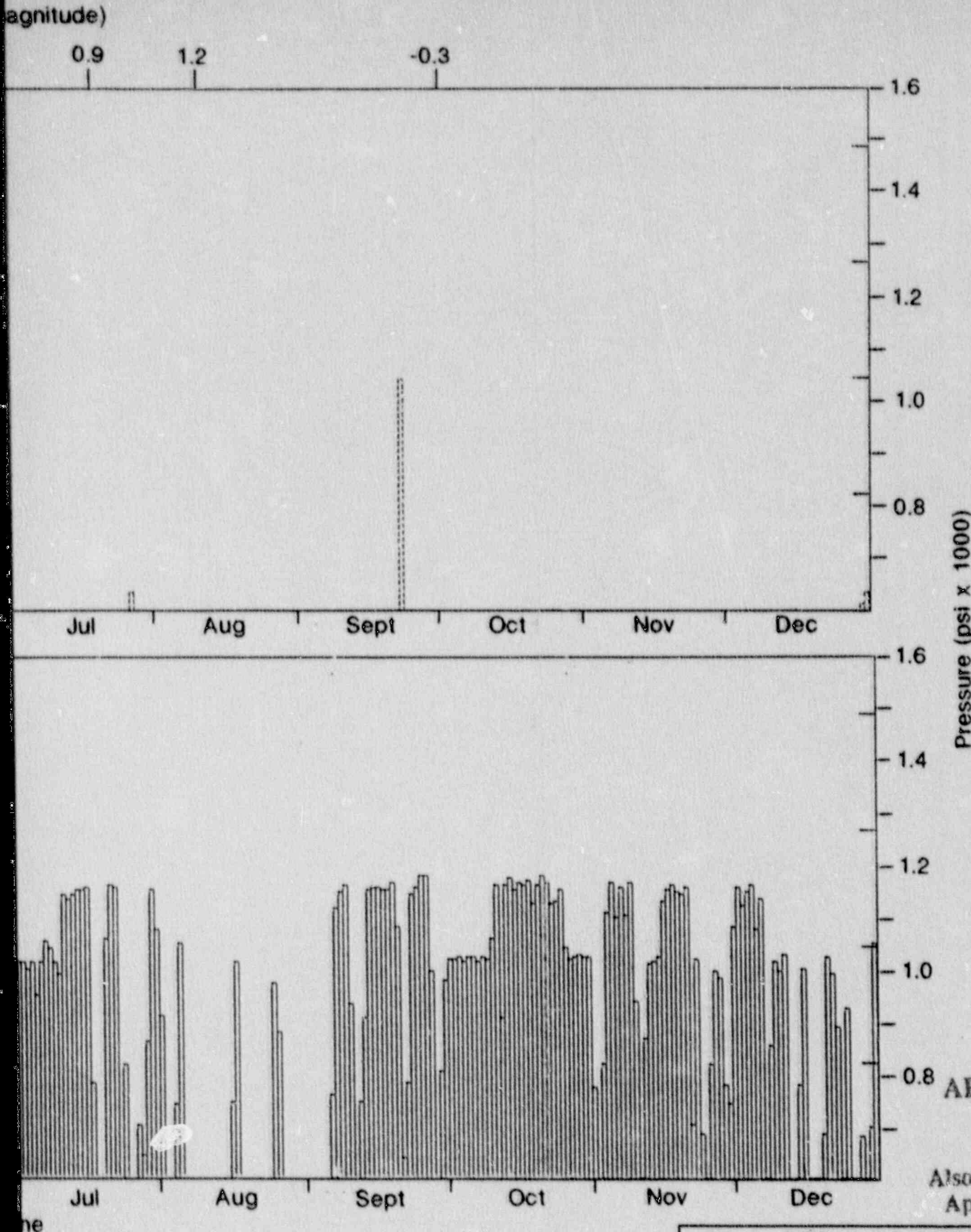
PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

INJECTION DATA AND SEISMICITY
WELLS #1 AND #2 SUPERPOSED
1988

Figure A3b



Injection values provided by ICI AMERICAS, INC.



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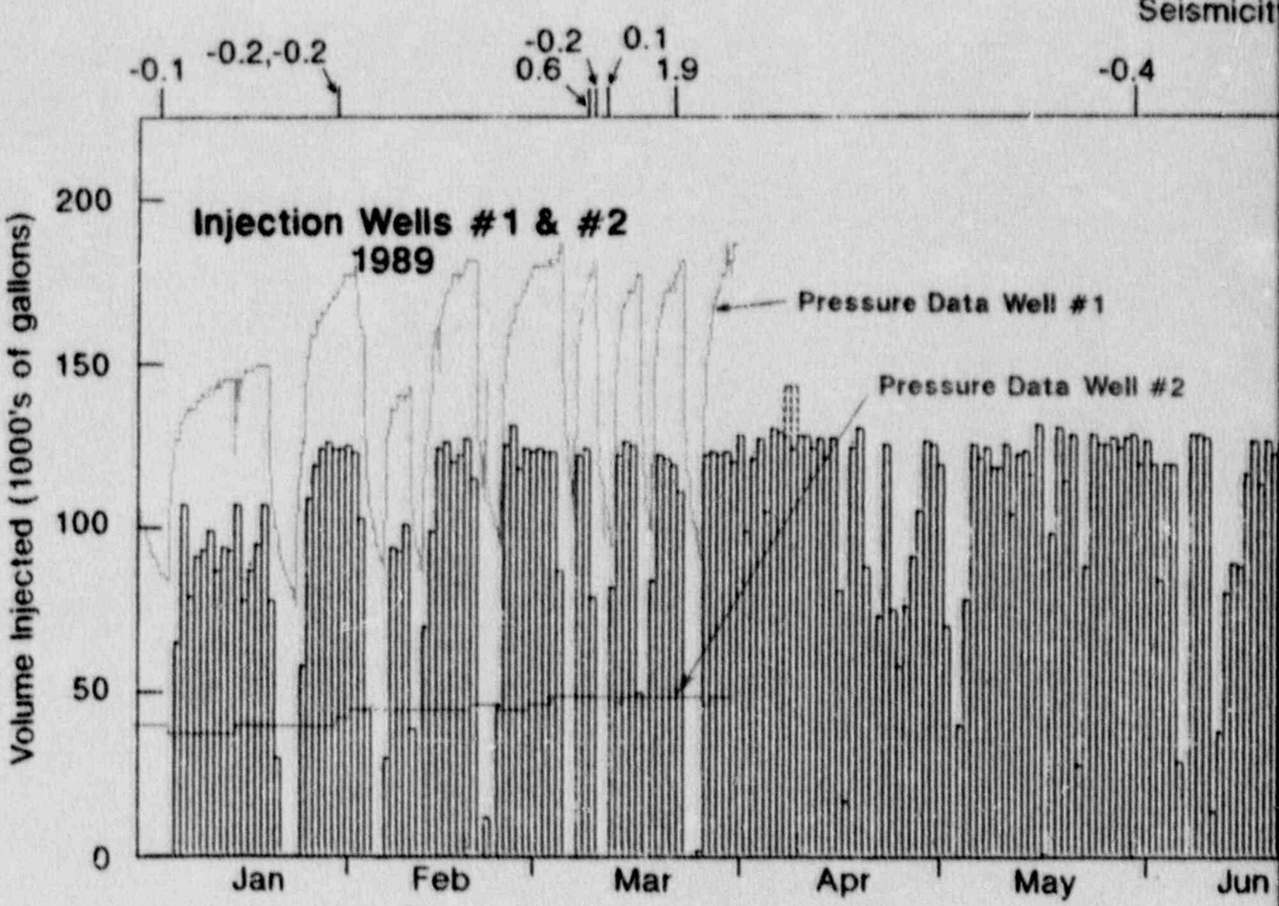
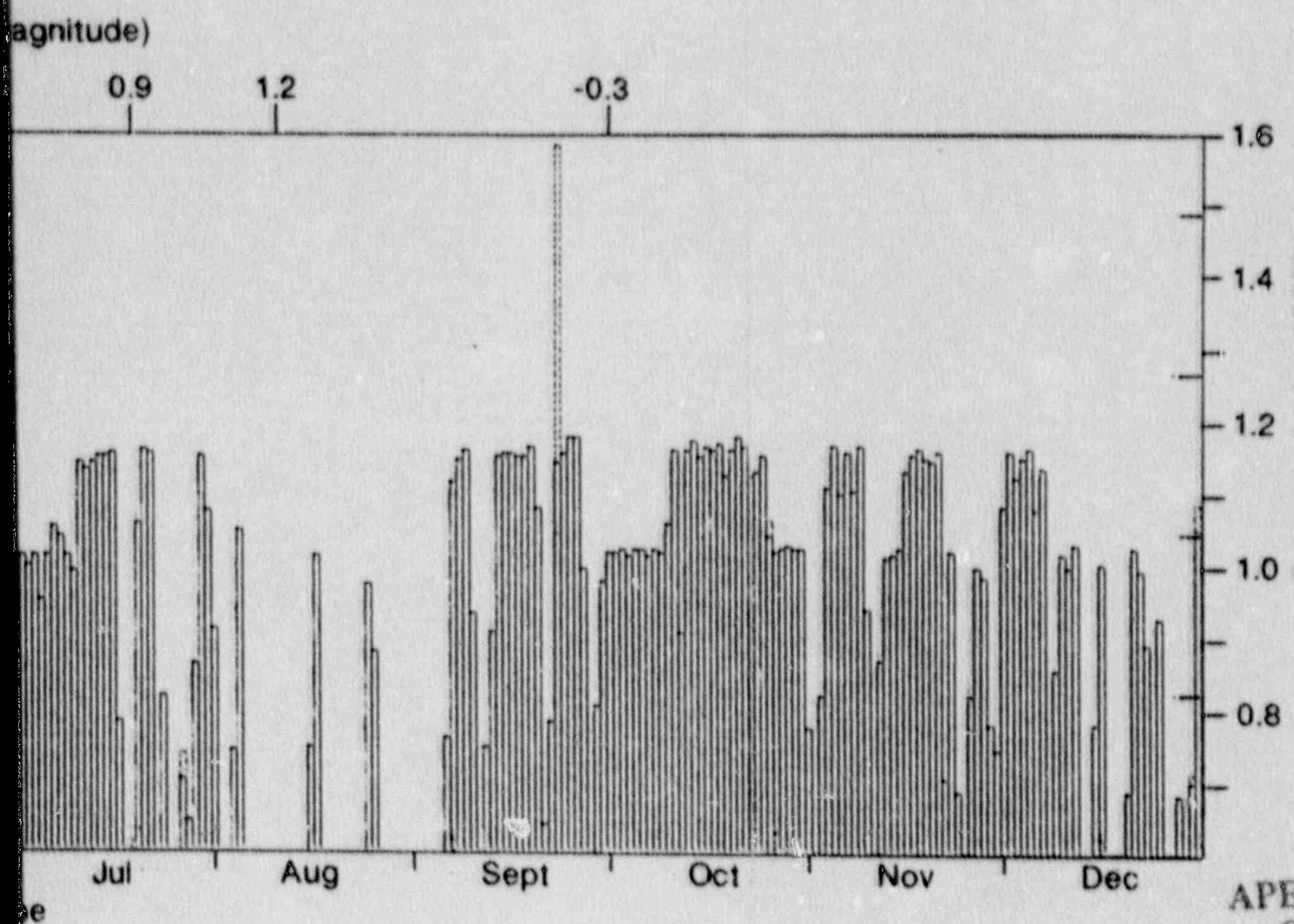
INJECTION DATA AND SEISMICITY
WELLS #1 AND #2
1989

Figure A4a

9004230314-07



Injection values provided by ICI AMERICAS, INC.



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INJECTION DATA AND SEISMICITY
WELLS #1 AND #2 SUPERPOSED
1989

Figure A4b