TECHNICAL REPORT 94-1

SEISMIC ACTIVITY NEAR THE V.C. SUMMER NUCLEAR STATION

FOR THE PERIOD

JANUARY-MARCH, 1994

BY

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CONTRACT NO. N622702

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INTRODUCTION

Analysis of the seismic activity near the V.C. Summer Nuclear Station in South Carolina between January 1 and March 31, 1994 is presented in this report. During this period, six events were recorded in the vicinity of the Monticello Reservoir. All six events were located and were of relatively small magnitude.

SEISMIC NETWORK

Earthquakes during this period were recorded on stations of Monticello Reservoir and South Carolina Seismic Networks. The configuration of stations utilized to locate Monticello Reservoir events is shown in Figure 1 and station coordinates are listed in Appendix I. The operational status of the network is given in Appendix II.

DATA ANALYSIS

Hypocentral locations have been determined using the computer program HYPO71 (Lee and Lahr, 1972). The velocity model used in the earthquake locations is given in Appendix III. The format of the HYPO71 output is given in Appendix IV. The event magnitude was determined from the signal duration at JSC using the following relation:

$$M_L = -1.83 + 2.04 \text{ Log } D,$$

where D is the signal duration (seconds).

An estimate of daily energy release was determined using a simplified magnitude (M_L) - energy (E) relation by Gutenberg and Richter (1956):

$$\text{Log}_{10} E = 11.8 + 1.5 M_L$$

OBSERVED SEISMICITY DURING JANUARY - MARCH, 1994

Seismicity around Monticello Reservoir was low during the first quarter of 1994. Six events were recorded and located (Figure 2). The events were scattered throughout the quarter with half occurring in February (Appendix V) and, generally, all events located to the south of MR10 (Figures 1 and 2). On January 10, 1994 at 17:46.00 UTC, the largest event of the quarter occurred and had a duration magnitude of 0.73 (Appendix V). All locations were rated good to fair (B-C; Appendix V). The long term decline in seismicity observed at Monticello Reservoir is continuing (Figure 3) and the cumulative seismicity has shown relative flattening since 1985-86 (Figure 4).

CORRELATION OF WATER LEVEL WITH SEISMICITY

Monticello Reservoir is a pumped storage facility. Any decrease in the reservoir level associated with power generation is recovered when water is pumped back into the reservoir. There can be normal variations up to five feet per day between maximum and minimum water levels. The water level has been monitored to see if there is any correlation between the daily or seasonal changes in the reservoir level and the local seismicity. Water levels are compared with seismicity in Figure 5. The top panel shows the average water level; the error bars show the maximum and minimum water levels each day. The second panel shows the change in water level from day to day. The number of events per day and the log of energy released are shown in the lower histograms. These charts include all reported earthquakes listed in Appendix V. The average water level, daily changes in water level, number of earthquakes and energy release are given in Appendix VI. No systematic correlation was observed between the seismicity and reservoir level fluctuations.

CONCLUSIONS

Seismicity during the first quarter of 1994 was low and occurred generally in the central part of the reservoir south of MR10 (Figures 1 and 2). No systematic correlation was observed between the reservoir level fluctuations and the seismicity.

REFERENCES

Gutenberg, B. and Richter, C.F. (1956). Magnitude and energy of earthquakes, *Ann. Geof.* 9,1-15.

Lee, W.H.K. and Lahr, J.C. (1972). A computer program for determining hypocenter, magnitude and first motion pattern of local earthquakes, revisions of HYPO71, U.S. *Geological Survey, Open-File Report*, 100 pp.

Monticello Reservoir Seismic Network

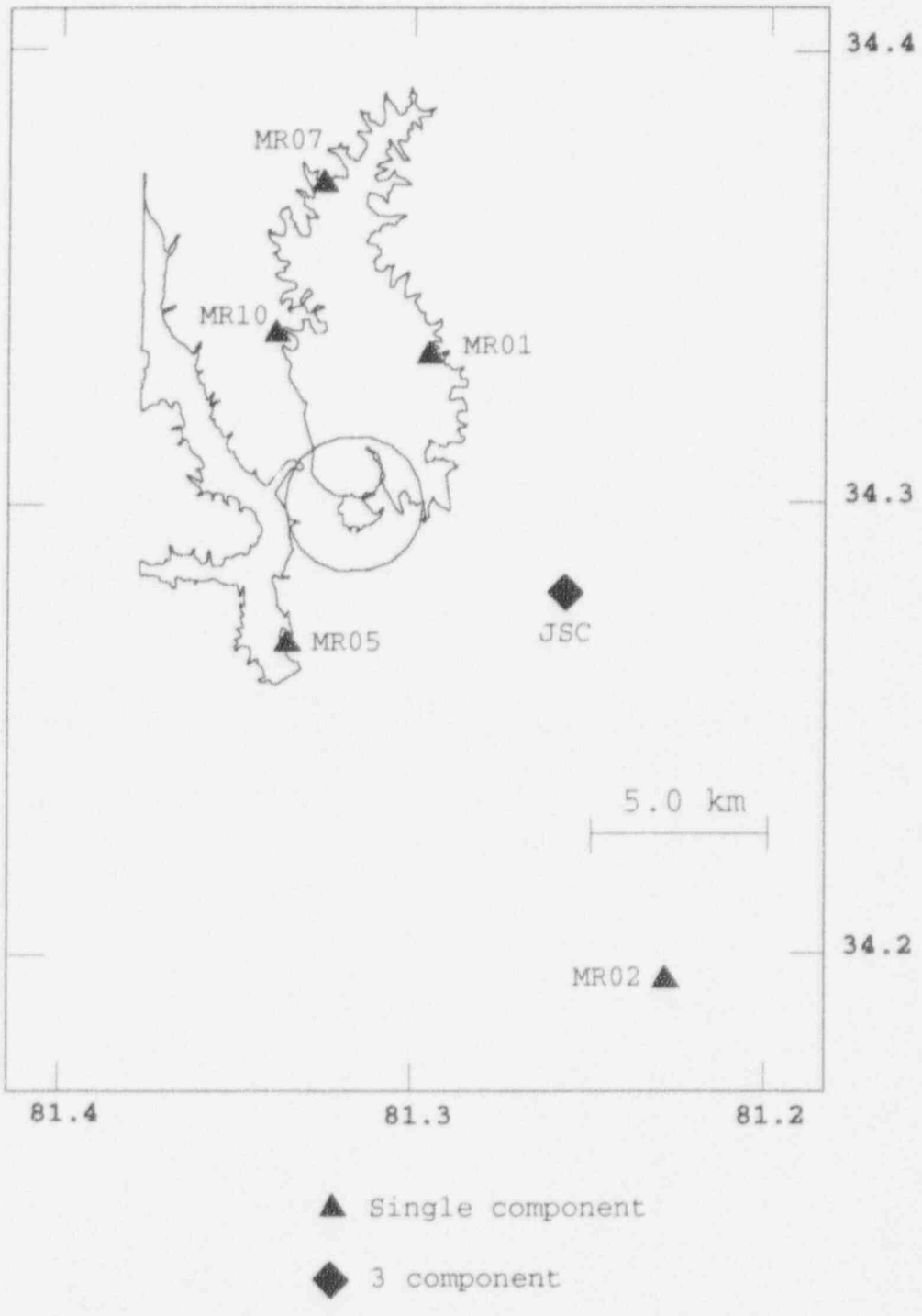

Figure 1 Location of Monticello Reservoir seismic stations.

Monticello Reservoir Seismicity

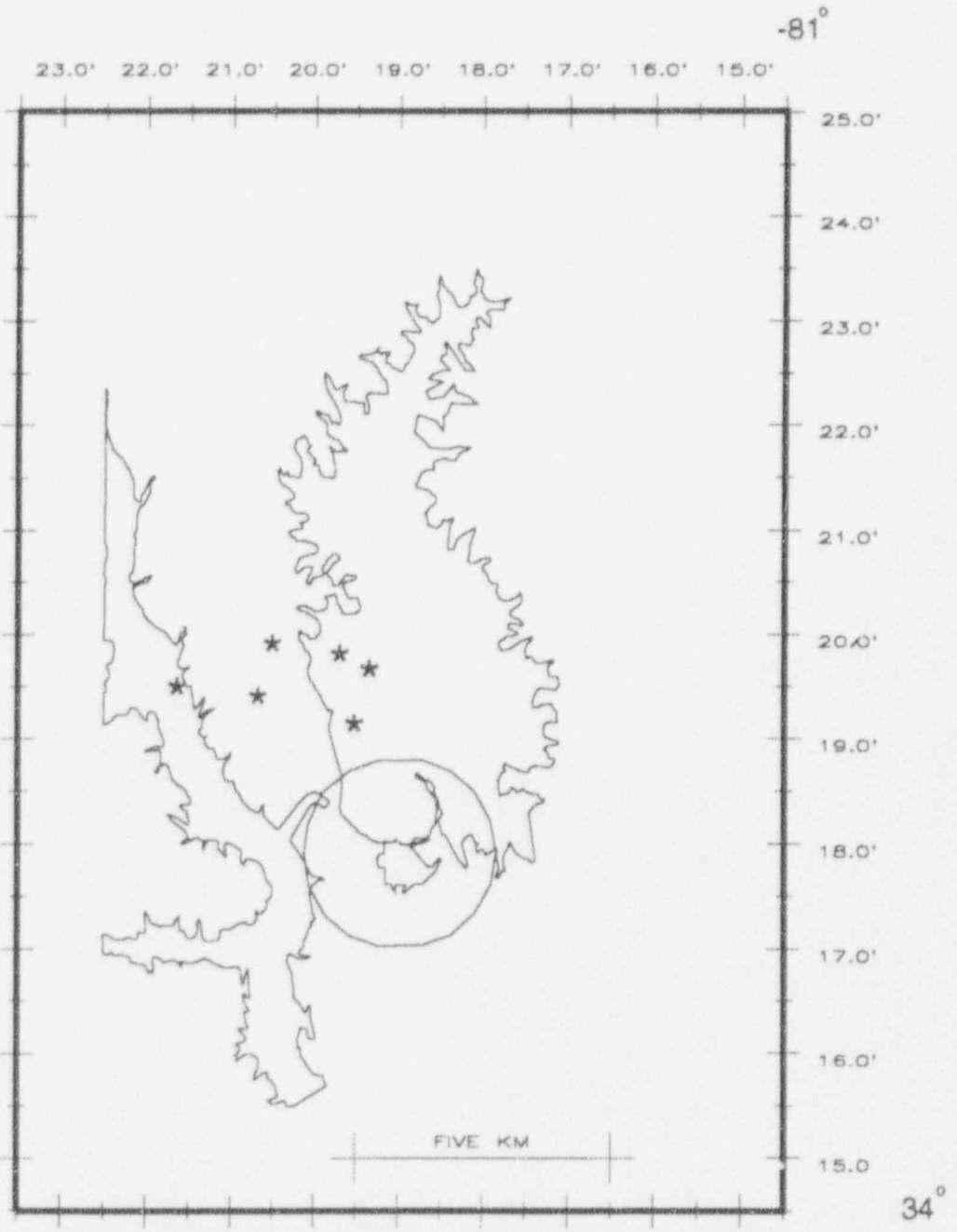

Figure 2. Events located near Monticello Reservoir during the period January - March 1994 (stars)

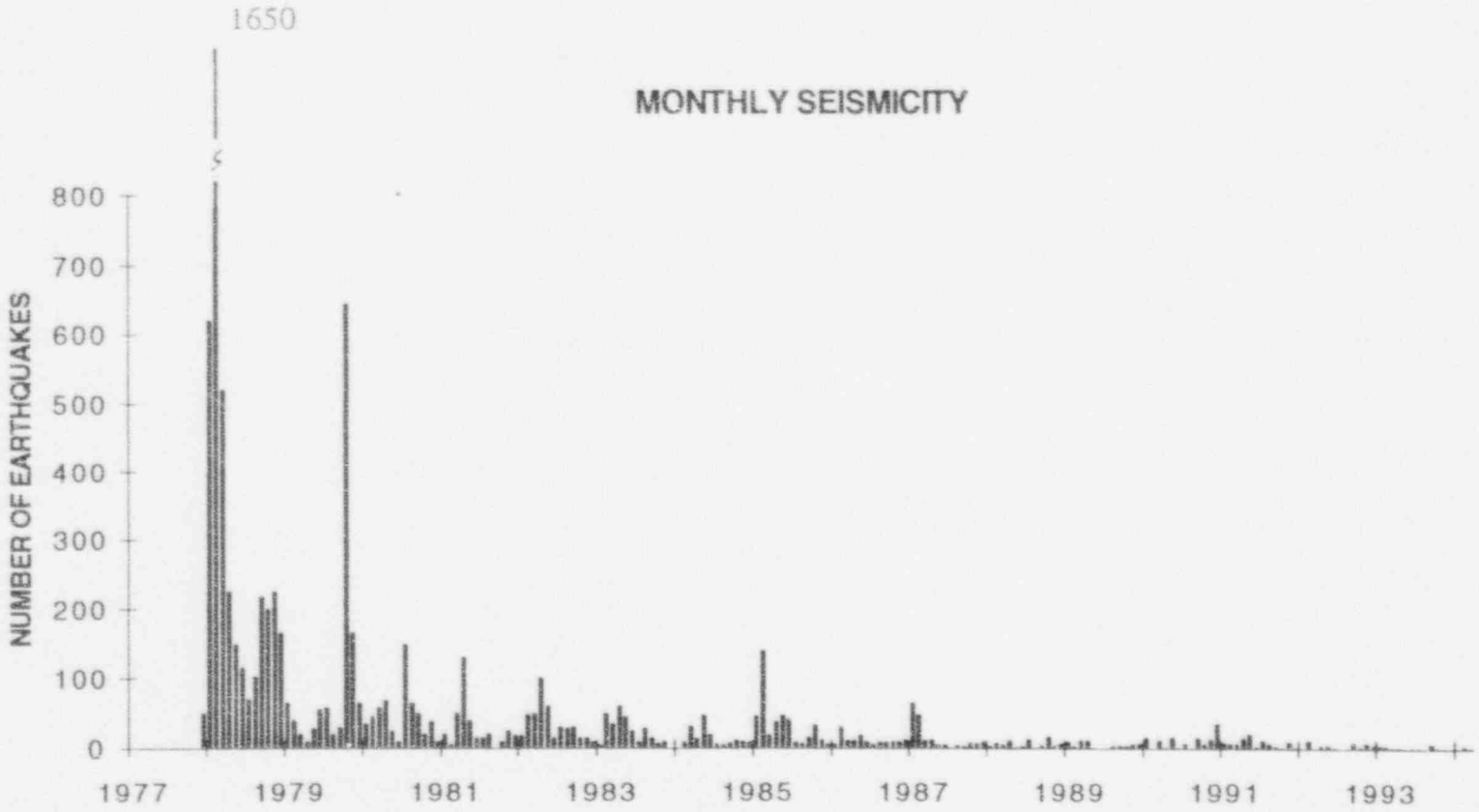

Figure 3. Earthquakes between impoundment and March, 1994.

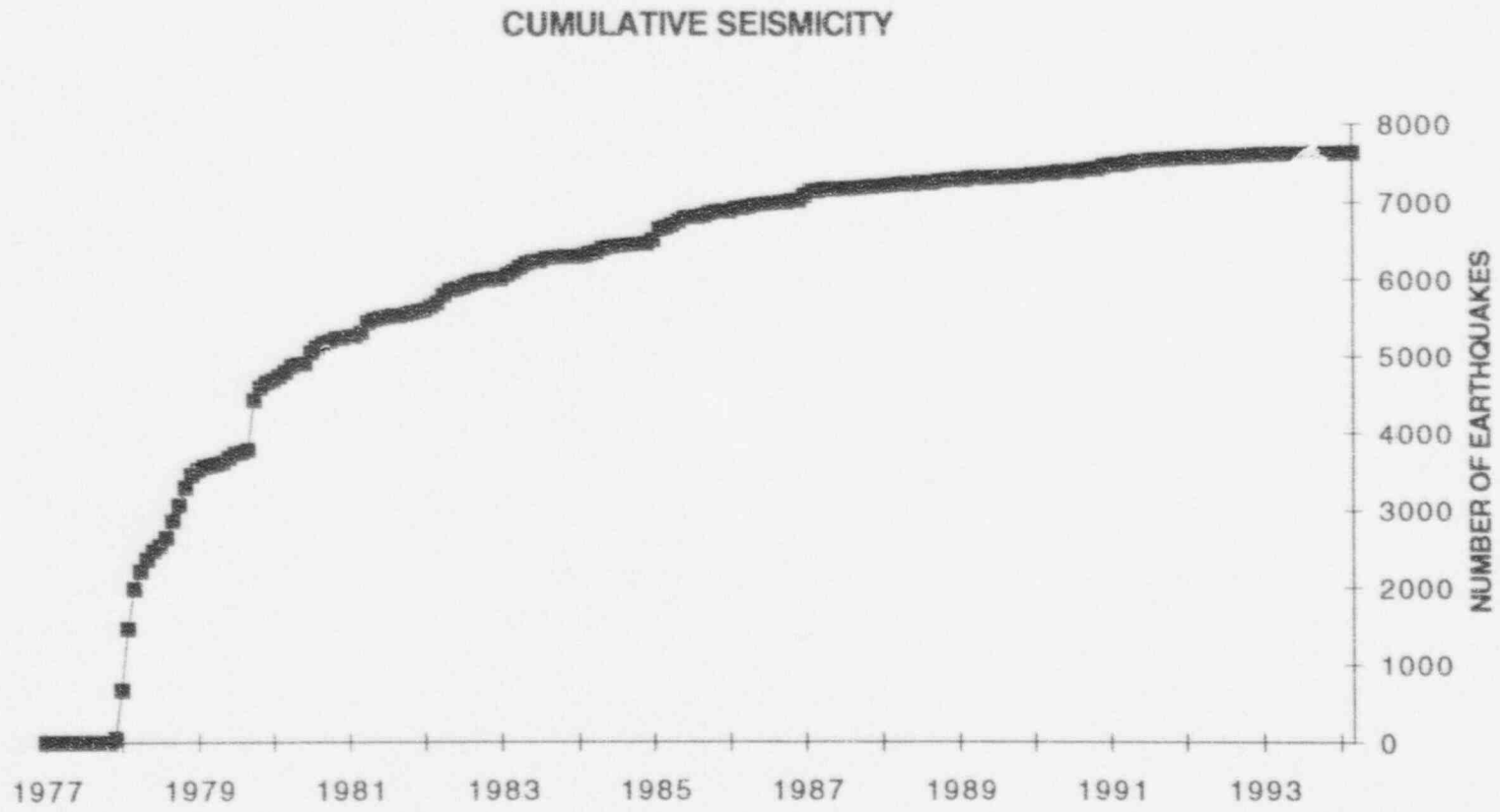

Figure 4. Cumulative seismicity near Monticello Reservoir since impoundment.

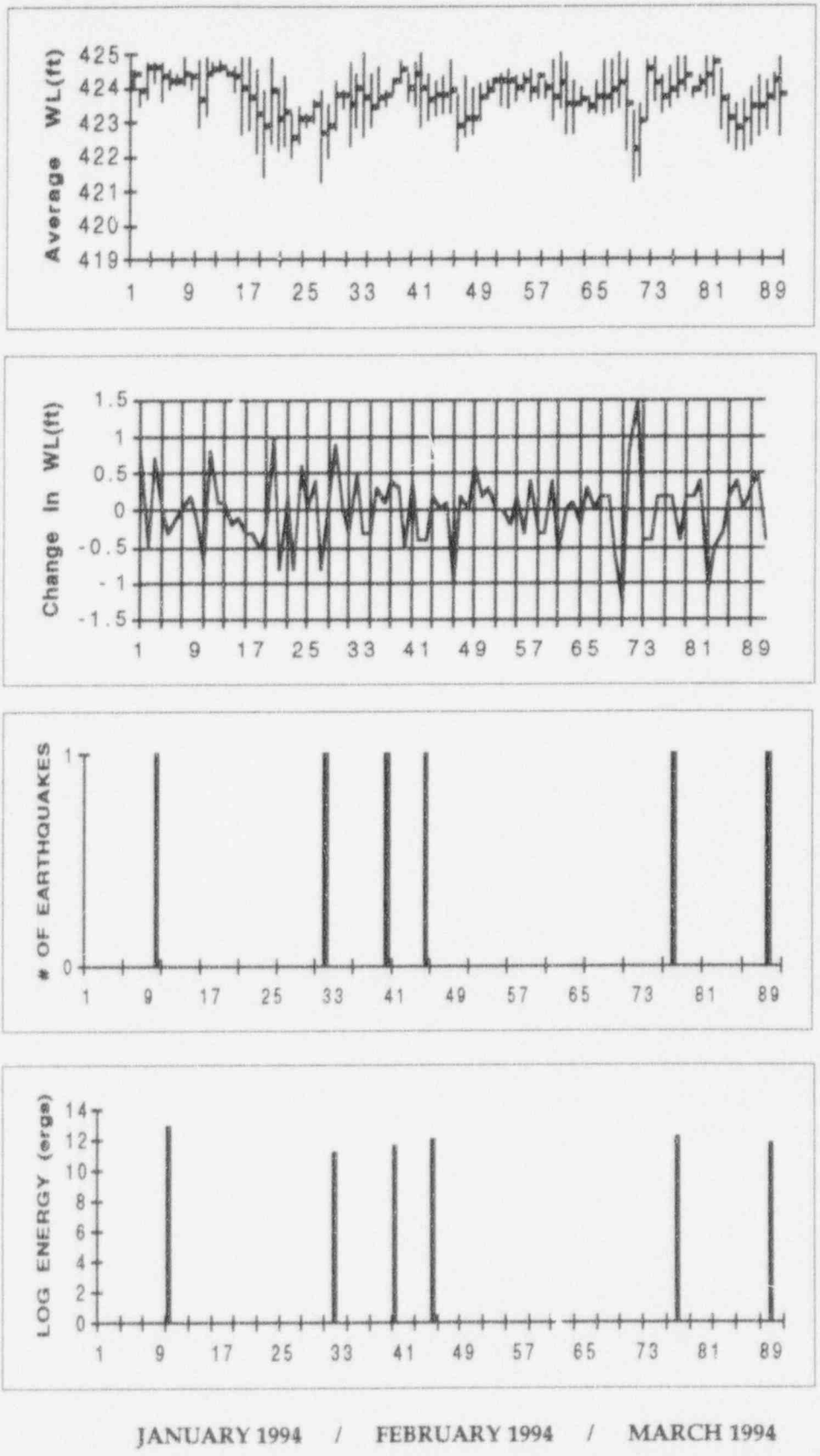

Figure 5. Comparison of daily lake level, changes in lake level, number of earthquakes and the log of energy release in ergs per day at Monticello Reservoir. Error bars in the top panel indicate daily fluctuations in water level.

APPENDIX I
STATION LOCATIONS

STATION	LAT° N	LONG °W
JSC	34°16.80′	81°15.60′
MR01	34°19.91′	81°17.74′
MR02	34°11.58′	81°13.81′
MR05	34°16.05′	81°20.05′
MR07	34°22.23′	81°19.50′
MR10	34°20.18′	81°20.25′

APPENDIX II

SEISMIC STATION OPERATIONAL STATUS

JANUARY 1 - MARCH 31, 1994

STATION	PERCENT DOWNTIME
MR01	0%
MR02	0%
MR05	17.8%
MR07	0%
MR10	0%
JSC	1.1%

APPENDIX III

MONTICELLO RESERVOIR

VELOCITY MODEL

Velocity km/sec	Depth to top km
1.00	0.00
5.40	0.03
5.90	0.18
6.10	0.46
6.30	0.82
8.10	30.00

APPENDIX IV

MONTICELLO EARTHQUAKES

HYPO71 FORMAT

Column	1	Date
Column	2	Origin time (UTC) h.m.sec.
Column	3	Latitude (N) degrees, min.
Column	4	Longitude (W) degrees, min.
Column	5	Depth (km).
Column	6	Local duration magnitude.
Column	7	No. of station readings used to locate event. P and S arrivals from same stations are regarded as 2 readings.
Column	8	Largest azimuthal separation in degrees between stations.
Column	9	Epicentral distance in km to nearest station.
Column	10	Root mean square error of time residuals in sec. RMS = R_i^2/No, where R_i is the time residual for the i^{th} station.
Column	11	Standard error of the epicenter in km*.
Column	12	Standard error of the focal depth in km*.
Column	13	Quality of the epicentral location.

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* Statistical interpretation of standard errors involves assumptions which may not be met in earthquake locations. Therefore standard errors may not represent actual error limits.

Note: If ERH or ERZ is blank, this means that it cannot be computed, because of insufficient data.

APPENDIX V
MONTICELLO RESERVOIR EARTHQUAKES
JANUARY - MARCH, 1994

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	Q	M
940110	1746 0.43	34-19.38	81-20.76	0.81	0.73	10	210	1.7	0.02	0.2	0.2	C	1
940201	254 6.50	34-19.96	81-20.60	0.30	-0.40	10	236	0.7	0.04	0.3	0.3	C	1
940210	552 32.03	34-19.13	81-19.51	3.45	-0.11	6	212	5.7	0.02	1.1	1.3	C	1
940214	13 7 39.50	34-19.83	81-19.67	2.33	0.12	9	157	1.1	0.04	0.3	0.3	B	1
940318	1048 22.83	34-19.49	81-21.69	2.81	0.21	6	276	2.6	0.08	1.2	1.5	C	1
940330	2038 34.61	34-19.73	81-19.34	1.80	0.01	8	168	1.6	0.03	0.2	0.3	B	1

APPENDIX VI

Maximum and minimum water levels, change in water level, number of earthquakes and log of energy release per day at Monticello Reservoir during January 1 - March 31, 1994. Dates are given in Julian Calendar.

J.DATE	WL (max)	WL (min)	WL (avg)	WL (ch)	# of eqs	Energy
1	424.5	424	424.4	0.8	0	0
2	424	423.5	423.9	-0.5	0	0
3	424.7	423.7	424.6	0.7	0	0
4	424.7	424.2	424.6	0	0	0
5	424.7	423.6	424.3	-0.3	0	0
6	424.5	424	424.2	-0.1	0	0
7	424.4	424.1	424.2	0	0	0
8	424.9	424.1	424.4	0.2	0	0
9	424.4	424	424.3	-0.1	0	0
10	424.8	422.9	423.6	-0.7	1	12.9
11	424.9	423.2	424.4	0.8	0	0
12	424.7	424.4	424.5	0.1	0	0
13	424.8	424.5	424.6	0.1	0	0
14	424.5	424.4	424.4	-0.2	0	0
15	424.6	423.9	424.3	-0.1	0	0
16	424.9	422.7	424	-0.3	0	0
17	424.9	422.8	423.7	-0.3	0	0
18	424.5	422.1	423.2	-0.5	0	0
19	423.9	421.4	422.9	-0.3	0	0
20	424.9	422.4	423.9	1	0	0
21	424	422.2	423.1	-0.8	0	0
22	424.3	422.3	423.3	0.2	0	0
23	423.2	422	422.5	-0.8	0	0
24	423.4	422.4	423.1	0.6	0	0
25	423.2	422.9	423.1	0	0	0
26	423.6	423	423.5	0.4	0	0
27	423.9	421.3	422.7	-0.8	0	0
28	423.5	422	422.9	0.2	0	0
29	424.2	422.8	423.8	0.9	0	0
30	423.9	423.4	423.8	0	0	0
31	424.7	422.3	423.5	-0.3	0	0
32	424.4	422.9	424	0.5	1	11.2
33	425	422.6	423.7	-0.3	0	0
34	424.4	422.9	423.4	-0.3	0	0
35	424.6	423.4	423.7	0.3	0	0
36	423.9	423.5	423.8	0.1	0	0
37	424.2	423.9	424.2	0.4	0	0
38	424.8	424.2	424.5	0.3	0	0
39	424.4	423.6	424	-0.5	0	0
40	424.7	423.5	424.4	0.4	1	11.64
41	425	422.9	424	-0.4	0	0
42	424.4	423.1	423.6	-0.4	0	0

APPENDIX VI (continued)

J.DATE	WL (max)	WL (min)	WL (avg)	WL (ch)	# of eqs	Energy
43	424.2	423.2	423.8	0.2	0	0
44	424.3	423.3	423.8	0	0	0
45	424.8	423.3	423.9	0.1	1	11.98
46	423.8	422.2	422.9	-1	0	0
47	424.3	422.6	423.1	0.2	0	0
48	424	422.7	423.1	0	0	0
49	424.1	423.1	423.7	0.6	0	0
50	424.2	423.7	423.9	0.2	0	0
51	424.2	424	424.2	0.3	0	0
52	424.4	423.5	424.2	0	0	0
53	424.5	423.4	424.2	0	0	0
54	424.3	423.6	424	-0.2	0	0
55	424.4	423.9	424.2	0.2	0	0
56	424.5	423.6	423.9	-0.3	0	0
57	424.4	423.7	424.3	0.4	0	0
58	424.2	423.7	424	-0.3	0	0
59	424.8	423.1	423.7	-0.3	0	0
60	425	423.4	424.1	0.4	0	0
61	424.7	422.7	423.5	-0.6	0	0
62	424.2	422.7	423.5	0	0	0
63	424	423.5	423.6	0.1	0	0
64	423.7	423.3	423.4	-0.2	0	0
65	424.2	423.3	423.7	0.3	0	0
66	424.8	423.2	423.7	0	0	0
67	424.8	423.3	423.9	0.2	0	0
68	425	423.4	424.1	0.2	0	0
69	424.8	422.2	423.5	-0.6	0	0
70	423.3	421.3	422.2	-1.3	0	0
71	423.5	421.4	423	0.8	0	0
72	424.8	423.1	424.5	1.5	0	0
73	424.9	423.6	424.1	-0.4	0	0
74	424.3	423.3	423.7	-0.4	0	0
75	424.6	423.4	423.9	0.2	0	0
76	424.9	423.7	424.1	0.2	0	0
77	424.9	423.9	424.3	0.2	1	12.12
78	423.9	423.7	423.9	-0.4	0	0
79	424.3	423.9	424.1	0.2	0	0
80	424.9	423.7	424.3	0.2	0	0
81	424.9	423.8	424.7	0.4	0	0
82	424.5	422.8	423.6	-1.1	0	0
83	423.8	422.4	423.1	-0.5	0	0
84	423.5	422.2	422.8	-0.3	0	0
85	423.6	422.2	423	0.2	0	0
86	424	422.3	423.4	0.4	0	0
87	424.3	422.6	423.4	0	0	0
88	424.2	422.8	423.7	0.3	0	0
89	424.4	423.6	424.2	0.5	1	11.82
90	424.9	422.6	423.8	-0.4	0	0