TECHNICAL REPORT 93-3

SEISMIC ACTIVITY NEAR THE V.C. SUMMER NUCLEAR STATION

FOR THE PERIOD

JULY-SEPTEMBER, 1993

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 July 1 and September 30, 1993 is presented in this report. During this period, seven events were recorded in the vicinity of the Monticello Reservoir. All seven 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 JULY-SEPTEMBER, 1993

Seismicity around Monticello Reservoir was low during the third quarter of 1993. Seven events were recorded and located (Figure 2). Five events were located which occurred during a six hour interval on September 6, 1993 between 11:22 and 17:17 UTC. They were located in a cluster near Station MR10 and to its west. The largest event of the quarter occurred on July 14, 1993 at 20:06:13 UTC and had a duration magnitude of 0.16. It was located on the east central section of the reservoir near Station MR01 (Figures 1 and 2). The final event of the quarter had a duration magnitude of -0.27 and was located south of the reservoir (Figure 2). 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 third quarter of 1993 was low and occurred generally in the central and southern part of the reservoir. 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

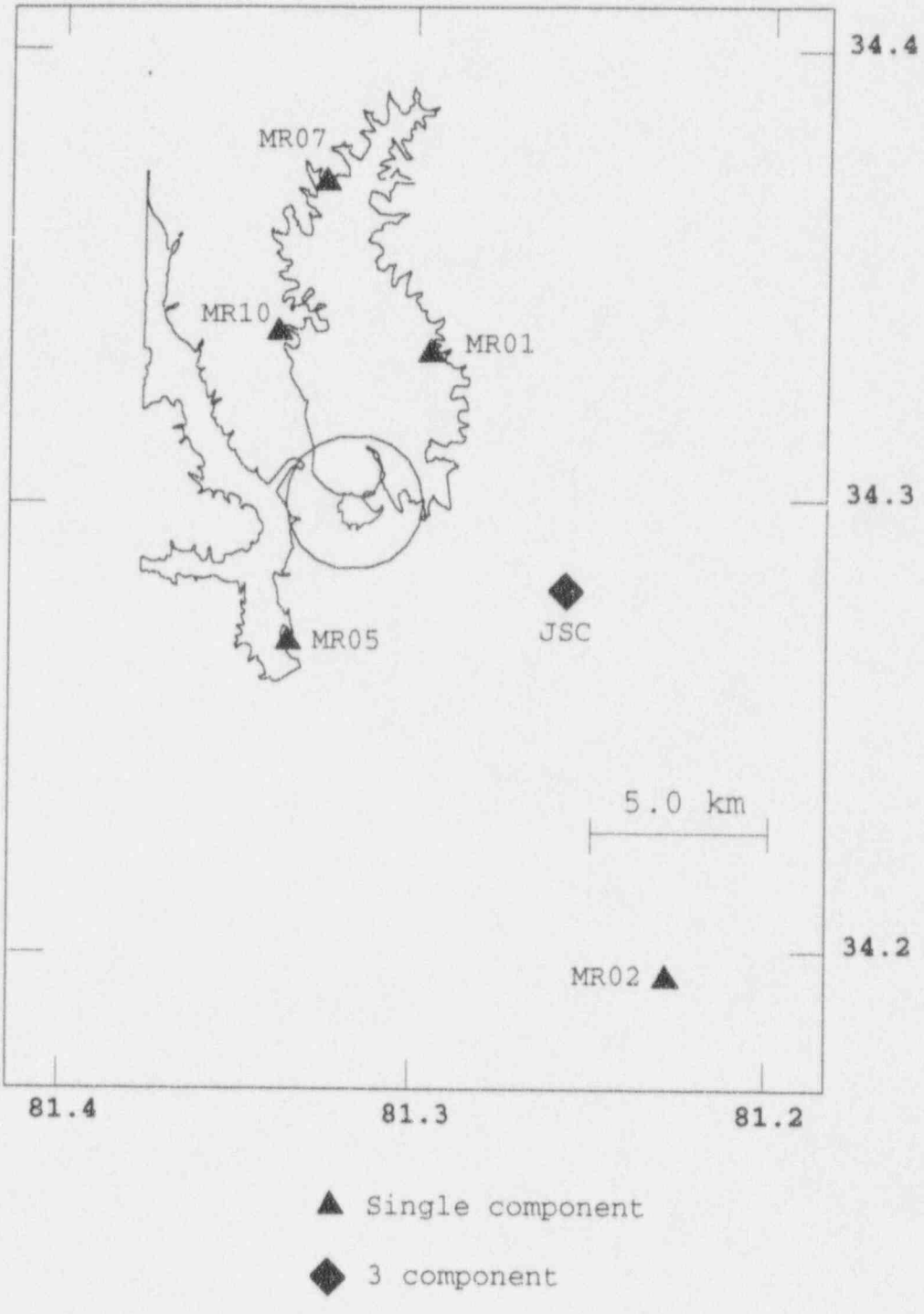

Figure 1 Location of Monticello Reservoir seismic stations.

Monticello Reservoir Seismicity

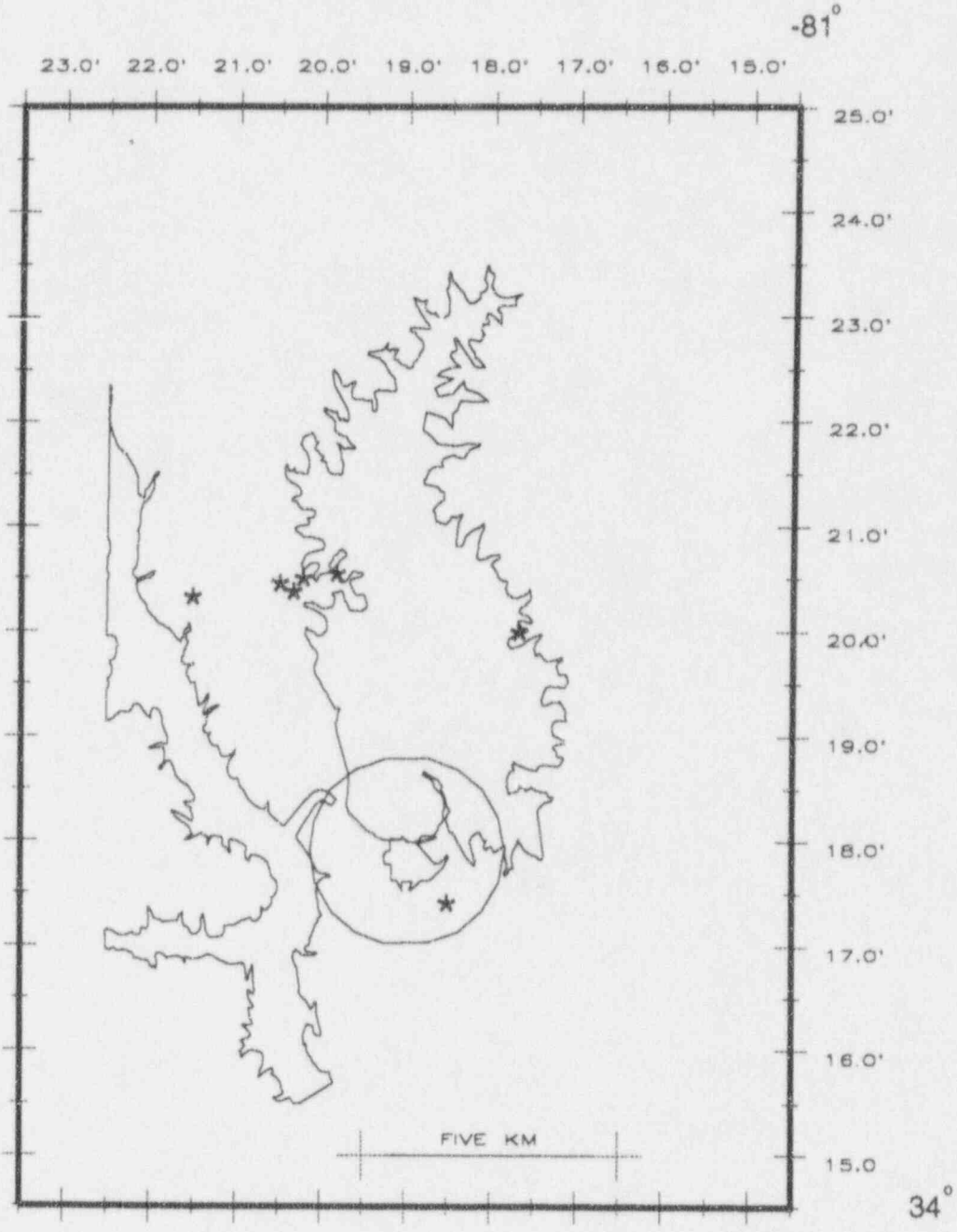

Figure 2. Events located near Monticello Reservoir during the period July - September, 1993 (stars)

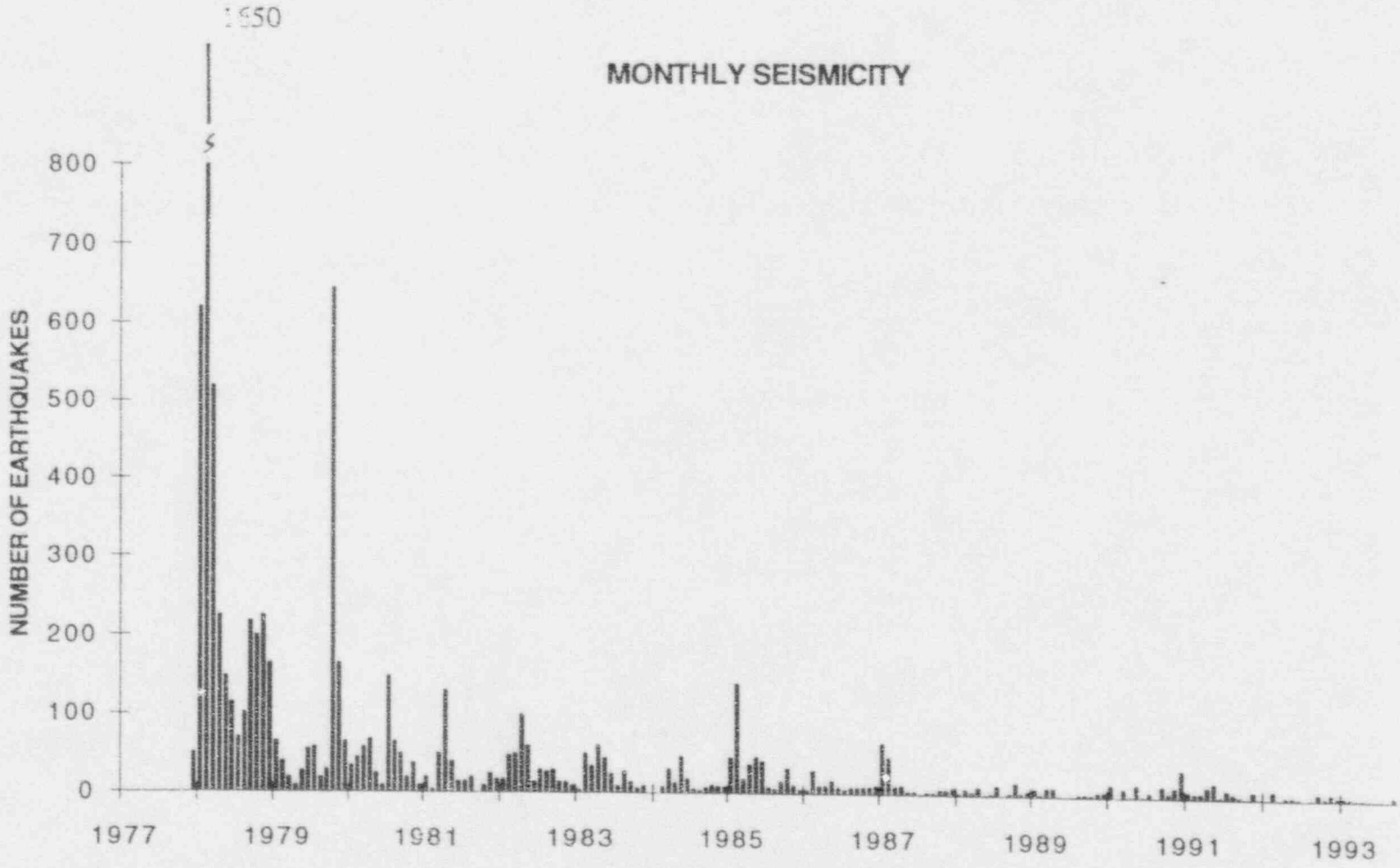

Figure 3. Earthquakes between impoundment and September, 1993.

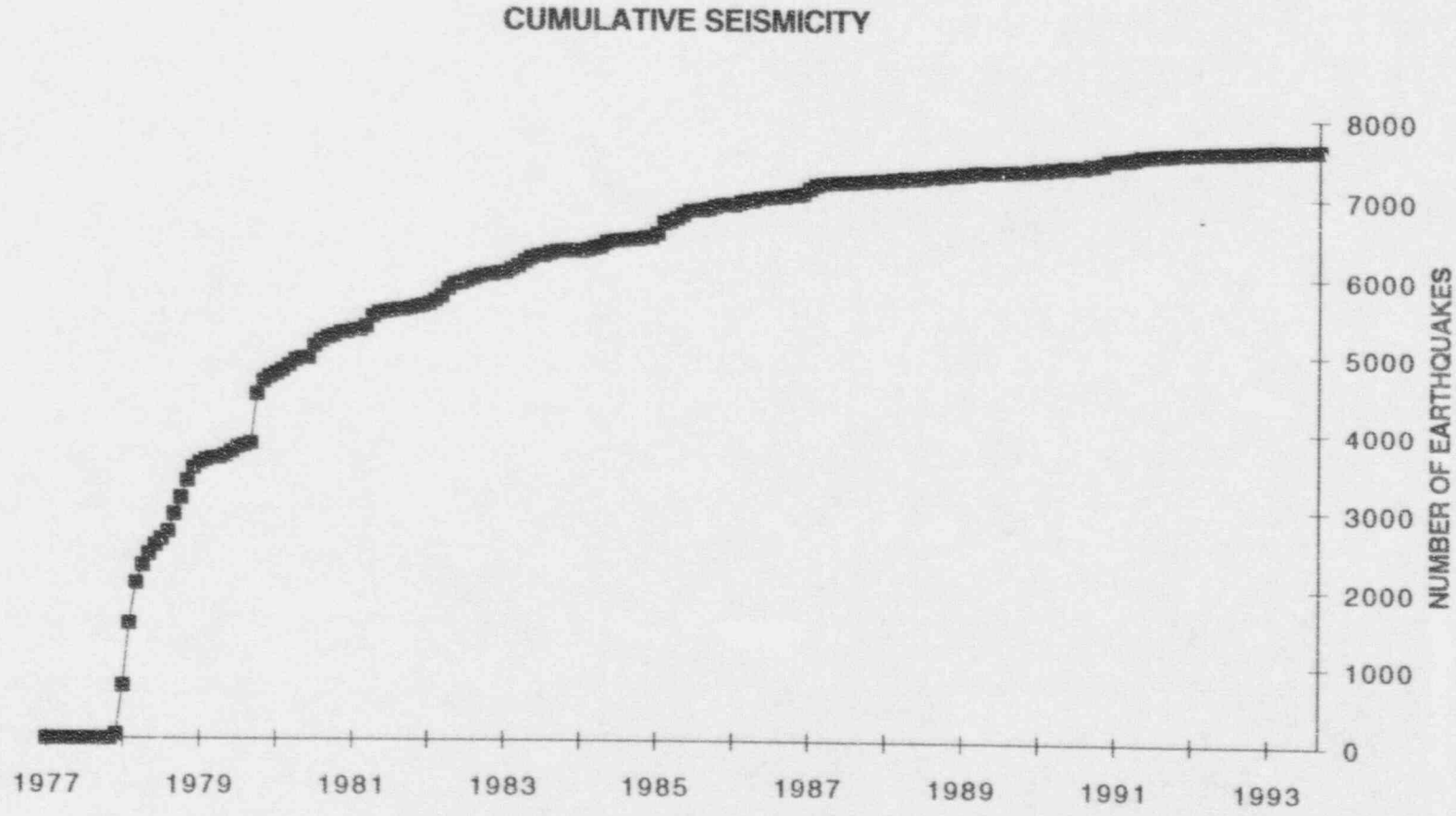

Figure 4. Cumulative seismicity near Monticello Reservoir since impoundment.

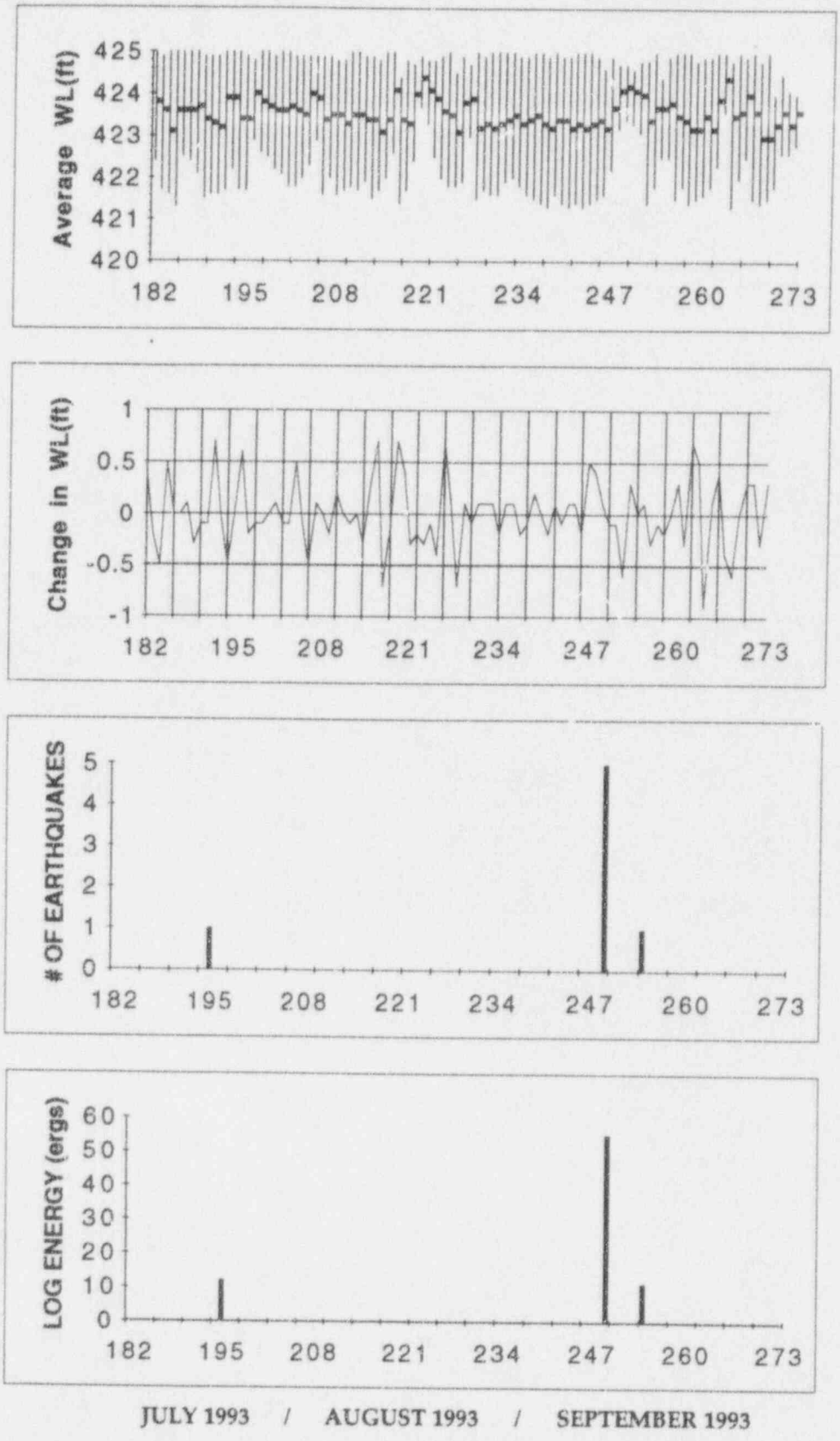

Figure 5. Comparison of daily lake level, changes in lake level, number of earthquakes and the log of energy release in ergs per day at Monticello Reservoir. Error bars in the top panel indicate daily fluctuations in water level.

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

JULY 1 - SEPTEMBER 30, 1993

STATION	PERCENT DOWNTIME
MR01	3.2
MR02	3.2
MR05	4.3
MR07	3.2
MR10	3.2
JSC	2.2

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
JULY - SEPTEMBER, 1993

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	QM
930714	2006 13.27	34-20.01	81-17.71	2.31	0.16	10	185	0.2	0.05	0.3	0.3	C1
930906	1122 6.58	34-20.24	81-21.51	0.47	0.00	12	236	1.9	0.10	0.7	2.0	C1
930906	1246 37.07	34-20.50	81-19.85	0.05	0.00	7	144	0.8	0.07	0.4	0.9	B1
930906	1542 35.05	34-20.52	81-20.20	0.12	0.00	8	192	0.6	0.03	0.2	0.3	C1
930906	1659 37.11	34-20.49	81-20.43	0.48	0.00	8	229	0.6	0.05	0.5	0.5	C1
930906	1717 4.29	34-20.41	81-20.29	0.04	0.00	6	291	0.4	0.02	0.4	0.4	C1
930911	345 12.04	34-17.38	81-18.49	3.87	-0.27	10	121	3.4	0.25	1.2	2.5	B1

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 July 1 - September 30, 1993. Dates are given in Julian Calendar.

J.DATE	WL (max)	WL (min)	WL (avg)	WL (ch)	# of eqs	Energy
182	425	422.4	423.8	0.4	0	0
183	424.9	421.7	423.6	-0.2	0	0
184	425	421.6	423.1	-0.5	0	0
185	425	421.3	423.6	0.5	0	0
186	425	422.5	423.6	0	0	0
187	425	422.4	423.6	0	0	0
188	425	422.1	423.7	0.1	0	0
189	424.9	421.5	423.4	-0.3	0	0
190	424.9	421.6	423.3	-0.1	0	0
191	424.9	421.6	423.2	-0.1	0	0
192	425	421.7	423.9	0.7	0	0
193	425	422.2	423.9	0	0	0
194	425	421.7	423.4	-0.5	0	0
195	424.9	421.7	423.4	0	1	12.04
196	424.8	422.9	424	0.6	0	0
197	425	422.6	423.8	-0.2	0	0
198	425	422.5	423.7	-0.1	0	0
199	424.9	422.2	423.6	-0.1	0	0
200	425	422.1	423.6	0	0	0
201	425	421.8	423.7	0.1	0	0
202	424.9	421.8	423.6	-0.1	0	0
203	424.9	422	423.5	-0.1	0	0
204	424.9	422.3	424	0.5	0	0
205	424.9	422.9	423.9	-0.1	0	0
206	424.9	421.6	423.4	-0.5	0	0
207	424.9	422	423.5	0.1	0	0
208	424.8	421.6	423.5	0	0	0
209	424.8	421.7	423.3	-0.2	0	0
210	425	421.8	423.5	0.2	0	0
211	425	421.7	423.5	0	0	0
212	424.9	421.9	423.4	-0.1	0	0
213	424.9	421.5	423.4	0	0	0
214	424.8	421.7	423.1	-0.3	0	0
215	425	422	423.4	0.3	0	0
216	425	422.6	424.1	0.7	0	0
217	424.4	421.4	423.4	-0.7	0	0
218	424.8	421.7	423.3	-0.1	0	0
219	424.7	422.4	424	0.7	0	0
220	424.9	423.7	424.4	0.4	0	0
221	424.8	423.3	424.1	-0.3	0	0
222	424.8	422.5	423.9	-0.2	0	0
223	424.9	422	423.6	-0.3	0	0

APPENDIX VI (continued)

J.DATE	WL (max)	WL (min)	WL (avg)	WL (ch)	# of eqs	Energy
224	425	421.8	423.5	-0.1	0	0
225	424.5	421.8	423.1	-0.4	0	0
226	424.9	421.9	423.8	0.7	0	0
227	424.7	423	423.9	0.1	0	0
228	425	421.5	423.2	-0.7	0	0
229	424.9	421.7	423.3	0.1	0	0
230	425	421.6	423.2	-0.1	0	0
231	425	421.6	423.3	0.1	0	0
232	425	421.9	423.4	0.1	0	0
233	425	422	423.5	0.1	0	0
234	424.9	421.8	423.3	-0.2	0	0
235	424.9	421.6	423.4	0.1	0	0
236	425	421.5	423.5	0.1	0	0
237	425	421.4	423.3	-0.2	0	0
238	424.9	421.3	423.2	-0.1	0	0
239	425	421.6	423.4	0.2	0	0
240	424.9	421.4	423.4	0	0	0
241	424.9	421.3	423.2	-0.2	0	0
242	425	421.4	423.3	0.1	0	0
243	425	421.3	423.2	-0.1	0	0
244	425	421.4	423.3	0.1	0	0
245	424.9	421.5	423.4	0.1	0	0
246	424.6	421.6	423.2	-0.2	0	0
247	424.9	422.2	423.7	0.5	0	0
248	424.7	423.2	424.1	0.4	0	0
249	424.7	423.4	424.2	0.1	5	55.17
250	424.6	423.3	424.1	-0.1	0	0
251	424.8	423.1	424	-0.1	0	0
252	424.8	421.4	423.4	-0.6	0	0
253	425	421.8	423.7	0.3	0	0
254	424.4	422.5	423.7	0	1	11.4
255	424.9	422.5	423.8	0.1	0	0
256	425	421.5	423.5	-0.3	0	0
257	425	421.8	423.4	-0.1	0	0
258	425	421.4	423.2	-0.2	0	0
259	424.8	421.5	423.2	0	0	0
260	424.9	421.6	423.5	0.3	0	0
261	424.9	421.8	423.2	-0.3	0	0
262	425	422.3	423.9	0.7	0	0
263	425	423.6	424.4	0.5	0	0
264	424.8	421.3	423.5	-0.9	0	0
265	425	422	423.6	0.1	0	0
266	424.9	422.5	424	0.4	0	0
267	425	421.5	423.6	-0.4	0	0
268	424.8	421.4	423	-0.6	0	0
269	425	421.5	423	0	0	0
270	424	421.8	423.3	0.3	0	0
271	424.5	422.6	423.6	0.3	0	0
272	424.1	422.6	423.3	-0.3	0	0
273	424	422.8	423.6	0.3	0	0