

TECHNICAL REPORT 94-3

**SEISMIC ACTIVITY NEAR THE  
V.C. SUMMER NUCLEAR STATION**

FOR THE PERIOD  
**JULY-SEPTEMBER, 1994**

BY

**PRADEEP TALWANI**  
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COLUMBIA, SOUTH CAROLINA 29208**

**CONTRACT NO. N622702**

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and

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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, 1994 is presented in this report. During this period, seven events were recorded in the vicinity of the Monticello Reservoir, all of which were located. Five of the events were of relatively small magnitude ( $< 1.0$ ) while two events were of moderate magnitude, 1.54 and 2.16, respectively.

## 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:

$$M_L = -1.83 + 2.04 \log D$$

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):

$$\log_{10} E = 11.8 + 1.5 M_L$$

## OBSERVED SEISMICITY DURING JULY-SEPTEMBER, 1994

Seismicity around Monticello Reservoir was low during the third quarter of 1994. Seven events were recorded and located (Figure 2). All events for the quarter were shallow and varied in depth between .09 and 3.0 km. The largest event occurred on July 23, 1994 at 01:12:15 UTC and had a duration magnitude of 2.16 (Appendix V). Three events occurred within a six day period between July 23 and July 28, 1994 (Appendix V). Three events occurred within a six day period between August 9 and August 14, 1994 (Appendix V). Four of the events were located in the northwest area of the reservoir near station MR07. Two of the events were located near station MR10 while the remaining event was located in the southeast area of the reservoir between stations JSC and MR01 (Figure 2). All of the event locations were of fair quality (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 1994 was low and occurred generally in the eastern section of the reservoir near Stations MR07 and MR10, with the exception of an event on the southeast flank. 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

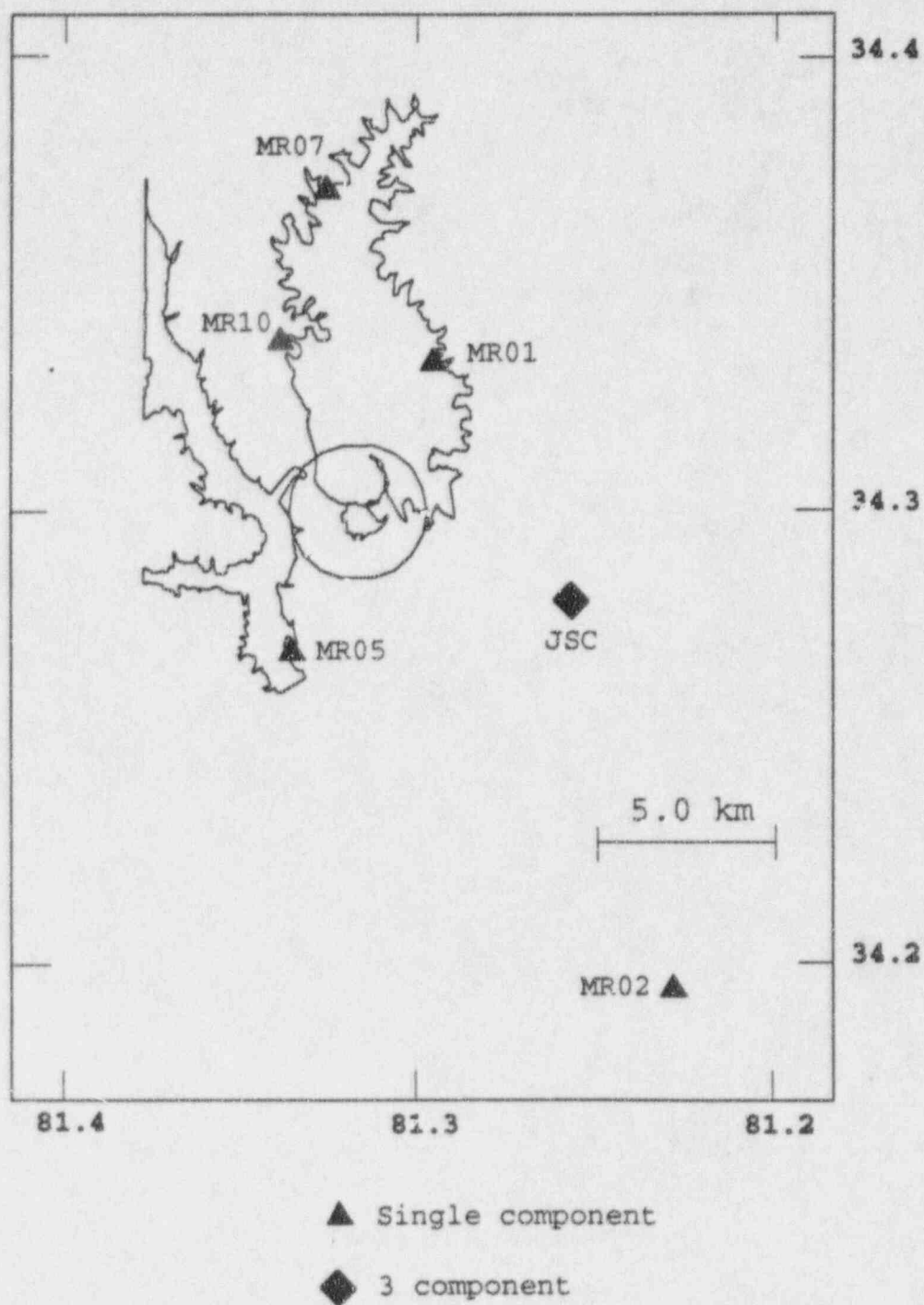


Figure 1 Location of Monticello Reservoir seismic stations.



## Monticello Reservoir Seismicity

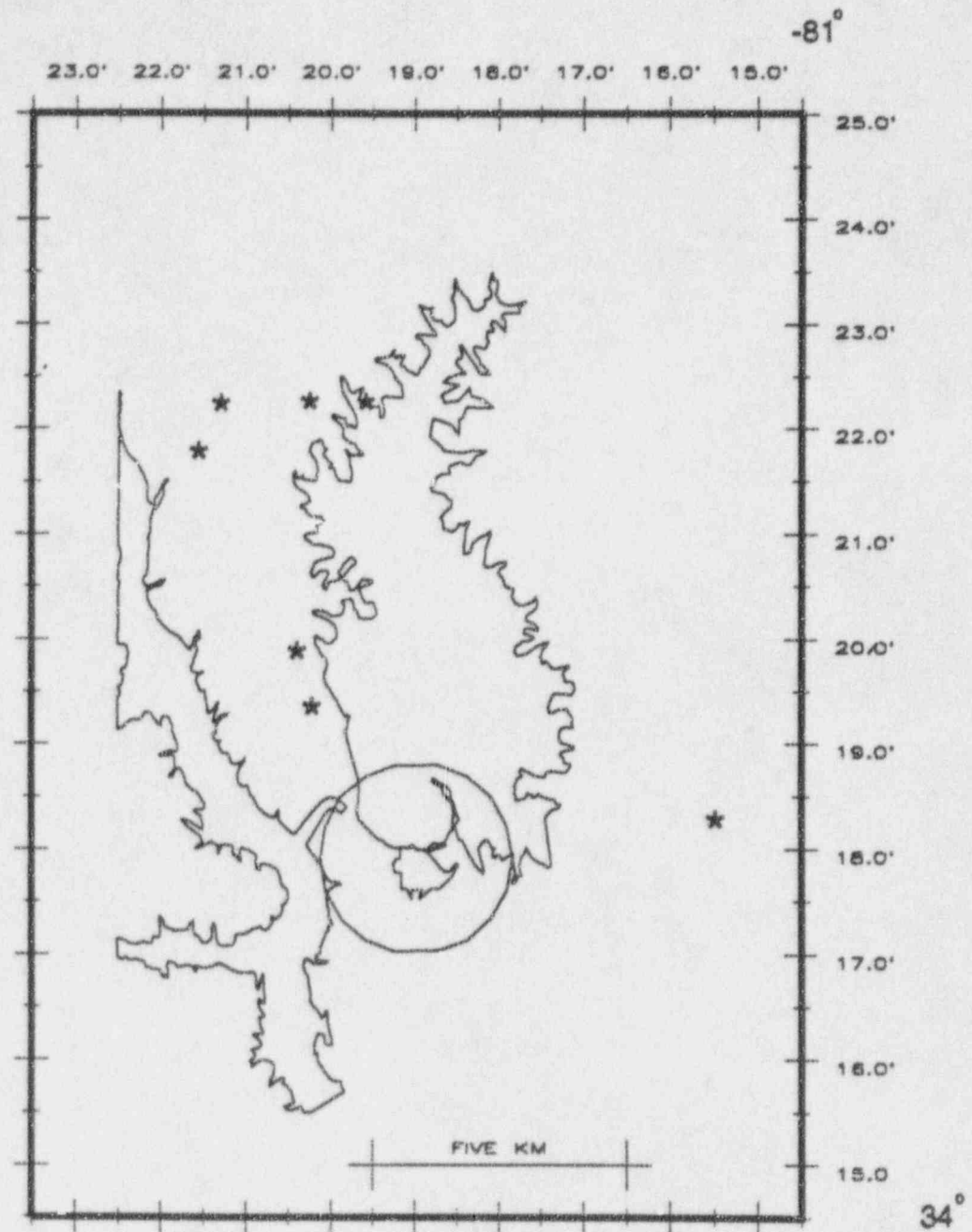


Figure 2. Events located near Monticello Reservoir during the period July - September 1994 (stars)

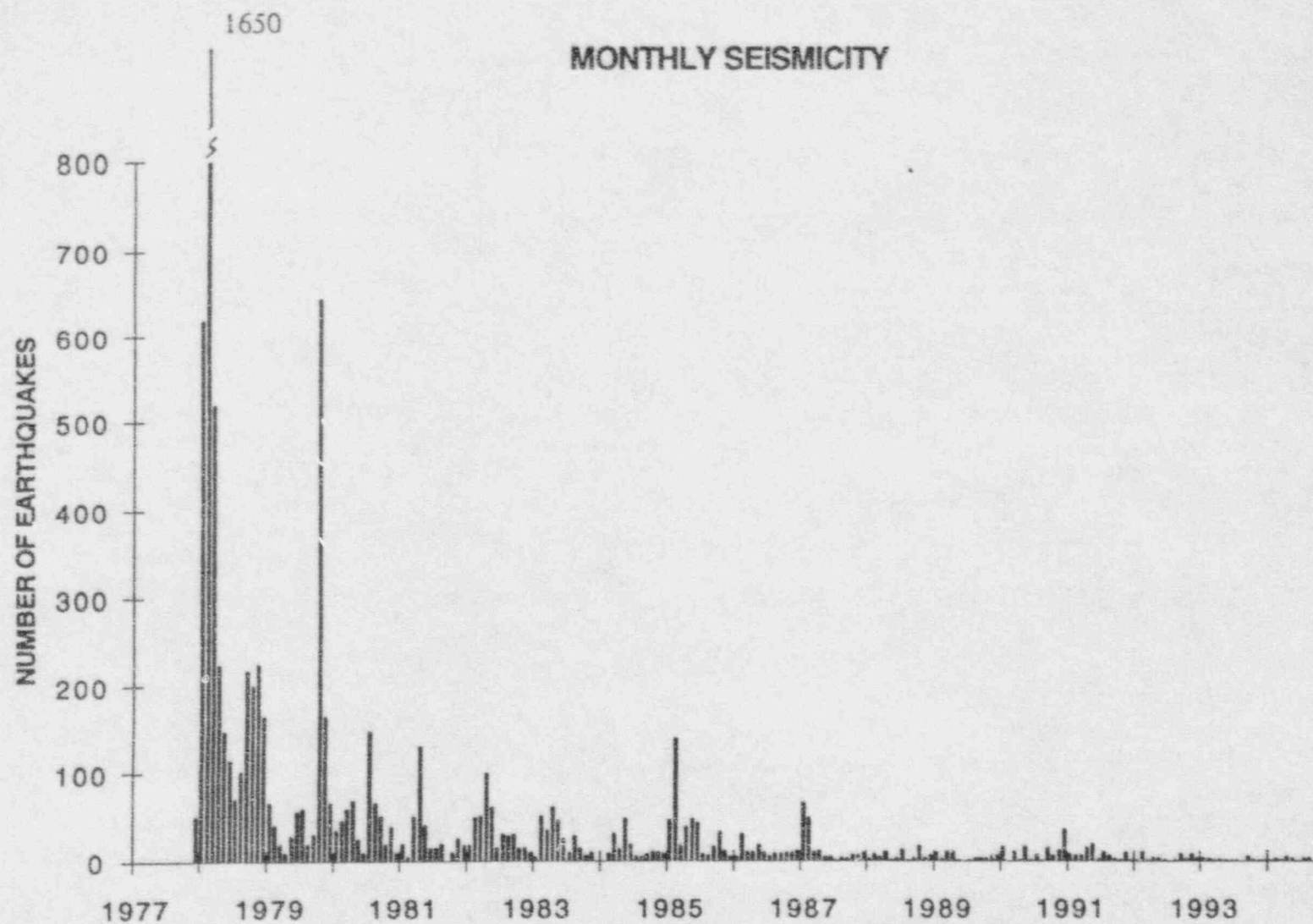


Figure 3. Earthquakes between impoundment and September, 1994.



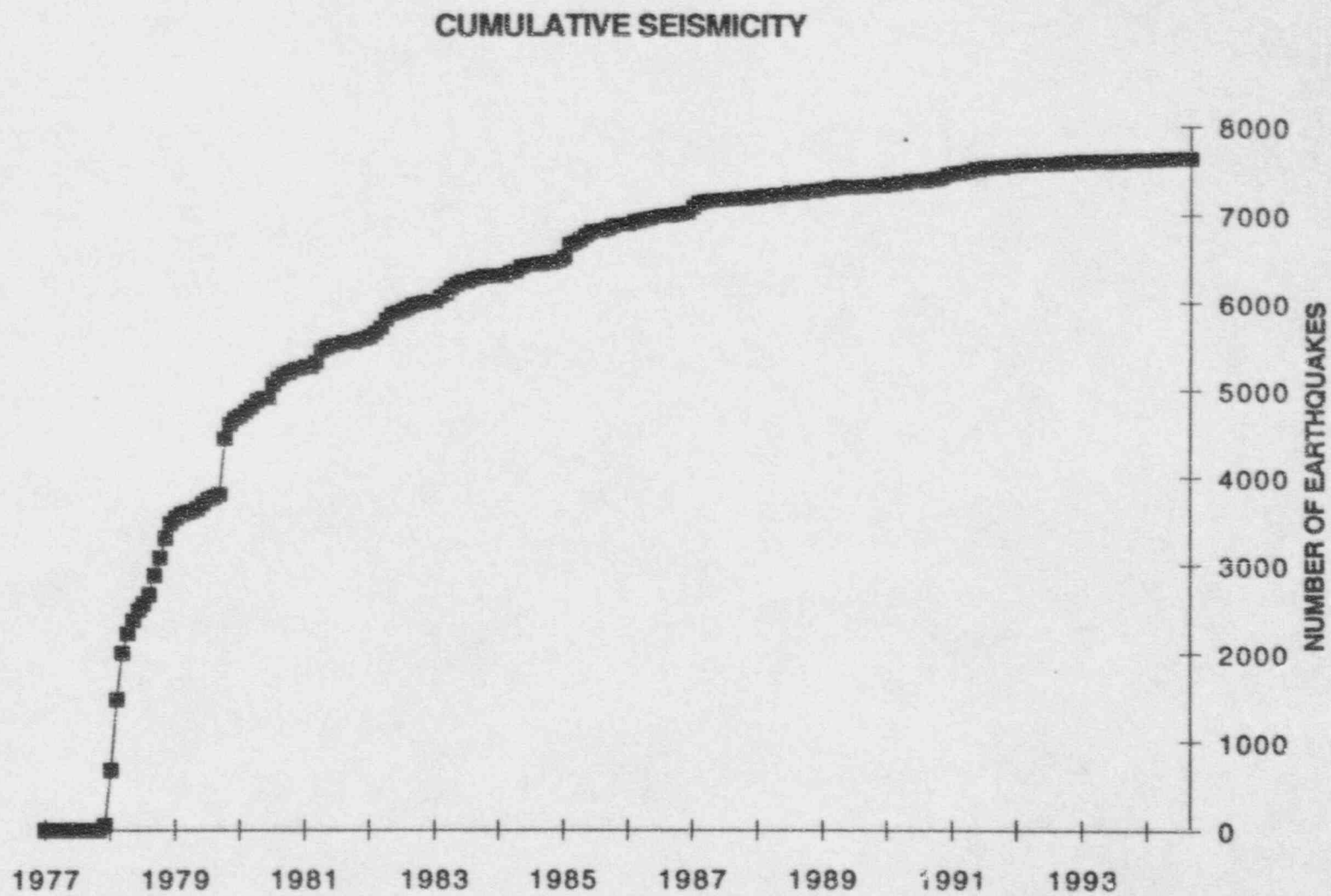
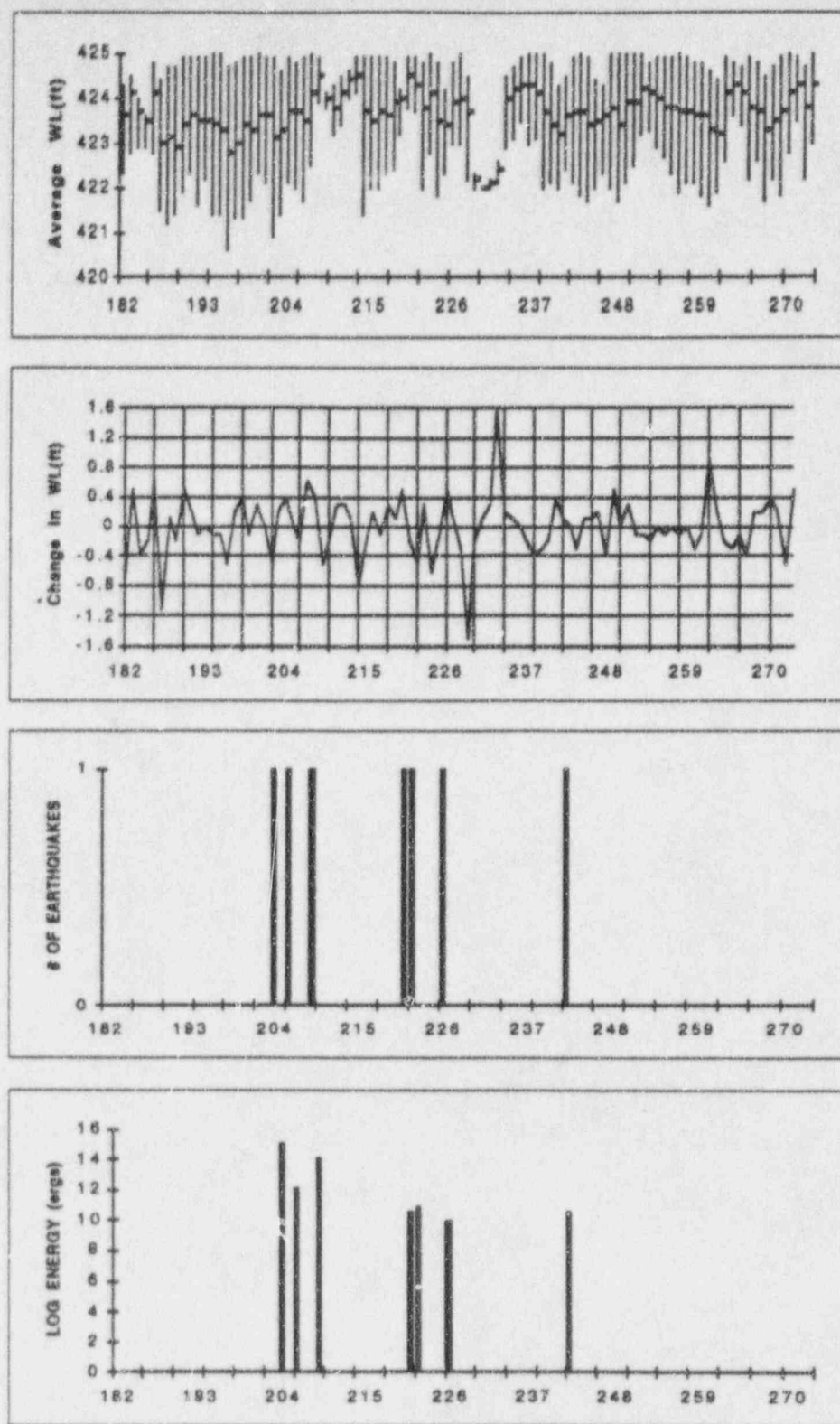


Figure 4. Cumulative seismicity near Menticello Reservoir since impoundment.



JULY 1994 / AUGUST 1994 / SEPTEMBER 1994

**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, 1994

STATION	PERCENT DOWNTIME
MR01	0.0
MR02	0.0
MR05	100.0
MR07	5.4
MR10	9.8
JSC	0.0

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. $RMS = R_i^2 / N_o$ , 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, 1994

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	Q	M
940723	112 15.94	34-21.83	81-21.64	0.09	2.16	10	290	3.4	0.04	0.8	1.3	C	1
940725	1211 39.73	34-22.33	81-19.60	2.21	0.21	8	344	0.2	0.04	1.4	0.3	C	1
940728	16 4 31.50	34-18.29	81-15.70	2.68	1.54	6	213	2.8	0.03	2.2	0.8	C	1
940809	945 47.63	34-19.89	81-20.35	0.91	-0.86	4	248	0.6	0.03			C	1
940810	233 20.48	34-22.29	81-21.35	2.95	-0.60	6	332	4.3	0.06	2.2	1.8	C	1
940814	1258 19.27	34-19.45	81-20.21	1.12	-1.22	4	232	1.3	0.01			C	1
940830	1257 47.58	34-22.33	81-20.31	3.00	-0.86	4	314	1.2	0.03			C	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 July 1 - September 30, 1994. Dates are given in Julian Calendar.

J.DATE	WL (max)	WL (min)	WL (avg)	WL (ch)	# of eqs	Energy
182	424.3	422.3	423.6	-0.7	0	0
183	424.5	422.8	424.1	0.5	0	0
184	424	422.9	423.7	-0.4	0	0
185	423.6	422.9	423.5	-0.2	0	0
186	424.8	422.8	424.1	0.6	0	0
187	424.4	421.5	423	-1.1	0	0
188	424.7	421.2	423.1	0.1	0	0
189	424.7	421.4	422.9	-0.2	0	0
190	424.9	421.9	423.4	0.5	0	0
191	424.9	422.3	423.6	0.2	0	0
192	424.9	421.6	423.5	-0.1	0	0
193	424.9	422.2	423.5	0	0	0
194	425	421.4	423.4	-0.1	0	0
195	425	421.4	423.3	-0.1	0	0
196	424.7	420.6	422.8	-0.5	0	0
197	424.8	421.3	423	0.2	0	0
198	424.9	421.3	423.4	0.4	0	0
199	424.9	421.7	423.3	-0.1	0	0
200	425	422.3	423.6	0.3	0	0
201	424.9	422.1	423.6	0	0	0
202	424.9	420.9	423.1	-0.5	0	0
203	424.6	421.4	423.3	0.2	0	0
204	424.9	422.1	423.7	0.4	1	15.04
205	424.8	422	423.7	0	0	0
206	424.9	421.7	423.5	-0.2	1	12.12
207	425	422.5	424.1	0.6	0	0
208	424.9	423.9	424.5	0.4	0	0
209	424.1	423.8	424	-0.5	1	14.11
210	424.3	423.2	423.8	-0.2	0	0
211	424.5	423.4	424.1	0.3	0	0
212	424.6	424	424.4	0.3	0	0
213	424.9	424.1	424.5	0.1	0	0
214	424.9	421.4	423.7	-0.8	0	0
215	424.9	422	423.5	-0.2	0	0
216	424.9	422	423.7	0.2	0	0
217	424.9	422.3	423.6	-0.1	0	0
218	424.8	422.4	423.9	0.3	0	0
219	424.2	423.2	424	0.1	0	0
220	424.9	423.8	424.5	0.5	0	0
221	424.9	423.7	424.3	-0.2	1	10.51
222	424.8	422	423.8	-0.5	1	10.9
223	425	422.8	424.1	0.3	0	0
224	424.8	421.8	423.5	-0.6	0	0
225	424.2	422.3	423.4	-0.1	0	0
226	424.8	423	423.9	0.5	1	9.97
227	425	423	424	0.1	0	0

# APPENDIX VI (continued)

J.DATE	WL (max)	WL (min)	WL (avg)	WL (ch)	# of eqs	Energy
228	424.5	422.2	423.7	-0.3	0	0
229	422.3	422	422.2	-1.5	0	0
230	422	422	422	-0.2	0	0
231	422.2	422	422.1	0.1	0	0
232	422.6	422.1	422.4	0.3	0	0
233	424.5	422.9	424	1.6	0	0
234	424.7	423.1	424.2	0.2	0	0
235	424.9	423.5	424.3	0.1	0	0
236	425	423	424.3	0	0	0
237	425	423.1	424.1	-0.2	0	0
238	425	422	423.7	-0.4	0	0
239	424.8	422.1	423.4	-0.3	0	0
240	424.3	422	423.2	-0.2	0	0
241	424.5	422.4	423.6	0.4	0	0
242	424.9	422.1	423.7	0.1	1	10.51
243	425	421.8	423.7	0	0	0
244	424.9	421.7	423.4	-0.3	0	0
245	424.4	422	423.5	0.1	0	0
246	424.3	422.3	423.6	0.1	0	0
247	425	422	423.8	0.2	0	0
248	425	421.7	423.4	-0.4	0	0
249	425	422.1	423.9	0.5	0	0
250	425	422.5	423.9	0	0	0
251	425	423.2	424.2	0.3	0	0
252	424.8	423.3	424.1	-0.1	0	0
253	424.9	422.9	424	-0.1	0	0
254	424.9	422.7	423.8	-0.2	0	0
255	424.9	422.3	423.8	0	0	0
256	425	421.9	423.7	-0.1	0	0
257	424.9	422.1	423.7	0	0	0
258	424.8	422.1	423.6	-0.1	0	0
259	424.8	421.8	423.6	0	0	0
260	424.6	421.6	423.3	-0.3	0	0
261	424.4	421.9	423.2	-0.1	0	0
262	424.9	422.6	424.1	0.9	0	0
263	424.8	423.6	424.3	0.2	0	0
264	424.7	423.4	424.1	-0.2	0	0
265	424.9	422.2	423.8	-0.3	0	0
266	424.8	422.6	423.7	-0.1	0	0
267	424.5	421.7	423.3	-0.4	0	0
268	424.7	422.2	423.5	0.2	0	0
269	424.9	421.8	423.7	0.2	0	0
270	425	422.8	424.1	0.4	0	0
271	424.9	423.5	424.3	0.2	0	0
272	424.7	422.2	423.8	-0.5	0	0
273	425	423	424.3	0.5	0	0