

TECHNICAL REPORT 92-2

SEISMIC ACTIVITY NEAR THE
V.C. SUMMER NUCLEAR STATION

FOR THE PERIOD

APRIL -JUNE 1992

BY

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INTRODUCTION

Analysis of the seismic activity near the V.C. Summer Nuclear Station in South Carolina for the period April-June 1992 is presented in this report. During this period, 10 events were recorded in the vicinity of Monticello Reservoir. Four events were located. The largest two events recorded were of magnitude $M_L = 1.0$. One occurred on April 2 (17:14:29.62 UTC) and the other was on May 29 (16:54:44.12 UTC). The seismicity during this quarter was at a very low level.

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 events is shown in Figure 1a and station coordinates are listed in Appendix I. The network was fully operational during most of this quarter except for stations MR01 and MR02, which were not operational for five days in May. The operational status of the network is given in Appendix II. Since April 29, the events from Monticello Network are also recorded digitally on the PUFFIN unit, in addition to the existing facility of analog recording on the tape recorders. The digital data retrievable on the computer provide more accurate P and S arrival times. Sample traces for the event on April 29, reconstructed from the digital data are presented in Figure 1b.

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 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 APRIL-JUNE, 1992

During this period, 10 earthquakes were recorded, of which 4 were located (Figure 2; Appendix V). Only one of the located events was of B quality and the rest were of C or D quality. There were two events of magnitude ($M_L=1.0$), one on April 2 (17:14:29.62 UTC) and one on May 29 (16:54:44.12 UTC). The other two locatable events were of magnitudes $M_L = 0.8$ and 0.2 , which occurred on April 29 and May 21, respectively. The remaining events during this period were generally of short duration (less than 1G sec) with an S-P time of 0.25 to 0.9 sec at JSC, MR07 and MR10 (Appendix VI). The located seismicity was scattered, with three events occurring to the north of the lake. Only one of the located events on May 21 ($M_L = 0.2$) occurred in the middle of the lake where some activity was reported during the last quarter also.

The long term decline in seismicity observed at Monticello is continuing (Figure 3). The seismicity at Monticello seems to have leveled off since 1985-1986 (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 Appendices V and VI. The average water level, daily changes in water level, number of earthquakes and energy release are given in Appendix VII. No systematic correlation was observed between the seismicity and reservoir level fluctuations.

CONCLUSIONS

The data collection and interpretational facilities for the Monticello Network have been further improved by digital recording of the data. The level of seismicity recorded during the second quarter of 1992 was generally of a low level. Of the ten recorded events only two were of magnitude $M_L \geq 1.0$. 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 HYC 071, U.S. Geological Survey, *Open-File Report*, 100 pp.

Monticello Reservoir Seismic Network

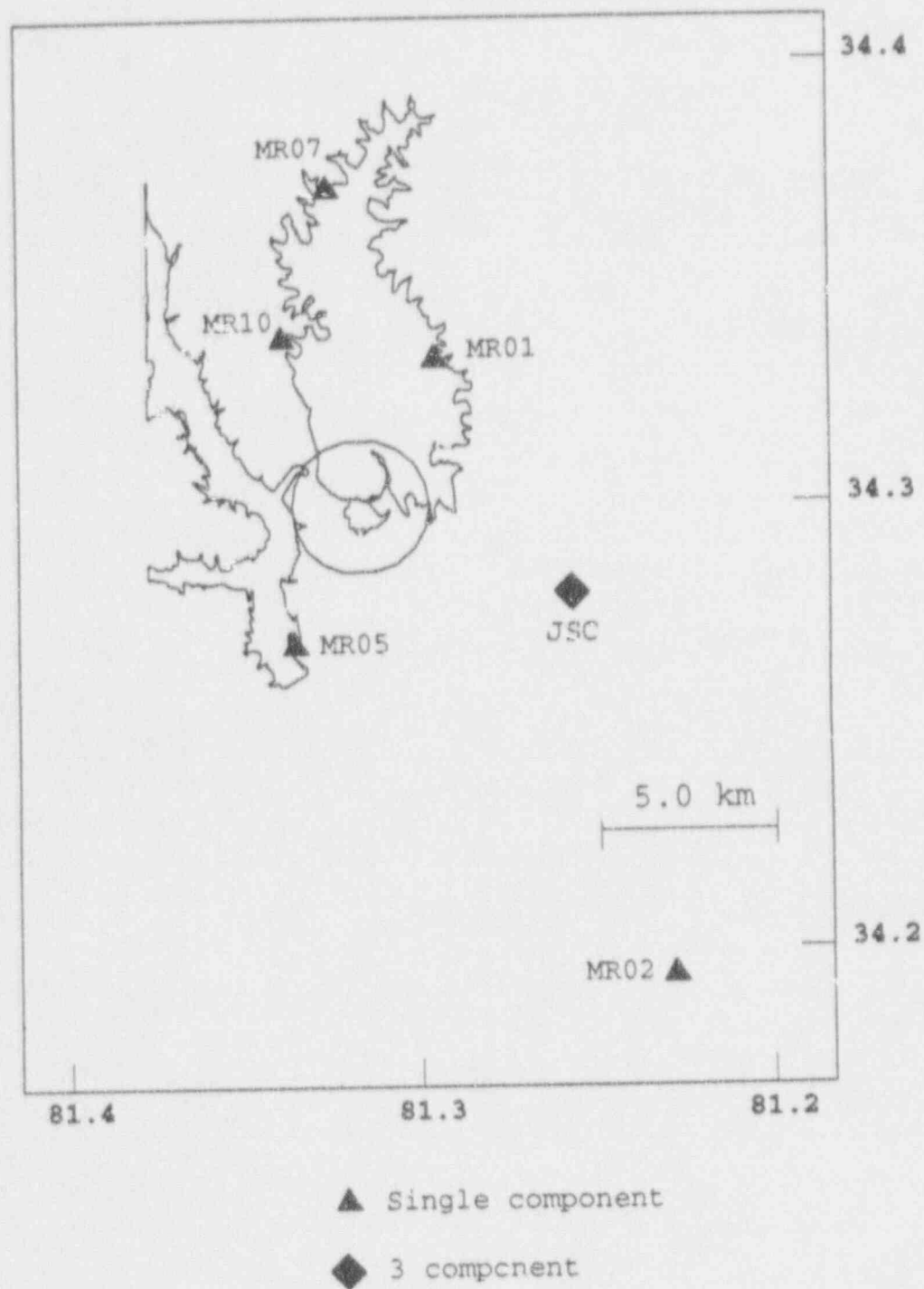


Figure 1a Location of Monticello Reservoir area showing seismic stations used in locating seismicity.

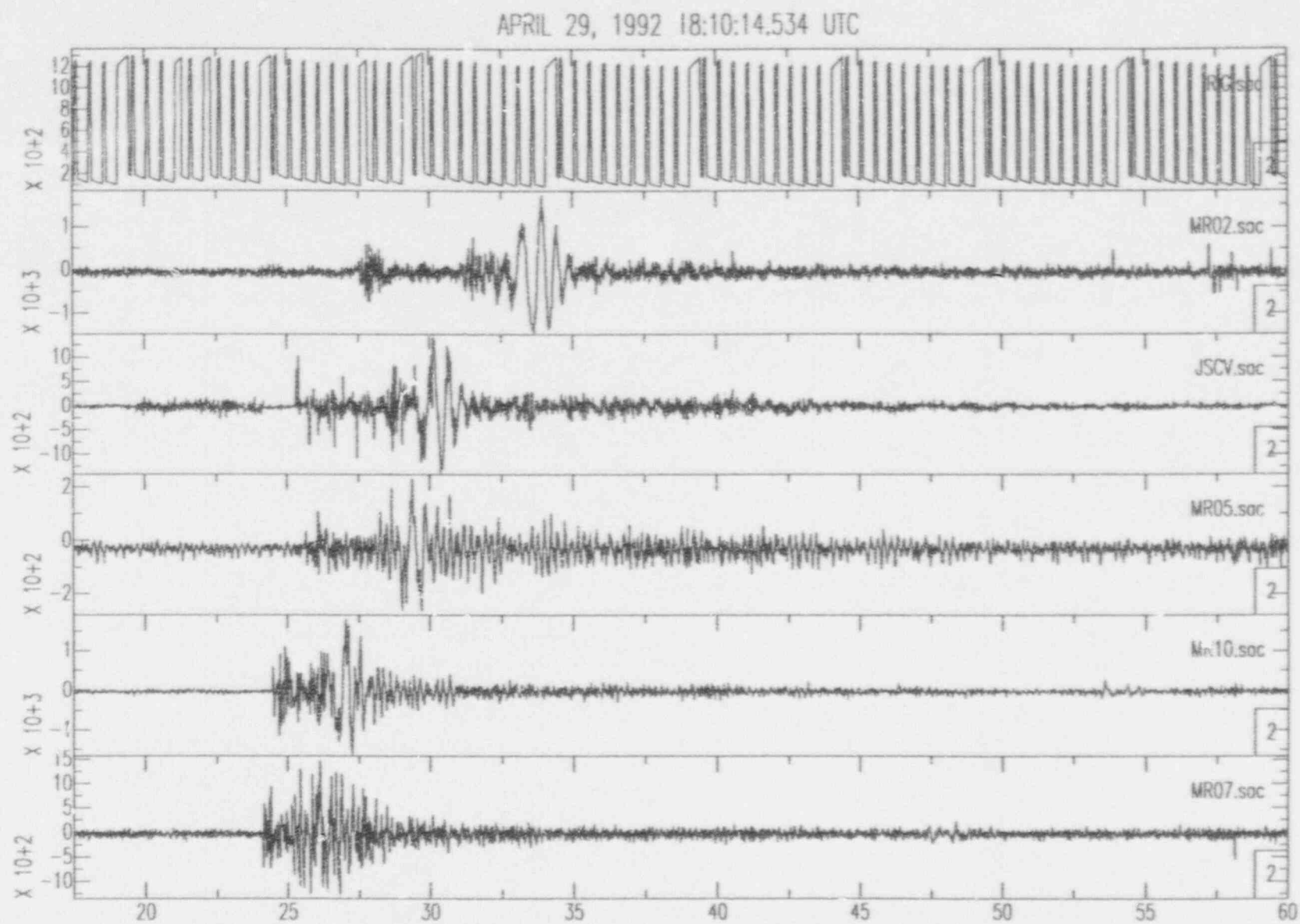


Figure 1b Play back of the $M_L = 0.8$ event on April 29, 1992 near Monticello Reservoir.

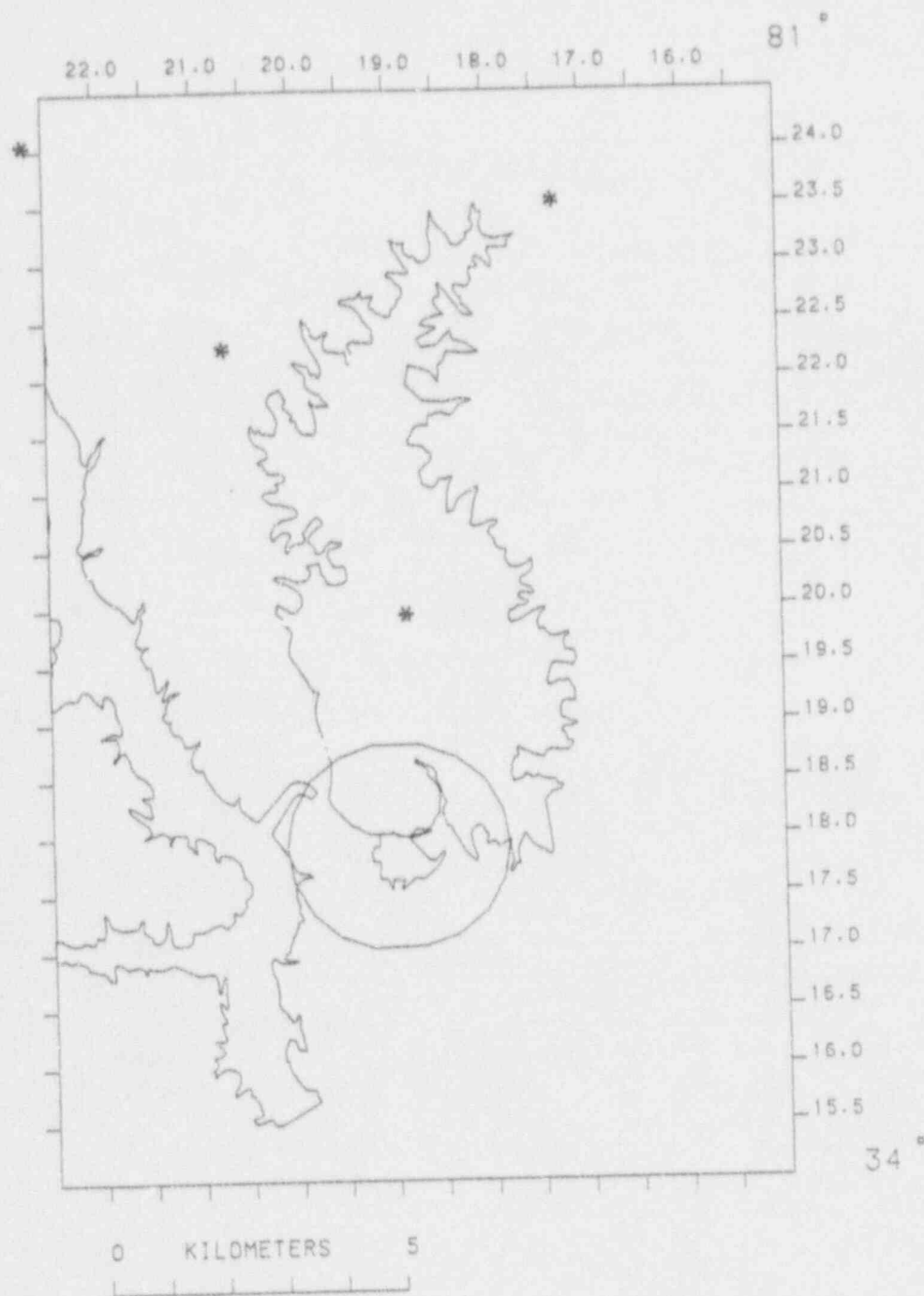


Figure 2. Earthquakes located near Monticello Reservoir during the period April June, 1992

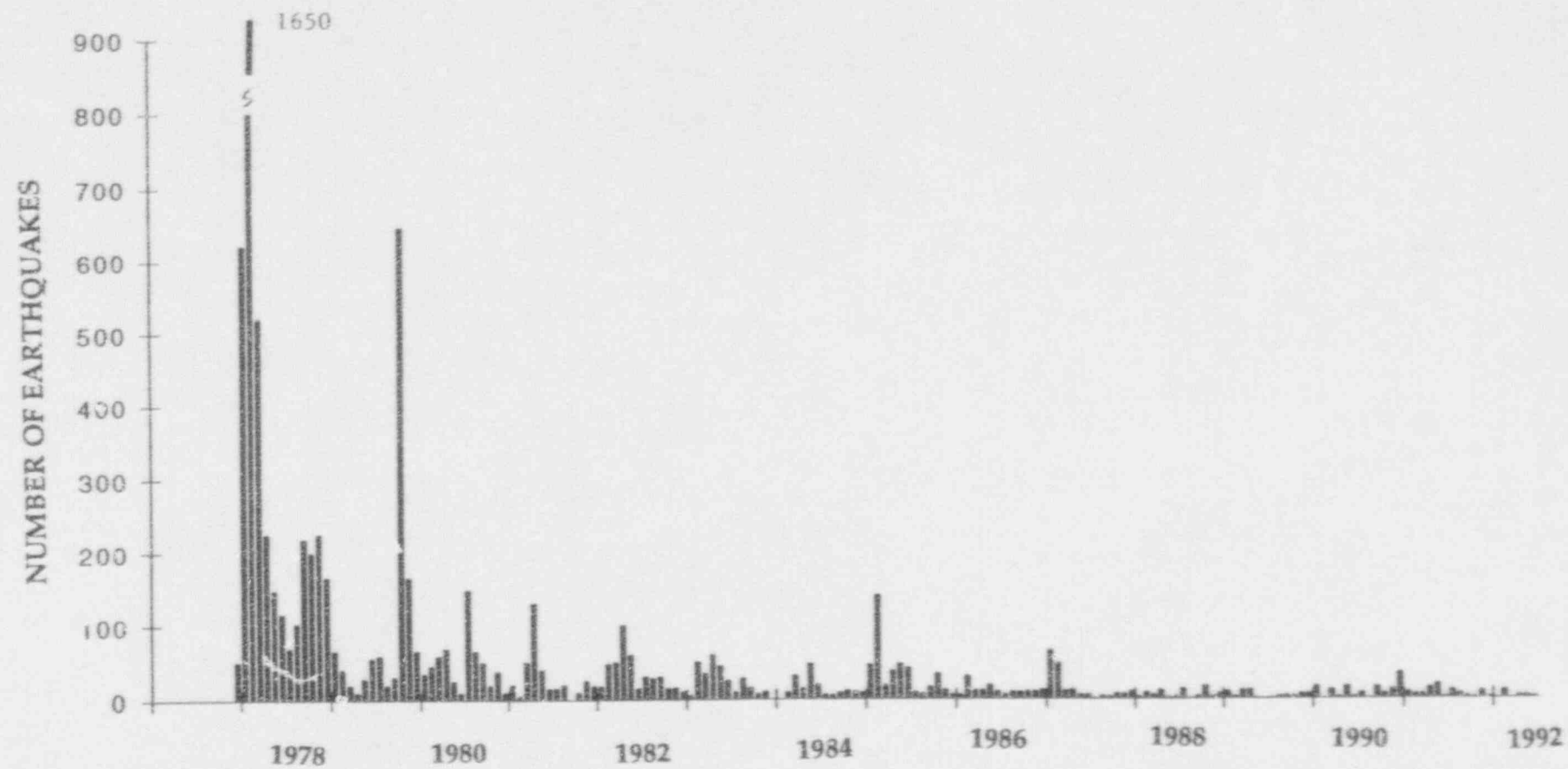


Figure 3. Earthquakes between impoundment and June 1992.

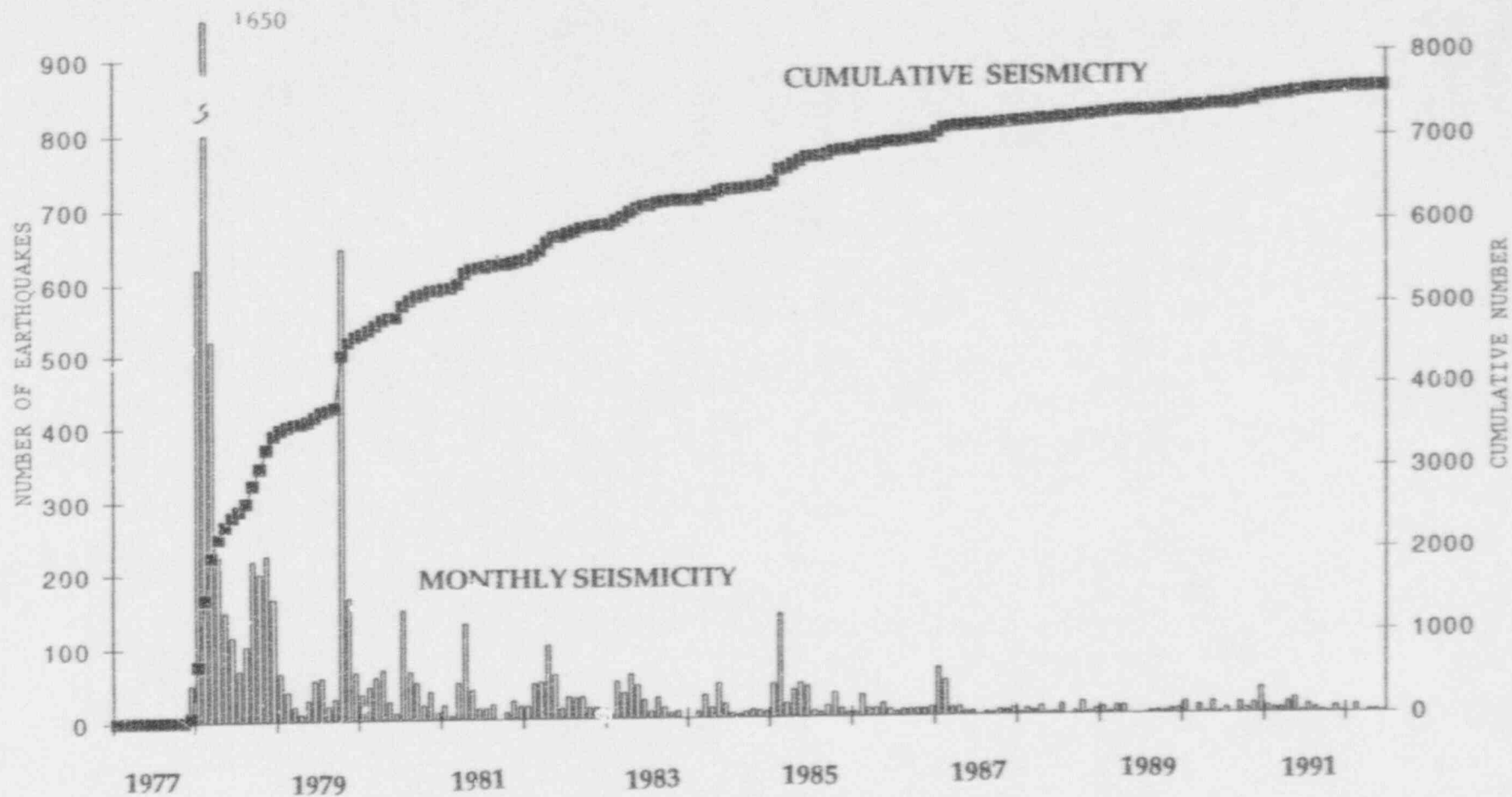


Figure 4. Monthly seismicity (bars) and cumulative seismicity (line) near Monticello Reservoir since impoundment.

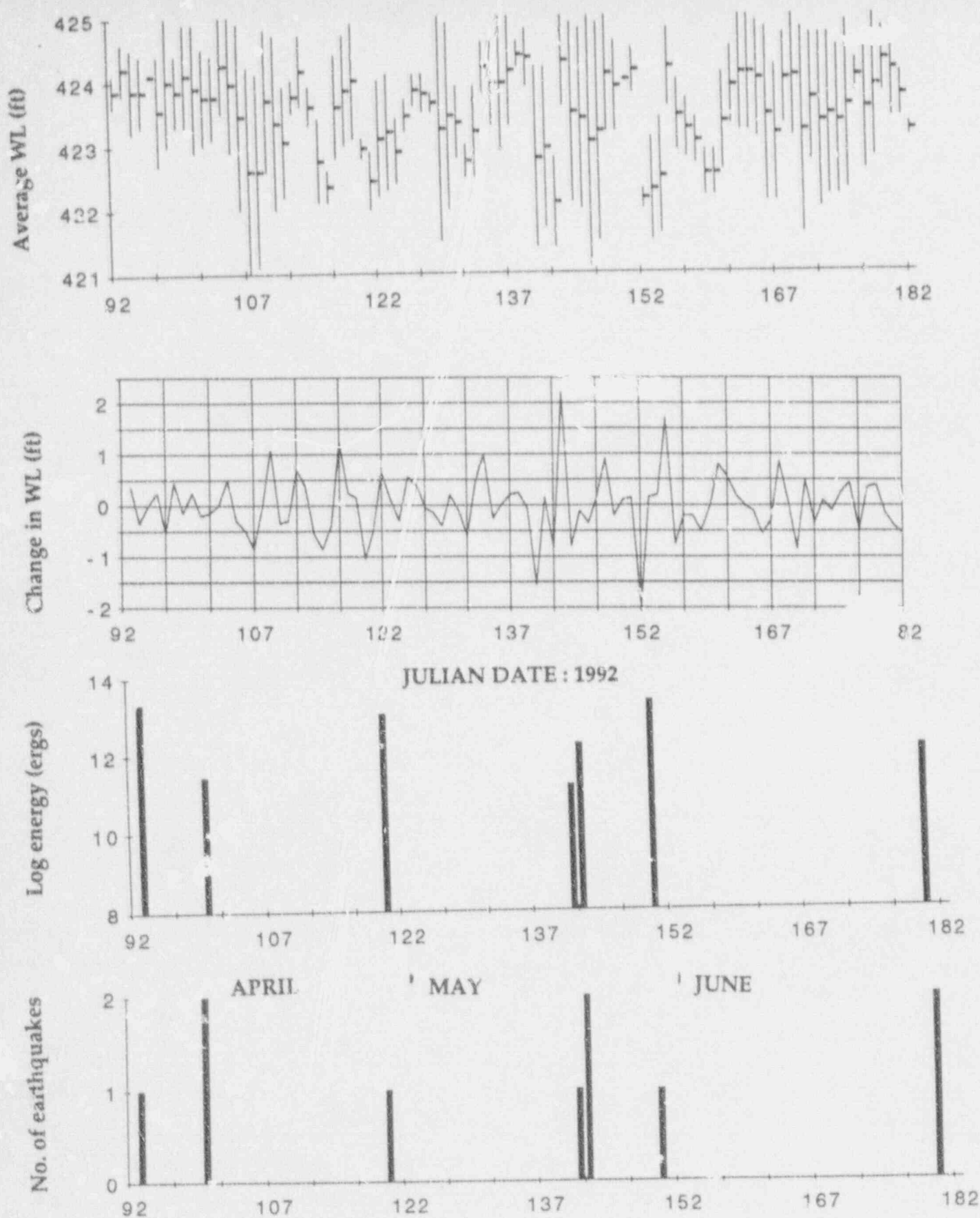


Figure 5. Comparison of daily reservoir level, changes in reservoir level, number of earthquakes and the log of energy release in ergs per day at Monticello Reservoir. Error bars in the top panel indicate daily fluctuations in reservoir level.

APPENDIX I
STATION LOCATIONS

STATION	LAT° N	LONG °W
JSC	34°16' 00"	81°15.60'
MR01	34°19' 00"	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

APRIL -JUNE 1992

STATION	% DOWNTIME
JSC	0
MR01	6
MR02	6
MR05	0
MR07	0
MR10	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. $RMS = R_i^2 / No$, 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.

* 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

APRIL 1 - JUNE 30, 1992

DATE	ORIGIN	LAT N	LONG W	DEPTH	MAG	NO	GAP	DMIN	RMS	ERH	ERZ	QM
920402	1714	29.62	34-22.33	81-20.66	1.00	1.02	7 281	1.8	0.15	2.9	4.5	D1
920429	1810	2.98	34-23.60	81-17.18	4.90	0.82	7 292	4.4	0.15	3.6	2.7	D1
920521	1431	33.09	34-20.01	81-18.79	0.42	0.21	7 111	1.6	0.08	0.8	2.1	B1
920529	1654	44.12	34-24.09	81-22.80	2.79	1.02	8 333	6.1	0.07	1.2	1.6	C1

APPENDIX VI

LIST OF EVENTS WITH (S-P) \leq 2.5 SEC RECORDED AROUND MONTICELLO RESERVOIR DURING APRIL - JUNE 1992

DATE	STATION	P-ARR.TIME	S-P(SEC)	EP.DIST (S-P)X8.5	DUR (S)	MAG
92 04 09	MR07	02 12 40.08	0.9	7.7	5	-0.4
92 04 09	MR07	22 32 07.50	0.25	2.1	4	-0.6
92 05 20	MR10	03 10 55.00	0.25	2.1	5	-0.4
92 05 21	JSC	14 46 34.05	0.5	4.3	8	0
92 06 28	MR07	11 55 42.90	0.7	6	10	0.2
	MR10	11 55 43.10				
92 06 28	MR07	11 56 04.50	0.3	2.6	5	-0.4

Appendix VII

Maximum and minimum water levels, change in water level, number of earthquakes and energy release (ergs per day) at Monticello Reservoir during April-June 1992. Dates are given in Julian Calendar.

DATE	WL (Max)	WL (Min)	WL (Avg)	Change	# of eqs	Log E
92	424.1	423.6	423.9		0	0
93	424.6	423.8	424.2	0.4	1	13.33
94	424.5	423.2	423.9	-0.4	0	0
95	424.4	423.3	423.9	0.0	0	0
96	424.1	424.1	424.1	0.3	0	0
97	424.4	422.7	423.6	-0.6	0	0
98	425	423	424.0	0.5	0	0
99	424.4	423.3	423.9	-0.1	0	0
100	424.9	423.3	424.1	0.3	2	11.44
101	424.9	422.9	423.9	-0.2	0	0
102	424.5	423	423.8	-0.1	0	0
103	424.4	423.1	423.8	0.0	0	0
104	425	423.5	424.3	0.5	0	0
105	425	422.9	424.0	-0.3	0	0
106	424.9	422	423.5	-0.5	0	0
107	424.2	421	422.6	-0.9	0	0
108	424.1	421.1	422.6	0.0	0	0
109	424.8	422.6	423.7	1.1	0	0
110	424.7	422	423.4	-0.4	0	0
111	423.9	422.2	423.1	-0.3	0	0
112	424	423.5	423.8	0.7	0	0
113	424.7	423.6	424.2	0.4	0	0
114	423.9	423.3	423.6	-0.5	0	0
115	423.4	422.1	422.8	-0.9	0	0
116	422.6	422.1	422.4	-0.4	0	0
117	424.4	422.8	423.6	1.3	0	0
118	424.7	423	423.9	0.3	0	0
119	424.9	423.1	424.0	0.1	0	0
120	423.1	422.8	423.0	-1.0	1	13.04
121	422.9	422	422.5	-0.5	0	0
122	424	422.2	423.1	0.7	0	0
123	424.1	422.3	423.2	0.1	0	0
124	423.4	422.4	422.9	-0.3	0	0
125	423.7	423.2	423.5	0.6	0	0
126	424.1	423.6	423.9	0.4	0	0
127	424.1	423.5	423.8	-0.1	0	0
128	423.8	423.5	423.7	-0.2	0	0
129	425	421.5	423.3	-0.4	0	0
130	424.9	422	423.5	0.2	0	0
131	423.9	422.8	423.4	-0.1	0	0
132	423	422.5	422.8	-0.6	0	0
133	423.9	422.5	423.2	0.4	0	0
134	424.6	423.8	424.2	1.0	0	0
135	424.6	423.3	424.0	-0.3	0	0
136	425	422.9	424.0	0.0	0	0
137	425	423.3	424.2	0.2	0	0
138	424.6	424.2	424.4	0.3	0	0
139	424.8	423.9	424.4	0.0	0	0
140	424.2	421.4	422.8	-1.6	0	0
141	424.2	421.7	423.0	0.2	1	11.19
142	421.4	422.8	422.1	-0.8	2	12.24
143	425	423.6	424.3	2.2	0	0
144	424.9	422.1	423.5	-0.8	0	0
145	424.8	422	423.4	-0.1	0	0
146	425	421.1	423.1	-0.3	0	0

147	424.9	421.5	423.2	0.1	0	0
148	425	423.2	424.1	0.9	0	0
149	424.6	423.2	423.9	-0.2	0	0
150	424	424	424.0	0.1	1	13.33
151	424.5	423.8	424.2	0.1	0	0
152	422.3	422	422.2	-2.0	0	0
153	423.1	421.5	422.3	0.2	0	0
154	423.4	421.6	422.5	0.2	0	0
155	424.8	423.6	424.2	1.7	0	0
156	424	422.9	423.5	-0.8	0	0
157	423.7	422.8	423.3	-0.2	0	0
158	423.4	422.7	423.1	-0.2	0	0
159	422.9	422.2	422.6	-0.5	0	0
160	422.9	422.2	422.6	0.0	0	0
161	424.1	422.6	423.4	0.8	0	0
162	424.5	423.3	423.9	0.5	0	0
163	425	423.2	424.1	0.2	0	0
164	425	423.2	424.1	0.0	0	0
165	424.9	423.1	424.0	-0.1	0	0
166	424.8	422.1	423.5	-0.5	0	0
167	424.2	422.1	423.2	-0.3	0	0
168	424.7	423.3	424.0	0.9	0	0
169	425	423.1	424.1	0.1	0	0
170	424.8	421.6	423.2	-0.8	0	0
171	424.7	422.7	423.7	0.5	0	0
172	424.7	422	423.4	-0.3	0	0
173	424.7	422.2	423.5	0.1	0	0
174	424.5	422.2	423.4	-0.1	0	0
175	424.9	422.3	423.6	0.3	0	0
176	424.3	423.8	424.1	0.4	0	0
177	424.5	422.6	423.6	-0.5	0	0
178	425	422.8	423.9	0.3	0	0
179	424.8	423.8	424.3	0.4	0	0
180	424.9	423.4	424.2	-0.2	2	12.11
181	424.1	423.4	423.8	-0.4	0	0
182	423.3	423.1	423.2	-0.5	0	0