Cooperative Central and Southeast US Integrated Seismic Network – USC

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INVESTIGATIONS UNDERTAKEN

The "Cooperative Central and Southeast US Integrated Seismic Network" conducts routine seismic monitoring for the central and southeast US. As part of this program, the South Carolina Seismic Network (SCSN) headquartered at the University of South Carolina (USC) routinely monitors seismicity in South Carolina. The SCSN monitors tectonic earthquakes as well as reservoir-induced earthquakes, and it continued to do so during the period October 1, 2003 – September 30, 2004. The tectonic earthquakes are mostly concentrated in Middleton Place Summerville Seismic Zone (MPSSZ) near Charleston, the focus of the USGS support. Support for monitoring earthquakes near reservoirs and other parts of the state is obtained from other sources and not from the USGS. The reservoir induced earthquakes are located around Monticello reservoir in central SC. Earthquakes that occur in other parts of the state are also recorded and located. Data from all parts of SC are continually recorded digitally and posted on the Internet at http://scsn.seis.sc.edu and also sent to USGS Golden and also archived at USC. Additionally, the SCSN publishes an annual bulletin which can be obtained from its website at http://scsn.seis.sc.edu/bulletin/bulletin.html. This Annual Project Summary provides a report of seismic monitoring in South Carolina during October 1, 2003 – September 30, 2004.

South Carolina Seismic Network Operation

(A) Station Locations

During October 1, 2003 – September 30, 2004, the SCSN comprised of 16 stations. These included three stations in the "main net", eight stations in the Coastal Plain network and five stations in the Monticello Reservoir sub-network. The present configuration of the seismic network is shown in Figure 1(a). The stations of the "main" SCSN (JSC, LHS) cover the area in the lower Piedmont and (COW) covers the upper Coastal Plain (Figure 1(b)). Data from these stations are telemetered and recorded at USC. The Coastal Plain Seismic Network consists of three bore-hole stations, CSB, RGR, and HBF, and six surface stations, CSU, DRC, MGS, SVS, TWB and WAS. These cover the meizoseismal area of the 1886 Charleston earthquake (Figure 1(c)). Data from these

stations are telemetered and recorded at Charleston Southern University and also transmitted to USC. The configuration of stations in the vicinity of Monticello Reservoir area is shown in Figure 1(d). Data from the five station Monticello Reservoir sub-network (Figure 1(d)) are telemetered and recorded at the USC Seismological Laboratory in Columbia.

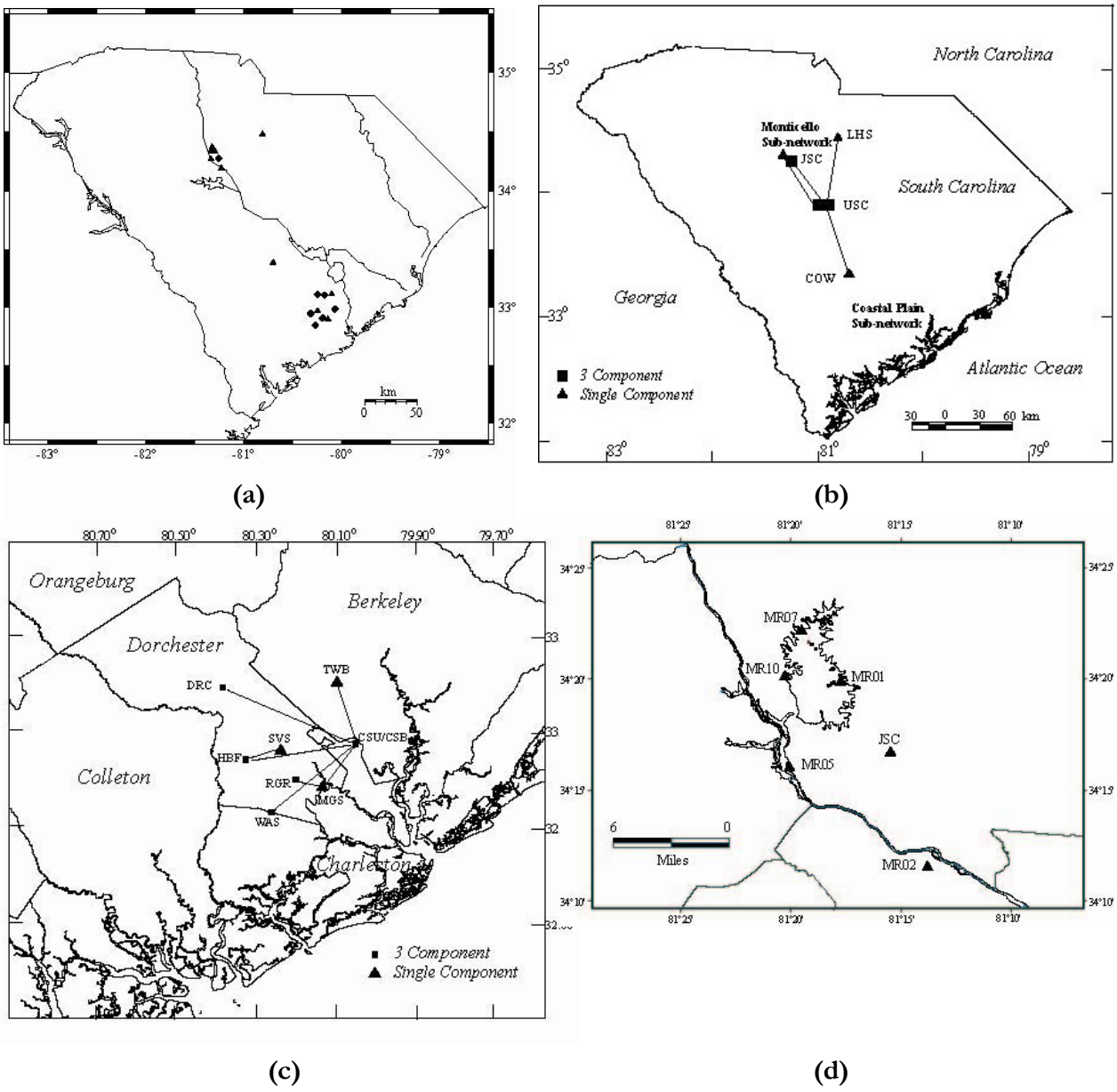

Figure 1: **(a)** Distribution of stations/subnets of the South Carolina Seismic Network during October 1, 2003 – September 30, 2004. Triangles (▲) represent single component stations while diamonds (♦) represent three component stations. **(b)** Stations of the Main Network (JSC, COW, LHS) and their telemetry routes. **(c)** Stations of the Coastal Plain Seismic Network and their telemetry routes (3-component station ■). **(d)** Stations of the Monticello Reservoir sub-network.

(B) Recording Facilities

Digital data are recorded continuously at USC on PC-based system at 50 samples/second. To facilitate easier storage of the continuous data being recorded at USC, a DAT tape drive was installed on our PCSUDS analysis workstation. This tape drive can store approximately 2 gigabytes of data on a single tape. Accumulating data at the rate of 288 Mb per day, the new tape drive has given us the ability to mass dump data each morning from hard disk to tape. A backlog of 30 days data is maintained at the present time. At USC data are also recorded on two Helicorders. In October of 1998, the USGS initiated the new phase of cooperative seismic monitoring. So the recording operations of both the Charleston Southern University and USC facilities were augmented with the installation of "Earthworm". Earthworm is a PC-based, event triggered and short term continuous data recording system that utilizes the Internet for data transfer and sharing. This allows data from the SCSN to be shared with networks at CERI (Memphis) and the USGS in Golden, Colorado as part of the Advanced National Seismic System (ANSS) for the Central and Southeast US region. It also gives the main data analysis group at USC the ability to import data from stations throughout the southeast, thereby enhancing our event detection and location capabilities. Currently the trace data from Earthworm are transferred in near real time to USGS Golden.

(C) Upgraded Facilities

Following a meeting between Mr. Richard Cannon, Network Manager at SCSN and Dr. Mitch Withers and his technical staff at CERI, Memphis in June 2004, efforts are underway to enhance seismic data recording capabilities and event location reporting to the NEIC. In late June 2004, Quick Data Distribution System (QDDS), a USGS program for distributing earthquake data over the Internet was installed on the Unix side of the Earthworm system at the University of South Carolina. It has been successfully tested and is now used to send event data for South Carolina to the USGS. Arrangements were made with Gregg Steiner, Technical Director for CERI, to have a number of PANDA II instrument packages released to the SCSN. As of September 2004, four of these 3-component, auto gain-ranging field systems have been received along with the pre-amplifiers, discriminators, racks, UHF transmitters/receivers, and new antennas. These will be used to update several key stations in the network as soon as necessary hardware and cables are obtained.

(D) Data Analyses

Data are analyzed at the USC's seismological laboratory. Identification of blasting activity, documentation of regional and teleseismic events, location and analyses of local earthquakes form a part of the routine analyses. The increased hard disk storage capacity of the new digital recording system allowed for more flexibility in the event triggering formula for the total network. The present configuration of triggering operators consists of six separate triggering parameters encompassing the several sub-networks and the main network and some combinations. This increased triggering has allowed for the recording and locating of events of $M_L < 1.0$.

The data are processed using the Seismic Analyses Code (SAC) and Pascal Quicklook programs on the Sun workstations. Hypocentral locations are obtained using HYPOELLIPSE programs with an appropriate velocity model for each region. Event magnitudes are determined using the following relation:

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

where D is the signal duration in seconds. The results of seismic monitoring in the state during October 1, 2003 – September 30, 2004 is presented in the next section.

RESULTS

South Carolina Seismicity: October 1, 2003 – September 30, 2004

In South Carolina, SCSN monitors tectonic earthquakes as well as reservoir-induced earthquakes. The tectonic earthquakes are mostly concentrated in Middleton Place Summerville Seismic Zone (MPSSZ) near Charleston. The reservoir induced earthquakes are located around Monticello reservoir in central SC. Any earthquakes that occurred in other parts of the state were also recorded and located. A map with all the earthquakes located in South Carolina during October 1, 2003 – September 30, 2004 is shown in Figure 2.

During the reporting period, seismic activity continued in the MPSSZ and Monticello Reservoir areas. A total of 34 events were located (Table 1). Out of these 34 events, 19 were associated with MPSSZ, 12 were reservoir-induced, and 3 occurred sporadically in other parts of the state. Detailed description of seismicity in each year is provided next.

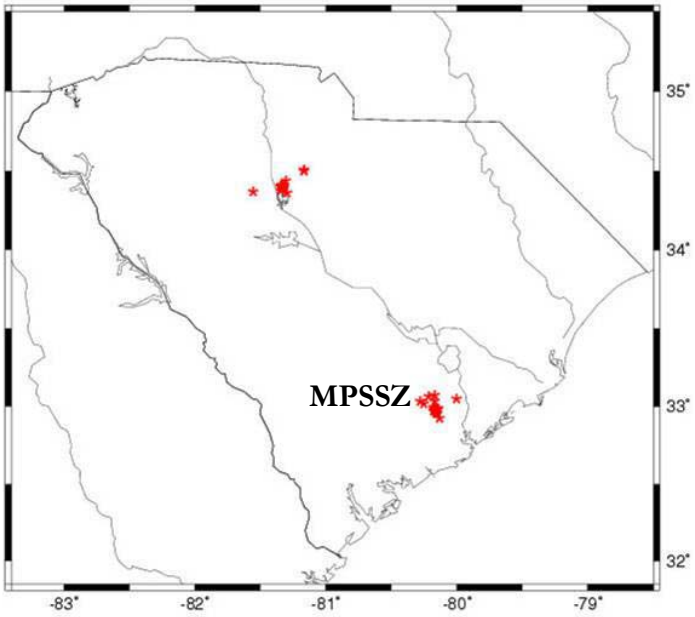

Figure 2: Map of South Carolina showing cumulative seismicity during October 1, 2003 – September 30, 2004 (red stars).

Middleton Place Summerville Seismic Zone

The MPSSZ continued to be the most active (non reservoir induced) seismic source zone in the Coastal Plain (Figure 3). A total of nineteen events were located with magnitudes ranging between M_L = 1.0 and M_L = 3.1 at depths shallower than 11 km (Table 1, Figure 3). Among the earthquakes in MPSSZ, 11 had $M_L \geq 2.0$ out of which 2 had $M_L \geq 3.0$. The largest earthquake in MPSSZ had a M_L = 3.1 and occurred at a depth of 10.3 km. The depth of earthquakes in MPSSZ ranged between 3 and 11 km. Most of the seismicity was located in a cluster north of Middleton Gardens with the exception of six events which were located about 10 km west, north, and east of the cluster respectively (Figure 3). Based on the locations of these events, and other analyses the cluster is associated with the N30°W oriented Sawmill Branch fault, whereas the events near Summerville are associated with the N23°E trending Woodstock fault (North).

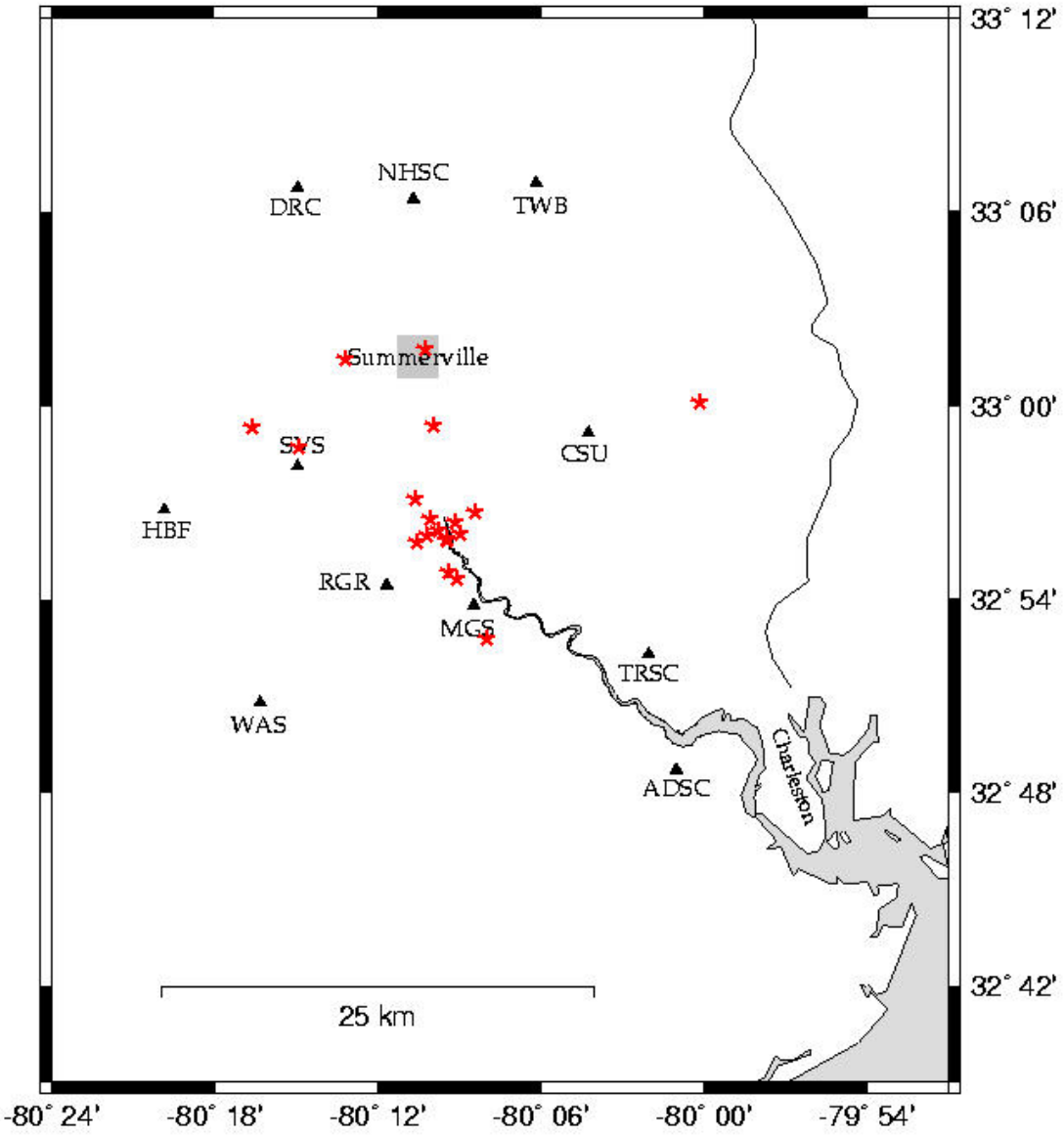

Figure 3: Seismicity in MPSSZ during October 1, 2003 – September 30, 2004 (red stars). The station locations are shown as solid triangles.

Reservoir Induced Seismicity - Monticello Reservoir

The seismic activity near Monticello Reservoir was at a low level during the reporting period. Twelve earthquakes were located near Monticello Reservoir (Table 1, Figure 4). Except for two events, all of the earthquakes had a $M_L < 1.0$. The largest earthquake had a $M_L = 2.5$ and occurred at a depth of 8.8 km. Except for the largest event, all depths were shallower than 2.5 km.

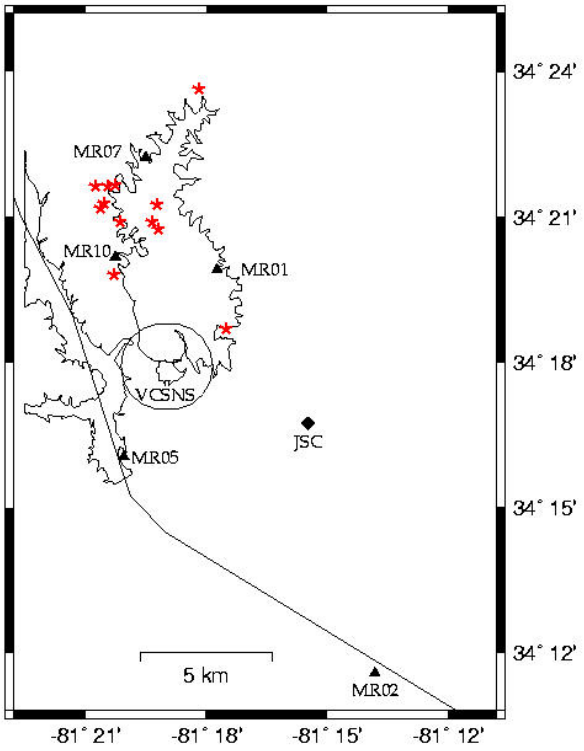

Figure 4: Seismicity near Monticello Reservoir during October 1, 2003 – September 30, 2004 (red stars). The station locations are shown as solid triangles except for JSC which is shown with a solid diamond.

Other Tectonic Activity

Three events of M_L 1.2 to 1.4 were located to the northeast and west of Monticello Reservoir area (Table 1, Figure 5). Their depths ranged from 1.9 to 3.3 km.

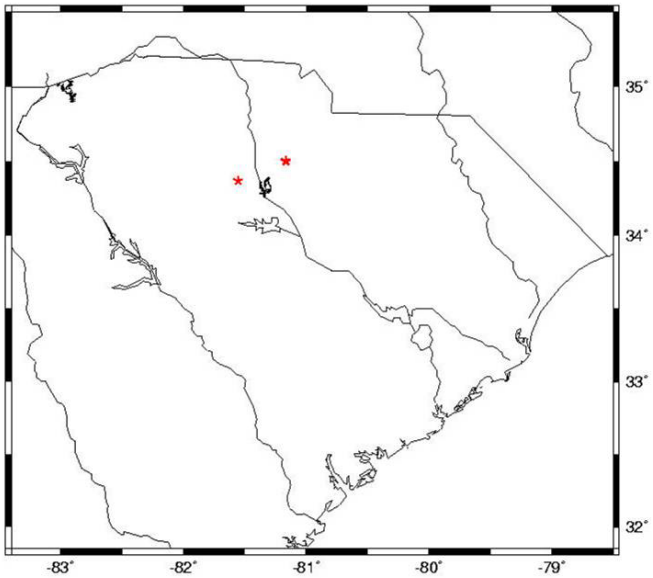

Figure 5: Seismicity in other parts of South Carolina during October 1, 2003 – September 30, 2004 (red stars).

TABLE 1
Earthquakes during October 1, 2003 – September 30, 2004
List of Earthquakes in MPSSZ

Date (UTC)	Hour	Min	Sec	Lat (°N)	Long (°W)	Depth (km)	Mag	Quality
20031014	10	45	38.62	32-56.75	80-10.59	7.2	2.5	A
20031020	05	59	32.01	32-55.51	80-09.46	7.0	1.4	A
20031022	23	36	27.90	32-58.99	80-09.93	7.5	2.4	A
20031028	16	42	43.51	32-55.60	80-10.17	7.4	1.7	A
20031118	06	49	13.75	32-52.40	80-09.77	3.4	1.1	A
20031201	09	18	19.59	32-56.34	80-08.41	8.6	2.2	A
20031202	21	21	31.11	32-55.66	80-08.96	5.4	1.4	A
20031222	07	32	12.52	32-55.72	80-09.73	10.1	1.8	B
20031222	23	50	26.04	32-55.44	80-09.44	5.6	3.0	A
20031222	23	53	59.94	32-54.26	80-09.06	6.7	1.5	A
20040113	18	19	26.87	33-01.03	80-13.15	7.5	2.2	A
20040212	11	03	35.20	32-54.47	80-09.39	9.1	2.0	A
20040229	12	40	05.26	32-56.13	80-10.08	7.7	2.0	A
20040501	04	16	28.27	32-59.71	80-00.16	10.7	2.7	A
20040508	11	25	21.68	32-55.37	80-10.52	5.8	1.9	A
20040720	09	13	14.44	32-58.32	80-14.90	10.3	3.1	A
20040813	04	11	05.09	32-58.94	80-16.57	7.0	2.2	A
20040818	03	43	46.36	33-01.35	80-10.28	7.7	2.5	A
20040820	01	56	21.34	32-56.00	80-09.11	6.9	1.9	A

List of Earthquakes near Monticello Reservoir

Date (UTC)	Hour	Min	Sec	Lat (°N)	Long (°W)	Depth (km)	Mag	Quality
20031125	18	53	52.80	34-21.43	81-20.46	0.6	0.1	B
20031218	05	51	31.96	34-20.57	81-19.18	0.7	0.7	A
20040120	05	45	27.64	34-21.07	81-19.21	1.1	0.9	A
20040120	16	57	51.31	34-20.72	81-19.33	1.5	0.95	A
20040130	17	42	30.85	34-21.47	81-20.27	0.6	0.5	B
20040202	15	45	52.18	34-20.99	81-20.62	1.7	0.9	A
20040202	15	46	40.78	34-21.10	81-20.53	2.0	0.1	A
20040311	08	54	47.33	34-21.43	81-20.76	0.9	1.0	A
20040329	10	09	16.46	34-20.71	81-20.13	1.7	0.7	A
20040404	09	18	55.52	34-19.62	81-20.29	8.8	2.5	A
20040416	01	49	53.14	34-23.44	81-18.17	0.4	0.4	B
20040709	01	25	36.82	34-18.51	81-17.52	2.1	0.9	A

List of Earthquakes in other parts of SC outside MPSSZ, and Monticello Reservoir

Date (UTC)	Hour	Min	Sec	Lat (°N)	Long (°W)	Depth (km)	Mag	Quality
20040112	01	55	16.90	34-27.13	81-09.82	2.5	1.4	C
20040325	03	03	11.44	34-19.24	81-33.33	3.2	1.2	C
20040329	23	15	40.66	34-27.34	81-09.83	1.9	1.4	C

REPORTS PUBLISHED

South Carolina Seismic Network Bulletin (2003), **XIII**, pp 27.

REFERENCES

South Carolina Seismic Network Bulletin (2003), **XIII**, pp 27.

NON-TECHNICAL SUMMARY

The SCSN continues to monitor seismicity across South Carolina with less than half of the available financial support for its maintenance and running from USGS. Upgrading of facilities at SCSN is being undertaken through continuous collaboration with USGS, Memphis. The focus of seismic monitoring in South Carolina continues to be Middleton Place Summerville Seismic Zone in Charleston, SC. Seismic activity during this reporting period showed an increase in the number of $M_L \geq 2.0$ earthquakes and among them there were two felt earthquakes of $M_L \geq 3.0$. Reservoir-induced earthquakes also continue to be monitored.

AVAILABILITY OF SEISMICITY DATA

The earthquake locations are posted on the SCSN website, soon after the earthquake is located. The location data are sent to USGS Memphis via Quick Data Distribution System (QDDS). Traces from representative stations (RGR, JSC, COW, HBF, LHS) as recorded using Earthworm are also featured on the Internet at http://scsn.seis.sc.edu/helicorders/index.html for continuous and real time look at the recording.