Quarterly Report to the Harry Reid Center
NSHE-DOE Cooperative Agreement
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Task ORD-FY04-006: Seismic Monitoring
Reporting Period: 01/01–03/31 2007

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Progress:

- During the second quarter of FY07 (January 1–March 31, 2007) the Nevada Seismological Laboratory has maintained its regional seismic network (weak and strong motion instruments) in the Yucca Mountain, NTS, and Death Valley region. This network consists of 51 seismograph stations with remote communications to the data center at the University of Nevada Reno. The densest part of the network is near Yucca Mountain, which includes most of the strong motion instrumentation. Six 6-channel seismograph stations (configured with velocity and strong motion sensors) have been operated in the ESF area, including 3 in the tunnel and 3 at corresponding surface locations directly above the underground stations. During the Quarter, two of the underground ESF stations were removed due to the ESF shutdown. Only two stations remain operating in the ESF; station AL5, at Alcove 5, and station NI3, at Niche 3 for the backwall coherency experiment. Also in the site area, we operated nine accelerometers in 3 boreholes on the ESF pad and a real-time multi-channel data acquisition system at borehole UZ-16. We have also maintained the telemetry infrastructure, combined analog and digital, for real-time data management at UNR. All seismic waveform and event locations (automatic and analyst reviewed) are compiled and archived in an Antelope data management system. Supplement 1 (below) summarizes the regional seismicity for the 2nd Quarter of FY07 (Figure 1) including reviewed and non-reviewed preliminary earthquake locations and magnitudes.

- Installation of seismic recording instrumentation and telemetry systems under the network upgrade subtask is continuing but has been delayed due to the fact that we have received only a fraction of planned FY07 funds. Eleven stations purchased in FY06 have been configured for installation, but we have only recently purchased the required radios for final installation.

- Preliminary event location/magnitude determination and event review for FY06 earthquakes have been completed. Event sheet review forms, timing check forms, and polarity check forms have been submitted according to IPR-001. The FY05 earthquake catalog has completed Technical and QA review.

- Located seismic events for the 1st Quarter of 2007 are shown in Supplement 1.

- Discussions have begun with the Sandia National Lab (lead-laboratory) on Performance Confirmation activities.

- We have finished and submitted for publication a study related to recording the Korean nuclear explosion detonated on October 10, 2006 at the Yucca Mountain Seismic Network. The abstract is included in Supplement 2 and the manuscript is in review.

Network Upgrade Status/Network Maintenance:

At present, a total of fifteen RT-130 dataloggers, mostly purchased with FY06 funds and others earmarked for portable deployment are available for installation. Backplane boards have been completed for eleven of these installations. 900 MHz Canopy IP radios have been ordered for these stations. The Skull Mountain and Angel Peak Harris IP licensed radio link has been completed and tested; testing indicated there is no detectable packet loss over this link. The final IP comm link to UNLV was completed. This provides Reno with direct communications to Skull Mountain, Yucca Mountain, and the ESF pad via a Canopy back-haul 30 Meg radio pair from Angel to UNLV . Therefore, the State microwave link from Skull Mountain to Las Vegas now provides a redundant communications path to existing RT130 IP dataloggers in the Yucca Mountain area. This will improve reliability, since downtime has been experienced over the State link during the past year. Reconnaissance for the installation of the Shoshone Harris radio link was continued; battery backup systems were ordered for Shoshone to accommodate the Harris IP radios. The Shoshone link will provide for communications to RT130 dataloggers in northern NTS and to Sober Peak outside of Beatty.

Seismic Network Maintenance:

Station and communication systems maintenance has been performed regularly over the Quarter. The ESF was closed during the Quarter and underground stations SME and NI5 were removed. Maintenance on underground station AL5 (Alcove 5) was performed to insure operations through the Quarter. This station and station NI3 (Niche 3; backwall coherence study) are the only remaining underground seismic stations. Access to the ESF will be allowed, as we understand, on a quarterly basis.

Adjustments were completed to the configuration of Canopy radios for the Yucca Node and the ESF data facility to optimize telemetry performance. Power levels on all subscriber modem radios were balanced to assure that no single radio ‘blinds’ the access point with too high a transmit power level. Radios, canopy-SYMS (side of Yucca Mountain) and canopy-RF13 (ESF borehole) have a few remaining issues, losing lock and re-establishing connection several times a day.

A second pair of Harris T1 microwave radios have been configured and tested in-house; these are earmarked for the Skull Mountain and Shoshone link. Harris IP radios provide up to eight 1.5mbps T1 data links. We are planning on two of the eight T1's to be active after installation establishing a 3mbps IP network link between Skull and Shoshone. This link is the next leg in the NTS area upgrade and is required for the Sober Peak link.

The Canopy Radio point-to-point link between Angel Peak and the Humanities building at UNLV is operational. This provides a redundant data path for NTS stations via UNLV through the UNR network tunnel as well as providing redundant data path for Las Vegas strong motion stations via State of Nevada T1. The automatic fail-over redundancy provided by the OSPF network routing protocol has been tested and confirmed by shutting down certain Cisco network interfaces and running traceroute to various seismic stations.

Data from Earthscope USArray stations have been integrated into the UNR operations stream and into USGS ShakeMap production; USArray stations will improve event locations in southern Nevada over the duration of the USArray deployment, including events in and around Yucca Mountain. They will also contribute to the quality of ShakeMap for the NTS area.

Software Qualification Activities:

Requirements definition and procedures for Validation Testing of the Antelope Real-Time System Data Acquisition and Processing v. 4.8 software were developed and incorporated in a draft Software Definition Report. The draft SDR was completed and circulated for technical and QA review. Reviews have been completed and are in the last stage of comment resolution. The SDR should be submitted for Control Point 1 approval early in the next reporting period.

New Network Operations Procedure (IPR-043):

A draft of new network operations procedures and been informally reviewed for technical completeness and conformance to QA. The new procedure, IPR-043, has received a document identifier. This procedure is intended to accommodate the operations of the network upgrade as well as address existing data collection activities with the older, obsolete, data acquisition systems. Along will Antelope software qualification, this procedure will consolidate a number of seismic network activities.

Strong Motion Network Operations (IPR-004):

The final station operating under IPR-004 was removed - station FOCS at the older FOC building in area 25. All other IPR-004 relevant stations from the 1995 strong motion deployment have been replaced and integrated under network upgrade subtask activities. QA for these stations is managed under Scientific Notebook 053 v. 2. Closeout activities of IPR-004 and Scientific Notebook 057 will be completed in the 3rd Quarter.

Borehole UZ-16 Data Collection and Analysis:

Investigations with the UE#25 UZ-16 borehole array at Yucca Mountain have continued. The horizontal azimuthal orientations of the borehole geophones were computed by rotating different recording levels relative to each other and cross-correlating signals to find the angles that maximize the correlations. Using these angles to rotate into north and east components show high visual coherence of waveforms up the hole even for 5 Hz low-pass filtered waveforms. Relative arrival times among the various recording levels for P and S-waves were computed using cross-correlation for over 80 earthquakes with magnitudes > 2 since late June, 2006. These arrival times were then inverted to determine the most consistent 1-D P and S velocity models of the bore hole to 500 m depth. A two layer model for both P and S-waves adequately

fit the travel times. Adding more layers to the model only slightly improves the fit. Consistent travel time variations are observed between levels. Some interval velocities are unlikely to be the actual velocities of the tuff. It appears that coherent interference of local scattered energy affects the best cross-correlation times at some levels. Spectral ratios were recomputed using frequency domain smoothing of 5%, which primarily smoothes out rapid oscillations in spectral amplitudes at high frequencies. These smoothed ratios yield more consistent frequency trends and demonstrate the attenuation up the hole. The surface geophones exhibit amplification at high frequencies (above 10 Hz) relative to the borehole geophone at 30 m depth.

Discussions were initiated with the University of Texas (UT) and DOE regarding an upcoming experiment in the Yucca Mountain block with the UT truck mounted vibrator. The scope will include recording in and around UZ-16 with assistance from UNR technical staff. The experiment is tentatively planned for the last week in April or the first week of May. A number of experiments have been discussed.

Kappa Project:

Four test cases for analysis of kappa were completed. These cases explore the consequences of sensor correction and the Silva velocity structure used as input to PSHA. A revised draft report will be distributed for review in the first half of the next quarter.

Remote Access Communications:

We have completed PHP scripting applications for mobile devices (e.g., blackberry/treo). PHP provides an efficient mechanism to interact with network functions through web interfaces; this protocol is more practical than Perl CGI. These are secure functions within the UNR computer network and increase our ability to monitor the performance of network functions in the IP communications environment for optimum data reliability.

canopymobile.php - Allows field technicians to check status on multipoint and point-to-point Motorolla Canopy radios; efficient for checking various radio status values such as receive level, signal jitter and reconnects from remote locations.

rtccmobile.php - Allows technicians to remotely check Reftek RT130 DAS status, confirm connection to RTPD server, reset DAS, clear station ram, ping dataloggers and verify that channels are being received at the data center.

orbstatmobile.php - Allows technicians to check latency and data rates for seismic data arriving at Antelope orbs. Many different types of queries can be done by selecting real-time processes, networks, and stations from drop down lists from a web page.

System Checks:

Wrappers were completed to automate the use of qualified software for seismometer system checks. System checks are initiated automatically every 10 days by field dataloggers. These checks are now located automatically within the continuous data recordings, and qualified software routine CALIB is applied. Results are put in a database and available for inspection by

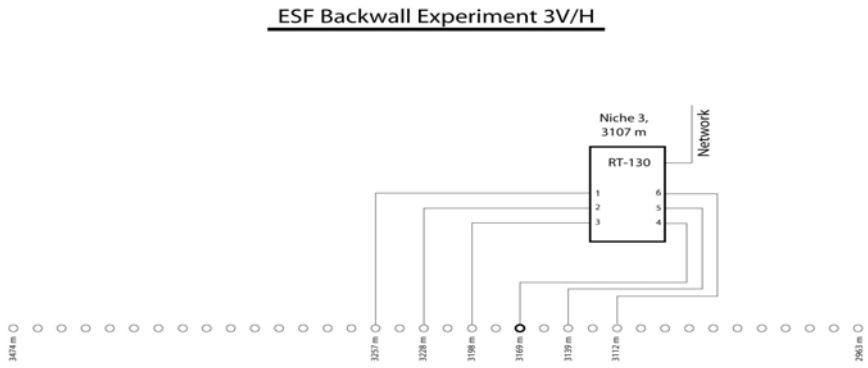
the reviewing seismologist. This system is expected to improve data quality by identifying sensor drift early on, so maintenance can be initiated before potential out of tolerance conditions.

The front-end interface for remote field system checks has been completed; the system check scripts will be driven by the mobile device PHP front end. This integration should be completed in the next quarter. This effort will make instrument-replacement system checks possible directly from the field and be the basis for generalized automatic routine system checks and automated preliminary in-house compliance checks. Field technicians can complete instrument maintenance activities and check remote system response with assurances that instrumentation performs according to expectations without additional field visits or coordination with the data center.

Coherence Experiment (ESF backwall):

Under the now-closed Task ORD-FY04-020, a 6-channel recorder (RefTek 130 DAS ID# 951B) was installed in the ESF tunnel, along the North-South segment (backwall), near Niche 3 to record 6 previously installed 10 Hz high-frequency geophones. (At each location there are one horizontal and one vertical geophone). The RefTek instrument was installed on June 7, 2005, and data recording and archiving began on June 14, 2005, once real-time communications was established to the Nevada Seismological Laboratory in Reno. The continuous data stream is being recorded in the Antelope data management system on a secure computer system in the Nevada Seismological Laboratory data environment. The instruments are being recorded in order to evaluate the coherence of seismic energy at high frequencies from local earthquake sources. This is a scoping study to evaluate the scientific value of the data from these particular high–frequency geophones.

Originally, six vertical-component geophones at 103 meter intervals (Experiment 1) were being recorded. After recording a reasonable number of earthquakes on both components, the sensor spacing was reduced to about 60 meters (Experiment 2) on 28 February 2006. On January 30, 2007, the array length was reduced to about 30 meter spacing (Experiment 3). Array geophones were calibrated before and after the change. The figure below shows the new array configuration and the sensor identifications.



Problems:

We continue to experience communications problems for some stations through the YM Node comm link due to the interference between the 200 MHz and IP communications systems. This has impacted stations CRF, STO, FRG and TAR, in particular. This problem should be fixed when we complete the IP radio upgrade of all YM node stations. The radios have recently been ordered.

A deficiency report was issued last Quarter covering a software issue related to final qualification of the FY03 earthquake catalog. All catalog technical reviews had been completed. This will require a data qualification exercise for the FY03 under QAP3.7. Currently a review of a revision of QAP3.7 is underway pursuant to Revision 17 of the QARD, in effect in May 2006. We are awaiting final QA review of the new revision.

An NCR was issued regarding continued operation of ESF backwall (near Niche 3) monitoring systems has been incorporated under Task 6. Backwall coherence activities were conducted under Task 20 which has since been completed. We have maintained backwall data collection under Task 6 at the request of DOE.

Until the upgrade of the YM area seismic network and communications systems are complete, we will continue to experience the additional QA that results from operating both the upgraded network systems and the older obsolete, 72A08 datalogger network. Additionally, we are concerned that the longer the upgrade is delayed several unsupported electronic systems required for the older network may malfunction. If this occurs, we could potentially lose portions of the network if corrective actions could not be taken. Also, field activities will demand maintenance and operations of both sets of datalogging devices and their particular telemetry systems. Funding delays will impact completion of the upgrade during FY08, the last year of the current Cooperative Agreement. If the funding delays continue, it may be could delay completion of the upgrade into FY10.

Status of Funds:

Only partial FY07 funding been received and the final amount of FY07 funds is still in question. At this time, staff is being supported with administrative funds provided the University of Nevada Reno in anticipation of FY07 funding. We have made only minor equipment purchases necessary to maintain network operations.

Plans and Notes:

All planning is contingent on funding schedules, which are not yet available. It would be efficient and timely to continue the upgrade with installation of next set of RT130 dataloggers and telemetry systems. We will install Harris IP radios at Shoshone Peak in the next Quarter if funds are received. We plan to complete FY06 catalog and FY05-FY06 consolidated seismicity report and complete Antelope 4.8 software qualification activities.

Supplement 1: Seismicity: January 1, 2007 through March 31, 2006. To date there have been 211 events located within 65 km of Yucca Mountain. These are preliminary event locations and

some auto-location pre-review events are included; all locations and magnitudes are subject to change following review.

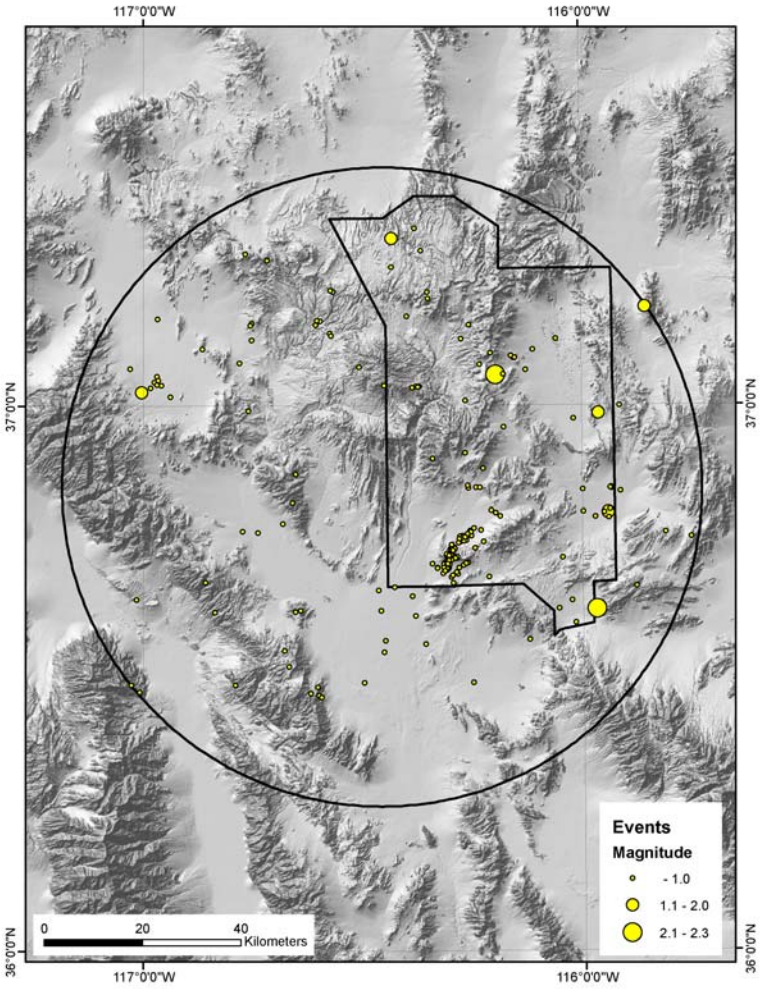


Figure 1. Preliminary earthquake locations for the 2nd Quarter of FY07; circle is 65 km radius from station RPY in the repository area.

Supplement 2:

Location and magnitude estimation of the October 9, 2006 Korean Nuclear Explosion, using the Southern Great Basin Digital Seismic Network as a large aperture array

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ABSTRACT

The Southern Great Basin Digital Seismic Network (SGBDSN) has been designed for monitoring high frequency (1-40 Hz) local events at and near Yucca Mountain Nevada, the designated site for the national high-level nuclear waste repository. We find that the network is also effective as a large aperture teleseismic array for monitoring events in and close to North Korea, the recent location of an underground nuclear test, that occurred on October 9'th, 2006, 01:35:28, NEIC m_b 4.3. We explain this by 1) low ambient noise; 2) energy efficient propagation paths (the nuclear explosion and nearby deep earthquakes show dominant frequencies between 0.9 and 2.5 Hz); and 3) coherent signal across the SGBDSN. The network, when used as an array, provides a particularly good beam signal-to-noise ratio (SNR) for the nuclear explosion. Estimated beam SNR is 20 dB at frequencies between 0.9 - 2.5 Hz.

Between January 1996 and December 2006, 55% of the events with $7.1 > m_b > 3.3$ located within 300 km of the North Korean nuclear explosion by NEIC are considered large enough to be confidently picked by an SGBDSN analyst. The first-arrival of the North Korean event itself is apparent on 25 of the 29 SGBDSN unfiltered recordings. The direct *P* phase is confidently identified using horizontal velocity and back azimuth estimated with cross-correlation and frequency-wavenumber (*fk*) methods. Static time corrections for beamforming are estimated using eleven deep earthquakes within 300 km of the nuclear explosion. Using a statistical method to determine relative delays, we calibrate the nuclear explosion single-array location to the NEIC location, using the delays derived for the eleven earthquakes. The same method is used to estimate magnitude corrections. The SGBDSN magnitude estimate is 4.3 using the Veith-Clawson (1972) body wave magnitude formula.