**Regional Update—ANSS-IMW Region**
**October 13–14, 2008 NIC Meeting**

Walter J. Arabasz, Regional Coordinator

Note: This update is based chiefly on replies to an e-mail inquiry I sent soliciting input for this report to the NIC. (A separate report from Nevada is appended.) I've added information regarding an upcoming planning meeting for YVO, and my summary for Utah follows. — *WJA*

**ARIZONA**
(E-mail from Mimi Diaz, Phoenix Branch Chief, Arizona Geological Survey, 10/3/2008)

> TA station adoption: AZGS partnered with all three state universities and received a Pre-Disaster Mitigation grant from FEMA in order to purchase 8 of the TA stations so that we can perform a new seismic hazard analysis and then update hazard mitigation plans across the state. We're scheduled to take ownership of the TA stations in November.
>
> Arizona Integrated Seismic Network: AZGS is creating the AISN, which will combine information from the Arizona Earthquake Information Center's Northern Arizona Seismic Network and the new Arizona Broadband Seismic Network (from the TA station project above). Goals include raising public awareness about earthquakes in Arizona, providing a one-stop shop for Arizona earthquake information, and creating a resource for seismologists and educators.
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> [From a follow-up e-mail:] I need to make a quick clarification about the paragraph I sent you about AISN: currently, AISN is NAU and AZGS. However, we are still approaching ASU and UA about including their networks.

**COLORADO**
(E-mail from Vince Matthews, Colorado State Geologist, 10/3/2008)

> I'm not sure whether you are only interested in ANSS, or all EQ activities, so I include the following:
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> The Colorado Geological Survey study of the 95-mile-long Anton escarpment on the eastern plains is complete and the results were presented at the AEG meeting last week. As a result of detailed studies of our 2,500-foot-long trench, we interpret the escarpment to be a result of eolian processes, rather than tectonic processes.
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> The Colorado Earthquake Hazard Mitigation Council (CEHMC) is finalizing recommendations to the Colorado Geological Survey to improve the seismic design for schools throughout the state.
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> The Colorado Earthquake Hazard Mitigation Council, the Colorado Division of Emergency Management, and the Colorado Geological Survey published "Colorado Earthquake Hazards", which contains a map of earthquakes and faults and accompanying text designed for free distribution to the general public.
>
> The Critical Infrastructure Conference at the end of this month will focus on a HAZUSms scenario for a strong earthquake in the Denver area.

> Various entities in Colorado are cooperatively exploring how best to take advantage of the Earthscope seismic array for obtaining permanent additions to the limited seismic coverage in Colorado.

Note: The September/October 2008 issue of *Seismological Research Letters* contains an article by G. Monsalve, C. Viviano, and A. Sheehan on "An assessment of Colorado seismicity from a statewide temporary seismic station network." Results are of particular value because of sparse permanent seismographic coverage in Colorado. — *WJA*

**IDAHO**
(E-mail from Bill Phillips, Idaho Geological Survey, 10/6/2008)

> The big news is clearly the McCall and Mayfield stations. We have finished the purchase of the Mayfield station [a TA stations near Boise, Idaho] and negotiated a 10-year agreement with the landowner. The station has been upgraded to 6-channels to permit future installation of an accelerometer by ANSS. We have a year one maintenance agreement in place with USArray to ensure continuous data collection while we work with ANSS to take over station operation.
>
> Mark Meremonte is the one to ask about the McCall station. Installation has been delayed for over a year now for various reasons and we are just hoping ANSS can get it in before the snow flies.

Note: Mark Meremonte gave me information about the status of the McCall, Idaho, regional broadband station. The station is being installed by the USGS to fill a significant hole in seismographic coverage in western Idaho. The site-use permit was finally secured the third week of September. The earliest the site installation can be scheduled is the first week of November, depending on weather. If bad weather becomes a problem, the installation may be delayed until next field season. — *WJA*

**MONTANA**
(E-mail from Mike Stickney, Montana Bureau of Mines and Geology, 10/3/2008)

> Our biggest news is that we landed a state one-time-only grant that allows us to take over and instrument 10 Transportable Array vaults. [Mike separately informed me that the amount of the one-time state grant was $140K. — *WJA*]
>
> We will be instrumenting the vaults with 24-bit, 4-channel NetDAS data loggers that will record three components of accelerometer data and one short-period vertical seismometer. Spread spectrum radio links will continuously telemeter seismic data from each site to an internet access point, with recording back at the Earthquake Studies Office in Butte.
>
> This project presents several challenges. It is basically an equipment grant that provides no long term support for operations and maintenance beyond the end of the state fiscal year (June 30, 2009), so taking on the existing telemetry costs for these TA sites is not an option. Also, the TA deployment is longer than originally planned for sites in western Montana (some installed in fall 2006), which are scheduled for removal in spring of 2009. I plan to identify the 10 TA sites we want to add to the Montana

Regional Seismic Network over the next several weeks and begin to plan how we will telemeter signals from these sites for the smallest continuing costs. Generally, we want to take over 3 sites in eastern Montana, that together with existing ANSS backbone sites, provide the best possible skeletal coverage of this vast region of low seismicity but numerous open pit mining operations. The other seven sites will be chosen to complement and extend the coverage of the existing network in western Montana.

I should mention that we are making extensive use of the TA data in our routine hypocenter locations. After determining a preliminary hypocenter from regional network data, we download waveforms from all TA stations that lie within a distance of (magnitude * 100) km from the epicenter, pick arrival times and incorporate these into the hypocenter location. Recent magnitude 2 earthquakes routinely use over 50 phase arrival times (80-90% being P arrivals) in their hypocenter locations and several magnitude 3 events use 90 phase arrival times. This unprecedented amount of P arrival data results in stunningly good fault
plane solutions for some magnitude 2.0+ events.

Other notable news is that last January the Montana Bureau of Mines and Geology hired Debbie Smith as an assistant/seismic analyst in the Earthquake Studies Office. The USGS grant provides approximately half of her salary and the Confederated Salish and Kootenai Tribes generously provide the rest. Since Debbie's arrival in January, we have caught up on a three-month backlog of routine network data analysis. One of these months was August 2005, which included weeks 2-5 of the aftershock sequence of the M 5.6 Dillon earthquake. Finishing hypocenter locations for this important month (I'm actually working on August 31, 2005 events today) lifts a heavy weight that has been riding on my shoulders for the past three years.

**NEW MEXICO**
(E-mail from Rick Aster, New Mexico Tech, 10/3/2008)

We are still investigating TA adoption possibilities, with several strategies under consideration, but don't have anything further to report in detail at this point (and yes, we realize that the TA clock is ticking!).

**WYOMING**

Besides the YVO seismic network (see next page), the Jackson Hole-Teton ANSS network operated by the USGS is the only other significant network in Wyoming. According to Mark Meremonte of the USGS, enhancements during this past field season included (1) installation of a new vault at station MOOW, (2) installation of an auto-reboot system at four stations for IP communications, and (3) installation of a low-voltage disconnect at two stations at which deep snowpack can cover the solar panels (preserving power allows onsite recording of up to two months of data that can later be recovered). — *WJA*

**YELLOWSTONE VOLCANO OBSERVATORY (YVO)**
(Information extracted from an e-mail distributed on 8/11/2008 by Jake Lowenstern, USGS, Scientist-in-Charge, YVO; Hank Heasler, YNP, Coordinating Scientist, YVO; and Bob Smith, UU, Coordinating Scientist, YVO)

YVO will hold a special planning meeting November 12–13, 2008, in Bozeman, Montana, devoted to Response Planning internal to the observatory, in order to better interact with the larger community in the event of volcanic or seismic unrest. Invitees include the state geologists from Wyoming, Montana, and Idaho; network seismologists from the University of Utah, NEIC, and the Montana Bureau of Mines and Geology; representatives from Yellowstone National Park; USGS managers from the Earthquake Hazards and Volcano Hazards programs; and representatives from the Cascades Volcano Observatory and Long Valley Observatory.

Some of the topics to be addressed in the one-and-a-half day meeting include:

- Goals and planning for a YVO Crisis Response Team
- Working groups
- Interactions with NEIC during crises
- Overview of the UU [Univ. of Utah] continuity of operations plan
- Temporary field stations during unrest
- Role of other USGS VO and groups such as ANSS during crises
- Call-down and push technology lists
- Designation of responsibilities for information flow to media, FAA, emergency managers, FEMA and state homeland security offices
- Organizing/automating and robust communications nuts and bolts
- Changing Volcano Alert Level: What would be our criteria?

After the meeting, a small group will write a short response-plan document to be published by YVO as a USGS Scientific Investigations Report similar to an existing monitoring plan (http://pubs.usgs.gov/sir/2006/5276/).

**UTAH**

During the past several months, four circumstances have had a major impact on our seismic network: (1) continuing developments from the August 2007 Crandall Canyon mine disaster; (2) the M 6.0 Wells, Nevada, earthquake on February 21, 2008; (3) our $1 million state network expansion project; and (4) preparations for moving our network center into a new building at the end of this year.

*Crandall Canyon aftermath*

- Writing and publishing a seismological report on the mine accident: Pechmann, J. C., W. J. Arabasz, K. L. Pankow, R. Burlacu, and M. K. McCarter (2008). Seismological report on the 6 August 2007 Crandall Canyon Mine collapse in Utah, *Seimological Research Letters* **79** (5), 620–636.

- Writing and publishing a paper on new approaches to monitoring mine seismicity in Utah: Pankow, K., M. McCarter, W. Arabasz, and R. Burlacu (2008). Coal-mining-induced seismicity in Utah—Improving spatial resolution using double-difference

relocations, *in* Proceedings, 27th International Conference on Ground Control in Mining, Morgantown, West Virginia, July 2008: Morgantown, West Virginia University, p. 91–97.

The ability to achieve fine spatial resolution of mine seismicity recorded by the University of Utah Seismograph Stations (UUSS) regional network—and the possibility of producing calibrated hypoDD locations on the fly—are of increasing interest to the coal mining community in Utah.

- UUSS and the University of Utah Department of Mining Engineering have joint funding from the National Institute for Occupational Safety and Health (NIOSH) to: (1) convene a panel of 16 international and national experts to address issues of monitoring mining-induced seismicity in "bump-prone" U.S. coal mines, (2) adopt two USArray TA stations in Utah's coal-mining region, and (3) improve locations for mining-induced seismicity in Utah using hypoDD. The expert panel meeting and workshop will be held October 20–22, 2008 (see http://www.seis.utah.edu/expertpanel.htm).

- Besides the adoption of two TA stations with NIOSH funding, UUSS will cost-share the adoption of a third TA station in Utah's coal-mining region with a Utah state agency that leases coal tracts on state trust lands.

*The M 6.0 Wells, Nevada, earthquake of February 21, 2008*

The Wells earthquake was widely felt in western Utah and along Utah's Wasatch Front urban corridor, prompting routine response efforts and media interactions. Because the earthquake was closer to Salt Lake City than Reno, UUSS became heavily involved in the early field deployment of instruments and in coordination and planning—not only with the USGS and the University of Nevada Reno (UNR), but also with supportive response efforts by the Utah Geological Survey and the Utah Department of Homeland Security.

- UUSS technicians installed and operated five strong-motion instruments and a four-station short-period telemetry array in the epicentral and aftershock area of the Wells earthquake. Two instruments were installed the same day as the mainshock and all nine UUSS stations operated for ~5½ weeks. A total of 27 stations were deployed by UNR, the USGS, and UUSS.

  One of the clear lessons from the Wells earthquake is the need for advance ANSS planning to implement real-time data acquisition and processing from temporary stations following a damaging earthquake in an uninstrumented area. Expectations and needs from ANSS for real-time earthquake information products are compelling.

- For the 2008 AGU Fall Meeting in San Francisco, a special session on "The 2008 M 6.0 Wells, Nevada Earthquake" has been organized and convened by Kris Pankow of UUSS and Glenn Biasi of UNR.

*State of Utah Network Expansion Project & Continuity of Operations*

In July 2007, after two years of efforts, UUSS received an appropriation of ~$1 million from the Utah State Legislature to expand seismic instrumentation and real-time earthquake information products in the St. George-Cedar City area (one of the fastest growing regions in Utah and the

western U.S.) and in parts of rural Utah outside the Wasatch Front area. Funding was also provided to achieve continuity of operations in event of a large Wasatch fault earthquake.

- During 2007–08, UUSS planned and has nearly completed the installation of 12 urban strong-motion stations in the St. George-Cedar City area as well as in Beaver, Kanab, and Richfield. Site selection was overseen by the Utah Strong-Motion Advisory Committee, and candidate sites—based on geologic site conditions—were identified with help from the Utah Geological Survey.

- The state appropriation included funds for ten regional stations. Funds were managed to ensure that all ten stations would have both broadband (BB) and strong-motion (SM) sensors. Also, cost savings in the project budget were used to buy equipment for an additional two BB/SM stations. Federal site-use permits are still pending for five of the first ten stations; installations are planned for late 2008 and 2009.

- A design for a robust, fault-tolerant, statewide seismic network in Utah (both in terms of telemetry and data processing) was developed in late 2007 with help from USGS scientists and engineers. Key elements include: 6–7 regionally distributed nodes with Earthworm systems; a "hot site" outside the Wasatch Front urban corridor in Richfield, Utah, which will receive the same data as our primary UUSS network center and serve as a backup collection/processing site; and a" point-of-presence" in the Salt Lake County Emergency Operations Center to allow emergency access to data stored at the hot site or the regional Earthworm nodes. All of the regional nodes and the backup hot site have been installed, and the point of presence will be completed within days.

- UUSS currently operates ~60 legacy short-period (SP) stations in the Utah region. As part of the redesign of our statewide telemetry, analog data from the SP stations will be digitized at eight telemetry nodes (mostly at "Mountain Top" sites), where the digital data will be fed into a state IP system. This step will allow digitized data from the SP stations to be extracted from the state IP at our UUSS regional Earthworm nodes, and it will also result in cost savings for usage on existing state microwave circuits. Work is under way to install new racks with custom-designed discriminators, radio receivers, and surge protection at the "Mountain Top" sites.

*New Building and Move of UUSS's Network Operations Center*

Construction is nearly complete of a new building for the University of Utah's Department of Geology and Geophysics. The $26 million building is being built with private funds and will provide ~5,000 square feet (at more than $200/sq ft) for UUSS's network operations center, its earthquake information center, and its technical staff. Part of the private funding for the UUSS space comes from a $600K donation for the "Rio Tinto Earthquake Information Center." Among the time-consuming planning for such a move, major efforts are being made to avoid significant down time in moving our data acquisition and processing systems. Once our continuity-of-operations project is finished, all of our network data streams will be in digital form, capable of being extracted anywhere. During our move, our Richfield hot site will temporarily become our primary data acquisition/processing site while we swap over to our new network operations center.

**Regional Update – ANSS IMW Region, Nevada**

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## NEVADA

### *Seismic Activity and Public Outreach*

*Wells Earthquake, Eastern Nevada, February 21, 2008*

Early on February 21, 2008 a normal-faulting earthquake with Mw 6.0 struck near the community of Wells in eastern Nevada. Shaking in town severely damaged unreinforced masonry structures in the historic district and put some structures, including the high school, out of service. University of Utah, USGS, and UNR personnel deployed seismic recorders, with the first stations arriving the same day. UNR implemented radio communications and took over maintenance of the USGS stations. Data were flowing to the IRIS DMC in real-time shortly thereafter. The earthquake occurred within the USArray Transportable Array network footprint, so broadband coverage at regional distances was outstanding. The aftershock sequence has followed a fairly typical pattern, and the region is seismically fairly quiet now. Three stations have been retained for continuing monitoring. Stations return data via a link of the Nevada Department of Information Technology through Las Vegas. The Nevada Bureau of Mines and Geology is presently developing a data report volume focused on documenting earthquake-related effects. The report is being prepared for release ahead of the one-year anniversary of the event. The report will also be provided to Nevada Legislature, which will meet this coming spring for the 2010-2011 biennium.

*Mogul Nevada Earthquake, West Reno, April 26, 2008.*

An exceptionally shallow swarm of small earthquakes started February 28, 2008, in the small community of Mogul, about 10 km west of Reno. S-P times of 0.4 seconds or less were commonly observed in the epicentral area. Earthquakes as small as M1.5 were felt in the epicentral area, and M2.5 earthquakes were causing mild alarm. Activity accelerated in time, with four M3 events on April 15, and two M4 events April 24. The largest event occurred at 23:40 PST on April 25$^{th}$ (06:40, 4/26/08 UTC). Four stations from the PASSCAL instrument center were deployed in the epicentral area in advance of the peak activity. Two recorded component ground motions above 0.8 g. Three of the four were two-sigmas or more above relevant ground motion prediction equations. Ten stations were ultimately deployed, with real-time radio communications implemented for most of the post-mainshock period. Data are being analyzed, with >3,000 events located so far. Manuscripts are being prepared describing the very strong observed ground motions in the epicentral region, and the swarm development and evolution. A special session entitled Observations and Phenomenology of Non-Volcanic Earthquake Swarms has been organized for the Fall AGU by Glenn Biasi and Steve Walter in part to discuss the Mogul sequence. Steady seismicity in the Mogul region was used as a seismic source

to develop data for shallow velocity modeling of the Reno basin. The deployment consisted of 200 Texan recorders from the PASSCAL instrument center. Community hosts for instruments were solicited on the NSL web site. Community participation was enthusiastic. Data are being organized and funds to cover analysis are being pursued.

*Public Outreach*

The extended period of felt aftershocks provided UNR with multiple opportunities for public speaking and outreach. There was widespread evidence of heightened preparation and earthquake awareness on the part of the public.

A server was installed at the Nevada Division of Emergency Management in Carson City as part of an effort to improve coordination and integration of seismic information. The server allows NSL to pull in waveforms and parametric information in real-time. Communications were implemented via radio as an independent path from NSL.

UNR organized and co-hosted an outreach to community stakeholders, with Chris Poland, Seismological Society of America 2008 Joyner Lecturer, addressing the topic of earthquake resilient communities. Resilience leads the community dialog beyond earthquake survival to consider the social and practical issues of reconstruction. Topics include the viability of "city hall" to provide plans, inspectors, and approvals; how long critical systems and businesses can be off-line; and what the requirements are for an effective reconstruction workforce. Poland notes that essential functions may be housed in buildings that are designed to code but only for life safety; occupants may be surprised to find the building unusable or usable only after substantial repairs.

***Network activity***

UNR purchased equipment for two western Nevada TA stations as a means of improving broadband coverage. Telemetry to one has been re-engineered to replace an unreliable serial radio link in favor of a simpler route with IP radios. A new relay on Verdi Peak will also provide improved coverage west of Reno for moving one strong-motion station to real-time telemetry and add another west of Mogul. Broadband sensors are being purchased for the upgrade of two more stations.

An FCC auction in the microwave spectrum affects all but one of UNR's microwave links. Legs on the Nevada Test Site are in the 1.7 GHz government band; engineering and design for those links has been submitted, and funding is in the pipeline. Civilian band (2.1 GHz) relocation work in Las Vegas Valley has been completed. Notices have been received for selected other links of commercial interest. Telemetry infrastructure will be converting to an IP-radio base, with Nevada Department of Information Technology and commercial IP fail-over routing implemented for most circuits.

Redundant communications have been implemented using a local Internet provider to eliminate a single-point-of-failure condition in the UNR campus routing connection. Most network stations come in by radio, but some imports and all exports were subject to interruption.

A paper describing remote seismic network monitoring capabilities developed at UNR was published in the July-August 2008 Seismological Research Letters (Slater et al., 2008, *Use of Mobile Devices for Earthquake Response, Network Applications, and Diagnostics*, SRL, v.79, 562-570). Technical and professional staff use Blackberrys check on and program radios, dataloggers, routers, and data acquisition processes. Elements of this work were first presented at the ANSS-hosted special session on High Performance Networking in May 2007 in Acapulco. Technical staff have substantially improved the efficiency of maintenance operations and field deployments, including the Wells and Mogul portable deployments.

Budget support from the State has seen a small reduction, and further, more significant cuts are being planned. Of some concern for seismic network operations is the potential impacts cuts could have on discretionary time available for network-related activities.