Divining Rod

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Sevilleta Basin Study Confirms Deep Faults Contribute to Surface Water Chemistry

by Will Keener, WRRI

Groundwater from deep beneath the Earth's surface is making a volumetrically small but chemically significant contribution, increasing the salinity of the waters within the Rio Grande Rift. That's one of the conclusions of a two-year effort to collect and chemically analyze waters in the Sevilleta National Wildlife Refuge (NWR) in central New Mexico by University of New Mexico graduate student Amy J. Williams.

As populations continue to grow in the Southwest and more demands are placed on water resources, the research, funded in part by the New Mexico Water Resources Research Institute, can help future researchers better understand the connections between geologic structure and water quality along the river. "I believe that this interdisciplinary study will shed new light on the sources of salinity to the Rio Grande by utilizing the concept of faults as conduits for fluids from great depth in the rift," Williams says.

By organizing extensive laboratory results with a view to the geologic structure of the area, Williams confirmed an earlier hypothesis that deep faults within the rift provide pathways for deep-earth fluids to reach the surface water systems. "These fluids produce spring flows on the order of several liters per minute, which may seem insignificant in the vastness of the Rio Grande rift," says Williams, who completed the work for her UNM

Amy J. Williams, University of New Mexico graduate, takes a water sample at Rio Salado Box Spring, south of Ladron Peak. Her master's degree project confirmed the role of deep rift faults in contributing to the water chemistry of the Rio Grande Basin.
Photo by Samantha Adelberg, Brown University

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Diving Rod

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U.S. Geological Survey's National Competitive Grant Program Awards Announced

Earlier this summer, the top-ranked proposals from the Fiscal Year 2009 NIWR/USGS National Competitive Grant program competition were announced. Sixty proposals were submitted requesting a total of over $10 million in federal funds. The program has approximately $1 million available. Projects slated for funding include the following.

Adjoint Modeling to Quantify Stream Flow Changes Due to Aquifer Pumping; Roseanna M. Neupauer, University of Colorado ($117,847; 3 years)

Characterizing and Quantifying Recharge at the Bedrock Interface; David Boutt and Stephen B. Mabee, University of Massachusetts ($174,490; 3 years)

Does Urbanization Decrease Baseflow? A Historical, Empirical Analysis in the Coastal States of Eastern United States; Joshua C. Galster and Kirk Barrett, Montclair State University ($82,489; 2 years)

Eastern Redcedar Encroachment and Water Cycle in Tallgrass Prairie; Chris Zou, Dave Engle, Sam Fuhlendorf, Don Turton, and Rodney Will, Oklahoma State University, and Kim Winton, U.S. Geological Survey ($226,890; 3 years)

Hydrological Drought Characterization for Texas under Climate Change, with Implications for Water Resources Planning and Management; Vijay P. Singh and Ashok Kumar Mishra, Texas A&M University ($235,148; 3 years)

The Role of Epikarst in Controlling Recharge, Water Quality and Biodiversity in Karst Aquifers: A Comparative Study between Virginia and Texas; Benjamin F. Schwartz, Texas State University, Madeline E. Schreiber, Virginia Polytechnic Institute and State University, and Daniel H. Doctor, U.S. Geological Survey ($100,494; 2 years)

Brent Bullock
In Memoriam

After a three year fight against cancer, Brent Bullock, a member of the WRRI water conference advisory committee, died at the age of 42 on September 19, 2009. Brent was an extremely conscientious and helpful water colleague who managed to stay optimistic even during the most difficult of times. Brent will be missed by all of us who had the privilege to work with him. Our thoughts and prayers are with his wife and family.

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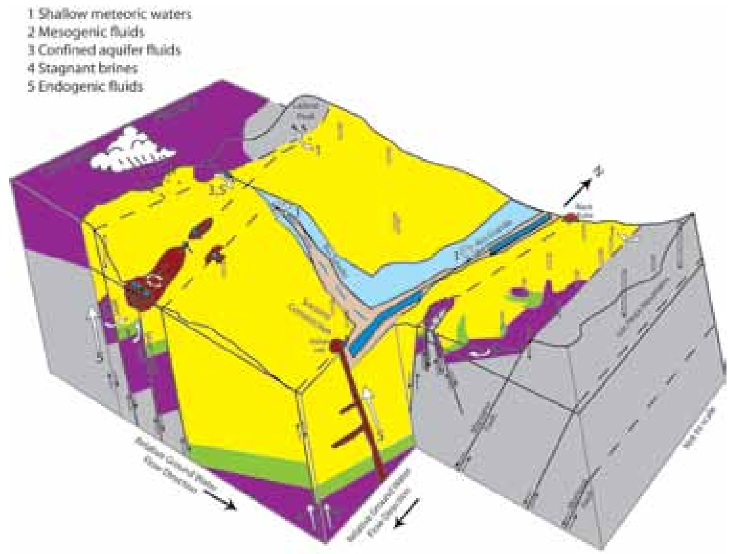
master's thesis. But geochemical analysis shows these waters contain much higher salt concentration levels than regional groundwater and may elevate the salinity of the river.

"Her work demonstrated significant similarities in elevated concentrations of trace elements such as boron, lithium, and barium in rift-bounding spring waters as well as at several locations across the rift," says Professor Laura Crossey, of UNM's Department of Earth and Planetary Sciences and Williams' thesis advisor. It corroborated earlier work by other UNM researchers, she adds.

The Sevilleta NWR is located about 50 miles south of Albuquerque, NM, at the intersection of the Albuquerque and Socorro basins. Williams describes the area as a window into a tectonically complex area, with uplifting, extension, an active magma body, and a range of rock units dating from Precambrian (546 million years ago) to the Quaternary (2.6 million years ago to present.) This wide age-range proved crucial to the geochemical interpretations that grew from the research, she says.

Williams' efforts produced the first comprehensive geochemical data on the springs and wells of the area.



This schematic diagram of the Sevilleta National Wildlife Refuge shows some of the key geologic units, including major faults. Different fluid flow paths described in the thesis are numbered on the diagram. Diagram courtesy of Amy J. Williams

Physically, the most difficult part of the study was collecting samples from 46 spring and surface water sources and 15 water wells. Several of the springs were sampled periodically over nearly two years to look at any changes in water chemistry.

"There were several days where our sampling was truncated by getting stuck in the sand!" says Williams. "Some days it was quite an effort to navigate the arroyos and between snakes and monsoons, sampling was always an adventure." Williams also received support from U.S. Fish and Wildlife Service personnel, who provided an all-terrain vehicle for access to a remote spring in the Rio Salado valley.

In the course of identifying different geochemical zones in the refuge, Williams learned that combining the structural setting

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Collecting water samples in a desert environment resulted in some obstacles for Williams, shown at a remote spring site. Photo courtesy of Amy J. Williams

NMSU Researchers Probe Pros and Cons of Wastewater Application

by Will Keener, WRRI, photos courtesy of Manoj Shukla

Graduate student Pradip Adhikari collects samples from catch funnels at the site and carefully measures them.

Is wastewater application an appropriate treatment in desert climates? Researchers at New Mexico State University are looking into this water treatment process at an industrial site near Las Cruces, New Mexico. They are asking critical questions about the key concept of this treatment method – will irrigation with treated wastewater impact soil properties and vegetation?

Right now, says Manoj K. Shukla, Associate Professor of Environmental Soil Physics, the answer isn't clear cut, although a picture is forming.

At the Las Cruces site, factory effluent is treated in a lagoon to decompose microbial contaminants and then is applied with a sprinkler system to a 90-acre area of high desert on the west mesa above the city. Called "wastewater application," this process has potential to provide low-cost disposal in areas not served by municipal treatment systems. In arid areas such applications might be considered for municipal or industrial disposal on rangelands, and on parks, golf courses, and some types of crops.

Before widespread use of wastewater application, a better understanding of the process is needed, says Shukla. With the help of Professors John Mexal, Geno Picchioni, and Ted Sammis and graduate students Michael Babcock and Pradip Adhikari – all in the University's Plant and Environmental Sciences Department – five years of increasingly detailed data have been gathered and analyzed. The effort has been funded by the New Mexico Water Resources Research Institute and the Southwest Center for Environmental Research Policy, with its 10 member universities in the U.S. and Mexico.

The spring grasses shown here in the areas between the larger plants are being endangered by an increasing sodium adsorption rate, researchers report. It's too soon to tell if the larger plants may also be threatened.

Early assessment of the site showed key differences in water application in areas covered by the dominant mesquite and creosote bushes and bare earth areas between the plants. After being held in settling ponds, the industrial wastewater is sprayed into the area using impact type sprinklers. As the water arcs through the air, the bushy plants tend to gather more than the bare "intercanopy" areas.

"Our hypothesis was that more wastewater and higher impacts would be concentrated in the canopy areas," says Shukla. The research team verified the hypothesis by carefully placing catch funnels to measure the flow intercepted by the bushes and that falling on the bare ground areas.

A study of chloride concentrations at depth also showed that the water under the plants tended to help chemicals leach deeper into the soil.

Using hand augers in the sandy soil, samples were collected along the drip lines of the shrubs and in the bare ground areas at 8-inch intervals to a depth of 7 feet. Researchers also took core samples to gauge density, porosity and rate of fluid flow through the cores.

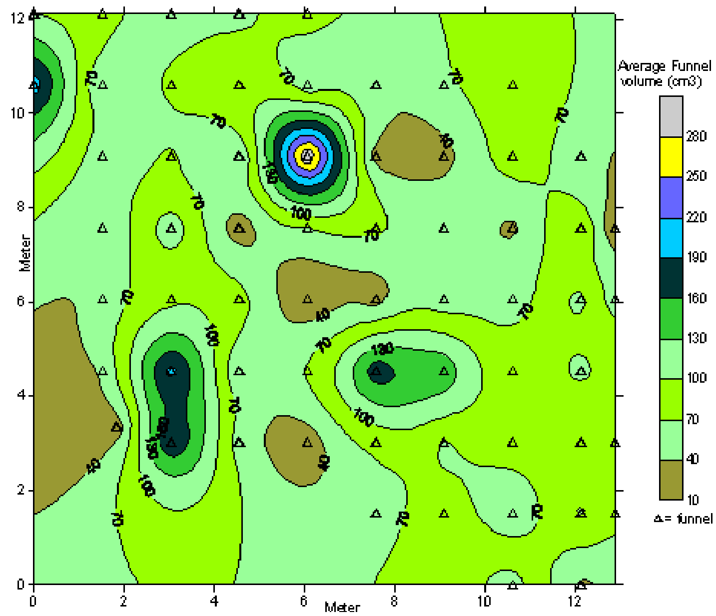
When compared to an unirrigated portion of the site, the measurements showed the following.

1. The rate at which water can flow through the soil profile has changed. Irrigation seems to have dispersed the tiny clay particles attached to soil particles and moved them into pore spaces, Shukla says.

2. Electrical conductivity increases under the shrub canopies. Electrical conductivities measured 1,363 parts per million (or 2.1 desiSiemens per meter dS/m) under mesquite and 2,080 ppm (or 3.3 dS/m) under creosote bushes. These values are low by definition (lower than 2,560 ppm or 4 dS/m) and therefore there is no immediate concern with regard to the electrical conductivity, Shukla notes.

3. The sodium adsorption ratio (SAR) increases. This measurement compares amounts of sodium, calcium, and magnesium in the soil and indicates potential to encourage plant growth. With SARs now above 15, grasses and other plants growing in the areas between the mesquite and creosote will not be able to flourish. It's more difficult to tell about the woody shrubs, says Shukla, because they tend to have deeper roots and lateral roots that help them adapt to the sodium-rich conditions.

4. The soil alkalinity increases. The native calcium-rich soils show a relatively high range of alkalinity (pH of 7.5 to 8.5), but wastewater application has pushed the numbers even higher – to about 9.4. Generally, if pH exceeds 9, micronutrients in the soil are immobilized and no longer available to plants, says Shukla.



The result of the measurements was this contour map by Pradip Adhikari, showing how the highest moisture volumes cluster around the large mesquite and creosote plants at the site.

These results point to some assurances that the process is working – that is, the arid region plants are taking up the waste contaminants. They also point to some uncertainties and to continuing concerns that need to be addressed, says Shukla. One factor that needs to be investigated further is the variability of the wastewater application and how chemical and physical properties of the soil relate to the differences in the amounts applied. Shukla, Mexal, and Pradip Adhikari, now working on his doctorate, will look at the west mesa sites and other sites to study these connections.

The catch funnels were placed at regular intervals to measure the distribution of water from the sprinkler system used at the site.

WRRI Mapping Project Moves Researchers Closer to San Francisco River Basin Resource Estimate

by Will Keener, WRRI

A team from the New Mexico Water Resources Research Institute (WRRI) has compiled a comprehensive digital model of the San Francisco River Basin combining available geologic and hydrologic data on the basin aquifers for the first time. The effort marks a major step toward a numerical estimate of the water resources in this rugged and historic highland area in west-central New Mexico and east-central Arizona.

The WRRI package – consisting of a detailed digital map, five cross sections of the basin's hydrogeology, and a report organizing hundreds of geologic units to help estimate their water-related properties – will provide the New Mexico Stakeholders Group with the tools needed to evaluate opportunities to use the basin's water. The funding was provided by the state legislature through the Interstate Stream Commission (ISC). The Stakeholders Group is involved in evaluating and developing projects for the New Mexico Unit of the Arizona Water Settlement Act (AWSA).

The AWSA is the last part of a lengthy legal and legislative process for allocating waters of the Colorado River. The AWSA allocates up to 14,000 acre-feet annually and $66 to $128 million in total funding to provide water to the region. Planning for use of the water has been underway since the act was signed in December 2004. Projects for a possible New Mexico Unit are to be evaluated and sent to the ISC by the end of 2010.

WRRI Associate Director Bobby Creel (right) and B.V.N.P. Kambhammettu, Geographic Information System and Water Resources Specialist, examine the cross sections and maps they provided for the San Francisco River Basin project.

The WRRI's work can also help later with the evaluation of proposals to create diversion structures for water storage along the largely free-flowing river, says Dr. John Hawley, WRRI Senior Hydrogeologist. Hawley joined Dr. Bobby Creel, WRRI Associate Director, and B.V.N.P. Kambhammettu, Geographic Information System (GIS) and Water Resources Specialist to create the model.

Lodged between the layer-cake geology of the Colorado Plateau and the spreading crust of the Basin and Range region to the south, the San Francisco Basin geology is distinctive. "It's not the Colorado Plateau and it's not the Basin and Range either, so we have just started calling it the transition zone." That fact is emphasized in the cross sections created by Kambhammettu working with Hawley's hand-drawings, which show steeply tilted and faulted areas and the intrusions of massive volcanic rock masses within the basin.

Basin water resources are tied directly to the fact that highlands in the area, some greater than 11,000 feet, are the first significant barrier to monsoon air masses flowing from the Gulf of California and often create above average precipitation. Up to 27 feet of snow have been recorded in the area in El Niño years, Hawley notes, although drought years also occur. The San Francisco River begins high in the Arizona portion of the basin, flows southeast into New Mexico to a point near Reserve, then turns to the south

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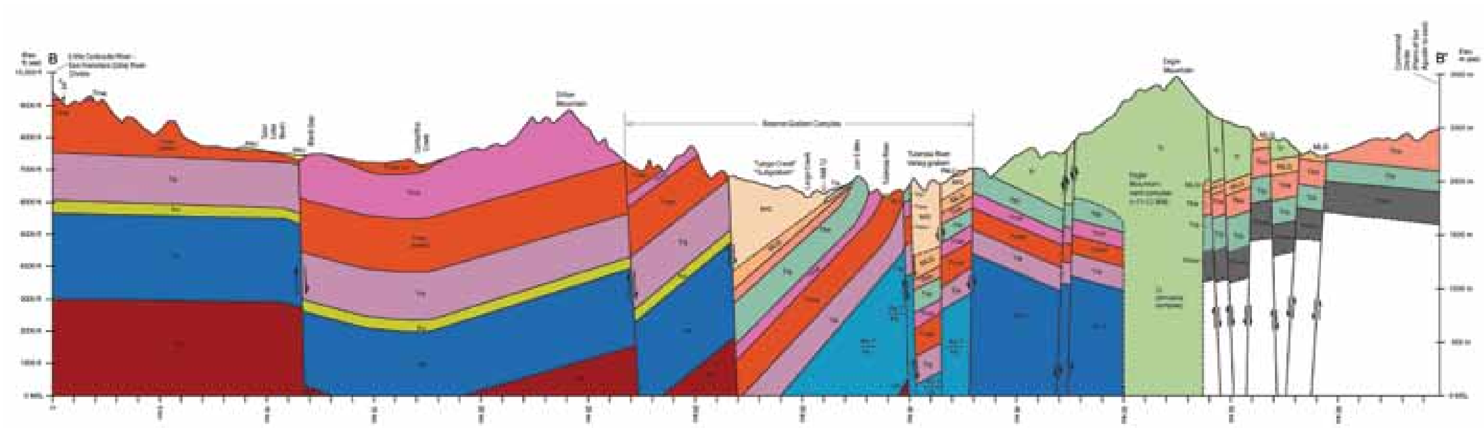


This northwest to southeast trending cross section across the San Francisco River Basin is one of five included in the WRRI digital modeling project. Bright horizontal layers at the left indicate the edge of the Colorado Plateau province, while light greys and greens show volcanic units from the Eagle Mountain intrusion. The jumble of warped and tilted strata in the middle of the basin illustrate why geologists refer to this area as the transition zone.

and eventually flows back into Arizona. The river joins the Gila near Clifton, Arizona.

Historically, the basin has seen human habitation beginning with the Native Americans, followed by Spanish conquistadors, mountain men, both Hispanic and Anglo settlers, religious pilgrims, and more recently hunters, miners, and ranchers. The basin, near Morenci, Arizona, is home to one of the largest open-pit copper mining operations in North America.

Geologically, the basin was squeezed during a widespread period of mountain-building activity beginning some 70 million years ago. Then it domed upwards when large volcanic calderas dominated the region 30 to 26 million years ago. Currently the region is thinning and fracture zones are opening so that waters circulate at deeper depths, says Hawley.

Over an intense three-month period, the WRRI team used structural models based on previous field mapping, available well data, and existing maps to integrate hundreds of geologic units named by the various geologists studying the area. "Instead of 14 different members or formations, you can group units and describe them according to their properties as aquifers," Hawley says.

Hawley chose a technique that emphasizes aquifer characteristics in developing a classification system for the many geologic units identified in the area. The scheme has been used successfully in basins along the Rio Grande; it groups strata based on rock description and radioactive dating chronologies, then assigns an estimate of potential as an aquifer to each unit, called a hydrostratigraphic mapping unit (HSU). The geologic structure of the basin, such as faults, intrusions by volcanic rocks, uplifts of plateaus, or changes in bedrock topography, is also taken into account.

Excellent field work done by "a who's who of New Mexico geologists" since the 1950s and detailed radiometric dating accomplished by the New Mexico Bureau of Geology (NMBG) over the past decade made the work possible, Hawley says.

Creel created the hydrogeologic map, compiled from published digital geologic-map databases (1:100,000 to 1:1,000,000-scale) acquired from the NMBG, Arizona Geological Survey, and the U.S. Geological Survey. The map shows the surface-distribution patterns of major bedrock and basin-fill mapping units, as well as large-scale tectonic and volcanic features. Detailed definitions of the HSUs and descriptions are available in a WRRI project completion report, available at ftp://water.nmsu.edu/pub/gila/hydrogeologic/

WRRI Senior Hydrogeologist John Hawley examines a soil horizon along the Rio Grande near Juarez. Hawley made use of an approach used in several Rio Grande basins to categorize rock units in the San Francisco River Basin.

54th Annual Water Conference Highlights

[ISC] undertook preparing a report…to look at all of the regional water plans…and [one recommendation] was to encourage greater dialogue with neighboring regions. Since the first round of regional water plans was done largely in a vacuum, regions that share watersheds did their plans independently...The recent Upstream-Downstream Project, established on the Rio Grande to enhance communication and collaboration among regions within the watershed…was a good model of what should have been done... – Angela Bordegaray, Interstate Stream Commission

During times of uncertainty, science can be our friend. Science can help us define our problems and lessen our fears of the future. Science can unite people with different goals by providing a common language and understanding. And perhaps most importantly, science can inspire, and encourage us to act. – Wes Danskin, U.S. Geological Survey

Traditional planning approaches are grounded in the concept of stationarity, assuming that the historical variability observed in natural systems can serve as a guide to the future. This may not be the case in water resources planning as evidenced by the scale of climate shift...not to mention the wide variety of other planning uncertainties. The scenario planning process can provide a means to developing a flexible strategic position... – Timothy Thomure, HDR Engineering

To me it comes down to cooperation, planning, and conserving versus litigation. I say we go the route of research, data, science, planning, settlement, and implementation and save litigation for the last resort. – Susan Kelly, Utton Transboundary Center, UNM

"Water Planning in a Time of Uncertainty"

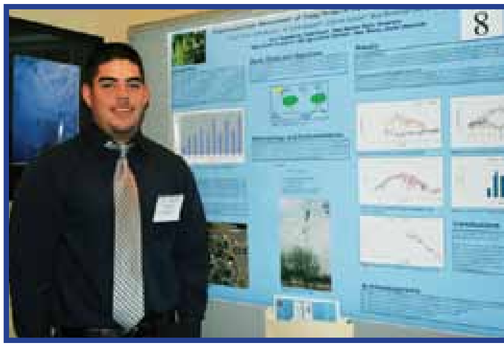
[This photo shows] the Burj Dubai skyscraper, which is 2,684 feet, the world's tallest structure. The minimum length of height [of pipe] is about 2,500 feet [in a deep well]. You can see how much pipe we are putting into the ground…it's an enormous undertaking.
– John D'Antonio, New Mexico State Engineer

One of the greatest threats affecting New Mexico's most precious natural resource is the infestation of zebra and quagga mussels. Impacts to our native biodiversity, sport fish, water infrastructure, and tourism could be devastating. It is vital that all of us do our part to stop the spread of aquatic invasive species because the impacts will affect us all.
– Barbara Coulter, New Mexico Department of Game and Fish

It is a shame that the legislature did not take this opportunity to require the Office of the State Engineer to enter into Memoranda of Agreement with Indian Tribes for management of these deep aquifers that potentially serve both the Tribes and the State. Collective management might take more time to put into place but it can forestall many greater debates and issues in the future.
– Ann Rodgers, Chestnut Law Firm

I keep wondering at what point the City of Albuquerque, for example…we keep allowing the expansion of population and giving [its citizens] meters and letting the town grow – eventually there will a point of no return and there won't be enough water for anyone and consequently, it'll be a catastrophe.
– Joe Stell, 2009 Albert E. Utton Lecturer

2009 Water Research Symposium Draws 162 Participants



The annual New Mexico Water Research Symposium was held in August 2009 at New Mexico Tech. For nearly a decade, the symposium has provided a forum for water specialists to meet, share their current research, and collaborate with their colleagues from around the state and region.

This year, 162 participants attended the daylong symposium, which included 84 students, many of whom presented papers and posters. All poster and paper abstracts are available online at http://wrri.nmsu.edu/publish/sympabs/abstracts2009.html.

The 2009 symposium was dedicated in fond memory of Professor Robert S. Bowman, faculty member at New Mexico Tech and a member of the symposium planning committee since its inception in 2002. Several of Rob's colleagues and students presented their research at the meeting.

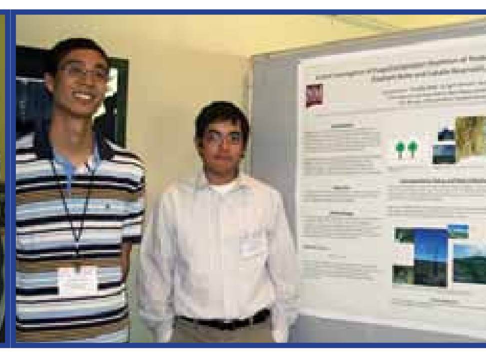
The August meeting opened with a presentation by Patricia Bobeck who has translated the work of Henry Darcy, *The Public Fountains of the City of Dijon*, originally published in 1856. Many in the water field are familiar with Darcy's Law, which was described in this work.

Three concurrent sessions were held this year, including a special session on water management models. This well attended session was moderated by Nabil Shafike of the New Mexico Interstate Stream Commission.

The WRRI would like to thank Sandia National Laboratories, Los Alamos National Laboratory, and the New Mexico Interstate Stream Commission for their financial and planning support of the event. Because of their financial contributions, the registration fee for the meeting has remained at $20 and is waived for students who are presenting papers or posters.

We look forward to another late summer symposium in 2010.





Seasonal Streamflow Forecasting in the Rio Grande Basin

By Jennifer Fletcher, WRRI student assistant and NMSU undergraduate majoring in mathematics

As Shalamu Abudu puts it, "There is always space for improvement." Even though his research in using partial least squares regression (PLSR) to forecast stream flows is still in its early stages, there have already been some promising results in improving the accuracy and efficiency of forecasting seasonal stream flows in the Rio Grande basin.

The study began back in 2007 with data collection from the Rio Grande headwaters in Del Norte, Colorado. The idea was to improve upon the official forecasting models developed in 1992 using Z-score regressions and Principal Components Regressions (PCR).

There are potential problems with both of these forecasting methods, since neither method simultaneously accounts for variations in the prediction or response variable. Z-score regression explains the responses by combining predictors into weighted indices, which emphasize good data and minimize bad data, but doesn't provide any information about the predictors themselves. PCR is based solely on correlations among the prediction variables, but does not level out or normalize anomalies in data, so it can be off the mark for the response variables. Hopefully, using PLSR will provide better forecasting equations by avoiding these issues.

The equations are developed from Snow Telemetry (SNOTEL) data at three measuring sites: the Rio Grande headwaters basin above Del Norte, CO; the Rio Grande Basin near San Marcial, NM; and at the Conejos River Basin near Mogote, CO. The data gathered are for snow/water equivalencies, precipitation, temperature, and previous flow conditions over the spring and summer months.

Shalamu Abudo is working on a Ph.D. in water resources engineering at New Mexico State University under the direction of Professor J. Phillip King.

Each of these variables was weighted according to its correlation to past data, and then the forecast equations were created using different variable combinations. Ultimately, the PLSR equations were compared to the PCR equations and the Natural Resources Conservation Service official forecasting equations, and the PLSR equations performed as well as PCR equations, but with fewer components. This shows that PLSR has great potential as a parsimonious and accurate forecasting tool.

In future research, Shalamu would like to include more gauging stations, adapt the method to these stations, and re-evaluate the method's effectiveness. Also, the current model ignores diversions and man-made lakes, so including these kinds of obstacles will further enhance the capabilities of the model.

The overall long-term goal is to continue to make the method more efficient, which can be done by adapting the model to less expensive and more readily available programs such as Excel, instead of the currently used and more expensive Visual Basic. As the technology and techniques continue to improve and additional research is carried out, the ideal of real-time forecasting is becoming more likely.

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with these geochemical zones yielded insight into both systems. Faults at rift boundaries that penetrate into basement rocks correlated with the presence of salty, deep-earth fluids. Shallower local fault systems had different water chemistries, reflective of interactions with subsurface rock units, surface waters, and recharge paths for precipitation. Other results suggested a mixture of deep and shallow waters in some sources.

Still-pending analyses of a few additional chemical parameters may provide some more information for the study, Williams says. Tritium will help identify surficial recharge to spring systems. Former work used helium isotope ratios in rift-bounding springs to help to quantify deep-fluid contributions to surface flow and aquifer recharge, a major salinity source in the area. But now Williams is on to her next project – work in the PhD program at the University of California at Davis.

Additional funding was provided by the National Science Foundation through the Hydrologic Sciences Program and the Ecology Division Long Term Ecological Research Program at the Sevilleta National Wildlife Refuge, the New Mexico Geological Society, and several UNM sources.

Upcoming Meetings

December 10-13, 2009	National Ground Water Association, **2009 NGWA Ground Water Expo and Annual Meeting**, New Orleans, LA (www.ngwa.org/2009expo)
December 10-18, 2009	American Geophysical Union. **AGU Fall Meeting**, San Francisco, CA (www.agu.org/meetings/fm09)
January 14, 2010	The New Mexico Water Dialogue, 16th Annual Statewide Meeting, **State Water Planning: A Path Forward?** Indian Pueblo Cultural Center, Albuquerque, NM (www.nmwaterdialogue.org)
February 18-19, 2010	**2010 MSSC Annual Salinity Summit**, Monte Carlo Resort & Casino, Las Vegas, NV (www.multi-statesalinitycoalition.com)
March 24-26, 2010	University of California, Riverside. **International Drought Symposium**, Riverside, CA (www.cnas.ucr.edu/drought-symposium)
March 29-31, 2010	American Water Resources Association, **GIS & Water Resources VI**, Orlando, FL (www.awra.org/meetings/Florida2010)
April 11-14, 2010	American Water Works Association, **Sustainable Water Sources Conference,** Albuquerque, NM (www.awwa.org)

Etc.

The 2008 Report of the Rio Grande Compact Commission to the Governors of Colorado, New Mexico and Texas has been published. The report will be posted on the OSE/ISC website soon: http://www.ose.state.nm.us/PDF/ISC/BasinsPrograms/RioGrande/Reports-Charts/RGCC_2008.pdf.

The federal Clean Water Act requires a review of New Mexico's water quality standards every three years. The New Mexico Environment Department has prepared proposed amendments and a narrative explanation, which includes consideration of public input received in August 2008. The proposed amendments will be considered by the New Mexico Water Quality Control Commission in December 2009. The full text of NMED's proposed amendments and the basis for amendment as well as other information about the status of the triennial review, are available on the Surface Water Quality Bureau's website at www.nmenv.state.nm.us/SWQB/Standards/.