New Mexico EARTH MATTERS

Summer 2003

NOTES FROM

What is the value of a state geological survey? Although not a question that is asked every day, it's one that crops up frequently in times of tight state budgets. A qualitative answer is easy to supply. State geological surveys (including the bureau, which—although a division of New Mexico Tech—acts as New Mexico's geological survey) conduct applied research programs that enable responsible development and management of natural resources. These resources include:

- Hard-rock minerals (copper, silver, gold, molybdenum, and others)
- Industrial minerals (mainly sand, gravel, pumice, perlite, building stone, limestone for cement, gypsum for wallboard, potash for fertilizers)
- Energy (coal, oil, natural gas, geothermal)
- Water (in particular, delineating potential new sources of ground water, maximizing their utilization, and monitoring or remediating their quality)

This broad range of tasks is accomplished primarily through field and laboratory work, including geologic mapping, locating resource concentrations and modeling their distribution, and conducting geochemical studies related to rock, soil, and water quality. State geological surveys such as ours typically have other major programs, as well, including:

- Monitoring natural hazards (volcanic events, flooding, earthquakes, and the like)
- Investigations of soil erosion and stability problems
- Maintaining records of mining and energy for the state

(Continued on page 4)

MANAGING OUR MOST IMPORTANT RESOURCE

New Mexicans become agitated when they start talking about water. It has been that way forever, but increasingly so for the past 10 years. Change—real, substantive, and often vexing—seems inevitable. A year or two back, before the drought became palpable, the inevitability of these problems could be ignored. No longer.

The Pecos River immediately below Sumner Lake, Spring 2001. Photo by L. Greer Price.

The Rio Grande and the Pecos River are both of particular interest at this time, because their problems affect a very large number of New Mexicans. The two rivers are at quite different stages in their problem-solving evolution. The Pecos offered us a wake-up call decades back, and we could have responded better to it than we did. But the lessons we learn on the Pecos will likely be called into play on the Rio Grande.

How River Systems Work

Water in perennial streams is generally connected directly with ground water. There are exceptions to this, but not on the river reaches where most people live. In some places the ground water-bearing aquifer is only a local feature, but most streams are connected to large regional aquifers. In fact, in most great rivers, much of the nearby ground water flows toward the river and discharges into it. In systems such as these, the river water can be thought of as overflow from the aquifer. Water that exceeds the capacity of the aquifer to transmit it down valley is discharged into the river. Thus, the river and ground water are two parts of the same hydrologic system.

This is the general condition on both the Rio Grande and the Pecos River. The large aquifers connected to the Rio Grande and to the Pecos are geologically quite different, but both can locally yield thousands of gallons per minute to large production wells, and each aquifer contributes significantly to the flow of the river.

Ultimately all the water in these river systems comes from precipitation within

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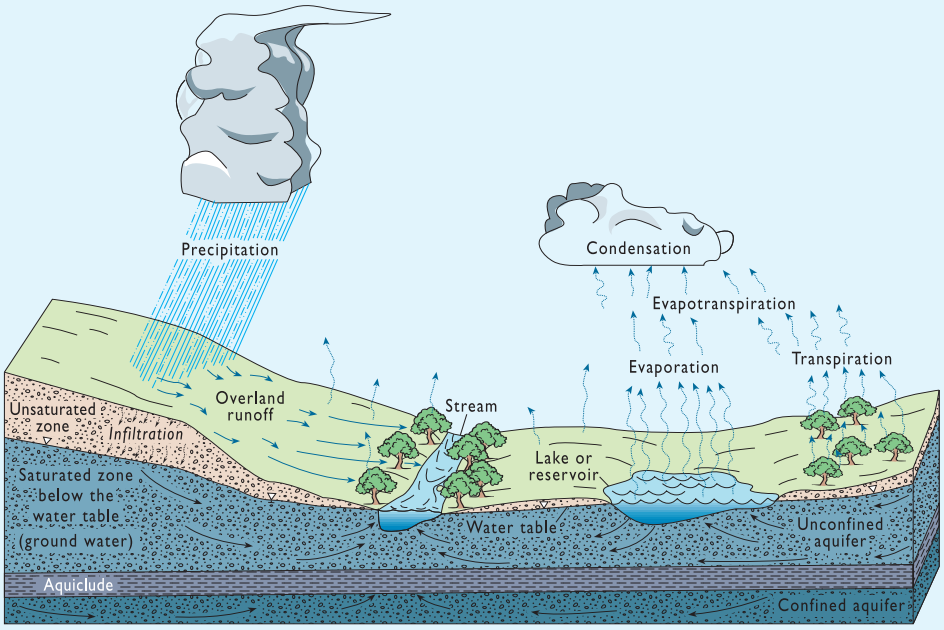
the respective drainage basins. Most of the river flow during the heavy spring runoff comes from melting of winter snowpack high in the headwaters region. Most of the flow later in the year comes from ground water discharging into the river, supplemented by thunderstorms whose water runs down otherwise dry arroyos into the mainstem river. The ground water discharging into the rivers mostly entered the aquifers anywhere from hundreds to thousands of years ago, high on the sides of the drainage basin (the recharge area), then flowed downhill, underground to the river.



In New Mexico not much water is naturally lost from the system between the recharge areas in the uplands and the floors of the river valleys. But the story changes dramatically along the rivers. The floodplains—the broad inner valleys of larger rivers—are flat; the meandering river channel tends to migrate slowly down river, leveling the surface as it goes. Here on the floodplain the water table is shallow. River bottom soils are rich, because the river continually reworks and enriches them during floods. Vegetation is lush here, and water loss from the system is at its highest. Plant transpiration—the process whereby plants use water to grow—and direct evaporation from open water and soil are both high. We commonly combine the two terms and speak of evapotranspiration (ET), but it's all a process of vaporization, and a loss from the system.

Along the floodplain is also where people settle, build, and grow things. Thus the major consumers of water in river basins are riparian vegetation—the uncultivated trees, shrubs, and grasses—irrigated crops, direct evaporation from rivers and reservoirs, and humans in urban environments.

The hydrologic interactions between river and ground water are complex. Although it's easy to paint a broad picture, the detailed physical conditions of where water is, where it flows, how much, how fast, etc. are labyrinthine. Such systems tend to be understood by a handful of technical experts, few of whom have been directly involved in decision-making positions. Lawmakers trying to pass wise laws—and administrators, courts, and lawyers trying to interpret these laws—almost always ask questions that are too simple. They usually try to solve problems that focus on single issues rather than on the reality of complex interrelationships.

The Problems, and Some Solutions

On the Rio Grande during the 1950s drought we got lucky. By 1956, after six years of drought, we were behind on water deliveries below Elephant Butte Dam by more than 500,000 acre-feet (the Rio Grande Compact does not permit debts over 200,000 acre-feet). We got out of this with almost no effort of our own, owing to three roughly simultaneous conditions: Precipitation increased markedly; the growing city of Albuquerque increased its ground water mining, depleting about half of what it pumped from its wells, with the remainder going to augment the flow of the Rio Grande; and the U.S. Bureau of Reclamation completed construction of the low-flow conveyance channel, which extends 50 miles upstream from the head of Elephant Butte Reservoir. The conveyance channel delivered Rio Grande water faster to the reservoir and drained an estimated 200,000 acre-feet of ground water from the river alluvium, conveying it also to the reservoir.

The history on the Pecos River is quite different. The Pecos has a century of productive agricultural development behind it, replete with emotional, quintessentially western, sometimes violent, water fights that appeared to defy neighborly solutions. In 1948 New Mexico and Texas signed an interstate compact, agreeing on the amount of water the river must be allowed to carry into Texas. Nevertheless, for 33 years New Mexico was judged to be short in its annual deliveries. A lawsuit filed by Texas was heard by the U.S. Supreme Court, and in 1988 the Supreme Court ruled that: (1) New Mexico owed 14 million dollars for water not delivered in the past; (2) New Mexico must never again be short in its deliveries under the compact; and (3) a River Master, appointed by the Supreme Court, would ensure that the terms of the decree are met.

It's the second of the conditions that currently causes nervousness. The combined effects of the current drought, and the failure (until recently) of all parties to agree on how to share the burden of annually delivering sufficient water to Texas, has threatened New Mexico's ability to comply with the Supreme Court decree. Non-compliance is risky, even foolhardy. Former state engineer Tom Turney and former interstate stream engineer Norman Gaume threatened the painful consequence of a "priority call" on the Pecos River and the Roswell artesian basin to force negotiation of a "consensus plan." That exercise, forcefully driven by Mr. Gaume, was finally agreed to by the parties on March 25, 2003. Now some solutions seem to be within reach. The

The Rio Grande, Socorro County. Photo by William Stone.

precedents they set, if and when they are implemented, will affect all of us in New Mexico. If we fail to implement them, the U.S. Supreme Court will choose the path of our future. Either way, water affairs on the Pecos will change.

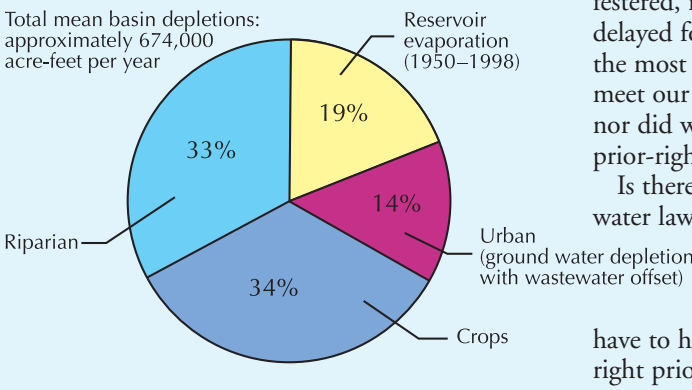
The Consensus Plan

The plan is to buy 6,000 acres of irrigated land in the Carlsbad Irrigation District, plus the water rights from 12,000 acres above Brantley Dam, mostly from the Pecos Valley Artesian Conservancy District, from willing sellers, and dry up that land. It also involves providing wells that will discharge 20,000 acre-feet of ground water a year into the Pecos River itself, and it involves an agreement by the Carlsbad Irrigation District to allow that augmented flow to pass its diversion dam without being intercepted. The plan will require valid offers from willing sellers, reasonable land prices, and a variety of good-faith exchanges if it is to work.

The consensus plan was born under duress but accepted by negotiators and their constituents alike. At this late date it seems to be the only way out, if we want to keep some semblance of water control in the hands of New Mexicans. Otherwise, we cede it to the River Master (an outsider), then through him very likely to the U.S. Bureau of Reclamation. So, for this river at this time, with its people and its history, this appears to be the right solution.

The Broader Issues

The Rio Grande will be the site of our next serious state water crisis. It is often stated that adjudication in the middle Rio Grande could take a hundred years. But substantive state engineer rulings and pro-active management might be needed next year to guarantee water delivery below Elephant Butte Dam under the terms of the Rio Grande Compact. (Note that nearly two-thirds of that water goes to New Mexicans downstream, only a little over a third to Texas.) The inevitable negotiations on the Rio Grande will be at least as painful as were those on the Pecos River.



Mean total middle Rio Grande depletions (including depletion from ground water storage) under present land use and ground water development conditions (from S.S. Papadopulos & Associates, 2000).

We wasted decades on the Pecos during which we hung tough, refusing to negotiate. Any of several negotiated settlements probably would have been better than the Supreme Court decree. Now, we may be wasting equally critical time statewide when vested interests in other basins under pressure fail to recognize that the state's ability to manage its own water affairs is imperiled. Why can't we get started in their critical negotiation?

We should recognize up front that, even though each river-aquifer system is different, we have principles spelled out in law, and basin-specific contractual agreements, to guide statewide water management. The Pecos conflict festered, it can be argued, because we delayed following those principles. At the most fundamental level, we didn't meet our contractual commitments, nor did we apply and enforce our own prior-rights water doctrine.

Is there anything in the body of state water law that says we don't have to honor our compacts? Of course not. Are there words that say we don't have to honor the principles of water-right priority? Well, not exactly, but interpretations of the law, have allowed acquisition of ground water rights that intercept water headed for a hydraulically connected river, thereby shorting future wet-water delivery to holders of senior surface-water rights. No priority system can function that way.

The Importance of Leadership and Science

Steve Reynolds, our state engineer for 35 years, was a brilliant, self-confident man and an effective state engineer. He led in the exploitation of New Mexico's water for the benefit of its people. But, being highly supportive of growth, he also allowed heavy exploitation of water resources in the Roswell artesian basin, reducing the flow of the Pecos River and thereby cutting the amount of water going to the senior surface-right owners in the Carlsbad Irrigation District and to Texas. It gave us wealth, of a sort, and growth. But those decisions have caught up with us. Now, particularly in

the face of the serious drought that is upon us, we can no longer ignore the reality that the resource is finite. Reynolds inherited from state engineers preceding him, and passed on to those who followed, a philosophy that the engineer's job was to administer water rights in the state, not to manage the state's waters. Although this may have been practical in earlier times, it is not possible today. Tom Turney was New Mexico's first state engineer (1995-2002) to recognize an important truth: water-rights administration must give way to water-resource management.

We were slow in the transition from administration to management, and we are also lagging behind in gathering the science we need to manage effectively the water we have. Good management requires good science, and there's a great deal we don't know. Very little of the Pecos Valley is geologically mapped in any detail. We lack detailed structural maps; hydrogeologic maps that show the extent and boundaries of aquifers; ongoing measurements of stream flow, spring discharge, and ground water discharge; detailed surveys of water quality; estimates of ground water age—these are just a few of the areas we need to pursue. This is where we have the potential to gain a real foothold and make real progress in providing a detailed picture of the geologic and hydrologic framework of New Mexico. This is the value in the kind of work we that we do at the bureau, endeavors that we share with other agencies and institutions in New Mexico. Ultimately these efforts will be to the benefit of all New Mexicans.

—Frank Titus

Frank Titus has worked in ground water science, contaminant hydrology, and geology since 1956, mostly in New Mexico. He is currently on the staff of the New Mexico Bureau of Geology and Mineral Resources.

Each issue of Earth Matters features an invited article on a subject of interest to New Mexicans. These articles represent the author's informed opinion on important geoscience issues in New Mexico. The New Mexico Bureau of Geology and Mineral

NOTES FROM THE STATE GEOLOGIST

(continued from page 1)

- Storing subsurface data (well cuttings, cores, seismic records)
- Publishing
- Maintaining libraries of geologic information on the state
- Conducting educational outreach activities

All of these are valuable activities that support the state's basic infrastructure and provide information needed by industry, government, and an informed electorate to manage growth, bring tax and royalty dollars into the state, or mitigate potential losses from natural hazards.

A more quantitative answer as to what these activities are worth— how much money is returned to state or local coffers relative to the dollars spent on supporting geological surveys — is, not surprisingly, more difficult to calculate. One reason is that the connections between geologic studies and eventual fiscal returns are not always direct, apparent, or immediate. In the energy area, for example, we store drill-hole cores and cuttings, conduct published research programs on potential oil and gas exploration plays, and hold conferences and field trips to stimulate exploration interest. How do we measure the results of those efforts and expenditures? In a recent example (Petzet, 2003), roughly two decades of work by Ron Broadhead, the bureau's senior principal petroleum geologist, was singled out by the *Oil and Gas Journal* as instrumental in the discovery of a potentially substantial new gas field near Tucumcari. This discovery likely will help to stimulate a wave of new exploration in similar settings throughout that basin and other areas of New Mexico. Clearly, I do not mean to lessen the importance of the entrepreneurial companies that financed and drilled these prospects, but the role of state-funded research should not be overlooked. Both combine to bring new jobs and very substantial tax resources (millions of dollars) back to the state, benefits that will far exceed the hundreds of thousands of dollars spent by the bureau on research over the previous two decades.

A more broadly based study was done recently by the Illinois Geological Survey on the economic returns from the complete geologic mapping of the state of Kentucky at a scale of 1:24,000. It showed some surprising but gratifying results (Bhagwat and Ipe, 2000). Although the mapping was originally done primarily to enhance coal production in the state, the eventual uses of the geologic data over the subsequent two decades were remarkably diverse. They spanned a wide range of fields including environmental safety (sinkhole collapse, landslide and earthquake hazard prediction), natural resource development (energy and minerals), land use management (landfill site selection, sand and gravel location for urban development), and others. Many of those uses were not even anticipated when the mapping was undertaken (from 1960 to 1978). The cost of the mapping program in Kentucky was $90 million. That investment resulted in returns to the state that were calculated at $2.25-3.53 billion through 1999, a 25- to 38-fold return on investment.

Similar results can be found in New Mexico for geologic studies related to energy and mineral resources, water planning, and land-use issues. We believe that it is a wise investment by the state in its future, especially because most dollars spent on basic geologic mapping are matched by federal dollars from the National Cooperative Geologic Mapping Program. The basic data collection and research conducted by our agency, coupled with the on-line and on-site information dissemination to industries, consultants, and the general public, provide benefits to the state now. In addition, it also will be used for many future needs, such as CO_2 sequestration, mine-site remediation, desalinization projects in deep aquifers, and other needs we cannot yet anticipate. It short, bureau research will continue to yield investment returns to the state for generations to come.

—Peter Scholle
Director and State Geologist

Bhagwat, S. B., and Ipe, V.C., 2000, Economic benefits of detailed geologic mapping to Kentucky: Illinois State Geological Survey, Special Report 3, 39 pp.

Petzet, A., 2003, How E&D is done in the US: Oil & Gas Journal, v. 101, no. 19 (May 12, 2003), p. 15.

Bureau News

New Field Geologists

In May of this year the bureau hired two new field geologists, Dan Koning and Geoff Rawling. Both will be working primarily with the STATEMAP program. Dan will be working in the Española Basin, out of the Albuquerque office. His work is critical to ground water studies in the Española Basin. Geoff will be mapping in the southern Albuquerque Basin and in the Sacramento Mountains and will be working out of the Socorro office. Both Dan and Geoff worked for the bureau in the past under contract as geologic mappers.

Rockin' Around New Mexico

This year's Rockin' Around New Mexico, our annual teachers workshop, was held in Santa Fe in June. Over 40 teachers from all over the state attended the workshop, which focused this year on seismicity, vulcanism, and hydrology. Excursions included a field trip to the Jemez Mountains and the Valles caldera, and a visit to the state headquarters for emergency management, in Santa Fe. Next year's workshop in June 2004 will take place in Albuquerque.

McLemore on Mining Advisory Council

Virginia McLemore, senior economic geologist with the bureau, has been reappointed to the New Mexico State Land Office Mining Advisory Council. Members of the council are appointed by Patrick H. Lyons, commissioner of public lands.

Linda S. Ulbricht

1951-2003

Linda S. Ulbricht, administrative secretary at the bureau since July 1999, died on March 9, 2003. She was a warm and familiar face in the Publication Sales Office, for visitors and staff alike, and we will all miss her.

2003 Mineral Symposium

This year's annual Mineral Symposium, sponsored by the Mineral Museum at the New Mexico Bureau of Geology and Mineral Resources, will be held November 8-9 at Macey Center on the campus of New Mexico Tech. The symposium provides a forum for both professionals and amateurs interested in mineralogy. It will include a day and a half of formal papers. Dinner and a silent auction will take place on Saturday, November 8. For more information call

Our Mission

The New Mexico Bureau of Geology and Mineral Resources, established by legislation in 1927, is a service and research division of the New Mexico Institute of Mining and Technology. It acts as the geological survey of New Mexico with these main goals:

- CONDUCT research and interact with state and federal agencies and industry to facilitate prudent exploitation of the state's geological resources.
- DISTRIBUTE accurate information to scientists, decision makers, and the New Mexico public regarding the state's geologic infrastructure, mineral and energy resources, and geohydrology (including water quantity and quality).
- CREATE accurate, up-to-date (digital and GIS-based) maps of the state's geology and resource potential.
- PROVIDE timely information on potential geologic hazards, including earthquakes, volcanic events, soils- and subsidence-related problems, and flooding.
- ACT as a repository for cores, well cuttings and a wide variety of geological data. Provide convenient physical and internet access for New Mexicans to such resources.
- PROVIDE public education and outreach through college teaching and advising, the Mineral Museum, and teacher- and student-training programs.

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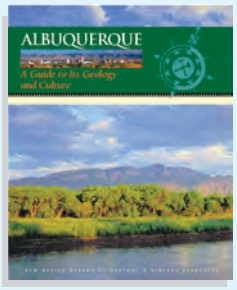
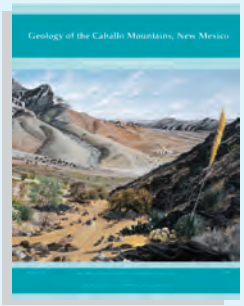
New Publications



Albuquerque: A Guide to Its Geology and Culture by Paul W. Bauer, Richard P. Lozinsky, Carol J. Condie, and L. Greer Price. Scenic Trip no. 18, 192 pp. $ 14.95

This all-new full-color guide to the Albuquerque area provides an overview of the geologic and cultural history of the region. Richly illustrated with over 100 photos, maps, and illustrations, it includes six detailed road logs throughout the area, from Cerrillos to Los Lunas. This authoritative but popular guide is the first volume in the newly redesigned Scenic Trip series; it replaces the now out-of-print Scenic Trip no. 9. Fully indexed, with glossary.



Geology of the Caballo Mountains, New Mexico by William R. Seager and Greg H. Mack. Memoir 49, 142 pp. $ 15.00

The complex geologic history of the Caballo Mountains, just south of Truth or Consequences, is well documented in this comprehensive description of the region. The geologic section here includes Precambrian igneous and metamorphic rocks and an extraordinary thickness of sedimentary rocks, which collectively give us an unparalleled picture of the evolution of southern New Mexico. The result of many years of study and field work, the volume is heavily illustrated with photographs, maps, stratigraphic sections, and other graphics.

Geologic Map of New Mexico 1:500,000, New Mexico Bureau of Geology and Mineral Resources. Two oversized sheets, 54” x 47” and 50” x 42” available rolled or folded (standard shipping on folded sheets; rolled map requires an additional charge of $10.00 for cardboard tube and shipping). $20.00

This full-color geologic map of New Mexico, published in July 2003, is the first state geologic map published at this scale since 1965. Close to 20 years in the making, this compilation represents the collective efforts of geologists from throughout the state. Over 100 geologic units are represented. Sheet two includes a detailed key, correlation charts, and references.

For more information about these and other bureau publications: visit our Web site at http://geoinfo.nmt.edu; write or visit our Publications Office on the campus of New Mexico Tech, 801 Leroy Place, Socorro, New Mexico 87801; call (505) 835-5410 or (505) 835-5490; or e-mail us at pubsofc@gis.nmt.edu. Payment (check or money order payable to NMBGMR) must be enclosed with mailed orders. Telephone orders may be paid with VISA, Discover, American Express, or MasterCard.

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