New Mexico EARTH MATTERS

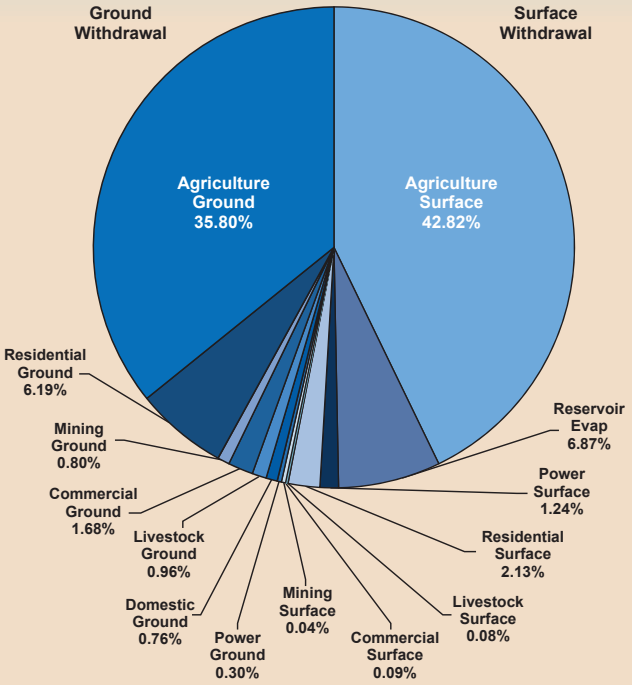
SUMMER 2014

The Role of Geology in Shaping New Mexico's Future

Facing the Challenges of the Years Ahead

In the coming years New Mexico faces a number of very real challenges, as we cope with a growing population, diminishing resources, an increasingly variable climate, and a shifting economy. We are not alone in this; most states face similar issues. But some of our issues are unique to New Mexico. We are a rural state, with a large agricultural base, and we're a state that values tradition. There is a growing concern with preserving the lifestyle and traditions that have made New Mexico what it is today, while adapting to the changes that are upon us.

Many of the solutions to these problems, and the strategies we'll need to develop in order to adapt, are grounded in an understanding of earth science issues. The kind of research that we (and others) are doing—detailed surface and subsurface geologic mapping, and basic research into the geologic framework and resources of our state—will provide much of the information we need. Some of this is information that we either don't have or for which we currently have only an incomplete picture. Less than half of New Mexico has been geologically mapped in detail, and our understanding of aquifers statewide is certainly incomplete. The policies, strategies, and solutions themselves will be up to the people of New Mexico and their elected representatives, both state and federal. What we, as earth scientists, can do is inform the debate and help people understand what it is we need to know, and why. What are some of the most prominent and pressing issues that we will face in the years ahead?



New Mexico water withdrawals in 2010 (as a percent of 3,815,944 acre/feet total). Includes surface and groundwater. From Longworth et al. 2013, New Mexico Office of the State Engineer Technical Report 54.

Water

In New Mexico no resource is more important, fragile, and scarce right now than water. Our supply of surface water is far from dependable and relies upon snowpack and precipitation, both of which are affected by our increasingly variable patterns of climate and rainfall. Our groundwater resources are finite; in many parts of the state we are "mining" groundwater that has taken thousands of years to accumulate. Groundwater extraction rates far exceed rates of natural recharge in many areas. Any discussion of the sustainability of groundwater resources depends upon a more complete understanding of our aquifers statewide than we currently have. This is even more true of the deep saline aquifers that have been largely untapped. Here, too, even if we are able to find ways to use those resources, they are finite, and we have little hard data on the quantity and quality of the water in these aquifers.

Around 75% of our water (surface and ground) goes to agriculture, although that percentage is declining, as demands for urban and industrial uses increase. But without sustainable water resources, much more than agriculture is at stake. Certainly the bulk of our industrial economy—including oil and gas development, mining, and energy generation—depends upon a secure source of water. One reason aquifer mapping and groundwater monitoring are so important is that both give us an idea of the sustainability of this resource. Water quality, and the protection of existing water resources, also depend upon an understanding of regional geology. Movement of groundwater—and of groundwater contaminants—in the subsurface is something we all need to be concerned with. This requires detailed geologic mapping, and a knowledge of subsurface geology.

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The Macho Springs solar facility near Deming. This is currently the state's largest solar power plant. Image courtesy of Carlos Javier Sanchez, Las Cruces Sun-News.

Finally, the infrastructure associated with the development of groundwater resources, particularly in rural areas of the state, is an issue of growing importance. The water crisis in Magdalena in the summer of 2013 was a good example of what's at stake. But it's not an unusual case. Hundreds of active public and community water systems in New Mexico rely upon a single source for domestic water supplies, and in many cases these sources are wells that are old, outdated, and in danger of failure. For any community to rely upon a single source of water is a recipe for disaster. In areas where groundwater levels are falling, detailed regional hydrologic studies can provide some insight into why, and how critical the problem is likely to be.

Energy

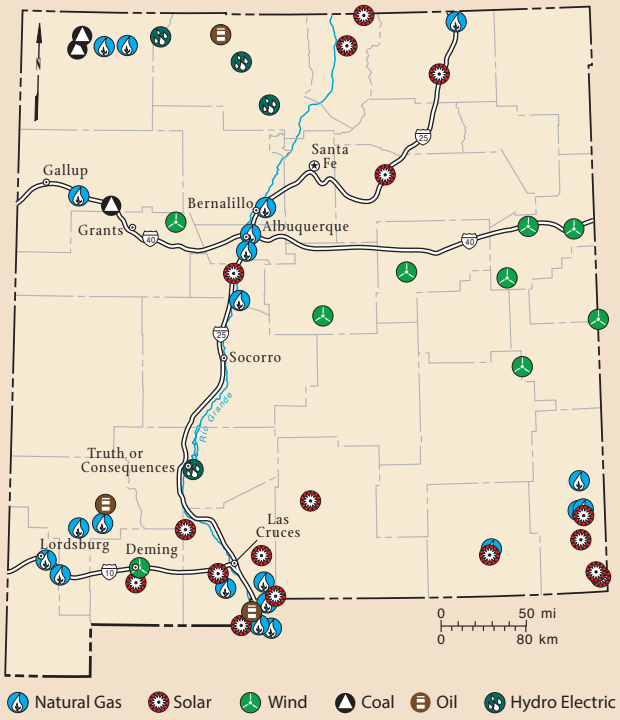
New Mexico is an energy-producing state, which means that we produce more energy than we use, and we export the excess to neighboring states. The bulk of that energy comes from oil and gas, and coal. While our economy has long depended upon these industries, they are not immune from the challenges that face us. The coal industry in New Mexico faces the challenges of increasing costs associated with implementing "clean coal" technologies. Most of our coal-fired plants are more than 30 years old. Regulations proposed in 2014 will require existing plants to meet more stringent emission standards. Increasingly, coal-generated power plants are being replaced with those fueled by natural gas. In many instances, it is cheaper to build a new gas-powered plant than to retrofit an existing coal-powered plant. However, the future of natural gas resource development in New Mexico will depend, among other things, upon the technologies associated with horizontal drilling and hydraulic fracturing ("fracking"). These technologies have been applied to oil drilling in recent years, resulting in enormous increases in production.

This isn't entirely a matter of choice; the easily extracted oil and gas reserves of the state have largely been developed, and to a significant extent depleted. To develop what remains—and these reserves are significant—requires these new technologies. The concern is, will we be able to continue hydraulic fracturing on a large scale, while at the same time protecting groundwater resources that may be at risk? Hydraulic fracturing has traditionally been a process that requires a large amount of fresh (or nearly fresh) water, a resource that is scarce in New Mexico. Developing technologies are changing that, and brackish or saline waters are now being used to some extent. But there remains the issue of disposal of the waste stream associated with the process. Technologies that permit the recycling of fracking fluids are just emerging, with the hope that we can eliminate some of the need for waste stream disposal.

New Mexico has other energy resources, as well. We are second only to Wyoming in our reserves of uranium. But there are "legacy" issues associated with uranium mining and processing in the past that have very much affected the willingness on the part of New Mexicans to invest in or permit further resource development. Many of our uranium resources lie in or adjacent to Native American lands, and the custodians of these lands are cautious about future development (and not entirely without reason). Whatever happens, it will require a full understanding of the regional geologic picture to facilitate any future development.

Geothermal energy has long played a role in our state, although we do not have the kind of high-temperature resources required for energy generation. But for many years we have used low-temperature geothermal resources for direct-heating applications such as aquaculture, greenhouses, and heat generation. The local economy of a town like Truth of Consequences (historically known as Hot Springs) depends greatly upon the sustainability of their geothermal resources. We are currently working with a number of local communities to help understand the sustainability of these geothermal resources, and to locate new ones.

Finally, New Mexico is a state that is ripe for the development of alternative energy resources, specifically wind and solar. We have abundant resources of both. But the development of those resources, which are intermittent in supply, depends upon a steady source of back-up energy, typically from natural gas or coal. It also depends upon the availability of specific mineral resources, including the so-called rare earth elements (REE), which is an area where New Mexico may play a role.



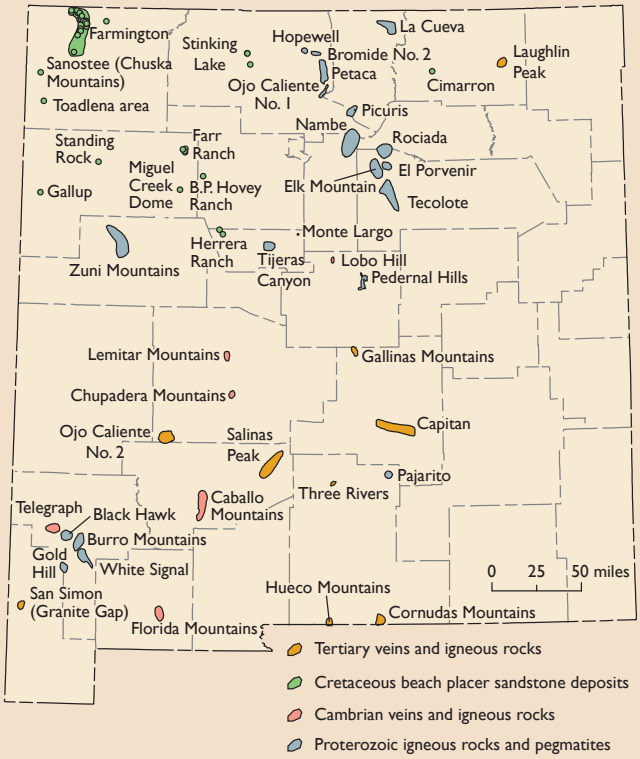
New Mexico gets its power from a variety of sources statewide. Note there are only 3 coal-powered plants, all in northwest New Mexico. There are three hydroelectric plants, but no nuclear plants. The increasing number of wind-generated plants is a relatively recent development.

Mining and Mineral Resources

New Mexico is a state with a long history of mining, and the mining industry continues to make important contributions to our economy. Copper, gold, silver, molybdenum, potash, industrial minerals, and aggregate have all played a large role in the economic development of New Mexico. But the mining industry here (as elsewhere) struggles with a shifting global economy. What we can produce economically in New Mexico depends a great deal upon what's happening in international markets. The molybdenum mine in Questa recently closed after nearly a century of operation. The global cost and availability of molybdenum certainly played a role in that, but the reasons for such closures are generally complex. The industry struggles with permitting regulations (federal and state) that are fairly stringent; opening a new mine can easily take years to get through the permitting process. The recent revival of the potash industry (used in industrial fertilizer for the agricultural industry) in southeast New Mexico has been a boon to that part of the state. Some of this is the result of new, more efficient processing methods, which our staff at the New Mexico Bureau of Geology helped develop.

The soaring price of gold has been an incentive for companies to re-examine resources that had been deemed uneconomic, and gold mining may well be a part of our future. The Summit mine in Grant County opened in 2009, the first operating gold mine in New Mexico since 1993, but is temporarily closed. A proposal to develop a new gold mine in Santa Fe County is currently underway, but faces stiff local opposition. The aggregate industry (sand and gravel, etc.) depends very much on local economic growth: If New Mexico is building, then the aggregate industry thrives. However, these are resources that are not cost effective to ship long distances. Often they need to be developed close to populated areas, where the markets are. And local economic growth depends upon a sustainable aggregate industry. Both the industry and the general public need to work together to find ways to co-exist.

The future of New Mexico's mining industry may lie in the search for so-called strategic minerals—minerals that are vitally important to the security and economic well being of our country. These include the rare earth elements (REE), which are in demand globally for a wide variety of high-tech electronic applications, including those associated with alternative energy sources like wind and solar, and batteries for electric cars. New Mexico has REE resources, and interest in these resources has increased in recent years.



Known deposits containing high concentrations of rare earth elements in New Mexico, by mining district.

The JWS Sinkhole in Eddy County, NM. The sinkhole is over 300 feet across and 150 feet deep. It formed in 2008 when cavities created by solution mining in bedded salt in the Permian Salado Formation collapsed. Photo by Lewis Land, National Cave and Karst Research Institute.

Geologic Hazards

New Mexico has been mercifully free of serious geologic disasters in recent years, relative to many states, but we do have a history of them. In 1906, the same year that an earthquake devastated San Francisco, New Mexico suffered two major earthquakes that caused a lot of damage. Interestingly enough, the area of highest seismicity in the state is an area just north of Socorro, in the Rio Grande rift. Much of that seismicity is associated with the Socorro Magma Body, a body of molten rock that lies 12 miles below the surface. Sophisticated geophysical techniques have allowed researchers at New Mexico Tech to map this magma body, and to track the seismicity associated with it.

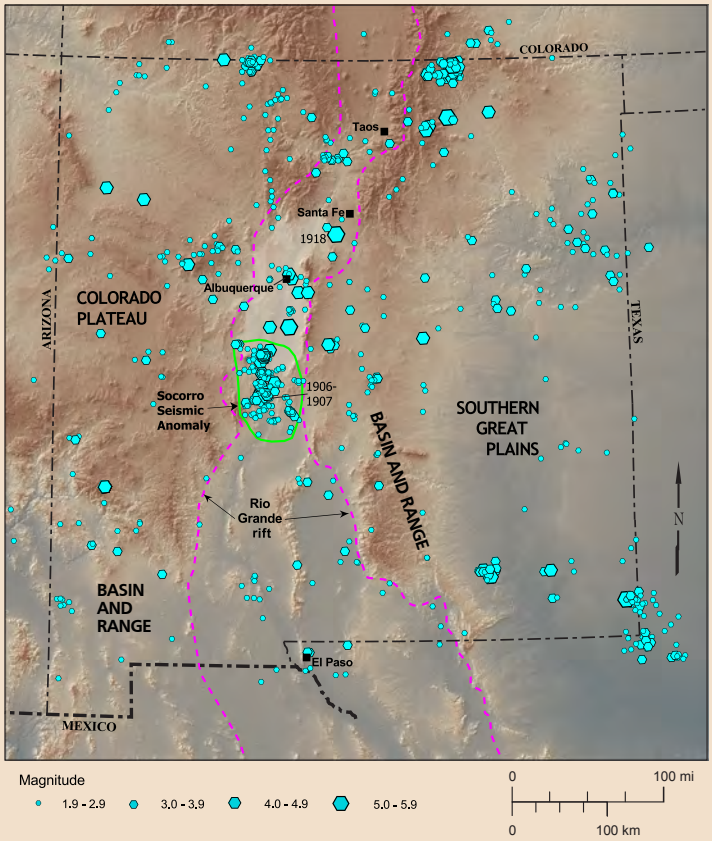
In southeast New Mexico, collapse associated with sinkholes and subsurface cavities has been very much in the news. Oil and gas drillers tell of losing mud circulation when they encounter large voids in the subsurface. In other parts of the state, a poor understanding of surficial deposits has led to the collapse of highways and other structures. The Bureau of Geology's archival collection of old mine maps, some of which go back 100 years, has been of great interest as developers in the Gallup area have moved into areas where the subsurface is pocked with defunct coal mine tunnels. Subsidence due to collapsible soils is an ongoing problem in housing developments throughout the state.

Flash flood debris from the 2011 Dixon Apple Orchard flood. The Las Conchas fire burned much of the drainage area for the creek that flows in the bottom of the canyon. Photo courtesy of Channel 13 News.

In a state like New Mexico, where water is scarce, flooding may seem like a remote issue. But the rain we get comes in short, intense

episodes. Much of the flooding (and associated debris flows) that happen in New Mexico are the result of such heavy intermittent rains, often in areas that have seen catastrophic forest fires. In the absence of surface vegetation, these terrains are subject to disastrous floods. Peak stream flows can increase the threat of floods throughout an entire watershed. The disaster that destroyed the Dixon apple orchard in 2011 was a combination of the Los Conchas fire, followed by unusually heavy monsoon rains. Following the Cerro Grande fire in 2000, a valid concern was the risk of flood waters carrying contaminants from Los Alamos National Laboratory into regional watersheds. In these instances, an understanding of how surface water moves, and the connection between surface water and groundwater are vital to assessing risks and mitigating flood damage. This in particular was an area where interdisciplinary studies that involved many cooperating agencies helped make a difference.

Volcanic hazards don't seem to worry many people in the state, but the fact is, New Mexico has a history of recent volcanism. The youngest lava flow in the state (the McCarty's flow at El Malpais) is a mere 3,900 years old. Prehistoric inhabitants of the region would have witnessed these eruptions, and in geologic terms, they are young. In 2013 scientists from the New Mexico Bureau of Geology initiated a study of young volcanic activity in New Mexico, with an eye toward gaging the probability of future eruptions. We who are alive today may not witness the next eruption, but ongoing volcanism in New Mexico is a geological certainty.



Map of historic seismicity in New Mexico, 1869 to 2008. Earthquake data are from the U.S. Geological Survey and New Mexico Tech. Boundaries of the Rio Grande rift and the Socorro Seismic Anomaly are shown. Some clusters of seismic events in southeast New Mexico and the Raton Basin were likely induced by fluid withdrawal or injection in oil and gas fields.

Induced Seismicity

There has been an enormous amount of interest lately in the issue of induced seismicity, not just in New Mexico but throughout the country. The concern is that the pumping of fluids into (or out of) subsurface rock units can alter the dynamics and balance of underground stresses, causing movement along existing faults that results in potentially damaging earthquakes. Many neighboring states with flourishing oil and gas industries, in particular Oklahoma, have taken a renewed interest in and study of induced seismicity, in response to this concern.

Most of the induced seismicity we're aware of is the result of the pumping of very large volumes of waste fluids into the subsurface. These are largely "produced waters," saline fluids that are produced when oil and gas is extracted from the subsurface. Typically such fluids are disposed of through subsurface injection. In order to prevent contamination of shallow aquifers, such fluids are pumped into the deep subsurface, and there has been some induced seismicity associated with this. In New Mexico, this has mainly been documented in the southeast part of the state, where the oil and gas industry thrives, and in the Raton Basin in the northeast. In the latter instance, the cause of the seismicity is less certain, although it may be related again to the disposal of produced waters associated with the development of coalbed methane resources in this part of the state.

One of the concerns has been with the potential for induced seismicity associated with hydraulic fracturing, which involves the pumping of fluids into the deep subsurface under pressure in order to fracture "tight" (low permeability) reservoirs, typically shales. In truth, there is currently very little documented seismicity associated with hydraulic fracturing, and the events appear to be extremely small. But it's a subject that merits some examination. Hydraulic fracturing will continue to play a big part in the development of these resources in New Mexico, given the nature of our reserves, and so the geologic community will be monitoring such activity to determine what effects there may be in the future.

Remediation of Existing Groundwater Contamination

One of the biggest issues in New Mexico is the remediation of contaminated sites that pose a threat to our increasingly scarce and valuable fresh water resources. The Environmental Protection Agency (EPA) currently lists twenty Superfund sites in New Mexico (a summary of these sites is available on the EPA website at:

http://www.epa.gov/earth1r6/6sf/6sf-nm.htm). These are hazardous waste sites, some of them quite old, including abandoned warehouses, factories, landfills, etc. All of them are potential threats to shallow aquifers that underlie them. Other so-called "legacy" sites also pose serious threats to groundwater. The Kirtland Air Force Base plume resulting from a years-old fuel spill is one such threat. Yet another example, in the Grants Uranium District, involves a contaminated groundwater plume that threatens groundwater resources that provide drinking water for the town of Milan. In both of these instances, there are solutions and remediation strategies that could go a long way toward preventing further contamination. But all of them require a detailed understanding of the subsurface, precisely the kind of work that we are doing. Without an understanding of how (and how fast) groundwater moves in the subsurface, and the interconnectivity of the enormously complex series of subsurface basins, we cannot hope to remediate these sites.

The Growing Importance of Data

The collection and archiving of data related to the geology of New Mexico has been part of our mission since 1927. But a number of things have made this mission more challenging, and ever more important. The amount of data we gather and store has increased—and continues to increase—at an astounding rate. Also, we are trying to serve this data in ways that make it more accessible, not only to other state and federal agencies, but to the general public. Data without some sort of explanation is useful only to a handful of people; posting data on a website without some explanation of its strengths, limitations, and uses, serves almost no one. We are working to provide these data in ways and formats that make it not only more accessible, but more meaningful. In this endeavor we are cooperating with a broad range of other state and federal agencies, all of whom are facing similar challenges. Finally, it's important that the data (and the databases) that we create and house interface with those of other states, on a national (and sometimes international) level. This applies not only to our geologic maps but to well data, geothermal data, seismic data, mining data, and other geologic data.

This isn't just an exercise in archive management. Long-term records of this kind are what allow us to make scientifically meaningful predictions about our future, to build models that can help us develop strategies and solutions, and to speak with some authority about where we've come from, and where we're going. This has always been part of what we do, but how we do it is becoming much more sophisticated, more challenging, and (we hope) more meaningful to a broader audience.

Who are the People Addressing These Issues?

All of these are issues to which we at the New Mexico Bureau of Geology and Mineral Resources are devoting staff, time, and money. We are not alone in this. Other state and federal agencies are working in their own way on many of these same issues. These include the Office of the State Engineer, the New Mexico Environment Department, the U.S. Geological Survey, New Mexico's Energy, Minerals and Natural Resources Department, the Water Resources Research Institute, and others. We work closely with all of these people. And behind the scenes, doing very important work, are the researchers in New Mexico's academic community, including New Mexico Tech, the University of New Mexico, New Mexico State University, and other colleges and universities. Their research ultimately provides many of the tools we can use to do our jobs. The national laboratories in New Mexico also play an important part, as do many private industries and utilities. Increasingly we are finding ways to work together, in partnership with these groups, local communities, the state legislature, and various branches of state government.

Ultimately the solution to many of these problems will come from these kinds of partnerships. Innovation will play an important role, as well, and this is why fundamental research is invaluable. Technology offers us new and improved tools, from geophysical tools that provide a more detailed view of the subsurface to radiometric dating techniques that can give us the age of the groundwater we're using. Finally, long-term planning and a balanced approach to these problems, given the constraints that all of us have, will in the end allow us to plot a course that will help us find solutions to these challenges.

—L. Greer Price

Greer is the director and state geologist for the New Mexico Bureau of Geology and Mineral Resources. He has worked at the bureau since January 2001.

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We work with many different state and federal agencies on some of the issues outlined here. Many of them have websites with information of interest to the general public. Among them are:

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130 South Capitol Street
Concha Ortiz y Pino Building
P.O. Box 25102
Santa Fe, NM 87504-5102

http://www.ose.state.nm.us
http://www.ose.state.ninfo_index.html (water information)
http://meas.ose.state.nm.us/ (real-time water measurement data)

New Mexico Environment Department
1190 St. Francis Drive, Suite N N4050
Santa Fe, NM 87505
http://www.nmenv.state.nm.us/
http://gis.nmenv.state.nm.us/EGIS/

U.S. Geological Survey
New Mexico Water Science Center
5338 Montgomery Blvd., NE Suite 400
Albuquerque, NM 87109-1311
http://www.usgs.gov/water/

New Mexico Energy, Minerals and Natural Resources Department
1220 South St. Francis Drive
Wendell Chino Building, First Floor
Santa Fe, NM 87505

http://www.emnrd.state.nm.us/index.html

This department includes:
Mining and Mineral Division
Oil Conservation Division
Energy Conservation and Management Division
State Forestry Division
State Parks Division

New Mexico Water Resources Research Institute (WRRI)
New Mexico State University
MSC 3167, PO Box 30001
Las Cruces, NM 88003-8001
http://wrri.nmsu.edu/index.html

U.S. Bureau of Reclamation
Upper Colorado Region: http://www.usbr.gov/uc/
U.S. Bureau Reclamation: Rio Grande and Pecos River Basins, *http://www.usbr.gov/uc/water/basin/tc_prg.html*

U.S. Bureau of Land Management
New Mexico State Office
301 Dinosaur Trail
Santa Fe, NM 87508
P.O. Box 27115
Santa Fe, NM 87502-0115

http://www.blm.gov/wo/st/en.html
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