WATER: A LIMITING FACTOR

DECISION-MAKERS FIELD CONFERENCE 2009

The Albuquerque Region

The diversion dam on the Rio Grande just south of the Alameda bridge.

© Adriel Heisey

Water Supply Limitations in the Albuquerque Area

Deborah L. Hathaway, *S. S. Papadopulos & Associates, Inc.*

Water: the limiting factor. Albuquerque residents and their political leaders are familiar with this concept, as are urban planners and developers. Water is a high-profile hurdle that confronts urban development and attracts uncountable legal and engineering efforts. Legions of attorneys and engineers make careers of developing "innovative" schemes to surmount the water supply hurdle, and although these may be time-consuming and expensive, seldom does lack of water impede a strongly motivated and well-financed development plan. "Finding water" often results in a water transfer, for example, a shift of water from agricultural to urban uses. What, then, is the driving question regarding water limitation within this region? Is there a water deficit, and if so, how will water supply limitations impact urban development? Or, is the corollary question, how will urban development impact the hydrologic landscape, more compelling? This paper identifies the water supply and limits in the Albuquerque area. Reflection on these topics suggests that although the physical supply of water available to the region is limited, the more immediate limits on water use involve other factors, including socio-political tolerance for impacts to the hydrologic landscape that ensue from the transfer of water among water use sectors.

THE WATER SUPPLY

The Albuquerque area water supply includes both surface water and ground water. These water sources are hydraulically connected and are part of an interconnected regional resource within the Middle Rio Grande Basin that extends well beyond Albuquerque. As such, the water supply can't be quantified without consideration of stream–aquifer interactions and Rio Grande Compact issues. Elements of the surface water supply include native surface water supply (*native inflow*) and imported surface water. Each has its own set of constraints on availability, as does ground water.

Natural flows of the Rio Grande and the Rio Chama above the Otowi gage near Pojoaque, or *native inflow*, supplemented by downstream tributary inflows, constitute the bulk of sustainable supply to the Middle Rio Grande region, including the Albuquerque area. This water supply is highly variable from year to year but in part can be stored by the Middle Rio Grande Conservancy District (MRGCD) at El Vado Reservoir. Native surface water represented by upstream inflow at the Otowi gage (with adjustment for upstream storage and imported water) is subject to apportionment under the Rio Grande Compact, which caps native surface water inflow available for depletion in New Mexico. Native surface water comprises the bulk of water used for agriculture in the Albuquerque area and is diverted into MRGCD canals at Angostura. Further north and south within the Albuquerque Basin, water for irrigation is diverted at Cochiti and Isleta, respectively.

Imported surface water from the San Juan–Chama Project, diverted from the upper Colorado River drainage, provides 70,400 acre-feet per year to users in the Middle Rio Grande region through contracts administered by the Bureau of Reclamation, of which 48,200 acre-feet per year is contracted to the Albuquerque Bernalillo County Water Utility Authority (ABCWUA) and 20,900 acre-feet per year is contracted to MRGCD. Abiquiu Reservoir provides storage for the ABCWUA San Juan–Chama water. San Juan–Chama Project water is the supply targeted for direct diversion by the Albuquerque Drinking Water Project. Availability is subject to drought in the southern San Juan Mountains of Colorado and shortages among the users under the Colorado River Compact.

Ground water in the Albuquerque area is found within sedimentary fill of the Albuquerque Basin, extending from Cochiti Reservoir to just north of San Acacia. Despite spatial variability in aquifer properties and the existence of structural features such as faults that can influence the movement of ground water, data suggest that ground water within the basin is interconnected. Historically, ground water has constituted the water supply for municipal, industrial, and domestic use in this region, by the city of Albuquerque, Rio Rancho, the University of New Mexico, Kirtland Airforce Base, two local power plants, and others. Pumping in the Albuquerque area has created a large cone of depression underlying the city, with historic water level declines exceeding 100 feet.

To date, all significant sources of ground water in the Albuquerque area have been found to be stream connected; that is, water pumped from the aquifer reduces river flows. Because the depletion of water from the Rio Grande is limited by the Rio Grande Compact, the state engineer has required, since 1956, offsets to calculated stream depletions that result from ground water pumping. Due to the delayed impacts of pumping on the river, the offset requirement increases over time. If a ground water pumper has not secured sufficient offsetting water rights in a given year as required, their pumping may be curtailed. Given the scale of the Albuquerque Basin, impacts may be delayed substantially in time, and the payback under current administrative practice may be deferred to future generations. However, without sufficient offsets, lagged ground water pumping impacts from past and present pumping would make it difficult to comply with the Rio Grande Compact in the future. Thus, ground water is not a separate water supply, rather, it serves as a storage reservoir from which water can be borrowed with subsequent payback, i.e., offsets that must continue even beyond the cessation of pumping. Finally, overall pumping must be limited to an amount that can, as a practical matter, be offset with water rights available to the region.

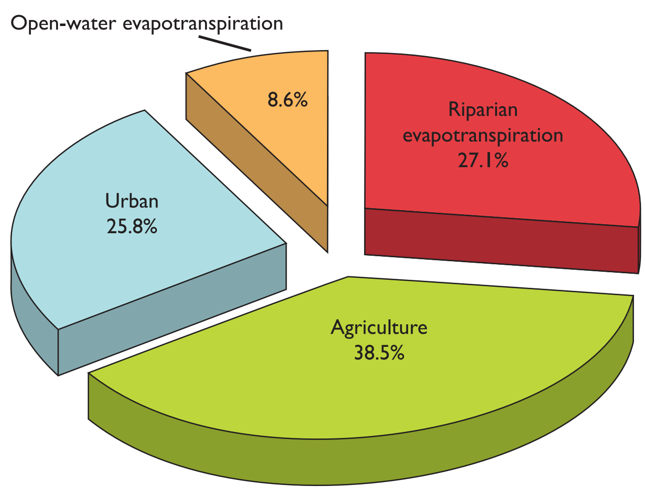
A devil's advocate might point out that the administration of ground water as a large, stream-connected, regulating reservoir (alternately drawn down and replenished), as opposed to a stock suitable for long-term mining, can be discarded if policy makers decide that the Rio Grande can be allowed to cease functioning as a river and allowed, instead, to function as a pipeline. This pipeline "river," disconnected from the aquifer, could conceivably be maintained by lining and/or replenishment via pumping, while the aquifer is mined. The downside of such a scheme, other than the improbable acceptance of the environmental consequences, is that, in the long-term, water production via ground water mining is unsustainable—a devil's policy?

Significant attention has developed recently over the potential for water supply augmentation via inter-basin transfers, or from deep saline aquifers, currently exempt from active management by the state engineer. Inter-basin transfers have been proposed that would import water from the Pecos River Basin, the San Agustin Plains, or the Estancia Basin into the Rio Grande Basin. These proposals are not only complex but controversial, and they raise significant concerns in the "move-from" basins, where the impacts of water withdrawal may spawn a new set of impacts. Transfers such as these do not provide a "quick and easy" solution to water limitations in the Albuquerque area. Water supply augmentation from deep saline aquifers is presently being evaluated for feasibility by developers and others in the Albuquerque region. However, an exemption from active state engineer administration does not entitle one to develop a water use that is detrimental to existing surface water rights or that impair existing rights to ground water. While there may be limited aquifers that prove to be hydrologically isolated from the declared basins, they will be costly to exploit and may not be sustainable over long time-frames. Although deep saline aquifers may augment some supplies locally, their proponents have not as yet provided data that would demonstrate their potential to significantly alter the water supply portfolio within the Albuquerque area.

WATER BUDGET: INFLOWS, OUTFLOWS, AND DEFICITS

The water budget provides a means of identifying whether a water surplus or deficit exists at a given point in time through comparison of the inflow of available water to a region with the outflow from that region. The outflow consists of water depletions (i.e., water consumptively used and not returned to the system) and water that flows out of the region at a point downstream. Because the water supply to the Albuquerque area is constrained by regional limits, i.e., those posed by the Rio Grande Compact and by the physical extent of the aquifer, it is difficult (if not impossible) to calculate a water budget specifically for the Albuquerque area. In reality, the water supply for the Albuquerque area is linked to that of all other users in the Middle Rio Grande region, and if water use increases in one area, an existing use in another area must decrease. However, relevant information regarding the water supply available to the Albuquerque area can be gleaned from examination of the larger regional water budget.

A detailed water budget was prepared for the Middle Rio Grande region, between Cochiti and Elephant Butte Reservoirs, by S. S. Papadopulos & Associates, Inc. in 2004 (*Middle Rio Grande Water Supply Study, Phase 3*). In this study water supply and demand was characterized in specific sub-regions or "sections" of the Middle Rio Grande. The northernmost sub-region, from Cochiti Reservoir to the Valencia/Socorro County line, contained the urban areas of Albuquerque, Los Lunas, and Belen, in addition to several pueblos and rural areas. Water depletion (based on population and land use as of about 2,000) is estimated within this region to be about 328,000 acre-feet per year; which is about 57 percent of all water depleted within the Middle Rio Grande for all uses (excluding the evaporation of water from Cochiti and Elephant Butte Reservoirs). The water uses in this sub-region are attributed to various water use sectors as shown in the pie chart. The urban water use percentage includes all urban uses in the Albuquerque Basin, as quantified in a U.S. Geological Survey study of the Albuquerque Basin, reduced by the quantity of wastewater returned to the river. These depletions can also be apportioned into those that impact surface water directly, about 78 percent, and those that are drawing down aquifer storage but not yet impacting surface water, about 22 percent. It should be noted, the chart is derived from data before implementation of the Albuquerque Drinking Water Project. However, this project will have no impact on the amount of urban water depletion, rather, the project changes the location and method of diversion and the location and timing of impacts to the river.



Consumptive water use in the northernmost sub-region of the Middle Rio Grande, from Cochiti Reservoir to the Valencia/Socorro County line.

The water demand, in terms of water depletion as described above, varies somewhat from year to year based on climatic conditions, as does the water supply. However, because the overall supply in the Middle Rio Grande basin is fixed, being limited by the Rio Grande Compact, the average water demand must remain, on average, constant, to avoid a deficit. Therefore, as demand in one sector increases, in theory, the water use in other sectors must diminish. For example, irrigation water rights may be retired to offset lagged impacts of pumping for municipal use, resulting in a transfer of water depletion from the agricultural to municipal sector. When such a process does not occur, the water budget becomes unbalanced, leading potentially to a compact deficit or to a future debt in the form of delayed stream impacts from ground water pumping.

Significant analysis has been conducted by regional planners and in the aforementioned *Middle Rio Grande Water Supply Study* to identify whether or not a balance between regional supply and demand exists, or whether a deficit is occurring. The *Middle Rio Grande Water Supply Study* concluded that for the Middle Rio Grande basin as a whole, available water supply appeared to fall below present levels of water use. Despite this imbalance, compact compliance has been supported by a combination of favorable operational factors and management actions. However, compliance with the compact will be more difficult in the future as the lagged impacts of past and present pumping more fully affect the river, and as adequate offsets become more difficult to acquire.

The ABCWUA addresses the issue of growth with the Albuquerque Drinking Water Project. By using San Juan–Chama Project surface water, ground water pumping can be reduced. Water currently held in reservoir storage, existing water rights, and the payback of water previously leased by entities including the MRGCD and the U.S. Bureau of Reclamation will be used to maintain a balance, providing necessary offsets for a period of many decades. However, given the singular nature of the water supply in the Middle Rio Grande region, this approach will impact other water use sectors, as the leased water is paid back and as beneficiaries of previously unused ABCWUA water must accommodate their needs elsewhere. Furthermore, the ABCWUA solution will not sustain indefinite growth. In some period of time, variously projected to occur between 2040 and 2080 depending on assumptions regarding the future pumping schedule, the ABCWUA pumping impacts on the river will again return to levels presently occurring and will continue to increase into the future.

THE WATER DEFICIT IN THE ALBUQUERQUE AREA: WHAT'S THE PROBLEM?

One need only observe the historic ground water declines evidenced in the cone of depression underlying the city of Albuquerque to understand that the Albuquerque area is experiencing a water budget deficit. The region has supported growth through extensive ground water pumping that will require future payback to avoid impacts to the river. On the other hand, the ABCWUA has also stored San Juan–

Chama water in Abiquiu Reservoir and has contracted San Juan–Chama water to other parties, with an expectation of future payback. While the ABCWUA accounts may balance, and a mechanism has been identified for maintaining balance for several future decades, this balance will be maintained in part by a shift in water use among water use sectors. For other urban users in the Albuquerque area, compliance with the state engineer's offset requirements has resulted in the transfer from agricultural to urban uses, and future water development will require further agricultural to urban transfers.

The water supply in the Albuquerque region is limited; therefore, urban growth will affect the distribution of water among sectors on the water depletion pie chart. Some argue for conservation and techniques such as gray-water use and rainfall harvesting to stretch the available water supply. However, many of these techniques will have little impact on the bottom line. Presently, return flows comprise part of the downstream delivery obligation under the Rio Grande Compact. Little benefit will accrue to the regional water supply unless conservation activities diminish actual water depletion; that is, activities that diminish return flows or natural runoff to the river do not provide a net increase in water supply at the regional level.

Considering the characteristics of the water supply, and the scant opportunity for meaningful augmentation, the Albuquerque area is faced with the prospect of learning to "live within its means." In other words, the available water supply for the region appears, at best, barely sufficient to support existing demands. Increases in water demand in one sector will draw from the water supply of another sector, or another region of the Middle Rio Grande. As urban water demand increases, agricultural and/or riparian water demands must decrease if a balance is to be maintained. To the extent that existing or future water policy supports the shift in water use among sectors, it is the hydrologic landscape that will change most dramatically. Shifting water away from riparian water uses along the river corridor would change the character of the river, reduce habitat, and render difficult the current efforts to collaborate in supporting endangered species and the riparian environment. Shifting water away from agricultural uses will impact the character of the Rio Grande valley and agricultural traditions. With urban growth, the ways in which water is distributed and the places in which water is used will change. Ultimately, it may be a landscape crisis, not a water crisis, that the region faces.

The Impact of the City of Albuquerque's San Juan–Chama Drinking Water Project on New Mexico's Rio Grande Compact Obligations

Kevin G. Flanigan and Amy I. Haas, *New Mexico Interstate Stream Commission*

After years of leasing its allocation of San Juan–Chama Project water, the City of Albuquerque (referring here to both the City of Albuquerque and the Albuquerque Bernalillo County Water Utility Authority, a joint agency of the City of Albuquerque and the County of Bernalillo that administers the water and wastewater utility for Albuquerque and Bernalillo County) soon will implement its Drinking Water Project to satisfy most of its current water demand. In late 2008 the city began to use its annual allocation of 48,200 acre-feet per year of San Juan–Chama water by direct diversion from the Rio Grande, with full consumption of that allocation anticipated by 2010.

Historically, the city has relied solely on ground water for its municipal supply. However, the discovery that the capacity of the aquifer underlying the Albuquerque metropolitan region had been exaggerated over the years, combined with the city's booming population, prompted city officials to reassess the long-term sustainability of the aquifer and Albuquerque's exclusive reliance on it. Transitioning to surface water is intended to provide the city with an adequate municipal supply while preserving the aquifer by reducing ground water use.

Consumption by the city of its entire allocation of San Juan–Chama water has been criticized as necessarily jeopardizing New Mexico's ability to meet its delivery requirements to the state of Texas under the Rio Grande Compact, which the state has historically struggled to satisfy. This criticism stems from the perception that the city's use of its San Juan–Chama water will increase the total amount of depletions in the Middle Rio Grande basin and that the city's ground water pumping impacts on the river will not be fully offset.

THE SAN JUAN–CHAMA PROJECT

The San Juan–Chama Project is a trans-basin diversion project operated by the U.S. Bureau of Reclamation in Colorado and New Mexico for the purpose of furnishing a supplemental supply of water to New Mexico's portion of the Rio Grande basin. Water is diverted from three tributaries of the San Juan River arising in the San Juan Mountains of southwest Colorado and delivered to the upper portion of the Rio Chama in New Mexico for storage and later delivery to the various project contractors upon their call for the water.

Deliveries of San Juan–Chama water to New Mexico began in 1971 and have averaged about 91,300 acre-feet per year through 2006. The firm yield of the project, which is the amount of water that can be reliably delivered on an annual basis, is 96,200 acre-feet per year. The City of Albuquerque receives 48,200 acre-feet per year of San Juan–Chama water, slightly more than half of the firm yield of the project.

All San Juan–Chama water is accounted for from its point of delivery into the Rio Grande basin to the point at which it is considered fully consumed. The accounting includes the amount of San Juan–Chama water diverted into the basin, its delivery into Heron Reservoir, its subsequent release to the various contractors, and its interim storage before its final consumption.

LEGAL AUTHORITIES GOVERNING THE SAN JUAN–CHAMA PROJECT

The enactment of two interstate river compacts, the Colorado River Compact and the Upper Colorado River Basin Compact, provided the basis for the San Juan–Chama Project. The Colorado River Compact was signed in 1922. This compact divided the Colorado River basin in two and apportioned the use of the waters of the Colorado River system to the upper and lower basins. Parts of New Mexico, Arizona, Colorado, Utah, and Wyoming constitute the upper basin. The Colorado River Compact provided for the apportionment of 7,500,000 acre-feet of water per year from the Colorado River system to the upper basin states in perpetuity.

The Upper Colorado River Basin Compact was signed by the upper basin states in 1948. Under this compact, the state of New Mexico receives 11.25 percent of the consumptive use of 7,500,000 acre-feet per year after the deduction of 50,000 acre-feet per year consumptive use by Arizona. Congress passed the San Juan–Chama Project Act in 1963, which authorized the initial phase of the project for irrigation purposes and for municipal, domestic, and industrial uses, and providing recreation and fish and wildlife benefits. New Mexico's San Juan–Chama water is a portion of the water allocated to it by the Upper Colorado River Basin Compact.

The Rio Grande Compact was signed by Colorado, New Mexico, and Texas on March 18, 1938. The Rio Grande Compact requires the upstream states of Colorado and New Mexico to deliver a specified percentage of flow in the Rio Grande to the next downstream state. These percentages are based on specified gaging stations and index schedules. The percentage New Mexico must deliver to Texas is based on the amount of annual runoff in the Rio Grande as measured at the Otowi gage on the Rio Grande in north-central New Mexico. Adjustments to the gaged flow at Otowi are made to account for storage in upstream reservoirs and water diverted from the Colorado River basin into the Rio Grande basin by the project. Article X of the Rio Grande Compact exempts San Juan–Chama water from New Mexico's delivery requirements.

ALBUQUERQUE'S DRINKING WATER PROJECT

Evaluation and planning for the city's Drinking Water Project commenced in 1997. This project will allow the city to transition from exclusive use of ground water to San Juan–Chama water as its primary water supply source. However, although the city will rely on surface water to satisfy most of its municipal needs, it will not cease ground water pumping entirely. Rather, it will reserve ground water supplies for times of surface water shortages (drought) and for future use when growth in annual demand exceeds surface water supplies. Additionally, the city will need to seasonally supplement its San Juan–Chama water supply with ground water when surface flows are insufficient to meet demand.

New Mexico State Engineer Permit 4830

The city filed Application Number 4830 with the state engineer in 2001 for a permit to divert surface water from the Rio Grande for municipal, industrial, and related purposes for its Drinking Water Project. In its application, the city proposed to divert approximately 94,000 acre-feet per year on average, with peak diversions of as much as 103,000 acre-feet per year, "generally comprised of 50 percent San Juan–Chama Project water, which will be fully consumed within the city's water service area, and 50 percent "native" Rio Grande water, which will be returned to the Rio Grande" as treated effluent via the city's wastewater treatment plant.

The state engineer ultimately granted the application and issued the city a permit to divert as much as 48,200 acre-feet per year of San Juan–Chama water, subject to multiple conditions of approval. The permit requires the city to reduce its diversion of San Juan–Chama water to account for conveyance losses and does not allow the city to consume any of the native Rio Grande water it diverts or to receive any return flow credits for the native Rio Grande water it returns to the Rio Grande. Furthermore, the state engineer limited the city's total annual combined diversion of surface water (San Juan–Chama and native Rio Grande water) under the permit to 96,400 acre-feet per year less conveyance loss. Moreover, prior to initial diversion, the state engineer required the city to demonstrate that it has 130,000 acre-feet of San Juan–Chama water in storage in Abiquiu Reservoir reserved for offsetting residual stream depletion effects to the Rio Grande as a result of its ongoing ground water diversions. In addition, the state engineer capped the city's total daily diversion rate at 130 cubic feet per second (cfs) and the amount of native Rio Grande surface water diverted under the permit to 50 percent of the total amount diverted at any time. Finally, the city must curtail its diversion of native Rio Grande water when the native flow is less than 195 cfs as measured at a point immediately upstream from the proposed point of diversion.

The San Juan–Chama Drinking Water Project

Construction of the surface diversion works and water treatment facilities for the Drinking Water Project began in 2004. The diversion works consist of an adjustable height bladder dam approximately 600 feet in length across the river. A fish passage canal provides means for fish to move around the dam and screens prevent fish from entering the water system intakes. Water impounded by the diversion dam will flow into an intake structure and pump station located adjacent to the dam. The pump station will pump the untreated river water via pipeline to a water treatment plant where it will be purified to potable standards. Return flow to the river will be routed through the city's wastewater treatment plant located on the south side of the city.

While the Drinking Water Project is operating, the city intends to release its San Juan–Chama water from reservoir storage at a uniform rate and in an amount sufficient to meet ongoing demand. During times of low natural flow in the river, the city plans to completely cease surface diversions and satisfy its entire demand with ground water.

IMPACTS OF ALBUQUERQUE'S DRINKING WATER PROJECT

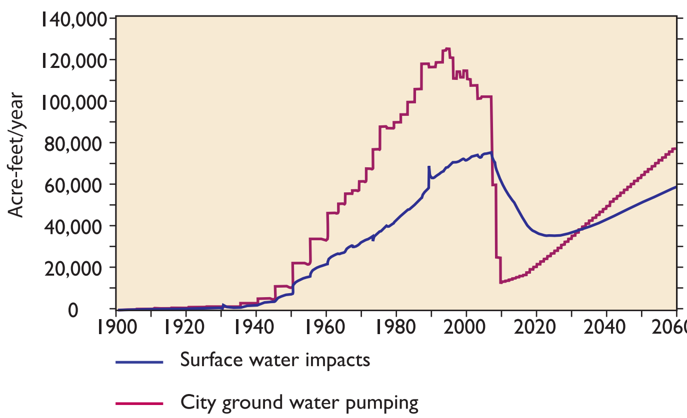
Water Budget Impacts of the City's Drinking Water Project

Except for a relatively small amount of water used for turf and landscape irrigation, the city has yet to apply any of its San Juan–Chama water to direct beneficial use. Instead, the city has leased or otherwise contracted the water to third parties. From 1971 through 2007 the city received about 1,400,000 acre-feet of San Juan–Chama water. The city provided most of that water to the Middle Rio Grande Conservancy District, the New Mexico Interstate Stream Commission, the Bureau of Reclamation, and other parties because it had no direct need for it at that time. A significant amount was also lost to reservoir evaporation. More than 10 percent (168,000 acre-feet) remained in storage in Abiquiu Reservoir at the end of 2007. Several of the city's agreements with the Middle Rio Grande Conservancy District and the Bureau of Reclamation require payback of water (totaling 108,000 acre-feet at the end of 2007) to the city.

All third party use of the city's San Juan–Chama water essentially stopped in 2003, except for those related to various ongoing agreements for minor amounts of water, a loan to the Middle Rio Grande Conservancy District and a contract with the Bureau of Reclamation. The city's San Juan–Chama water that had been historically provided to various Middle Rio Grande water users constituted a small portion of the entire supply available to the Middle Rio Grande valley, and did not result in a significant increase in depletions in the Middle Rio Grande Basin.

Historical Stream Depletions

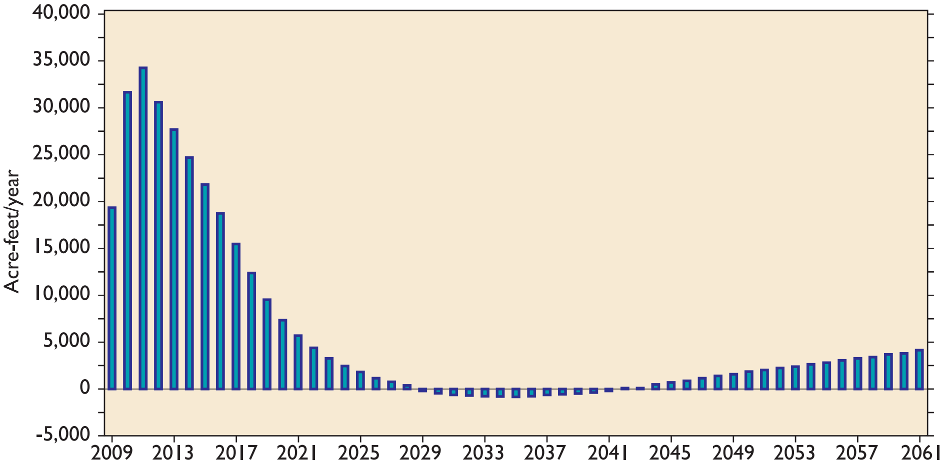
The city will continue to rely wholly on ground water for its municipal water supply until Drinking Water Project operations begin. The state engineer requires the city to offset all of the stream depletions that result from its ground water pumping. As of the end of 2006 stream depletion impacts on the Rio Grande calculated by the state engineer's Middle Rio Grande Administrative Groundwater Model were occurring at a rate of approximately 74,900 acre-feet per year. The city has four types of offset rights available to it: pre-basin vested ground water rights, transferred pre-1907 surface water rights, surface water return flows, and its San Juan–Chama water. On average, the annual amount of return flow has been approximately 50 percent of withdrawals since 1960. To date, the sum of the city's pre-basin vested rights, its transferred pre-1907 surface water rights, and its return flow credits has exceeded its stream depletion impacts, and it has not had to use San Juan–Chama water for offset purposes.



Stream depletions that will result from historical and projected future ground water pumping by the City of Albuquerque, quantified using the state engineer's Middle Rio Grande Administrative Groundwater Model. Under this scenario, stream depletions will decline rapidly upon startup of the Drinking Water Project and then begin to increase as the city's future ground water pumping increases. It also assumes that the city's annual allocation of San Juan–Chama water will not be available for offset, since that water will be fully consumed by the Drinking Water Project. Future pumping schedule based on personal communication with Andrew Lieuwen, Albuquerque Bernalillo County Water Utility Authority, 2007.

Historical pumping data from the Office of the State Engineer indicate that the city's ground water pumping peaked in 1994 and 1995 when the city withdrew about 125,000 acre-feet of ground water each year. Since that time, annual withdrawals have declined due to conservation efforts. In 2007 the city pumped about 100,000 acre-feet to meet its demand.

A comparison of the historical amount of surface return flows to stream depletions indicates that stream depletion impacts have consistently exceeded surface return flows, requiring the city to use a portion of its pre-basin rights and transferred pre-1907 rights to offset depletions. The only exception occurred between 1973 and 1979, when the city's surface return flows



The difference between modeled future stream depletions and water rights and return flow offsets. Three years after the startup of the Drinking Water Project, the amount of stream depletion impacts not offset by vested or acquired pre-1907 surface water rights or by return flows will reach a maximum of about 34,000 acre-feet per year. The impacts not offset by water rights or return flows will then slowly abate with time until approximately 20 years after startup. At that time, the city's vested or acquired pre-1907 surface water rights, in combination with its return flows, will be greater than projected impacts to the river. The city then will have sufficient offsets from vested or acquired pre-1907 surface water rights or from return flows for approximately 15 years before having to acquire additional rights to offset depletions to the river. The total volume of impacts requiring offset for the period from 2009 through 2029 is roughly equal to the amount of the city's San Juan–Chama water stored in Abiquiu Reservoir for offset purposes plus the water owed to the city by the Middle Rio Grande Conservancy District and the Bureau of Reclamation.

exceeded stream depletions on the Rio Grande in amounts ranging from 2,000 to 7,000 acre-feet per year, effectively augmenting flows in the river for that period.

Future Stream Depletions Compared with Available Offsets

The stream depletions that will result from historical and projected future ground water pumping by the city, quantified using the state engineer's Middle Rio Grande Administrative Groundwater Model, are shown in the figure on the previous page. Under this scenario, stream depletions will decline rapidly upon startup of the Drinking Water Project and then begin to increase as the city's future ground water pumping increases. It also assumes that the city's annual allocation of San Juan–Chama water will not be available for offset, since that water will be diverted and fully consumed by the Drinking Water Project. Surface return flows will consist of a combination of diverted Rio Grande native surface water and ground water, although the city will not receive return flow credit for the portion of its surface return flows consisting of native Rio Grande surface water.

The figure above shows the difference between modeled future stream depletions and available offsets, not including the 170,000 acre-feet of San Juan–Chama water stored by the city in Abiquiu Reservoir. It indicates that, three years after the startup of the Drinking Water Project, the amount of stream depletion impacts not offset by vested or acquired pre-1907 surface water rights or by return flows will reach a maximum of about 34,000 acre-feet per year. The amount of impacts not offset by water rights or return flows will then slowly abate with time until approximately 20 years after startup of Drinking Water Project operations. At that time, the city's vested or acquired pre-1907 surface water rights, in combination with its return flows, will be greater than projected impacts to the river. The city then will have sufficient offsets from vested or acquired pre-1907 surface water rights or from return flows for approximately 15 years before having to acquire additional rights to offset depletions to the river.

The amount of surface water impacts requiring offset during the first 20 years of the Drinking Water Project by means other than vested or retired pre-1907 surface water rights and return flow totals approximately 270,000 acre-feet. That amount is roughly equivalent to both the current amount of San Juan–Chama storage available to the city in Abiquiu Reservoir (168,000 acre-feet as of the end of 2007) and the 108,000 acre-feet of San Juan–Chama water owed to the city by the Middle Rio Grande Conservancy District and the Bureau of Reclamation. With proper management the city will have ample offsets for approximately 40 years after startup of the Drinking Water Project, provided the paybacks occur in a timely fashion.

CONCLUSIONS

In many ways, Permit 4830 represents a turning point in New Mexico's administration of the waters of the Rio Grande basin. The city's Drinking Water Project is the first major surface water diversion project for municipal and industrial purposes within the Rio Grande basin in New Mexico. It has the potential to have a significant impact on New Mexico's compliance with the Rio Grande Compact and other senior water rights in the basin. However, review of the conditions of approval of Permit 4830 indicates that it was intended to be managed by the state engineer in conjunction with the city's existing permits (Permits RG-960 and 4819) to ensure that there are no negative impacts on New Mexico's Rio Grande Compact deliveries or to downstream senior water rights. These conditions are intended to guarantee that all current and future stream depletion impacts resulting from the city's ground water pumping will be fully offset, and that the amount of water consumed by the Drinking Water Project will not exceed the amount of San Juan–Chama water that actually arrives at the point of diversion.

The city's permit contains several conditions that ensure compliance. The permit does not allow the city to consume native Rio Grande water, and the city must fully offset all residual and future stream depletion impacts to the Rio Grande resulting from its historical ground water pumping pursuant to the city's state engineer ground water permit.

Moreover, the city will have sufficient offsets for future stream depletion impacts resulting from its projected ground water pumping through the year 2060, assuming it receives timely payback of approximately 108,000 acre-feet of water owed to it and is able to manage its water supply operations to maximize return flow credits. The city may be required to limit its demand if it does not receive the water owed to it or if it fails to maximize return flow credits.

Assuming both full compliance by the city with its permit conditions and proactive management of the permit by the state engineer, the Drinking Water Project will not result in increased depletions in the Middle Rio Grande, will not jeopardize New Mexico's Rio Grande Compact obligations, and will not adversely impact the regional water budget.

The full text of this article was published originally in the Natural Resources Journal (Spring 2008, Vol. 48, No. 2), by the University of New Mexico School of Law.

The authors acknowledge that other variables may impact San Juan–Chama water supply and demand, including impacts from climate change, sustained drought and unprojected growth in the Albuquerque metropolitan area. Although these factors ultimately may bear on the analysis and conclusions herein, they are beyond the scope of this discussion.

The views of the authors do not necessarily represent those of the New Mexico Interstate Stream Commission.

Water Quality in the Albuquerque Area

Marcy Leavitt, *New Mexico Environment Department*

The New Mexico Environment Department implements surface water quality surveillance programs to document ambient water quality conditions and to identify impairments in New Mexico's surface waters. A similar surveillance program does not exist for ground water quality. Ground water quality is evaluated through monitoring at sites regulated by the agency (sites where discharge permits have been issued or releases have occurred) and in response to suspected contamination events on an "on demand" basis. This paper summarizes several recent water quality projects that have been undertaken in the Albuquerque area, including surface water quality studies along the Middle Rio Grande and select ground water contamination remediation projects.

SURFACE WATER QUALITY ON THE MIDDLE RIO GRANDE

The Environment Department investigated surface water quality in the Middle Rio Grande from October 2005 through September 2007. The investigation included quarterly sampling of water, sediment, and fish tissue at ten stations covering a 180-mile stretch of the Rio Grande from Bosque del Apache downstream of San Antonio north to the Angostura Diversion Dam upstream of Bernalillo. This investigation included the entire stretch of the Rio Grande that runs through the Albuquerque area (from the Alameda bridge to the northern boundary of Isleta Pueblo).

The Environment Department evaluated data collected during the investigation (along with other data collected from 2000 through 2007 from the U.S. Geological Survey, the Environment Department, and others) against New Mexico surface water quality standards to identify exceedences of surface water quality criteria. These data included aluminum, copper, selenium, ammonia, *E. coli*, radiologicals, nitrate, temperature, dissolved oxygen, and pH. Additional analyses conducted for sediment chemistry, fish tissue contaminant concentrations, and sediment toxicity data were not used for comparison to water quality standards, but provided additional information of potential chemical stressors in the Middle Rio Grande that may affect the fish community. In the Albuquerque area, the only water quality impairments identified were those for dissolved oxygen and bacteria (*E. coli*).

Dissolved oxygen concentrations were found to be below acceptable levels near Alameda bridge, the I–25 bridge, and the Rio Bravo bridge. Aquatic life (fish and other organisms) need adequate levels of dissolved oxygen in the water column. Low dissolved oxygen levels for extended periods of time may cause impacts on the aquatic life. The magnitude and duration of low dissolved oxygen readings at these three stations are severe enough to warrant further investigation. Cooperation by a variety of stakeholders will be needed to identify the possible causes of the low dissolved oxygen levels.

Identifying the source or sources of bacteria in surface water is a complicated task. In 2005 a microbial source tracking study was conducted in the Albuquerque area to assist in developing management strategies for nonpoint sources of surface water contamination. The microbial source tracking study area spanned the Rio Grande segment from the Isleta diversion dam at the northern border of Isleta Pueblo to the Angostura diversion dam. The microbial source tracking study concluded that the top bacteria contributors are fecal matter from wildlife (primarily birds), at 46 percent, and pets (primarily dogs), at 24 percent. These two groups account for 70 percent of the bacteria detected in water samples. Humans and livestock contributed the remaining 16 and 14 percent, respectively. Although there is little that can be done about the contribution of bacteria by birds, there are some initiatives that might reduce concentrations. Both the city of Albuquerque and Bernalillo County have ordinances limiting the number of dogs at a residence. These agencies are also implementing public information campaigns aimed at creating a significant behavior change by pet owners to regularly pick up after their dogs on both public and private property.

Bacteria contributions from humans can also be reduced through reduction of sewer system overflows and leaks, compliance with wastewater treatment permit limits, and identifying and repairing failing septic systems. Sewer system overflows are caused by pipeline blockage and/or lack of adequate pipeline capacity. A wastewater conveyance system capacity management and operations and maintenance program was implemented by the city of Albuquerque in the 1990s, which significantly reduced sewer system overflows.

Permitted "concentrated animal feeding operations," such as dairies, are required to capture manure and water in contact with the manure. Three medium-sized dairies are located in the Isleta Drain watershed. The bovine bacteria contribution detected at the Isleta Drain sampling station was much less than the average bovine contribution at all the sampling stations. Therefore, concentrated animal feeding operations may not be the major source of bovine bacteria. Some residential areas do have significant livestock populations, predominantly horses and cattle.

GROUND WATER CONTAMINATION REMEDIATION PROJECTS

Sites that are addressed by the Ground Water Quality Bureau remediation programs are identified in a variety of ways. Many are self-reported when a release has occurred or is discovered. Others are identified through monitoring conducted by other department programs. For example, contaminants may be detected during routine compliance monitoring of public supply wells that is required by the Safe Drinking Water Act and the New Mexico Drinking Water regulations, or contaminants such as chlorinated solvents may be detected in samples collected in monitoring wells that were installed as part of a leaking underground petroleum storage tank investigation. In addition, the department periodically conducts water fairs in communities across the state to assess ground water quality and provide private well owners the opportunity to have their private well water analyzed for a select list of analytes. In some cases members of the public or community representatives report complaints or request the department's assistance with addressing environmental issues in their communities. Most sites are addressed by the state remediation programs, but in some cases they are nominated to the federal National Priorities List (Superfund) sites. There are three Superfund sites in Albuquerque, New Mexico:

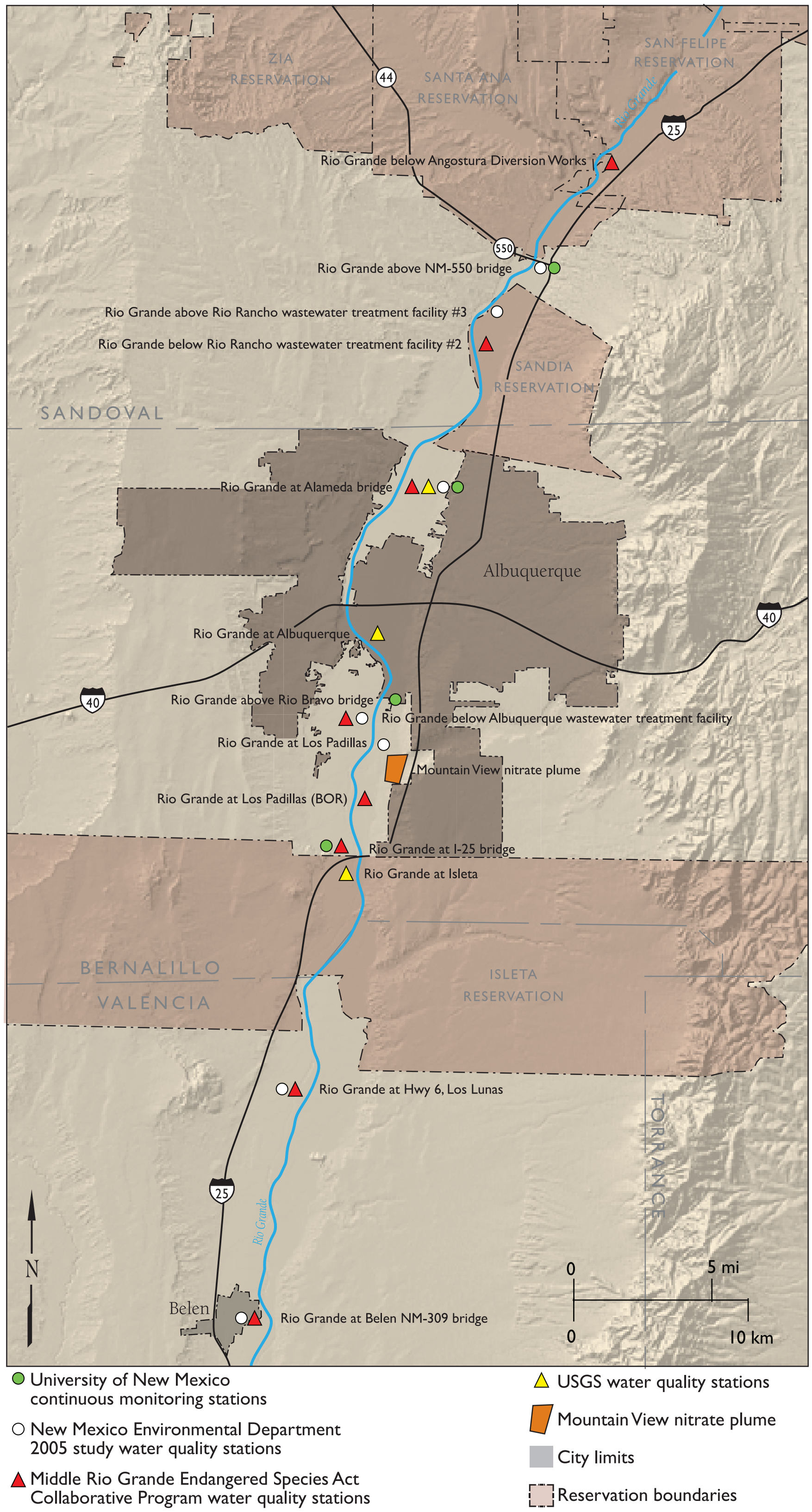
South Valley Superfund Site

In 1980 two wells in the San Jose well field (SJ #3 and SJ #6) of the Albuquerque water system were taken out of service due to contamination from chlorinated solvents. In 1981 the Environmental Protection Agency (EPA) and the Environment Department designated a one-square-mile area around municipal well SJ #6 as a Superfund site. The South Valley Superfund Site was added to the National Priorities List in 1983. Investigations identified contamination from chlorinated solvents in both soil and ground water. The primary responsible parties are the Air Force Plant 83/General Electric (GE) and Van Waters & Rogers (Univar).

At Univar, shallow aquifer remediation includes a ground water extraction and treatment system, operational since 1992. Univar also implemented a soil vapor extraction system operational from 1998 through 2006. By agreement with EPA and the Environment Department, the ground water and soil vapor systems have been idle since 2007. Ground water monitoring continues at Univar. At GE, remediation has included soil removal in the residential district to the north, a shallow aquifer ground water extraction and treatment system, and a deep aquifer ground water extraction and treatment system. The shallow aquifer system has been operational since 1994 and the deep aquifer system since 1996. By agreement with EPA and the Environment Department, the northern half of the shallow aquifer system has been idle since May of 2008 with continued ground water monitoring. The deep aquifer system continues to operate with continued ground water monitoring.

The ground water extraction and treatment systems have proven to be effective in reducing the vertical and horizontal extent of contamination. More than 3,400 pounds of contaminants have been removed by the various remediation systems operating at the site. More than 5.1 billion gallons of ground water have been treated to date. Most of this ground water has been injected back into the aquifer for future use. The ongoing remedial actions continue to contain, capture, and reduce the concentrations of contaminants within the ground water.

An issue of concern at the South Valley Superfund Site is 1,4-Dioxane, which has been detected in ground water associated with the Univar site. 1,4-Dioxane is a synthetic industrial chemical used as a solvent. EPA has identified 1,4-Dioxane as a probable human carcinogen. Acute and chronic exposure to 1,4-Dioxane can affect liver and kidney function in humans. It is unknown whether children differ from adults in their susceptibility to the effects of 1,4-Dioxane or whether it can cause birth defects. Neither EPA nor the Environment Department currently have standards for 1,4-Dioxane. However, several states have recently established a standard for 1,4-Dioxane, and EPA has published an emerging contaminant fact sheet for 1,4-Dioxane that states its environmental and human health concerns. Univar will continue to monitor 1,4-Dioxane concentrations; however, the current ground water remediation system does not address 1,4-Dioxane concentrations.



Water quality monitoring stations on the Rio Grande, from north of the Angostura diversion works to the city of Belen. All monitoring stations shown are on the river.

AT&SF Albuquerque Superfund Site

The Atchison, Topeka, and Santa Fe Railway Company (AT&SF) Albuquerque Superfund Site is located at 3300 Second Street SW, within the South Valley area of Albuquerque. AT&SF treated wood for railroad ties between 1908 and 1972 at this site. EPA listed the site on the Superfund National Priorities List on December 16, 1994, and issued a Record of Decision in June 2002. The primary responsible party is Burlington Northern and Santa Fe (BNSF).

Site-related soil contaminants are benzo(a)pyrene equivalent and zinc. Highly contaminated soils and process residues were removed from the site under an EPA Unilateral Order for a Removal Response Action in 1999. Site-related ground water contaminants include dense non-aqueous phase liquid (DNAPL), and dissolved phase semi-volatile organics derived from creosote.

Several cleanup and removal actions were completed from 1990 through 2000. These actions eliminated unacceptable health risks associated with soil, sludge, and waste. These actions resulted in the removal and disposal of 8,250 tons of creosote-tainted debris; excavation and disposal of approximately 45,000 square feet of wastewater reservoir soils excavated to a depth of 2 to 5 feet; and excavation and disposal of approximately 6,012 tons of sludge and process residue from the wastewater reservoir. In 1999 three recovery trenches were installed to collect DNAPL through a gravity feed system. In 2000 five recovery pumps were installed to extract DNAPL from the shallow and intermediate aquifer zones, which collectively extend to nearly 80 feet below ground surface.

Site soil remediation and ground water treatment facility construction is projected to be complete by the end of 2009. The ground water remedy will include DNAPL recovery and recovery of ground water impacted by dissolved-phase contaminants, followed by treatment and subsequent re-injection of clean water. Contaminated soils that exceed EPA-established soil remediation goals to a depth of 3 feet below ground surface will be removed. Soils that contain DNAPLs will be moved to an approved off-site disposal facility, and the remaining contaminated soil will be stabilized by mixing with bentonite, portland cement, and water and subsequently deposited in a capped on-site repository. Achievement of ground water cleanup standards is expected to take 20 years or more.

In 2008 twenty acres of the original twenty-eight-acre site was sold to GCC Premium Transloaders after existing site-related soil contamination was remediated. This property conveyance was accompanied by execution of an environmental protection easement and declaration of restrictive covenants.

Fruit Avenue Plume Superfund Site

The Fruit Avenue Plume Superfund Site is located within the city limits of Albuquerque. The site was identified when several wells in the Fruit Avenue area were determined to be contaminated with solvent-related constituents. The Coca Cola production well was removed from service in 1989 when trichloroethylene (TCE) levels exceeded the federal Safe Drinking Water Act maximum contaminant level of 5.0 micrograms per liter (µg/L). The Saint Joseph Hospital well was removed from service in December 1996 when TCE levels approached the maximum contaminant level. The city of Albuquerque municipal well Yale 1 exhibited trace levels of TCE and perchloroethylene in 1999. It has not been determined whether the contamination source of Yale 1 is from the Fruit Avenue site; however, Yale well 1 is located down gradient of the site. No viable parties were identified as responsible for the contamination, therefore the site is primarily funded by the federal Superfund. The state of New Mexico is responsible for 10 percent of the remedial action costs and will be responsible for 100 percent of the operation management costs after 10 years of ground water remediation system operation, projected to be in May 2016.

The site was listed on the National Priorities List on October 23, 1999. The source of release to the ground water is a defunct dry cleaner that operated from approximately 1940 to 1970. The estimated size of the plume is two-thirds of a mile long, 550–1,300 feet wide, and at least 544 feet deep.

A treatment system was constructed between August 2004 and September 2005. Routine operations of the system started on November 18, 2005. The remediation system is a pump and treat system and is composed of one ground water extraction well and two injection wells, and an air stripper treatment plant. The treatment system extracts ground water contaminated with chlorinated volatile organic compounds and treats the water in the air stripper and re-injects the treated water into the aquifer.

The remediation system was shut down on December 15, 2006, due to problems associated with microbially induced corrosion in the system piping and pumps. Additionally, there were problems with pH fluctuations. EPA modified the well vault piping with acid-resistant materials, redeveloped the injection and extraction wells, and replaced the extraction well pump to better control pH fluctuations.

As of June 27, 2008, approximately 97.4 million gallons of ground water had been pumped from the extraction well and treated by the air stripper, approximately 94.8 million gallons of treated water had been re-injected via the injection wells system, and approximately 1.9 million gallons of treated water had been discharged to the sanitary sewer. Approximately 6.11 kilograms of volatile organic compounds are estimated to have been removed from the ground water aquifer since the treatment system began operation. The remediation system is working effectively, and the size and concentration of the contaminant plume have decreased. Ongoing ground water monitoring of contaminant concentrations continues.

MOUNTAIN VIEW NITRATE GROUND WATER RESTORATION PROJECT

The Environment Department is working in collaboration with the Office of Natural Resources Trustee to address ground water contamination in the Mountain View neighborhood in the Albuquerque South Valley. Following World War II, a vegetable farm in Albuquerque's South Valley east of the Rio Grande and northeast of Broadway and Tijeras Arroyo over-fertilized the land, causing one of the largest known ground water nitrate-nitrogen (nitrate) plumes in New Mexico. The plume impacted a supply well for the Mountain View Elementary School in the 1960s and many domestic wells following that period. Current maximum concentrations of nitrate are in excess of 200 milligrams per liter (mg/L), which is twenty times the human health-based standard of 10 mg/L. In 1984 a Mountain View infant was hospitalized with methemoglobinemia (blue baby syndrome) after ingesting contaminated well water containing nitrate concentrations of approximately 500 mg/L. The City of Albuquerque provided water service in 1985 to the residential area hardest hit by the contamination through cooperation between the state, county, and city.

Since the discovery of the contamination, the direction of the ground water flow has changed from south-southwest to the east due to the influence of the city of Albuquerque's pumping of ground water for public water supplies. Depth to ground water is approximately 43 feet along 2nd Street and 125 feet near Broadway.

New Mexico Water Quality Control Commission regulations require that owners/operators and/or responsible persons assess and remediate soil and ground water contamination. In this case the owners of the farm are deceased, and the farm has been subdivided into multiple lots, so there is not a responsible party of whom to require assessment and remediation of the contamination.

In 2007 the New Mexico Office of the Natural Resources Trustee dedicated funds from settlement of a nearby ground water contamination case to the assessment and restoration of the Mountain View ground water nitrate plume. This restoration project will be performed in cooperation with the Environment Department through a Memorandum of Agreement. The project will be completed in two stages. The first stage includes an assessment of the residual contamination in the vadose zone of the former farm, an assessment of the current ground water plume, and an evaluation of restoration options. The second stage includes design and implementation of ground water restoration.

BROWNFIELDS SUCCESS IN ALBUQUERQUE

Brownfields are real property, the expansion, redevelopment, or re-use of which may be complicated by the presence of a hazardous substance or pollutant; the potential presence of hazardous substances, pollutants, contaminants, controlled substances, petroleum or petroleum products; or property that is mine-scarred. Cleaning up and reinvesting in these properties takes development pressures off undeveloped, open land and both improves and protects the environment.

The New Mexico Environment Department has collaborated with the city of Albuquerque and other Albuquerque-based entities on several projects through the Environment Department's Voluntary Remediation Program and supporting Targeted Brownfields Assessment services, Brownfields Cleanup Revolving Loan Fund. The department works with city planning departments, councils of government, and private and nonprofit developers, among others.

The Voluntary Remediation Program oversees cleanup of contaminated soils and ground water in accordance with the Voluntary Remediation Act. The act is designed to encourage and provide incentives for cleanup of sites that are not being cleaned up under existing regulatory/enforcement programs. The Voluntary Remediation Act allows participants and the state to work in a cooperative partnership to successfully remediate the site. Participants that successfully complete the program receive site closure documentation from the Environment Department and liability protection for lenders and future purchasers. When the voluntary remediation has been successfully completed, the participant is entitled to a Certificate of Completion or a Conditional Certificate of Completion. Prospective purchasers, new property owners, or operators who did not contribute to the contamination at the site can receive a Covenant Not to Sue from the Environment Department upon successful completion of a voluntary remediation project.

The Voluntary Remediation Program also provides Targeted Brownfields Assessment services to tribal or local governments and some nonprofit groups in order to facilitate returning underused properties to productive use. Targeted Brownfields Assessment services include site screenings, "all appropriate inquiry" (or ASTM Phase I environmental site assessment) activities, Phase II environmental site assessments, and remediation planning costs. The department also created a Brownfields Cleanup Revolving Loan Fund that provides low- or no-cost loans to municipalities, nonprofits, and private developers to support cleanup of contaminated sites where there is planned redevelopment. Examples of Brownfields sites in Albuquerque are provided below:

The old Albuquerque High School. This Brownfields redevelopment project was a catalyst for new buildings and businesses returning to downtown Albuquerque.

Old Albuquerque High School

One of the city's first Brownfields sites, addressed with an EPA Brownfields Pilot Grant, was the old Albuquerque High School property, a city landmark that sat vacant for more than twenty years. The city assessed the five buildings at the property using the pilot grant, and redeveloped one of the buildings into urban loft condos. Nearly all remaining buildings have been privately renovated, including the former library building, which is occupied with offices. The Brownfields redevelopment project was a catalyst for new buildings and businesses returning to the downtown neighborhood.

Ponderosa Products Site

The Ponderosa Products site, a former manufacturing facility owned by the Sawmill Community Land Trust, has been a key element in revitalizing the surrounding neighborhood. The property, a contaminated historic particle-board plant was redeveloped into a new, low-income housing community. The Environment Department provided incentives for cleanup including a Brownfields loan agreement for $225,000 to fund remediation of contaminated surface soil associated with an abandoned rail spur at the facility. The Sawmill Community Land Trust plans to expand residential development by constructing an artisan village on the site of the former manufacturing property, which has since been demolished. Property development plans include mixed-use space integrating housing, artist studios, retail, and dining venues.

Former Albuquerque Coronado Landfill Cell Americus-Mechenbier Site

Americus LLC plans to turn portions of a former city of Albuquerque landfill into 120,300 square feet of office and warehouse space. Five hundred thousand dollars will be borrowed from the Environment Department's Brownfields Cleanup Revolving Loan Fund Program to excavate buried solid waste material that has potential to contain hazardous waste. The developer's intent is to make former unusable property available to commercial companies who find it advantageous to locate in the north I–25 corridor. Plans also include widening Venice Avenue on the north side of the property and installing both wet (e.g., water and sewer) and dry (e.g., electric and telecommunications) utilities for the redevelopment project.

Bell Trading Post

The city of Albuquerque and the Family Housing Development Corporation partnered and recently redeveloped the Bell Trading Post, which was a former jewelry manufacturer, photography developer, and office space, into 15 loft units and two office suites. Nine of the residential units will be sold as affordable housing. The former facility was assessed for interior

The Bell Trading Post

asbestos, solvents in soil and ground water, and heavy metals in soil, which were later removed through the department's Targeted Brownfields Assessment Services. Asbestos-containing material, lead-based paint, and pigeon droppings found through out the building were removed with financing through the city of Albuquerque's Brownfields Cleanup Revolving Loan Fund.

Albuquerque Locomotive Shops

The city of Albuquerque recently purchased the former BNSF railyard facility from Old Locomotive Shops, LLC. The site was used by ATSF/BNSF as a maintenance yard between the 1880s and early 1990s but now sits mostly vacant. Many small and large structures supported various railroad maintenance activities on the 27-acre site. The three largest buildings have a combined floor area of 254,000 square feet. The Environment Department will be assisting the city with Targeted Brownfields Services by investigating soil and ground water at the northern section of the property, where redevelopment plans are currently prioritized. One building has been renovated and is being used by Amtrak as office space. The former railyard has also been used in movie productions, including *Beer Fest* and *Transformers*. The city will be using a portion of the site for low-income housing but is still considering uses for the remainder of the property.

The Downtown @ 700-2nd Project

The Supportive Housing Coalition of New Mexico is developing an $11 million, 72-unit demonstration workforce housing project in downtown Albuquerque that will integrate a diverse population of formerly homeless persons, persons with disabilities, retirees, and low-wage workers as well as market rate tenants in a mixed income, mixed use, and sustainable "green" environment. Located in downtown Albuquerque at the corner of Lomas and 2nd Street, Downtown @ 700-2nd will demonstrate how a public-private partnership can work to revitalize the city core. The city of Albuquerque made this existing parking lot land available and the project has broad community support, receiving endorsements from many business, community, and neighborhood groups. Downtown @ 700-2nd will conserve natural resources by incorporating innovative sustainable design features, including

The innovative Downtown @ 700-2nd project incorporates a number of sustainable design features, including solar collectors, rooftop water catchments, and domestic gray water recycling. It overlies the footprint of the Fruit Avenue Plume Superfund Site.

solar collectors for domestic hot water and space heating, wiring for future photovoltaic panels, domestic gray water recycling, and rooftop water catchment for landscape use. This site overlies the footprint of the Fruit Avenue Plume Superfund Site. The Environment Department provided Targeted Brownfields Services by funding an environmental assessment required for real estate transactions. Subsequently the Supportive Housing Coalition of New Mexico entered the Environment Department's Voluntary Remediation Program in order to take advantage of the benefits the program offers to prospective purchasers, new property owners, or operators who did not contribute to the contamination at the site.

Suggested Reading

Water Quality Monitoring of the Middle Rio Grande, Annual Baseline Condition and Trends of Key Water Quality Parameters, prepared by New Mexico Environment Department Surface Water Quality Bureau, July 2008.

Middle Rio Grande Microbial Source Tracking Assessment Report, Prepared for New Mexico Environment Department Albuquerque Metropolitan Arroyo Flood Control Authority Bernalillo County by Parsons Water & Infrastructure Inc., October 2005. Available at: www.nmenv.state.nm.us/swqb/RioGrande/Middle/MST/index.html

Deep Nonpotable Aquifers: The Exceptions to the Rules

Michael S. Johnson, Peggy Barroll, and Douglas H. Rappuhn, *Office of the State Engineer*

As much as one billion acre-feet of brackish, or nonpotable, ground water may exist in New Mexico aquifers. This ground water has long been recognized as an important potential resource, and although little used to date, this resource has recently received increased attention. In the last few years, several entities have expressed their intent to pump large amounts of nonpotable ground water from deep aquifers west of Albuquerque to provide water for urban growth in the region.

The recent notices of intent are among the first to propose diverting nonpotable water from deep aquifers for municipal supply and other long-term uses. If realized, the proposed appropriations would greatly increase the short-term water supply to the Albuquerque region. It is not yet known, however, how much pumping is sustainable from these deep aquifers or what long-term hydrologic impacts could result to shallow aquifers, other ground water users, and the flows of the Rio Grande.

Although the state engineer maintains general statutory jurisdiction over the appropriation and use of ground water in New Mexico, there is an exception in state law that limits the state engineer's jurisdiction over certain aquifers. This paper describes this statutory exception, outlines procedural differences between the appropriation of ground water by traditional means and under the exception, notes pertinent trends, and discusses some of the issues related to this exception to state ground water administration.

BACKGROUND

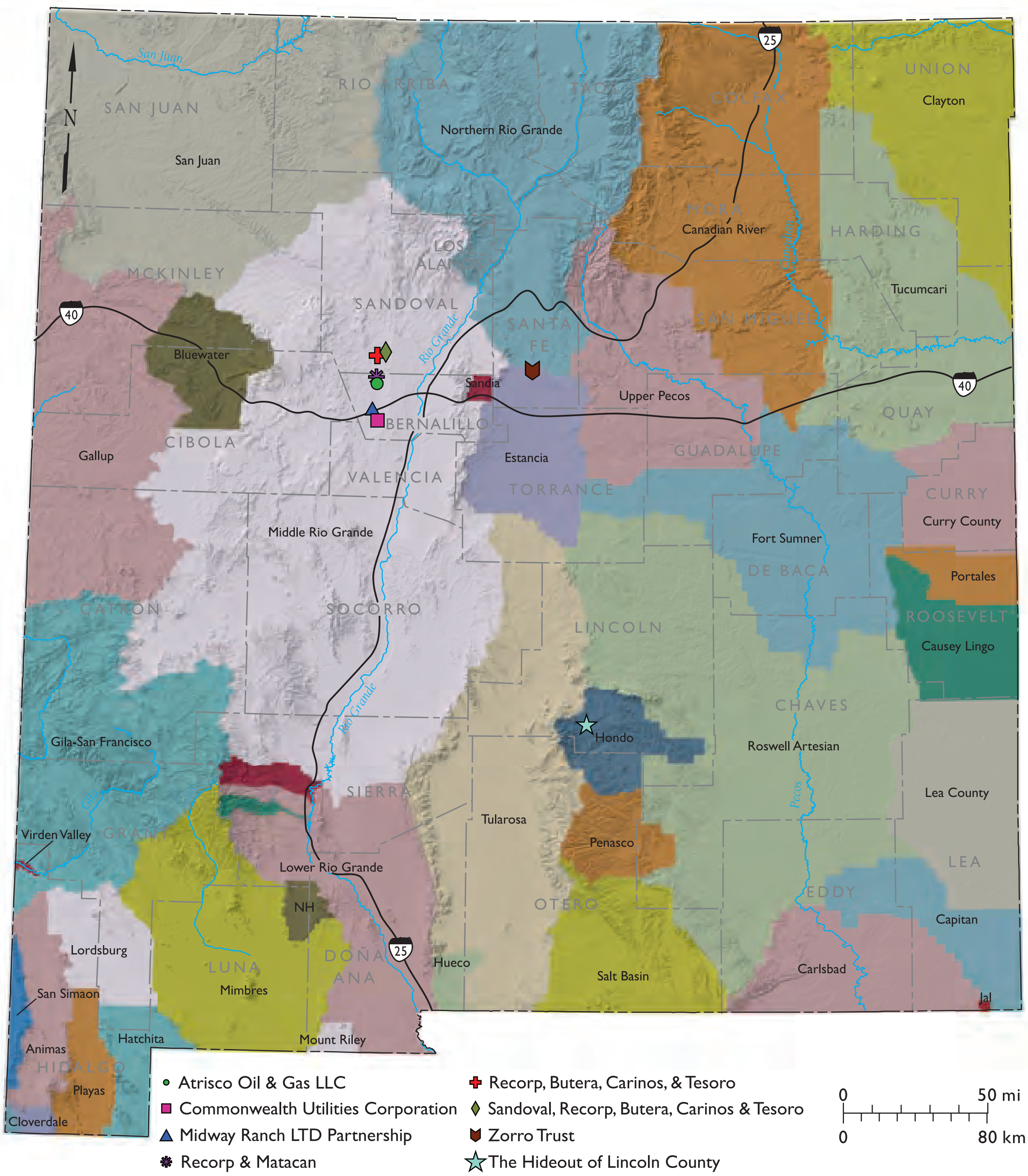
Since 1931 the state engineer has exercised jurisdiction over the appropriation of ground water in "underground water basins" that have been defined and declared by the state engineer. As of 2005 the state engineer had declared forty underground water basins that collectively cover all of the state's surface area. In 1967 the legislature passed an act that excluded nonpotable water in deep aquifers from inclusion in any declared underground water basin, which was codified as NMSA sections 72-12-25 to 72-12-28. For the purposes of this paper, these statutes will be referred to collectively as the "excepted aquifer statutes," and the aquifers will be referred to as "excepted aquifers."

In order to be excepted, the top of the aquifer must be at least 2,500 feet below ground surface and the aquifer must contain nonpotable water (defined in section 72-12-25 as water with a concentration of dissolved solids greater than 1,000 parts per million). Although the statutes provide public notice (section 72-12-26) and reporting (section 72-12-27) requirements, there is no requirement for review or approval by the state engineer in order for a person to appropriate ground water from an excepted aquifer. Legal relief to potentially impacted water users is provided in section 72-12-28, which allows any person to file suit in district court based on a claim of impairment.

Enactment of these statutes simplified life for oil and gas producers, since nonpotable water is often a by-product of hydrocarbon production, and at that time there was little desire to beneficially use this brackish, oil-tainted, "produced water." A primary consideration was excluding produced water in the southeastern part of the state from state engineer jurisdiction. Historically oil and gas producers have considered produced water to be a waste by-product, disposed of primarily through deep well injection or evaporation. In theory, these statutes could also be used in cases of geothermal development, as deep, hot waters are typically nonpotable.

Recent attempts in the legislature to change the excepted aquifer statutes have been unsuccessful. For example, in the 2008 session a bill was introduced that would have allowed the state engineer to declare deep nonpotable water to be part of an underground water basin. The bill contained explicit protections so as not to affect the use of produced water or withdrawals for geothermal use, but any other uses would be subject to the existing statutes governing the appropriation of ground water. The bill died in the Senate Conservation Committee.

Until recently there have been no proposals for large-scale, long-term development of excepted aquifers. Since 2006 various entities have filed notice under the statutes and begun deep drilling projects to supply municipal and other fresh-water uses in the greater Albuquerque area. Exploration of these deep nonpo-



Declared underground water basins in the state of New Mexico. As of 2005 the state engineer had declared 40 underground water basins. Also shown are the locations of statewide notices of intent to appropriate ground water from excepted aquifers as of October 2008.

table aquifers has been prompted in part by advances in desalination technology, which have decreased the cost of development, and by the increasing value of existing potable resources. Desalination technology has advanced considerably since 1967, and current developers propose treating the nonpotable water that they will pump. It appears that the economics of deep drilling, water treatment, and waste disposal may now compare favorably with the costs of acquiring a traditional water right.

PROCESS

In order to appropriate ground water from a declared underground water basin, an applicant must apply for a permit from the state engineer, and follow the requirements outlined in state law. Except for wells for domestic use, stock watering, and certain temporary uses, applicants must advertise their intentions, address protests, and demonstrate that approval of the application would not impair valid water rights, be contrary to water conservation, or be detrimental to the public welfare. If the application is protested, or denied and then aggrieved by the applicant, a hearing is held and the state engineer makes a decision. Ultimately the state engineer may deny the application, or may approve it, either partially, fully or conditionally. Such actions by the state engineer may be appealed to district court, and from there to the court of appeals and ultimately the state supreme court. This process can be time-consuming and costly, with no guarantee of success for the applicant.

The process to appropriate ground water from an excepted aquifer is very different. The state engineer and the public are still notified, but opportunities for public objection are more limited. In addition, the entity proposing to pump from an excepted aquifer does not have to obtain state engineer approval to appropriate. Objectors must file suit in district court, where the burden of proof is on the objector rather than the appropriator. Beyond impairment it is unclear what other issues may be considered in such a suit. These differences are summarized in the table below.

A well that taps an excepted aquifer may be drilled through declared aquifers. To protect declared aquifers and prevent waste, the state engineer maintains regulatory jurisdiction over the drilling and design of these deep wells through its well construction regulations (19.27.4 NMAC). Under this authority, and that provided by section 72-12-27, the state engineer has been overseeing the recent drilling of wells to exploit excepted aquifers. This oversight is exercised to obtain pertinent data for the determination of whether the well will tap an excepted aquifer, to ensure well design that provides continued isolation of the excepted aquifer from declared aquifers, to protect the overlying, declared aquifers from contamination by water from excepted aquifers, and to prevent ground water from flowing uncontrolled to the surface. This process helps

	DECLARED UNDERGROUND WATER BASIN	EXCEPTED AQUIFER
WHAT IS FILED WITH THE STATE ENGINEER?	Application to appropriate ground water	Notice of intention to drill or recomplete well
NOTICE TO PUBLIC	Advertisement in local newspaper required	Advertisement in local newspaper required
OPPORTUNITY FOR OBJECTION BY OTHER WATER USERS	Protest to state engineer on grounds of impairment, contrary to conservation, or detrimental to public welfare; participation at state engineer hearing; opportunity to appeal state engineer decision to district court	Any person may bring action in district court based on claim of impairment to existing water rights
STATE ENGINEER PARTICIPATION IN COURT ACTION?	Yes	Yes; upon motion of any party state engineer shall be joined
IS THERE A REQUIREMENT FOR STATE ENGINEER REVIEW AND APPROVAL?	Yes	No; but state engineer can determine whether aquifer is excepted
STATUTORY REQUIREMENTS FOR STATE ENGINEER APPROVAL	Water must be available for appropriation; proposed appropriation cannot impair other water users, be contrary to conservation of water or detrimental to public welfare	None
REGULATORY REQUIREMENTS FOR STATE ENGINEER APPROVAL	Well design and construction	Well design and construction
BURDEN OF PROOF	On applicant	On plaintiff
INFORMATION REQUIRED	All technical data needed to meet the requirements above; state engineer may require metering and monitoring as a condition of approval	State engineer may require pertinent data with respect to each well, and may require metering and reporting of well diversions and water chemistry

Appropriation of ground water (non-domestic) from a declared underground water basin vs. from an excepted aquifer.

the state engineer ensure that the well does not obtain any water from an aquifer that is part of a declared underground water basin, which would be subject to the statutes for appropriation of ground water.

TRENDS

A total of nine notices of intent to appropriate ground water from excepted aquifers have been filed with the state engineer as of October 2008. Information about these notices is summarized in the table on the following page; locations of the notices and locations of proposed wells in the Albuquerque region are shown on the accompanying map.

For 30 years after the excepted aquifer statutes were enacted no notices of intent were filed. In 1997 Midway Ranch Ltd. filed notice of intent to explore the Gallup Sandstone in the Rio Puerco area west of Albuquerque, to supply water for construction and operation of a proposed motor speedway. The well was completed to a depth of almost 2,800 feet, and the top of the aquifer determined to be at 2,559 feet. The state engineer evaluated the notice and available data, and concluded that the proposed appropriation was from an excepted aquifer. However, development of the speedway stalled, and the intended appropriation of 400 acre-feet per year has not been exercised.

No notices of intent were filed for almost ten years following the Midway notice. Since 2006 eight notices have been filed with the state engineer that incorporate at least 134 proposed deep wells and the appropriation of almost 180,000 acre-feet of water. To put the total numbers of proposed wells and proposed diversions in perspective, in 2007 the City of Albuquerque pumped about 100,000 acre-feet from some 300 wells. Most of these notices have been filed for subdivision and related uses associated with urban growth in the area west of Albuquerque and Rio Rancho. Another notice has been filed in the Estancia Basin north of Stanley, along with two in the upper Hondo Basin near Ruidoso in Lincoln County. As of October 2008, only a handful of these proposed wells have been drilled, and the limited available data are still under review.

ISSUES

The excepted aquifer statutes raise several legal, technical and policy issues that must be addressed to ensure the appropriate application of the statutes. A few of these are discussed below, along with possible solutions and questions for consideration:

- ***Determination***—New Mexico has not developed procedures for determining whether a particular deep geologic zone constitutes an excepted aquifer. One issue is that the term "aquifer" as used in section 72-12-25 is undefined, and in any given case several potentially conflicting definitions may be possible. Potential solutions include defining the reasonably ascertainable bottom boundary of each declared underground water basin in the state, analogous to the legal descriptions of the basin boundaries on the land surface. Existing statutes and case law indicate the state engineer has authority to do this. Difficulties would include insufficient data and resources to undertake this task in many basins.

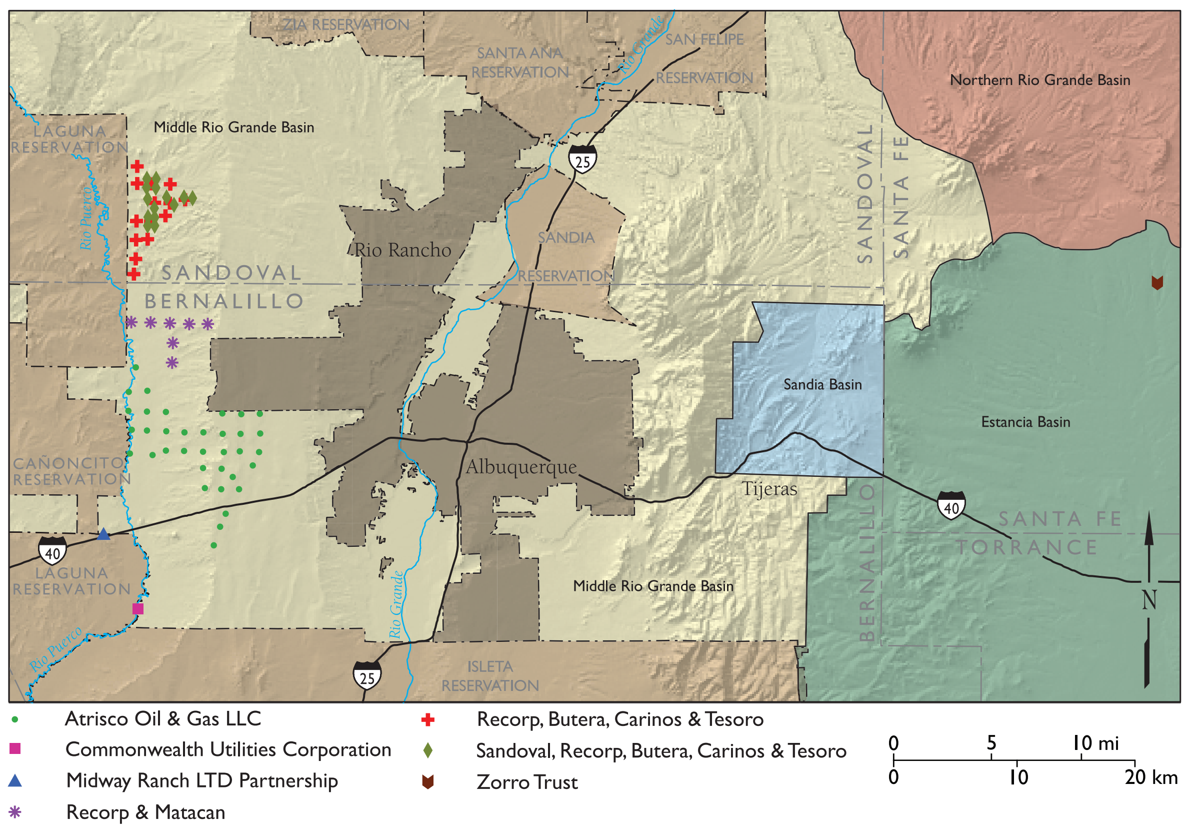
- ***Data requirements***—The state engineer can require the submission of hydrologic data, but collection of data sufficient to characterize a deep aquifer may be difficult, costly, time-consuming, and ultimately inconclusive. Furthermore, standards for data requirements have not yet been developed. Possible solutions include developing standards based on experience gained from current projects, and amending state law to explicitly empower the state engineer to require such data collection according to these standards.

- ***Administration***—Theoretically, beneficial use of water from excepted aquifers would result in the development of water rights. It is unclear under the excepted aquifer statutes how and by whom such rights would be administered. For example, can excepted aquifer rights be transferred to other places and uses? The state engineer generally does not approve interbasin ground water transfers, and limits transfers to the amount of water that has been placed to beneficial use. Should similar limits be placed on the transferability of excepted aquifer rights? How would excepted aquifer rights be handled in adjudications?

- ***Sustainability***—Deep, nonpotable aquifers may be hydrologically isolated zones of water or lack an efficient source of recharge, and may therefore be depleted relatively quickly. Use of such water for long-term water supply purposes, such as to provide water for municipal growth, could be problematic, particularly if a deep supply wanes as use continues or expands. One solution could include requiring certain types of

DATE FILED	FILED BY	USE(S)	AMOUNT (ACRE-FT/YR)	NUMBER OF WELLS	WELL DEPTHS (FT)	BASIN	COUNTY
08/20/1997	Midway Ranch Ltd Partnership	Construction, drinking, and sanitary	400	1	2,800	Middle Rio Grande	Bernalillo
06/16/2006	Recorp, Butera, Carinos, and Tesoro	Subdivision/related uses	16,000	14	3,000–6,000	Middle Rio Grande	Sandoval
02/22/2007	Recorp and Matacan	Subdivision/related uses	8,000	7	3,000–10,000	Middle Rio Grande	Bernalillo
11/28/2007	The Hideout of Lincoln County	Subdivision/related uses	300	2	3,500	Hondo	Lincoln
01/16/2008	Sandoval County, Recorp et al.	Subdivision/related uses	32,000	14	3,000–10,000	Middle Rio Grande	Sandoval
07/16/2008	Commonwealth Utilities	Subdivision/related uses	110,000	60	5,000	Middle Rio Grande	Bernalillo
07/23/2008	Atrisco Oil and Gas LLC	Subdivision/related uses	12,000	35	3,500–10,000	Middle Rio Grande	Bernalillo
09/28/2008	Zorro Trust	Subdivision/related uses	500	1	3,500	Estancia	Santa Fe

As of October 2008 nine notices of intent to appropriate ground water from excepted aquifers had been filed with the state engineer. Locations of proposed wells in the Albuquerque region are shown on the map below.



Locations of proposed wells to appropriate ground water from excepted aquifers in the Albuquerque region as of October 2008. Also shown (in color) are the declared underground water basins.

uses to acquire valid established water rights. This may require changes to state law. County subdivision regulations generally require demonstration that the proposed source aquifer can provide water sufficient for the intended use for a specific period of time, but the state engineer's role in the application of these regulations is only advisory.

- ***Hydrologic effects*—**If a deep, nonpotable aquifer is not hydrologically isolated, then large withdrawals would have effects on other aquifers and potentially upon the flows of hydrologically connected streams and rivers, including those subject to interstate compacts. In some cases data may be insufficient for the state engineer to assert that the aquifer is part of a declared underground water basin, but the risk associated with the potential hydrologic effects may be substantial. Potential solutions include empowering the state engineer to require acquisition of valid water rights in order to offset these effects, even if the claimed excepted aquifer status is not challenged.
- ***Economic viability*—**The cost and environmental impacts of these projects could be significant. Pumping from deep aquifers, conversion of nonpotable water into fresh water, and transportation of potable water to end users will involve the use of significant amounts of energy and the generation of large quantities of waste that will require disposal. Market considerations and project economics, including the costs imposed by requirements of any applicable environmental regulations, will ultimately be the determining factors in project viability.

CONCLUSION

In most parts of New Mexico, much more is known about shallow fresh ground water aquifers than about deep nonpotable aquifers, simply because the shallow aquifers have been easier and more economical to exploit and to study. The lack of deep hydrologic exploration has led to greater uncertainty regarding the magnitude and accessibility of nonpotable resources.

The magnitude of the nonpotable ground water resource that may exist beneath declared basins is unknown, but it could be that most of the nonpotable ground water in the state exists in excepted aquifers. With fresh water supplies in the Albuquerque area limited, under increasing demand from population growth, and susceptible to drought, it is no surprise that nonpotable deep aquifer resources are being considered for development. The excepted aquifer statutes provide a framework that encourages exploration and use of this resource, but many questions remain regarding the consequences of large-scale exploitation, dependency on a potentially unsustainable supply, and how use of excepted aquifers fits into the overall picture of water management in New Mexico.

The recent notices filed with the state engineer regarding plans to pump large amounts of nonpotable water from deep excepted aquifers strongly suggest that the time to address these issues has arrived. Careful consideration is required if these resources are to be safely exploited to the benefit of New Mexico residents, without harming the environment or fresh water resources, impairing existing water rights, or compromising the state's interstate compact obligations.

Authors' Note

Since this paper was written (in late 2008) a number of additional notices of intent pursuant to NMSA section 72-12-25 have been filed with the state engineer, bringing the statewide total to 29 notices involving over 250 proposed wells. As of February 2009 the quantity of water associated with all such notices totaled almost 550,000 acre-feet per year. A notice filed in late February by Lion's Gate Water appears to lay claim to all unappropriated deep, nonpotable water throughout the state not yet claimed by previously filed notices.

Legislation was introduced during the 2009 New Mexico legislative session to amend NMSA section 72-12-25, allowing the state engineer to declare deep, brackish water aquifers. These changes put the appropriation of water for municipal use from these deep aquifers under the same laws that ordinarily govern the appropriation of ground water in New Mexico. As this goes to publication the bill has been passed by the State House of Representatives and is waiting to be heard in the Senate.

Urban Water Administration in the Albuquerque Urban Area

Susan Kelly, *Utton Transboundary Resources Center, University of New Mexico School of Law*

The allocation of Rio Grande waters in the Albuquerque urban area involves a complex system of administration of surface and ground water rights by the Office of the State Engineer. This administration takes place within a framework of interstate compacts, federal and state laws, the rights of six Middle Rio Grande pueblos, and several local water agency projects and operations. Coordination of the many regulatory agencies and water rights holders into a workable water allocation and distribution system is complicated, made even more difficult by the fact that the Rio Grande is a fully appropriated river system—or an over-appropriated system, as many would argue. The terminology doesn't really matter; in most years there are more claimed water rights than there is actual water. As the Albuquerque area grows in population and as municipal use is transitioned from ground water to conjunctive use of both surface and ground water, the area's residents will become more aware of water supply issues.

Albuquerque's historic water supply practice, and indeed the water supply practices of other communities in the Middle Rio Grande, have relied on ground water pumping from the aquifer far from the river. The city's strategy also includes returning treated effluent to the river, which has augmented the river's natural flows. Ground water pumping in the basin is regulated and administered to protect surface flows in the Rio Grande. A water right to divert ground water is in reality a right to diminish surface flows in the river by the amount of the right. The Rio Grande Underground Water Basin was "declared" in 1956. After 1956 a permit was required to pump water from wells and also to provide offsetting water rights (usually purchased or retired surface water irrigation rights). By 1956 State Engineer Steve Reynolds had determined that the water in the Rio Grande was fully appropriated and that pumping from the aquifer ultimately had an effect on the flow in the river. He stated at the time that use of ground water was viable to increase water use for a number of decades, but eventually the usage should be stabilized at approximately the 1956 total rate. The declaration of the basin in 1956 was the beginning of the water rights transfer process in the Middle Rio Grande.

Like most other western states, New Mexico water law is based on the notion of prior appropriation, meaning that rights to water were initially distributed on a first-come, first-serve basis, as long as the user put the water to some sort of beneficial use. These water rights are tied to property and run with the title to the land; so that if land is sold, the water rights go with it, with the original date of appropriation, unless the water rights are explicitly severed. Although the law is rooted in prior appropriations, as a practical matter (for many reasons, including the un-adjudicated nature of Middle Rio Grande water rights and inherent difficulty in curtailing junior ground water pumping), water rights have not been managed that way.

The earliest priority rights are irrigation water rights, and the Rio Grande valley is the oldest continually irrigated area in North America. The Treaty of Guadalupe Hidalgo in 1848 recognized that the oldest rights belonged to Native American users, followed by Spanish colonial settlers. About a thousand irrigation and drainage ditches and channels built by the early inhabitants are still in use today. The most senior water rights holders are the pueblos. Albuquerque is bounded on the north by lands of Sandia Pueblo and on the south by those of Isleta Pueblo. The senior rights of those pueblos, along with four other pueblos in the Middle Rio Grande region, are recognized as having priority use of water before all other users in the area. Yet the total quantity and nature of these rights is not settled. Short of adjudication or settlement, however, at least one practice to protect the pueblos is in place: Even in severe drought conditions when flows are bypassed by New Mexico for delivery to Texas, prior and paramount water for the six middle Rio Grande pueblos is stored in El Vado Reservoir and is available for their use. And in recent years, believing that the transfer of water rights from downstream of Isleta to upstream will impair its water rights, the Pueblo has filed a number of protests.

In 1907 New Mexico's territorial government enacted a state water code, requiring that new diversions after that point in time obtain a permit from the state engineer. The law recognized that all the water rights allocated before 1907 were vested in the landowner. Therefore, permits issued after 1907 are considered junior to "pre-1907" water rights. These junior rights include part of the water rights held by the Middle Rio Grande Conservancy District, created in 1923. But the MRGCD permit also includes early irrigation rights, developed before the creation of the MRGCD and later consolidated into the MRGCD system, that are vested, privately owned rights and Pueblo rights. The MRGCD permit claimed 123,000 acres having water rights. But the district's irrigation plans were never fully realized, and the full 123,000 acres were never developed, mainly because of insufficient water supply. About 80,000 acres of MRGCD water rights were claimed to be perfected before 1907 (which included 7,000 acres of Indian land in cultivation). Of these 80,000 acres, about 27, 000 acres were by that time in swamp, alkali, or salt grass conditions but had been cultivated at some point prior to the creation of the MRGCD.

An Office of the State Engineer on-the-ground survey dated 1917–18 is the primary source of information about conditions before 1907. Under current OSE policy, the water rights appurtenant to property shown on the 1917–18 maps as swamp, alkali, or salt grass are not available for transfer unless additional evidence of cultivation is provided.

The Rio Grande Compact was ratified by Congress in 1939 and was based on the apportionments in a temporary compact (1929) that reflected the magnitude of the various water uses at that time. A 1937 report stated the Rio Grande was at or beyond the limits of water that it could be expected to provide. The compact is an agreement between New Mexico, Colorado, and Texas. Under this agreement, Colorado is required to deliver a certain amount of water to New Mexico every year, and New Mexico is required to deliver a certain amount of water to Texas. The delivery obligations are based on gaged flows in the Rio Grande at specified locations, so that in dry years the requirements are lower. The compact contains a system of credits and debits, to help achieve compliance with delivery obligations. But the maximum amount allowed to be depleted in the Middle Rio Grande cannot exceed 405,000 acre-feet. So even in extremely high flow years, the Middle Rio Grande valley's usage is capped. The Interstate Stream Commission manages New Mexico's compliance with the Rio Grande Compact.

Next, enter the growth of Albuquerque and the boom that followed World War II. Albuquerque has always relied heavily on ground water from the aquifer. After the state engineer declared the basin in 1956—based on the understanding that ground water development was affecting river flows and potentially inhibiting New Mexico's ability to meet its obligations under the Rio Grande Compact—Albuquerque challenged the state engineer's declaration. Albuquerque filed four well applications without proposing to offset the wells' effects on the river. The state engineer denied the applications after a hearing in 1957. The city challenged the decision and initially won in district court. But the Supreme Court decided against the city in *City of Albuquerque v. Reynolds* (1963), emphasizing the connection between ground water and surface water and upholding the state engineer's plan to require offsets. As part of the settlement of the litigation, Albuquerque's existing ground water pumping was "grandfathered" with no offset rights requirement. These rights constitute the current city-county water utility's vested or "pre-basin" rights.

In the middle of the twentieth century, when Albuquerque's infrastructure was growing fastest, it was believed that there was an enormous amount of water in the ground beneath the city. Advertisements for builders and residents to come to the city boasted that a virtual Lake Superior was contained in the aquifer. The city was indeed built on that belief, and even in 1980, an *Albuquerque Journal* article describing Reynolds' views said the Albuquerque Basin had sufficient recoverable fresh water to serve the entire state for 575 years at the current rate of withdrawal. But as early as 1984 the city began to experience unexpected draw downs in wells, which led hydrologists to begin more detailed and comprehensive studies of the aquifer. In the early 1990s a U.S. Geological Survey study revealed there was far less water than was previously thought. By that time, moreover, Albuquerque was removing far more water from the ground than could be naturally replenished. The USGS also found that the connection between the river and the aquifer was misunderstood—it was not as direct as had been thought.

The timing of the effects of ground water pumping on the river is still not fully understood, but models have been created by the USGS and are used by the state engineer to simulate these effects. Depending upon many factors, including distance from the river, many years may be needed for the delayed effects of ground water pumping to diminish surface water flows.

This fact is one of the prime motivations for the Albuquerque Bernalillo County Water Utility Authority's (ABCWUA) project to divert and use its San Juan–Chama water. The San Juan–Chama Project was approved by Congress in 1962 and was built by the U.S. Bureau of Reclamation. The project diverts water from the Colorado River system into the Rio Grande for use by Albuquerque, the MRGCD, several other towns, and some of the pueblos and tribes of the upper Rio Grande. Albuquerque originally planned to keep its 48,000 acre-feet per year in the river to offset future pumping effects. But because the studies in the

1990s revealed that water pumped from the aquifer was not drawing water from the river in the timeframe the scientists had thought, the city decided instead to directly use the San Juan–Chama water.

The ABCWUA, formerly the City of Albuquerque water department, was granted a permit in 2004 to withdraw roughly twice its SJC water allocation, use the water and return half of it to the river at the wastewater treatment plant. The permit has many conditions and operational requirements, including minimum flows for the Rio Grande silvery minnow; municipal water conservation requirements; releases from storage in Abiquiu Reservoir to offset impacts on Rio Grande water supplies beyond the utility's water rights holdings; accounting and reporting; and environmental protection and monitoring. Issuance of the permit is currently on appeal in state court by several interest groups protesting the permit. The protestors have a number of concerns, including a concern that the project may cause harm to the ecosystem in the 17-mile reach between where the water is withdrawn and where one-half is returned. But the main point of the protest is their conviction that the project will impair senior water rights downstream of the Albuquerque urban area.

The ABCWUA provides the infrastructure and water to its customers for much of the Albuquerque/Bernalillo County area's municipal water use. It was created in 2003 by state statute and is the largest water utility in the state. It is in charge of 172,000 customer accounts, representing approximately 520,000 water users. It has 96 major wells, which collectively pump out more than 32 billion gallons per year. The authority's board is made up of appointed members: three Albuquerque city councilors, three Bernalillo County commissioners, the mayor of Albuquerque, and a non-voting member from the village of Los Ranchos. Rio Grande water rights for its well permits are consolidated under Permit RG-960. In 2003 the allowable pumping limits under RG-960 were increased from 132,000 to 155,000 acre-feet per year, under the conditions of the state engineer's Middle Rio Grande Administrative Area Guidelines.

The state engineer established its Middle Rio Grande Administrative Area Guidelines in 2000 to prescribe the process for permits from that date forward. The guidelines, developed under State Engineer Tom Turney's administration, designate a Critical Management Area in Albuquerque where there have been excessive water table declines. No new wells will be approved in this area, except replacement wells and domestic wells. The guidelines provide for joint management of ground water and surface water, and the rules state that the ground water table may not be drawn down more than 2.75 feet per year in the non-critical areas. The guidelines also require that anyone wanting to pump ground water must own valid surface water rights before diverting (pumping) ground water, while taking return flows to surface water into account. Since these guidelines only apply to permits granted after 2000, permitted rights of municipalities (mainly Albuquerque, Rio Rancho, and New Mexico Utilities Company) that were granted their permits before the guidelines took effect are subject to a different rule: Valid surface water rights must be in effect at the time the modeled pumping effects are determined to reduce flows in the river, which, as mentioned, may be many years in the future.

The City of Rio Rancho takes ground water from the Middle Rio Grande as well. It is one of the more rapidly growing cities in the Southwest, and its water demand will exceed supply within the next twenty years. Since 1981 it has seen a 420 percent population increase, from 10,000 people to more than 52,000, and the population is expected to double again by 2020. Until now Rio Rancho has been using approximately 3.5 billion gallons of water per year, but it will need about 10 billion gallons of water per year by 2040. Under the requirements of its diversion permit, which was doubled to allow pumping of as much as 24,000 acre-feet in 2001, Rio Rancho is seeking new water rights, as well as aggressively developing conservation, reuse, treatment, and recharge programs.

The Albuquerque urban area experiences effects not only from municipal wells but from the drilling of domestic wells. Domestic wells are exempt from the offset required for larger wells; surface water use does not have to be retired in proportion to the amount pumped out of each new well. Domestic wells have been viewed as a de minimus withdrawal from the ground (i.e., not significant enough to justify requiring a water right), but in the three-county region of Bernalillo, Valencia, and Sandoval Counties, domestic well withdrawals were estimated to be 12,000 acre-feet in 2005. Although permits are technically required, metering is not, except in the Critical Management Area, and no real record is available. The state does not know how many domestic wells exist or how much they pump out of the aquifer every year, although thousands of drilling permits are issued every year. State Engineer John D'Antonio adopted Domestic Well Management Guidelines in 2006, which allow significant restrictions on domestic well permits in areas where such wells are contributing to excessive draw downs or are impacting stream flows. A New Mexico District Court recently held that the domestic well policy of the state violates the doctrine of prior appropriation, but the Office of the State Engineer has appealed. The appeal stays the enforcement of the court decision, so for now the domestic well policy continues.

Local agencies and groups have an important role in water issues as well. The Middle Rio Grande Water Assembly is a volunteer, nonprofit organization that has organized around long-term planning for the Middle Rio Grande region and the Rio Puerco y Jemez sub-region. With the Mid Region Council of Governments, the assembly developed a Regional Water Plan for the Middle Rio Grande, which was adopted by the Interstate Stream Commission and nineteen local governments in 2004. The plan contains a vast amount of information about the region's water development history, legal framework, current water use, and future projected supply and demand. The plan identifies and evaluates 44 alternatives for meeting water supply. Most require local governmental or state action. If the region follows through on these ambitious activities, there is a good possibility of achieving a long-term sustainable water supply. The Water Assembly continues to promote implementation of the plan, and local governments and agency actions often coincide with the plan's recommendations.

CONCLUSION

We face many challenges in stretching our water supply to sustain future generations in the Albuquerque urban area. Critical management decisions will need to be made that are going to be difficult. Can we effectively manage water deliveries in times of shortage without a full adjudication of water rights, yet still protect senior water users and meet due process requirements? Can we preserve flow in the river and support the riparian corridor given continued growth in demand, delayed ground water pumping effects on the Rio Grande, and projected climate change? Can we preserve a healthy agricultural area given future urban demands? Can we conserve water now to preserve the aquifer as a future drought reserve?

There are some encouraging signs: The ABCWUA, Rio Rancho, and Bernalillo and Sandoval Counties are aggressively pursuing water conservation, and there are many more tools available to them to continue to improve. The ABCWUA is working on aquifer recharge and reuse projects. Rio Rancho is pursuing reuse and is developing surface infiltration and direct injection recharge demonstration projects to determine requirements for aquifer storage and recovery of treated water.

The state senate passed legislation in 2007 that allows transfer of "conserved" water. If rules can be developed that create incentives for farmers to conserve water and transfer the conserved water to meet growing demand, there may be an opportunity to preserve Middle Valley agriculture and still meet municipal demands. Care must be taken to develop rules to ensure that there is no resulting increase in consumptive use. And resources will be necessary for the Office of the State Engineer to develop such rules and a system of monitoring.

Many agencies are working collaboratively on habitat restoration, and on ways to reduce riparian depletions while enhancing the quality of the bosque and the river habitat for ecosystem health.

The ABCWUA strategy—to rest the aquifer for a period of time after the start of the project to divert and treat San Juan–Chama water for drinking water—will provide some time and space to allow the divergent interests in the Albuquerque urban area to work on the challenges of meeting long-term demand. We will have an opportunity to refine and implement plans and to be strategic about how to meet the future needs of this urban area. The Albuquerque area is part of the Rio Grande growth corridor and vital to the New Mexico economy. We can work with the state and other communities in the larger region to sustain our water supply, quality of life, and treasured natural environment.

The author would like to thank Judith Calman, UNM law student, for her assistance with this article.

Suggested Reading

Water Resources Management Strategy, Albuquerque Bernalillo County Water Utility Authority, available at: www.abcwua.org/content/view/190/332/

History of Water Development in the Middle Valley, New Mexico, Gary Daves, WRRI, 1994.

Middle Rio Grande Administrative Area Guidelines, available at: www.ose.state.nm.us/doing-business/ mrgbasin/crit9-13.pdf

New Mexico Administrative Code, Part 19.27.5, Domestic Wells Rules and Regulations.

The Middle Rio Grande Regional Water Plan and other materials are located on the Middle Rio Grande Water Assembly Web site at: www.waterassembly.org/

Water Conservation in the City of Albuquerque: Are We Doing It Effectively?

Jean Witherspoon

Conservation is the least expensive way to provide for the future.

Water conservation is a relatively recent concern in the Albuquerque urban area. The sole source of urban drinking water from 1916 to late 2008 has been ground water produced by City of Albuquerque-owned wells (Albuquerque Bernalillo County Water Utility Authority after 2003). The utility system expanded rapidly with the post-war growth of the 1950s. Usage at that time was around 150 gallons per capita per day (gpcd). In the mid-1970s the system was extended outside the city limits to serve parts of the valley where private wells' ground water quality was often poor.

The highest annual production to date occurred in 1989, when 42,085 million gallons were pumped to provide 267 gpcd to a service population of 431,324. (Per capita usage includes not only the individual's use, but also his/her share of park, school, hospital, industry, commercial, and utility use.) Utility projections were based on ongoing increases in the per capita usage and service population, i.e., a continuously growing demand. Projections assumed that the Albuquerque area aquifer would essentially provide an unlimited supply for the known future. The city's San Juan–Chama surface water would be used to balance the effects of the pumpage on the aquifer.

In the mid-1980s dropping water levels in city wells led to questioning the assumptions about an almost infinite underground supply. The City of Albuquerque contracted with the U.S. Geological Survey to better define the physical limitations of the supply. In 1988 their first report was issued, dramatically changing the perception of an unlimited supply. This led to reassessment of the city's approach to managing its water supply. A three-pronged approach including protecting ground water quality, assuring best use of the city's surface water, and conserving the ground water supply was adopted. In addition, the New Mexico Office of the State Engineer, which regulates the utility's use of water, began requiring conservation as a component of the utility's operation. Recognition that conservation is the least expensive way to provide water for the future was beginning.

Following an initial task force effort, the city council adopted legislation in 1992 calling for development of a Long-Range Water Conservation Strategy and initiating several conservation actions related to landscaping, public awareness, and reducing wasted water. Following a contractor's effort, staff work, and ongoing communication with various sectors of the public and staff, the Long-Range Water Conservation Strategy was put forward for adoption. It involved two primary components: (1) a landscaping and water waste ordinance that was at the forefront of conservation efforts nationwide and (2) a "laundry list" of other conservation measures to be implemented. The strategy was adopted in late 1994, and implementation began immediately. The adopted goal was to reduce water use by 30 percent in ten years, from 250 to 175 gpcd.

Albuquerque's conservation effort benefited from the experience of many other cities, their "lessons learned" and successes. It was strongly supported by the mayor, the city council, and the media, as well as already-active groups like the Xeriscape Council. And it benefited from an early recognition that the public must understand the effort and be integrally involved in its implementation. Marketing was initiated before adoption, task forces involving both staff and the public developed legislation and administrative procedures, and the strategy was finalized in a town hall (which made the legislation more stringent). In addition, conservation nationwide took a giant step forward with the 1994 U.S. Congressional adoption of low water-use standards for plumbing fixtures. New toilets could use no more than 1.6 gallons per flush (versus 3.5 or more gallons for older fixtures). Showerheads and other plumbing fixtures were similarly affected.

Measures implemented in Albuquerque between 1994 and 2002 included:

- A 20 percent maximum for high water-use landscaping (includes all square footage except building footprints and drive pads) for new development

- Toilet rebates of as much as $100 for replacement of high-flow toilets

- Free residential audits, including free showerhead and aerator installation
- Enhanced water waste enforcement with fees assessed on water bills
- Youth education
- Annual water budgets for parks and golf courses, with surcharges for overuse
- Xeriscape rebates of $.25 per square foot for replacing grass
- Marketing and education, including prime-time videos, TV and radio PSAs, newsletters, calendars, educational brochures, and manuals
- Investigation of unaccounted-for water (utility losses)
- Non-residential audits including cost-benefit analysis of recommendations
- A large-users ordinance aimed at apartment and non-residential customers using 50,000 gallons per day or more
- Washing machine rebates of $100 for replacing high-use machines
- Hospitality ordinance prohibiting serving water unless requested in restaurants and promoting multi-day use of linens in hotels and motels
- Rates/surcharge modifications to penalize waste and benefit conservation

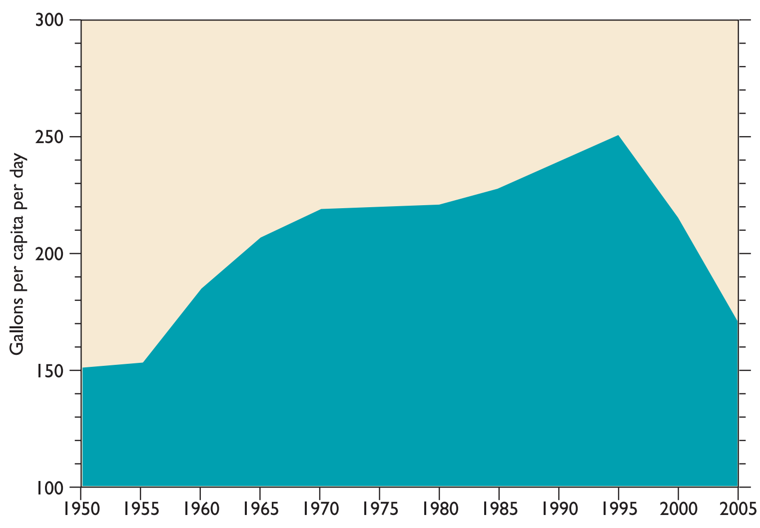
One result of the conservation effort has been that new development, which is subject to fairly stringent landscaping requirements and must use low-use fixtures, will use less water. A comparison of post-1997 new residential construction to pre-1997 residences indicates an almost 30 percent decrease in water usage. As newer development becomes a larger percentage of the total, the per capita usage will decline. Conservation-friendly developments with "built-in" reuse, higher densities, and common open space should use even less.

Conservation program overall progress is relatively easy to track. Once a baseline usage is established, progress can be monitored by comparing current usage to baseline usage. The goal adopted in late 1994 was to reduce overall usage by 30 percent within ten years. By the end of 2005, usage had been reduced 30 percent from the baseline 250 gpcd (based on 1987 through 1994) to 175 gpcd. Per account usage by billing class was also tracked (usage divided by number of accounts). Residential responded best with a 39 percent reduction by 2005. The three other classes had reduced by the following amounts by that time:

- Commercial (which includes apartments): 27 percent
- Industrial: 10 percent
- Institutional (which includes schools, hospitals, parks, and golf courses): 34 percent.

In 2003 the state of New Mexico mandated the formation of an Albuquerque Bernalillo County Water Utility Authority. This agency, which replaced the city's water utility, is overseen by a board composed of both city and county elected officials. Although it retains much of the legal authority of the city-owned utility and, presumably better represents the interests of all utility customers, the "split" also separates the land use authority and law-making function of the city and county from the utility-related function of the Water Utility Authority. The authority continued the adopted conservation program and goals.

The Middle Rio Grande Water Assembly, a regional planning group under the New Mexico Interstate



Albuquerque's per capita water use every fifth year from 1950 to 2005. Note the decline following the 1995 implementation of the conservation program.

Stream Commission, formulated their plan by 2003. Their water budget documented an annual deficit of 55,000 acre-feet in the Cochiti to San Antonio reach of the Rio Grande. As a result a more stringent water conservation goal for Albuquerque was needed. At the same time, the San Juan–Chama project, which will provide almost 48,000 acre-feet per year for authority usage, was projected to go on line around 2008. Convincing the citizenry that increasingly more stringent conservation is required concurrent with a significant influx of "new water" seemed untenable.

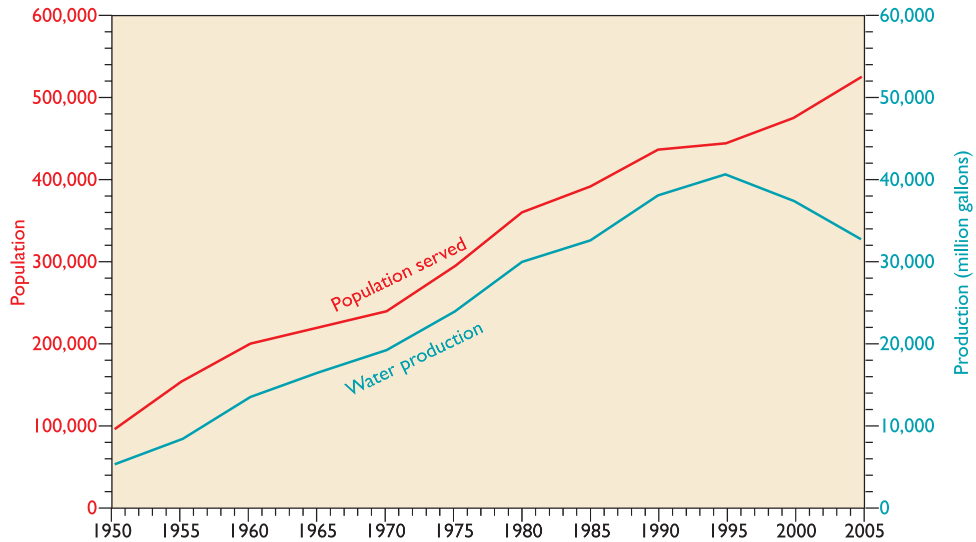
A Water Resource Advisory Committee was established to evaluate Albuquerque's conservation program and goals. After months of heated deliberation, the committee recommended additional measures and an additional 10 percent reduction goal, to be reached by 2014. The recommendations were adopted by the authority, the city, and the county in 2003. The same 150 gpcd goal was included in an OSE finding relative to approval of the San Juan–Chama project. As a result, the Water Utility Authority must expedite a further reduction of per capita usage by one percent per year until 2014. In 2006 Bernalillo County adopted a Water Conservation Strategy, providing more authority to apply measures outside the utility service area.

Most of the measures implemented in the first stage of the conservation effort are still underway. Additional measures that have been added include:

- Rebates for dishwashers (now rescinded), hot water recirculation units, rain barrels, and moisture sensors
- Increased toilet and xeriscape rebates
- Audits for the 1,400 irrigation-only accounts
- Commercial use-specific audits and give-aways (e.g., restaurants)
- Targeted marketing to high-use residential customers
- Targeted education and assistance, such as smart watering classes
- Additional rate changes

Legislation has also been proposed that would significantly increase the requirements for new housing, including water harvesting. This legislation is in limbo while issues concerning which agency has the authority and will to impose these new sanctions are resolved. The Water Utility Authority, by itself, does not have the land use authority to adopt and implement these changes. The requirements were not initially supported by the building industry.

Program progress is still measured by per capita and other comparisons of baseline to current usage. Goals for overall annual and monthly usage, given service population projections and needed reductions, have been established as benchmarks. To date the goals are being reached if the area's rainfall is somewhere around normal. Water usage will probably always be subject to weather variations because almost half of all usage is outdoors. The ups and downs created by weather variation should be expected, as long as overall downward progress occurs. Water production



A comparison of parallel increases in Albuquerque's water production (pumpage) and population from 1950 to 1995, which was followed by a decrease in production after the implementation of the conservation program in 1995. Even with the continued growth in population, water use decreased.

continues to decrease as population increases.

Increasing long-term water demand is inevitable with increasing population. Communities in this country are rarely willing to limit growth (though a few unique communities, like Boulder, do limit the number of building permits). When growth from immigration and births is coupled with predictions for drier conditions in the Southwest and global warming, it's clear that a growing water demand must be met with a decreasing supply. The Water Utility Authority projects that, by meeting conservation goals, reusing water (mostly for irrigation purposes), and maximizing surface water use, the existing supply will be adequate to around 2060. Conservation—using less water for the same number of people—will have to be a significant part of the region's future. The public, however, will probably not accept increasingly stringent sanctions with no imminent crisis in the urban supply.

In the more immediate future, a number of measures can be supported and implemented to further reduce water use. On a national level, the Environmental Protection Agency's WaterSense program and the LEEDS program ("Leadership in Energy and Environmental Design," a program of the U.S. Green Building Council) will both lead to less water use. The EPA focus is on product efficiency, largely appliances, whereas the LEEDS program rewards new building efficiency, particularly energy but also including water. These voluntary efforts will "push" the country toward more efficient water use. Research also continues into more efficient plumbing fixtures, landscaping, grass, and irrigation.

Locally, greater efficiency can be achieved. The authority's rate structure, although encouraging conservation, does not adequately penalize those who waste on a regular basis. Increasing block rates that, within a given class, charge more per unit for larger amounts of water, should be put in place. This will make the rates more complicated, but will better utilize rates to reward low use and penalize wasteful usage. The authority's current charge of $1.64 per 1,000 gallons is a low to moderate one. Santa Fe charges $4.09 and $14.64 per 1,000 gallons (for lower and higher blocks), for example. The winter water average, which is the basis for the authority's summer surcharge and the monthly sewer charge, should also trigger penalties for excessively high use. All this can be achieved without raising average customer costs.

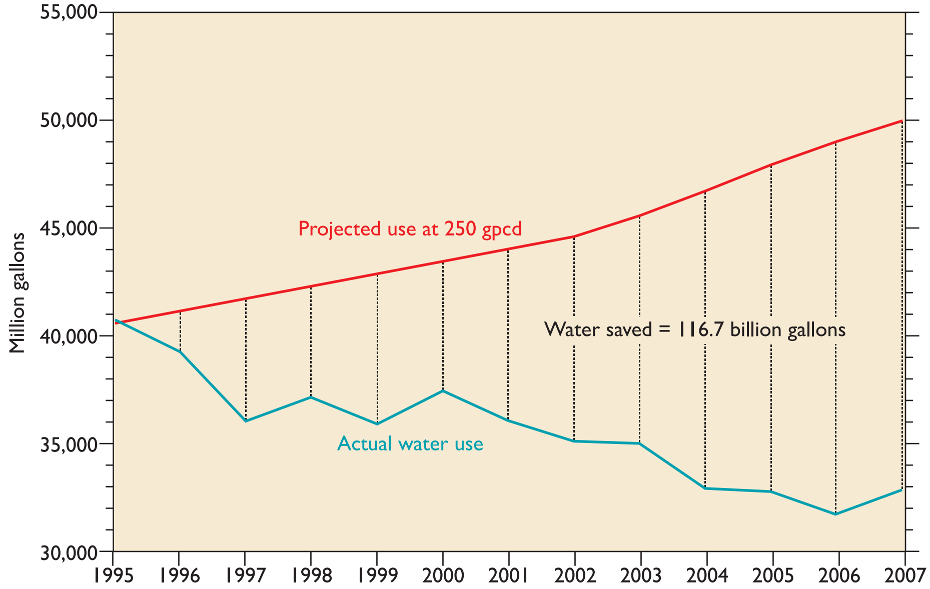
Landscaping is still a major challenge. Although xeriscaping has gained popularity and acceptance, many older neighborhoods and those that are protected by very out-of-date covenants need to convert to low-use landscaping. Grass is almost never needed in front yards, residential or non-residential. Xeriscaping does not automatically result in lower use, either, as lush xeriscapes may be watered more than grass. Marketing, rates, and penalties should encourage property owners and managers to monitor their water use. Large (apartment, school, institutional) irrigation system efficiencies are increasing, but most in-place systems are 60 percent efficient at best. Rebates and technical assistance to improve this should continue to be available and promoted. Rainwater harvesting, both passive (using berms and other low-tech devices) and active, offers a relatively untapped way to reduce use.

Plumbing issues will continue to be important because they represent almost all indoor use. Properly maintaining low-flow fixtures and appliances is critical to their efficiency. Newer features that waste water (e.g., "gang showers" and misters) should be prohibited. And more efficient indoor use in commercial, industrial, and institutional settings should become the norm.

Education and marketing have been a major success of the conservation effort to date. Initial efforts to encourage everyone to own the problem and to focus on residential use served the goal well. But intensity and focus are lacking now, with the lower goal (exceptions being the recent "Flush Rush" and 1-2-3-2-1 irrigation promotions). The many educational opportunities offered by the authority will only reach those willing to learn. High-use residential customers need direct marketing, incentives, and penalties to "get with the program." In addition, all customers need to understand issues about maintaining fixtures, irrigation management, and how important water use habits are.

Non-residential uses are a particular challenge because there is so much variation in efficient usage. These customers are often focused on the bottom line and the short term, so that funding improvements for long-term savings, water and/or money, seems undoable (e.g., the school system has only recently committed to replacing toilets). Although a few industries, businesses, and institutions have been exemplary in increasing water efficiency, much more can be done. Examples of success include:

- Water-intensive semiconductor industries modifying their processes to use less water and reuse water
- Hospitals eliminating leaks and continual flows and installing water-efficient equipment



A comparison of Albuquerque's projected water use (at 250 gallons per capita per day) to actual water use following implementation of the conservation program in 1995. Between 1995 and 2007, a savings of 116.7 billion gallons was achieved.

- Restaurants installing low-flow pre-rinse nozzles and air-cooled icemakers
- Hotels promoting multi-day use of towels and installing xeriscaping and low-flow fixtures
- Golf courses and parks installing automated, weather-sensitive, more efficient irrigation systems
- Car washes cleaning and recycling water.

Greater water efficiency in the future can be achieved through low-use equipment and processes, educating managers and employees, xeriscaping, low-use fixtures, and reuse.

Lastly, in-house utility efficiency (historically called "unaccounted-for water") has not been adequately addressed. Reducing water lost through leaks, broken or under-reading meters, broken lines, and system maintenance is an ongoing challenge that needs to be better met. These losses, which may also represent lost revenue, will increase as the system ages.

The Albuquerque conservation effort has been very successful to date. The community should be proud of that progress. Albuquerque's conservation program, to date, has saved more than 116 billion gallons. At the same time, it's clear that additional conservation can and must occur in the future. *Conservation is the least expensive way to provide for the future.* Waste, both profligate and minor, occurs continuously and, at some point, will be unacceptable. As the climate becomes drier, population grows, and the demand for all types of water use becomes more critical, the Albuquerque urban area will undoubtedly pursue further reductions.

One acre-foot of water = 325,851 gallons—the amount of water it would take to flood a football field to a depth of one foot. 50,000 acre-feet = the amount of water it would take to flood a football field to a height of almost 10 miles.