2

Middle Rio Grande Region - Past and Present

This Chapter presents background information relating to water planning for the Middle Rio Grande Region (MRG Region). The following topics are included:

- Description of the Region
- Special Regional Considerations
- Relationship with Other Regions and Subregions
- Historical Overview of Water Use in the Region

2.1 Description of the Region

The Office of the State Engineer and the Interstate Stream Commission's 2002 Framework for Public Input to a State Water Plan states, "The key fact about our water: demand exceeds supply." Writing specifically about the MRG region, this report notes,

> Many groundwater users, including municipalities and industries, in the Middle Rio Grande were allowed to begin pumping without securing water rights. Because of return flows of treated wastewater and the delayed impact of groundwater pumping on river depletions, this practice has not resulted in net river flow diminishment. However, the accumulated eventual need for groundwater users to acquire and transfer water rights is very large and exceeds the quantity of currently transferable water rights. Under current practices, only pre-1907 water rights can be transferred. The 1930 water rights developed by the Middle Rio Grande Conservancy District have never been available for transfer. Further, the ability of return flows from pumped groundwater to offset river depletions caused by pumping depends on ever increasing groundwater pumping. When pumping levels off, which it must, return flows will no longer be sufficient to offset the depletion of the Rio Grande caused by historic pumping. (p.45)

Other points about the MRG Region in the report include:

- Growing and increasingly diverse demands for water in the Middle Rio Grande Region-including the state's needs for water supply for about half its population and economy, and for wildlife and ecological uses-cannot all be met.
- Current water consumption exceeds the long-term average supply that is legally available for use in the Middle Rio Grande.
- Since the surface-water system is closely interconnected with groundwater, pumping more groundwater does not solve the problem.

Appendix C provides summaries of several key documents that thoroughly cover the history of the MRG Region, including reports by Niemi and McGuckin (1997), Scurlock (1998), and Nims et al. (2000).

2.2 Special Regional Considerations

This Section briefly describes attributes that impose special considerations for water planning within the Middle Rio Grande Region. Included topics are:

- Rio Grande Compact
- San Juan-Chama Project Contracts

- Critical Management Areas
- Sovereign Nations

2.2.1 Rio Grande Compact

The region is affected by the requirements of the Rio Grande Compact among Colorado, New Mexico, and Texas (see Supporting Document H-9). Those requirements allocate a certain amount of the annual native Rio Grande water that flows through the Otowi gage (near the Los Alamos highway) to consumptive use between Otowi gage and the Elephant Butte Dam (maximum 405,000 acre-feet per year [afpy]). The state of New Mexico is obligated to deliver the rest of that native water to the Elephant Butte dam. Complex rules exist for adjusting the available amounts in wet and dry years, and for multi-year accounting of credits and debits. Consumers of the available water are in three New Mexico planning regions: Jemez y Sangre, Middle Rio Grande, and Socorro-Sierra regions.

2.2.2 San Juan–Chama Project Contracts

Several jurisdictions in the Rio Grande Basin contracted with the Bureau of Reclamation to build a tunnel through the continental divide and to deliver an average 96,200 afpy of San Juan River water to the Rio Grande Basin, using the Chama River and Rio Grande as conduits. About 72,000 afpy of that is designated for consumptive use by the Middle Rio Grande region. The San Juan-Chama project has been delivering that water for consumption north of the Elephant Butte Dam since 1972.

The delivered San Juan –Chama Project water, which is "owned" by the contracting jurisdictions, has been utilized by lessees and Middle Rio Grande Conservancy District (MRGCD) irrigators over the years, while native Rio Grande water has been allowed to flow on downstream to meet the state's obligations under the Rio Grande Compact.

Albuquerque is building a diversion dam and river water treatment facility so as to consume its 48,200 afpy of San Juan-Chama Project water instead of pumped groundwater. This Drinking Water Project is projected to start operations in 2006. It is proposed to divert some 94,000 afpy, consume the 47,000 afpy, and return the rest to the river channel through the sewage treatment plant.

This Drinking Water Project will enable the city to reduce groundwater pumping initially by 94,000 afpy. Continuing river leakage will start to refill the aquifers, until groundwater pumping to meet growing demand, again starts to exceed leakage rates (estimated to occur in a few decades).

2.2.3 Critical Management Designations

Starting in 1956 the State Engineer declared the Rio Grande Basin to be "fully appropriated." That meant that no new additional appropriation of water rights would be allowed. New consumptive uses of water would have to be accompanied by a comparable retirement of an already existing right to consumptive use of water. The retirement of rights from one use in one place to an authorization of rights for another use and/or in another place are called water rights "transfers."

Subject to a fairly elaborate set of State Engineer permission procedures, water rights could be transferred from any point within the Rio Grande Basin to another point within the basin. The water rights could and frequently were transferred from surface water use to groundwater use. In addition, the State Engineer is required to permit new "domestic wells" that allow the unmeasured pumping of three afpy. About 3000 such wells are being newly permitted each year in the Rio Grande Basin.

Relatively recently, the State Engineer became concerned that our large scale and increasing use of groundwater would have serious adverse effects in localized areas. The State Engineer has declared areas of serious aquifer drawdown to be Critical Management Areas. In such areas, the State Engineer imposes tight constraints on groundwater use including inhibition on water rights transfers to groundwater pumping in the area and imposes constraints on domestic well authorizations.

Figure 2-1 shows the forty-year drawdown of the aquifers in the Albuquerque area and surrounding Bernalilllo County. The State Engineer has declared a substantial portion of the Basin in and near

Figure 2-1 Cones of depression show a lowering of water table levels in excess of 120 feet on the east side of Albuquerque (Source: Modified from Bexfield and Anderholm 2002)

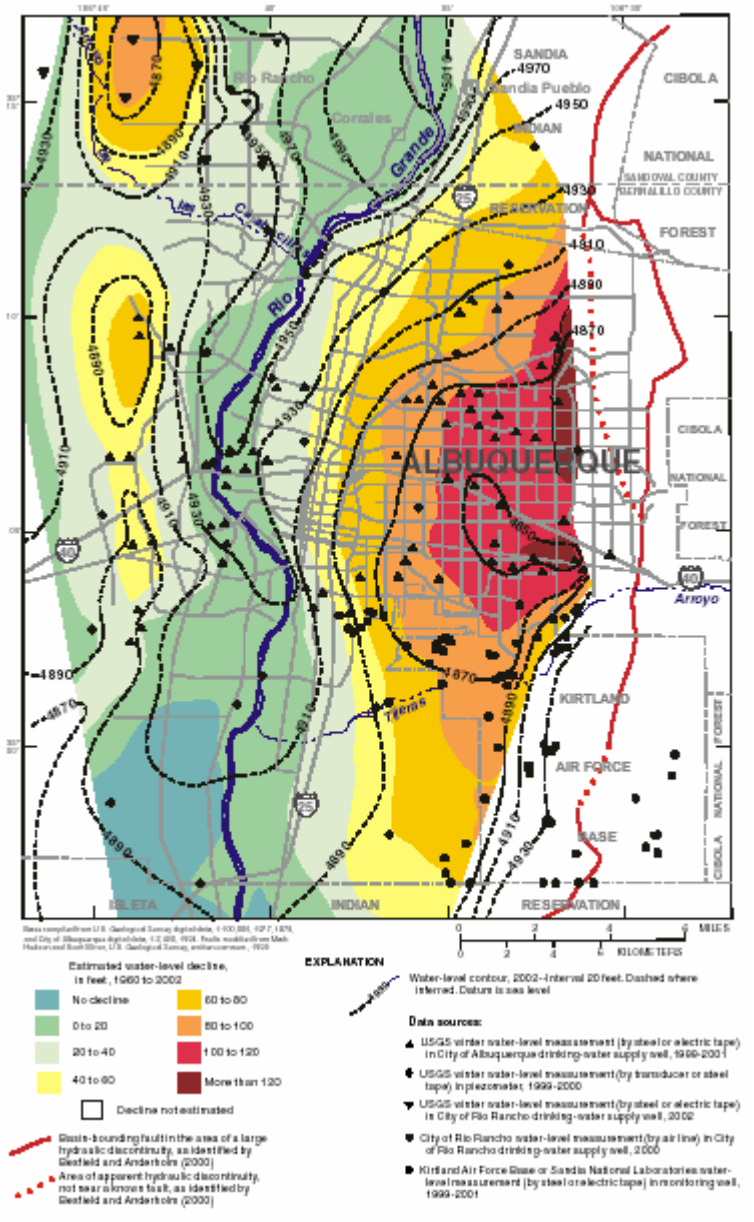
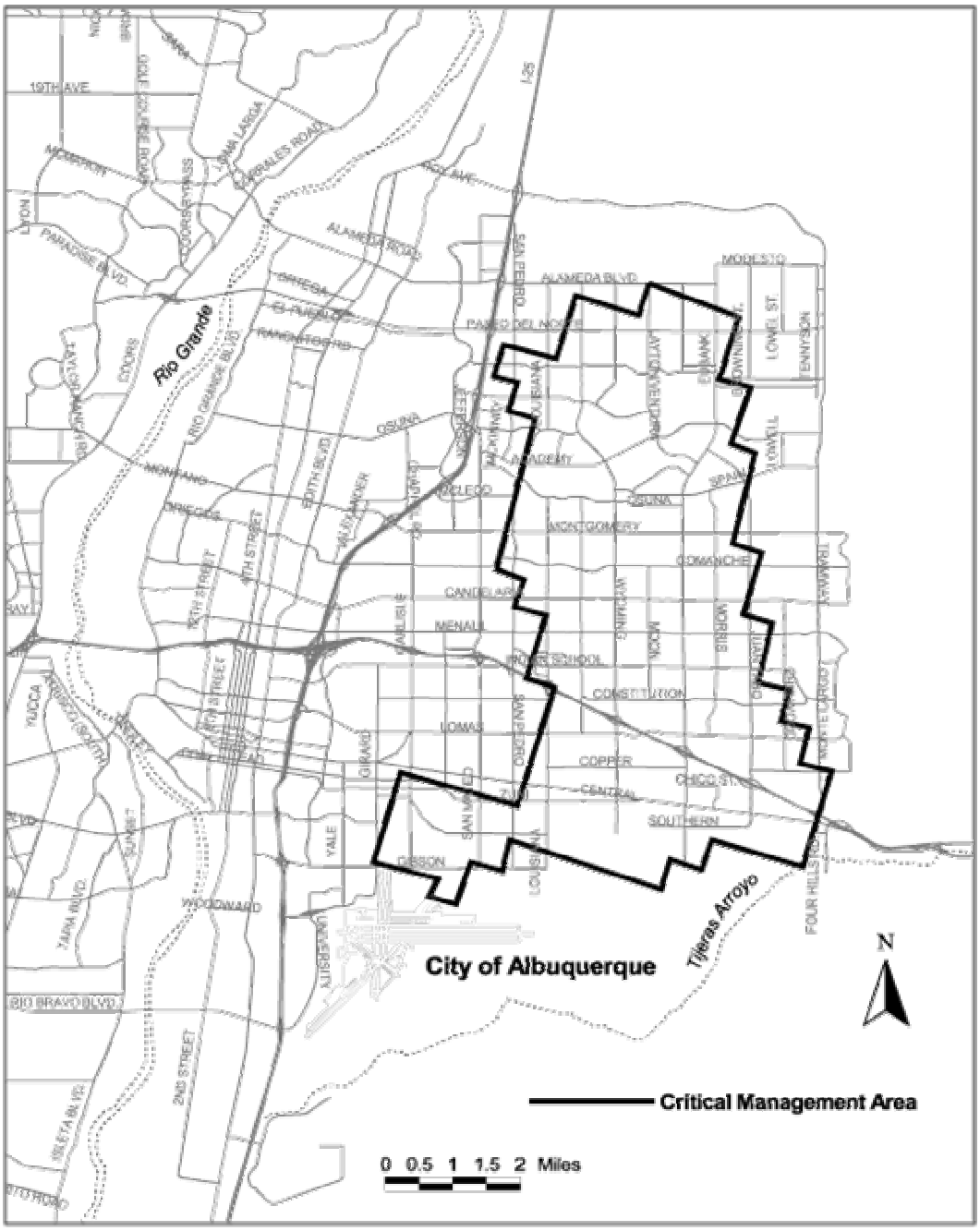


Figure 2-2 Critical Management Area as designated by the State Engineer in the Albuquerque area (Source: Mid-Region Council of Governments with data from the US Geological Survey)



Albuquerque to be a Critical Management Area, allowing tighter controls on groundwater uses. This Critical Management Area within the region is shown in Figure 2-2.

2.2.4 Sovereign Indian Nations

The Middle Rio Grande Region includes several sovereign Indian nations, which possess "prior and paramount rights" to use of water. The nations have been invited and encouraged to participate in the regional planning process. For various reasons, and with some exceptions, these sovereign nations have chosen not to participate (or to participate only superficially) in the regional planning process. The lack of participation, as well as the uncertainties about the nature and quantification of the nations' prior and paramount rights impacts the quality of the regional planning process.

2.3 Relationship with Other Regions and Subregions

This section briefly discusses the water relationships between the Middle Rio Grande Region and its neighbors. We consider these areas:

- Jemez y Sangre Region
- Socorro-Sierra Region
- Other Neighboring Regions
- Subregions

2.3.1 Jemez y Sangre Region

The Jemez y Sangre Region is upstream of the MRG Region. Only a small portion of that region lies between the Rio Grande inflow measurement point (Otowi gage) and the northeast edge of the MRG Region (Sandoval County line). The consumptive use of water within that Jemez y Sangre portion is sufficiently small that we can consider it negligible for our planning purposes.

Through informal official dialogue between the regions, the Jemez y Sangre Regional Water Plan (Daniel B. Stephens and Associates 2003) proposes to import about 2,000 afpy from the MRG Region. The Middle Rio Grande Regional Water Plan does not include a concomitant export of 2,000 afpy. That difference is an issue that will have to be resolved after the planning period, presumably through a collaborative effort among the two regions and the Interstate Stream Commission.

2.3.2 Socorro-Sierra Region

The Socorro-Sierra Region is downstream of the MRG Region. A very substantial portion of that Socorro-Sierra Region lies between the MRG boundary and the Rio Grande outflow measurement point (Elephant Butte Dam). Particularly, Elephant Butte Reservoir, which evaporates on average a large fraction of the Rio Grande Compact allowable consumption (140,000 afpy) lies within the Socorro-Sierra Region.

Fairly extensive dialogue has been conducted among the two regions and the Interstate Stream Commission staff. With some expert guidance, the regions have concurred on a planning estimate for the average historical interface (river flows) between the regions, accounting for the difference between the flow measurement point at San Acacia and the regional boundary about 20 miles further north (the Valencia/Socorro County line).

The estimate is that average historical flow was 169,000 afpy plus deliveries to Elephant Butte Reservoir (for both evaporation and Compact deliveries). Following Interstate Stream Commission staff guidance, the two regions have mutually agreed to omit the deliveries to Elephant Butte Reservoir from their incomes and outgoes (like reimbursable expenses).

This Middle Rio Grande Regional Water Plan projects a future import of water from the Socorro-Sierra Region. The Socorro-Sierra Regional Water Plan does not provide for a concomitant export. That

difference is an issue that will have to be resolved after the planning period, presumably through a collaborative effort among the two regions and the Interstate Stream Commission. Refer to Section 9.3.11.

2.3.3 Other Neighboring Regions

The MRG Region is hydrologically separate from neighboring regions to the east and west. Those neighboring regions do not have a surplus of fresh water to export. While the Estancia Basin Regional Water Plan discourages export of any water, several entities have considered treating and importing (via pipeline) brackish or mine water from those regions to the Middle Rio Grande. At this time, such considerations appear only at the study level. Desalinating and importing Tularosa Basin water has been studied more seriously (see Section 9.3.10).

2.3.4 Middle Rio Grande Subregions

The Middle Rio Grande Region of Sandoval, Bernalillo, and Valencia Counties was divided into three hydrologically separate subregions. The subregions are Rio Puerco, Rio Jemez, and mainstem Rio Grande. The Rio Puerco and Rio Jemez subregions have decided to develop a single subregional plan, which is not in conflict with the mainstem Rio Grande subregional plan. Throughout the planning process there has been extensive and ongoing dialogue among the three subregions.

The Rio Puerco and Rio Jemez plan is presented as Chapter 12 of this Middle Rio Grande Regional Water Plan. Chapters 1 through 11 of this plan really refer to the mainstem Rio Grande subregion, even though those chapters use the word “region” rather than “subregion.” Figure 2-3 shows the subregions.

2.4 Historical Overview of Water Use in the Region

The following insert to this plan is a revised version of an informational handout created and distributed between 1994 and 1996 by various individuals with an interest in water awareness for the region. Mike Kernodle originally compiled the information for a presentation at New Mexico Tech in 1994. The piece was updated in 1995 to include additional activities and archive discoveries. A year later more current numbers on the basin’s ground-water budget were added. The document has not been widely used since 1996. It provides a synopsis of the history of water issues in the region and appears in this plan largely as it appeared when used as a handout.

Handout on a Brief History of Water Awareness in the Albuquerque Basin

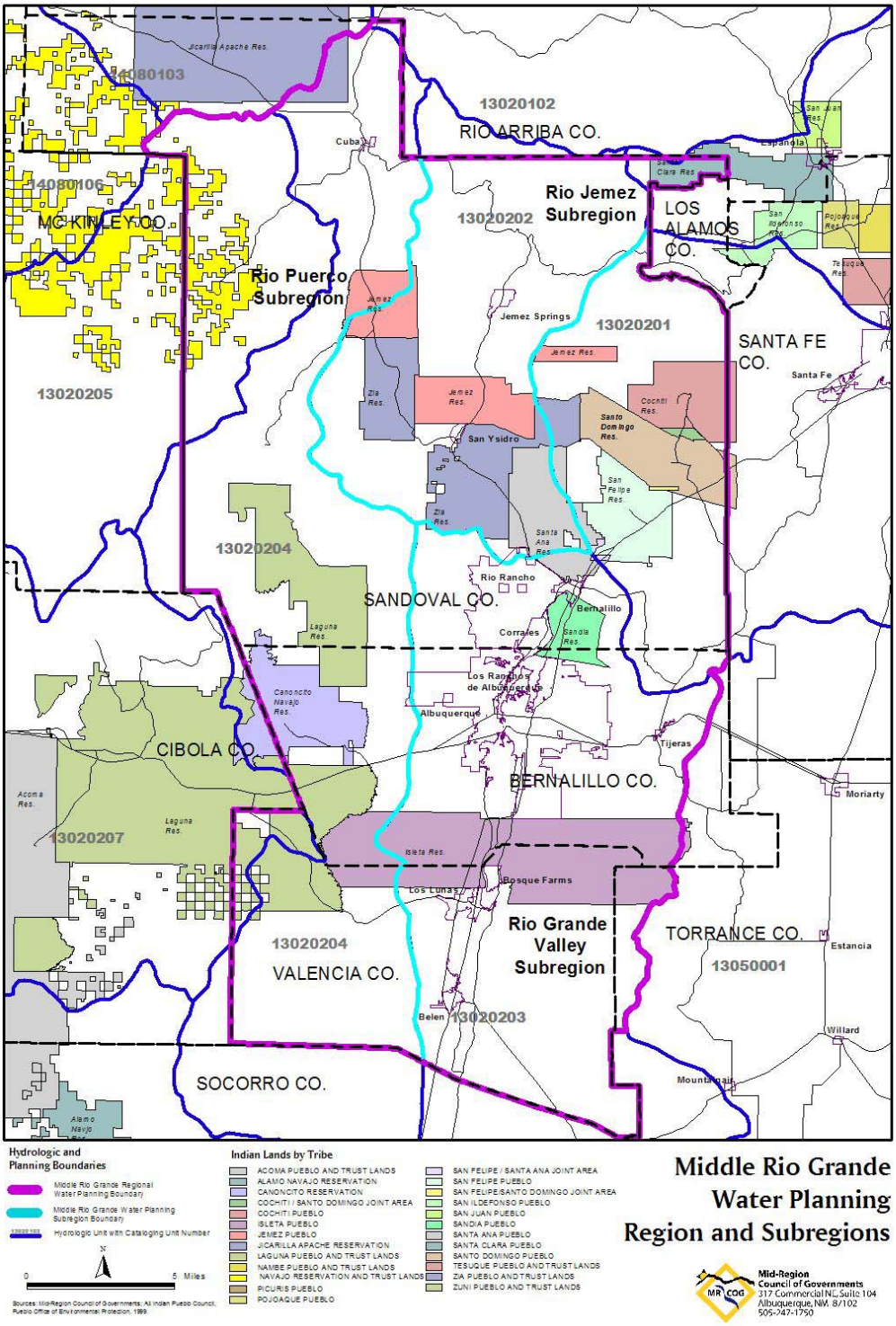
The First Era

This first era actually has two major parts. Both are much more complex than should be dismissed with a few short sentences. However, during the 1300's, or earlier, Native Americans of Chacoan descent established communities (pueblos) near the Rio Grande in New Mexico. Pueblos, much more numerous then than now, depended on irrigated agriculture for their primary sustenance. Later, in the late 1500's and early 1600's, Spaniards from the south first explored and then settled the region. With them they brought a tradition of irrigation practices, which blended with the Native American methods of irrigation to produce an entire culture surrounding the annual cycle of agricultural events. If there ever was a time of balance between the valley and civilization, this was it.

The Second Era

This was an era of great cultural change in the southwest. Anglo America was expanding westward into land cared for by a blend of Native American and Spanish resource-management practices. Famed explorer John Wesley Powell saw great potential in the west and he sought to protect the land and its new settlers from the east by limiting

Figure 2-3 Middle Rio Grande Region and Subregions (Source: Mid-Region Council of



Governments)

development to the region's sustainable-resource level -- a battle that he eventually lost. Powell's initiative was to quantify the resource and then allow an appropriate level of land development. The "status ante quo" investigation was a successful effort by territorial expansionists to defeat Powell's efforts and populate the west without regard for sustainable resources. The subsequent growth was so rapid that railroad construction alone virtually depleted the labor force and reduced agricultural harvests to a fraction of normal. The era ended with the two comprehensive water assessments by Follett and Lee, both driven by fierce international competition for scarce water.

Second Era Timeline

4/1/1878: John Wesley Powell's "Report on the Lands of the Arid Region of the United States" was delivered to Congress.

1881: John Wesley Powell named second Director of the U.S. Geological Survey.

1884: The flood of record strikes the middle valley. The peak flow was estimated to be 100,000 cubic feet per second.

3/20/1888: Joint Resolution to implement Powell's plan to inventory the water resources and uses in the “upper Rio Grande,” defined as being above the El Paso Narrows. Funding was appropriated in the Sundry Civil Bill of 10/2/1888.

12/9/1888: Camp Embudo (New Mexico) established.

1//1889: Embudo Gage established. This was the first systematic stream gage in the U.S., still in use today.

1/17-3/28/1890: "status ante quo" investigation.

8/30/1890: Funding cut and engineering and hydrographic sections of the Irrigation Survey disbanded.

5/1894: Powell resigned as Director of the Geological Survey.

8/18/1894: Very modest funds reauthorized for stream gaging activities.

1898: W.W. Follett was ordered to inventory the use of water for irrigation on the Rio Grande del Norte and issue a report back to Congress. The effort was prompted by concerns by the Mexican Government that the proposed dam at Elephant Butte would virtually eliminate water flows to Mexico.

1904: International treaty with Mexico guarantying 60,000 acre-feet/year.

1904: Another large flood, estimated to peak at 50,000 cubic feet per second at San Marciel.

1907: W.T. Lee's milestone report on water resources of the Rio Grande. (beneficial water uses in 1907 become the basis for senior water rights in the Middle Rio Grande Basin.)

The Third Era

The third era began as one of environmental desolation in the New Mexico middle valley followed by partial engineered recovery. Uncontrolled natural floods, large-scale upstream diversions, and poor irrigation practices caused virtual economic destruction of

the valley's agricultural and 'riparian' systems. The channel of the Rio Grande, clogged by debris and sediment, steadily gained altitude. Interior-valley land was submerged by ground water or by frequent devastating floods. Almost no bosque existed, because it was ripped out by floodwaters, eaten by beavers, or could not survive in swampy, alkali soil. The new conservancy district drained the swamps and over time restored the land to productive capacity.

Third Era Timeline

1912: Soil survey of the Middle Rio Grande Valley. Most notable for the huge areas of mapped 'alkali soils' and general depth to ground water of less than a foot.

1920: The Rio Grande flood of 1920 is greatest since at least 1884 and probably since 1741; information from W. H. Yeo's file on floods. USGS Water Resources Data, 1998; Otowi Gage.

1925: Middle Rio Grande Conservancy District formed.

1928: Bryan's report on the geomorphology of the Rio Puerco valley.

1929: Two summer floods from the Rio Puerco drainage completely wipe out several Rio Grande valley communities south of Socorro, including San Marcial and Valverde, which were buried under several feet of mud and silt. The flows peaked at about 35,000 and 30,000 cubic feet per second.

1930: D.W. Bloodgood's report on "The Ground Water of Middle Rio Grande Valley and its Relation to Drainage." Bloodgood documents over 1,000 shallow monitor wells that were completed in the valley between Bernalillo and Isleta.

1933-36: MRGCD implements irrigation, reclamation and modest flood-control efforts.

1935: High-resolution aerial photographs of the middle Rio Grande Valley. The photos still showed large areas of swampland and transitional zones.

1937: Another flood on the Rio Grande.

1938: C.V. Theis' report "Ground Water in the Middle Rio Grande Valley."

1938: C.V. Theis publishes his equation for non-equilibrium drawdown in a pumping well.

1938: Bryan's report "Geology and ground-water conditions of the Rio Grande depression in Colorado and New Mexico"

The Fourth Era

This was an era of extremely rapid growth (up to 11 percent per year) driven by cold-war urgency, and of inadvertent disregard for the environmental consequences of that growth. What little long-range planning was attempted was almost immediately obsolete. New neighborhoods popped up on the east mesa, water was needed, and a conveniently close well was drilled (if the plumbing supplies could be acquired fast enough). New wells were completed in a tiny pocket of world-class aquifer and the City grew confident that the Basin's aquifer was just as good everywhere and went as deep as they cared to drill. All the while, scientists were advising caution and test-well drilling, and chastising

developers and community leaders for their lack of foresight and planning. Finally, Steve Reynolds, the new State Engineer declared that this unfettered growth had gone on long enough and that the City of Albuquerque (as well as other ground-water users in the Middle Rio Grande Basin) were subject to laws and regulations governing wells and water withdrawals. The era ended in the courts with the State Engineer the victor. Meanwhile, the Bureau of Reclamation's mid-1950's construction of levees and jetty-jacks established a stable environment for the beginning of the bosque as we know it today. Amid all of this was one of the best-kept secrets of good ground-water-hydrology interpretation: Tom Meek's 1949 report on ground-water conditions in the Albuquerque area.

Fourth Era Timeline

Exact dates and the quotations refer to articles from New Mexico newspapers.

1941: Major flooding in the Albuquerque area.

1942: First year that Elephant Butte Reservoir was brim full.

1942: Rio Grande Interstate River Compact enacted.

5/23/1947: "...could become necessary in the future for the city to use water from the Rio Grande." However,.."There seems to be water under this entire valley and if necessary, new wells could be drilled almost anywhere."

April, 1949: Tom Meeks (for Soil Conservation Service) reports about the ancestral Rio Grande axial-channel deposits east of the valley; the ground-water trough west of the valley, with water flowing south to join the river in the lower basin; and, the role of fault zones in impeding ground-water flow.

7/6/1951: Mandatory water-use restrictions due to an "acute shortage". This was an infrastructure problem caused by rapid growth (6percent per year), and lack of equipment for new infrastructure.

7/28/1952: Previous master plan obsolete before it was finished. Weakness of new master plan is that "ground water in the basin needs further expert study."

11/11/1952: "City is Warned: May Face Fight On Water Supply" Albuquerque is causing loss of 20,000 acre-feet of water to downstream users.

12/29/1952: "This group has now completed its investigations and reported back to the city to the effect that a supplementary source of water is 'an absolute necessity' for the city's future development." .. "The report urges the city to present its case for the San Juan diversion project to the Bureau of Reclamation and to seek the support of the state in further studies." … "It will be wise to begin looking toward securing a new and additional source of water."

Jan. 1953: C.V. Theis gives "ostrich in its typical posture" and "no banker at the checkbook" talk to the Albuquerque Chamber of Commerce.

9/11/1953: Ground-water irrigation project on East Mesa (Osuna east of Edith) to grow 170 acres of alfalfa lauded as a soil-saving success (the area is now a deep gravel pit).

1/3/1954: "Water Usage Up 11 Percent"

6/5/1954: "Buy Water Rights, Erickson Urges" The SEO also suggested the control of ground-water basins.

Early-mid 1950's: Elephant Butte twice goes completely dry.

6/24/1954: "Gonzales said the new Heights wells would not be further east than the Love well, which is as close to the Sandia Mountain foothills as practical."

9/29/1954: Clyde Tingley bitterly opposed the consulting engineering firm that suggested a plan to drill wells on the East Mesa.

12/8/1954: "City's New Trial Wells Successful" Tingley lost and the 'savings due to friction loss' campaign began**.**

6//1954: Glover and Balmer publish the analytical approach now used by the State Engineer to determine the effect of Albuquerque's pumpage on flow in the Rio Grande.

mid 1950's: U.S. Bureau of Reclamation re-engineers the drains, restricts the channel of the Rio Grande, and builds levees. The bosque as we know it today gets its first good toe hold because of the man-made environment.

4/20/1956: "Engineer Asks Study of Underground Water" A USGS study was proposed by Conrad Gonzales to "prove the resource" and to prevent the current "hand to mouth opportunistic policies."

7/10/1956: "Plans Under Way to Start Study of Water Resources" "Gonzales has said that one of the reasons the underground water survey is needed is so the city can 'easily assure future citizens, developers or industries that what we claim for water resources is true and available'."

11/30/1956: "Albuquerque Area Water Basin Established" "The state engineer said the purpose of the basin is to protect surface water supplies through controlling ground water (sub-surface water)." .. " It certainly follows that if we do protect such rights, we insure our ability to meet our compact commitments." .. " He explained that the city may increase its own water rights by buying up existing rights and '*drying up*' the land which those rights have been irrigating." .. "The President's water resources policy commission ... has classed the Rio Grande Valley as one of the 10 major water problem areas of the nation, with claims exceeding the water supply, and with any growth in urban or industrial uses possible only at the sacrifice of other uses." The new state engineer is Steve Reynolds.

12/12/1956: "Mid-Rio Water Officials Balk at New Order"

12/13/1956: "Water Wastage Problem Faces Rio Grande District"

12/15/1956: "Water Engineers Differ on Planned New Wells"

12/17/1956: "Underground Water Plan Offered by State Engineer Draws Fire From Sanchez" "Our city master plan has until 1980 to run, and by that time--if farm land is retired--we will have a desert, a dust bowl in the valley."

12/18/1956: "Mecham Favors Order Setting Up Rio Grande Water District" "The only thing we've got to go on is the report of the U.S. Geological Survey there is no independent source of ground water in the valley, but it all comes from the river."

12/19/1956: "Albuquerque Can Claim All Water, Says Chairman" (Pueblo Grant Right, a California case)

12/19/1956: A mention of Reynold's "installment plan" in an editorial.

12/26/1956: "New Rio District to Let Farmers Drill Water Wells" "Under Reynold's regulations they must agree to an *'installment plan'* system of retiring surface water rights to obtain permits for new wells."

12/30/1956: "Open Panel Discussion on Water Basin Planned at Albuquerque Chamber"

1/4/1957: "Water District Draws Fire" "Dr. Charles V. Theis, official of the U.S. Geological Survey and nationally recognized as an authority on underground waters, declared pumping of a well upsets the *'natural balance'* of underground waters, which in time has an effect upon waters some distance from the well."

1/4/1957: "More Hearings Due on Water Basin Order" "*'We have a water problem and the future of the entire area depends upon how we settle it.'* Those words provided a peaceful end yesterday to an open discussion of the highly-criticized Rio Grande Underground Water Basin in Albuquerque. W.D. Reeves, chairman of the Chamber of Commerce committee, summed up comments and questions ..." ... "Using the Theis study as a basis, explained Reynolds, the method of installment buying of water rights .. was worked out."

1/7/1957: "Water in Colorado" "The first bill introduced in the Colorado Legislature deals with a subject now under consideration in the Middle Rio Grande Valley. The bill asks the Legislature to declare that underground water is presumed not to be tributary to any surface stream."

1/8/1957: "Farm Bureau Votes Here to Set Aside Basin Order"

1/8/1957: "City Studies Legal Action On Basin"

1/15/1957: "Basin Water Suit Expected"

1/15/1957: "Chamber Takes Cloudy Stand On Water Issue; Directors Okay Two Confusing Motions on Rule"

2/4/1957: "City Psychiatrist Defies Edict on Water Wells"

2/6/1957: "Court Gets First Rio Grande District Test Case"

2/13/1957: "Water Well Plan For Albuquerque Wins Approval" "The state engineer has agreed to a plan whereby Albuquerque can drill new water wells without having to buy and retire water rights immediately, according to City Water Engineer Conrad Gonzales."

2/14/1957: "Compromise Nears on Underground River Basin Bill"

2/16/1957: "Surface, Ground Water Relation Not In Dispute"

4/19/1957: "City Bypasses Permits to Drill 4 Water Wells"

5/21/1957: "City Asks Injunction in Water Dispute" "The scientific reliability of the interrelation of surface and ground waters of the Rio Grande underground basin has not been established, the city also contends."

9/10/1957: "Protest Against City Water Wells Dismissed By State Engineer"

9/23/1957: "Four Hills Well Completed; Test, Permit Awaited"

9/29/1957: "Four Additional Wells Proposed"

11/5/1957: "City Can't Drill Four New Wells, Reynolds Says"

11/21/1957: "Speakers Dispute Effects of Water Basin on Growth" "If the project is realized (San Juan diversion), Reynolds said, the city would not have to retire any surface water rights until after the year 2000 AD." .. Peter Gallagher, special attorney for the city of Albuquerque: "Unless the residents of the city of Albuquerque are aroused, it could end up without a sufficient water supply or else have to pay dearly for that water supply."

12/5/1957: "Supreme Court (NM) Hears Dispute in Water Case"

8/7/1958: "City Loses Water Basin Fight"

The Great Bliss

The long-awaited report that would "prove the resource" was finally published and summarily misinterpreted, whether inadvertently, intentionally, or as a result of an overly optimistic attitude of a can-do population. Reports that followed never challenged the complacent attitude about the future water supply and developers ran rampant with their lake-in-a-desert sales campaigns. People even ignored Reynold's warnings because the warnings were so cloaked by optimistic projections supporting the possibility of further growth (given enormous sacrifices).

1961: Bjorklund and Maxwell's report: "Availability of Ground Water in the Albuquerque area, Bernallilo and Sandoval Counties, New Mexico." Their cross section of the basin was misleading and people did not read the report or at least listen to what was being said. The Conrad Gonzales' drive to "prove the resource" prevailed and the report was interpreted to suggest a near-infinite resource.

1963: Jemez Dam and Reservoir completed to aid in flood prevention.

1967: Reeder and others report "Quantitative analysis of water resources in the Albuquerque area" sealed the coffin of unwarranted optimism that was begun by Bjorklund and Maxwell.

1974: Cochiti Dam operational. Great floods on the Rio Grande are eliminated at Albuquerque.

1976: Cox vs. Middle Rio Grande Conservancy: legal impasse on transfer of pre-1907 rights outside of the Conservancy and beginning of SEO policy of dedication of rights.

1977: V.C. Kelley's "Geology of the Albuquerque Basin". This is another "sleeper". If anyone had ever bothered to read this report they would be well briefed of today's problems.

1979: The U.S. Army Corps of Engineers' report parroted recent works and offered no new science.

1980: Editorial claims Albuquerque can support 1.5 million people if all non-Indian agriculture is eliminated from Cochiti to Elephant Butte.

1986: Kernodle and Scott tied both hands behind their backs, put on blinders to science, and constructed a steady-state ground-water-flow model based on the Bjorklund and Maxwell conceptual model (which was OK) but with an intentional serious misrepresentation of the surface-water/ground-water interconnection.

1987: Kernodle and others constructed a transient model based on the same flawed representation. Because of the flaws and other problems, simulations could only be run to 1979 and no projections were made.

Another Awakening

A joint New Mexico Bureau of Mines and Mineral Resources (NMBMMR) and USGS study unlocked the first modern geohydrologic interpretation of the framework of a New Mexico rift basin (Mesilla) and, coincidentally, soon thereafter the city of Albuquerque drilled a few deep test holes (after 30 years of pleas from hydrologists). Meanwhile, numerical-modeling approaches and techniques were making great strides, particularly in regard to simulation of rift basins, and computer power to process spatial data and run the models was growing beyond belief.

1985-86: Hawley and Stevens piece together framework of Mesilla Basin, the prototype work for the modern hydrogeologic concept of Rift basins.

1986-90: Kernodle developed interfaces between geographic information systems and numerical ground-water flow models. The techniques were benchmarked in a model of the San Juan Basin, New Mexico and Four Corners area and later used to construct a model of the Albuquerque Basin.

1988: At Kelly Summers' insistence, Albuquerque begins a program of deep test-well drilling, revealing that the 'Lake Superior' aquifer has a shallow bottom and limited extent.

1988: Pumping test analyses performed on all Albuquerque well fields.

1989: Summers and Shomaker document the deep test drilling.

1990: Kernodle's "Summary of Ground Water Flow Models in the Southwest Alluvial Basins" began to piece together geohydrologically significant components of rift-basin models.

1990, 1991: Russell and Snelson describe the modern interpretation of the structural style and tectonic evolution of the Albuquerque Basin but, their sections are at inopportune and unrepresentative locations having been somewhat biased by some faulty interpretations of fault locations by Kelley.

1992: Heywood described the isostatic-residual gravity anomalies in New Mexico. These interpretations formed the basis for new structural interpretations by Hawley in 1994-95.

1992: Hawley and Haase "Hydrogeologic Framework of the Northern Albuquerque Basin." The benchmark study that sharply focused our attention on the effective diminished size of our ground-water resource.

1993: National Biological Survey completes detailed digital mapping of riparian vegetation, irrigation infrastructure, and wetlands in the middle Rio Grande Valley for 1935 and 1989.

1993: Thorn and others "Geohydrologic Framework and Hydrologic Conditions in the Albuquerque Basin, central New Mexico."

1995: US Bureau of Reclamation and US Fish and Wildlife Service complete detailed digital mapping of land use and irrigation infrastructure in the middle Rio Grande Valley for 1935, 1955, 1975, 1989, 1992, and 1993.

1995: Kernodle and others "Simulation of ground-water flow in the Albuquerque Basin, central New Mexico, 1901-1994, with projections to 2020."

Just The Beginning, Or Another Complacent Era?

Much is continuing to happen with research and research-directed water-resources management in the Basin. Many investigations are now underway that will further define the water-resource potential of the basin. The NMBMMR is continuing to refine the hydrogeologic conceptual model of the basin based on a continuous stream of incoming new information. The USGS is continuing to update the ground-water flow model based on the NMBMMR work and additional water-use data. A massive and elaborate aquifer test in the Albuquerque area is providing supportive and new data. This test has been able to measure

- effects of earth tides at solar and lunar frequencies
- earthquakes as far away as Japan
- the end of the irrigation season
- water-level and land-elevation and aquifer-thickness changes in response to weight changes as small as that of a truck-load of dirt and as large as 4 million gallons in a water reservoir
- the movement of the aquifer itself to and from the test well as the test began and ended)

Ground-water levels and surface-water flows are being measured across extensive networks by several public agencies. One current investigation is intended to determine the best way to quantify the effect of Albuquerque's pumpage on the river. The Bureau of Reclamation and the USGS are nearing conclusion on field investigations on the local water budget, natural recharge, the effects of drains and canals on the ground-water system, and on riparian and agricultural consumptive uses.

New investigations are starting or are proposed. Albuquerque is about to undertake a desperately-needed program of monitor-well construction both for the recently enacted ground-water protection program and to monitor water-level changes. An SEO-headed task force has recommended a five-year, $40 million study of the middle Rio Grande Valley from Colorado to Elephant Butte Reservoir. The USGS, Geologic Division, in cooperation with the NMBMMR, is about to begin a detailed mapping project for the Basin, with emphasis on geologic structure and lithologic correlations, both of which are essential to improved geohydrologic understanding. USGS is proposing a study to measure the change in the force of gravity resulting from water-level declines: the change is a direct measurement of how much water is being depleted from storage.

The US Geological Survey is conducting a multi-year comprehensive, multi-disciplinary investigation with a federally-funded $350,000 annual budget, directed toward completing the geohydrologic puzzle of the Albuquerque Basin. This is part of a new National Critical Basins Program, which was initiated largely in response to the urgent need to solve water-resource management problems in four regional basins nationwide, with the Albuquerque Basin at the top of the list.

History does repeat itself

Albuquerque's water-supply problem is not so simple that a conservation program -- even an extremely aggressive one -- offers a permanent solution. All of our current water rights, 68,600 acre-feet per year, will indefinitely support only a population of about 1/2 million people (assuming 250 gallons per day per person and 50 percent return to the river). However, at present we not using any of our water rights to our own advantage and are borrowing water from the aquifer at a rate (67,800 acre-feet per year) that now almost equals, and in the near future will exceed, all of our rights. The borrowed water is measured by depletion of aquifer storage and the depth of the ever-growing water-level cone of depression in the aquifer. Expressed in financial terms, each year we are spending an amount almost twice our entire income (borrowed plus impact on the river) and we've been doing that, on average, for over forty years. The State Engineer, with his "installment plan," has indeed been a very kind banker.

In the Middle Rio Grande Basin the State Engineer's primary responsibility is to "keep the river whole," that is, to assure that whatever Albuquerque (or anyone else) does with water does not impair the rights of downstream users who also have vested rights. We depend on ground water. When we pump ground water we "upset the natural balance" and eventually affect flow in the Rio Grande. We have vested rights to affect that flow and we have purchased additional rights from the San Juan-Chama Diversion Project. The total of these rights are our annual water income.

Soon after Steve Reynolds "declared" in 1956 that the waters of the Rio Grande were fully appropriated he ruled that Albuquerque had a "vested right" to deplete the flow of the river by 18,000 afpy. In the mid-1960's the city contracted to buy 48,600 acre-feet of water per year from the San Juan-Chama Diversion Project.[1] Meanwhile, since 1956, the City has purchased a total of only about 2,000 acre-feet of pre-1907 water rights. Our total water rights are therefore about 68,600 acre-feet of consumptive use per year.

This is where the book-keeping gets interesting. The key phrase in the preceding paragraph is "consumptive use" of water from the Rio Grande. The State Engineer uses a 1954-vintage equation and 1960-vintage simplified aquifer data to compute the effect of the City's pumpage on flow in the Rio Grande. This combination is intentionally 'conservative' with regard to protection of downstream users in that it over-predicts the effect of ground-water withdrawals on the river. The State Engineer computed this depletion to be about 79,000 acre-feet for 1993 and about 81,000 acre-feet for 1994; the recent USGS model computed the depletion to be 53,000 acre-feet for the period of spring 1993 to spring 1994. Direct-measurement with statistical techniques recently employed by the Bureau of Reclamation place the total depletion by all users as low as 38,000 acre-feet, but if they add in deep percolation from excess irrigation water their estimate rises to about 71,000 acre-feet.

The city is allowed to use its reclaimed wastewater discharge to the river as a credit toward this depletion. The wastewater discharge generally is about half of what the city pumps from the aquifer. The good news and the bad news are the same! The good news is that we may not be depleting flow in the Rio Grande as fast as the old method predicts: if this is true, we can keep on growing and the reclaimed wastewater more than offsets the depletion of flow in the river, as long as the State Engineer doesn't change the rules of the game. The bad news is that we may not be depleting flow in the Rio Grande as fast as the old method predicts: we may be building up a massive debt that there is no hope of ever being able to repay and there is no way to passively use our water rights to offset

[1] According to the City of Albuquerque, this number is actually 48,200 afpy.

1993 Rio Grande Streamflow Depletion by City Pumpage		
Method	**Bernalillo to Isleta City of Albuquerque**	**Paseo del Norte to Rio Bravo Deep Percolation**
USGS (1998)	70,600x.77=54,400	
USBOR	66,000x.77=50,800	
Yellow Book	76,300x.77=58,800	
USGS Bosque Budget		27,000
Model Version I	53,000	28,000
Model Version II	56,000	
Model Version III	~50,500	(Note: VK 600:1)
Average	53,900	
SEO-Glover, Balmer	79,000	

depleted flow (that was the plan from the 1960's until 1995). Passive use means that just sending San Juan-Chama water down the river would replace the water loss that our pumpage has caused. Instead, we will have to find some costly engineering method to take advantage of our water rights.

If we can keep using more water simply by continuing to grow, why worry? Because we are very close to either running out of aquifer or running out of water rights. Most probably, we are running out of aquifer. If we continue growing as we are at present, in the next 26 years by the best-case scenario (USGS) we will accumulate a debt equal to at least 36 years of all of our water rights. At the same time, according to the SEO method, our accumulated debt would be much less but we would be using virtually all of our water rights to repay the river, with a very grim future wherein our "interest payment" would soon exceed our total "income." The Current Trend Projection table shows the "financial statements" for a few selected years according to the USGS model for depleted river flow and the amount "borrowed" from aquifer storage (quantities are acre-feet per year; an acre-foot is about 325,000 gallons).

It should be fairly clear that the more we pump, the more we put back into the river. With the latest USGS numbers the return nicely offsets the depletion and the State Engineer should be satisfied that the river is "whole," for now. But, take special note that we are reduced to splitting scientific or perhaps just engineering hairs when deciding Albuquerque's future based on streamflow depletion: today the 'disputed' quantities are so small relative to the total flow of the Rio Grande, which is about 1,210,000 acre-feet per year (long-term average) entering the basin, that they cannot even be determined except also by the use of long-term, repeated measurements and statistical analysis. One thing is certain: by 2020 the effect will be great enough that we will be able to measure with certainty which method is correct, but it will be too late to matter.

Are we adding water to the river or taking it away; are we using up our water rights or sending them to Texas and Mexico? Regardless of these issues and whether you use SEO or USGS numbers, there are two inescapable problems of greater concern to Albuquerque: the annual debt is getting larger, as is the depleted flow in the Rio Grande (which can be thought of as the interest on the debt). It is a continuous spiral that with the past and recent water-management approach we can stay ahead of only by continuing to

Current Trend Projection					
				USGS	SEO
	1959-60	1979-80	1993-94	2020	2020
What do we do with it?					
Pumped	34,300	86,400	123,000	177,000	166,519
Returned to river	20,743	39,383	61,891	88,500	83,260
Consumed	13,557	47,017	61,109	88,500	83,251
Where does it come from?					
Depleted flow (SEO)	33,075	48,655	81,479	--	142,319
Depleted flow (model)	13,100	38,000	53,000	77,000	
Borrowed storage	13,600	48,100	67,800	95,900	24,200
Taken from bosque	7,000	1,000	2,500	4,700 not considered	
Net River Gain (+) or Loss (-)					
State Engineer	-12,332	-9,272	-19,588	--	-59,060
Model	+7,643	+1,383	+8,891	+11,500	--

pump more and 'flush' more each year -- that is, grow more. If we ever stop growing, our debt soon will catch us. However, whether you are professionally or personally pro-growth or against it, almost anyone will concede that geographic, resource, or political barriers eventually will slow or stop Albuquerque's municipal infrastructure growth and we may be in serious trouble with our water supply unless changes are made very soon. In the present situation, we can continue to grow only if we can continue to borrow as much or more than our income (total water right).

To be totally fair, while the SEO method deliberately and defensibly over predicts the effect of pumpage on the river, it is very probable that the USGS model under predicts that effect (the reasons are documented in the 1995 report). Somewhere in between is the probable correct number. Because the USGS model is the most optimistic for Albuquerque's water-rights future—and that future is grim—and the SEO model is a worst-case situation, the conclusions above still hold true.

The extent of the aquifer relative to future growth has now also become important. Albuquerque has vastly outgrown the areal extent of the "world-class aquifer" that it accidentally developed in the 1950's and 1960's and is now in the situation of Rio Rancho where, because the aquifer is only a fraction as good as beneath Albuquerque's northeast heights, the extent of the well fields needed to support growth has to be several times larger than the urban area that is served. Take special note of the fact that development on the mesa west of the volcanoes cannot possibly be supported by local ground-water resources and will have to be supported or at least supplemented by imported water; presently there is no infrastructure for the west mesa to import either ground water from the valley, which is currently near an optimum and "politically correct" production level, or more probably out of necessity, treated Rio Grande water. Using surface water will immediately impact our water rights but may be the most practical way to take advantage of them.

Albuquerque is hooked on quick-and-easy solutions. That's the way we grew during and after the war. Therefore, we will simply opt to drill more wells, buy more plumbing, and postpone a head-on confrontation with the depletion-of-surface-water-rights issues. Where will Albuquerque's expanded well field(s) be located to meet our planners' vision of the future? Virtually all of the aquifer in the non-Pueblo northern part of the Basin is fully developed by Rio Rancho, so that area is ruled out. To the west past the volcanoes is not a likely possibility because wells there yield 1/10 to no more than 1/2 of a normal Albuquerque East Mesa well, and usually exceed present EPA standards for heavy metals, most notably arsenic. That leaves the Pueblos themselves (Cochiti, Isleta, San Felipe, Sandia, Santa Ana, Santa Domingo, Zia) or to the south to areas around Los Lunas and Belen. These are promising areas for ground-water development. Securing the water from the Pueblos or other areas would pose many problems and large infrastructure expenses but offer many benefits.

Also, be warned that integrating water into our current infrastructure from a centralized surface-water facility or from outlying new well fields will be difficult and expensive. Albuquerque's system is gravity driven and divided into 37 trunk and zone areas. Trunks are main lines that run east-west, up and down hill, and interconnect water-pressure zones. There are three trunks east of the river and two trunks west of the river. The trunk lines are fairly large and can move enough water between zones to satisfy the peak demand for at least one zone that might have a well-field failure. The situation is very different for the north-south connection along zones and between trunks. Connection between trunks at equal pressure zones is very limited both because the lines are small and because there are no booster pumps to move water between trunks at the same pressure zone. Finally, not one water line, however small, crosses the river. Our current infrastructure is designed to be decentralized and compartmentalized. It is not designed or able to distribute water imported from centralized or regional sources outside of the 37 semi-autonomous service areas.

The conservation program certainly will help our situation. The primary reason that it will help is that considerable effort is directed at reducing irrigation of high-water-use grasses and plants in the summer. Summer water demands are almost twice the winter demands and virtually all of this peak demand is consumed (lost forever) by evapotranspiration. (Gary Daves, with the City, often says that "wet wastewater is better than no water at all.") Meanwhile, wastewater return is almost constant from winter to summer. By promoting or requiring attractive xeriscaping (not "zeroscaping"), Albuquerque can greatly reduce its peak summer pumpage and "rate of borrowing", slowly reduce its interest payments, and still keep approximately the same return-flow credits. A major coincidental benefit is that less peak-demand infrastructure would be needed (for example, the proposed and locally protested Atrisco 5 and Armijo 2 wells might not be needed if summer irrigation with city water were reduced in the southwest valley trunk).

The suggested new surcharge-rate structure for excessive water use would have been an effective part of the conservation program. Ten percent of the residential users in Albuquerque account for almost 30 percent of the total residential water use. In addition, most of these users are located in the heights east of about Eubank where their water rate falls short of the cost of water delivery (one small area only pays about one half of the cost of water delivery). In effect, the rest of the Albuquerque users, especially those at the lowest altitude in the valley, are subsidizing these people to waste water!

Once conservation is implemented, the next logical question is "if we aren't using all, or possibly any, of our water rights, what should we do with them?" At present, Albuquerque is leasing the water to other developments, communities, and enterprises throughout the state, or storing the water (at a great loss to evaporation) in several reservoirs. In essence, we are not using the water to our benefit when we should be

> looking toward either reducing our accrued debt or our rate of borrowing. Meanwhile, we are also fostering a dependence by other New Mexico consumers on water that will eventually have to be recalled to meet Albuquerque's needs. Los Campanas, in Santa Fe, is a good example of a new development that presently is dependent on Albuquerque's water and might soon be turned brown for lack of water.
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> The city recently signed a contract with a consulting firm to use the USGS model and other techniques to evaluate the economics and technical feasibility of various methods of using the San Juan-Chama Project water to the city's advantage. There are many possible options but just a few examples include direct treatment and use to meet base-load needs throughout the city, with wells used to meet peak summer demands; direct diversion (the inflatable dam) and treatment; treatment and recharge via injection wells; spread-recharge at arroyo headwaters; and, engineered changes to reduce the efficiency of the riverside drains, perhaps with a French-drain arrangement to collect shallow ground-water for direct use in the trunk system. Also, if the need arose, wastewater could be treated to meet drinking-water standards, injected into the aquifer, and San Juan-Chama water could be used to offset flow loss in the river.
>
> None of these courses of action would be inexpensive. But, something needs to be done to start putting water back into the bank as a nest egg for the future. It is essential that in addition to the current conservation program we, who are both the debtors and investors in the future, begin to take full advantage of all of our current water rights as soon as possible.

For historical information since 1995, consult Nims et al. 2000, for which the executive summary is available as Appendix C-7.

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