CONSTRAINTS ON NEW MEXICO WATER RESOURCE AVAILABILITY
by W. Peter Balleau
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The physical availability of water in New Mexico is over five million acre feet (MAF) per year from streams[1] and 3,000 MAF stored in underground aquifers.[2] Constraints make little or none of the streamflow available for additional uses. New project development is based on transfer of water from previous uses or on use of the large stored volume of groundwater. Often a little of both is required.

The Albuquerque basin water balance illustrates the situation. According to a 1999 draft water budget[3], 1.4 MAF comes into the Albuquerque Basin annually, and half is transmitted through to Elephant Butte and Texas, while half is consumed by riparian and open water evaporation, agriculture or is induced into municipal wellfields. The natural variability of water supplies has provided a surplus since 1981, so that about 2.2 MAF of water in recent decades has been overdelivered to Elephant Butte and Texas. Variability had caused an underdelivery in the earlier decades. How do new project developments acquire water under these circumstances?

ALTERNATIVE SOURCES OF WATER

The alternative approaches to obtaining water for a new development project are listed below.

1. Use an existing water right
   - Cities and government bodies (reserved rights)
   - Other public or private water systems
   - Irrigation districts
   - Imported water (San Juan-Chama Project)

2. Transfer surface water from former use to new use (the Border Authority, Santa Fe County approach)

3. Appropriate stored groundwater and transfer surface-water impacts (the Intel, Albuquerque, Rio Rancho, Bernalillo County approach)

The decision about the form of the application for a new water development is among the most important on the path to a successful project. The New Mexico Office

[1] State Planning Office, 1967, "Water Resources of New Mexico Occurrence, Development and Use."
[2] U.S. Bureau of Reclamation, 1976, "New Mexico Water Resources Assessment for Planning Purposes."
[3] Action Committee of Middle Rio Grande Water Assembly, March, 27, 1999.

of the State Engineer (OSE) has recently presented two important changes in administrative practice; a set of administrative guidelines for review of applications to appropriate or transfer water rights[4], and a hydrologic model to calculate the effects.[5]

The guidelines contain objectives, standards and criteria for permit review. The guidelines currently are open for public comment. The draft guidelines require that wells cause no more than 2.5 feet per year of drawdown, and a large area of Bernalillo County is frozen in a Critical Management Area. Total drawdown is limited to 250 feet or less. The OSE model illustrates the method for calculating the hydrologic effects of water use at a new place or purpose of use, which cannot be greater than the extended effects calculated from the former place or purpose. Offset of effects can include return flow, retirement of active exercise, or importation of water. Successful applicants design the form of their proposal (appropriation, transfer or offset) around the understanding of hydrologic effects.

THE FLOWING RESOURCE

The yield of a water basin is counted in two hydrologic components; a flow component (rate) and a stored component (volume). The ratio of the two is the residence time for the system (volume/rate = time). Groundwater and surface streams have markedly different characteristics in this regard, and are used differently to take advantage of these characteristics.

Surface water consists of overland runoff of snow melt or rain, and baseflow. Ground water is the extensive volume of water in the saturated parts of the earth's crust. As to the size of each resource, about 70 percent of the annual output of the world-wide hydrological cycle is discharged as runoff, and 30 percent is discharged through the ground-water component (Lvovitch, 1975)[6]. Surface streams typically flush through a complete cycle of their contents dozens of times each year, whereas the much larger volume contained in ground-water flow systems is cycled out more slowly, commonly on a time-scale of centuries.

Typical streams in New Mexico are water short when compared to the total size of water claims (New Mexico Bureau of Mines and Mineral Resources, 1965)[7]. Even the earliest priorities may not be fully served each year. The order of priority of water claims establishes their utility and, thereby, their value. Later priority implies access to

[4] New Mexico Office of the New Mexico State Engineer, 1999, "Draft Middle Rio Grande Administrative Area Guidelines for Review of Water Right Applications."

[5] Barroll, P., 1999, "Draft Documentation of the Administrative Groundwater Model for the Middle Rio Grande Basin," New Mexico Office of the State Engineer, Hydrology Bureau Report 99-3.

[6] Lvovitch, M.I., 1975, "World Water Balance in Selected Works in Water Resources," Asit K. Biswas—Editor, International Water Resources Association.

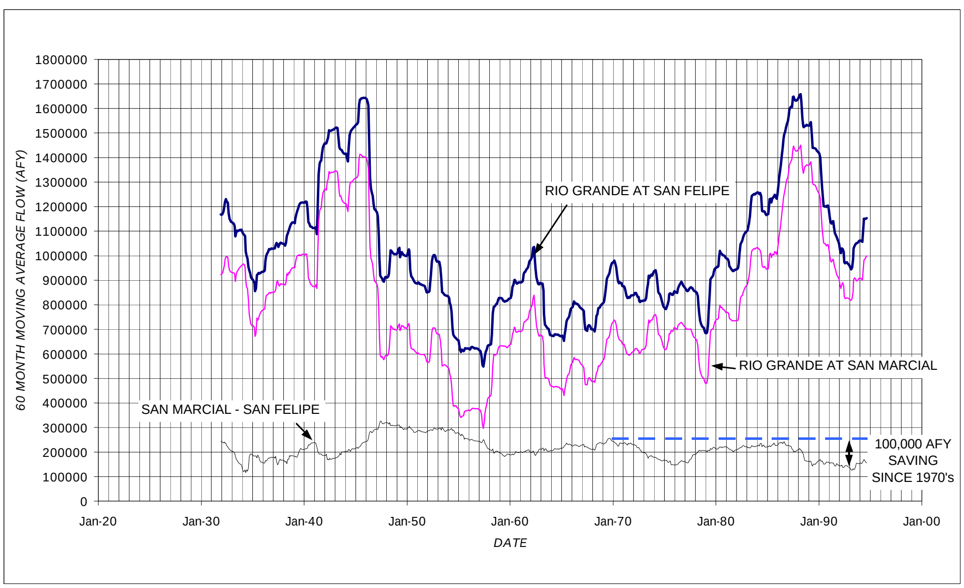
[7] New Mexico Bureau of Mines and Mineral Resources, 1965, "Mineral and Water Resources of New Mexico," New Mexico Institute of Mining & Technology, Bulletin 87.

a lesser duration of flow and a correspondingly larger fraction of empty water claims. Many later priority water claims are predominantly empty. The senior users often represent the only water claims with a substantially full natural supply. The most-senior surface water users can be affected by diversions from ground water.

Essentially all water supplies are presently in use, although the degree of protection for those uses varies greatly. New purposes for using water accompany economic change and require a transfer from the former use. The new purposes usually produce higher economic benefits, and a greater capacity to pay the costs of obtaining water. When water rights are transferred to uses of more value to society, fair marketplace also transfers economic benefits to the prior owner of the water resource. Water flows to wealth, while wealth properly flows to the prior user of the water in an equitable exchange.

The historical trends in surface-water supplies of a Middle Rio Grande Basin (MRGB) are illustrated on Figure 1 showing the record of gaged river flow at San Felipe at the upstream part of the MRGB, and at San Marcial, the station measuring deliveries out of the MRGB. The difference between the two stations shows that the MRGB reach depletes the flow of the river between 320,000 acre feet per year (AFY) in the 1950s to 120,000 AFY in the 1990s. The San Juan-Chama Project has imported 51,500 AFY from 1972 to 1995 (Rio Grande Compact Commission Reports, 1972 to 1995)[8]. Municipal return flow adds another 60,000 AFY from basin storage. In recent decades, the net yield of the MRGB has increased by 100,000 AFY.

FIGURE 1. HISTORICAL TRENDS IN SURFACE-WATER SUPPLIES



8 Rio Grande Compact Commission Reports, 1972 to 1995.

THE STORED RESOURCE

The stored volume available in the basin includes the contents of the river channel, the surface-water reservoirs and the groundwater reservoir. Stored water is not static in either case, but is the volume that fills the system and continually is replenished by the flux components discussed above.

The surface reservoirs that are dedicated to the MRGB include El Vado, Heron and some fraction of Abiquiu and Cochiti, with typical storage totaling about 600,000 AFY of MRGB contents (Ortiz and Lange, 1997)[9] (Table 1).

TABLE 1. SURFACE-WATER RESERVOIR CAPACITIES

Reservoir	Capacity (AF)	Storage End of Water Year 1996 (AF)
Heron Reservoir	401,300	335,150
El Vado Reservoir	186,250	45,160
Abiquiu Reservoir	1,198,500	145,510
Cochiti Lake	502,330	56,560
Jemez Canyon Reservoir	172,800	18,110
Totals	2,461,180	600,490

The groundwater reservoir is the largest stored resource in the basin. For the illustrative case of 400 feet of drawdown throughout the basin, the groundwater reservoir holds about 91 million acre feet (MAF) (Table 2) of recoverable water. If the OSE requires a 250-foot limit on drawdown, the available volume will be about 57 MAF. In this estimate the drawdown is limited by the 250-foot to 400-foot threshold of Santa Fe Group subsidence (Haneberg, 1996)[10], although drilling has shown potable

[9] Ortiz, D. and Lange, K.M., 1997, "Water Resources Data New Mexico Water Year 1996," U.S. Geological Survey Water-Data Report NM-95-1.

[10] Haneberg, W.C., 1996, "Depth-Porosity Relationships and Virgin Specific Storage Estimates for the Upper Santa Fe Group Aquifer System, Central Albuquerque Basin, New Mexico," New Mexico Geology, Vol. 17, No. 4.

recoverable water to depths below 2,000 feet (Brown, and others, 1996[11], and Shomaker, and others, 1994)[12].

TABLE 2. GROUNDWATER RESERVOIR CONTENTS

	Area (Acres)	Specific Yield	Dewatered Thickness (ft)	Volume of Water (AF)
Albuquerque Basin Model	1,518,080	0.15	400	91,084,800
Bernalillo County	741,760	0.15	400	44,505,600

The stored aquifer source is equivalent to about 100 years of average river flow, and is 150 times the total surface-reservoir contents. The physical water resource available to the MRGB is summarized in Table 3.

TABLE 3. MAGNITUDE OF WATER RESOURCE IN THE MIDDLE RIO GRANDE BASIN

	Surface Water	Groundwater	Total
Flowing Resource (AFY)	1.2 million	0.14 million	~ 1.3 million AFY
Stored Resource (AF)	0.6 million	91 million	92 million AF
Residence Period (years)	0.5	650	70

About one MAF of groundwater storage has been depleted through 1992 (Thorn, and others, 1993)[13]. Despite reports of a locally diminishing aquifer (City of Albuquerque, 1997)[14], the aquifer storage remains the major source of available water in the MRGB. Four major applications to appropriate 80,000 AFY of groundwater for future needs are pending in early 1998 to serve the City of Albuquerque, suburban cities and the County of Bernalillo.

Overall physical availability is not a management concern when usage is about one third of the renewable surface-water supply and one thousandth of the stored

[11] Brown, F.L., Nunn, S.C., Shomaker, J.W. and Woodard, G., 1996, "The Value of Water," Report to the City of Albuquerque in response to RFP95-010-SV.
[12] Shomaker, J.W., Finch, Jr., S.T. and Pearson, J.W., 1994, "Effects of Pumping Water-Supply Wells Intel Corporation Sandoval County, New Mexico," John Shomaker & Associates, Inc.
[13] Thorn, C.R., McAda, D.P. and Kernodle, J.M., 1993, "Geohydrologic Framework and Hydrologic Conditions in the Albuquerque Basin, Central New Mexico," U.S. Geological Survey. Water-Resources Investigations Report 93-4149.
[14] City of Albuquerque Public Works Department, 1997, "City of Albuquerque Water Resources Management Strategy Evaluation of Alternatives and Strategy Formulation Summary Report."

volume. The limitations lie in the specific effects of development on the local structures and the external administrative requirements for water rights, compacts and treaties. New projects are constrained primarily by accounting for effects on required pass-through deliveries to Elephant Butte.

The OSE administrative model will reduce a lot of current uncertainty in the calculation of effects of wells on streams. Aquifer parameters are specified in the model, rather than being variables. A higher transmissivity or a lower storage coefficient for the aquifer being developed will cause a quicker response in the interrelated stream. Transmissivity, indicating how readily water is transmitted through the aquifer under a unit hydraulic gradient, is measured as the volume of water transmitted per unit of time through a unit width of the aquifer ($L^3/T/L$). Greater transmissivity means greater response at the interrelated stream. Storage coefficient, indicating the fraction of the volume of dewatered aquifer space that yielded water, is a dimensionless ratio. Smaller storage coefficient means greater response at the interrelated stream. Aquifer characterization has been a problem, and is less of a problem with an administrative model adopted.

An applicant for approval of a new water management operation seeks new benefits, a protestant seeks to avoid new costs and the administrative officials seek to promote public values such as efficiency, conservation and community (Tarlock, 1996)[15]. Some of the types of effects to be assessed and an appropriate management response involve, for example, a surface supply shortage which can be addressed by a market exchange with administrative review, aquifer depletion which should be considered a beneficial investment for the future and the hazard from land subsidence which requires all users to manage the local groundwater level by site specific drawdown and recharge operations.

LIMITS OF WATER DEVELOPMENT

Some limits to growth of water consumption in the MRGB, including physical and administrative limits, are listed in Table 4. This listing tends to illustrate that the MRGB water use will reach a water rights and compact limit at about 300,000 AFY before it reaches a physical limit.

[15] Tarlock, A.D., 1996, "Water Law," In Water Resources Handbook, Mays, L.W.—Editor in Chief. McGraw-Hill.

TABLE 4. PHYSICAL AND ADMINISTRATIVE LIMITS ON WATER USE IN THE MIDDLE RIO GRANDE BASIN

Irrigation Water Rights	126,300 AFY (OSE, 1983)
Municipal Water Rights	96,000 AFY (Balleau, 1994)
Rio Grande Compact (Average Year)	261,000 AFY (New Mexico Statutes 1978 Annotated, 1997)
San Juan-Chama Project Imports	51,500 AFY (Rio Grande Compact Commission Reports, 1972 to 1995)
Tributary Inflow	227,000 AFY (Thorn, et al, 1993)
Rio Grande Inflow	1,210,000 AFY (Thorn, et al, 1993)
Virgin Flow, Predevelopment	3,060,000 AFY (Natural Resources Committee, 1938)
Aquifer Stored Resource	91,000,000 AF

Today's use of water for the established pattern of agricultural, background and municipal purposes cannot grow to a larger net amount of water without new interstate agreements. Instead of growing, the established patterns are shifting as they have in the past, with increased municipal and industrial uses and reduced agricultural and background use. Transfers of use are the order of the day for surface water. Conversion from natural background uses to managed permitted uses is a major historical trend. Abundant stored groundwater remains to be appropriated from sites where transfers can offset associated surface-water effects.

WATER-RIGHTS ADMINISTRATION

New Mexico has among the highest density of water professionals in the nation. Based on professional society membership, New Mexico has 5 times the number per capita as New York or Texas. The founding fathers of modern ground-water hydrology, O. E. Meinzer, C. V. Theis, M. S. Hantush, and C. E. Jacob, did their original work in New Mexico. The state is rich in water expertise. There are two experts for every water issue.

Water-right owners have the mission of creating benefits from their water operations and avoiding costs imposed by other water operations competing for the same water. A regulatory agency has the mission of examining and approving or denying applications for proposed water-management operations based on legal standards. The legal standards include impairment of existing uses, resource conservation and public welfare. In this paper, I distinguished the roles as management and administration. It may be useful to view management as looking after the narrow proprietary account, and administration as looking after the broader public-interest account. Other commentators extend management to include public policy-setting, which is subsequently administered by agency officials (Corker, 1971)[16]. However, if management is what owners do to enhance project benefits, then government agencies generally do not "manage the water resource."

Many of the issues of MRGB planning would be removed by having a listing of water-rights quantity, location and seniority. The American Society of Civil Engineers (1987)[17] advised that "The major water adjudications within a hydrologic unit can, if properly handled, offer a solution to many organizational and financing problems which are otherwise extremely troublesome."

Transfer of water to a higher-value purpose of use requires a corresponding payment to the owner of the former purpose of use. Also required is an administrative examination of accounting of effects on rights, conservation of the resource and public welfare.

CONCLUSIONS

1. The water resource in the MRGB consists of about 1.3 MAF of annually renewable water, and 57 to 92 MAF of stored reservoir contents. Both the renewable and the stored resource exceed the current and projected level of use in the basin. The stored resource in the aquifer is large and its continued use is essential for the future of the basin.

2. Uses are not limited by the physical supply, but by compact and treaty agreements to deliver most of the physical supply to downstream sites. The working principle for the future involves transfers of value to existing users and corresponding transfers of water to new users. The design of an application for appropriation, transfer, or offset is critical. Hydrologic effects must be understood before application.

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[16] Corker, C.E., 1971, "Groundwater Law, Management and Administration," National Water Commission, Arlington, VA.

[17] American Society of Civil Engineers, 1987, "Ground Water Management," ASCE Manuals and Reports on Engineering Practice No. 40, Third Edition.

3. Managers and owners of water operations must remain able to propose beneficial new project operations that enhance the value of water in the basin. The ability to adapt to new opportunities is aided by clear administrative criteria. The greatest shortcoming in basin administration is the lack of a court decree of water-right priorities and amounts. Without a starting position, water cannot move.

4. The management, administration, and science of the basin will be better in the future, and will support a larger community of users with less impact on the background environment.