Climate, Groundwater, and Population Growth

In many urban areas in the Southwest, rapid population growth plays a key role in determining the ability to strike a balance between groundwater withdrawals and aquifer recharge. Arizona is the second-fastest growing state in the nation, with a 6.4 percent growth rate between April 2000 and July 2002. New Mexico ranked 23rd for the same time period, but individual counties still had growth rates of more than 20 percent, as Table 1 illustrates (1).

The combination of climatic variability and population growth is likely to have more notable consequences on Arizona and New Mexico than would either factor alone. To see how these factors might interact, the CLIMAS Project (home of END InSight) examined the water budgets (supply and demand figures) of five Arizona cities under drought conditions of varying degrees to identify how much groundwater mining (see sidebar below) would be required to meet the needs of expanding populations. The full report is available at http://www.ispe.arizona.edu/climas/pubs/CL1-00.html (4).

The analysis started with the 1995 water budgets for five Arizona locations: the Phoenix Active Management Area (AMA), the Tucson AMA, the Santa Cruz AMA (where the border city of Nogales is located), the Sierra Vista subwatershed, and the subwatershed of Benson. We extrapolated how projected population increases might increase water demand, including plans for supplementing water supplies.

We then identified the most severe one-, five-, and ten-year droughts for the climate divisions in which the study locations were located. We used winter (November through April) rainfall totals for four of the five areas because hydrologists believe that in these

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Table 1. Population Growth for Arizona and New Mexico, 1990–2000.

Location	Growth rate, 1990-2000	Actual number of new residents
ARIZONA (2)	40.0%	1,465,293
Maricopa County (Phoenix)	44.8%	950,048
Pima County (Tucson)	26.5%	176,789
Coconino County (Flagstaff)	20.4%	19,729
Cochise County (Sierra Vista)	20.6%	20,131
NEW MEXICO (3)	20.1%	303,977
Santa Fe County (Santa Fe)	30.7%	30,172
Doña Ana County (Las Cruces)	28.9%	39,172
Bernalillo County (Albuquerque)	15.8%	76,101

Why groundwater "mining"?

Hydrologists believe that most of the water in the vast aquifers underlying Tucson and Phoenix was deposited during the last ice age, when huge freshwater lakes covered much of the Southwest. These ice age waters eventually percolated down to form the aquifers that underlie much of the region (6). Due to the current aridity of the region, a relatively small portion of the water pumped out of the aquifer can be replaced by natural recharge; thus a significant portion of groundwater is a non-renewable resource and must therefore be "mined" in much the same way fossil fuels deposited during earlier geological times are mined.

Table 2. Percentage of total water supply likely to be obtained through groundwater mining in various scenarios.

Location	1995[1] or 1990[2] Population, Average Climate	2025 Population, Average Climate	2025 Population, Driest Year	2025 Population, Driest Five-Year Period	2025 Population, Driest Ten-Year Period	2025 Population, Driest Ten-Year Period, Additional Condition[3]
Phoenix AMA	20	24	68	47	39	59
Tucson AMA	*70	15	36	28	25	69
Santa Cruz AMA	17	20	40	35	33	60
Benson Subwatershed	29	30	78	56	44	43
Sierra Vista Subwatershed	25	32	76	56	47	49

*Note that in 1995 Tucson was not yet using CAP water; deliveries began in 1998.
[1]1995 population figures used for Phoenix AMA, Tucson AMA, Santa Cruz AMA
[2]1990 population figures used for Benson and Sierra Vista Subwatersheds
[3]Additional Conditions: Phoenix AMA – No CAP water; Tucson AMA – No CAP water; Santa Cruz AMA – NIWTP treated effluent discharged cut by 2/3; Benson Subwatershed – Higher population projections; Sierra Vista Subwatershed - Higher population projections

Growth, continued

areas, most summer precipitation is lost to evaporation and runoff before it has a chance to infiltrate the aquifer. For the Nogales AMA, however, we used year-round rainfall, because the aquifer in this area is shallower, more sensitive, and responds directly to summer, as well as winter, rainfall.

In addition to varying the population figures and precipitation totals, we also examined the impacts of different water supply and use scenarios relevant to each location. For example, in each location we calculated the impacts of eliminating agriculture, because a reduction in agricultural activity is often cited as a means by which urban areas might cope with long-term drought.

We also calculated the impacts of Phoenix and Tucson having their Central Arizona Project (CAP) allocations of Colorado River water cut. This could occur in the event of a severe drought throughout the western United States, because these Arizona cities have junior rights to river water (see the CLIMAS report on Arizona water law and policy in response to climate at http://www.ispe.arizona.edu/climas/pubs/CL2-01.html [5] for a more detailed explanation).

In the Santa Cruz AMA, we included a scenario in which Mexico retains a greater share of the effluent it currently sends to the Nogales International Wastewater Treatment Plant. The treated water is discharged into the Santa Cruz River in Arizona and supports a rich riparian habitat, in addition to forming an important component of the area's annual aquifer recharge.

In Sierra Vista and Benson, additional population projections, which some say more accurately reflects the area's growth potential, were included to assess the impacts of population pressure beyond the official projections.

For all scenarios, we calculated a the percentage of the total water demand that could not be met by renewable supplies (including natural and intentional groundwater recharge). This bottom line amount would have to be compensated for through groundwater mining. Table 2 shows a sample of the results.

The results of these scenarios show that climatic variability could necessitate a great deal more groundwater pumping than is currently necessary, particularly when combined with population growth and changes in water supply and land use.

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Is Population Growth Really the Issue?

Dr. Gary Woodard of the University of Arizona conducted research in the 1980s that showed how indoor water demand (water uses that feed into sewer or septic systems) differs from outdoor demand (uses that lead to most of the water evaporating). Indoor demand is a function of the number and type of people; it doesn't matter much whether they live in large families or alone. Outdoor demand, on the other hand, is NOT a function of the number of persons in the household. Turf needs the same amount of irrigation regardless of whether the house it surrounds is occupied by one person or six; same with evaporation from a pool.

Indoor and outdoor uses have fundamentally different impacts on a basin's water balance. Indoor uses basically move water from one point to another and perhaps affect the water quality. For example, when you shower, groundwater is pumped from one part of the basin, transported to your home, and then is carried off by the sewer system to another part of the basin. It isn't "used up"; it can be treated and reused or recharged into the aquifer. Outdoor uses, by contrast, are consumptive uses. When the water evaporates from a pool or is transpired by landscape plants, it's lost to the basin.

Several socio-demographic trends are decreasing the size of households, including lower fertility rates; longer life expectancies; more single-parent households; lower mortgage rates; and more people, especially retirees, having multiple homes. In addition, the percent of Americans that own their homes is at an historic high. All this means there are more residences (and landscapes and pools and gardens) for a given population than ever before. And that means higher rates of outdoor, consumptive water demand.

References

(1) U.S. Census Bureau. USA statistics in brief: state populations. Accessed at http://www.census.gov/statab/www/part6.html on Jan. 17, 2003.

(2) FedStats. Arizona MapStats. Accessed at http://www.fedstats.gov/qf/states/04000.html on Jan. 17, 2003.

(3) FedStats. New Mexico MapStats. Accessed at http://www.fedstats.gov/qf/states/35000.html on Jan. 17, 2003.

(4) Cater, R. H., P. Tschakert, and B. J. Morehouse. 2000. Assessing the sensitivity of the Southwest's urban water sector to climate variability: case studies in Arizona. CLIMAS Report CL1-00. Institute for the Study of Planet Earth, University of Arizona, Tucson. Available at http://www.ispe.arizona.edu/climas/pubs/CL1-00.html.

(5) Cater, R. H., and B. J. Morehouse. 2001. An examination of Arizona water law and policy from the perspective of climate impacts. CLIMAS Report CL2-01. Institute for the Study of Planet Earth, University of Arizona, Tucson. Available at http://www.ispe.arizona.edu/climas/pubs/CL2-01.html.

(6) Glennon, R. 2002. *Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters.* Island Press, Washington. p. 28.