

AFTERWORD

There was a whole folklore of water. People said a man had to make a dipperful go as far as it would. You boiled sweet corn, say. Instead of throwing the water out, you washed the dishes in it. Then you washed your hands in it a few times. Then you strained it through a cloth into the radiator of your car, and if your car should break down you didn't just leave the water to evaporate in its gullet, but drained it out to water the sweet peas. Wallace Stegner, Wolf Willow, A History, a Story, and a Memory of the Last Plains Frontier.

As the above quote shows, the best water managers in the West have relied on imagination and creativity to get the most out of a drop of water. Some may argue, however, that the quote describes a far simpler time than the present. Today, we use vast amounts of water for purposes frontiersmen never dreamed; we've become a bit more particular about water quality, too.

In fact, if you have read the first seven chapters of this report and aren't confused by now, then you haven't been paying attention. Tucson's water situation is a fiendishly complex, multi-dimensional conundrum. Each piece of the puzzle is linked to others, some in obvious ways, some in ways that are far more subtle.

This complexity comes from the innate nature of the resource, as well as the relationships among various factors. For instance, as a physical resource, water involves disciplines ranging from chemistry and microbiology to civil engineering and hydrogeology. In a larger context, water resources are often tied to issues like pop-

ulation growth, property rights and quality of life.

While individual aspects of a particular water issue may be well understood by the research community, the interactions are often poorly understood. This is true within the physical sciences, but is particularly acute when the interactions involve physical sciences, social sciences and the humanities.

To further complicate matters, only a limited community consensus exists on what we are trying to accomplish. We all want a reliable, bountiful, sustainable water supply. We demand that it be safe, palatable, and environmentally benign. And we want it provided to our homes, businesses and parks at the lowest possible cost.

We also want fairness, or equity, as each of us defines it. Here is where the consensus starts to break down. For some, equity means traditional uses of water are favored. Others demand economic equity — those who benefit, pay. In practice, this might mean that those continuing to pump groundwater should subsidize those who switch to renewable supplies.

Some want political equity — those who are affected, should decide. This would require new political mechanisms whereby all water users could vote on the candidates and initiatives that determine their water future. And still others are concerned with inter-generational equity. They don't want today's consumption decisions to limit the options and quality of life of future Tucsonans.

We also would like less political strife over water. This can tempt us to put off difficult decisions, perhaps by calling for yet another study. Groundwater overdraft is the sort of problem that is easy to ignore. A declining water table is out of sight and out of mind. There is no perceived sense of urgency, no hard deadlines by which we absolutely must act. And so inaction becomes a tempting course.

As tempting and politically expedient as it may be, inaction is itself a form of decision-making, but one rarely based on sound analysis or the expressed preferences of citizens. There are other compelling reasons to act sooner rather than later. Options may diminish over

time, or grow more expensive. Political costs often rise over time, too.

The decisions we make, or avoid making in the next few years are likely to have important, lasting consequences. Assuming we act, who should decide on our course? Are technocrats or self-appointed water experts best suited to make the hard decisions? Not likely. The former tend to have deep but narrow knowledge; the latter may offer appealingly simplistic but unproven solutions.

The authors of this report also decline to make recommendations, for two reasons. First, some of the most informed water researchers are among the least certain of how to proceed. (We get confused at times, too.) Second, and more importantly, physical and social scientists simply have no basis for making policy decisions. These water resource issues aren't about right and wrong decisions. They are about values and priorities, expressed as choices with social consequences.

Does that mean voters must directly decide details of our water strategy, as they have been asked to do recently through initiatives? Is it fair or reasonable to expect a busy, preoccupied electorate to become informed on the nuances of groundwater hydrology and the finer aspects of alternative water purification systems? Clearly not. Rather, it is up to the technocrats to describe possible courses of action, and their respective costs and tradeoffs. Voters must express their beliefs, values, and preferences with respect to water. Then our elected officials must do the heavy lifting of turning this information into sound, long-term water policy.

How then can the reader help make decisions about Tucson's water future? Part of the

process is examining your personal goals and values and then considering what options will best achieve your objectives. No single "magic bullet" is available to assure a long-term, high-quality water supply. Most choices have both benefits and drawbacks.

BALANCING THE BUDGET

We invite you, the reader, to work through a series of options in order to shape your recommendations to decision makers. We begin by restating the overdraft problem, and determining how important achieving a sustainable water supply is to you.

A simplified water balance was presented in bar chart form in the Preface (See page vi). This shows that in 1997, water demand in the TAMA totaled some 345,400 acre-feet. Renewable supplies, consisting of natural groundwater replenishment, CAP water, and effluent totaled only 194,500 acre-feet, leaving a water deficit of 150,900 acre-feet of mined groundwater.

A somewhat more detailed water budget is depicted on the adjoining page. This information is graphically depicted as an "octopus" on the following page. The top section of the water budget lists all water sources that contribute to the aquifer, including natural, incidental, and direct recharge. Gains to the aquifer also include underground flow into our aquifer from the Santa Cruz AMA to the south. The center section of this water budget tallies losses from the aquifer, which are mainly groundwater pumping for municipal, industrial, and agricultural uses. Other losses from the aquifer include underground flow from our aquifer into

the Pinal AMA to the north, and evapotranspiration from shallow groundwater.

The bottom portion of the budget represents direct uses of effluent and CAP water, which are renewable supplies. While these uses do not directly affect the aquifer balance, there may be indirect impacts. For example, if CAP water was not available to irrigate some agricultural land, groundwater might be used instead. On the other hand, effluent not used to irrigate a golf course might be left in the riverbed, where much of it would become incidental recharge to the aquifer.

The bottom line of this water budget is the same as in the bar chart in the introduction — we are pumping far more groundwater than is being replaced in the aquifer. This situation is not sustainable in the long run. The only options for approaching or attaining sustainability are making full use of our CAP allocation, severely limiting current and future water demand, or some combination of the two.

TO SUSTAIN OR NOT TO SUSTAIN

How important is a sustainable water supply to you? Sustainability is not an all-or-nothing concept. When using our water supply, we have a range of choices, including the following:

- Try to balance water supply and water demand to guarantee water availability indefinitely;
- Try to prolong the life of the water supply over a shorter term, say 50 or 100 years;

“Wet Water” Budget*

For Tucson Active Management Area, 1997 data (in acre-feet)

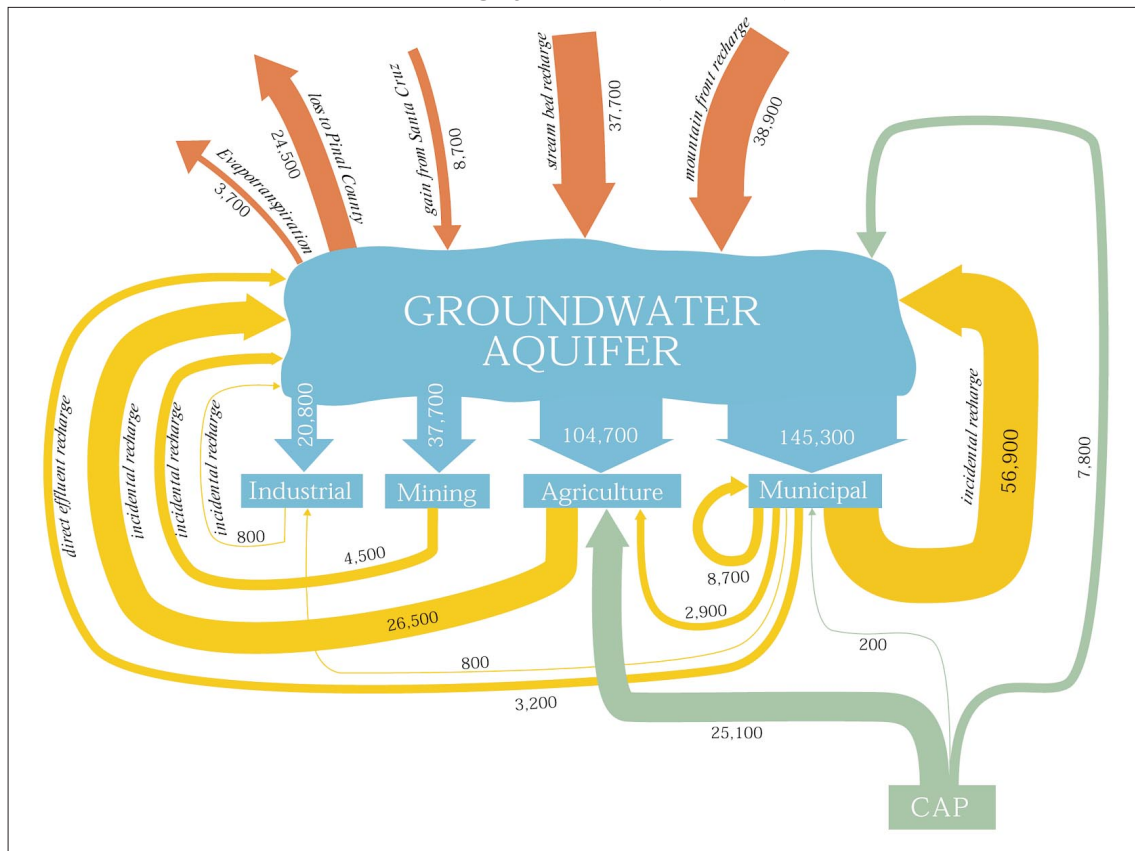
GAINS TO AQUIFER	
GROUNDWATER INFLOW FROM SANTA CRUZ AMA	8,700
RECHARGE	
Natural	38,900
Mountain Streambed subtotal	<u>37,700</u>
Incidental	76,600
Municipal Industrial Agricultural subtotal	56,900
Industrial	5,300
Agricultural	<u>26,500</u>
subtotal	88,700
Direct	7,800
CAP Effluent subtotal	<u>3,200</u>
subtotal	11,000
Total recharge	176,300
Total of all gains to aquifer	185,000
LOSSES FROM AQUIFER	
GROUNDWATER OUTFLOW TO PINAL AMA	-24,500
GROUNDWATER PUMPING	
Municipal	-145,300
Industrial	-57,700
Agricultural	<u>-104,700</u>
Total groundwater pumping	-307,700
EVAPOTRANSPIRATION (from shallow groundwater)	-3,700
Total of all losses from aquifer	-335,900
AQUIFER BALANCE	
Total of gains and losses (overdraft)	-150,900
DIRECT USE OF RENEWABLE SUPPLIES**	
EFFLUENT (Direct Use)	
Municipal	8,700
Industrial	800
Agricultural	<u>2,900</u>
Total direct effluent use	12,400
CAP (Direct Use)	
Municipal	200
Agricultural	<u>25,100</u>
Total direct CAP water use	25,300
Total of direct use of CAP water & effluent	37,700

NOTES ON WATER BUDGET CALCULATIONS

* This budget uses data from ADWR, but differs from ADWR’s “paper water” budgets by considering only the physical use and movement of water. Direct recharge is counted as a gain to the aquifer in the year recharge occurs, not when recharge credits are used. Irrigation with CAP is counted as direct CAP use, not groundwater or *in lieu* “recharge.”

** These uses may indirectly benefit the aquifer by serving as a substitute for groundwater that would have been pumped. Incidental recharge from these uses is already included in the “Gains to the Aquifer” section.

Water budget flow chart. (1997 data)



Sources: Arizona Department of Water Resources, Water Resources Research Center.

- Plan to deplete some parts of the aquifer (Avra Valley, for example) while protecting the central city from subsidence; or
- Use as much water as we want for as long as it lasts.

Current state law directs us to aim towards prolonging the supply into the future, but does not require complete sustainability. This is be-

cause “Safe yield” allows a certain amount of groundwater mining.

People who support sustainability or prolonging the life of the water supply are mainly concerned about:

- Avoiding subsidence;
- Assuring an affordable water supply for future generations;

- Assuring water quality for future generations;
- Complying with requirements of state law;
- Preserving the desert from “urban sprawl” or “overdevelopment.”

People who don’t support sustainability usually feel that:

- The present is more important than the distant future;
- New technologies may be developed over time to solve the problem;
- The problem is too far off to be a concern;
- Information about water supplies and water quality is incomplete or not credible;
- Their family may not be here when the problems arise;

Do you recognize your views in either list? Or do you identify with some statements from both lists? How much do you value a sustainable water supply? What kind of limitations are you willing to impose on others? What sacrifices are you willing to make?

WATER BUDGET SCENARIOS

Conventional wisdom is that most people in the community support either a sustainable supply or at least prolonging our supply. But there are many divergent views as how best to approach this goal. To balance supply and demand we can control water use and/or increase the supply. We can control water use by limiting the number of people using water and/or limiting the amount each person uses. We can also transfer water use from one sector to another (e.g., reduce agricultural activities to save water for other uses). Water supplies can be increased by capturing more rainwater and snow

Supply & Demand Scenarios*

Based upon Approximate Current Levels of Demand by Sector, in Acre-Feet

	Demand (% of current)			Supply	Groundwater Pumping				CAP	Balance [†]
	Muni.	Indus.	Ag.		Muni.	Indus.	Ag.	Total		
Current levels	100	100	100	Groundwater for all sectors	150,000	50,000	125,000	325,000	0	-180,000
	100	100	100	Groundwater for municipal, CAP for others	150,000	0	0	150,000	175,000	-5,000
	100	100	100	CAP for municipal, groundwater for others	0	50,000	125,000	175,000	150,000	-30,000
2X Municipal	200	100	100	Groundwater for all sectors	300,000	50,000	125,000	475,000	0	-273,000
	200	100	100	Groundwater for municipal, CAP for others	300,000	0	0	300,000	175,000	-98,000
	200	100	100	CAP for municipal, groundwater for others	0	50,000	125,000	175,000	300,000	+27,000
2 Mun. ½ Ag. & Ind.	200	50	50	Groundwater for all sectors	300,000	25,000	62,500	387,500	0	-201,000
	200	50	50	Groundwater for municipal, CAP for others	300,000	0	0	300,000	87,500	-113,000
	200	50	50	CAP for municipal, groundwater for others	0	25,000	62,500	87,500	300,000	+99,000
	200	50	50	Half groundwater, half CAP for all sectors	150,000	12,500	31,300	193,800	193,800	-7,000
2 Mun., Ag. & Ind.	200	200	200	Groundwater for all sectors	300,000	100,000	250,000	650,000	0	-417,000
	200	200	200	Groundwater for municipal, CAP for others	300,000	0	0	300,000	350,000	-67,000
	200	200	200	CAP for municipal, groundwater for others	0	100,000	250,000	350,000	300,000	-117,000
	200	200	200	Half groundwater, half CAP for all sectors	150,000	50,000	125,000	325,000	325,000	-92,000

* This table represents a range of supply and demand scenarios for general illustration; it should not be used to make specific future projections. Simplified assumptions (e.g. all groundwater or all CAP for a sector) have been made to clarify the relationships between supply, demand and the aquifer balance.

† This number represents the approximate “wet water” loss or gain to the regional aquifer. The value is calculated as: (net natural recharge [76,600]) - (groundwater outflow [24,500]) - (evapotranspiration [3,700]) - (groundwater pumping) + (incidental recharge) + (groundwater inflow [8,700]). Incidental recharge is itself calculated as 38% of municipal demand (multi-year average), 20% of agricultural demand, and 12% of industrial demand. This balance does not consider factors such as long-term storage through recharge, or changes in incidental recharge rates.

melt, importing and using water from elsewhere and accepting wastewater as a supply for more uses.

Here is where you bring it all together, combining the factual information gleaned from the first seven chapters with your values and preferences, to generate tentative choices. The final step is to see what the consequences of those choices are, and how your choices interact with each other. To do that, we use water budget scenarios.

The table on the preceding page shows ten illustrative water supply and demand scenarios. The left side of the table shows municipal, industrial and agricultural demand expressed as percentages of current demand. The “supply” column describes who pumps groundwater and who uses CAP water under each scenario. (Note that use of effluent has little effect on the water budget bottom line, because nearly all effluent not re-used is directly or incidentally re-charged.) These assumptions about water demand levels and supply allocations on the left side of the table are used to estimate resulting groundwater pumping by sector, CAP usage,

and aquifer balance, as shown on the right side of the table.

The first three scenarios hold demand at current levels. The first scenario shows that if everyone uses pumped groundwater, we have a large deficit in the aquifer. The second scenario suggests that if all growth were halted and groundwater were reserved solely for municipal uses, the aquifer would be nearly in balance. The next three scenarios correspond to an eventual doubling of municipal demand, as population grows. Here, reserving groundwater for municipal uses does not bring the aquifer close to balance. By contrast, using CAP water for all municipal uses actually produces a surplus in the aquifer.

The third set of scenarios combines municipal growth with a halving of industrial and agricultural demand. Note that serving a 50-50 blend of groundwater and CAP water to all sectors nearly balances the aquifer. The final set of scenarios corresponds to a doubling of water demand in all sectors. This could occur, for example, if population growth continued unabated, mining expanded, and tribal water allocations were used to expand irrigated agri-

culture on reservation lands. In such a situation, there is not sufficient CAP water available to bring the aquifer close to balance.

Those of you with Internet access are now invited to try your hand at water budgeting by making your own assumptions. An interactive version of this budget is on the Web at:

<http://ag.arizona.edu/AZWATER/>

Use it to construct a scenario that reflects your values, preferences and sense of fairness. Try out a number of options. For example, you may want to limit water use by controlling population, or by requiring more conservation; or you may want to lessen long-term salinity problems by using less CAP water.

See how close your preferred options come to balancing supply and demand. Remember that if you make some changes, other figures will be affected. For example, if you eliminate agriculture and replace it with naturally vegetated park land, the water savings will be greater than if you replace it with golf courses. If you use more effluent, you will have less incidental recharge. To get close to water sustainability, you will have to make hard choices. When push comes to shove, where are you willing to compromise?