

A RATIONAL WATER POLICY FOR DESERT CITIES

By W. G. Matlock

I. Introduction

Many cities in semiarid regions of scant rainfall are faced with a dwindling water supply. Some are dependent entirely on pumped groundwater, frequently from an aquifer with limited natural recharge and a falling water table. A generally favorable climate continually attracts many people from other areas. Thus city planners are faced with the problem of providing a dependable water supply for a rapidly expanding desert population.

Compounding the problem are the real estate promotions which often attempt to entice purchasers with artificial lakes, expansive grassed areas, shrubs and trees, all of which are significant water users. Developers literally try to create an oasis in the desert. A recent estimate showed that in the Phoenix, Arizona area nine subdivisions, three of which had water-related names, accounted for about 2500 acre-feet of annual water loss by evaporation from lakes, ponds, and fountains (Greaves, 1972). This quantity, although small in relation to total water use in the Phoenix area, nevertheless is sufficient for about 12,500 people. Similar operations are prevalent throughout the southwest.

In many water-short areas a deliberate impression of plentiful water is given. Consulting engineers' reports concerning available water supply for potential developments are usually positive. They often fail to consider existing "demand" on the surface water and groundwater resources. And in the author's opinion the unsuspecting buyers are easily misled. Of course they want to be surrounded by green lawns and plenty of large shade trees, just like they had in Illinois or Michigan or elsewhere.

Seldom are organized campaigns conducted to persuade desert dwellers to conserve or use less water. No penalty is assessed for deliberate waste or excessive use. Water use for washing cars or watering lawns never has been restricted as it has in many humid climates where such a practice is accepted as commonplace by the residents.

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II. Patterns of Water Use in Desert Cities

In the discussion to follow, Tucson, Arizona, is used as an example. Other cities of like size and similar climate would probably serve as well. Tucson is a city of 350,000 located in the Sonoran Desert about 65 miles north of the United States-Mexico International Boundary. An impressive rate of population increase has occurred in Tucson, particularly since the end of World War II.

Tucson is one of the largest cities in the United States, perhaps in the world, which is entirely dependent on a groundwater supply. Approximately 200 wells are currently in use to provide the more than 50 million gallons per day now required. Water levels in the underlying aquifer are falling as the withdrawal in the groundwater basin is probably more than double the natural recharge (Matlock and Davis, 1972). Suburban users increase the deficit. Wells must be deepened or replaced, and new wells must be drilled in developing residential areas to keep pace with the increasing demand for water.

Total water use in the city of Tucson in fiscal 1971-72 was 21,200 million gallons or about 65,000 acre-feet. This represents about 680 gallons per service per day or 180 gallons per capita per day (City of Tucson, 1972). Water use in Tucson has increased at a rate slightly higher than the number of services, an assumed measure of population (Figure 1). A projection by city planners for future use in the area also predicted an increasing per capita per day factor (Schwalen and Davis, 1964).

Water use varies seasonally and in addition is influenced by rainfall variability. Figure 2 shows the relationship between average daily water consumption per service and the average of April to September rainfall at three stations in the Tucson Area. Water use is significantly increased in dry years.

There are no controls on water use in Tucson regardless of purpose. No measurements have been made, but the average homeowner has an estimated 3500 square feet of lawn area, shrubs and trees. This represents a water use of 600-700 gallons per day in the summer or from one-third to one-half of the total use per service on an annual basis. Excessive irrigation water is frequently seen running into the streets.

Many homes have swimming pools which must be considered a "water luxury" because of the evaporation loss and filter wash water. The author's personal experience shows evidence that a swimming pool and associated deck space use less water than a lawn of the same area. Exact quantities of water required for swimming pools are unknown.

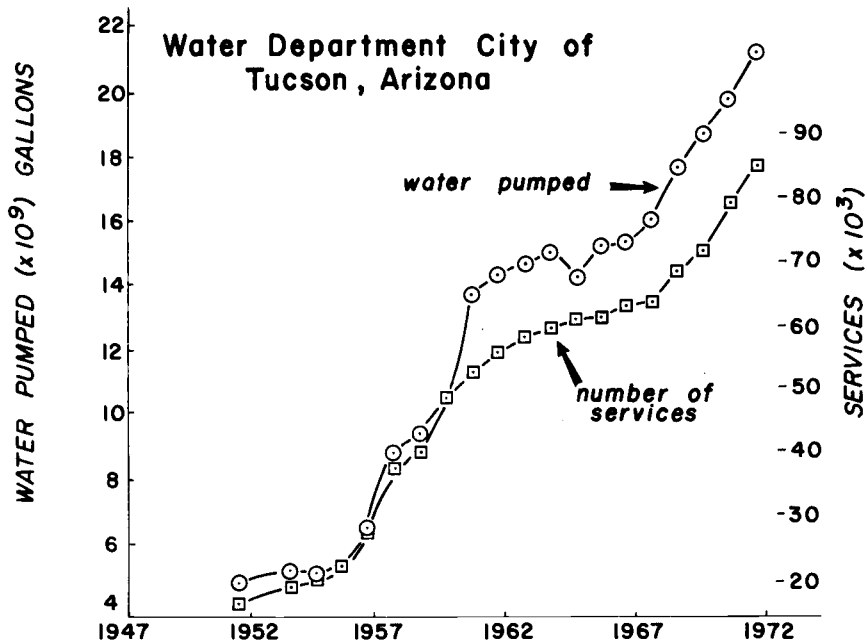


Figure 1 : Number of services and total annual water pumped

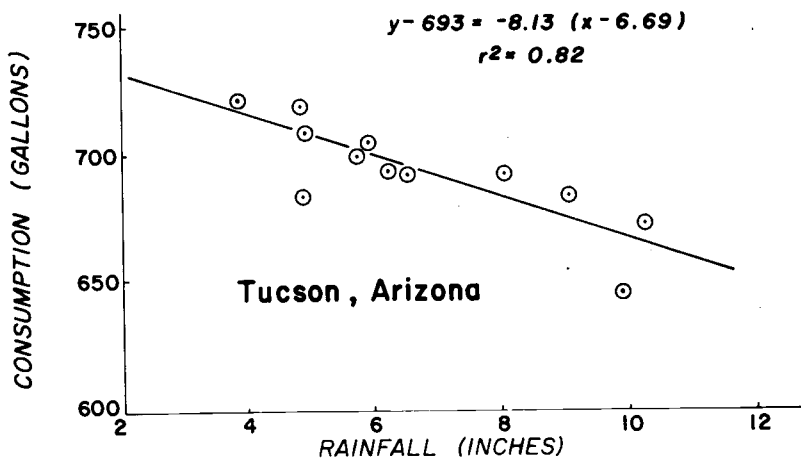


Figure 2 : Daily consumption per service 1960-61 to 1971-72 vs. Rainfall (inches) April - September

Car washing at home is not common in Tucson today. Do-it-yourself car washes are heavily patronized. In this case, the return flow goes to the sewer system.

The cost of water in Tucson has always been low; cost does not seem to have much effect on per capita water use. Table I compares basic cost and total water-use data for Tucson and several other United States cities.

Analysis of Table I shows that cost of water did not affect water use in any one of the ten cities listed. Water use remained relatively constant or increased up to 100 per cent while cost was increasing up to 400 per cent. Pricing policy alone would thus not seem to be effective in reducing water use in a given location at least in present price ranges.

Also of interest, however, is the variation in per capita water use among these cities. Citizens of Tucson in 1970 used more water than all others except those in Albuquerque, Chicago and Phoenix. Oklahoma City residents, on the other hand, used only a little more than half as much as Tucsonans. It should be noted also that water use per capita per day was lowest in Oklahoma City where the cost was half as great. Four of the five "desert cities" are in the top five water users; three of the "desert cities" are among the bottom five cities in water cost.

In a model for forecasting residential water demand, Whitford (1972) considered six factors. Regulation on water use by appliances, pricing policy, public education, housing patterns, supply cost, and use technology were combined in a three-level matrix to predict probabilities of future water use in Baltimore and Phoenix. Among other conclusions Whitford stated that water demand would increase through the years but at a decreasing rate. In-house water use, in general, was not price sensitive but lawn sprinkling was. Lawn sprinkling could also be reduced by public education. Data on residential water use and its components in these two cities were found to be very incomplete. Unfortunately this is true for most cities.

Little information is available on the use of water in households. Gross use figures or rough estimates are available but no measurements have been made of water use for cooking, washing clothes, bathing, cleaning, flushing toilets, etc. Neither swimming-pool nor car-washing requirements have been evaluated.

TABLE I. Water cost and use data for selected cities

		1945	1950	1955	1960	1965	1970
		D E S E R T C I T I E S					
TUCSON	COST	1.50	1.50	2.05	2.67	3.60	3.75
	USE	166	153	161	157	172	215
ALBUQUERQUE	COST	2.12	2.12	2.12	2.12	2.12	3.75
	USE	133	145	143	169	175	264
EL PASO	COST	N/A	3.15	N/A	4.20	N/A	5.00
	USE		134		165		195
LUBBOCK	COST	4.90	4.70	4.70	6.00	8.10	8.10
	USE	110	129	145	143	165	180
PHOENIX	COST	2.00	2.00	2.00	2.40	2.50	3.47
	USE	215	204	201	196	191	232
		O T H E R C I T I E S					
CHICAGO	COST	.55	.60	.90	1.20	1.65	2.06
	USE	244	230	234	233	216	230
LOS ANGELES	COST	1.48	1.48	2.08	2.39	2.90	3.79
	USE	180	190	182	187	171	187
NEW YORK	COST	1.50	1.50	1.50	1.50	1.50	5.25
	USE	146	126	145	157	134*	177
OKLAHOMA CITY	COST	2.63	3.53	3.80	6.35	6.35	7.34
	USE	73	85	94	92	101	119
PHILADELPHIA	COST	.80	.97	1.34	1.73	1.91	2.62
	USE	167	165	177	165	163	188
COST (\$/1000 CUBIC FEET)		USE (GALLONS PER CAPITA PER DAY, INCLUDES ALL					
* WATER SHORTAGE		USE)					

III. A New Water Policy

The limited quantity of water available to desert areas makes its management increasingly important. In most cases a basin-wide water-management policy is required for effective control. Piecemeal attempts are not enough. Some suggestions by the author for an improved water policy for desert cities are given below.

THE POTENTIAL SUPPLY

Four sources of water supply for desert cities are rainfall, runoff, groundwater, and imported water. The potential for use of each varies.

Rainfall. The ultimate source of all water supply is the rainfall. For the City of Tucson this amounts to more than 48,000 acre-feet per year within the city limits alone. If the surrounding drainage basin is included, the total annual rainfall is about 1.5 million acre-feet. Direct use of rainfall in these areas is uncommon, its main benefit coming from the plant growth it supports. Almost no direct recharge to the groundwater aquifer occurs because of shallow impermeable layers and the high evaporation rate.

Runoff. Runoff is a fraction of rainfall; some storms produce very little. Runoff reaching stream channels provides recharge to groundwater supplies. For the area around Tucson runoff ranges from 10 to 30 per cent of the total precipitation. However, runoff from urbanized areas is greater because of more paved streets, roofs, sidewalks, and other impermeable areas, and as population increases the percentage of rainfall which becomes runoff probably will increase as well as total runoff volume. Urban runoff also presents a disposal problem. Runoff in large quantities generally carries a heavy sediment load and presents difficult problems of storage and treatment before direct use or recharge.

Groundwater. As previously discussed groundwater aquifers are an important water resource in desert areas, but in most cases they are already overdeveloped. Ultimately, use of groundwater cannot exceed recharge (natural and artificial) to the aquifer. Future groundwater use must therefore be reduced unless recharge can be augmented. Recharge in the Tucson Drainage basin under existing conditions is estimated as five per cent of total rainfall.

Imported water. Water may be imported from a water-surplus area. For Tucson and similar inland regions this involves either inter-basin transfer or use of desalted sea water. Both of these methods are expensive and require time not only to construct the needed facilities for conveyance, storage and treatment but also to accomplish the necessary political and legal agreements, decisions, and compromises.

POLICY CHANGES

Governmental bodies can institute various policy changes to eliminate or at least reduce the imbalance between water supply and demand. Several such changes are proposed below.

Water use and waste. Restrictions should be placed on water-use luxuries such as swimming pools, subdivision lakes, fountains, etc. Flagrant waste of water should be prohibited or made prohibitively expensive. For example, backflush water from swimming pools should be discharged to the sewer system (for possible recovery), or returned directly to the aquifer through recharge wells. Excess water from car washing or irrigation should be similarly treated.

Pricing. Water pricing should be progressive; that is, each unit of increased use above a reasonable minimum should be charged for at an increasing rate. Prices should reflect true costs, including actual costs of supplying water to the consumer, depletion costs, and research costs. Depletion costs might be based on the estimated cost of supplying water from the most economical alternative source; for example, costs of desalting and transporting water from the Gulf of California to Tucson. Receipts in excess of actual costs should be put in a water "bank" to provide funds for research and developing new sources. Such a pricing policy may not decrease use but at least it will assess costs where they should be.

Salvage, conservation. Runoff from individual properties, homes, storage, and supermarkets should be minimized through use of onsite recharge wells. Property owners/developers should be responsible for recharging, as feasible, increased runoff caused by development. Decreased water use would be promoted by encouraging use of desert vegetation for landscaping, gravel yards, and minimum lawn areas. Sewage effluent should be sufficiently treated so as to make it useable for some purpose.

Capture. Various collection methods should be initiated. Cisterns and other collection systems might be tried to provide water for immediate use. Rainfall collectors can be used in remote areas to provide domestic water (Matlock and Shaw, 1966).

Education. A campaign to acquaint the general public with a new water policy must be inaugurated. Users must know and understand the rationale for the new policy. More efficient use of water where possible and change in life style to reduce water use are both promotable.

Community water uses can be decreased. For example, highway medians might be designed for nonwater use. Citizens could be encouraged to meet their needs for greenery in public parks rather than in their own back yards.

Research. The research needs for increasing water supplies in desert areas are many. Ways to use rainfall directly must be developed. Low-cost methods of increasing runoff from large unpopulated areas must be found. Then ways to recharge or otherwise store the runoff are needed. The feasibility of recharging urban runoff must be investigated and practical methods determined. Costs of all these proposals have to be determined and evaluated.

IV. Summary and Conclusions

Desert living with all its desirable attributes is possible, and perhaps it won't be necessary to restrict population for lack of water. (Space or other requirements may limit it!) The seemingly meager water resources can be so managed to provide the optimum benefit for all concerned. The key is adaptation to the environment and a constant awareness that the desert is not a humid area.

New water-management policies for entire drainage basins are required. Policies must be defined regarding use and waste, pricing, salvage, conservation and capture. Education campaigns will be needed to gain popular support.

Considerable research effort will be required to increase available supplies. Methods to make better use of rainfall and increase recharge must be studied.

Living with less water should result in lower monthly water bills. Reduced areas of lawn, shrubs and trees will also decrease maintenance time and costs, although some homeowners may view yard work as having a hobby or therapeutic value.

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