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# HYDROLOGIC FACTORS AFFECTING GROUNDWATER MANAGEMENT FOR THE CITY OF TUCSON, ARIZONA

by

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## ABSTRACT

Assessment of the basic hydrologic and geologic parameters controlling the occurrence and availability of local groundwater is one of the first steps in formulating any comprehensive water management plan. Each of several parameters must be carefully evaluated both individually and in relation to the other factors which together describe the occurrence and movement of the subsurface water resources. These evaluations are fundamental to the legal and political decision-making framework within which the Water Utility must operate for both short and long-range water management planning.

Recent changes in several hydrologic parameters have been observed throughout much of the groundwater reservoir tapped by numerous users in the Tucson Basin. Accelerated water level decline rates, decreasing production capacities of existing wells, increased hydrologic interference and increased demand for water are all having an impact on our water resource. These conditions must be evaluated before basin-wide groundwater management alternatives can be implemented.

## INTRODUCTION

In regard to the development of a municipal supply of water, the City of Tucson, Arizona holds a rather unique position in that Tucson is one of the largest cities in the United States which is completely dependent upon groundwater. The Tucson Water Utility has no surface water sources upon which to rely in supplying its customers with water. This total reliance upon the subsurface water resources of the area has both positive and negative aspects as shall be explored in this presentation.

## SOURCES OF SUPPLY

To meet the needs of a metropolitan area such as Tucson, whose daily demand for water averages 60 mgd (million gallons per day), requires a tremendous investment in source development, transmission and delivery systems. To provide an adequate year-round supply, the Tucson Water and Sewer Department operates and maintains approximately 300 wells which are located throughout the Tucson Basin and Avra Valley.

### INTERIOR WELL FIELD

Of the total amount of water pumped by the Utility to meet the needs of the City, approximately 60 percent is obtained from some 200 wells which are located within the area which is referred to as the "interior well field." The interior well field is depicted on Figure 1 and generally corresponds to the principal incorporated portions of the City. The greater percentage of these wells were not constructed by the Utility, but rather were acquired through the purchase of private water companies over the past three decades. In recent years, the Utility has augmented these wells by the construction of more modern installations in an effort to increase overall efficiencies and reduce operation and maintenance costs associated with a number of the older, less efficient wells in the system.

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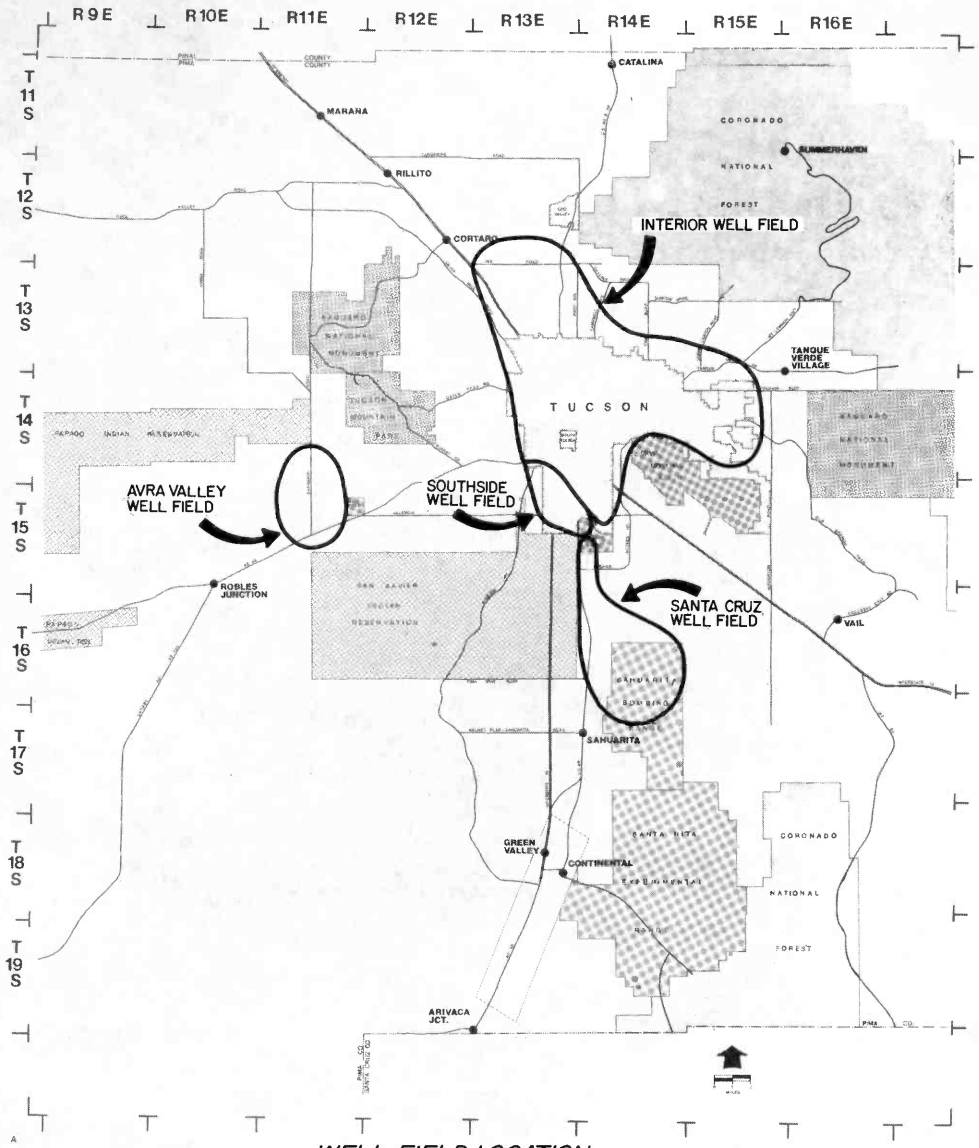



*WELL FIELD LOCATION*

(TUCSON & AVRA BASINS)

FIGURE I

## SOUTHSIDE WELL FIELD

As shown on Figure 1, the Southside Well Field is located generally south of the downtown area of the City and along the channel of the Santa Cruz River. Presently, some 13 wells provide about 5 percent of the total amount of water pumped by the Utility. This well field is important to the Utility in ways other than its value as a supply potential. This well field lies topographically and hydrologically upgradient from the City and affords the benefit of gravity flow into our distribution system. Also, many of the wells in this area receive some measure of recharge in response to runoff events in the Santa Cruz River. The past several seasons have not witnessed significant surface flow in the Santa Cruz; however, the unprecedented events of this winter have increased the amount of water in storage in the area of this well field. This recharge is not permanent, but it is offsetting to a degree.

## SANTA CRUZ WELL FIELD

South of the City, beginning near the northwest corner of the municipal airport and extending in a generally linear fashion to an area northeast of Sahuarita, Arizona is located the Santa Cruz well field. This field is indicated on Figure 1. There are presently 26 wells in this field which together provide about 20 percent of the water pumped by the Utility. This field, as does the Southside well field, lies upgradient from the City both physiographically and hydrologically, and represents an important source of water for the Utility. Competition for groundwater in this area has been intense.

There has been a great deal of interest generated recently concerning the Santa Cruz Well Field area. It has been the subject of an Arizona Supreme Court decision which favored local agricultural interests and has been included in litigation imposed on all water users in the basin by the Federal Government on the behalf of the Papago Indians. The result of these legal issues poses a serious question as to the future availability of the Santa Cruz well field as a source of municipal supply.

## AVRA VALLEY WELL FIELD

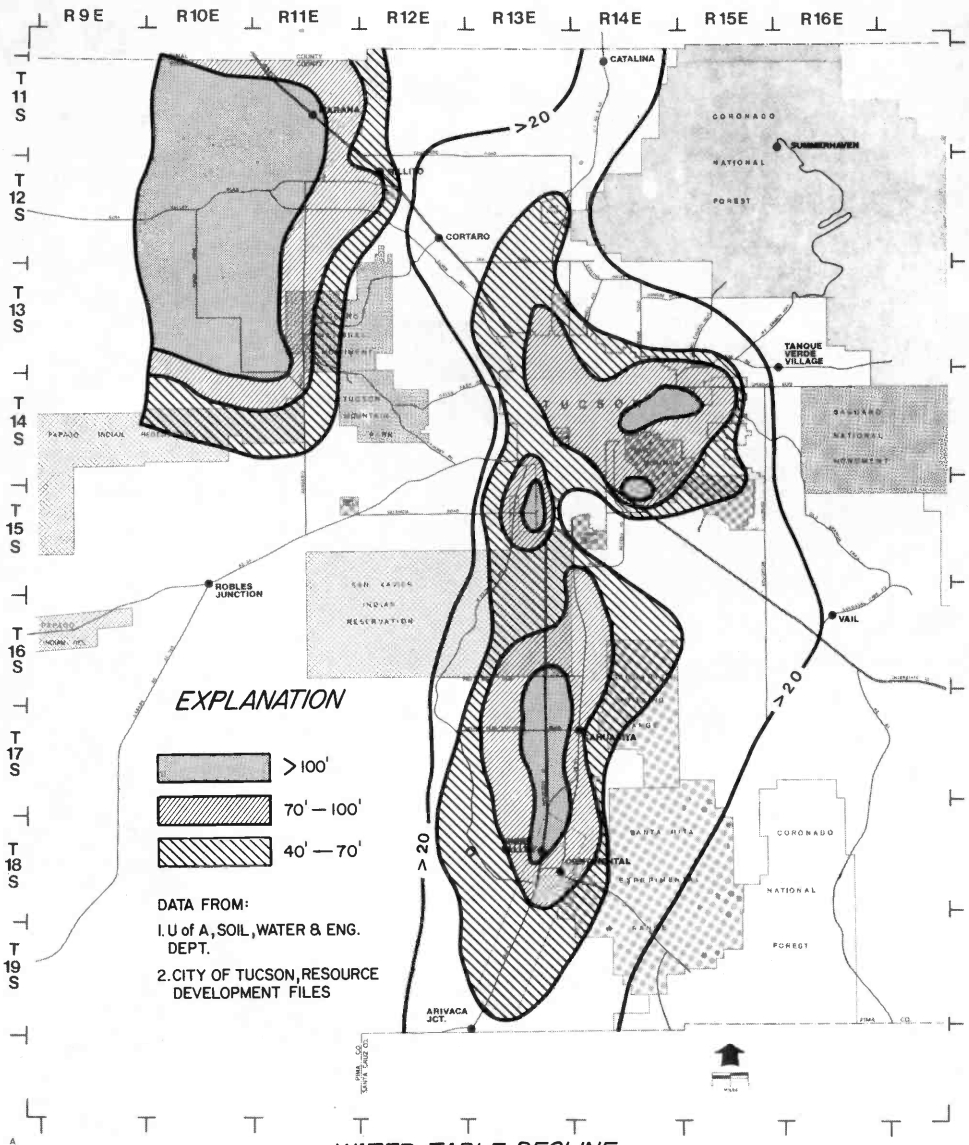
Located some 15 miles west of Tucson in the Avra Valley, the Water Utility presently has 25 well installations of which 16 are now operational and supplying water. The location of this well field is shown on Figure 1. Current production from this well field provides about 15 percent of the total amount of water pumped by the City. The Avra Valley source area is capable of supplying more water; however, the City is limited by a series of judgments handed down by the Arizona Supreme Court which allows only about 2.0 acre feet per acre per year to be pumped from the retired agricultural acreages purchased by the City in Avra Valley. The water pumped under these stipulations is brought into Tucson via a 42-inch diameter transmission main along Valencia Road to the Martin Reservoir, and thence into our distribution system. In efforts to secure additional supplies of water from Avra Valley, the City has continued, until recently, to purchase additional acreages which have a history of agricultural water usage. Under the present legal constraints, this is the only mechanism by which the City can obtain additional sources of water from this supply area.

## WATER LEVEL DECLINES

Declines in the water tables of the Tucson Basin and Avra Valley have been historically well documented as a result of ongoing hydrologic monitoring programs conducted by the City of Tucson and the University of Arizona. The nature and significance of these declines in water levels up through 1975 have been discussed by staff of the Water Utility (Wright and Johnson, 1976, p. 22-29), as well as other investigators.

Figure 2 depicts, for the Tucson Basin, the total water level decline which occurred between 1947 and 1977 (30 years) as a result of groundwater pumpage by all users. The densely-dotted pattern indicates those areas wherein declines have been in excess of 100 feet. The medium-lined pattern shows areas where declines over this period have ranged from 70 to 100 feet while the open-lined pattern denotes the area where declines have been between 40 and 70 feet. The heavy dark line indicates those areas within which declines have been greater than 20 feet over the 30-year period.

For the Avra Valley (Figure 2), the period of record extends from 1952 to 1977 (25 years). The areas of greatest decline correspond to those portions of the valley where agricultural activities have been the most intense.




## WATER TABLE DECLINE

AVRA-ALTAR VALLEYS: 1952—1977 (25 YEARS)
TUCSON BASIN: 1947—1977 (30 YEARS)

FIGURE 2

The decline areas encompassed by each of the intervals shown on Figure 2 have expanded slightly during the two years of additional records since our staff study in 1976. Competition for our groundwater has remained intense with the resultant impacts of lowered water levels and increased pumping costs as one would expect. However, the impact these declines are having on the production capacity of many of our well installations is of even greater importance to the Water Utility.

## WELL FIELD PRODUCTION CAPACITIES

Basinwide water level declines, continued competition for local groundwater resources in the Tucson Basin and Avra Valley, and decreased plant efficiencies result in a loss of production capacity amounting to about 6 mgd per year for the City of Tucson. This loss, added to the increased demand created by an average growth in population of 3 percent per year, must be replaced to maintain a status quo throughout the system. As shall be seen, the four primary well fields have been affected by water level declines to differing degrees.

### INTERIOR WELL FIELD

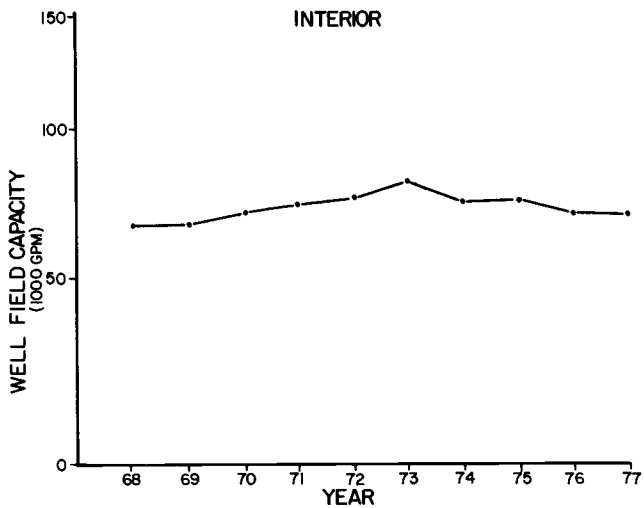



FIGURE 3

The interior well field supplies about 60 percent of the total amount of water pumped by the Water Utility. Figure 3, above, shows the production capability in thousands of gpm for the period 1968 through 1977. The majority of the 200 wells in this field are considered to be local service wells as they pump directly into distribution lines within the populated areas of the City.

Figure 3 indicates the total capacity has been increased since 1968. While this is true in the absolute, several points should be considered. The pronounced peak in 1973 and the overall increase in capacity is the result of purchases of private water companies and the production well drilling program conducted by the Water Utility. There are few remaining water companies whose inclusion into our system would significantly increase our supply. Replacement drilling sites in favorable hydrologic areas within the interior well field area which have the same expectation of success as those in the past are becoming harder to locate.

SOUTHSIDE WELL FIELD

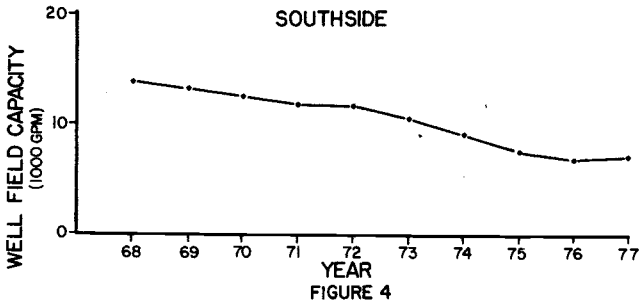


FIGURE 4

The Southside Well Field (Figure 4) presently contains 13 active wells and produces approximately 5 percent of the total supply of water pumped by the Utility. This field has incurred large total declines in the water table as shown in Figure 2 and has an annual decline ranging from 4 feet to in excess of 8 feet per year. These declines have affected the capacity of the well field as seen in Figure 4. Since 1968, this well field has shown a steady loss which by 1977 amounted to about 6,000 gallons per minute. The density of wells located in this area precludes additional new well construction to increase the supply. Recharge from the Santa Cruz River may certainly help maintain production from this field; however, the infrequent runoff patterns of the past several years have added only marginally to the subsurface supply. It is hoped the runoff this past winter marks the beginning of a wetter cycle for the region.

SANTA CRUZ WELL FIELD

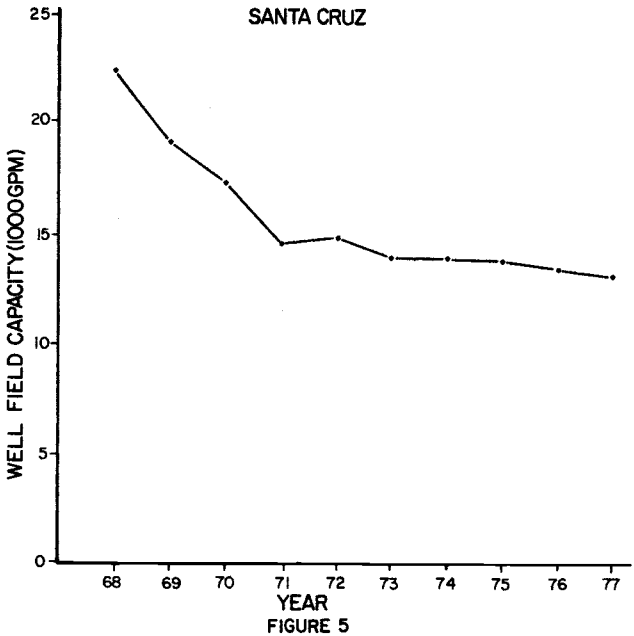


FIGURE 5

Figure 5 shows graphically the impact competition for groundwater has had in the vicinity of this well field. Since 1968, capacity has declined some 9,000 gallons per minute. This is particularly significant when one considers that six new wells were added to this field in 1975, yet production continues to decline. Clearly, local development of the available supplies far exceeds nature's capability to recharge this well field under present pumping conditions.

AVRA VALLEY WELL FIELD

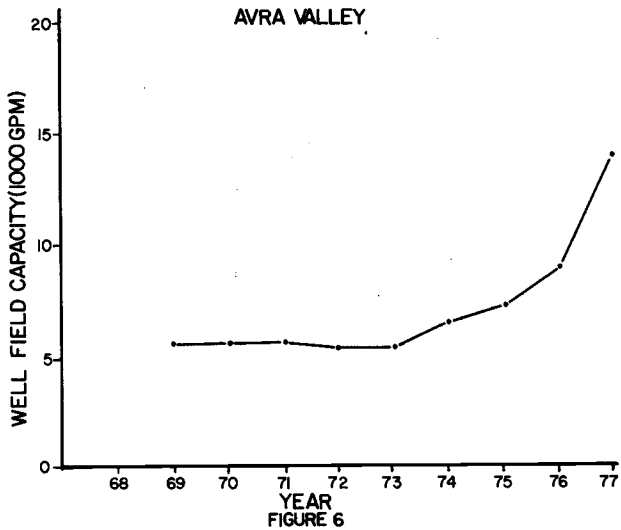


FIGURE 6

Production capacity of the Avra Valley well field, as shown on Figure 6, has been greatly increased by the addition of new well installations within the area in Avra Valley indicated on Figure 1. It is the increased production capability from this well field which has, in a large measure, replaced the losses incurred in the Southside and Santa Cruz well fields. Reliance upon the Avra Valley source area is projected to increase with further investment for land purchases and needed capital improvements in the north and central portions of the valley.

## MANAGEMENT CONSIDERATIONS

The relationship between the ongoing competition for groundwater resources and the resulting declines has been explored in past work (Wright & Johnson, 1976). In this present work, the relationship between water level declines and observed decreases in production capacity in the major well fields operated by the Water Utility has been established. These declines, however, have additional effects which must be considered in formulating management alternatives.

### PUMPING COSTS

One immediate impact the decline of the water table is having is in the area of increased costs for pumping water. As the water levels drop, the direct costs for pumping increase. These costs must be recovered through revenues contributed by the customers served by the Utility, yet increased costs meet with understandable resistance by the public served. Under these conditions well fields which enjoy a gravity flow condition to the service area, such as the Southside and Santa Cruz fields, must be managed to prolong their usefulness for as long as possible. These fields, however, have shown the greatest impact from continued production.

## SUBSIDENCE

A report by the United States Geological Survey (Davidson, 1973, p. 51-54) indicates that in basins similar to Tucson detectable land surface subsidence may occur when water level declines reach 100 to 150 feet. Declines of 150 to 200 feet may create significant surface subsidence. In basins near Tucson, additional investigations conducted by the United States Geological Survey (Laney, 1976, p. 39) indicate there is a definite relationship between extensive groundwater pumpage, water level declines and the occurrence of land surface subsidence.

## WATER QUALITY

Available hydrologic and geologic information suggest the possibility of encountering water of poorer quality as pumping levels lower throughout various parts of the Tucson Basin. Development of groundwater with excessively high ionic concentrations and high temperature may require extensive treatment facilities. Our well fields should be managed to forestall these conditions if at all possible.

## CONCLUSION

In recognition of the potential problems with groundwater quality at depth, and the potential for land surface subsidence resultant from water level declines, it becomes clear that present production levels of the interior field should be reduced.

The observed loss of capacity in the Southside and Santa Cruz well fields must be replaced. From a management point of view, considering all of the foregoing factors, it is felt that increased withdrawals from the Avra Valley represent the best alternative course of action to pursue.

## ACKNOWLEDGMENT

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## REFERENCES CITED

Davidson, E. S. 1973. Geohydrology and Water Resources of the Tucson Basin, Arizona. United States Geological Survey Water Supply Paper 1939-E, 81 pages.

Laney, R. L. 1976. Water Level Declines, Land Subsidence and Earth Fissures in South-Central Arizona.
Arizona Watershed Symposium, Proceedings, Report No. 8,30-39.

Wright, J. J. and Johnson, R. B. 1976. The Significance of Groundwater Level Declines in Eastern Pima County, Arizona. Arizona Watershed Symposium, Proceedings, Report No. 8, 22-29.