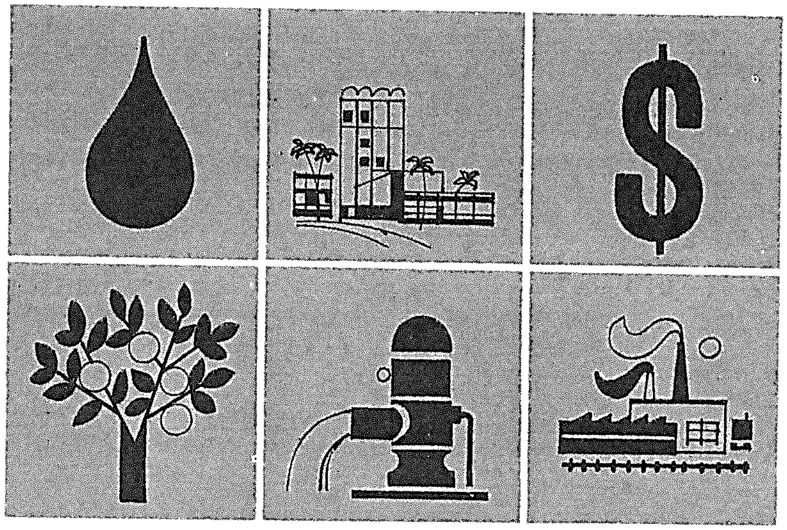

THE ECONOMICS OF ARIZONA'S WATER PROBLEM

Robert A. Young and William E. Martin

As Arizona stands at the critical point in making decisions on water, it is important to examine the economics of the state's water problems.

Most people in the arid Southwest have long regarded water as a unique commodity. They have felt that its development and allocation should not be subject to the dollars and cents discipline of the marketplace. Although this view can be defended in areas where water is so scarce that life itself depends on it, it is hard to support in Arizona where annual per capita consumption of water ranks among the highest in the nation if not the world. Therefore, it is presumed that signals offered by the price system should have relevance in allocation of water in Arizona.

This analysis further assumes policies should be evaluated in terms of their relative ability to create jobs and income for Arizona citizens. We advocate choices which would maximize the aggregate income of the state's population. In addition, we require that no one segment of the population should gain an unfair advantage over any other segment in the distribution of income gains. We are concerned with the *size* of the "income pie" attributable to each alternative water policy and the *division* of this pie.

The following analysis outlines basic facts pertinent to the present water situation, then examines two major alternative solutions in terms of the ability of each to meet stated goals. Finally, conclusions are drawn which seem to follow from the analysis. We expect to demonstrate that first, the water crisis in Arizona is not as widespread or as critical as some believe; second, that the Central Arizona Project has not been clearly established as a satisfactory solution to the problems which do in fact exist; and third, that alternatives to the Central Arizona Project are available which will permit the economic growth of the state to continue at its recent rapid rate.

FACTS BEHIND THE PROBLEM

The current supply and consumption of water in Arizona and some of the economic factors bearing on the value of additional water to the state must be understood.

Water Consumption[1]

Crop irrigation accounts for over 90 percent of the water consumed each year in Arizona. All uses other than crop irrigation — manufacturing, thermal generation of electricity, mining and smelting, livestock watering, timber products, recreation, municipal and household uses

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• *This article is based on a series of studies carried out at The University of Arizona over the past several years on the economics of water development and use in Arizona. Drs. Young and Martin are Associate Professors of Agricultural Economics. The authors gratefully acknowledge insights into the various issues provided by Dr. Maurice M. Kelso.*

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[1] For a more detailed breakdown see William E. Martin and Leonard G. Bower, "Patterns of Water Use in the Arizona Economy," *Arizona Review*, Vol. 5, No. 12, December 1966 (Table 1, page 4).

— together take only one-half million acre-feet (m.a.f.) of the six and one-half million used.[2] Of the water used on cropland irrigation, 2.5 million acre-feet are used on high value intensive crops (cotton, vegetables, field fruits, citrus), while the remaining water — 3.5 million acre-feet — is used to irrigate low value extensive crops (feed grains and forages).

Put on a per capita basis, use of water in Arizona is about 4,700 gallons per person per day, some three times the average for the United States. This makes Arizona the seventh largest water user per capita in the nation.

Water Resources[3]

Water resources are conveniently considered in two categories: surface flow from rivers and streams and groundwater stored in water bearing strata beneath the valleys of the state. Surface water is derived primarily from continuing flow of the Colorado, Salt, Verde and Gila rivers. The Supreme Court decision of 1964 in the Arizona-California controversy over the division of waters in the Colorado allocated 2.8 million acre-feet to Arizona in years when the usual flow is available. The Secretary of the Interior has authority to allocate and distribute waters of the mainstream of the Colorado in water-short years.

Net diversions from the Colorado in Yuma County have averaged around 1.0 million acre-feet in recent years. A priority has been given to the Colorado River Indian Reservation out of Arizona's apportionment, but some 1.2 million acre-feet remain for development. The Salt-Verde and the Gila River systems have long been fully developed. These also contribute an annual flow of about 1.0 million acre-feet.

An estimated *4.5 billion* acre-feet of groundwater (water clinging to and saturating the rock strata below the earth's surface) was once stored in Arizona. Perhaps some 15 percent of this (700 million acre-feet) was economically recoverable. Some 100 million acre-feet have been already withdrawn.[4] The current annual rate of withdrawal from groundwater reserves is estimated at 4.5 million acre-feet. An estimated 1.0 million acre-feet is recharged through natural processes, leaving a net withdrawal (or overdraft) of about 3.5 million acre-feet per year. At this rate of withdrawal, there will be an economically available supply for some 170 years.

Thus, we assume here that, in general, groundwater resources are subject to an economic rather than a physical limitation. We recognize, of course, certain exceptions such as where water bearing strata are physically limited or water quality problems exist. But these are exceptions, not the rule.

Consumption and supply is summarized by the 1965 water budget for Arizona:

Annual Supply		*million acre-feet*
Annual Diversion from Surface Water Flow		2.0
Annual Groundwater Recharge		1.0
Total Annual Available Supply		3.0
Annual Consumption		
All Uses Other than Cropland Irrigation		0.5
Cropland Irrigation		6.0
High Value Intensive Crops	2.5	
Low Value Extensive Crops	3.5	
Total Annual Consumption		6.5
Annual Deficit		
(Met by Groundwater Overdraft)		3.5

Income Generating Capacity of Arizona Industries

Table 1 illustrates the relative income generating capacity of water in various alternative uses in Arizona. Personal income is defined here as the sum of wages, rents, profits and interest received by persons in each sector of the economy. This total is then divided by the acre-feet of water consumed to provide an estimate of the income generating capacity per acre-foot of water used for each sector. (The personal income figure is *not* the value of the water. The personal income is greater than the price the producer could pay for an acre-foot

TABLE 1

PERSONAL INCOME PER ACRE-FOOT OF WATER INTAKE IN ARIZONA SECTORS AND RANK OF EACH, 1958[a]

Sector	Dollars of Personal Income per Acre-Foot[b]	Sector Rank[c]
Food & Feed Grains	14	10
Forage Crops	18	9
High Value Intensive Crops[d]	80	8
Livestock & Poultry	1,953	6
Agricultural Processing Industries	15,332	3
Utilities	2,886	5
Mining	3,248	4
Primary Metals	1,685	7
Manufacturing	82,301	1
Trade, Transportation & Services	60,761	2

a Adapted from Anilkumar G. Tijoriwala, William E. Martin and Leonard G. Bower, *The Structure of the Arizona Economy: Output Interrelationships and Their Effects on Water and Labor Requirements, Part I, The Input-Output Model and Its Interpretation and Part II, Statistical Supplement*, Arizona Agricultural Experiment Station Technical Bulletins 180 and 181 (forthcoming), 1967.

b Personal income is here defined to include wages and salaries, rents, profits and interest.

c Ranked from highest to lowest value added.

d Includes cotton, vegetables, citrus and other fruits.

[2] An acre-foot is the volume of water required to cover an acre to the depth of one foot — approximately 326,000 gallons.

[3] For additional details, see J. W. Harshbarger, *et al., Arizona Water*, U.S. Geological Survey Water Supply Paper 1648, Washington, D.C., 1966, and references cited therein.

[4] Harshbarger, *et al., op. cit.*

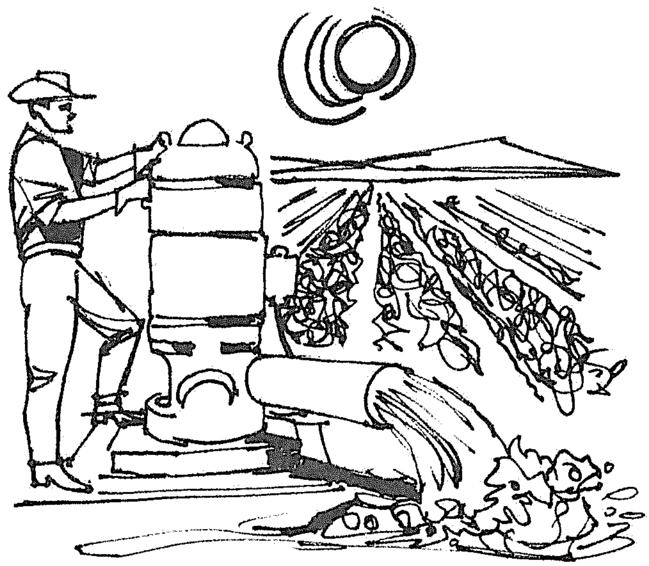
of water since the wages, rents and interest must first be paid.) The comparative values shown between the high intensity and the low intensity crops are striking. The various nonagricultural sectors generate incomes ranging from 20 to nearly one thousand times as large per acre-foot of water as even high value intensive agricultural sectors.

The proportion of total personal income in the state generated by agricultural activities is of interest. Feed and food grain and forage crop sectors use about 54 percent of *all* water consumed in Arizona and yet these sectors directly account for only about 1.5 percent of personal income in the entire economy. High valued intensive crops, using 38 percent of all water, directly contribute six percent of the personal income in the state.

What about personal income generated indirectly because inputs must be purchased from other sectors of the economy? While a dollar's worth of personal income is being produced by food and feed grains, requirements for inputs generate 23 cents of personal income in the rest of the economy. Six cents of personal income is indirectly generated while a dollar of personal income is being produced by forage crops. About 16 cents is indirectly generated while producing a dollar of personal income with high value intensive crops. These values can be converted to dollars of personal income generated *indirectly* by an acre-foot of water use and compared with personal income generated directly (Table 1). Food and feed grains generate an additional three dollars, forage crops an additional one dollar and high value intensive crops an additional $13. When direct and indirect effects of water use are added together, the sums are still far smaller than even the direct effects of water use in other sectors of the economy.

The Outlook for Irrigated Agricultural Crops in Arizona

Other considerations of the water problem relate to the long-term outlook for various classes of Arizona's irrigated agricultural crops.



Cotton has long been the major income producer among irrigated crops in Arizona. However, serious inroads into cotton's traditional markets have been made in recent years by competition from foreign cotton producers and synthetic fibers. The current cotton program has tried to stem this trend by reducing permitted cotton acreage (Table 2) and lowering the effective price to domestic mills by over one-fourth. In spite of these steps, as well as a substantial increase in population and a war-inflated economy, domestic cotton consumption is still lower than it was in 1950-51. Although the will of Congress is uncertain, the long-term outlook for cotton prices is probably for a substantial reduction. Future lint prices will most likely be 25 cents or less per pound as compared to a current effective price of about 32 cents.

Trends in production of other Arizona irrigated crops are also shown in Table 2. Specialty crops such as fresh vegetables are not of major importance as water users, although they do return a relatively large income. With the exception of lettuce, the Arizona share of these crops is declining, perhaps due to competition from more favorable production and markets in other states and Mexico.

TABLE 2

ACREAGE OF SELECTED IRRIGATED CROPS IN ARIZONA, SELECTED YEARS, 1945 - 1965

Year	All Cotton	Wheat	Sorghum for Silage and Grain	Barley	Alfalfa Hay	Alfalfa Seed	Carrots	Lettuce (Early Spring)	Lettuce (Fall)	Cantaloupe (Early Summer)
				(1,000 Harvested Acres)						
1945	154	24	55	78	232	40	10	13	17	10
1950	275	25	99	157	201	60	8	14	15	11
1955	355	42	173	174	223	34	5	12	14	7
1960	426	22	160	150	225	20	2	24	21	2
1965	339	26	187	169	191	16	2	17	19	1
1966 (Est.)	251									

Source: Arizona Crop and Livestock Reporting Service, *Arizona Agricultural Statistics 1867-1965*, Phoenix, 1966.

Citrus fruits are not shown in Table 2 because comparable data is lacking. This sector is not of major importance — less than five percent of irrigated crop acreage in the state. There is little incentive for expansion in the near future. In fact, huge investments in orange groves in Florida in recent years resulted in sharply increasing supplies and depressed prices. For the first time the government has entered into price support operations for orange products.

Generally speaking, markets and prices for high value crops grown in Arizona have been in unfavorable trends. There is no evidence that this trend will change.

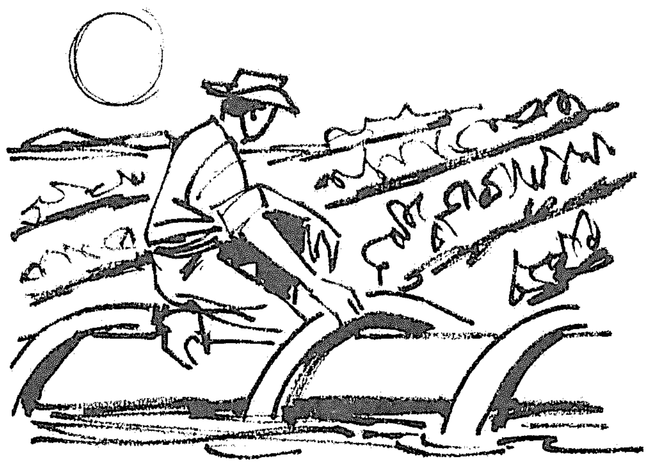
ARIZONA'S REAL WATER PROBLEM

There are vast supplies of groundwater still untapped and an increment of surface water in the Colorado River yet undeveloped. Water consumption is at a comparatively high rate. In fact, water is so inexpensive that most present uses are relatively unproductive in terms of income generated. Wherein, then, lies Arizona's water problem?

Most of the public discussion on water has focused on the continuing deficit in the groundwater account and the resulting plight of farmers in areas relying on pumped groundwater for irrigation. It has also focused on water problems municipalities may face in meeting the needs of a rapidly growing population.

Beginning with the farmers, consider the claim that large acreages of irrigated farmland have gone out of production due to lack of water or high cost of pumping. While we know that certain lands have been abandoned from these causes, evidence available does not support the more extreme assertions made on this point. A study at The University of Arizona comparing changes in amount of land in crop production in a sample of lands supplied by pump water in central Arizona between 1957 and 1963 showed a net increase in irrigated land.[5] Furthermore, general statistics on total lands cropped in Arizona over the last two decades fail to support the crisis thesis. There were some 50 percent more acres of irrigated crops in Arizona in 1965 than in 1945 and the 1965 acreage was still higher than that in 1955. The 1965 irrigated acreage was somewhat less than the peak acreage reached during the Korean War cotton boom of the early 1950's, but the downward adjustments seem associated with changes in the cotton acreage control programs.[6]

Are the claims of difficulties made in behalf of farmers and farm communities then unfounded? Serious problems do in fact exist. Rising costs and shrinking markets faced by Arizona's farmers are clearly real. Increasing costs imply a decreasing earning power (other things unchanged) which is, in turn, reflected in declining prices for which the land can be sold.[7] We hypothesize that this inexorable erosion of their asset value is a major factor motivating farmers to get water at a stable, low price. The cost and income situation of farmers has further but differential impacts on communities serving farmers. Increased water costs imply increased business for those dealing in energy and equipment for pumping water but it also implies decreased family consumption. As farmers are eventually forced out of business — and many of them will be unless conditions are changed — communities serving them will experience losses in employment and income. However, as we will show in the following sections, high water costs such as proposed under the Central Arizona Project are not the answer to the farmers' economic problem. Higher income sectors of agriculture will persist without subsidy from nonagricultural sectors.



Now we turn to municipal and industrial water uses. The population of central Arizona's major metropolitan areas has grown very rapidly since World War II, but the resulting demand for water is not large relative to the economy as a whole (less than ten percent). The Phoenix metropolitan area has, in part, been able to absorb the increasing demand because agricultural water rights were acquired as farmland was converted into urban uses. Tucson, relying entirely on groundwater, is moving further and further from the city in developing new well fields. The resulting water comes at higher costs. Even in Pima County, however, consumption of water by the relatively small agricultural sector outstrips that of the urban population. Therefore, water is available for municipal uses if needed.

One of the constraints faced by municipal water planners in their water acquisition programs has been the fear that, if new water supplies were obtained at the

[5] Reported by M. M. Kelso in *Arizona Farmer-Ranchman*, Phoenix, September 19, 1964.

[6] See, for example, Thomas M. Stubblefield, ed., *Agriculture*, Tenth Arizona Town Hall, Arizona Academy, Phoenix (forthcoming), 1967, Chapter IV.

[7] The farm budgets shown in Tables 3 through 5 show that net returns are indeed low.

expense of agricultural production, resulting impacts on agricultural employment and income would make the effective cost of the water quite high. In view of the estimates presented earlier concerning the indirect income generating capacity of agricultural production (and further evidence presented in a later section) it appears such indirect costs would not be large.

Thus, evidence does not show Arizona's water problem to be a physical shortage of water or a rapidly collapsing agricultural sector due to the groundwater overdraft. *Arizona's real problem lies in allocating its available water so as to maintain a high rate of economic growth.*

Next we examine two alternative proposals to meet this problem.

THE CENTRAL ARIZONA PROJECT

The Central Arizona Project has been proposed as a device for partially stemming the overdraft on Arizona's groundwater supply and furthering the growth of the economy. The project envisions delivery of approximately 1.2 million acre-feet of water (about one-third of the overdraft) from the Colorado River into central and southern Arizona for both municipal and agricultural users. Financial support from both federal and state sources has been proposed. Costs of construction must be repaid in either case, but the federal financing would be somewhat more favorable due to lower interest charges and the fact that some costs would not be reimbursable by purchasers of water. Our general conclusions do not appear affected by the source of financing. We use the Bureau of Reclamation's figures on construction costs while relying on our own estimates of economic benefits.

Water delivered to central Arizona by the Central Arizona Project will cost from $25 to $30 per acre-foot at the canal side. Since this price is conceded to be too high for farmers to pay, a lower price would be charged to farmers. The difference would be made up from higher prices to municipal and industrial users and by revenue from either the proposed dams or property taxes. In the tentative proposals for either a state-financed or a federally-financed project, $10 would be charged to farmers at delivery points on the main canal. Municipalities would be charged $50 per acre-foot. These figures do not include the cost of facilities to transport water from the Project canal to final users. In cases where such organizations do not already exist, irrigation districts have been formed which would construct and operate the necessary distribution systems. These facilities would add a cost variously estimated to average $5.50 to $7.83 per acre-foot to the farmer's canal-side price if such facilities were not already available.[8] (Since no plan has yet been settled

[8] Of this additional cost, $3.33 is due to water losses between the main canal and the farmers' headgate. This cost would occur even if distribution facilities were already available.

TABLE 3

TYPICAL INCOME, WATER USE AND VARIABLE COSTS PER ACRE FOR PINAL COUNTY FIELD CROPS[a b]

Item	Pumping Lift (feet)[c]		
	315	460	504
Upland Cotton (skip-row planted)			
Water Use per Acre (acre-feet)[d]	6.0	5.0	5.0
Total Income per Acre ($)[e]	320.54	310.46	310.46
Total Variable Costs ($)	187.01	193.53	200.78
Income over Variable Costs ($)	133.53	116.93	109.68
Barley			
Water Use per Acre (acre-feet)[d]	3.0	2.5	2.0
Total Income per Acre ($)[e]	91.27	85.00	77.80
Total Variable Costs ($)	59.47	62.97	60.04
Income over Variable Costs ($)	31.80	22.03	17.76
Alfalfa Hay			
Water Use per Acre (acre-feet)	6.1	6.1	6.1
Total Income per Acre ($)	159.50	159.50	159.50
Total Variable Costs ($)	126.56	146.27	154.17
Income over Variable Costs ($)	32.94	13.23	5.33
Grain Sorghum			
Water Use per Acre (acre-feet)[d]	3.3	2.75	2.2
Total Income per Acre ($)[e]	104.24	97.42	88.92
Total Variable Costs ($)	70.92	74.78	71.14
Income over Variable Costs ($)	33.32	22.64	17.78

[a] Source: Based on a 1964 survey of over 600 Arizona farmers under the project, "Water in Relation to Social and Economic Growth in an Arid Environment."

[b] Price of cotton projected at $.25 per pound. Other prices are approximately at current levels.

[c] Approximate variable pumping costs for these lifts are:
$ 7.05 per acre-foot 315 feet of pumping lift
$10.30 per acre-foot 460 feet of pumping lift
$12.08 per acre-foot 540 feet of pumping lift

[d] Quantity of water applied is reduced as pumping depth and variable cost of pumping increase.

[e] Income per acre varies with quantity of water applied.

upon as to final disposition of the water, estimates are conjectural.) It is precisely these areas where distribution systems are not presently constructed that the farmers' water problem is becoming most critical. The Maricopa-Stanfield area is an example.

The CAP as a Solution for Agriculture

Since the Project has been primarily justified as a solution to the water problem of the agricultural sector, the questions arise: could farmers purchase this water at a total cost of $15.50 to $17.83 per acre-foot? Even if they could, would such a purchase be profitable?

We approach answers by showing changes in net income which would accrue to a typical central Arizona pump-irrigated field crop farm under two different situations. The first is in an average year of the 60-year planning horizon when it is assumed to pump its own water supply. The second alternative is when various quantities of project-supplied water would be available.

Characteristics of this typical central Arizona farm are adapted from a survey of over 600 Arizona farmers taken under the direction of the authors in 1964. This

TABLE 4

OVERHEAD COSTS FOR TYPICAL PINAL COUNTY CROP FARM[a]

Item		Dollars per Farm — Pumping Lift (feet) 315	460	540
Buildings, Concrete Ditches, Fences, etc.				
Depreciation and Repairs	$ 3,864			
Insurance	215			
Machinery and Equipment				
Depreciation	12,135			
Insurance	652			
Interest on Investment at 6 percent	4,483			
Miscellaneous Insurance, Licenses, Fees, etc.	656			
Taxes: Real Estate and Personal Property (excluding wells)	4,550			
Depreciation, Interest and Taxes on Irrigation Wells and Equipment[b]		$10,584	$13,027	$13,531
Total		$37,139	$39,582	$40,086

a Source: Based on a 1964 survey of over 600 Arizona farmers under the project, "Water in Relation to Social and Economic Growth in an Arid Environment," Department of Agricultural Economics, The University of Arizona. A charge for investment in land and improvements other than wells is not included.

b Includes depreciation of wells and equipment, property taxes and interest on investment at six percent on the equipment.

TABLE 5

NET INCOME SUMMARY FOR TYPICAL PINAL COUNTY CROP FARM[a]

Item	Dollars per Farm — Pumping Lift (feet) 315	460	540
Gross Income	$135,455	$130,681	$128,231
Variable Costs	85,383	90,563	92,408
Income Over Variable Costs	50,072	40,118	35,823
Overhead Costs	37,139	39,582	40,086
Return to Management and Investment in Land and Improvements[b]	12,933	536	—4,263

a Source: Derived from Tables 3 and 4. Crop acreages are: 270 cotton, 175 barley, 115 alfalfa and 140 grain sorghum.

b A charge for investment in irrigation wells and equipment is included in fixed costs.

typical farm has 700 cropland acres allocated as follows: cotton, 39 percent; alfalfa, 16 percent; barley, 25 percent; and grain sorghum, 20 percent. In addition, the following assumptions are made:

> *Assumption One.* Changes in product prices and costs of purchased materials are assumed to be such that the margin of income over expenses remains constant over the planning period. Assumed prices for farm products are: cotton lint, $.25 per pound; barley, $2.50 per hundredweight; alfalfa hay, $25 per ton; and sorghum, $2.25 per hundredweight.

> *Assumption Two.* Demand for food and fiber commodities produced in Arizona will increase no more rapidly than will the increased unit yields resulting from technological advances.

Analysis of income changes to the typical farm is shown in Tables 3, 4 and 5. Table 3 shows returns (income) over variable costs per acre for three different pumping depths. Note that when water depth reaches 540 feet and variable water costs are slightly over $12 per acre-foot, returns over variable costs for all crops except cotton (and of course specialty crops) are under $20. Thus, at these water costs, there is little income over variable costs to help cover the farm's overhead expenses such as taxes, insurance, depreciation, interest on investment and the manager's effort and risk.

Table 4 summarizes the farm's overhead expenses except for a return to management and investment in land and improvements. Table 5 summarizes crop budgets and overhead expenses into a total farm statement of expenses and returns. Table 5 shows that a farmer in deep water areas of Arizona would be in financial difficulty if cotton prices fell to the levels we project. He will be in dire need of inexpensive water. Unfortunately, even under favorable terms proposed in the Project, water will not be inexpensive. Implications for the farmer to contract for Project water at the assumed cost of $10 per acre-foot at the main canal are discussed below. Three situations will be considered, two where present water supplies are entirely pumped and one where distribution systems for surface irrigation exist.

> *Situation One.* Assume a farm whose variable cost for pumping water is now $10.30 per acre-foot. A farmer must decide whether or not to contract to receive water costing $17.83 per acre-foot from a new irrigation district with a new distribution system to deliver Central Arizona Project water.

Each farmer receiving water makes a contract for enough surface water to grow all his crops without resorting to pumping. Typically (shown in our budget) this is about four acre-feet of water (3.91) per acre of crops. Our typical farm would contract for 2,735 acre-feet of water per year at $17.83 per acre-foot for a total additional overhead cost of $48,765. (In the early stages of the Project enough water would be available to supply about 285 farms of this size, taking into account transmission losses.) Variable water costs would be reduced by $28,170; overhead costs on irrigation wells and equipment would be reduced by $13,027 per year (if the wells were already paid for and the farmer could count on enough water so no supplementary pumping would be necessary).

Under these conditions, all crops would be grown and all water used since (once the contract had been made) the additional cost of actually using the water would be very small. However, net returns to management and investment in land and improvements would fall to a minus $7,024. Assuming the lower projected cotton prices, the farmer would already be in trouble before the new water became available. He would be receiving only $536 for his management and investment with $10.30 per acre-foot as the variable cost of water. But with Project water his return would become negative.

Such a loss could not be sustained indefinitely. Since his net returns would decline more rapidly with high cost Project water than pumped water, the farmer would be forced out of business much sooner than if he had not made the contract. Since net farm income would decline and fewer farms would be in operation, the net multiplier value and thus the secondary income effects on the Arizona economy would obviously be negative. Under these assumptions income in Arizona would *decline* as a result of the Project as proposed.

> *Situation Two.* Each farmer in a new irrigation district (now pumping water at $10.30 per acre-foot) contracts for about one and one-half acre-feet of water per cropped acre. Such a situation would imply higher irrigation district distribution costs than in the first example since more farmers would be receiving less water individually. Distribution systems would have to cover a much larger area. We have no exact estimates of distribution costs under these circumstances, but we assume a price of $20 per acre-foot to the farmer for water including the cost of a distribution system.

The farmer's additional overhead costs would be $20 times 1.5 acre-feet times 700 acres to equal $21,000 for 1,050 acre-feet of water. Variable water costs would be reduced by $10,815. Additional water would be pumped as before at a cost of $10.30 per acre-foot. As long as the farmer could remain in business (cover both overhead and variable costs for the entire farm) he would continue to grow his low return crops (barley, sorghum, alfalfa) as long as they return more than variable costs and thus contribute toward covering overhead costs for the entire farm. Since $10.30 is still less than the break-even variable costs for these crops (Table 6) these crops would be included.

Net return to management and investment in land and improvements would now equal *minus* $9,649 as compared to $536 when his water supply is entirely pumped. The farmer would be worse off than if he had to buy four acre-feet of water per acre and much worse off than if he were pumping all his own water. This is so because he must maintain his pumping plant. Thus, these overhead costs are not ignored as in the case of purchase of his entire water supply. The net multiplier effect on the Arizona economy would, of course, be negative.

TABLE 6

WATER COSTS AT WHICH CROPS JUST COVER THE VARIABLE COST OF PUMPING

Crop	Cost (Dollars per Acre-Foot)
Cotton @ 25.0¢ per lb.[a]	$33.69
(Cotton under current government support)	(54.83)
Barley	19.11
Alfalfa	13.28
Grain Sorghum	18.53

[a] Source: Long-run projected price.

In both Situations One and Two, farmers could remain in business at the start of the Project as long as cotton prices remained at or near recent levels. If and when cotton prices fall to a level near our long-term forecast, farmers in deep water areas could not remain in business over the long term with or without Central Arizona Project water.

Table 6 illustrates the problem farmers are facing. Alfalfa, barley and sorghum can only be grown at water prices of less than about $19 per acre-foot — and then only if they are grown in conjunction with a crop such as cotton at current prices also covering their overhead costs. For example, grain sorghum covers only variable costs at a water price of $18.53 and at that price contributes no net return toward payment of overhead costs such as taxes, insurance, depreciation, mortgage payments, etc.

As pumping costs rise above these figures, these crops will no longer be grown. When pumping costs reach $19.11, cotton will be the only nonspecialty crop left in production.

> *Situation Three.* In this case it is assumed that the water for irrigation will be delivered to farms within operating irrigation districts with existing distribution systems. Project water would then replace the water of those districts presently being obtained from underground sources.

Project water would be supplementary to existing low cost surface water supplies. There would be little or no additional investment required for distribution systems. Farmers could afford the water. The cost of water from the Central Arizona Project would be approximately equal to the variable cost of the water these districts are now pumping.

Nevertheless, at least two objections can be raised to this situation as well. The first question concerns the extent of direct irrigation benefits which could be attributed to the Project. The 1964 Supplemental Information Report on the Central Arizona Project lists direct irrigation benefits of $32 million.[9] Agricultural deliveries are set at 817,000 acre-feet per year, implying direct benefits from irrigation of some $40 per acre-foot.

Now we examine this figure in terms of our typical Pinal County field crop farm. At current prices (used by the Bureau) our typical farm generates $170,000 of income on its 700 acres or about $243 an acre. Assuming a consumption of about four acre-feet of water per acre, this is $61 of income per acre-foot of water consumed. Estimates derived from Tables 3, 4 and 5 indicate that on this typical farm $32 per acre-foot is required to meet cash expenses and depreciation. This leaves only $29 per acre-foot of water consumed to pay for water costs, return to management and investment in land and improvements. If we assume land is valued at $500 per acre, an interest rate of five percent and allocation of five percent of gross income for management, another $9 per acre-foot is accounted for. This leaves some $20 per acre-foot as the limit the farmer could pay for water. This is our estimate of the maximum value of an acre-foot of water on previously uncropped land. The Bureau calls this concept "new land equivalent." Applying their concept our estimate of direct benefits is only one-half as large as theirs. We further maintain that, since the land to be irrigated by the Project is being farmed and has a water supply, the new land equivalent concept is erroneous and overestimates benefits attributable to additional water.

Secondly, as we assumed earlier, potential income gains from the Project should be distributed in an equitable manner. The amount of subsidy to agriculture which nonagricultural sectors can afford remains to be examined.

One way to approach this issue is by examining the indirect irrigation benefits attributable to the Project by the Bureau of Reclamation. In the Supplemental Information Report previously cited this figure is given as $36.5 million per year, or roughly $45 of indirect irrigation benefits per acre-foot of water. We find this figure is also startlingly large. Our recent analysis of income generated by various sectors of the economy through their purchases from the various other sectors[10] shows that, in the cotton and feed grain sectors, a dollar of additional output will generate approximately one additional dollar in income in all the other sectors of the state's economy.[11] Only the net profit in the additional dollar (after all other factors of production are paid) can be considered available to pay for water. Again we use $61 as the income per acre-foot of water consumed on our typical farm. If we assume a liberal seven and one-half percent rate of profit on gross sales, net indirect benefits to the state from irrigation would be only $4.58 per acre-foot.[12] This would be the *limit* to which farmers could *equitably* be subsidized by nonagricultural sectors of the economy. If the subsidy to agriculture is limited to this amount and if the total water cost is $25 to $30 at canal side, a price of $21 to $26 per acre-foot at canal side and $26 to $34 at the farm is implied. Our previous analysis indicates this price would compare unfavorably with pumped water costs for many years to come. Even farmers in existing irrigation districts would find this price unfeasible.

The CAP as a Solution for Municipalities

Municipalities would not necessarily be acting in the best interests of their citizens if they contracted for Colorado River water at $50 per acre-foot when, in most cases, they have readily usable groundwater supplies available. It will be many decades before the cost of groundwater would exceed the cost of purchasing Central Arizona Project water and purifying it for household use. Furthermore, it appears that forcing high cost water on municipalities and industries would impede economic growth rather than encourage it.

A recent study indicates that irrigation wells produce water for a total cost at the pump of about $.03 per acre-foot per foot of lift.[13] Thus, even when pumping lifts reach 500 feet, water would cost no more than $15 per acre-foot to produce (500 x $.03 = $15). It is likely that wells producing water for municipal use could improve on these costs since the more stable urban demand would permit a more effective use of the pumping plant. Cities could establish their well fields at some distance away from their boundaries and still have groundwater at a net cost less than $50 per acre-foot for many years.

[9] Bureau of Reclamation, U.S. Department of the Interior, *Pacific Southwest Water Plan: Supplemental Information Report on the Central Arizona Project*, Boulder City, Nevada, January 1964.

[10] Anilkumar G. Tijoriwala, William E. Martin and Leonard G. Bower, *The Structure of the Arizona Economy; Output Interrelationships and Their Effects on Water and Labor Requirements; Part I, The Input-Output Model and Its Interpretation and Part II, Statistical Supplement*, Arizona Agricultural Experiment Station Technical Bulletins 180 and 181 (forthcoming), 1967. Also, William E. Martin and Leonard G. Bower, "Input-Output: An Arizona Model," *Arizona Review*, February 1967.

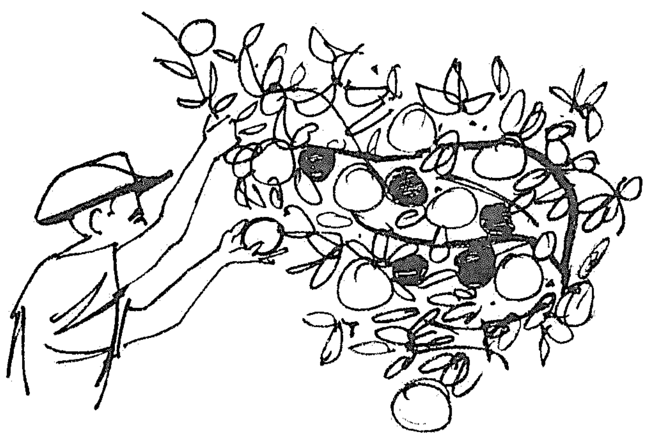
[11] Adapted from Tijoriwala, Martin and Bower, *op. cit.*, to include additional effects not considered in the bulletins. The Bureau of Reclamation figures cited are for the national economy and therefore not strictly comparable. In terms of evaluating a state project or the pay-back capacity of a federal project only the income generated in the state is relevant.

[12] We are by no means the first academic economists to disagree with the Bureau as to the benefits attributable to water projects. For a recent example, see J. S. Bain, *et al.*, *Northern California's Water Industry*, Johns Hopkins University Press, 1966.

[13] Aaron G. Nelson and Charles D. Busch, *Costs of Pumping Water in Central Arizona*, Arizona Agricultural Experiment Station, Technical Bulletin 182 (forthcoming), 1967.

The CAP: Conclusions

Our estimates cast doubt as to whether the Project can generate economic benefits to the state in excess of costs entailed by its construction and operation. This is not to say the Project cannot be financed. Just as a business firm can make one unprofitable investment and cover the losses out of other profitable activities and reduced dividends to stockholders, so can Arizona make an investment which fails to return a margin over its costs and finance the loss by increasing taxes on the public or by charging higher prices to municipal and industrial water consumers. The fact that sufficient resources are available to finance an investment is no measure of the investment's economic desirability.



ALTERNATIVE TO THE CENTRAL ARIZONA PROJECT

Arizona's basic goal should be to utilize her natural resources to attain a high rate of economic growth. Our water resources consist of three parts: the almost fully developed surface waters within our state, our "overdeveloped" groundwater supply and the unused portions of the Colorado River to which we are entitled. Each of these sources must be allocated to its most productive use for the highest rate of economic growth.

What are these uses? With the exception of current plans for the Colorado River water under the Central Arizona Project, proper allocations are being made today. Our inexpensive surface waters are used by agriculture (where return per acre-foot is relatively low) until they are needed for municipal and industrial use. These users can purchase the water from agriculture as needed since they can afford to pay a much higher price per acre-foot. This has occurred in Phoenix area cities, for example, which have expanded throughout the Salt River Project.

Our groundwater reserves are presently mined in considerable excess of their recharge. This overdraft and consequent lowering the groundwater table has generated the "Arizona water crisis." It is for this reason that the Central Arizona Project is proposed. But as our analysis shows, even at the outset when the maximum Colorado River water would be available, the Central Arizona Project would cancel only one-third of the overdraft. Two-thirds of the overdraft would remain, the groundwater level would continue to fall and the basic "water crisis" would be with us just as it is now. Cancellation of one-third of the overdraft would be a Pyrrhic victory, gained by charging municipalities higher prices for water than they can expect to pay for many years for pump water. Further, the Project would bring in water farmers in pump areas could not afford to buy and farmers in irrigation districts do not particularly need. As shown in the previous section, such action would have a negative multiplier effect on the overall Arizona economy.

The alternative is to continue to pump groundwater for agricultural use as long as farmers can afford to pay the price. It follows that total agricultural acreage will decline as the least profitable crops are no longer grown. As acreage declines and water use diminishes, the overdraft will diminish and high valued agricultural and domestic uses will pump the water as before. When higher valued uses need the groundwater they will bid it away just as they have done with our surface waters.

Even the adjustment in agriculture may not be as drastic as suggested. Recent projections of agricultural adjustment in Pinal County through the year 2006 indicate the following:[14] acreage of feed grains and alfalfa will decline continuously but cotton acreage will not decline from the 1966 level; however, while total acreage will drop by 50 percent between 1966 and 2006, net income to farmers (income over variable costs) will decline by only 20 percent because feed grains and alfalfa are presently contributing only slightly toward net income.

The remaining question is how to use our Colorado River water entitlement. The obvious answer is that, since it cannot be effectively used in central Arizona, we should at least investigate the possibility of using the water near its source in the river. There are no good data relative to this alternative — precisely the reason it needs investigating. Some rough figures might set the problem in perspective, however.

If 1.2 million acre-feet are available from the river and if diversion and transfer losses are about .2 million acre-feet, the remaining one million acre-feet could support about 167,000 acres of agricultural land. (About six acre-feet per acre are needed on the sandier soils near the Colorado as compared to four acre-feet in central Arizona.) Is there this much arable land proximate to the river? No comprehensive studies of arable lands are available. However, possibilities for further development

[14] Harold M. Stults, "Predicting Farmer Response to a Falling Water Table: An Arizona Case Study," presented to the Committee on the Economics of Water Resources Development of the Western Agricultural Economics Research Council, Las Vegas, Nevada, December 8, 1966.

include (1) the Yuma desert (where water requirements per acre are extremely high but which has a potential for citrus production); (2) areas adjacent to present irrigation projects (the Wellton-Mohawk in particular); (3) lands in the Cibola-Ehrenberg district; and (4) some of the valleys and plains which lie from 50 to 80 miles inland from the river (Cactus Plain, Ranegras Plain, McMullin and Butler Valleys). At least ten townships or 230,000 acres appear promising within these areas — more than enough to absorb the one million acre-feet of available water.

As in central Arizona barley, grain sorghum and forages would be marginal users of water. But surely the cost of delivering water to these crops would be less than with the Central Arizona Project. Whether a "Western Arizona Project" would actually provide benefits above its cost would require further investigation. Plans for such a project should include provision for making the water available to central Arizona once demands from the growing economy and costs of alternative sources so dictate.

CONTINUED ECONOMIC GROWTH

We wish to demonstrate one final point: economic growth can continue in Arizona without importation of water. Table 2 illustrated relative income generating capabilities of various sectors of the economy as related to their use of water. Reallocation of water from low valued uses, such as agriculture, to high valued uses, such as manufacturing, is an important avenue for growth. Each time a business firm establishes a new plant in Arizona using land and water resources formerly used in lower valued uses, a jump in income and employment is recorded. Recently, for example, a large meat processing company decided to build a livestock slaughter facility in Tolleson. Their water demands seem large — 2 to 2.25 million gallons a day or about six to seven acre-feet. However, in a year this plant would use no more water than would, for example, 600 acres of sorghum. Six hundred acres of sorghum generate about $58,500 per year of gross income and about 9,000 man-hours (or perhaps three and one-half man-years) of employment. The work force contemplated for the processing plant is about 225 employees, or some *65 times as large* as the sorghum crop. The relative volume of income generated by the proposed plant would probably be even larger since wages in such employment are greater than in farming. Furthermore, much of the water used in this plant would not be lost in the process, as it would be in agriculture, but would be available for use again in crop irrigation after being suitably processed.

In order to facilitate this process of reallocation to higher valued uses, it is important that Arizona water policy include legislative provisions to insure that water supplies are freely transferable between uses when economic factors so dictate.

CONCLUSION

If the water problem is viewed simply in terms of the groundwater overdraft, the obvious solution is to import surface water from other river basins. However, if the problem is to obtain maximum economic growth for the state, this water must generate benefits in excess of costs of transporting and distributing it. Since this is not the case, reallocation of available water becomes the preferred solution.