HYDROLOGY AND WATER RESOURCES IN ARIZONA AND THE SOUTHWEST, VOLUME 7, P. 15-27.

Proceedings of the 1977 meetings of the Arizona Section of the American Water Resources Association and the Hydrology Section of the Arizona Academy of Science, held in Las Vegas, Nevada, April 15-16.

AN ECONOMIC ANALYSIS OF THE CENTRAL ARIZONA PROJECT

by

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and

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INTRODUCTION

The Central Arizona Project (CAP) is a multiple-purpose capital investment currently funded by congressional appropriations that are governmental by Reclamation Law. If completed on schedule in 1985 it would provide Colorado River water to central Arizona in accordance with water entitlements that have been established over a 50-year period that dates back to the historic Colorado River Compact (1922). CAP construction was authorized in 1968 as part of the Colorado River Basin Act, and roughly $400 million has been expended to date on project facilities. Further funding of the CAP was halted in January, 1977 by presidential order, pending a review of the project's economic and environmental impacts. More recently that executive decision to discontinue CAP funding has been reaffirmed, placing the completion of the project in further jeopardy. Critics contend that these actions have been taken without sufficient justification and we would agree that little in the way of explanation has emerged since the funding halt was ordered. By the same token, we would argue that insufficient effort has gone toward providing a realistic assessment of the CAP's potential impacts throughout the course of its development, making the average citizen's stance on the project a matter of faith rather than reasoned judgment.

In another paper we have examined many of the CAP's likely impacts,[1] particularly as they would affect central Arizonans. This paper extends that analysis in several ways. First, we develop a simulation model of CAP costs, water operations, and capital repayment alternatives. A variety of experiments are conducted to isolate the features of the CAP that would importantly determine the distribution of financial burdens required to meet the capital costs of the project. Second, we analyze the operating costs of the CAP by comparing its projected operations, maintenance and repair (OM&R) costs to the actual cost experience of the Metropolitan Water District of Southern California (MWD). This comparison provides, in our view, the most realistic picture of what these OM&R costs are likely to be. Finally, we consider some of the indirect benefits and costs that would be created by the CAP and attempt to summarize the overall economic impact of the project.

BACKGROUND

In this section we present some basic facts about the CAP that outline its institutional and economic structure. This descriptive material is necessarily brief;[2] its intended purpose is to motivate the analysis that follows.

CAP CAPITAL COSTS

It has been estimated that CAP construction would require a capital outlay of $1690 million if the land, labor, and materials were all obtained at 1976 prices. Since construction is phased over the period 1972-1985, the realized costs would be considerably larger; we estimate total realized CAP costs at more than $2300 million. Construction funds are to be provided by congressional appropriations, but the bulk of this money is to be repaid according to terms established in a Master Contract signed by the Central Arizona Water Conservation District (CAWCD) and the U.S. Department of Interior in 1972. In effect, the funding consists of a low interest (3.42%) loan for part (41%) of CAP's facilities, an interest free loan for another part (33%), and direct federal financing of the third part (25%). The exact distribution of costs into these broad categories is governed by terms of the Master Contract, and it depends among other things on the availability of CAP water and the allocation of that water to different user classes. The interest bearing portion of the CAWCD loan applies to the (allocated) costs of constructing the CAP's electric power facility and the costs of water delivery facilities for municipal

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1. Barr and Pingry, "The Central Arizona Project: An Inquiry into Its Potential Impacts," Arizona Review, April, 1977.

2. A more complete description is provided in our recent paper, including a detailed bibliography of other source materials.

and industrial (M&I) users. Interest is to accrue on these outlays from the time they are undertaken, so that the CAWCD's total capital obligation would include interest occurring during construction of an additional $116 million. This brief overview of the project's capital costs provides some indication of their relative magnitudes, and reveals the broad financial structure of CAP funding. Table 1 summarizes the CAP cost allocations just described in terms of 1976 ("current cost") input prices and indicates the magnitude of the CAWCD's capital repayment obligation.

Table 1

CAP Costs and the CAWCD Repayment Obligation*
($ Million in terms of 1976 input prices)

Project Function	Allocated Costs	Federal Finance	Non-Interest Bearing Loan	Interest Bearing Loan	Interest Bearing Costs
Irrigation Water Delivery					
Private	556		556		
Indian	189	189			
M&I Water Delivery	581			581	97
Electric Power	122			122	19
Flood Control	130	130			
Recreation	17	16	1		
Fish & Wildlife	49	49			
Other[1]	46	46			
Totals	1,690	430	557	703	116
CAWCD Repayment Obligation			557	819	

[1]Primarily the cost of the Colorado River Division facilities, and the Indian Irrigation Distribution System.

Source: Unpublished data, September, 1976 Arizona Projects Office, Bureau of Reclamation. These cost estimates are based on the bureau's existing estimates of costs, water availability, and the water allocation and are subject to change.

THE CAP POWER SUPPLY

The CAP owns a 24.3% share of the Navajo Power Station which has been operating since 1975. This feature, due to its size and the way its costs and revenues are allocated by the Master Contract, plays a pivotal role in any economic analysis of the CAP. The CAP's share of Navajo power is sufficient to pump water through its acqueducts at their capacity limit (2.17 million acre feet/year). However, the expected water availability for the project is much less than its aqueduct capacity, with current estimates ranging from .8 to 1.2 million acre feet per year (maf/year).[3] Power not used to pump CAP water is to be sold on a wholesale basis to other companies in the southwest power grid. At present CAP's entire share of Navajo power is sold in this fashion; it is expected to return net repayment revenues of $16.3 million in 1977 alone. When CAP water deliveries commence, about half (on average) of the project's power supply would be sold as surplus power.

The capital costs and revenues derived from this Navajo surplus power have been "packaged" into the CAWCD repayment obligation. As can be seen from Table 1, it must repay $122 million as part of its interest bearing obligation, but all surplus power revenues are then to be credited to its account.[4] This financial arrangement has two important consequences. In the first place it provides a substantial subsidy to the financing of the CAWCD's water delivery operations. Second, it acts to protect the CAWCD financially from revenue losses it might experience if less water is available for delivery. For when such shortfalls occur, the CAWCD would receive offsetting revenues from the sale of additional surplus power. It will be seen below in the simulation analysis that the CAWCD water charges needed to meet its capital repayment obligation are rather insensitive to changes in water availability; this is largely a reflection of the offsetting financial impact of surplus power sales.

CAP WATER SUPPLY

One of the major questions surrounding the CAP involves the amount of Colorado River water it would have to deliver. The Bureau of Reclamation has constructed a CAP water supply forecast that is based on a sequential average of recorded virgin flows of the Colorado River during the period 1906-1969, together with estimates of other established rights and priorities already perfected and anticipated. This forecast yields average diversions over the 50-year CAP repayment period of 12.19 maf per year. Our own assessment[5] of the basic data leads to a considerably lower forecast of CAP water availability. This view

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3. A recent Bureau of Reclamation study estimates CAP Colorado River diversions at an average of 1.21 maf/year. Our own estimates (op. cit.) are substantially lower than this figure, in the range of .8 to 1.0 maf/year.

4. In addition, "exchange" power revenues derived from Hoover and Parker Dam power generation are to be credited to the CAWCD loan after 1990. They would amount to a total of $133 million by 2035.

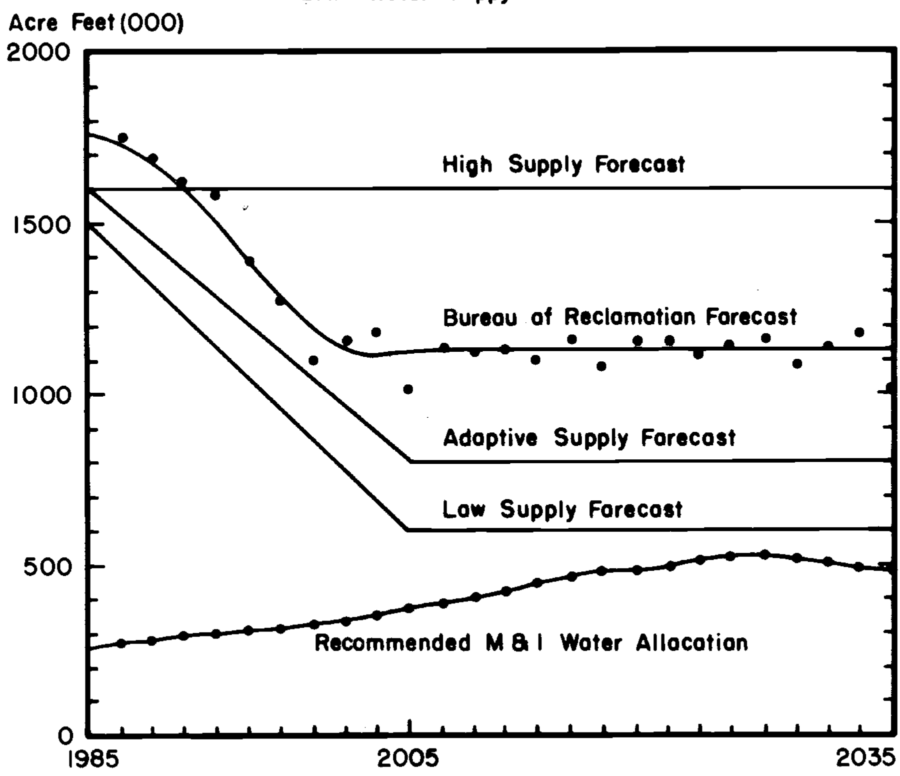
5. See Barr and Pingry, op. cit., pp. 28-33.

stems primarily from the expectation that water users in the upper Colorado basin will exploit their entitlements to a greater extent than the Bureau of Reclamation anticipates. For this reason we have labeled this outcome the Adaptive Supply Forecast. The supply forecast that we endorse in this analysis is in our view conservatively high; it calls for declining water availability over the first 20 years of CAP operations and average diversions of .96 maf/year.

Water supply has been a central issue in the debate over the CAP's social investment value, and to be sure, if there is not going to be much water available there is no point in building the water supply facilities. However, as we have suggested above, the inclusion of a large, profitable power supply in the CAP obscures the real cost of the water delivery system in the event that a low water supply materializes. To be able to demonstrate this point, we will consider two other water supply forecasts in our simulation analysis. The high supply forecast calls for constant Colorado diversions of 1.6 maf/year. The low supply forecast is a more pessimistic version of the adaptive supply forecast, averaging .72 maf/year. The four water supply forecasts used in this study are depicted in Figure 1 for the repayment period, 1985-2034.

Figure I

CAP Water Suppy Forecasts



We have also depicted the currently recommended M&I CAP water allocation[6] on Figure 1. The recommendation calls for the M&I water allocation to increase from 269,000 af to more than 500,000 toward the end of the repayment period (average: 412,000 af/year). These figures will be useful in interpreting the simulation results of Section III.

6. Arizona Water Commission, November 24, 1976.

ANALYTICAL PERSPECTIVE: CAPITAL COST ANALYSIS

The CAP is a well defined contractual entity. About 75% of its total capital cost is to be repaid by the CAWCD, which has broad power to allocate CAP water to private users, set water charges, and levy property taxes in the central Arizona (Maricopa, Pima, and Pinal) counties. These financial instruments, together with the surplus power revenues, comprise the elements of the repayment package that the CAWCD must assemble to meet its federal loan obligation.

The simulation analysis of the next section is concerned exclusively with identifying the capital recovery charges (so-called "canal side" charges) required to meet the repayment obligation under a variety of circumstances. These charges are distinct and separable from the OM&R and distribution costs, treatment costs, and administrative costs that would be incurred in operating the CAP system.[7] The simulation analysis addresses four specific questions regarding capital recovery charges:

A. Water user capital recovery charges: existing contractual arrangement. One obvious question concerns the attractiveness of the CAP as an investment proposition, given the terms of the Master Contract. This analysis will be conducted in terms of the current dollar ($1976) cost of the project so that the capital recovery charges can be compared to current per acre foot capital costs of groundwater retrieval. No tax levies will be permitted in these simulated repayment plans so that the project's (current) capital cost must be recovered entirely by water charges. The resultant canal side charges will indicate what CAP subscribers must be willing to pay for water in current dollar terms for capital recovery only.

B. Water user charges for the incremental capital cost of the water delivery system. The Navajo Power Plant is operating at its designed capacity and the CAP is selling its share of output to the power grid. In a real sense this investment is separable from the CAP water delivery system. The crucial question from a social investment point of view is, "What is the incremental value of the water delivery system?" To answer this question we have purged the current CAP cost estimate of the Navajo investment cost and have simulated CAWCD repayment plans without either the Navajo capital costs or the surplus (and exchange) power revenues. We have retained the other financial terms of the Master Contract, such as the low interest and interest free loan provisions. These simulation experiments provide a partial answer to the incremental cost of CAP's water delivery facilities; the charges required on water deliveries indicate what users must be willing to pay in current terms to recover the capital costs of the water delivery facilities only. This experiment is seen to eliminate the project subsidy provided by the Navajo feature. It is the appropriate test, indeed the compelling test at this juncture, required to judge whether the water supply facilities should be built or not. The Navajo Station is in place; the remaining features of the project must be evaluated on an incremental cost basis.

C. CAP management alternatives: distributing expected realized costs. If CAP construction is completed, the CAWCD will be obligated to repay a portion of the total capital costs that are realized. We estimate that this total would be more than $2.3 billion if the construction work proceeds according to schedule. This simulation experiment retains all terms of the Master Contract and derives the likely options that would be available to the CAWCD. Several trade-offs are established between tax levies and water charges under different assumptions about water availability and its allocation. These results indicate what capital recovery charges would have to be to repay the expected realized capital costs of the project. These estimates differ from those of [A] by the extent realized capital costs would differ from the estimated cost in current dollar terms, and by the extent to which capital costs are financed by tax levies.

D. Water user charges for capital recovery without federal interest subsidy: current cost configuration and incremental water delivery system costs. This experiment inquires further into the question of what the full economic cost of CAP water deliveries would be. Again we are only concerned in this instance with the user charges needed for capital repayment. Here we suppose that federal funding of the CAP is withdrawn and the project is financed by 5% revenue bonds. Two cases are considered: (1) the Navajo Station is retained as an integral part of the project, and (2) the CAP water delivery system is financed separately, with the understanding that power will be supplied to the project at cost. The first case approximates the user cost of capital inclusive of the Navajo subsidy while the second case approximates the incremental user cost of capital for the water delivery facilities alone. This experiment is conducted for both the Bureau of Reclamation water supply forecast and the adaptive supply forecast.

CAPITAL COST REPAYMENT SIMULATIONS

In this section we simulate the capital cost repayment program that would be undertaken by the CAWCD under different financial and water supply conditions. The approach is to combine sets of assumptions about construction costs, water availability and its allocation, repayment methods, etc., and then to simulate the "operation" of the CAP over the repayment period.[8] The appeal of such simulation studies is that they can capture the interaction effects of any assumed conditions and, at the same time, they can isolate the impact of changes in particular conditions. Using this technique, we can assess the sensitivity of the project's economic impacts to two distinctly different kinds of influences: (1) project operating rules over which there is control (e.g., the repayment package) and (2) conditions which are subject to uncertainty (e.g., CAP water availability). By considering

7. These costs will be dealt with in Section IV.
8. Both the Bureau of Reclamation (Arizona Projects Office) and the Arizona Water Commission have conducted similar unpublished studies of CAP operations.

variations in both kinds of influences we can get a "feel" for the range of possible economic outcomes and identify which operating rules and contingencies are particularly influential. Initially we adopt all of the rules stipulated in the Master Contract that govern the CAWCD's capital repayment obligation and other aspects of CAP operations. In addition, we make the following basic assumptions so that we can focus on a manageable set of influences in the simulations:

A1. The main water delivery system will be completed by 1985, and the repayment period will refer to the period 1985-2034.

A2. The user water distribution system will be completed by 1985 so that they can take delivery of CAP water according to schedule.

A3. The current directive on the Indian water allocation will continue to be operative (257,000 af/year until 2005, thereafter 5% of total project deliveries or 10% of agricultural deliveries, whichever is larger in each year).

A4. Repayment revenues derived from other Bureau of Reclamation projects (Hoover, Parker Davis, et al.) will be available according to schedule (these revenues commence around 1990 and will average roughly $2 million per year).

A5. The CAWCD will meet its repayment obligations according to schedule during the repayment period, and further, the package of repayment charges levied is assumed to just meet that obligation.

These assumptions (particularly A1-A3) may not be entirely realistic, but they establish a setting wherein we can analyze factors that importantly affect the CAP's direct payoffs to its constituents. The following influences, or variables, are considered in the simulations:

V1. Total CAP construction costs, including interest charges accruing during the construction period.

V2. CAP water availability (this consists of a 50-year schedule of Colorado River water diversions from Lake Havasu), plus additional water derived from the Salt and Gila Rivers.

V3. The CAP water allocation (this consists of an annual division between agricultural and M&I users of available water (V2) less the Indian allocation (A3) and evaporation losses.

V4. The canal side capital recovery charge for agricultural water, referred to as P_A.

V5. The canal side capital recovery charge for municipal and industrial water, referred to as P_M.

V6. The ad valorem tax rate levied on assessed real property in the central Arizona counties. This taxing authority is limited to a levy of no more than 10 cents per $100 assessed valuation (referred to as t = .01, .02, . . . , etc.).

V7. The magnitude of surplus power revenues derived from the CAP interest in the Navajo Station.

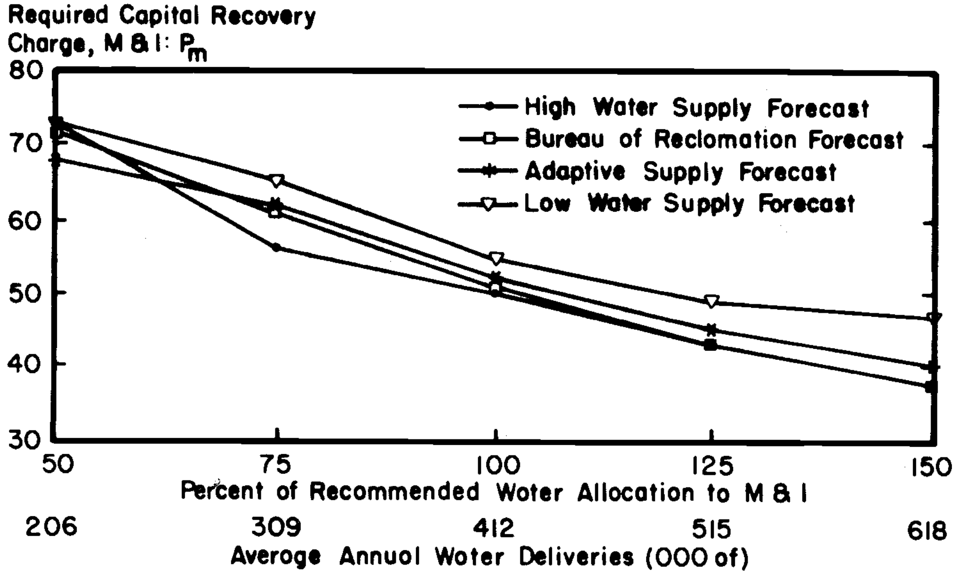
All of these variables cannot be predetermined independently if the budget balancing assumption (A5) is to be satisfied. Our basic approach will be to specify conditions for all variables listed except the charge for M&I water, P_M, and then solve for its value in accordance with (A5). This orientation is based on our prior belief that, to the extent possible, the CAP should be financed by (voluntary) water charges. Since the agricultural water charge, P_A, is to be based on ability to pay considerations (and agricultural water is in effect a residual supply), this leaves P_M as the major price instrument available to the CAWCD. This is not to say that the tax instrument is not important; indeed it will be seen to be crucial to the financial viability of CAP. Rather, the taxing authority is construed in the Master Contract as a residual revenue source, and thus it is given secondary importance in the analysis. The first simulation experiment described below reflects this priority in that it determines the M&I water price required to repay the CAWCD's capital obligation on a purely voluntaristic basis (t = 0).

A. Water user capital recovery charges: existing contractual arrangement. This experiment employs the current dollar capital cost estimate ($1690 million), a capital recovery charge for agricultural water deliveries of $2/af and surplus power revenues that are consistent with the alternative water supply conditions of Figure 1. The simulation results are expressed in terms of the capital recovery charge for M&I water required to meet the CAWCD repayment obligation. Figure 2 presents a summary of results for alternative water supply conditions, and alternative water allocations expressed as year by year percent increases or decreases from the currently recommended allocation. It can be seen that the required capital charge P_M is rather insensitive to the assumed water supply condition given the water allocation; this stems from the offsetting effect of surplus power sales and the fact that agricultural water users must be assessed a low capital recovery charge. The required capital recovery charge for expected supply and allocation conditions is $51-52/af; if the M&I water allocation were increased by 50% it would reduce P_M to $37-40/af.

B. Incremental capital recovery user costs. This experiment identifies the user cost of the CAP water delivery facilities in current dollar terms (see Figure 3). When the Navajo subsidy is removed from the repayment package, capital recovery costs increase (vis a vis A) by about 15-30%. For expected water supply conditions and the current allocation, the required capital charge for M&I water would be $64-$67/af. Incremental user costs are seen now to be dependent upon the assumed water supply since surplus power revenues have been eliminated, but the water allocation is still more influential in determining the required capital recovery charge. These user cost estimates reveal that the separable

Figure 2

Required M & I Capital Recovery Charges
Existing CAP Configuration
($ 1976)



cost of the water delivery system is (a) higher on a per acre foot basis and (b) more sensitive to CAP water availability than the overall project cost repayment analysis indicates.

C. Simulated repayment packages for the realized cost obligation. This experiment identifies a set of feasible CAWCD repayment packages while recognizing that realized capital costs ($2300 million) will be considerably more than costs estimated in current dollar terms (see Figure 4). In the main, the analysis reveals that the CAWCD would have a considerable degree of flexibility in setting capital recovery charges while still remaining within the limit of its taxing authority. Put another way, the relatively large tax revenue source would permit the CAWCD to levy very modest capital recovery charges. For the sake of comparison, note that an M&I charge of $67/af would be needed if no taxes are levied. The currently suggested charge of $32.50 could be combined with a 6¢/$100 AV tax levy if the current water allocation were adopted. These results indicate that a range of feasible pricing policies would exist, from the users' willingness to pay standpoint, either if M&I users are allocated more CAP water than is currently recommended or if relatively high tax rates are levied.[9]

D. Unsubsidized user capital costs and incremental capital costs. In this experiment we again express CAP capital costs in current dollar terms but apply a uniform cost of capital of 5% to all borrowed funds. The repayment obligation is first defined to include the Navajo Station costs and revenues and then defined on an incremental cost basis. The required capital recovery charges for M&I water increase dramatically, but do not depend appreciably on whether capital costs are viewed as "packaged" or incremental. This somewhat surprising result stems from the fact that the Navajo Station investment earns an effective rate of return of 5% when its energy is priced according to prevailing policies. As can be seen in Figure 5, the water allocation would importantly affect the magnitude of required capital recovery charges, but for any allocation considered, these user charges are considerably higher than those discussed in experiments A and B. Lastly, note that the per acre foot capital recovery charge is lower for the adaptive water supply forecast than for the Bureau of Reclamation forecast when the M&I water allocation is low. This occurs despite the fact that less water would be available for delivery in the adaptive supply forecast. The result occurs because the Navajo energy is worth more sold as surplus power than it would be worth when used to pump agricultural water at $2/af.

To summarize this analysis, the expected capital costs of delivery M&I water are more dependent on the water allocation than on the amount of the deliverable supply due to the requirement that agricultural users must be subsidized. The current dollar capital charges for expected supply conditions are presented in Table 2. Taken together these estimates indicate the financial importance of the water allocation and the CAP subsidy elements that we have identified.

9. Taxpayers are currently paying 3¢/$100 AV to defray interim administrative expenses.

Figure 3

Required M & I Capital Recovery Charges
Incremental Costs of the CAP Water Delivery System
($ 1976)

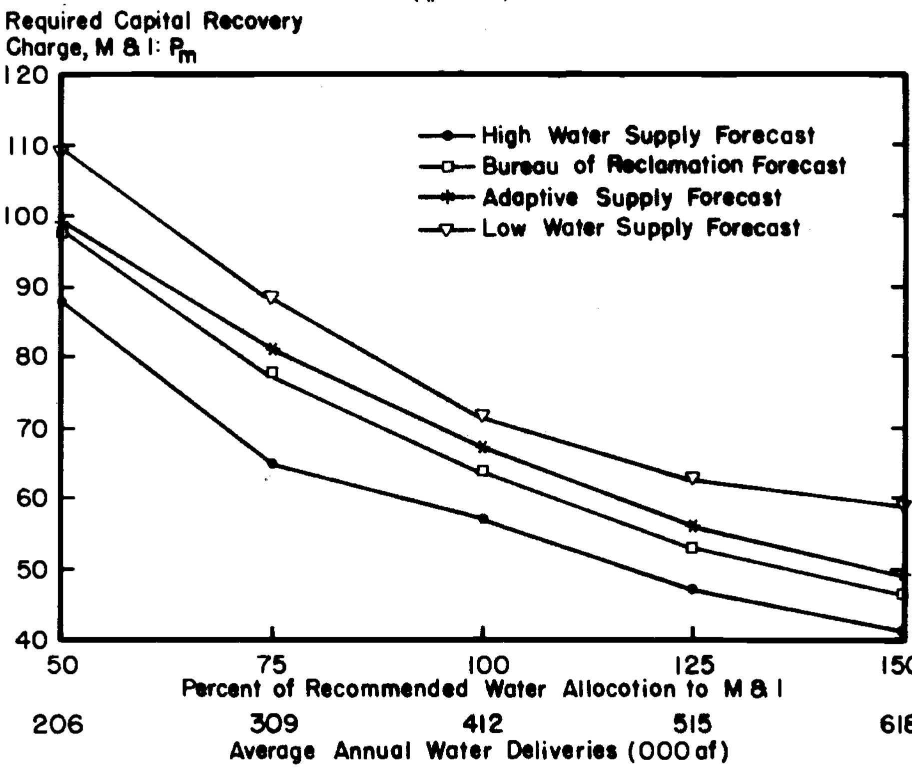


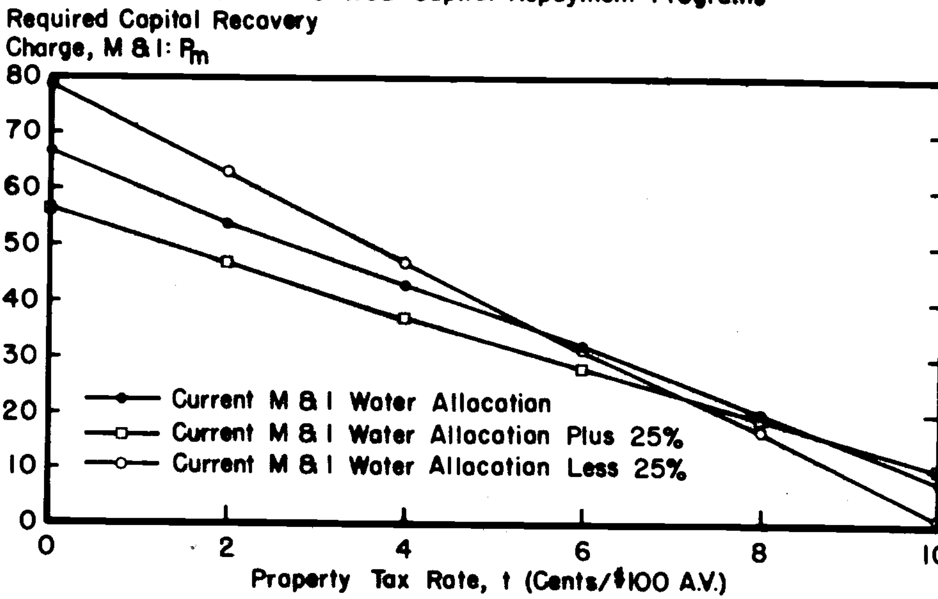
Table 2

Summary: CAP Capital Recovery Charges for M&I Water, ($1976/af)

	I Bureau of Reclamation Water Supply Forecast		II Adaptive Supply Forecast	
	(a) Current Water Allocation	(b) 50% Increase in M&I Water from (a)	(a) Current Water Allocation	(b) 50% Increase in M&I Water from (a)
Existing Contractual Arrangement:				
1. Capital Recovery, Inclusive of the Navajo Power Station	51	37	52	40
2. Incremental Capital Recovery Costs	64	46	67	49
5% Revenue Bond Finance:				
3. Capital Recovery, Inclusive of the Navajo Power Station	193	99	186	104
4. Incremental Capital Recovery Costs	194	129	193	129

Figure 4

Feasible CAWCD Capital Repayment Programs



CAP OPERATING COSTS

To estimate the full delivered cost of CAP water we must add OM&R costs and distribution costs to the capital recovery charges just discussed. OM&R costs include the operating costs of the water delivery system and the cost of pumping energy. Distribution costs refer to the per acre foot cost borne by CAP water users in transporting water from the main aqueduct to their use sites. In some cases this might be only a few miles, but in others it might be an appreciable distance. In any event, distribution costs are to be financed separately by users; they must build, maintain, and operate their own facilities. A third cost involves water treatment, but this is only relevant for municipal water deliveries. We will defer discussion of this cost question until the end of this section.

A. OM&R costs. The Bureau of Reclamation[10] has estimated OM&R costs at about $22 per delivered acre foot in terms of 1976 prices. That is, this cost measure is comparable to the current cost estimate discussed earlier. To judge whether the $22 figure is realistic, we must look at the way in which this estimated charge is computed. The cost estimates discussed here are summarized in Table 3. The OM&R estimate consists of three component charges, two of which are derived from the Navajo generating cost.

The $1976 cost of operating the CAP's share of the Navajo station was estimated to be $26.44 million, of which $14.17 million were operations, maintenance and overhead expenses, and $12.27 million were the (delivered) fuel costs. In determining OM&R charges these current dollar annual costs are allocated to M&I water, irrigation water and surplus power on the basis of estimated energy used (net of losses). By this, the pump energy cost included in the CAP OM&R water charges would only cover the variable costs of producing the energy. The estimated energy charges appear to be realistic when compared to the actual budget figures for the Navajo Station. In addition to variable energy costs, the estimated OM&R costs of the conveyance system are allocated (nearly) in proportion to water deliveries. This cost allocation procedure yields per acre foot OM&R charges of $22.16 and $21.30 for M&I and irrigation water deliveries, respectively. The estimation procedure just described indicates that OM&R delivery costs would be determined by proportionally assigning variable energy costs and delivery system costs.

The annual water delivery system OM&R costs of $9.17 million would include expenses for aqueduct maintenance and repair, and CAP administration. We have little feel for the likely magnitude of these costs; one fragmentary piece of information is the annual budgeted costs of the Bureau of Reclamation's Arizona Projects Office for the fiscal years 1976-1977. These costs were $6.7 and $11.2 million, respectively, to plan and administer the CAP construction work and its future operations. The 1976 FY budget for the CAWCD was $245,000. To summarize this cost discussion, the $1976 cost estimate appears to be realistic, barring any abrupt changes in Navajo fuel costs. This eventuality is not expected by the Navajo Station owners, but variable costs are expected to increase over time:

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[10] Arizona Projects Office, preliminary unpublished estimates September, 1976.

Figure 5

User Capital Recovery Costs Versus Incremental Costs of the Water Delivery System

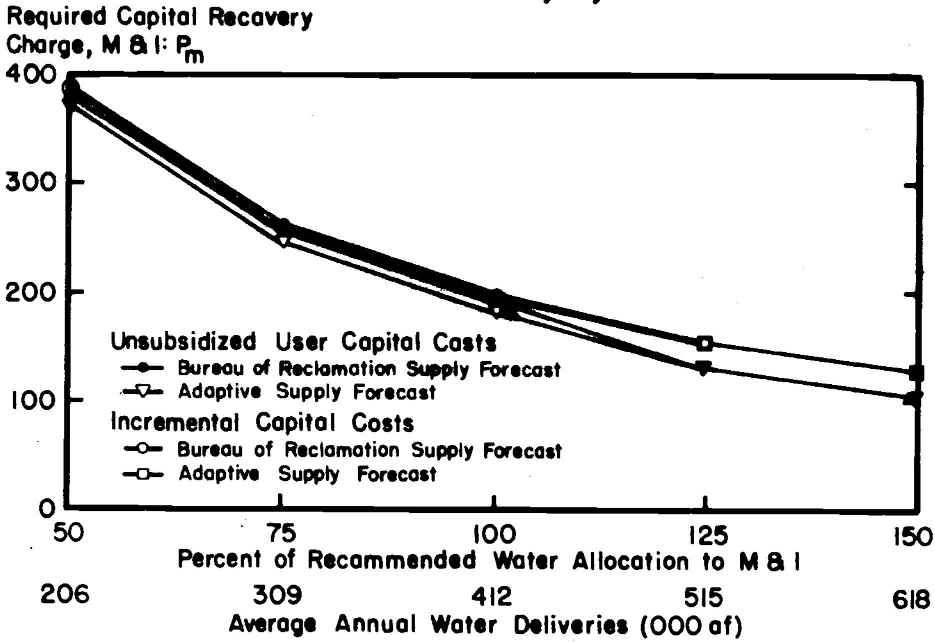

Table 3

Estimated OM&R Water Delivery Costs ($1976) and Navajo Budgeted Costs 1977*

	Estimated[1]				Actual Budget 1977[2]	
	Total	Irrigation	M&I	Surplus Power	Total	Surplus Power
1. Operations, overheads & maintenance ($million)	14.17	5.31	3.71	5.15	11.01	11.01
2. Fuel costs ($million)	12.27	4.59	3.22	4.46	11.62	11.62
3. Total ($million)	26.44	9.90	6.93	9.61	22.63	22.63
4. Kilowatt hours used (million)	3354	1256	879	1219	3334	3334
5. Cost/KWH	7.88	7.88	7.88	7.88	6.79	6.79
6. Water Delivery System OM&R costs ($million)	9.17	5.53	3.64	--		
7. Total OM&R costs (3) + (6)	35.61	15.43	10.57	9.61		
8. Water deliveries (000 af)		732	483			
9. OM&R charge/af[3] ($1976)		$21.30	$22.16			

[1]Data presented here are for a sample year (1997). Estimated water OM&R charges vary from year to year (range: $20.16 to $25.04) according to estimated energy losses and total water deliveries.

[2]The estimated 1977 sale price of surplus energy is 11.68 mills/KWH, comparably less in terms of costs than the sale price of 12.9 mills/KWH used to compute surplus power revenues in the simulation experiments of Section III.

[3]OM&R charge includes a storage charge by Lake Mead authorities of $.285/af.

Sources: Unpublished data, Bureau of Reclamation Arizona Projects Office, September, 1976. These estimates are to be regarded as preliminary and subject to change. The 1977 Navajo Station budget data was obtained through private correspondence, February 11, 1977.

Fuel costs may escalate at a rate somewhat higher than the level of general inflation while other costs should escalate with general price levels. There are no major cost changes anticipated in the future that would cause overall station operating costs to abruptly increase.[11]

Further discussion of the CAP's expected OM&R costs will be presented below in our discussion of the Southern California experience.

B. Distribution costs. As far as we can ascertain, little effort has gone toward estimating the magnitude of these costs. Engineering studies should be conducted by prospective CAP water subscribers to determine these costs. What is certain is that these must be borne on an individual basis at unsubsidized interest rates. Furthermore, these capital costs will be incurred by users prior to the delivery of CAP water. We have suggested previously[12] that average distribution costs per acre foot might be around $15/af, but we are less confident about this estimate than the other cost components of CAP water. Some concrete evidence appears to be available from the historical record of capital costs and recent engineering studies for extending the southern California water distribution system.

C. The Southern California experience. The CAP is not a unique water delivery system. One need only travel to the western shore of Lake Havasu itself to find its older counterpart. The Colorado River Aqueduct, owned and operated by the Metropolitan Water District of Southern California (MWD), delivers water to the Los Angeles area by remarkably similar means to those proposed in the CAP. The physical similarities of the two delivery systems are summarized in Table 4.

Table 4

A Tale of Two Aqueducts

	Colorado River Aqueduct	CAP	
1. Diversion Point	Lake Havasu	Lake Havasu	
2. Average Annual Deliveries	1.039 maf (1960-1975 average)	1.077 maf (Bureau of Reclamation Average Water Conditions)	
3. Energy Required per Diverted Acre Foot	2034 KWH (1974-1975)	1942 KWH (Bureau of Reclamation estimate)	
		Phoenix	Tucson
4. Length	242 miles	190 miles	315 miles
5. Vertical lift	1600 feet	1200 feet	2100 feet
6. Deliveries by User Class			
% M&I	69	36	
% Agriculture	14 (1958-1975)	64	
% Groundwater Replenished	17 averages	--	

The Colorado River Aqueduct (CRA) was built during the 1930's at an approximate capital cost of $220 million. By 1976 the outstanding indebtedness of the project was only $60 million. The MWD has subsequently undertaken other large investments, notably for the State Water Project delivery facilities and treatment facilities, and the overall capital costs of the system are financed jointly by property taxes[13] and uniform water charges. Still, the physical similarities between the two aqueducts indicate that the MWD's operating cost experience with the CRA can provide relevant information on CAP operating costs.

The enacting legislation (MWD Act, 1927) for the CRA clearly establishes the priorities for MWD operations; it is to "first develop, store, and distribute water for domestic and municipal purposes; and then if surplus water is available, it can be sold for other beneficial purposes" such as irrigation and groundwater replenishment. Perhaps more important, both from a managerial standpoint and on economic efficiency grounds, the MWD is resolved (Resolution 5821, September 1960) to price its water uniformly[14] (regardless of point of use or point of supply) and to charge water users all OM&R costs and at least one-half of annualized capital costs. In order to comply with Resolution 5821 it has had to dramatically increase water charges during the last 15 years, and it plans to more than double existing rates over the next decade to reach and maintain full compliance. In what follows we will highlight the MWD cost and water pricing experience where it appears relevant to CAP operations.

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11. Private correspondence, John Daer, Manager of Rates and Taxes, Salt River Project, February 11, 1977.

12. Barr and Pingry, op. cit., p. 47.

13. The current rate levied is 12¢/$100 AV. The rate has varied over the period 1931-1976 from 4¢ to 50¢ and has averaged about 25¢.

14. This has not been interpreted to mean that agricultural users should pay the same costs as municipal users. The adopted pricing policy attempts to charge agricultural water users marginal energy costs plus a modest charge per acre foot as a contribution to capital and other fixed costs. This is similar to the CAP's agricultural water pricing, but since the MWD's marginal energy costs are high and increasing, this will result in rapidly increasing agricultural water prices over the next decade.

1. Power costs. The primary concern of the MWD is the cost of power:[15]

The most critical factor in the (pricing) study continues to be the future cost of power required for pumping water through the Colorado River Aqueduct and the State Water Project. Such future costs cannot be evaluated accurately, but it is anticipated that costs for pumping State project water will increase very substantially when the rates in the present contract between the Department of Water Resources and the power suppliers expires in 1983 and must be replaced by new rates. As presently anticipated, the resulting power costs could increase by a factor of possibly 10 over costs applicable prior to that time.

Like the CAP, the MWD owns a substantial interest in the Hoover Dam generating facilities and a smaller interest in the Parker Dam facilities. The MWD also purchases energy from Glen Canyon and Southern California Edison at substantially higher cost than that of its own supplies. These energy sources and their respective costs are presented in Table 5. The MWD is understandably concerned about the expiration of its Hoover and Parker Dam contracts since the cost of this energy is 75-80% below that of its alternative sources. By comparison, the transfer price (equal to Navajo variable costs) proposed in the CAP for pumping energy is slightly higher than the 1974-1975 average MWD energy cost for pumping Colorado River water. The average OM&R cost of delivered Colorado River water depends importantly on the extent to which it must use its marginal power source (Edison). The estimated average OM&R cost per acre foot in 1974-1975 was about $22-$24. Inasmuch as average energy costs in this period were comparable to the estimated CAP pumping energy cost, this cost experience serves to validate the estimated OM&R cost discussed previously.

Table 5

MWD Operating Costs and Water Pricing

1. 1974-1975 Energy Costs, Colorado River Aqueduct*

Source	Million KWH	Percent	Unit Cost mills/KWH	Energy Cost/ Diverted Acre Foot
Hoover	1,246	62	2.47	$ 4.99
Parker	234	11	2.47	$ 4.99
Glen Canyon	200	10	12.00	$24.25
California Edison	320	16	17.90	$36.20
	2,000	100%	5.92 (avg.)	$11.84 (avg.)
Estimated CAP Costs (Table 3)	2,135		7.88	$13.52

*Source: 1974-1975 Annual Report, MWD, pp. 4-11.

2. MWD Water Pricing, Untreated Colorado River Water*

	(dollars/acre foot) 7/1/60	7/1/75	7/1/76	Planned 7/1/87
M&I	17	58	62	115
Agriculture	11	25	29	103
Groundwater Replacement	10	32	36	115

*Sources: 1974 Water Pricing Study, Volume 3, MWD Study Report 912 and 1977 Water Pricing Study, MWD.

2. MWD water pricing. In the past decade MWD has been able to charge modest rates for Colorado River water due to a combination of low energy costs and low capital costs, even though the latter includes a share of the capital costs of the State Water Project. Because of the expiration of the Hoover power contract, the MWD is anticipating a dramatic jump in pumping costs after 1987 and is planning to increase its water rates to all users in roughly equal increments during the interim period. Agricultural water rates would be affected the most, since they are to reflect the marginal energy costs of delivery. As the CAP is currently construed, it would not be subject to the same energy cost pressures, although it is quite possible that its energy costs could increase a lot faster than it is currently anticipated. The MWD situation underscores the pivotal role that energy costs play in determining the viability of large-scale water delivery projects. In a contractual sense, the CAP is fortunate to contain a relatively low cost energy source and an additional power supply that can be sold to supplement its water revenues. But in an opportunity cost sense, the Navajo power must be valued in terms of the long run incremental cost of additional power supplies, and this resource cost would be considerably higher than the variable costs reported in Table 4. For this reason it is misleading to claim that CAP water would be low cost water, just as it is misleading to claim that MWD water pumped by Hoover power is inexpensive--the current marginal cost of MWD Colorado River water is considerably higher (Table 5) and the contractual price for Hoover power will be probably comparable in 1983 even though it is turned on the same generators. Proponents of the CAP are correct in their judgment that the project is affordable as it is contractually arranged, but this stance could possibly be altered by a sobering look at Figure 5 and an appreciation of the opportunity cost of Navajo power.

15. John H. Lanten, General Manager, MWD, "1977 Pricing Study, Proposed 10-Year Program of Water Rate Increases," March 2, 1977.

D. Treatment Costs. The quality of Colorado river water at Lake Havasu is relatively poor. It contained on average in 1975 a concentration of total dissolved solids (TDS)--so called salinity--of 700 ppm. and a concentration of calcium carbonate--so called "hardness"--of 335 ppm. There is no economical means to treat salinity on a large scale basis, while hardness can be reduced by chemical additives. In addition to these dissolved concentrates, Colorado River water contains suspended materials of dubious to negative value that must be removed by filtration before the water is suitable for domestic use.

The MWD has filtered almost half of the Colorado river water it has delivered. Prior to 1975 it also softened (to 185 ppm.) about half of the water that it treated. When the higher quality State Project water became available in sufficient quantities in 1974, the MWD discontinued its water softening operations and switched to blending the two supplies in equal amounts. Blending has reduced hardness to about 220 ppm. and has also reduced salinity appreciably. The MWD currently operates four treatment plants that both filter and blend water. The existence of a second major supply thus permits treatment to be carried out on a large-scale, centralized basis. However, one unavoidable cost of this arrangement is that many agricultural users must subscribe and pay surcharges for unnecessarily filtered and blended water.

When compared to surface and groundwater supplies in central Arizona, CAP water would be significantly harder and probably contain more TDS. (The salinity of existing water supplies in the Phoenix area is comparable to Colorado River water, but groundwater in the Tucson area is significantly better in this respect.) A variety of studies exist[16] that suggest that the differential salinity and hardness of CAP water could impose additional costs on domestic users of about $10-$20 per acre foot if it is not blended or treated otherwise.

Colorado River water filtration costs are better known, since the MWD has just completed the Skinner treatment plant. It has an annual capacity of 240,000 af, a plant size that might be appropriate for Phoenix area users. The per acre foot costs at the Skinner plant have been estimated (in $1976) at slightly more than $25, assuming capacity utilization and 5.085% revenue bond financing.[17] CAP water treatment costs could be expected to vary from user to user, depending on the size and compatibility of existing treatment facilities.

E. Summary. To conclude this comparative analysis, we submit that the operating cost experience of the MWD is directly relevant to the task of forecasting CAP costs. Fortunately, the MWD has conducted thorough cost studies of its operations, and the management principles that it adheres to are worth studying in and of themselves.

SUMMARY

We can now aggregate the cost components just discussed. The user cost estimates in Table 6 are based on the CAWCD's contractual obligation.

Table 6

Estimated User Costs of CAP Water
($1976)

	M&I	Irrigation	Incremental Cost, M&I
Capital Costs[1]	40-55	2	45-65
OM&R	22	22	30
Distribution	15	15	15
Treatment	25	0	25
Quality Associated Costs	10-20	0	10-20
Total User Cost	$112-$127	$39	$125-$145

[1]The cost range reflects the differential charges for 100% and 150% of the current recommended water allocation.

The capital recovery charge for irrigation water was assumed to be $2/af throughout the simulation analysis. In part this value was used because it is the current "suggested" charge, but the other reason is that even at that subsidized rate, irrigation water costs ($37/af) would be equal to or greater than agriculture's (average) ability to pay for water. This restriction that agriculture water deliveries be subsidized acts to increase the required capital recovery charge for M&I water. The uniform capital recovery charge would be around $25/af, but then agricultural users could not afford the uniform price ($62/af).

We have defined incremental user costs to be the per acre foot costs of the CAP water delivery system, assuming that pumping energy would be provided at cost. This would increase the required M&I user cost by about $9-15/af. Finally, the full user capital cost (Figure 5) approach implies even higher CAP water costs.

16. A number of these studies (some that appear to be in the guesswork stage), have been summarized in the 1974 Water Pricing Study, MWD Study Report No. 912, Volume 2, Appendix G.
17. "Skinner Water Treatment Cost Analysis," unpublished document, MWD, 1976.

Even though the water cost estimates developed in this study are somewhat higher than existing CAP cost estimates, they still may be palatable to a great many Arizonans. Many benefits, both tangible and intangible, have been attached to CAP development. Some of these would include the reduction of current groundwater overdrafts, the increase in the renewable water supply in central Arizona, and the mere satisfaction of obtaining the Colorado water entitlement.

Several kinds of indirect economic benefits would also accrue to CAP constituents. The project's Orme Dam facility would provide flood control and recreation benefits which are in part to be financed by the federal government. To the extent that groundwater use is reduced, the CAP would reduce the threat of ground subsidence. The project will provide employment opportunities during its construction phase, and this temporary stimulus would benefit the construction industry and, indirectly, taxpayers to the extent that derived tax revenues create a net fiscal surplus. The boost in measured personal and corporate income derived from the construction work (and its multiplier effects) would be beneficial to the extent that it reduces the existing unemployment rate. But the sum of these temporary stimulative effects should not be regarded by the CAP as an end in itself.[18]

In any event, we must conclude that there are real cost issues that must be weighed before the CAP's overall merits can be decided. Some of the issues concern contractual costs while others concern equally important opportunity costs. Finally, our analysis points up the importance of <u>who</u> is to receive the water; but then, in central Arizona this has been the issue for some time.

18. Similarly, it would be difficult to unambiguously measure the welfare gains to Alaskans created by the spurt in measured income derived from the construction of the Trans Alaskan pipeline.