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Economic Discovery in Federally Supported Irrigation Districts: A Tribute to William E. Martin and Friends

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Ex post evaluation of economic projections validates our shared understanding of economic methodology and methods. The recent economic history of Central Arizona Project (CAP) agriculture reveals the predictive power of economic reasoning and its policy impotence within a political environment intent on obtaining its share of federally allocated water. The financial inability and unwillingness of large irrigation districts to pay for CAP water under existing federal rules produced an urban tax- and rate-payer controlled CAP decades earlier than planned. Yet irrigation districts remain a large residual buyer of CAP water under new pricing and allocation rules. Unfortunately, water markets remain an underutilized and distrusted tool in the water development game.

Key words: Bureau of Reclamation, Central Arizona Project, economics of water projects, management improvement programs, water pricing

Introduction

> . . . the Project would bring in water farmers in pump areas could not afford to buy and farmers in irrigation districts do not particularly need.
>
> Young and Martin, p. 17

> I see CAP agriculture attempting to shift as much of its CAP water allocation and associated debt as is legally and economically possible to other CAP water users, that is, M&I and Native Americans. Without these changes in CAP contracts, a majority of the CAP districts, and a significant portion of the growers, will declare bankruptcy and surrender their economic fate to the bankruptcy courts.
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> Wilson, p. 54

The notice of substantial completion of the Central Arizona Project (CAP) in 1993 represented the realization of a 70-year quest for many agricultural, community, and political leaders of Arizona. Federal debt repayment of approximately $2.1 billion pursuant to the master repayment contract between the federal government and the Central Arizona Water Conservation District (CAWCD) has begun. Construction of this water delivery system to transport Colorado River water through a 335-mile aqueduct to farms and cities in Maricopa, Pinal, and Pima Counties required the ongoing financial and technical support of the federal government (i.e., Bureau of Reclamation) for most of these 70 years.

The road towards the realization of the CAP dream began in 1919 with the formation of the League of the Southwest, an organization of the Colorado River basin states having

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the expressed purpose of promoting the development of the river (Johnson). In 1923, all the basin states, except Arizona, approved the Colorado River Compact. The compact evolved into the Boulder Canyon Project Act (1928) which allocated 2.8 million acre-feet annually to Arizona. During the 1930s both Boulder (now Hoover) and Parker Dams on the lower Colorado River were completed by the Bureau of Reclamation (BOR).

In 1941 Arizona Senator Carl Hayden asked the BOR to study all the realistic proposals for transporting Colorado River water to central Arizona. To complement this political effort, the Arizona State Legislature finally ratified the Colorado River Compact in 1944 and the state began to enlist the support of other basin states for the CAP. That same year the BOR recommended building the CAP and began engineering studies. Two years later, the Central Arizona Project Association (CAPA) was established as a lobbying entity solely for the purpose of insuring that the CAP dream would become a reality.

The 1950s were a decade of litigation. CAP authorization bills repeatedly failed to pass Congress due to ongoing water rights disputes between Arizona and California. So in 1952 Arizona filed an interstate legal suit against California to adjudicate its rights to the use of Colorado River water. In 1963 the U.S. Supreme Court decreed that Arizona had a right to 2.8 million acre-feet (*Arizona v. California,* 373 US 546). That same year CAPA opened an office in Washington, DC, to assist the Arizona congressional delegation in securing authorization and appropriation legislation from Congress. After some deft political maneuvering by Senator Hayden, Representative Morris Udall, and other political leaders, Congress authorized the CAP as part of the Colorado River Basin Project Act (Public Law 90-357) in 1968.

Obtaining and maintaining federal funding for the CAP proved to be as politically challenging as the authorization process. By 1970, some federal funding was authorized to begin CAP preconstruction planning. Construction finally began on the Havasu Pumping Plant in 1973 but the enthusiasm generated by the construction start-up event soon waned. In 1977 the CAP was placed on the Carter administration's "hit list" of federal water projects. Not only did current appropriated funds have to be justified, but the feasibility of the entire project was restudied by the Department of Interior, the Office of Management and Budget, the Council on Environmental Quality, and the Corps of Engineers. To combat this threat to the future of the CAP, the CAPA mobilized 17 chambers of commerce and 104 water companies, irrigation districts, and public utilities to send petitions and supporting resolutions to Congress. This communitywide effort was successful; several months later President Carter approved continued funding for the CAP contingent upon groundwater management legislation being passed and implemented by the state of Arizona.[1]

In 1980, Interior Secretary Cecil Andrus announced that Indian reservations in Arizona would have priority right to 309,828 acre-feet (ac.-ft.) of CAP water, followed by 640,000 acre-feet for municipal and industrial (M&I) users, with the balance of the 1.5 million acre-feet (mil. ac.-ft.) going to non-Indian agriculture. The Harquahala Valley Irrigation District took delivery of CAP water in 1985, followed by the city of Phoenix and Tonopah Irrigation District in 1986, and the irrigation districts in Pinal County in 1987. Households in Tucson, at the end of the 335-mile aqueduct, began drinking CAP water

[1] This federal condition for future fiscal support for the CAP produced the 1980 Arizona Groundwater Management Act. This legislation established the Arizona Department of Water Resources (ADWR), the four active management areas, the three irrigation nonexpansion areas, and the current planning process involving water resources on a statewide basis.

in November 1992. However, the Tucson City Council in the fall of 1993 voted to discontinue the delivery of potable CAP water to Tucson households due to widespread complaints concerning poor water quality. A citizen-led "clean water" initiative passed in 1995, which prohibits the delivery of CAP water as potable water for at least five years. Current plans are for Tucson to recharge to groundwater a significant portion of its CAP allotment and to sell 20–30,000 acre-feet to agriculture at prices competitive with groundwater.

Some of the earliest water development in the West, decades prior to the authorization of the CAP, was self-financed by agricultural, municipal, and mining interests. The willingness of the direct beneficiaries to fund infrastructure improvements implicitly indicated that these projects were economically beneficial. As water project implementation was relinquished to the federal government during the early part of this century and accelerated under BOR sponsorship, the projects on the margin became increasingly less economically viable. To justify the agricultural portions of these public investments on economic grounds, the BOR instituted a number of formal and informal policies such as low estimates of project costs, zero interest loans for agriculture, extended repayment periods, the ability-to-pay rule, postage-stamp pricing, and using power revenues to repay irrigation costs (Rucker and Fishback; McCool; Gardner). These, as well as other policies, masked the true costs of these projects, creating an unsustainable financial obligation for agriculture that could only be met through taxpayer largess.

This article traces the political economy surrounding the CAP as a case study of these BOR policies and the role of economic analysis in water resource management. The analytical projections of William E. Martin, as well as other economists, are evaluated using findings from recent economic analyses of non-Indian CAP agriculture. The article concludes by discussing the ongoing "work out" of project policies and programs that prematurely vaulted the CAP into the status of an urban and Native American water project.

Back to the Future II

Early economic analyses, one prior to the signing of the Colorado River Basin Act, challenged the existing water-use ethic in Arizona which argued for increased supplies to support a growing economy (Young and Martin; Kelso, Martin, and Mack). The CAP, it was argued by these authors, would deliver water to the farmer at higher prices than pumped groundwater. If the grower was forced to buy CAP water, this substantial increase in costs would drive many agricultural producers out of business or reduce their income. All projections pointed to CAP water being more expensive than groundwater for years to come; contrary to the arguments of some project proponents, a crossover in groundwater and CAP water price levels would not occur (see Beck projection in table 1). And even if there was a crossover well into the next century, the water price would be high enough that profitable agricultural production would be impossible. The real problem according to these modern day prophets was the misallocation of existing water supplies. As noted then,

> Water scarcity, even growing scarcity, is far less costly to the Arizona economy than is popularly supposed; whatever costliness the scarcity does impose, amelioration is far more a matter of re-

Table 1. Cost, Ability, and Willingness-to-Pay Comparisons in Past Economic Analyses

Source (Year)	Area of Analysis	Projected Water Cost ($/ac.-ft.)		Decision Variables ($/ac.-ft.)	
		Groundwater	CAP	Ability to Pay	Willingness to Pay
		(1992 dollars)			
1960s					
Young and Martin (1967)	Representative Central Arizona Farm	41	74	82	53
1970s					
Kelso, Martin & Mack (1973)	Roosevelt Water Conservation District				35
Barr and Pingry (1977a)	Central Arizona	58–116	70		
R. W. Beck and Associates (1977)	CAIDD	109	58		
1980s					
Bookman–Edmonston Engineering (1981)	MSIDD	57	72	126	
Bush and Martin (1986)	MSIDD	60*	70*		61
1990s					
Wilson (1992)	MSIDD	25*	52*	39	<39

Note: Asterisk denotes actual variable costs for water.

> forming man-made institutional inefficiencies in water administration and management than in reforming its nature-made physical scarcities. (Kelso, Martin, and Mack, p. 244).

Urban growth, long an objective of Arizona politicians, still could occur as municipalities urbanized farmland and obtained groundwater pumping rights or as agricultural water was transferred or sold to higher value uses.

In the year the CAP was placed on President Carter's hit list of federal water projects and funding was discontinued, Barr and Pingry (1977a, b) released reports which analyzed the complex cost structure of the CAP. They argued "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" (Barr and Pingry 1977b, p. 15). Using an investment analysis approach, the authors focused on the subsidies and costs of the project under different scenarios or experiments. They concluded that project costs would be significantly higher than originally predicted. Repayment for the main canal would be close to $2.3 billion, not $1.2 billion; the variable costs of CAP water would be twice those of pumped groundwater; power revenues would be necessary to subsidize water delivery; and that postage stamp pricing of CAP water would increase the OM&R costs of the system. They pointed out that the M&I users and the taxpayers in the three-county service area eventually would pay the majority of the costs incurred to supply irrigation water to agriculture. The authors suggested that a reappraisal of the CAP should look closely at the opportunity costs of continued CAP funding.

However, funding for the CAP was renewed in 1977 and agricultural irrigation districts began planning their CAP water distribution systems. These investments in irrigation infrastructure surpassed $100 million in the larger districts. Bush and Martin analyzed these investment decisions by projecting variable and fixed costs for representative farms in eight irrigation districts, with and without CAP water, over a 50-year planning horizon. They concluded that most irrigation districts would be worse off with the CAP than without it. Bush and Martin pointed out that the price of electrical energy, not the price of surface water, was the key factor in the survival of central Arizona agriculture.

Nevertheless, nine districts contracted for CAP water and built distribution systems with BOR and Central Arizona Water Conservation District (CAWCD) encouragement and support. These decisions downplayed all earlier economic analyses. Martin argued that growers, through their districts and lawyers, were playing a water development game. As soon as the physical infrastructure was in place and the costs of the CAP had to be paid, past experiences had shown that the costs of water for non-Indian agriculture were negotiable within the existing institutional environment.[2] Ironically, Martin predicted that these negotiations by non-Indian agricultural interests would use the same economic analyses which questioned the economic feasibility of the project for over two decades.

Economic Discovery

It became clear to progressive water managers in the late 1980s that economically sustainable water prices were unavailable to irrigation districts contracting for CAP water. Short-run projections by the CAWCD produced future CAP water prices of $60–80 per acre-foot, approximately twice the average economic value of the water in agricultural production and close to three times its marginal value. Anticipating these looming economic pressures and at the request of the U.S. Water Conservation Laboratory (USDA/ARS) in Phoenix, the farmer-dominated board of directors of the Maricopa-Stanfield Irrigation and Drainage District (MSIDD) agreed to participate in the Interagency Management Improvement Program (IMIP) in 1990.[3] Originally designed for improving water management in developing countries, the implementation of the IMIP methodology in the MSIDD was the initial use of this technology transfer tool in the U.S. (Lowdermilk et al.; Clyma and Lowdermilk). The overall goal of the IMIP was to improve the economic profitability and sustainability of irrigated agriculture in the MSIDD under the "new" reality of the CAP.

The IMIP brought together stakeholders in a proactive, nonconfrontational manner to

[2] The idea of the willingness to play the water development game was put forward by Martin, Ingram, and Laney. The Salt River Project in Arizona, the first Bureau of Reclamation–funded irrigation project, is a revealing case study of negotiations with the bureau (Smith).

[3] The MSIDD was formed in 1962 in anticipation of the arrival of CAP water. Located 30 miles south of Phoenix, the district's boundaries encompass approximately 87,000 acres of farmable land. Upland and American-Pima cotton and durum wheat are the major crops. The MSIDD is a conjunctive use district, blending groundwater from district-controlled wells with CAP water and delivering water to "farm gate" turnouts. Low-cost hydroelectricity is purchased from Electrical District No. 3. CAP water deliveries began in 1987, with the entire district on line in 1989. MSIDD staff manage 225 miles of canals, delivering water to 50 individual customers at 15 cubic feet per second. Approximately 50% of the irrigated land is sloping furrows, 25% level and low-gradient furrows, and 25% level basins. The predominant soils range from sandy loams to clay loams.

design and implement programs to improve water management.[4] Phase I of the IMIP in the MSIDD was a diagnostic analysis, an effort to identify and evaluate areas of high and low performance on farms and in district operations (Dedrick et al.). Management planning activities (Phase II) followed, with support and regulatory agency personnel working with growers to reach a shared understanding of the status of irrigated agriculture and designing new policies and programs directed at improving irrigation water management. Phase III, completed in January 1994, monitored and supported the initial implementation of the Phase II programs (e.g., improved on-farm water measurement, greater reliance on automated water delivery, negotiated water cost reductions). Growers and irrigation district personnel played a critical role throughout all phases of the IMIP process. Ex post evaluation of the IMIP concluded that an interorganizational and interdisciplinary approach to improving water management in federally supported irrigation districts holds promise (LeClair, Bautista, and Rish).[5]

Yet throughout the IMIP, it became increasingly clear to the participants that irrigated agriculture in the MSIDD was not economically sustainable under current prices and policies, even with increased technical efficiency. Plans to deliver CAP water to the MSIDD were fundamentally flawed from the beginning because they incorrectly modeled on-farm economic decision making, ignored principles of financial risk, and overestimated the ability of the MSIDD to control water policy decisions at the state, regional, and national level.

Farm Level

The IMIP diagnostic analysis revealed deteriorating farm-level economic conditions in the MSIDD. Upland and American-Pima cotton yields since 1987 had trended downward, with wide year-to-year variation. Analysts attributed this unfavorable trend to poor soil fertility conditions due to an evolving cotton monoculture, poor growing weather, and damaging pest infestations (e.g., boll weevil, pink bollworm, whitefly).[6] Real cotton prices had trended downward for the last 20 years. When combined with rising real costs for inputs, particularly CAP water, MSIDD growers found themselves in a difficult cost-price squeeze where their only survival strategies were cost-saving actions through better management practices and financial/legal restructuring.

Until 1986, Arizona's agricultural lenders had made loan decisions based on repayment capacity and the market value of the grower's assets, particularly land. With land values appreciating rapidly in central Arizona due to urban development and speculative market pressures, lenders were assured that even bad loans could be repaid by selling the col-

[4] The principal supporting agencies in the IMIP were the USDA/ARS Water Conservation Laboratory (Lead Agency), USDA/Soil Conservation Service, U.S. Department of Interior–Bureau of Reclamation, Arizona Department of Water Resources, Arizona Department of Environmental Quality, Arizona Department of Agriculture, and The University of Arizona College of Agriculture.

[5] The IMIP continues today under the oversight of the grower-led MIP Coordinating Group. Nongrower members include the MSIDD general manager and representatives from the Natural Resource Conservation Service, Arizona Department of Water Resources, Central Arizona Water Conservation District, University of Arizona Cooperative Extension, West Pinal Natural Resource Conservation District, USDA Farm Services Agency, and the U.S. Bureau of Reclamation.

[6] Although crop rotation (e.g., cotton, alfalfa, and small grain) was practiced historically in the district, due to recent financial stress growers had followed a near cotton monoculture. Over the period of 1989–91, cotton represented 96% of the planted acreage in MSIDD (Dedrick et al.).

lateral. However, "paper equity" financing produced loan portfolios that could not be sustained on the value of agricultural production alone.

With external macroeconomic pressures (e.g., recession, increased regulation, interstate banking) in the mid-1980s, lenders began to modify their lending practices, particularly with borrowers in CAP irrigation districts due to the economic factors discussed above. First, repayment capacity became the dominant criterion for loan approval. Secondly, most lenders began to require at least a 25% margin on their loans. But most important, a risk grading system for loans was followed more deliberately where the rating attached to the loan reflected its riskiness to the lender. Loans which did not receive a "passing grade" required that the lender establish a reserve for the loan. These reserves represented bank capital upon which no return was earned, thereby raising the cost to the lender of loaning money to businesses experiencing financial difficulties. Loan officers became wary of lending to customers with marginal cash flow projections, low collateral values, a restricted loan, or were out of margin on an existing loan, or who had experienced recent carryovers. Partially as a result of this stricter lending environment, farmed acreage in the MSIDD declined by over 20,000 acres from 1988–91.

District Level

In conjunctive-use irrigation districts, where the district manages both ground- and surface-water resources, growers are dependent on the economic success of their neighbors. The MSIDD, a conjunctive-use district, must sell water to justify its existence and survive as an operating entity. And the water must be sold at a price which covers the cost of water and the cost of irrigation district services. Reductions in planted acreage due to the inability of growers to obtain financing or, worse yet, growers declaring bankruptcy threaten the economic viability of the irrigation district. For example, let $Q^* = TFC/(P-AVC)$, where Q^* is the acre-feet of water which needs to be sold to generate sufficient revenues to cover district-level, variable- and fixed-financial obligations; TFC represents the costs which are fixed and not subject to the amount of water delivered; P is the district water price; and AVC represents expenses which vary with the volume of water sold. Reasonable approximations for the MSIDD in the early 1990s were $5.5 million in annual fixed costs, a water price of $40/acre-foot, and average variable costs of $20/acre-foot. In this scenario the MSIDD needed to sell 275,000 acre-feet to break even. Assuming that 4.5 acre-feet per acre are applied to MSIDD farms, 61,000 acres would have to be farmed to cover district financial obligations. Planted acreage in the district averaged 50,000 acres in the early 1990s. This acreage pattern was not financially sustainable. Assuming farmed acreage remained unchanged, economic survival was dependent on the district taking action to lower its water costs, its fixed financial obligations, or both.

The MSIDD attempted to maintain water at affordable prices through two programs: conjunctive management of groundwater and CAP water, and participation in the indirect recharge or groundwater savings program. A "low" average price for water was possible by blending well and surface water. Electrical power to operate deep water wells was purchased from Electrical District No. 3 which had long-term, low-cost hydroelectric power contracts with the Arizona Power Authority and the Western Area Power Administration. During the period of 1990–93, approximately 60% of the irrigation water for MSIDD growers was pumped from deep water wells at a variable cost of $25/acre-foot.

Under the Arizona Department of Water Resources' groundwater savings program started in 1992, the MSIDD agreed to not pump as much groundwater in exchange for groundwater pumping credits which were then "exchanged" with the CAWCD for a substantially lower price on a portion of MSIDD's CAP water allocation. CAWCD could sell these credits in the future to irrigation districts and municipalities out of compliance with groundwater withdrawal regulations or use credits to offset future droughts.

As with many BOR-supported projects, an important portion of the cost of water is treated as a fixed cost and paid by ad valorem taxes, generally property taxes (Miller). In the case of the MSIDD, the cost of constructing the distribution systems from the main CAP canal to and within the boundaries of the irrigation district was $110 million, 80% funded interest free by the federal government, and 20% financed through the sale of private, interest-bearing bonds. To meet debt payments, each acre in the MSIDD with a grandfathered water right is assessed a tax: approximately $85 per acre in the early 1990s. This tax figure was adjusted downward through 1993 by lease payments (i.e., well credits) from the MSIDD to the grower based on the appraised value of the grower's wells in 1989 which were turned over to MSIDD's management control. These well credits ranged from $20–$69 per acre. As a result, the growers with low well credits had relatively high tax payments which were treated as cash expenses in their financial projections prepared for their lender. Although CAP irrigation water was priced at $40/acre-foot, the actual cost of CAP water was $50–55/acre-foot if the grower planted 75% of his grandfathered acreage. To insure a "safety net" acreage level in 1992 and 1993, the MSIDD Board of Directors used financial reserves to pay the tax assessments for all its active growers. In 1994 the tax assessment was reduced to approximately $40 for all growers to reflect the actual cost of the district's debt service obligations. Well lease payments now are handled as a separate financial transaction between the district and the well owner.

Through the IMIP process, MSIDD management and BOR staff discovered that farming was not sustainable with the relatively high and increasing cost of CAP water. Making water delivery more technically efficient, although important, did not confront two looming economic realities. First, current acreage levels and tax payments would not support districtwide debt payments for more than three additional years. Both public and private debt obligations needed restructuring. Secondly, growers, district personnel, and agency staff realized that the future of the MSIDD was jeopardized under current contractual obligations. The federally mandated "take-or-pay" provision required the district to either buy its full allocation of CAP water or pay $22.50/acre-foot [a charge for operation, maintenance, and replacement (OM&R)] for the portion of the allocation not delivered to the district. MSIDD management recognized that enforcing the take-or-pay provision would force the district into default and Chapter 9 municipal bankruptcy.

Systemwide

The original federally supported feasibility studies envisioned that the majority (60–80%) of the 1.5 mil. ac.-ft. of imported Colorado River water allocated to Arizona would be used in non-Indian agriculture during the initial three decades of the project. MSIDD alone expressed interest in buying over 400,000 acre-feet of CAP water (Arizona Water Commission). It was anticipated that as the urban population of central Arizona grew and as the Indian reservations were able to use their CAP allocations, the amount of

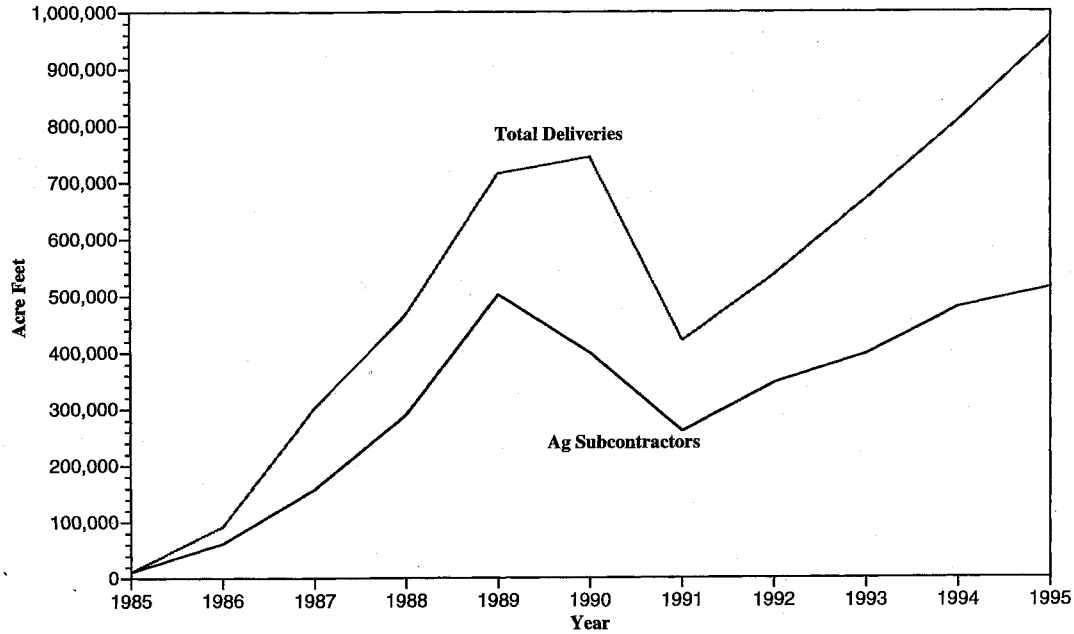

Figure 1. Central Arizona project water deliveries, 1985–95

Source: Central Arizona Water Conservation District

project water available to non-Indian agriculture would decline due to its lower priority right. As predicted by Martin and others, this scenario did not unfold in the initial years of this project. Non-Indian agricultural sales of CAP water peaked at 501,000 acre-feet in 1989; then declined precipitously to 260,000 acre-feet in 1991 due to relatively high CAP water pricing (fig. 1). Sales to agriculture have rebounded since 1991 due to extremely favorable price incentive programs (i.e., indirect recharge, pool pricing) supported by urban rate- and taxpayers. Since 1992 the weighted average cash price for MSIDD has ranged from $14–22 per acre-foot (CAWCD).

Underutilization was predictable. Owners of only 50% of the potentially irrigable acreage in central Arizona voted to accept CAP water. Not surprisingly, the first and foremost reason was cost. Many districts have access to lower-cost water, either by other surface supplies (i.e., the Salt, Verde, and Gila Rivers federally supported irrigation projects), effluent, or low-cost groundwater due to preferential electric power contracts, and/or shallow pumping lifts. Secondly, the owners of agricultural land recognized that CAP water would fall within the scope of the Reclamation Reform Act of 1982 (RRA). Under the RRA, lands with nonresident alien owners or with 26 or more owners would not be eligible to receive CAP water at favorable, below "full cost" prices. Also, the 960-acre limitation under the RRA discouraged many landowners, particularly in Maricopa County, from contracting for CAP water.

Feasibility studies for constructing distribution systems in irrigation districts were conducted by the BOR and private engineering firms during the late 1970s and early 1980s.[7]

[7] A representative feasibility study is Bookman-Edmonston Engineering. A twin report was done for the Maricopa-Stanfield Irrigation and Drainage District. All other districts had similar feasibility reports written to support private bond financing.

These reports provided the basis for federal loan approval and the ability of districts to issue private securities to build their distribution systems. Bookman-Edmonston Engineering's estimates of the "ability to pay" for CAP water exceeded $100 per acre-foot in 1992 dollars (table 1). The present analysis has the benefit of hindsight, yet the non-price assumptions and methods used in these earlier analyses were fundamentally flawed in four areas: acreage farmed, high-value crops, groundwater usage, and treatment of uncertainty (Wilson).

Farmed Acreage. The feasibility studies generally assumed that all the CAP-eligible acreage in the district would be farmed every year for 50 years. This assumption was based on historical transitions made in California irrigation districts. Revenue from every acre would be available to pay for water and the acreage tax assessment. Yet due to government set-aside programs, the lack of crop financing, the Groundwater Management Act of 1980, as well as other factors, all the acreage in these districts was not farmed over the last two decades. Approximately 50% of the acreage in the CAP districts was farmed in the early years of the project. And as noted in the IMIP analysis, decreased cropped acreage places a greater financial burden on each producing acre.

High-Value Crops. The selection of a representative cropping pattern is an important step in the development of a representative farm budget. The crop mix determines expected gross revenues and operating costs. If these representative farm acreages are aggregated to reflect district-level acreage, care must be taken to insure the aggregate acreage figure is reasonable. Certain crops can be used as proxies for all specialty crops, but the aggregate figures should reflect conservative conditions.

The feasibility studies for the largest CAP districts, MSIDD and Central Arizona Irrigation and Drainage District (CAIDD), did not follow these guidelines. In the MSIDD it was assumed that the representative farm (700 gross acres) harvested 70 acres of fall lettuce each year for 50 years. With 133 representative farms in the MSIDD, the study assumed that there were 9,310 acres of lettuce planted each year in the MSIDD. To compound matters, a similar assumption was made in the CAIDD feasibility study thereby producing over 18,000 acres of lettuce in these two districts on an annual basis. Between 1978–81 only an average of 2,600 acres of fall and spring lettuce were planted in all of Pinal County (Arizona Agricultural Statistics Service).

Groundwater Usage. By selecting the "ability-to-pay" methodology rather than "project generated payment capacity," the BOR and engineering firms created a secondary role for groundwater and farm-level decision making in their feasibility studies. The ability-to-pay procedure does not recognize the decision-making process of the grower or the conjunctive-use district when substitute water resources are available at lower prices. Project generated payment capacity would have calculated the additional income produced by the existence of the CAP which would be available to retire the new debt associated with the investment. Estimates of net farm income with and without the project over a 30–50 year planning horizon would have been generated. Explicit assumptions would have been made on future costs of groundwater relative to CAP water, the cost of financing the district distribution systems, and the discounted rate of return on the projects.

Secondly, the ability-to-pay procedure does not recognize marginal decision making. It is an accounting or, worse yet, a political criterion. Rational farmers equate the marginal value, not the average values, with the cost of the additional acre-foot of water. The marginal willingness to pay is less than the ability to pay. As illustrated in table 1,

the BOR-related estimates overstated the willingness of growers to purchase CAP water on the margin. Project analysts and others wrongly assumed that improved cotton prices and yields would increase dramatically the amount of CAP water sold, ceteris paribus. Again, rational business people use their lowest-cost resource first (i.e., groundwater) irrespective of what happens to commodity prices. Lower-cost groundwater is pumped up to the preferential power supply limitation. Then the next highest cost source of water is purchased. Therefore, as long as groundwater is relatively less expensive the underutilization of CAP water in the non-Indian agricultural sector would continue.

Uncertainty. There is no record of any sensitivity analysis being carried out in the district feasibility studies. Acreage planted, crop mix, yields, and relative prices were assumed to be constant over the repayment period. Yet variability inherent in agricultural production is a well-established fact which demands consideration in any economic feasibility study (Reutlinger 1970). For example, Wilson demonstrated that with a 5% decline in gross revenues, a central Arizona grower's ability to pay for irrigation water dropped to $28 per acre-foot in the realistic representative farm model. This value was $8 less than CAWCD's energy cost in 1992 for delivering an acre-foot of CAP water to a district. A 10% decline in gross revenues produced an ability to pay $19 per acre-foot. Simple sensitivity analysis using realistic farm models and scenarios would have demonstrated the tenuous economic future of CAP-dependent irrigation districts.

The Workout: Negotiations and Beyond

The CAP is designed as a multiple-purpose public works program providing irrigation water delivery, M&I water delivery, electric power generation, fish and wildlife habitats, recreation facilities, and flood control. Funds for repaying the estimated $2.1 billion debt associated with the main canal are generated by the sale of water, the sale of power from the Navajo Generating Station in northern Arizona, a four mill surcharge on power sold in Arizona from Hoover Dam, and a $0.10 per $100 assessed value ad valorem property tax within the CAWCD's service area. By the spring 1992, the water resource and political leaders of Arizona finally recognized publicly that the underutilization of CAP water was a reality under current policies. Fundamental to this realization, but often unappreciated by policymakers, were the economic interdependencies between agriculture and M&I inherent in the CAP.

First, water sales to non-Indian agriculture could not be sustained unless the price of CAP water was competitive with groundwater.[8] Without a groundwater saving program or a price subsidy, combined with the elimination of the take-or-pay provisions, sales of agricultural irrigation water were projected in 1992 to decline within several years to a few thousand acre-feet. Lower water sales would create financial difficulties for the CAWCD assuming that power sales continued to generate a small, uncertain profit margin and the ad valorem tax remained unchanged. Yet formal water sales projections developed by CAWCD in 1989 had included an 80% increase in revenue between FY92 and

[8] It has been assumed that the federal government would pay the water costs for water delivered, and the OM&R costs for the water allocated, to the Native American communities. This assumption currently is being negotiated in Bureau of Reclamation and CAWCD discussions.

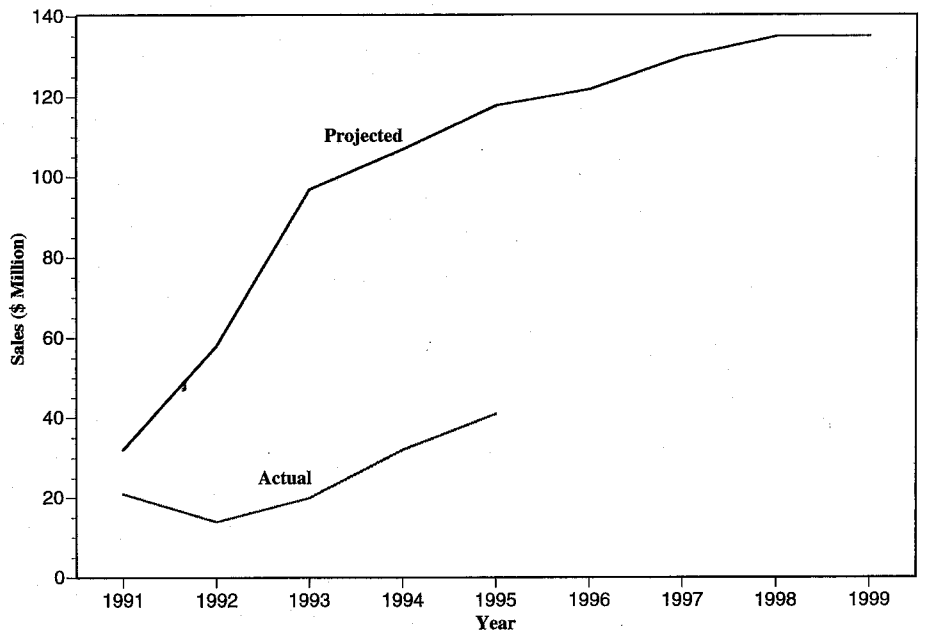

Figure 2. Projected and actual water revenues (millions of dollars)

Source: Central Arizona Water Conservation District

FY93 and an additional increase of 68% the following year (fig. 2).[9] Projected water sale revenues were to increase from $32.1 million to $97.4 million over these two years. These projections were unrealistic in 1989 and were not attained in the early to mid-1990s. Furthermore, these overly optimistic sales projections raised questions concerning the ability of the CAWCD to retire its debt, without drawing down its financial reserves or raising ad valorem taxes.

Secondly, M&I users of CAP water became concerned about the viability of CAP agriculture, particularly cities like Tucson that had committed at the time to full dependence on CAP water by the end of this decade. This economic interdependency arises from the existence of CAWCD's fixed OM&R costs estimated at $30 million per year. M&I users realized that if non-Indian agriculture ceased to buy CAP water and was relieved of its take-or-pay provision, then M&I users would carry most of the OM&R burden. These fixed OM&R charges spread over 200,000 acre-feet of demand would drive the effective price of water to municipalities far beyond $150 per acre-foot within a year. Consequent water rate shock would be politically unacceptable to city councils throughout central Arizona.

A third interdependency was the interest obligation on the federal debt for the main canal. Under the master repayment contract between the U.S. government and the CAWCD, no interest is paid on the federal loan for that portion of the system serving agriculture. The outstanding balance of the portion of the canal investment dedicated to serving M&I users is charged a 3.342% interest rate over the life of the repayment period.

[9] These overlay optimistic projections can be found in documents such as the Contract Revenue Bonds, Series B 1991 ($110,671,353.90) for the Central Arizona Water Conservation District, 13 August 1991, pp. C31–C32. A copy is available from the author or the CAWCD.

Table 2. Status of Original CAP Irrigation District Subcontractors, 1996

	Type[a]	CAP Eligible Acres	Operating Status in 1996
Maricopa County			
Chandler Heights Citrus	CU	1,140	Waived rights, leasing CAP water
Harquahala Valley	GC	33,200	Formally out of CAP, water rights "sold" for Indian water rights settlement, buying CAP water on spot market.
Queen Creek	GC	20,648	Waived rights, leasing CAP water
San Tan	CU	2,037	Long-term contract plus leasing CAP water
Tonopah	GC	3,470	Waived rights, leasing CAP water
County subtotal		60,495	
Pinal County			
Central Arizona	CU	87,081	Waived rights, leasing CAP water, resolved Chapter 9 bankruptcy in 1996
Hohokam	GC	28,167	Water rights sold to Phoenix-area municipalities, leasing CAP water
Maricopa-Stanfield	CU	87,363	Waived rights, leasing CAP water, renegotiated federal and private debt in 1996 without declaring bankruptcy
New Magma	CU	26,640	Waived rights, leasing CAP water, resolved Chapter 9 bankruptcy in 1995
County subtotal		229,251	
Total		289,746	

[a] A conjunctive use (CU) district controls and allocates virtually all water resources within its boundaries, i.e., pumped groundwater and surface water. Grower controlled (GC) districts deliver only CAP water to growers on demand and the growers control their individual groundwater wells.

As agriculture is delivered less and less water, the share of cost-bearing interest increases for the CAWCD. If the CAP were to become an M&I project, the annual interest payments alone to the federal government could surpass $50 million. The interest savings to the M&I sector for selling 200,000 acre-feet to non-Indian agriculture is $10 million annually (Arizona Department of Water Resources).

Arizona Governor Fife Symington formed two task forces, one in the summer of 1992 and a second in January of 1993, to study the underutilization issue and propose a workout plan (Brophy). Yet as these task forces labored and negotiated in the public limelight, individual district management took unilateral actions to preserve the economic integrity of their districts and their growers. First, Harquahala Irrigation District, the first district to accept CAP water, sold its rights to CAP water to the federal government for nearly $29 million in December 1992. This water was used in the settlement of a long-standing legal claim of the Fort McDowell Indian Community. Near Chapter 9 bankruptcy for two consecutive years, Harquahala was able to free itself of its federal and private debt and still buy CAP water on the spot market (table 2).

In late 1993 the Hohokam Irrigation and Drainage District transferred its rights to CAP water (approximately 28,000 acre-feet per year) to the Arizona Municipal Water Users' Association, a private, nonprofit corporation acting on behalf of Chandler, Glendale, Mesa, Phoenix, Scottsdale, and Tempe. In exchange the association assumed vir-

tually all the outstanding federal and private debt ($31 million) Hohokam had incurred in constructing its distribution system. In January 1994, New Magma Irrigation and Drainage District filed for municipal bankruptcy in federal district court. The district had faithfully met its private bond payments but was in significant arrears with its federal debt. Chapter 9 bankruptcy enabled the district to protect its $26 million investment in the distribution system, to continue receiving CAP water, to restructure both its federal and private debt, and to maintain control over its day-to-day operations (Baker). The New Magma bankruptcy represented the first Chapter 9 filing by a federally supported irrigation district in the nation. In August 1994, Central Arizona Irrigation and Drainage District also declared bankruptcy, noting in court depositions that William Martin's early analysis raised questions about the economic viability of CAP agriculture. Concurrent with the New Magma and Central Arizona actions, the MSIDD retained an investment banking firm to investigate ways its federal and private debt could be restructured. In 1995, MSIDD initiated preliminary legal discussions with the state of Arizona and its private bondholders in anticipation of its inability to make bond payments in the future.

In light of the interdependencies between non-Indian agriculture and the other users of CAP water, the governor's task forces and the CAWCD recognized that the only means to retain agriculture in the system was to reduce the price of CAP water to irrigation districts (Central Arizona Project Advisory Committee).[10] Yet the take-or-pay provisions of current subcontracts and debt repayments for the distribution systems would still burden the districts and growers. After extended negotiations, eight irrigation districts agreed to waive their long-term rights (i.e., subcontracts) to CAP water, substituting short-term, subsidized leases instead. These lease contracts do not contain take-or-pay provisions. Pool 1 ($27/ac.-ft.), Pool 2 ($17/ac.-ft.), and Pool 3 ($41/ac.-ft.) were made available through lease arrangements with 200,000 acre-feet available in both Pools 1 and 2 and all remaining agricultural water in Pool 3. Prices were to increase by $1/ac.-ft. until 1999. All of Pool 1 and 2 allocations are leased through 2003. An irrigation district recommendation that the CAWCD assume the district-level debt associated with the distribution systems was rejected by the M&I users and the CAWCD Board of Directors.

With agricultural demand for CAP water running significantly less than expectations, the CAWCD attempted to sell surplus Navajo power at a profit through the Western Systems Power Pool. Yet by selling power on the short-term market, CAWCD could not guarantee that the price received would cover the costs of producing the energy. The governor's task forces and the CAWCD recognized that profitable energy sales were necessary to support the debt service associated with the CAP. In 1994, the Salt River Project's (SRP) offer to purchase the surplus Navajo capacity for $21.75 million annually was accepted.[11] CAWCD pays SRP for energy generated at a price that covers the production and transmission costs. Under the agreement CAWCD's Hoover and New Waddell capacity and energy is integrated with SRP's power distribution system. SRP contracts this capacity and energy at favorable long-term rates. In essence, the SRP agreement enables the CAWCD to use low-cost Hoover energy to pump CAP water while

[10] A comprehensive discussion of the evolving CAP workout process can be found in Glennon. Special emphasis is given to the events surrounding the CAP over the last three years.

[11] The SRP, although not an original contractor for CAP water, now has an in-lieu-of arrangement with CAWCD, with plans to use 200,000 acre-feet for agriculture in Maricopa County.

holding higher-cost resources in reserve if needed; a strategy not unlike the decisions made at the grower and irrigation district level with regard to another resource, water.

Summary: Getting Economics Right

As the federal government and the CAWCD negotiate the "final" repayment obligations of the state of Arizona, all current economic evidence validates the prophetic analysis of William Martin and colleagues who questioned the economic wisdom of investing in the CAP for non-Indian agriculture. Districts with low-cost groundwater and surface-water supplies did not contract for CAP water. Districts with relatively higher-cost groundwater supplies contracted for water but were unable to afford the water. Eight of the nine original agricultural subcontractors have waived their rights to CAP water. M&I users now subsidize non-Indian agriculture and finance recharge projects (e.g., Arizona Water Bank) while CAWCD sells water to new agricultural customers (e.g., SRP); all efforts to increase the utilization of Arizona's Colorado River allotment, protecting the allotment from California and Nevada interests. As predicted by Barr and Pingry, the sale of surplus electric power has become a critical source of funds for project repayment. And even M&I users (e.g., Tucson) have discovered that CAP water is significantly more expensive than alternative sources of water.

The water community of the West should use the CAP experience to stimulate the exploration of the net benefits of markets for getting their economics right (Saliba and Bush; Wahl; Colby). The recommendations from the governor's Central Arizona Project Advisory Committee recognize the potential of water markets for allocating CAP water efficiently in central Arizona and beyond. The CAWCD now has control over the CAP agricultural pool and thousands of groundwater savings credits which could provide a foundation for market development. Yet there still is strong suspicion of and political resistance to the market mechanism. Arizona has leaned heavily over the years on "command and control" policies for water allocation and management. Ironically, translating the recognition that markets are capable management tools into concrete action also was championed a quarter of a century ago: ". . . 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" (Young and Martin, p. 18).

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