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Emerging Agricultural Water Conservation Price Incentives

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Recent Bureau of Reclamation policies encourage or require irrigation districts to adopt price conservation incentives. Using unpublished survey results and new district-level information, we examine the rate structures and incentives of district water pricing. Our findings reveal that the majority of districts use fixed charges independent of the quantity of water delivered and that most conservation rate structures recently implemented are designed so that the first tier quantity allocation satisfies most crop water needs. Although other district management objectives may be satisfied, price incentives are diminished or nonexistent. The question of whether conservation is being achieved is tautological and depends on how each district defines conservation.

Key words: conservation, irrigation districts, price incentives, rate structure, water use policy

Introduction

Agriculture uses close to 90% of the water consumed in the western United States (U.S. Congress, Office of Technology Assessment). Of the 46 million acres of land irrigated in 17 western states, almost 20% receives water from U.S. Department of the Interior (USDI), Bureau of Reclamation (BOR) water supply, storage, and distribution projects (USDI 1996b). The BOR is the largest supplier and manager of water in the West.

BOR projects annually divert more than 40 million acre-feet (MAF) of water from western rivers and supply 25.4 MAF of water to 9.2 million acres of land (USDI 1996b, p. 3-2), an average of almost 2.8 acre-feet of water per acre. Although water supplies and uses vary from year to year, U.S. Geological Survey estimates from over the last 20 years indicate that land irrigated with BOR project water receives from one-quarter to one-half acre-foot more water than the average delivery per acre of all irrigated land in 17 western states (USDI 1996b, p. 3-53). Municipal and industrial deliveries of 4.4 MAF, representing 14% of total BOR deliveries in 1991, helped to meet the needs of almost 30 million people (USDI 1996b, p. 3-1). Approximately one-quarter of total diversions

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(around 10 MAF) are "lost" in operational spills and conveyance to agricultural and municipal uses (Moore).

Following almost three-quarters of a century of structural water development projects, the BOR focus has turned from the construction of new supply facilities to management of existing water resources (USDI 1992). Management strategies adopted by BOR in response to pressure from growing demands, increasing costs, legislation, and litigation include conservation measures implemented at the irrigation district level, modifications in water supply contract terms, and changes in operating rules (Moore; Wahl and Osterhoudt). Stated goals of these new management approaches are to encourage the efficient and beneficial use of water, protect the environment, and safeguard the investment in BOR facilities (USDI 1992). In particular, conservation by irrigation districts has been mandated by Congress as a strategy to better manage and extend the use of existing BOR supplies and facilities as well as reduce negative environmental impacts.

Under the Reclamation Reform Act (RRA) of 1982 and the Central Valley Project Improvement Act (CVPIA) of 1992, irrigation districts that receive BOR project water are required to have conservation plans. In late 1996, almost 15 years after passage of the RRA, the BOR adopted a new policy which encourages and, in some cases, requires districts to incorporate conservation price incentives as part of their conservation plans. Price incentive programs are promoted as a voluntary economic method to achieve water conservation at the district level. However, relatively little is known about preexisting irrigation district rate structures, the adoption and design of price incentive programs, or district objectives of price incentive programs.

Our objectives are to identify and examine rate structures that have been adopted by irrigation districts and analyze emerging irrigation district price programs in terms of providing water conservation incentives and achieving BOR and district management objectives. We use unpublished survey results and new district-level information to examine and characterize rate structure adoption and water conservation price incentives. BOR conservation pricing objectives, policies, and requirements provide the framework and criteria for our analysis.

Conservation Policies and Compliance

In 1982, Congress enacted the Reclamation Reform Act (P.L. 97-293) to address a number of concerns about BOR water entitlements and pricing. After litigation stymied several initial attempts in the 1980s to formalize regulations implementing the RRA, the BOR finally settled on regulations calling for "a new water conservation program to encourage actively and assist districts in the development of high quality, locally tailored water conservation plans" (USDI 1996c, p. 15). The 1992 Central Valley Project Improvement Act (P.L. 102-575) goes a step further by requiring conservation plans for districts with new, amended, or interim water service contracts to include tiered pricing or receive an exemption. Section 3405 (3,d) of the act also institutes water pricing reform between the BOR and Central Valley Project districts, requiring the specific use of "inverted" (increasing) block rate pricing.

Irrigation districts have been slow to prepare conservation plans and reluctant to adopt new price incentive rate structures. Repeated changes in regulations have led to

confusion about the objectives and requirements of conservation plans. Districts and farmers also continue to express concerns about potential legal ramifications regarding conserved water ownership and use, effects on water right entitlements, and district and farm fiscal and economic impacts.

Irrigation district water conservation plans required by the RRA were originally due by early 1987 (USDI 1996d, p. 3). By 1996, under BOR's 1985 (and revised 1989) conservation policy guidelines, less than half of 494 required districts had submitted a conservation plan (USDI 1996b, p. 3-26). In the four states receiving the largest quantity of water from BOR projects (Idaho, California, Washington, and Arizona), 43% of the districts had submitted conservation plans. In California by early 1996, approximately 28% of the required districts had submitted conservation plans. By mid-1997, approximately 50 out of 110 districts required to submit conservation plans under the CVPIA had BOR-reviewed and approved plans (Slavin). Uncertainty about conservation plan and price incentive requirements continues to be an issue for irrigation district managers in preparing plans and for BOR staff in reviewing and approving plans. Gradual implementation of conservation pricing is recommended for districts reluctant to adopt price incentives because of uncertainty regarding irrigator acceptance and changes in water use, user cost, and district revenue (USDI 1997a).

The recommended content and goals of water conservation plans are described in general terms in *Reclamation Policy for Administering Water Conservation Plans Pursuant to Statutory and Contractual Requirements* (USDI 1996d). Irrigation districts are responsible for selecting their own water management conservation goals. According to the BOR reclamation policy, "Water management and conservation efforts should be a means of achieving specific goals such as: saving money, increasing production, reducing soil erosion, eliminating drainage problems, improving water supply and delivery reliability, or freeing up water supplies for additional uses" (USDI 1996d, p. 6). In our opinion, this menu provides a smorgasbord of broadly defined goals for districts to choose from, some of which may be inconsistent with the original intent of conservation requirements or BOR-specified conservation pricing measures as shown later in this article.

The BOR defines conservation measures as "those methods, techniques, policies, practices, procedures, activities, institutional arrangements, structural projects, physical facilities, equipment, or devices which reduce water consumption, reduce water withdrawal or diversion, reduce water loss or waste, improve water use efficiency, or increase water recycling or reuse" (USDI 1996d, p. 4). BOR recommends four "fundamental" measures as applicable to all districts' conservation programs: (*a*) water measurement and accounting systems, (*b*) water pricing, (*c*) information and education programs, and (*d*) assignment of responsibility for conservation activities (USDI 1996d, pp. 6–7). Although water pricing entails aspects of all four elements, pricing is a separate element "that encourages efficiency improvements by water users" (USDI 1996d, p. 7).

Rate structures are categorized by BOR as either providing incentives or disincentives to efficiency improvements by water users. "To encourage efficient use, a pricing and billing strategy is based, at least in part, on the quantity of water delivered" (USDI 1996d, p. 7). Examples provided of pricing disincentives to improvements in water use are decreasing block rate structures and fixed charge (per acre) rates that are assessed regardless of the quantity of water used. Recognizing that the adoption of quantity-

based pricing may be inconsistent with other objectives and could impact district revenue and user cost, the BOR also states that "a conservation pricing strategy does not necessarily imply that a district would alter its overall revenue requirements, increase costs to users, or eliminate all present methods of recovering certain fixed costs" (USDI 1996d, p. 7). BOR has produced two guides—*Achieving Efficient Water Management: A Guidebook for Preparing Agricultural Water Conservation Plans*" (USDI 1996a) and *Incentive Pricing Handbook for Agricultural Water Districts* (USDI 1997a)—on conservation plan content and methods to develop district-level price incentive programs.

Although the Reclamation Reform Act requires each district to develop a water conservation plan (RRA, 43 USC 390jj, §210b), it does not provide specific authority or an enforcement mechanism that BOR can use with districts that do not comply. The policy adopted by the current administration is to assist districts in preparing conservation plans, with the hope that all districts will submit or revise their conservation plan within five years of adoption of the December 1996 policy (USDI 1996d; Phillips). It is important to recognize that BOR will review, but does not approve, district conservation plans under the RRA (USDI 1996d, p. 3). Therefore, under the RRA, the preparation of conservation plans and use of incentive pricing are essentially voluntary.

Under the Central Valley Project Improvement Act, districts must submit a conservation plan for BOR regional office review and approval. Districts must include some form of conservation pricing as part of their conservation plan or receive an exemption from BOR based on other district-identified water management objectives or constraints. Without an approved plan, a district is subject to the 80-10-10 provision [CVPIA, §3405(a)3d] which increases the cost of the water it receives. Under this provision, the first 80% of water delivered to the district by BOR is assessed at the operation and maintenance rate, the last 10% is charged at the full cost rate, and the middle 10% is charged at a rate between the operation/maintenance and full cost amounts.[1] Districts also become subject to this pricing provision when they enter into new or interim BOR service contracts. Given these conservation pricing policies and requirements, what are the characteristics of district rate structures? We address this question in the section that follows.

Irrigation District Rate Structures

The institutional system under which prices are administered is key to understanding the design of irrigation district rate structures and adoption of conservation price incentives. Irrigation districts enter into water supply service and repayment contracts with the BOR. Water supply costs assessed by BOR are based on project construction, operation, and maintenance costs. Opportunity costs are not considered in the allocation or pricing of BOR water. Individual districts in turn establish rate structures for their users to satisfy BOR contractual costs and district costs of operation and delivery. Districts are not-for-profit intermediaries between the BOR and irrigators. Therefore,

[1] For further information on repayment and full cost pricing, see "1997 Irrigation Water Rates: Central Valley Project, California" (USDI 1997b) and "Bureau of Reclamation: Information on Allocation and Repayment of Costs of Constructing Water Projects" (U.S. General Accounting Office).

it should not be surprising that district pricing of water reflects this arrangement such that rate structures and irrigator payments are designed to cover just operation, maintenance, and BOR contract costs. Legal, institutional, and physical restrictions limit the ability and incentive for the BOR, irrigation districts, or water users to consider other costs in water price structures. Because of these constraints and to avoid conflict, the focus of the BOR conservation price incentive policy is based on "present district-to-user pricing" (USDI 1996d, p. 8).

Despite an emphasis on price incentives in conservation plans, there is an almost total absence of information regarding historical or current rate structures used by irrigation districts. The BOR neither reports nor compiles data on irrigation district rate structures. There is some evidence that prior to the RRA, few districts had implemented pricing that would encourage conservation. In the early 1980s, Mann reported that a total of 13 of 61 irrigation districts chosen by the BOR as having water conservation potential used some form of tiered or block rate pricing. However, 10 of these districts employed a decreasing block rate structure where the price of water delivered in the second tier was less than the price of water in the first tier. Wichelns and Cone analyzed the adoption of an increasing block rate structure designed to reduce the volume of drain water in a single district. The purpose of this price structure was for water quality rather than conservation.

The best and only comprehensive information on district rate structures was obtained by analyzing the responses to an unpublished survey of BOR irrigation districts conducted jointly by the U.S. Department of Agriculture/Economic Research Service and BOR (Negre, Moore, and McGuckin).[2] Each irrigation district receiving BOR project water was sent a survey on its 1986 rate structure (fixed cost assessment, block prices, and water quantity allocations). The 196 valid survey responses account for more than 70% of total BOR district irrigated acreage.

Both typical and innovative irrigation district rate structures can be characterized from the results of the 1986 irrigation district survey. At that time, essentially prior to conservation pricing adopted in response to RRA and CVPIA regulations, a typical district (86% of the districts) assessed a fixed service charge per acre that was independent of the amount of water delivered (figure 1). Forty-eight percent of the districts assessed only this fixed charge, and 38% assessed a fixed charge plus a quantity-based (decreasing, constant, or increasing) rate. In more than 80% of the districts with fixed charge plus quantity-based rates, the variable or marginal price per unit of water was uniform (constant). Of the total number of districts responding, 14% used a quantity-based rate structure with no fixed charge, and 96% of these had a constant per unit water price. These results indicate that in 1986, half of the irrigation districts already satisfied BOR's definition of conservation rate structures where pricing "is based, at least in part, on the quantity of water delivered" (USDI 1996d, p. 7).

Implied irrigation district water prices per acre-foot are shown by type of rate structure in table 1.[3] The difference between the implied average water price for farmers

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[2] Prior analysis of this survey had not been undertaken, in part, because of difficulties in coding, compiling, and aggregating the myriad of district rate structure survey responses.

[3] When interpreting these implied prices, it is important to distinguish between allocation quantities and rate structures reported by districts (yielding implied prices) and actual deliveries and costs incurred by farmers. Implied prices have the potential to be misleading because they are calculated using rate structure allocation quantities rather than quantities of water actually delivered. Complete rate and allocation data were not available for all districts.

Table 1. Implied Average Water Price by Irrigation District Rate Structure (1986 $/acre-foot)

Type of Rate Structure (n)[a]	Average	Std. Dev.	Range	
			Low	High
Fixed assessment only (64)	5.87	5.03	0.50	24.18
Fixed plus quantity pricing (42)	12.54	9.73	2.00	51.57
Quantity pricing only (23)	14.56	20.73	0.90	90.00
All rate structures (165)	12.01	14.47	0.50	90.00

Note: Implied prices are based on 1986 rate structure prices and water quantity allocations.
[a] Sample size.

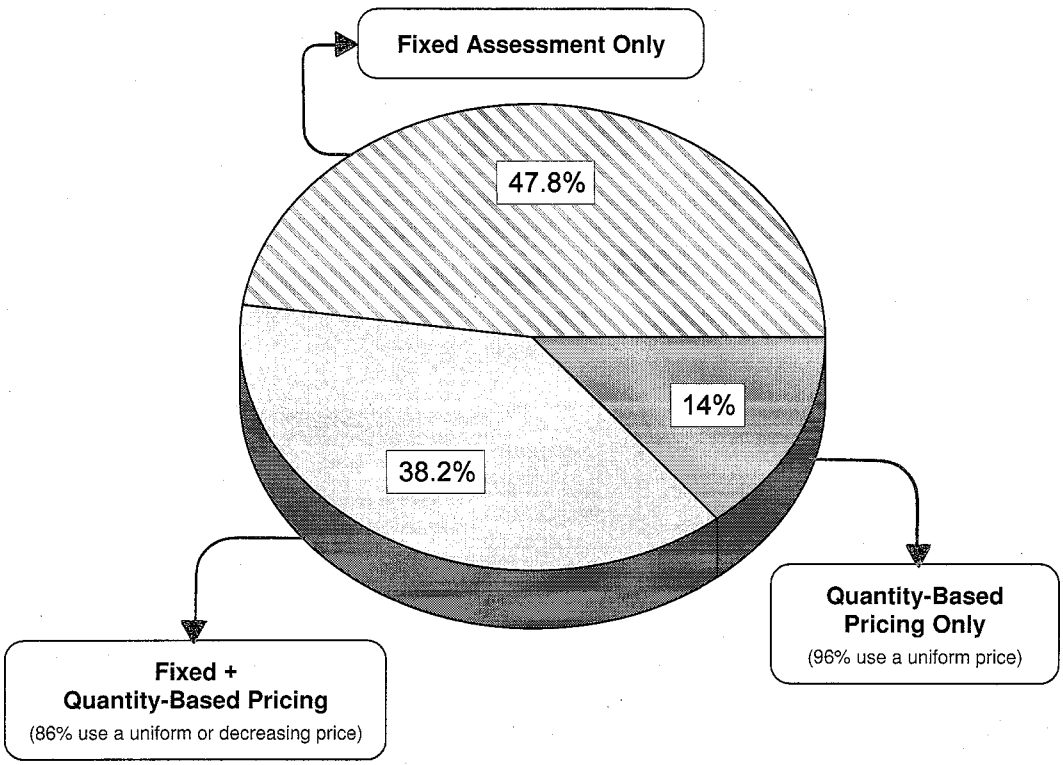

Figure 1. Irrigation district rate structure distribution (1986)

Table 2. Water Allocation Quantity by Irrigation District Rate Structure (acre-feet/acre)

Type of Rate Structure (n)[a]	Average	Std. Dev.	Range	
			Low	High
Fixed assessment only (63)	3.44	1.82	0.8	10.0
Fixed plus quantity pricing (44)	3.12	2.04	0.8	9.0
Quantity pricing only (21)	4.13	2.62	1.7	10.0
Quantity pricing only, < 10 AF (18)[b]	3.16	0.99	1.7	5.0

Note: Calculations are based on 1986 irrigation district rate structure water quantity allocations.
[a] Sample size.
[b] Allocation quantity excluding those districts with 10 acre-feet per acre allocations.

in districts that used a fixed assessment only ($5.87/acre-foot) and the average price in districts that used a fixed assessment plus quantity-based pricing ($12.54/acre-foot) or only quantity-based pricing ($14.56/acre-foot) was statistically significant at the 95% confidence level using a test of sample means with unknown population standard deviation (Hildebrand and Ott). The difference between the average water prices in districts that used fixed assessment plus quantity-based pricing and the average price in districts that used only quantity-based pricing was not statistically significant.

Water quantity allocations are shown by rate structure in table 2. The average quantity of water allocated in districts with only fixed assessments was 3.44 acre-feet per acre. In districts with a fixed assessment plus quantity-based pricing, the average allocation was 3.12 acre-feet per acre, and in districts with quantity-based pricing only, the average allocation was 4.13 acre-feet per acre. Excluding a small number of Arizona districts with allocations of 10 acre-feet per acre, the average allocation for quantity pricing only rate structures decreases almost one acre-foot to 3.16 acre-feet per acre. Of particular interest is the finding that there was no statistically significant difference in the average quantity of water allocated by the different types of rate structures. Analysis of the district survey responses indicates that the quantity of water allocated in the first rate block was typically more than adequate to cover most irrigation applications for normal years.[4] Increasing block price incentives would have limited impact under these conditions.

One explanation for the lack of significant variation observed in rate structure quantity allocations is that allocations are often independently established based on legal rights or contractual water duties set on the basis of crop requirements and assumed application efficiency (independent of economic value). These allocation obligations need to be fulfilled regardless of the type of rate structure. Although the 1986 survey data are the most comprehensive available, the extent to which actual deliveries differ from irrigation district rate structure allocations, as well as the adoption and design of conservation price incentive rate structures, is unknown.

[4] Our conservation pricing survey update and case studies of recent conservation price incentive programs suggest that little has changed in rate structure quantity allocation since the 1986 survey, and that the first block water quantity allocation is commonly set by districts to cover most crop water needs. This is also consistent with the rate structure findings of Willey and Diamant for a sample of Washington State irrigation districts.

Updates of Conservation Price Incentives

The 1986 survey was updated with information from districts that have adopted and/or were identified as the best examples of conservation price incentive programs by BOR staff and other water managers (Slavin; Christopherson; Phillips; Powers; Davidoff; Townsend) and from recent studies (Wichelns and Cone; Pequod Associates, Inc.). Staff at each of the BOR regional offices were contacted and asked to identify districts that had significantly changed their rate structures or adopted any types of conservation-oriented pricing structure in the last 10 years. Most reported that none or few districts in their region had significantly changed price structures or adopted conservation pricing. Those districts identified by BOR staff as having changed rate structures or adopted conservation pricing were then contacted, and information was compiled on their 1997 rate structures, prices, typical water deliveries, special conditions, and primary conservation program/water management objectives. Although price levels for some districts had increased in response to increases in delivery costs, we found only a small number of irrigation districts that had significantly changed their rate structure or had adopted conservation pricing since the 1986 survey.[5] The 1986 survey remains the only comprehensive source of rate structure information. However, results of the updated sample, summarized in table 3, provide useful information in characterizing the adoption, design, and objectives of recent conservation-oriented rate structures.

Conservation Pricing and Cost Recovery Objectives

The districts identified in table 3 were classified as having a conservation-oriented rate structure in 1997 because the cost of water was based, to varying degrees, on the quantity of water delivered to the irrigator, and the marginal cost of water either was constant (uniform) or increasing (USDI 1996d, p. 7). Although classified as conservation-oriented pricing under the BOR definition, objectives other than conservation appear to determine the design and incentives of these rate structures. We found the majority of these districts continue to have a fixed charge in their rate structure, and in many cases the fixed charge is a substantial portion of total water cost. For example, the fixed charge is approximately one-third or more of the total water cost in the rate structures used by the Arvin-Edison, Broadview, and Firebaugh Canal irrigation districts. In some districts, such as Grand Valley, Frenchman-Cambridge, and Twin Loop, the fixed charge covers almost all of the total water cost. The primary rate design objective for most of these districts was related to district cost recovery or contractual and regulatory requirements.

Although not conservation oriented, fixed charges have attributes desirable in meeting other district objectives. A fixed charge provides revenue (cost recovery) stability regardless of variations in supply and use, requires no quantity measurement or accounting record for assessing cost, and is simple to calculate and understand, thus incorporating several of the conditions of a desirable rate structure as identified by Bonbright, Danielsen, and Kamerschen. For example, the beginning of the 1998 crop

[5] Some of the districts identified had changed prices in response to changes in their BOR supply contracts. These were not classified as districts adopting conservation pricing.

Table 3. 1997 Illustrative Sample of Irrigation Districts Employing Conservation Price Incentive Programs

Irrigation District	State	Rate Type / Marginal Cost Classification		No. of Tiers	Water Quantity	
		1986 Survey	1997 Update		Total Average Delivered AF/Acre	First Block Allocated Acre-Feet
Arvin-Edison	CA	Uniform	Uniform	1	2.70	2.70
Broadview	CA	Uniform	Increasing	2	2.07	2.60
Central CA (CCID)	CA	Uniform	Increasing	2	3.22	3.00
Firebaugh Canal[b]	CA	Fixed	Increasing	4	2.50	1.00
Irvine Ranch[c]	CA	Uniform	Increasing	4	Crop	Crop
Panoche	CA	Uniform	Increasing	2	2.00	2.40
Delores[d,e]	CO	Increasing	Increasing	2	1.96	1.96
Grand Valley	CO	Increasing	Increasing	2	5.30	4.00
Uncompahgre	CO	Increasing	Increasing	2	4.00	4.00
Buffalo Rapids	MT	Increasing	Increasing	2	2.50	2.50
Glasgow[f]	MT	Uniform	Uniform	1	2.00	3.00
Greenfields	MT	Fixed	Increasing	2	2.10	2.00
Farwell	NE	Increasing	Increasing	2	1.50	1.00
Frenchman-Cambridge	NE	Increasing	Increasing	2	1.15	1.00
Twin Loop[d]	NE	Increasing	Increasing	2	1.00	1.50
Casper-Alcova	WY	Increasing	Increasing	2	2.50	2.00

Note: Table displays 1997 rate structures, prices, and quantity allocations.

[a] Arvin-Edison: Fixed cost sum of general administration $23.14/acre, plus $71/acre standby cost; variable of $41 plus $9 per lift, average $65/AF; tiered rate has not been implemented.

[b] Firebaugh: Third tier is 2–3 AF at $21/AF; fourth tier is > 3 AF at $23/AF.

[c] Irvine Ranch: Uniform rate billed monthly; year-end assessment by crop to determine allocation; penalty surcharges for use above allocation; not a BOR district.

[d] Delores and Twin Loop: Initial rate structure classifications apply to 1987 when the districts began operations.

[e] Delores: 1997 is first year of full project acreage; previously first block water was available up to 26 inches/acre; entire project is pressurized delivery; variable cost is largely pumping cost.

[f] Glasgow: First block allocation is not limited; 3.00 AF used only for illustration.

[g] Casper-Alcova: Fixed charge of $150 for the first AF on total irrigated acreage; uniform marginal cost per AF up to 2 AF for first block allocation.

Table 3. Extended

Fixed Charge ($/acre)	Marginal Price: First Block Price ($/AF)	Marginal Price: Next Block Price ($/AF)	District-Defined Conservation Objective(s)
94.14[a]	65.00	65.00	Ground water management
77.00	47.14	77.14	Reduce drainage water (allocation by crop)
0.00	7.00	20.00	Encourage efficient management, protect rights
22.00	14.00	16.00	Reduce drainage water, increase efficiency
0.00	241.00	265.00	Efficient use (allocation by crop), penalty
0.00	50.00	100.00	Reduce drainage water
0.00	26.35	110%–160%	Encourage efficient management, penalty
14.30	0.00	4.95	Contract requirement
19.75	0.00	4.94	Penalize overuse of water
25.00	0.00	7.70	Cost recovery (pumping)
18.01	3.00	3.00	Cost recovery, delivery capacity constraint
16.66	0.00	8.33	Increase carryover storage
26.00	0.00	17.00	Manage excess ground water
29.50	0.00	21.00	Cost recovery (BOR purchase cost)
26.40	0.00	21.00	Reduce waste, reduce runoff, water management
[g]	11.00	20.00	Increase storage carryover

season in California was wet and cool, so farmers had little need to irrigate. This resulted in revenue and repayment problems for districts with per unit pricing instead of fixed charge pricing (Cone). It is reasonable to expect that districts with an interest in conservation, but concerned about these issues and irrigator acceptance or response to variable water rates, may therefore choose to have a fixed charge in their rate structure.

Tier Allocations and Conservation Objectives

Water allocation quantities are critical in providing conservation incentive. In most cases, the rate structures that have been adopted are designed so that the quantity of water delivered at the first tier price is sufficient to meet most typical grower water needs. That is, the price incentive to conserve starts near or above the typical quantity of water applied. This characteristic can be seen in table 3 by comparing the first block allocations and typical delivery quantities. For example, the volume allowed at the first block price for the Broadview irrigation district was 2.6 acre-feet per acre for cotton and tomatoes, while the average delivery was 2.3 acre-feet for these crops and 2.07 acre-feet for all crops from 1992 through 1995 (Cone). First block allocation quantities also exceed average use levels for the Panoche, Glasgow, and Twin Loop irrigation districts, and first block allocations for Arvin-Edison, Delores, Uncompahgre, and Buffalo Rapids irrigation districts are the same as typical water deliveries.

Another characteristic noted in both the 1986 survey and the 1997 update sample is that most of the tiered rate structures use only two blocks (table 3). The exceptions in this group are the Firebaugh Canal Water District (four tiers) and Irvine Ranch Water District (four "penalty" tiers). Even with these multiple tiers, the initial block allocations cover most deliveries. For example, agricultural users have never exceeded the first block allocation of the four-tier Irvine Ranch Water District rate structure (Ash), and the first two tiers of the Firebaugh Canal Water District cover deliveries up to two acre-feet with average deliveries of 2.5 acre-feet (Bryant). Legal or contractual obligations and the desire not to restrict "beneficial" uses of water were the most frequently cited objectives in setting tier quantities at or near typical use levels.

A few districts vary the quantity of water allocated within a tier depending on the type of crop grown. For example, the first block allocation for farmers in the Broadview irrigation district is 2.6 acre-feet per acre if cotton or tomatoes are grown, and 1.7 acre-feet per acre if melons are grown (Cone). Crop-based tier quantities are designed to not penalize farmers for growing water-intensive crops by adjusting the block quantity to satisfy specific crop water needs. At the same time, the tiers are set to reduce "wasteful" water use as determined by the district. This type of rate structure assumes that different quantities of water used reasonably should be provided at the same cost to all irrigators within the district. Although it is not economically efficient in the sense of equating the opportunity costs of water supply internal or external to the district, the rate structure does encourage increased application and hydrologic efficiency, and therefore may achieve other district objectives such as reducing return flows where drainage is a problem.

Within-season block allocations also have been implemented to satisfy drainage flow objectives and manage variation in supply sources (e.g., direct flow rights) and limitations in facility capacity (storage reservoirs and canals). Since they are a form of tiered

quantity-based rate structures, they were classified as conservation pricing. The Panoche and Broadview irrigation districts in California use two within-season increasing block rate structures in efforts to reduce return flow drainage water. The tier allocations were established based on typical historical water deliveries considered by the district to be reasonable. During the pre-irrigation season, the first block quantity in both districts covers water deliveries up to 0.75 acre-feet per acre.[6] Use above this amount is charged a significantly higher "penalty" rate—an additional $50 and $30 per acre-foot for Panoche and Broadview, respectively (table 3). A second set of rates applies to the entire growing season, including pre-irrigation deliveries. Several district managers (e.g., Hedrick; Cone) reported that these rate structures have been effective in reducing delivery quantities by making irrigators more aware of their water use and by discouraging water use above established levels, in part, through peer pressure. However, these anecdotal reports of changes in water use have not been adjusted for variation in other factors such as temperature, hydrologic conditions, cropping patterns, or implementation of other conservation measures, and have not been otherwise statistically validated.

Price Incentives and District Objectives

The amount of the price incentive varied depending on district objectives and opportunities for economic gain in reallocating conserved water. Districts with objectives associated with increasing opportunity costs (reallocation to higher value use, increased pumping costs, drainage or delivery restrictions, etc.) had clear economic reasons to adopt conservation pricing incentives. When cost recovery was the primary objective, districts had little incentive to adopt conservation pricing, especially if it might result in unstable, insufficient, or excess revenue.

Consistent with responses from the 1986 survey, many of the districts in the updated sample identified by BOR staff and district managers as having conservation incentive pricing had tier pricing that by itself, or when combined with tier allocation quantities, would result in negligible or small increases in total water cost. For example, in the Uncompahgre Water Users District, the price for water used above the first block was set at the average cost of the first block, $4.94 per acre-foot. But with typical deliveries of four acre-feet per acre, the average total cost of water was $19.75 per acre, the same as the first block price (table 3). The primary objective was to generate sufficient revenue for cost recovery. With a primary objective of controlling and reducing drainage water, the Firebaugh Canal Water District implemented a four-tier increasing rate structure. The first tier covered up to one acre-foot at $14 per acre-foot; the last tier was $23 per acre-foot for deliveries above three acre-feet (Bryant). With typical deliveries around 2.5 acre-feet, the total water cost, including the $22 per acre fixed charge, was $62.50 per acre, or an average of $25 per acre-foot. If the per unit price remained at the first block rate of $14 per acre-foot, the total cost would have been $57, or $22.80 per acre-foot.

Uniform quantity-based rates, classified as conservation oriented, also have been adopted to meet other district objectives. The Arvin-Edison Water Storage District uses

[6] Broadview reduced the pre-irrigation season first tier water quantity to 8 inches per acre in 1998 (Cone).

a uniform rate of $65 per acre-foot of surface water. The rate was established for cost recovery and held constant for rate stability, but is also intended to encourage the use of surface water during normal water supply years.[7] Ground water management is the conservation objective here. During a future drought, the district plans to implement an increasing block rate structure to encourage irrigators to pump ground water when surface supplies are low. A recent agreement with the Metropolitan Water District to recharge and exchange up to 250,000 acre-feet of ground water over the next 25 years provides additional economic incentive for Arvin-Edison (Lewis). The Glasgow Irrigation District uses a uniform price of $3 per acre-foot as incentive in allocating limited system delivery capacity.

The Central California Irrigation District (CCID) is one of a relatively small number of districts that has a quantity-based rate structure without fixed costs. CCID went from uniform pricing/$6 per acre-foot in 1986, to increasing tier pricing in 1989. During the 1997 growing season, the first block (up to three acre-feet) was $7 per acre-foot, and the second block (more than three acre-feet) was $20 per acre-foot (table 3).[8] The relatively large increase in price was established as a penalty to discourage wasteful water use (Porter). Water deliveries in the district vary widely by crop, from less than one acre-foot per acre for barley and radishes to 14 acre-feet for basil, with deliveries for cotton and alfalfa, the two largest crops, averaging 3.55 and 3.91 acre-feet per acre, respectively, in 1996 (CCID). Districtwide water deliveries averaged 3.22 acre-feet per acre for a total cost of $25.40 per acre in 1997 (Porter). The district reports that water has been conserved in terms of reduced deliveries, and the new rates generate surplus revenues which are used in a revolving fund for individual irrigator water conservation efforts. Financial success of the program may be attributed to the opportunities available for water use and economic gain. Conserved water is available for irrigation within the district, and 15,000–20,000 acre-feet per year have been sold at $40–$50 per acre-foot (more than twice the highest block rate) and transferred for use outside the district.

Many of the conservation price incentives in the updated sample were designed to provide a "reasonable" quantity of water at rates that cover district costs, and to penalize irrigators only for unreasonably high quantities of water use. The term "penalty" was frequently used by districts in describing the purpose of increasing block rates. The concept is that only those irrigators using water "wastefully," as defined by an individual district, are penalized. For example, the Irvine Ranch Water District establishes its reasonable water allocation quantity by crop, varying the allocation each season based on previous water use, current season daily evapotranspiration, and application efficiency of 80%. Blocks above the reasonable level of use are given names which convey the wasteful message: a "penalty" rate applies to the first 10% of water used above the allocated reasonable amount, followed by an "excessive" rate for the next 10%, and an "abusive" rate for additional water use. All deliveries have fallen within the first block; that is, farmers have not exceeded their base allocation to incur penalty rates.

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[7] District staff estimate the full (capital, depreciation, operation, and maintenance) cost of ground water pumping to be greater than $65 per acre-foot (Arvin-Edison Water Storage District).

[8] A six-tier rate structure was implemented by CCID in 1998 to provide additional price incentives to reduce excessive water use. It is estimated that the new rate structure will have a small impact on average users, increasing total cost by about $1 (Porter).

BOR conservation policy recommends a water pricing structure "that encourages efficiency improvements by water users" (USDI 1996d, p. 7). At the same time, BOR policy leaves it up to districts to define their own conservation objectives. Districts have responded by designing rate structures to accomplish a variety of hydrologic, financial, environmental, legal, and political management objectives under the name of conservation pricing. These rate structures may be achieving the desired "conservation" effects as they have been defined by individual districts.

Water Conservation Is a Catchword/Symbol

"Conservation is a catchword and symbol of national water policy" (Weatherford, p. 3). Defining water conservation is not a didactic exercise, but rather determines implementation of conservation policy and practices and subsequent outcomes. Mann categorizes conservation definitions as follows:

- *Beneficial Use.* Water, like other resources, should be developed and used for the benefits it brings to society. Water that is not used is wasted.
- *Preserve and Protect.* Preserve and protect water for aesthetic and environmental values.
- *Hydrologic Efficiency.* Maximize output from water use and thus eliminate evaporation, transpiration, and ocean returns.
- *Economic Efficiency.* Water is neither a free good nor a priceless commodity, but rather a resource that may be developed or conserved on the basis of the benefits and costs to society (pp. 12–13).

The BOR remains silent on water conservation objectives (USDI 1996b), leaving irrigation districts and others to define and debate the meaning, and consequently the measures of effectiveness, of conservation programs. The result is that under current BOR policy, the question of whether conservation is being achieved is tautological. It depends on how conservation is defined—and irrigation districts have been placed in the position of individually defining the meaning of conservation. For many of the reasons discussed above, some irrigation districts appear to slant conservation policy and practices, including rate structure incentives, toward beneficial use and hydrologic efficiency. The net effect may not match the policy maker's initial conservation objectives as demonstrated by Huffaker and Whittlesey, and by Huffaker et al.

Noticeably absent in most irrigation districts' water pricing programs is the use of market water prices to signal opportunity costs and allocate resources efficiently. Contractual obligations between BOR and irrigation districts, combined with legal restrictions on water transfers, often limit the ability of districts and farmers to fully reflect opportunity costs in water use and pricing. Weatherford's strategy of "conserve-and-transfer" to achieve the highest and best use for water in society cannot be accomplished without conservation in terms of decreased consumptive use. District measures of conservation change the form, place, and time of water use in a basin or watershed, but consumptive water use may increase and the quantity of water available for other uses may remain the same or even decrease (Huffaker et al.).

Summary and Conclusions

Recent BOR policies and regulations encourage or require irrigation districts to adopt conservation price incentives. Unpublished survey results and new district-level information were used to examine and characterize historical and emerging rate structure adoption and water conservation price incentives. We found the overwhelming majority of districts had adopted rate structures with a fixed charge that did not vary with the quantity of water delivered. The rate structures used by approximately half of all districts in 1986 had some form of constant or increasing quantity-based rate structure, and already met BOR's 1996 definition of conservation pricing. We determined, however, that the actual design of many of these rate structures was unlikely to result in major changes in water use. The quantity of water allocated by districts with fixed charge and quantity-based rate structures was the same. Where price incentive rate structures have been adopted, the common practice has been to set the first tier quantity so that it satisfies typical deliveries and most crop application needs. Conservation price incentives were minimal or nonexistent as long as water use remained within these reasonable use allocations. Water use above typical amounts was generally considered wasteful (excessive) by water managers, and rate increases were applied as penalties and for internal district cost recovery. Reports of conservation price incentive effectiveness were anecdotal, without adjustments for variation in other factors such as temperature, hydrologic conditions, cropping patterns, or implementation of other conservation measures, and were not otherwise statistically validated.

While requiring conservation plans and incentive pricing, the BOR remains silent on the purpose of conservation, leaving irrigation districts and others to define the objectives of conservation and measures of effectiveness. Under this policy, the question of whether conservation is being achieved by price or other measures is tautological; it simply depends on how conservation is defined by an individual district. Districts are typically interested in conservation as beneficial use or hydrologic efficiency, where water not used is wasted. This will continue to be the case as long as BOR and state institutions limit water management opportunities to the economic costs that are internal to each district.

An economic alternative for establishing effective and efficient pricing would be to implement policies that allow water management objectives to be associated with appropriate opportunity costs. For example, to achieve efficient levels of conservation for internal and external district use, BOR and district water allocations and prices could be established at the opportunity cost of external use. If the goal is to manage drainage water, rate structures for delivered water could be established at the marginal drainage cost times irrigation efficiency. Pricing is not a panacea. Pricing water deliveries or return flows may result in greater consumptive water use. In evaluating the adoption, design, and effectiveness of conservation pricing rate structures, it is important to recognize that current legal, contractual, and institutional arrangements severely constrain both the BOR and districts from implementing pricing that reflects other water management objectives and opportunity costs.

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