widely. For example:

■ Maintaining a constant amount of ground-water storage, such as the goal of the Raymond Basin decision, which apportioned the "safe yield" of the basin.

■ Providing for a zone of regulatory storage, such as the goal in the San Fernando Basin where ground water is alternatively removed and recharged in response to water requirements and surface water conditions.

■ Mining the ground-water supply, as is being practiced in the high plains area of west Texas.

Another management policy involving ground-water quantity may address the prevention of subsidence. An example is the plan being implemented in the Santa Clara Valley using artificial ground-water recharge.

From the standpoint of water quality, policies may vary from enhancing or maintaining ground-water quality—as is being implemented in coastal basins of southern California via water spreading and injection—to allowing ground-water quality to degrade by the introduction and disposal of wastes.

In developing a ground-water management plan, the principal technical details include: the definition of aquifers; calculation of ground-water storage; analysis of water levels and associated changes in storage; determination of direction and rate of ground-water flow; determination of pumpage, perennial or safe yield, and overdraft; consideration of natural and artificial recharge; and evaluation of water quality.

A good ground-water management plan considers alternative actions. These may include coordinated use of surface- and ground-water supplies; importation of supplemental surface supplies for direct use or ground-water recharge; cyclic pumping on a seasonal, annual, or longer period; use of well fields; artificial ground-water recharge; modified patterns of pumping; and possible segregation of surface- and ground-water supplies depending on specific quality considerations.

Finally, drought conditions impose additional burdens. Ground-water sources may make it possible to provide adequate supplies for domestic consumption and irrigation of essential crops during critical periods of short surface supplies. But only through a good management program, designed to replace the ground water removed from storage during a drought, can ground water be continually available to meet both short-term emergency and long-term sustained needs.

Verne H. Scott is Professor of Water Science and Civil Engineering, and Joseph C. Scalmanini is Associate Development Engineer, Department of Land, Air, and Water Resources, Water Science and Engineering Section, University of California, Davis.

Can water pricing encourage conservation? Some principles and some problems

J. Herbert Snyder ■ Richard G. Rohde ■ Charles V. Moore ■ Gerald L. Horner ■ Richard E. Howitt

Development or conservation? Build new dams and canals or eliminate inefficient and wasteful uses? New water development has not been eliminated as a possible future alternative. For the moment, however, conservation of existing supply and increased efficiency of use seem to dominate decision-making processes. A major problem to be resolved thus becomes: How do we get people to stop wasting water and use it more efficiently?

It has been suggested that market-oriented pricing of available supplies is the most simple and rational approach to increased efficiency of water use and equitable allocation of this vital resource. (Reducing demand for water by increasing water use efficiency is also supported by those who question construction of new and additional water projects.)

Two methods of resource allocation by using prices are possible: (1) administer a set of fixed prices that, in effect, would ration water among users, or (2) encourage a system of variable prices responding to market conditions. A combination of the two methods now operates in California.

Mechanics of price conservation

Reliance on a system of freely variable market prices appears more feasible than reliance on arbitrarily administered prices. The flexibility of freely variable market prices enables adjustments to occur between uses in an individual farm or business as well as among numerous users in an industry or area.

Marketing institutions and legal arrangements have to be flexible enough, however, to permit transfer of water from one user to another in response to higher bidding prices. Before freely variable market prices can be used to effect water conservation in California, the institutional barriers to transfer of water between and among water agencies and users must be relaxed or eliminated. If a price-oriented system is to function, water-short districts or individuals would have to be free to bid for and negotiate for water from districts or individuals willing to sell it.

How would this work? Price-oriented allocation is based on the simple economic principle of supply and demand. Other things being equal, as the price of a commodity goes up, quantity demanded of that commodity goes down. Demand is "price inelastic" if the quantity used changes but little as price changes greatly. It is "elastic" if large quantity changes result from relatively small price changes. Thus, if demand for a water is inelastic, price conservation schemes make little sense, because people will continue to use large amounts of the commodity even if price increases are relatively great.

Is the demand for water elastic or inelastic? Many communities operate on a flat-rate water charge depending on lot size. Water use in such communities is insensitive to changes in the level of these charges. Introduction of metering tends to reduce water consumption levels. But, as has happened with steadily rising gasoline prices, consumption then may tend to return to precrisis levels, with only minor grousing about the high cost of living! In general then, residential water pricing by any method will not reduce the quantity demanded, unless the final user sees that changes in his consumption are significantly reflected in his water bill.

Industrial water users appear to be more responsive to changes in the price of water. Consumptive use of water by a factory or refinery tends to be fairly low. Most of the water going into a plant goes out of it as a waste-carrying effluent, often becoming a problem to downstream users or overburdening the municipal sewage treatment system. Either an increase in the price of water or a requirement to treat effluent waste will tend to cause the industrial user to recycle effluent water, thus lowering total quantity demanded. Depending on the amount of the price increase, it may even become economically feasible to introduce new, more water-efficient manufacturing processes.

Agricultural water price relationships

The nature of agricultural demand for water is not as clear-cut. In agriculture, the prime determinant of water use is biological—how much water is required by plants to produce a crop? Different crops consume different amounts of water. While there may be adjustments in water use for a given crop as water prices increase, the evidence suggests that most farmers will absorb higher costs for water, up to a point, and then reduce the quantity demanded.

Also complicating the picture is the fact that the price of water is a minor part of the total cost of producing many high-income, capital-intensive crops. The acreage, and hence water, committed to these crops may be determined more by market projections and labor costs than by water prices. However, in areas where water is scarce and expensive, such as the southern San Joaquin Valley and the South Coast specialty-crop areas, farmers are investing in water-efficient technology such as drip irrigation to lower the quantity of water demanded.

In times of severe water shortage, freely operating markets for water and water rights might serve as very efficient allocators of the scarce resource. If one user or district values an additional acre-foot of water more highly than another, then presumably both would be made better off if a transfer of water could be made. For example, if one district grows a preponderance of pasture and feed grains, while another produces fruits and vegetables, in a water-short year the area producing high-valued crops may be willing to bid a very high price for water from the district growing lower value crops. If the offering price becomes sufficiently high in relation to expected net income per acre-foot in the low-valued operation, it will be economical for water to be transferred and let a portion of the low-valued acreage go out of production for the season. This could lead to the establishment of a system of annual water-right rentals.

To make such a simple solution possible in California, many issues and problems would have to be resolved—including basic changes in the California Water Code. There are issues involving compensation to the so-called "third party" water user, who is dependent on return flows but is not involved in the negotiations between seller and buyer. This third party may be an irrigator or even a duck hunter.

Another issue arises from the beneficial-use philosophy underlying California water law. That is, if you as a water-right holder sell or lease that right, even for a one-year period, are you placing that right in jeopardy insofar as you have not put the water to a beneficial use? An annual water-right rental market is a new idea for California, but not for the West—water-rental markets have existed in Utah and Colorado for a number of years.

In addition to the legal factors, many questions are being asked concerning the probable effect on the agricultural industry of increased reliance on market-oriented pricing of available water supplies. What will be the nature and magnitude of the effect of periodic or long-term shifts away from relatively low-value, high-water-consuming crops such as rice, irrigated pasture, alfalfa, and feed grains? What might be the effect of such crop shifts on the livestock, dairy, and cattle-feeding industries in California?

Other questions relate more broadly to water and energy resource relationships. What would be the likely impact of a possible widespread return to ground-water pumping if the price of surface water supplies climbs past the cost of pumping? What is the likely impact of increased ground-water pumping on energy use and basic energy costs to residential-industrial consumers as well as to agricultural consumers competing for this energy? What might be the impacts of increased ground-water pumping on ground-water storage capacity and attendant legal problems? Research into the physical, legal, economic, and overall institutional aspects of these questions must be accelerated to provide timely answers to water planners during the coming years.

In summary, general and direct administered pricing of water to reduce use, regulate the variety and extent of crops grown, and, in essence, control the water market is not seen to be a likely or desirable prospect for the future. At present, there is no unit of government that appears to have either a solid political or legal base to impose administrative water pricing for the sole purpose of reducing water consumption. However, restructuring the institutional basis for transfer of water between districts in response to market-oriented bidding for water supplies would permit a flexible response to varying natural supplies of water and varying economic conditions. Furthermore, it would permit the districts and water users to operate more responsively in a competitive market economy.

J. Herbert Snyder is Professor of Agricultural Economics and Director, Water Resources Center; Richard G. Rohde is Staff Research Associate, Water Resources Center; Charles V. Moore is Agricultural Economist, Economic Research Service, USDA; Gerald L. Horner is Agricultural Economist, Economic Research Service, USDA; and Richard E. Howitt is Assistant Professor of Agricultural Economics. All are located at the University of California, Davis.