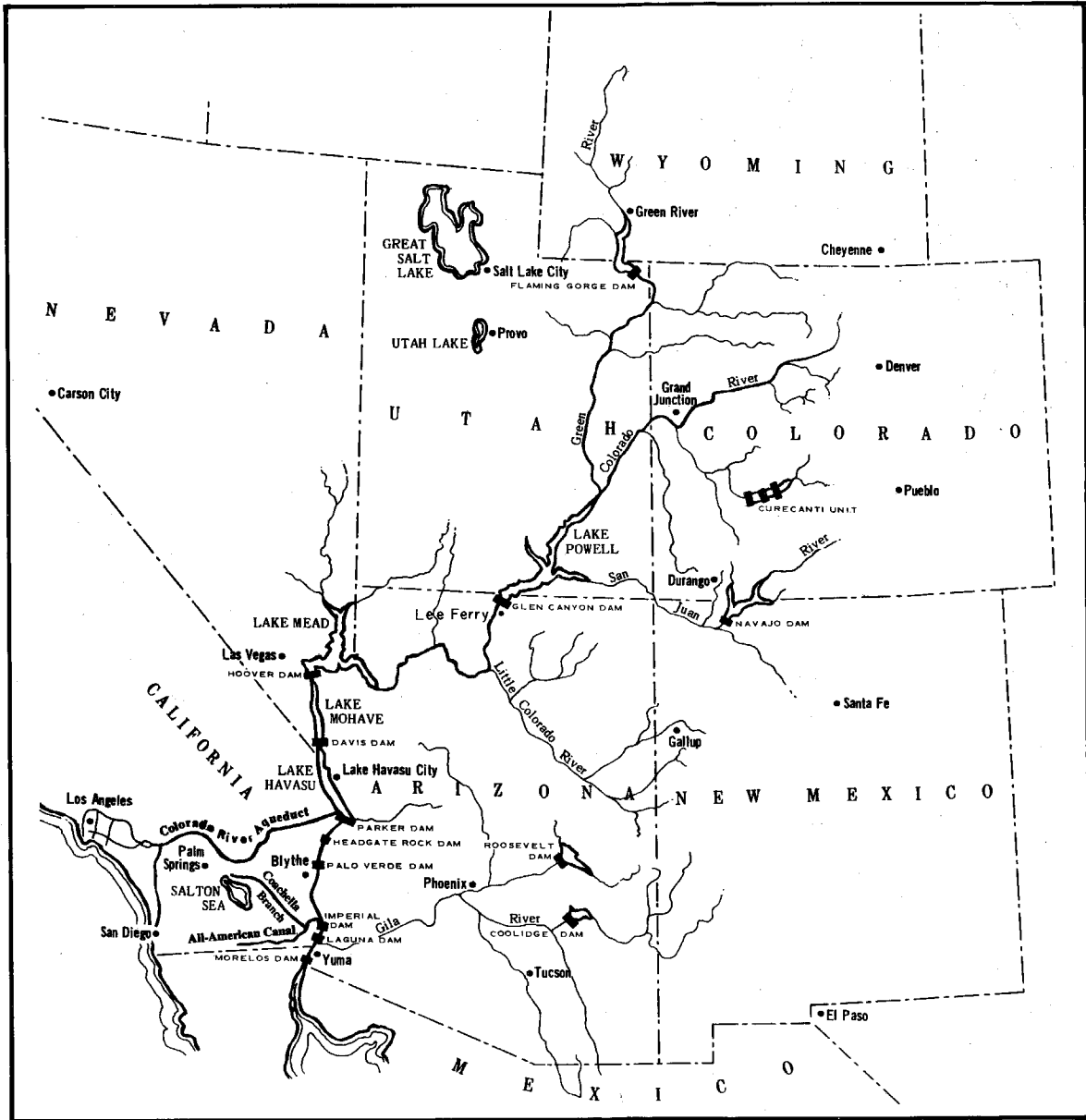


Map courtesy of the 1977 Annual Report of the Colorado River Board.



The Simple Economics of Water

by James P. Quirk

An economist explains the existing water rights to the Colorado River—and how they got that way

The Colorado River, which is the only source of surface water in the southwestern part of the United States, has a fascinating history. I suspect it is the most controlled river in the world, and it's a tiny river at that, with an annual average flow of only about 13.5 million acre-feet (maf). (An acre-foot is roughly the amount of water that it takes to fill an Olympic-size swimming pool—326,000 gallons, or approximately what a family of four uses in a year.) In contrast, the Columbia River, which drains about the same size basin as the Colorado, has an annual flow of 180 maf, so it's almost 14 times as large. What water there is in the Colorado, however, is rigidly controlled and allocated.

The main tributaries of the Colorado are the Green River and the San Juan River that come into it in Utah, the Little Colorado that comes in below the Glen Canyon Dam but above Lake Mead, and the Gila River that enters in Arizona—and hasn't delivered any water to the Colorado for over 50 years. The Phoenix-Tucson area uses up every drop of water in the Gila except for what falls in the form of desert rainstorms at odd times of the year.

There are some flows of water into the Colorado from Wyoming, Colorado, Utah, New Mexico, Arizona, and even Nevada. California doesn't contribute a single drop of water to it. Of the 13.5 maf of water that flow in the Colorado on the average per year, California is currently using 5.0 maf, and its use has gotten up as high as 5.4 maf. So California uses close to 40 percent of the river's water without contributing any part of it. This is cause for some concern among the other states in the Colorado River Basin.

There are a number of dams and reservoirs along the river. The two large ones are the Glen Canyon Dam (located north of Grand Canyon) and Hoover Dam. Lake Powell, the reservoir behind Glen Canyon Dam, has a capacity of about 27 maf. It currently holds about 14 maf, but it reached a peak storage of around 22

maf just two years ago. Lake Mead, which is behind Hoover Dam, is about the same size, 27 maf, and it now stores about 22 maf. The reservoirs located south of Hoover Dam are for holding water to be drawn on for irrigation.

About 85 percent of the Colorado River water is used by irrigation districts. The other large user is the Metropolitan Water District, which brings water through the Colorado River Aqueduct to the Los Angeles Basin, supplying supplementary water to Los Angeles and most of the cities in the basin, including San Diego. It is a major source of water for them.

For purposes of water allocation the river is broken in two, and the split occurs just below Glen Canyon Dam at a town called Lee Ferry. The northern part of the river is called the Upper Basin, the southern part is the Lower Basin. The Lower Basin states are California, Arizona, and Nevada; the Upper Basin states are Wyoming, Colorado, Utah, and New Mexico.

The flow of water in this river has been measured rather precisely since 1896. From 1896 to 1922, the average annual flow of 16.4 maf was relatively high. In fact, scientists making studies of the tree-ring growth over the last 400 years argue that this might have been one of the wettest periods in the history of the Colorado River Basin. Since the early 1920's, the flow has been near the average calculated from these studies—around 13.5 maf. The fact that the flow was heavy between 1896 and 1922 is important because the Colorado River Compact was signed in 1922. That means that the estimates of stream flow available to the people who signed the compact were unrealistically high.

In 1922 there was a meeting in New Mexico among all seven of the states in the Colorado River Basin. The meeting was brought about by the following events: In 1900 the Imperial Valley Irrigation District was opened up. It is the largest irrigation district in the

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western world, and it uses Colorado River water. At that time the water was delivered to the Imperial Valley through the Alamo Canal. In 1905 a heavy flow in the Colorado caused a break in the banks of the Alamo Canal, which was apparently not the best-constructed canal in the history of engineering, and the entire flow of the river was diverted to the Imperial Valley.

For two years the Colorado River flowed not to the Gulf of California but rather to the Imperial Valley, and in the process the Salton Sea attained its current size. What that indicated to the farmers in the Imperial Valley was that there was need for flood control on the river, and of course they also were interested in evening out the flow of the river for irrigation purposes. So they began to lobby for the building of a large dam on the Colorado River.

Ultimately California was joined by the Upper Basin states as lobbying partners. The community of interest was due in large part to the way in which property rights to water are established in the Western states. And this is where economists get interested in the problem.

In English Common Law, water rights were established under what is called the "riparian" system, where each property owner along a watercourse has the right to the unimpaired use of the water in that watercourse. In principle, then, if I take water out of a river under the riparian system, someone downstream from me can sue me because I have interfered with his right to enjoy that water. Now, a riparian system really makes sense if you're talking about using a river for boating or fishing or swimming or other recreational uses. It does not make sense for irrigation uses, or any uses in which you actually have to consume the water, remove it from the river.

In the western part of the United States, since water is used for irrigation purposes, a different system of property rights developed, called the "appropriative" system. Under the appropriative system a person establishes a property right to water by physically consuming the water. The first person who comes along a river gets seniority over people who come later on; that is, "First in time means first in right."

On the lower Colorado River the first users of water were the Palo Verde Irrigation District (1870), then the Imperial Valley Irrigation District (1900), and later the Coachella Valley Irrigation District. In the Upper Basin the only use of Colorado River water

in the early 1900's was in the state of Colorado for small-scale irrigation. But the people in the Upper Basin could see as early as the first decade of the 20th century that California and Arizona were going to be a problem. In these areas, where the land was quite fertile, uses of water for irrigation were going to grow, thereby establishing seniority rights over the Upper Basin users. The Upper Basin states wanted some sort of agreed limitation on the Lower Basin use of Colorado River water. So there was an incentive both for California water users and for the people in the Upper Basin to get together on an agreement to build a dam—the Hoover Dam. Their goal was to satisfy the desires of the irrigators in California and to give some guarantees to the people in the Upper Basin states that their future claims to water wouldn't be washed away. And that's actually what happened.

In the Colorado River Compact, the seven states of the basin got together and divided the river at Lee Ferry, using as the basis for allocating water the "virgin flow" at Lee Ferry, that is, the amount of water that would flow through Lee Ferry if there were no irrigation use or reservoir losses above Lee Ferry. At the time the compact was signed, data on the flows between 1896 and 1922 indicated that the average virgin flow was 16.5 maf in the river, so that when the river was split 50-50, the Upper and Lower Basins were each assigned 7.5 maf of water per year. An extra million acre-feet was also made available to the Lower Basin. This was surplus water above and beyond the 50-50, and the Lower Basin got first crack at it. And there was one further important provision: namely, that the Upper Basin guaranteed to deliver 75 maf each ten-year period to the Lower Basin.

As we have seen, the amount of water in the river was overestimated; and when it turned out to be 13.5 maf instead of 16.5, the Upper Basin bore the whole burden of that loss. What started out as a 50-50 split in the river has become a split of 7.5 maf to the Lower Basin and roughly 6.0 maf to the Upper Basin. This hasn't caused any problems so far because the Upper Basin has been slow in developing its uses of Colorado River water.

Within the next 10 to 15 years, however, the Upper Basin will start running into the limits imposed by the compact. When that happens, there are going to be problems. In the Lower Basin we know fairly well how much water is used each year because it's used by very large irrigation districts, and it's relatively easy to

Colorado River Agreements

- 1922 — Colorado River Compact
Divided the river at Lee Ferry
Upper Basin to deliver 75 maf to Lower Basin
each 10-year period
- 1928 — Boulder Canyon Project Act
Authorized Hoover Dam
Allocated Lower Basin Water: California 4.4 maf,
Arizona 2.8 maf, Nevada 0.3 maf
- 1944 — Mexican Treaty
Guaranteed Mexico 1.5 maf annually
- 1948 — Upper Colorado River Basin Compact
Allocated Upper Basin Water: Arizona 50,000 af,
Colorado 51.75%, Utah 23%, Wyoming 14%,
New Mexico 11.25%
- 1956 — Upper Colorado River Storage Project Act
Authorized Flaming Gorge, Glen Canyon,
Navajo, and Curecanti dams
- 1963 — Arizona vs. California
Supreme Court ruled that Arizona had the right
to 2.8 maf from the mainstream of the
Colorado
- 1968 — Colorado River Basin Project Act
Authorized the Central Arizona Project
Provided an absolute priority of 4.4 maf to
California

monitor the water that they divert and return to the river. In the Upper Basin, users are mainly small irrigators, so no one knows how much water is, in fact, being used. Currently, the Bureau of Reclamation estimates how much water it takes to irrigate an acre and how many acres are in use, then multiplies them together to get an estimate of the total use of water in the Upper Basin. But when the Upper Basin runs into the limits imposed by the Colorado River Compact, there are certainly going to be court cases looking into whether the estimates make sense or not. Is the Upper Basin using more or less than it is entitled to?

The Colorado River Compact did nothing at all about dividing water among the states themselves. The division in the compact was only between the two groups of states, the Upper and Lower Basins. It was expected that the states would decide among themselves how to split the water up, but Arizona wanted no part of it, so Arizona didn't sign the compact.

In 1928 Congress, nonetheless, took the six-state compact as the basis for passing the Boulder Canyon Act, which authorized the building of Boulder Dam, or Hoover Dam. The Bureau of Reclamation, which was going to operate the dam, was instructed to sign contracts with the three Lower Basin states—

California, Arizona, and Nevada—agreeing to deliver to California 4.4 maf, Arizona 2.8 maf, and Nevada 300,000 af per year. That division was negotiated in Congress, not between the states. It was part of the dickering that took place to get this act passed—which California farmers wanted, and which the Upper Basin people were willing to give them because the Lower Basin had agreed to not take more than 7.5 maf per year from the Colorado.

The dam was built, with Arizona fighting every inch of the way. When Parker Dam was started (the Colorado River Aqueduct draws its water from the Parker Dam reservoir), the governor of Arizona sent National Guard troops to stop the construction. Federal courts acted to force Arizona to send the soldiers home. This was the beginning of a series of six law suits filed by the state of Arizona against the state of California, five of which were thrown out of the Supreme Court. These were all attempts to stop California from using Arizona water and to establish rights to a certain amount of water from the river.

Because the Colorado is not only an interstate river but an international one, one of the provisions of the compact was that the Upper and Lower basins would share responsibility for any deliveries to Mexico to which the federal government might commit the states. In 1944 a treaty was signed with Mexico under which the United States agreed to deliver 1.5 maf per year to Mexico. In principle the Upper Basin is supposed to deliver 750,000 af and the Lower Basin 750,000, but there's a problem of evaporation loss in the river, and so if you start out with 750,000 af someplace up the Colorado, it's not 750,000 by the time it gets to the Mexican border. Who bears the evaporation losses? That hasn't come to litigation yet, but it probably will. The Mexican treaty had no provision in it for the quality of water either, and that turned out to be a problem later on.

In 1948 the four Upper Basin states got together and signed a compact among themselves splitting their part of the river on a percentage basis, plus a token 50,000 af to Arizona. At this time the Upper Basin had no reservoirs, and the federal government wouldn't build dams in the area until the states themselves had agreed on what water they had rights to. So there was pressure on the Upper Basin states to come to an agreement, and once they did, it was possible for them to go to Congress and ask for funds to build reservoirs. In 1956 the Upper Colorado River Storage Project

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Act was passed. It provided funds for four dams, Glen Canyon being the most important because it has a reservoir behind it that is roughly the size of Lake Mead, which makes it the major storage reservoir in the Upper Basin.

Glen Canyon was built right above Lee Ferry—for one reason only. According to the Colorado River Compact, the Upper Basin was supposed to deliver an average 7.5 maf per year to the Lower Basin, but the Upper Basin didn't have any way to control that delivery. So Glen Canyon was built at a site where every drop of water that enters the Colorado in the Upper Basin can be caught. No tributary of the Colorado in the Upper Basin comes in below Glen Canyon Dam. It has no use as a dam for irrigation purposes. It provides for recreational uses and electric power generation, but basically it's there to allow the Upper Basin to control releases to meet the terms of the compact.

Since Glen Canyon was opened in 1963, the releases per year have turned out to be very constant at close to 8.25 maf per year—7.5 maf required by the compact, plus 750,000 af to Mexico. Since the Upper Basin uses of water have grown much more slowly than the Lower Basin uses, the water that is not being used gets stored in Lake Powell behind the Glen Canyon Dam.

Between 1963 and 1975 a little over 20 maf was stored in Lake Powell. By 1975 there was a total of 48 maf of water stored on the Colorado—four years' flow. Evaporation losses from the reservoirs had reached 1.5 maf per year, something like 13 percent of the flow of the river. This is a loss that doesn't get back into the system. All this buildup was essentially because the Upper Basin states knew that at some time in the future they were going to run into the limitations of the Colorado River Compact, and so there was an incentive to just simply keep storing water.

The Bureau of Reclamation has been storing water according to rules based on the Arizona vs. California decision and on the 1968 Colorado Basin Act. These rules amount to stating that there would be no further uses of water in the Lower Basin except those that had already been contracted for, and that Lake Mead and Lake Powell should be filled to roughly the same levels. That's the way the Bureau of Reclamation has operated the dams since 1963 when the Glen Canyon Dam was closed.

The background of the 1963 Arizona vs. California

case is the following: California has the All-American Canal, opened in 1939 to replace the Alamo Canal. It delivers water to the Imperial Valley Irrigation District and the Coachella Valley Irrigation District. California also has the Colorado River Aqueduct built by the Metropolitan Water District to deliver water to the L.A. Basin and San Diego. The state of California is in a position to use all of the water to which it has rights (and more!). Arizona, on the other hand, which could get 2.8 maf per year from the Colorado (according to the Boulder Canyon Project Act), is not in a position to use that water. About 1.2 maf per year has been used by Arizona in irrigation districts located right next to the Colorado River, but there is no main aqueduct system for carrying water from the Colorado to the places where the Arizona citizens want it—mainly in the Phoenix-Tucson area. What Arizona wanted Congress to do was to finance such an aqueduct.

There's no way that the people of Arizona are going to pay for such an aqueduct because it's simply not economical. But under federal government sponsorship, costs to water users are reduced substantially since Bureau of Reclamation projects are paid for on a no-interest-rate basis over long periods of time. The aqueduct that will take water to Phoenix-Tucson will cost between \$1.5 billion and \$2 billion (maybe more than that now) and will be paid off over a period of about 68 years at a zero interest rate, which means that the payment for it by users will amount to only something like 10 percent of the cost of the project.

Anyway, Arizona wanted such an aqueduct system, and the Arizona senators and representatives kept asking Congress to pass a bill authorizing its building. But California's representatives in Congress opposed it with a real Catch-22 argument that goes as follows: Congress shouldn't appropriate any money for building

Claims on the Colorado River	
Upper Basin Use	7.5 maf
Lower Basin Use	7.5 maf
Reservoir Evaporation Losses	1.5 maf
Deliveries to Mexico	1.5 maf
Total	18.0 maf
Water Available	
400-Year Average	13.5 maf
Deficit	4.5 maf

this aqueduct because it might turn out that Arizona doesn't have legal rights to the water it wants to use. It's up to Arizona, in other words, to establish that, sure enough, it does have rights to the water. But under the appropriative system the way you establish your right to water is by using it.

The long-time tradition of the Supreme Court was that it wouldn't get involved in a question of deciding on water rights until there was a dispute about water that was actually in use. So Arizona kept going to the Court (5 times in 30 years) and getting turned down, and going to the Congress and getting turned down. Arizona couldn't establish rights without using water, and it couldn't get the aqueduct to enable them to use it without having the rights.

The sixth time Arizona went into court, the Supreme Court took the case under advisement, and after five years (it was the most expensive case in the history of the U.S. Supreme Court) an almost completely arbitrary decision came down. Going back to the 1928 Boulder Canyon Act, the court said that the contracts signed by the Bureau of Reclamation with California, Arizona, and Nevada under that act constituted the assignment of rights, that in fact California got 4.4 maf, Arizona got 2.8 maf, Nevada got 300,000 af, of the Lower Basin's 7.5 maf allotment.

Those figures in the Boulder Canyon Act were just the result of the lobbying back and forth among congressmen in order to get the act passed. I'm sure that if they had known that this was going to be the basis for the water rights for all eternity, it would have taken a lot longer to have the act passed. At any rate, the main point, so far as Arizona was concerned, was that the 2.8 maf that Arizona had rights to was from the mainstream of the Colorado. California had argued that the million acre-feet that the Gila River could bring to the Colorado if it hadn't been dammed is part of the flow of the Colorado, just as all of the other tributaries are, and so Arizona's 2.8 maf allotted by the Boulder Canyon Act should consist of 1.0 maf from the Gila River and 1.8 maf from the mainstream of the Colorado.

The Supreme Court didn't buy this argument, and so Arizona got to use both the Gila's 1.0 maf (that it had been using for 50 years) plus 2.8 maf from the Colorado mainstream. Once the Arizona vs. California decision came down, Arizona went back to Congress, and in 1968 the act was passed that authorized the Central Arizona Project. This provides for the aqueduct

(the Central Arizona Project, or CAP) that is going to carry water from the Colorado to the Phoenix-Tucson area, mainly for irrigation. But there was an extended debate and final compromise in Congress in order to get support from California for CAP. Under the compromise, California was given an "absolute priority" to 4.4 maf of water per year, but just what an "absolute priority" means is a matter for more future lawsuits.

Let me indicate one way of looking at what's been going on in this highly litigated river. Strictly speaking, the Upper Basin is supposed to get 7.5 maf per year, the Lower Basin the same. Reservoir evaporation losses currently are running 1.5 maf per year, and there is the 1.5 maf that has to go to Mexico. This adds up to 18 maf per year for a river with an estimated average annual flow of 13.5 maf. Needless to say, there will be further litigation in the future for the river.

Within the next ten years, the river will be fully used, the Central Arizona Project will be in operation, and some important changes will be in store for present users, especially in the state of California which has been using some 600,000 to 1,000,000 af per year above its rights.

The problem that is going to cause difficulties in California is the seniority of claims within the state. The Palo Verde Irrigation District followed by the Imperial Valley Irrigation District and the Coachella Valley Irrigation District have seniority in claims within California to 3.85 maf of water per year. These are the first three priorities so far as claims to water in the state are concerned. Then comes the Metropolitan Water District with priority number four for 550,000 acre-feet and priority number five for another 550,000 acre-feet. The city of San Diego, which now belongs to the MWD, has also merged its claim to 112,000 acre-feet of water with the MWD.

California has rights to 4.4 maf under the Supreme Court decision and you can see that when you add all these priorities up, you come up with 5.1 or 5.2 maf of water. Since 1964 California has been using anywhere from 0.5 maf to 1.0 maf of water per year more than its rights under the Supreme Court decision. It was able to use that water because Arizona was not in a position to use it. That is what accounts for the excess of use of water over California's rights. But when it comes to the point where California is actually restricted to 4.4 maf per year, the people who will get hurt are the ones at the bottom, the MWD users in the Los Angeles-San Diego area.

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The MWD, through the Colorado River Aqueduct, has the capacity to deliver 1.2 maf per year to the L.A. Basin. That capacity was not fully utilized in the mid-1970's because the MWD was using water from the State Water Project. In 1977, when the state cut off the delivery of water through the California Aqueduct to the Los Angeles area, the MWD switched back to Colorado River Aqueduct water. So, during the drought, southern California simply shifted from northern California water to Colorado River water.

Arizona is now using much less water than it has rights to, but the magic day is going to come when Arizona claims its full water rights. In about 1985, when the Central Arizona Project comes on line, California is going to be cut back on Colorado River water. When the cutback occurs, it's going to hit the MWD. The MWD will have an aqueduct with a capacity of 1.2 maf per year but with water rights to only about 500,000 af per year. Is there any way to replace the water that the MWD (and especially the city of San Diego) is going to lose because of this cutback? The physical capacity to deliver the water to the L.A. Basin from the Colorado, namely the Colorado River Aqueduct, is sitting there, and it certainly can be used. The answer is that there's water available from the Imperial Valley and the Coachella Valley. At least, in principle there's water available there for the MWD to use.

In the Imperial Valley water is currently selling for about \$4 to \$6 an acre-foot. Basically, the irrigation district is required to just charge enough for water that it will break even. It's a nonprofit organization. The charge for water keeps going down over time because the Imperial Valley is in the process of paying off the bonds on the All-American Canal, a main item of cost for the district. So as time goes on and more bonds are retired, water gets cheaper and cheaper. But water in the L.A. Basin is worth a great deal more than \$4 to \$6 an acre-foot (even net of delivery charges), and the MWD would be quite willing to pay considerably more than that—maybe ten times that amount, say, \$40 to \$50 an acre-foot. People in the Imperial Valley should be quite happy to sell water at those prices.

In any other market goods move to where their prices (after delivery charges) are highest. This is not true in the case of water because of certain existing laws. There is, first of all, a federal law that prohibits any irrigation district from selling water outside the district so long as money is still owed on Bureau of

Reclamation projects for the district. So, currently, the Imperial and Coachella Valleys, which still owe money to the federal government for the All-American Canal, can't sell water outside the districts. They can use the water for purposes other than irrigation, but the water has to be used within the geographical limits of the Imperial or Coachella Valleys.

There's a state law that prohibits any irrigation district from selling water outside the district too. So, in order to get water transferred from these districts to where it has a higher value (namely, the L.A. Basin) you'd have to change both federal and state laws. I don't think they're impossible to change, but it's interesting that these laws have been on the books for years and years.

I think it is important to point out that we aren't going to destroy agriculture in the Imperial Valley and Coachella Valley by changing these laws and permitting the districts to sell water to the MWD. We're talking about a relatively small amount of water in any case. If we replace the water that is going to be lost to the MWD when the Central Arizona Project comes on line, we're still talking about less than 15 percent of the water that is currently used in the Imperial-Coachella valleys.

It might even turn out that there is no need to lose any water there at all. There could be water that the MWD can get without any decrease in water available for farmers. The All-American Canal is now an unlined canal. It has dirt sides, and it is estimated that anywhere from 150,000 to 500,000 acre-feet of water per year is lost through seepage in the canal. Currently it doesn't pay to line the canal with cement to stop the seepage because water in the Imperial Valley is only worth \$4 to \$6 an acre-foot. But once water gets up to \$40 an acre-foot, it might very well pay the people of the Imperial Valley to cement the canal; and they might find that they won't have to cut their use of water at all.

Despite a number of apparently adverse factors—that the Colorado River is an intensively used and controlled waterway, that the Lower Basin uses are very close to the 7.5 maf allotment right now, that in the next five to ten years completion of the Central Arizona Project is going to yield an additional 1.3 maf to Arizona, and that there will be a consequent cut-back in California withdrawals of water—the truth is that there is no need for panic. We've got lots of water. All we have to do is get it to the right places. □