The water I will draw tomorrow from my tap in Malibu is today crossing the Mojave Desert from the Colorado River, and I like to think about exactly where that water is. The water I will drink tonight in a restaurant in Hollywood is by now well down the Los Angeles Aqueduct from the Owens River, and I also think about exactly where that water is: I particularly like to imagine it as it cascades down the 45-degree stone steps that aerate Owens water after its airless passage through the mountain pipes and siphons.

—JOAN DIDION, *THE WHITE ALBUM*

Expanding Watersheds

Stand at the top of a snow-covered ski run on the summit of Mammoth Mountain in the winter, and think about where the water under your feet may be by midsummer. Much of what drains eastward will end up in Los Angeles instead of Owens Lake. Turn around for a view of the western slope; there water will run down to the San Joaquin River. Some of the river water may reach the Central Valley and turn northward toward San Francisco Bay. Most of it, however, will be diverted onto farm fields in the San Joaquin Valley.

Plate 51. Spring snow conditions near Tioga Pass, west of the Yosemite National Park entrance.

Or get out of your car at Tioga Pass, at the eastern entrance to Yosemite National Park. Melting snow that drains westward from here will feed the Tuolumne River, which merges with San Joaquin River water flowing toward the sea (pl. 51). But much of the Tuolumne water will go, instead, into San Francisco's water supply system. Walk just a few steps outside the park and the drainage begins sloping to the east. Snow-

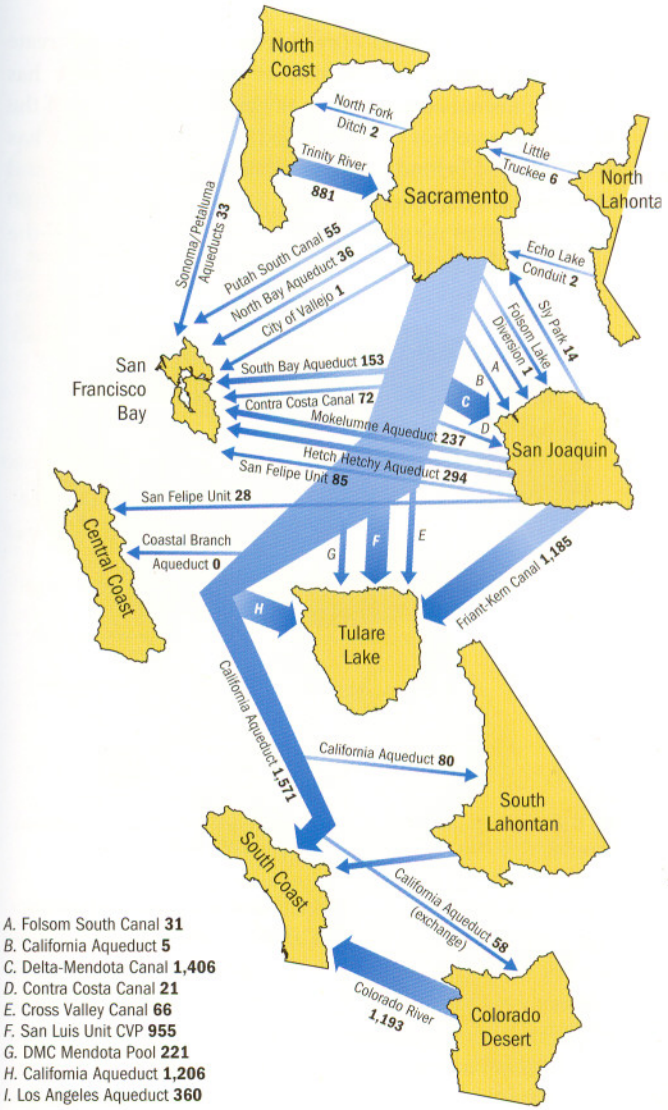
melt from here may reach Lee Vining Creek, a tributary to Mono Lake, but some will be diverted and become the northernmost water entering the Los Angeles Aqueduct.

Drive Interstate 80 from Reno, Nevada, toward San Francisco. The American and Yuba Rivers flow westward, paralleling this route through the mountains, also aiming for the Pacific Ocean via the Golden Gate. Much of that water will be diverted out of the Delta and moved southward to irrigate crops in the San Joaquin Valley.

Farther north, the Feather River is the source for the State Water Project's California Aqueduct. Much of that water will emerge from Southern California faucets after traveling over 600 miles through natural channels and aqueducts. Some water brought to Southern California cities covers even greater distances, starting 1,400 miles away in the Colorado River headwaters in Colorado and Wyoming. Winter snowfall in the Sierra Nevada is more critical than local rainfall to the Bay Area's water supply, and both Sierra Nevada and Rocky Mountain winters are far more critical than local weather to Southern Californians.

Because of long-distance aqueducts, the great majority of Californians live within "virtual watersheds," with distant snowpacks and long-distance transportation systems providing most of their water. (Map 11.) Sierra Nevada and Rocky Mountain snow assures the economic wealth of California, a state with the world's fifth-largest economy, bigger than almost every *nation's*. The enormous population growth of Southern California and the San Francisco Bay Area was only made possible by damming distant rivers and importing their water, so that local resource limits could be made irrelevant. Without outside water, there could only be about three million people in Southern California, where 18 million now reside from Ventura down to San Diego.

Because California's water landscape has been reengineered, about 75 percent of the *demand* for water originates south of Sacramento, although 75 percent of the water *supply*



Map 11. Regional water imports and exports, at 1995 level of development (thousands of acre-feet per year). (Redrawn from California Department of Water Resources 1998.)

in the state comes from north of the capital city. To create twenty-first-century California, an intricate network has been engineered across the face of the state (map 12). Of the 42 million acre-feet of "developed water"—water that has been gathered behind dams, pumped from the ground, and transmitted along aqueducts and through pipes—about 80 percent irrigates the state's farms, and the rest "irrigates" the urban population and its industrial needs (fig. 6).

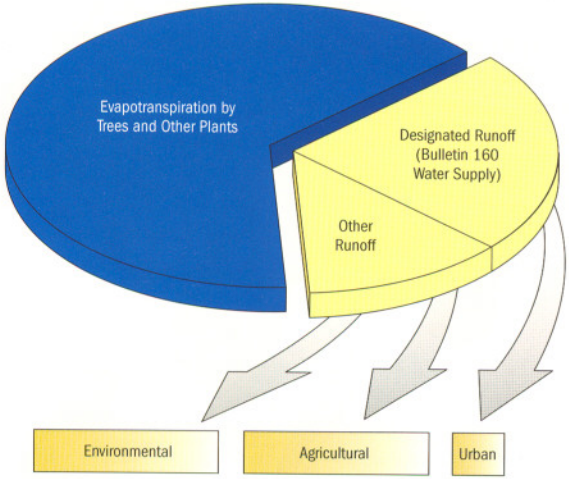


Fig. 6. Disposition of California's average annual precipitation. (Redrawn from California Department of Water Resources 1998.)

Six major systems of aqueducts and associated infrastructure redistribute water within California: the State Water Project, the Central Valley Project, a number of Colorado River delivery systems, the Los Angeles Aqueduct, the Tuolumne River/Hetch Hetchy system, and the Mokelumne Aqueduct to the East Bay. The state, federal, and regional agencies that operate these transportation systems are, in most cases, wholesalers that pass their life-giving product on to hundreds of local districts for delivery to retail consumers.

Map 12. Major water transport systems. (Redrawn from California Department of Water Resources 1998 and from McClurg 2000b.)

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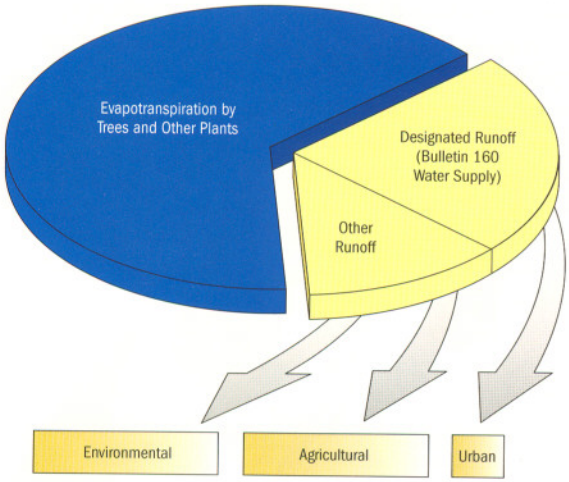

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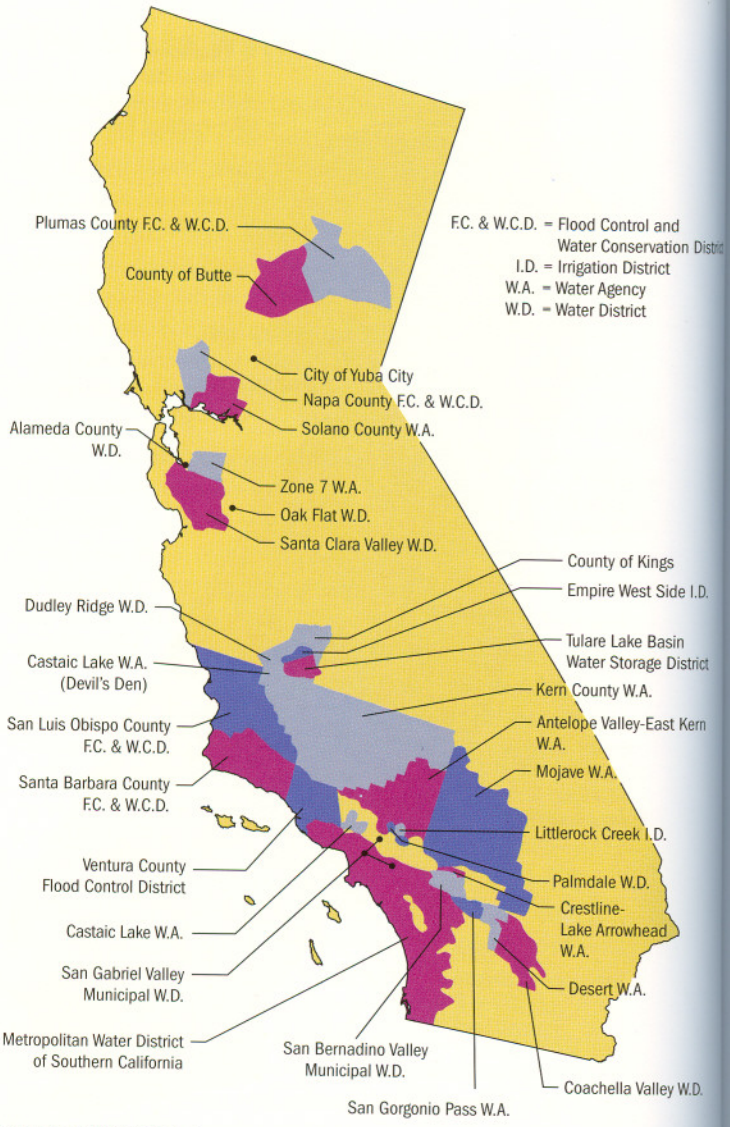
The State Water Project

The DWR operates the massive California State Water Project (SWP), the largest state-built multipurpose water project in the United States (maps 13, 14). The SWP moves water from the Feather River watershed in the Sacramento Valley to urban and industrial consumers (70 percent of its contracts) and the balance to agricultural irrigation districts (mostly in Kern County in the San Joaquin Valley). More than two-thirds of Californians receive some of their water from the SWP. About 2.3 million acre-feet are delivered in average years, although the overcommitted system has contracted to deliver 4.2 million acre-feet.

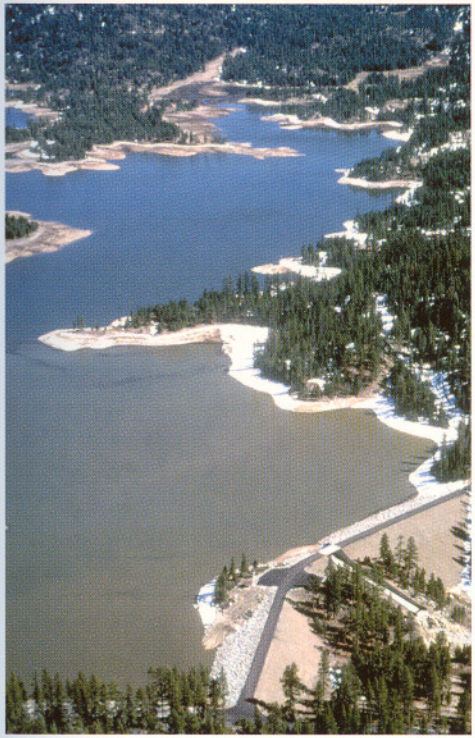
Twenty-nine agencies hold those contracts for SWP water. The contractors cover the SWP's major operating costs and have slowly chipped away at the $1.75 billion bond debt that funded the initial construction. Since 1960, the SWP has built 29 dams, 18 pumping plants, five hydroelectric power plants, and about 600 miles of canals and pipelines. Four additional combination pumping/generating plants move water uphill into storage basins when electricity costs are low (off-peak hours), then generate power by releasing the same water through turbines during peak energy demand periods.

The SWP system begins 600 miles north of its southernmost service area with the Lake Davis, Frenchman Lake, and Antelope Lake reservoirs on upper tributaries of the Feather River (pls. 52, 53). Oroville Dam, where the Feather River passes out of the foothills, forms the largest SWP reservoir (pl. 54). The dam towers 770 feet above the riverbed; it is the tallest in the United States. When full, its reservoir covers 15,000 acres with 165 miles of shoreline, and holds 3.5 million acre-feet (2.7 million acre-feet for water supply, 800,000 acre-feet for flood control). A power plant is located *underneath* the reservoir to maximize hydroelectric generation. It is an eerie feeling to visit that plant and know you are standing beneath hundreds of feet of water.

Map 13. State Water Project facilities. (Redrawn from two maps in California Department of Water Resources 1998.)



Map 14. State Water Project service areas. (Redrawn from Hundley Jr. 2001.)



Above: Plate 52. Lake Davis, in the headwaters region of the Feather River and the SWP.

Left: Plate 53. Antelope Dam and Lake, in the headwaters region of the Feather River and the SWP.

Plate 54. Oroville, the primary SWP storage reservoir for Feather River water.

SWP water travels from the Lake Oroville reservoir along the natural channel of the Feather River and enters the Sacramento River. At the Sacramento–San Joaquin Delta some is pumped into the North Bay Aqueduct toward Napa and Solano Counties. More is diverted by powerful pumps at the Harvey O. Banks Delta Pumping Plant, which pull the SWP's allotment of Delta water into the Bethany Reservoir and the start of the California Aqueduct. In an average year, about 2.1 million acre-feet (of the 2.3 million total) are extracted here from the Delta. The 444-mile-long "Governor Edmund G. Brown California Aqueduct," to use its formal name, extends southward along the west side of the San Joaquin Valley as a concrete-lined, open canal (pl. 55). Bethany Reservoir is also the point where water is pumped into a side branch, the South Bay Aqueduct, which heads for Alameda and Santa Clara Counties.

Plate 55. The California Aqueduct south of the Delta.

Plate 56. The San Luis Reservoir, which stores both SWP and CVP water.

Sixty-three miles to the south is San Luis Reservoir, off Hwy. 152 below Pacheco Pass in the Diablo Range (pl. 56). Water is pumped uphill into this off-stream storage facility. The reservoir, its forebay, and its pumping plants are jointly operated by DWR and the federal Central Valley Project (CVP). (CVP water moves from the Delta to this location in a separate, parallel aqueduct, the Delta-Mendota Canal.) Southward, for 103 miles, the aqueduct carries both "kinds" of water.

The California Aqueduct parallels Interstate 5, passing beneath that other important transportation corridor several times (pl. 57). The Coastal Branch Aqueduct splits away, 185 miles south of the Delta, to direct some water toward the coastal cities of San Luis Obispo, Santa Maria, and Santa Bar-

Plate 57. Dos Amigos Pumping Plant on the California Aqueduct, which parallels Interstate 5 in the Central Valley.

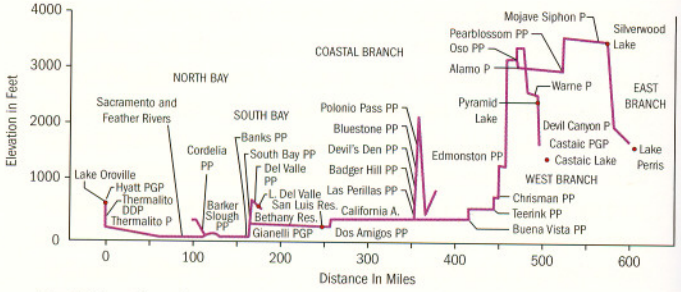


Fig. 7. Elevation changes of water moving in the State Water Project.

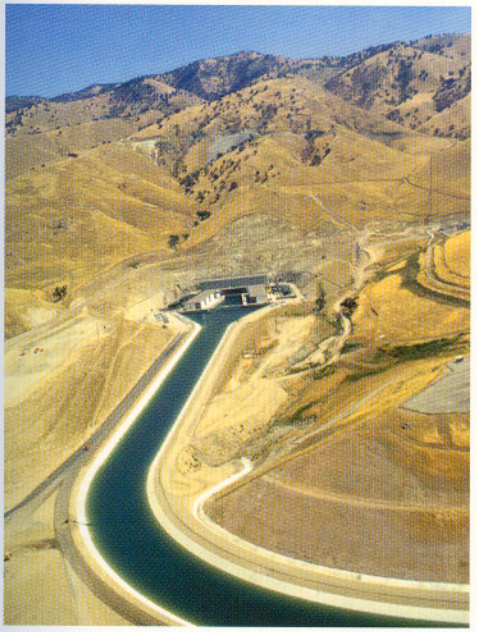


Plate 58. The A.D. Edmonston Pumping Plant, which lifts SWP water almost 2,000 feet over the Tehachapi Mountains.

bara. Central Coast voters decided to fund this artery during the drought that ended in 1993.

The balance of SWP water flows to the south end of the San Joaquin Valley, where it encounters a 2,000-foot-tall barrier, the Tehachapi Mountains (fig. 7). Here the A. D. Edmonston Pumping Plant lifts the water 1,926 feet into 10 miles of tunnels and siphons that pass through the mountains (pl. 58). The SWP is California's largest energy consumer, and this pumping plant burns more energy than any other single user or facility in the state. Although the hydroelectric generating plants of the SWP can, together, generate 5.8 billion kilowatt-hours per year (2.2 billion kilowatt-hours at the Oroville reservoir alone), that is only three-fourths of the electricity consumed in lifting SWP water uphill through the Central Valley and making the massive lift over the Tehachapis. Water

Plate 59. Pyramid Dam and Reservoir, with Interstate 5 in the background.

Plate 60. Castaic Pumping Plant on the west branch of the California Aqueduct, after it enters Southern California.

Plate 61. People playing in Castaic Lake, the terminal reservoir on the west branch of the California Aqueduct.

Plate 62. California Aqueduct and new housing made possible by its water deliveries to the Mojave Desert.

is heavy! Carry an eight-pound gallon bucket or jug the next time you go upstairs to better appreciate that fact. Each acre-foot demands 3,000 kilowatt-hours of electricity to overcome the Tehachapis and be redistributed to the Southland.

Below the Tehachapis, the California Aqueduct divides. The west branch stores water in the Castaic and Pyramid Lake reservoirs in north Los Angeles County to serve coastal cities (pls. 59–61). The east branch flows by the Mojave Desert city of Palmdale, in the Antelope Valley, and stores water in the Silverwood Lake reservoir in the San Bernardino Mountains (pls. 62, 63). The final SWP facility in this long chain of trans-

Plate 63. Silverwood Lake, an SWP reservoir in the San Bernardino Mountains.

Plate 64. Windsurfer on Lake Perris, the terminal reservoir on the east branch of the California Aqueduct.

portation infrastructure is Lake Perris, a reservoir in Riverside County (pl. 64). The Metropolitan Water District of Southern California (MWD) is the largest SWP contractor, taking more than two million acre-feet each year (48 percent of the SWP's contracted water).

The DWR operates three SWP visitor centers for the public: Lake Oroville Visitors Center, Romero Visitors Center at San Luis Reservoir, and Vista del Lago at Pyramid Lake.

One of the surreal circumstances shaping California water policy is that the SWP cannot actually deliver the amounts in its contracts. This has created "paper water," as opposed to the essence of real life, "wet" water. Paper water must not be used as the supply basis for authorizing new developments, nor marketed in water transfers. Paper water, if viewed as a legal entitlement, would drive bad government planning and policies by forcing the real world to accommodate to hydrological wishful thinking. (Table 2.)

The Central Valley Project

The CVP was conceived to tame seasonal flooding and to shift water southward to irrigate three million acres of drier farmlands (15 percent of the CVP goes to urban/industrial uses). President Franklin D. Roosevelt signed the measure that authorized the CVP and transformed the Central Valley into one of the most important agricultural regions on Earth. The CVP is operated by the U.S. Bureau of Reclamation (although some of the facilities were built by the Army Corps of Engineers). One of the largest water systems in the world, it stores seven million acre-feet, or about 17 percent of the state's developed water, and delivers it to 139 landowners and eight water districts (map 15).

Broader in scope and scale than the SWP (which primarily draws on the Feather River watershed), the CVP dams and diverts water from five major rivers: the Trinity (Trinity Dam),

the Sacramento (Shasta Dam), the American (Folsom Dam), the Stanislaus (New Melones Dam), and the San Joaquin (Friant Dam). One of its original goals was to end groundwater overdrafting in the southern half of the Central Valley. Instead, more acreage went into production after CVP water became available, and groundwater pumping actually increased.

Friant Dam, on the San Joaquin River, was completed in 1944, forming Millerton Lake. This was the first of 20 reservoirs in the CVP, which also includes 11 power plants and three fish hatcheries. Shasta Dam spanned the Sacramento River in 1945 (pl. 65). The canal system to deliver irrigation water from Shasta to the San Joaquin Valley opened in 1951. The CVP also dammed the Trinity River and, in 1963, began shipping that water out of the North Coast region to Whiskeytown Reservoir, which passes it along to Shasta.

Keswick Dam, nine miles below Shasta, evens out the flow from variable releases through the upstream power plants. Fish-trapping facilities there catch salmon and move them into the nearby Coleman Fish Hatchery, operated by the U.S. Fish and Wildlife Service.

Red Bluff Diversion Dam raises the Sacramento River 17 feet, creating a gravity "head" so water will leave the river and enter the Tehama-Colusa and Corning Canals. One-third of the river's water is diverted into those canals to irrigate 300,000 acres of farmland and provide seasonal water to several national wildlife refuges along the west side of the Sacramento Valley. Red Bluff Dam's fish ladders were never effective, and the dam became a major barrier to migrating fish. After years of court fighting, the dam's gates are now kept open eight months of the year, and the intake to the canals has been reengineered with improved fish screens.

Water stored behind Shasta Dam can be moved 450 miles to Bakersfield, traveling the first leg of that journey in the Sacramento River itself. At Sacramento, American River water stored behind Folsom Dam is added. About 2.5 million acre-feet are pumped annually from the Delta at the Tracy

Map 15. Central Valley Project facilities. (Redrawn from Hundley Jr. 2001.)

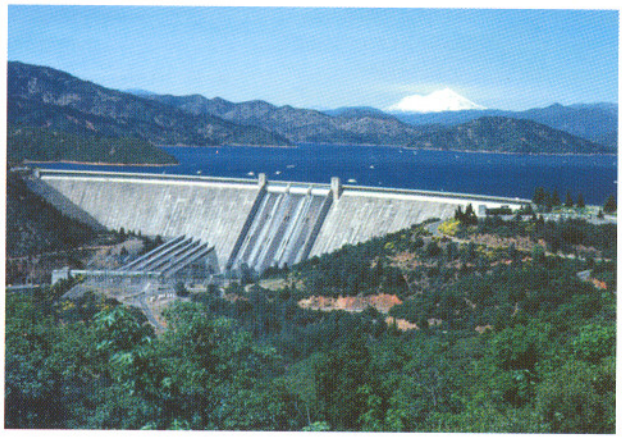


Plate 65. Shasta Dam and Reservoir with Mt. Shasta in the distance.

Plate 66. Pumping from the Delta into the Delta-Mendota Canal, part of the CVP.

Pumping Plant (not far from the SWP pumps that serve the California Aqueduct) into the Delta-Mendota Canal. Some CVP water is stored in San Luis Reservoir and, from there, shares space within the California Aqueduct, which parallels the Delta-Mendota Canal (pl. 66) but heads farther south.

New Melones Dam on the Stanislaus River was completed in 1979. Before the gates were closed to impound the Stanislaus, a fight developed, because the reservoir would flood a spectacular river canyon that, among other values, was popular for white-water rafting. New Melones Reservoir was filled in 1982.

Just below the confluence of the north and middle forks of the American River, construction of the Auburn Dam began in 1974, but it was halted the next year because of seismic risks. Plans for that dam, in a number of manifestations, remain a "never-ending story" in California's perennial water debates.

Operation of the CVP has generated controversies about environmental degradation, the prices charged (or subsidies given) to farmers, and lax enforcement of acreage limitations. Bureau of Reclamation water was meant to serve farms limited to 160 acres, to encourage small farmers who lived on their land. That type of land ownership was never the broad pattern in California, however. Under Spanish and Mexican land grants, just a few individuals owned large ranches. Federal land grants later transferred 11 percent of California's acreage to railroads; much of that land spanned the Central Valley. A few entrepreneurs manipulated federal homestead, timber, and swampland programs to circumvent acreage limits and acquire massive parcels. Henry Miller and Charles Lux ultimately controlled about 750,000 acres along both sides of the San Joaquin River for 100 miles, plus a 50-mile stretch along the Kern River. Similarly, James Ben Ali Haggin acquired more than 400,000 acres in the Central Valley. A transition from a few large landholdings to many smaller farms was conceivable, but the vision of many thousands of farms limited to 160 acres was never actually realized.

In 1982, a reform act increased CVP acreage limitations to 960 acres and dropped the former residency requirement. Today, however, 80 percent of the huge farms still exceed 1,000 acres.

Another major reform came in 1992, when the Central Valley Project Improvement Act (CVPIA) elevated fish and wildlife protection and restoration to primary purposes of the

CVP. To correct environmental damage, including endangered species designations for native fish, 800,000 acre-feet of annual runoff were dedicated back to the environment (600,000 acre-feet in dry years). Also, CVP contractors were allowed to market water to buyers outside the CVP service area.

One of the biggest environmental consequences of the CVP was not corrected by the CVPIA. At Friant Dam the entire flow of the San Joaquin River is diverted into the Friant-Kern and Madera Canals. The Friant-Kern Canal travels southward 152 miles from Friant Dam, and the Madera Canal extends 36 miles northward. A little water is allowed down the San Joaquin River channel for 28 miles, to Gravelly Ford, to serve users holding priority riparian rights, but from there the channel goes dry until Mendota Pool. (Pl. 67.)

Mendota Pool is a strange place in California's redesigned waterscape. There the Delta-Mendota Canal delivers Sacramento River water to serve CVP "exchange contractors." Irrigators in the San Joaquin Valley who held water rights to the San Joaquin River's natural flow agreed to accept this alternate CVP water, provided as the highest-priority right coming out of the Delta. They take delivery of their exchange water at Mendota Pool (pl. 68) and soon divert it to farm fields. The San Joaquin channel dries up again not far below Mendota. Other than in very wet years, the San Joaquin River is actually *not* a river for about 60 miles, until the Merced enters its channel with a transfusion from the Yosemite watershed. The Tuolumne and Stanislaus add their water farther north. Some agricultural drainage water is returned to the channel, carrying salts, fertilizers, and pesticides, and some treated municipal effluent is returned as well. The San Joaquin River, before it finds its rather pitiful way to the Delta, has been called "the lower colon of California."

Of course, after the CVP diverted the San Joaquin's water to grow crops, other life that depended on the river diminished or disappeared. In particular, 100,000 salmon could no longer reach spawning grounds. After a consortium led by the Natural Resources Defense Council (NRDC) sued and prevailed in the courts, a settlement agreement between the consortium and the Friant Water Users Authority led to restoration studies (with findings expected in 2002). The agreement adopted two guiding principles: that the river's natural functions be restored and that irrigators not lose water or additional money. In 2003, the issue returned to court when negotiations broke down.

Plate 67. The Friant-Kern Canal, heading southward below Friant Dam and leaving very little water for the San Joaquin River, seen in the distance.

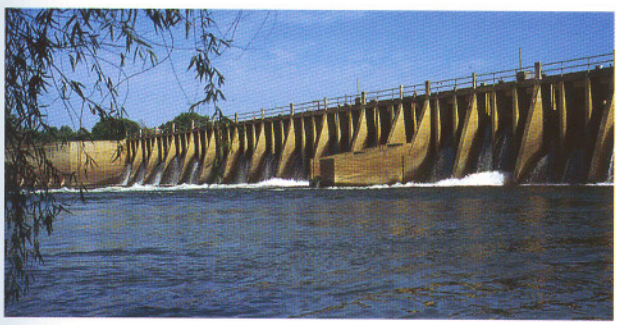


Plate 68. Mendota Pool, where Sacramento River water taken from the Delta is delivered to the dry San Joaquin River channel to serve CVP exchange contractors.

Colorado River Delivery Systems

The Colorado River is currently the source for up to 12 percent of California's developed water. Six other states along the river's watershed, plus the nation of Mexico, share allocated portions of the river's flow. (Map 16.) California's allotment is 4.4 million acre-feet per year. Three-fourths of that is used to irrigate 900,000 acres of farmland. Priority water rights are held by three irrigation districts. The Palo Verde Irrigation District (PVID) is located 110 miles north of the Mexican border, just west of the river. The Imperial Irrigation District (IID), in Imperial County, south of the Salton Sea, receives the majority of the state's Colorado River allotment via the All-American Canal. The Coachella Valley Water District (CVWD) serves farms north of the Salton Sea, in parts of Riverside, Imperial, and San Diego Counties (map 17.)

The fourth priority water right is held by the MWD. Member agencies of "the Met" include 14 cities, 12 municipal water districts, and one county water authority. It is the water wholesaler to 95 percent of the South Coast region. Along that coastal plain, from Ventura County down to the Mexican border, the MWD provides about 60 percent of the water supply. The Colorado River portion of its supply (SWP water also serves the MWD) travels 242 miles, crossing the desert in the Colorado River Aqueduct.

Lake Mead, behind Hoover Dam, is the primary storage reservoir in the lower Colorado River basin. The Colorado River Aqueduct begins at Parker Dam, 155 miles downstream from Hoover. The aqueduct can handle 1.2 million acre-feet annually, or more than 1 billion gallons a day. (Pls. 69, 70.)

The newest large reservoir in California was completed by the MWD in 1999. Diamond Valley Reservoir, near Hemet, was built to alleviate concerns that aqueducts feeding Southern California could be cut off by earthquakes and to provide optional water during droughts. The off-stream reservoir was filled in 2002 with 800,000 acre-feet of water (a six-month

Map 16. Colorado River watershed and facilities. (Redrawn from Water Education Foundation 1991.)

supply for the MWD) from the Colorado River Aqueduct and the California Aqueduct.

Every drop of Colorado River water has been allocated to water rights holders. In fact, the river is overallocated, because

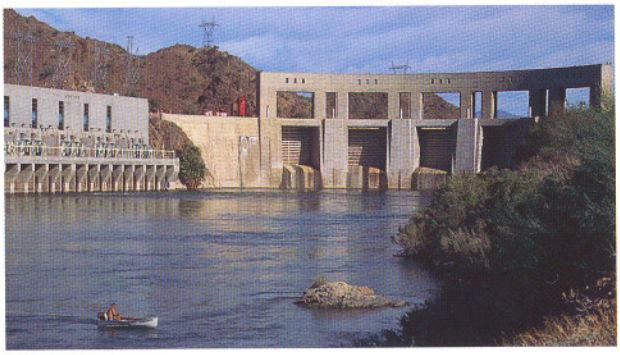
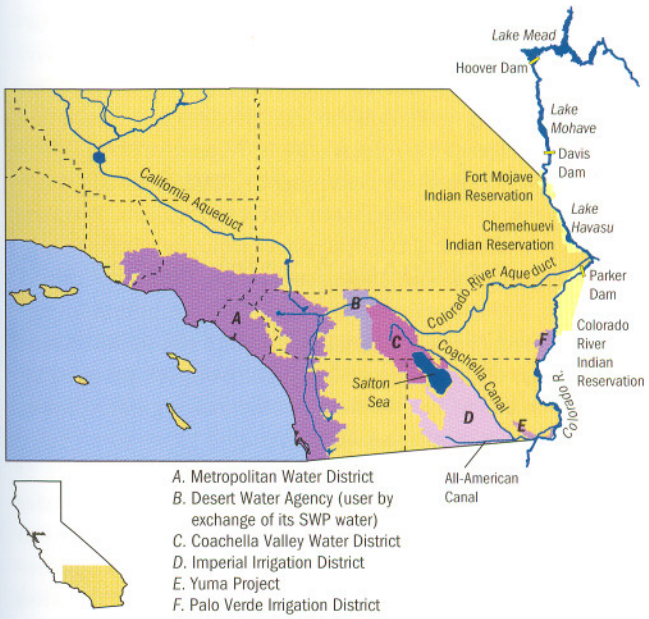


Plate 69. Parker Dam, which forms Lake Havasu, the diversion point for Colorado River water into the Colorado Aqueduct.

Plate 70. The Colorado River Aqueduct crossing the desert.

apportionments to the states were based on overestimates of the annual runoff. In *Cadillac Desert* (1986, 126), Marc Reisner described the Colorado as "unable to satisfy all the demands on it, so it is referred to as a 'deficit' river, as if the river were somehow at fault for its overuse." Of course, the Colorado is not to blame. The river itself is not a water rights holder.

In a treaty, the United States promised to pass along 1.5 million acre-feet of Colorado River water as far as the border



Map 17. Colorado River service areas. (Redrawn from Water Education Foundation 1991.)

of Mexico. In most years, diversions inside Mexico have left nothing to reach the Gulf of Mexico. There was once a wetlands estuary at the mouth of the Colorado; the United States, Mexico, and the International Boundary and Water Commission are studying possibilities for restoring it.

For many years, California took more than its allocated 4.4 million acre-feet of Colorado River water, because other states in the lower river basin were not prepared to divert their full allotments. Southern Californians became accustomed to about 800,000 acre-feet of surplus to keep the MWD's Colorado River Aqueduct full; they took a total of 5.3 million acre-feet in 2000. But by then, Arizona had plumbing in place to handle all of its allotment, and Nevada, with the Las Vegas region booming, was asking to exceed its portion.

The secretary of the interior controls use of the river's "surplus" water. Under pressure from the other Colorado River states, the secretary ordered California to show good progress toward weaning itself from the extra 800,000 acre-feet or face mandatory cuts. The Colorado River Water Use Plan, or "4.4 Plan," was to be ready by December 31, 2002, and had to convince the other watershed states that it was realistic. Planners aimed to reallocate 800,000 acre-feet annually within Southern California without pulling more from Northern California's already heavily impacted rivers. That meant that Imperial and Coachella Valley agriculture had to give up water. The alternatives of urban demand reduction or population stabilization to live within the limits of the existing water supply were not given serious consideration.

A list prepared for the 4.4 Plan included a transfer of 110,000 acre-feet between the MWD and the IID, a transfer of 200,000 acre-feet between the IID and the San Diego County Water Authority (SDCWA), a shift of 100,000 acre-feet between the IID and the CVWD, the lining of irrigation canals with concrete to control seepage and save 94,000 acre-feet, and groundwater sources totaling 300,000 acre-feet in Arizona, the Mojave Desert, and the Coachella Valley.

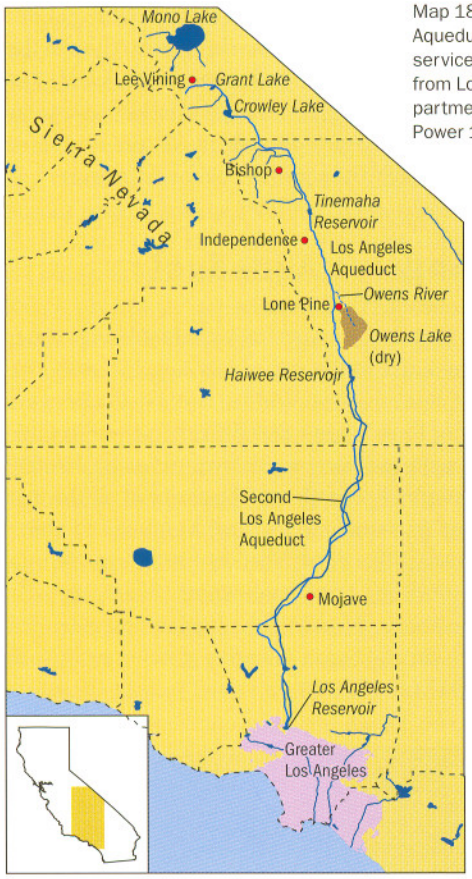
There were problems with almost all of the proposals. Groundwater banking for future withdrawals was not as controversial as pumping of native groundwater. Conservation measures, such as concrete lining of irrigation canals, were not as controversial as land fallowing, which would shut down extended economies in farm communities. In the Imperial Valley, fallowing would also exacerbate the salinity issues of the Salton Sea, because irrigation flows to the sea would be cut back. The IID balked at land fallowing and wanted assurances that it would not be liable for damages to the Salton Sea environment.

When the deadline arrived with no agreement, the Department of the Interior announced it would immediately reduce the MWD's access to surplus water by about 415,000 acre-feet. It also intended to punish the IID by shifting about 200,000 acre-feet from the farmers to the MWD (though the overuse had all originated with the urban wholesaler). The IID vowed to legally fight the attack on its historic water rights, yet the forced transfer of agriculture water to serve urban interests seemed to be a sign of California's future.

The Los Angeles Aqueduct

Completed in 1913, the Los Angeles Aqueduct brings water from the Eastern Sierra to the city of Los Angeles (map 18). Construction of this aqueduct and its associated reservoirs was the first major long-range water delivery project in California. The city acquired water rights by purchasing 300,000 acres of the Owens Valley, or about 98 percent of all the private land in that Eastern Sierra valley, hundreds of miles north of Los Angeles. The imperialistic pressure exerted by a distant city on unwilling rural landowners became an ugly part of California's water history. The aqueduct was extended into the Mono Basin and began diverting streams away from Mono Lake in 1941 (pls. 71, 72).

Plate 71. Lee Vining Creek at the point where water is diverted from the Mono Lake tributary into the Los Angeles Aqueduct.



Map 18. Los Angeles Aqueduct facilities and service areas. (Redrawn from Los Angeles Department of Water and Power 1988.)

The Los Angeles Department of Water and Power moves an average of 400,000 acre-feet of Eastern Sierra water to the city each year—enough to serve about 3.2 million people. With additional MWD water and some local groundwater, the Los Angeles population has grown to four million, at least eight times the number that local water supplies would have allowed. (Pl. 73.) That growth is one of the clearest examples

Plate 72. Los Angeles Aqueduct pipe in the upper Owens Valley.

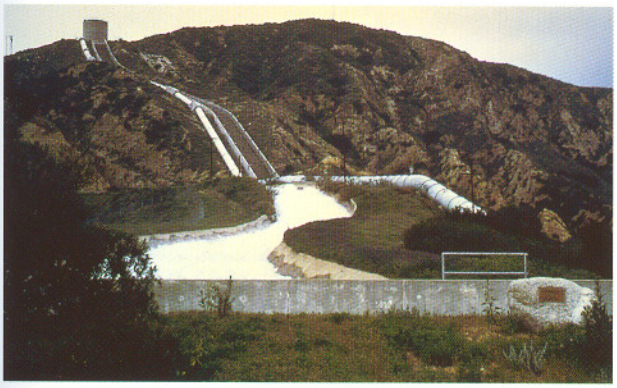


Plate 73. The cascade, visible from the Golden State Freeway, where Los Angeles Aqueduct water enters the San Fernando Valley.

of William Mulholland's observation "Whoever brings the water, brings the people." Mulholland was the engineer who oversaw the early design, construction, and operation of the Los Angeles Aqueduct system.

After four decades of stream diversions from the Mono Lake basin, damage to the lake and the dewatering of its tributary streams fostered an environmental battle in the 1980s and victory for the lake defenders in 1994. Other issues arose

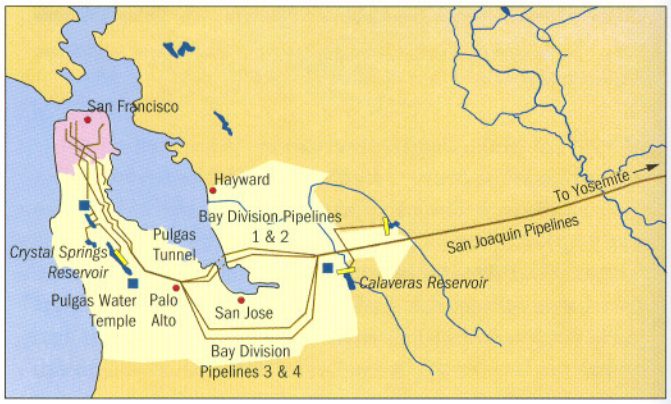
when dust from the bed of Owens Lake, which was completely dried up by the diversions, became a major air pollution source at the south end of the Owens Valley. To stabilize Mono Lake, correct violations of air quality laws, and rewater portions of the lower Owens River, Los Angeles has found ways to reduce its reliance on Eastern Sierra water. Most of that reduction has been achieved through water conservation. The city pursued an aggressive program of toilet replacement, offering free low-flush toilets to its customers. This and other conservation and water-recycling efforts allowed Los Angeles to grow by 30 percent during the final decades of the twentieth century, yet see a seven percent *decrease* in its total water use and a 15 percent drop in per capita demand.

The Hetch Hetchy Aqueduct

The Hetch Hetchy Aqueduct brings Tuolumne River water to 2.3 million people in San Francisco and other portions of the Bay Area (map 19). The system originates at Hetch Hetchy Valley, inside Yosemite National Park, where O'Shaughnessy Dam was completed in 1923 to dam the Tuolumne River (pls. 74, 75). The water system of the San Francisco Public Utilities Commission (SFPUC) also includes five reservoirs in the Bay Area: two in Alameda County (San Antonio and Calaveras) and three on the Peninsula south of San Francisco (San Andreas, Crystal Springs, and Pilarcitos). Those reservoirs supplement the system with runoff from local watersheds, but 85 percent of the city's water comes from the Tuolumne River. About two-thirds of that Hetch Hetchy water is sold to 26 other cities and water districts in San Mateo, Santa Clara, and Alameda Counties.

The system also generates electricity—a major revenue source for San Francisco (pl. 76). After water leaves Hetch Hetchy, it passes through tunnels leading down to a series of powerhouses. Three massive pipes then bring water across the Central Valley. The aqueduct that delivers water to San Francisco is entirely gravity fed, so a 25-mile-long tunnel had to be constructed through the Coast Ranges. One segment of the aqueduct crosses beneath the south part of the bay and another portion swings south of the bay. They rejoin at the Pulgas Water Temple, a monument marking the arrival point for aqueduct water on the Peninsula (pl. 77).

Below and facing page: Map 19. Hetch Hetchy Aqueduct, facilities, and service areas. (Redrawn from San Francisco Public Utilities Commission, no date.)



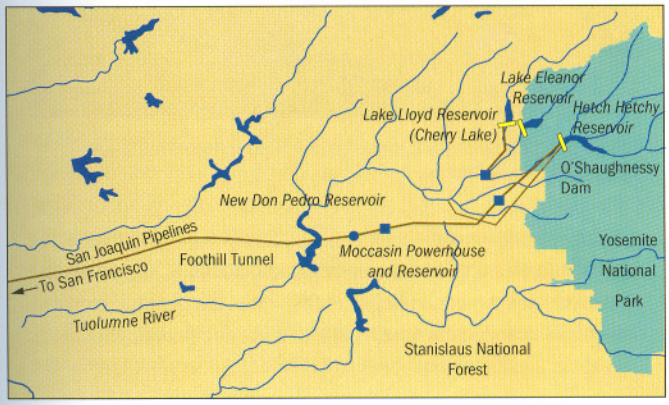


Plate 74. Hetch Hetchy Valley, 1913.

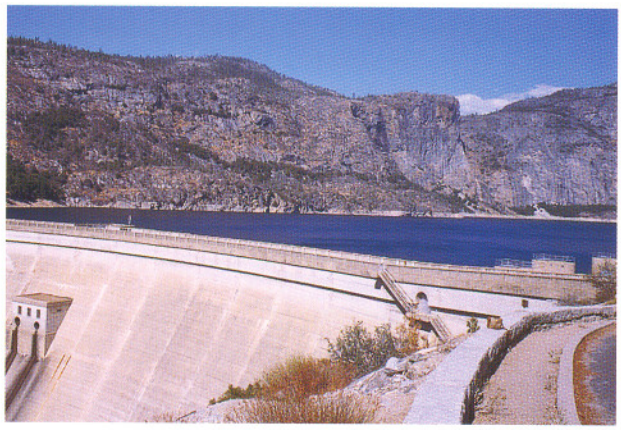


Plate 75. O'Shaughnessy Dam and Hetch Hetchy Reservoir, inside Yosemite National Park.

Some of the exceptionally clean Tuolumne water goes directly into the city's water system, and some is stored in the Peninsula reservoirs. Hetch Hetchy water that goes directly to city pipelines does not have to be filtered, because it exceeds

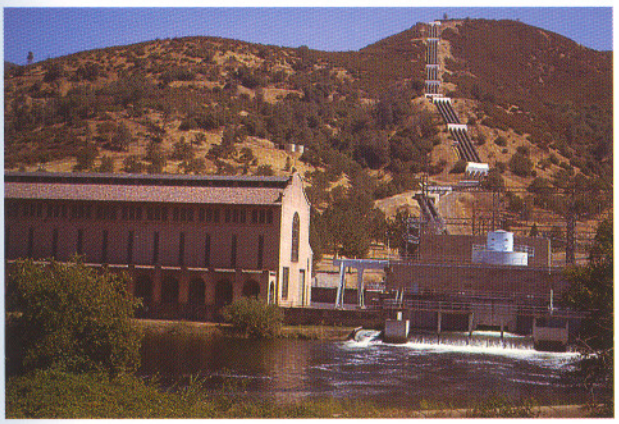


Plate 76. Moccasin, a hydroelectric power plant that is part of the SFPUC's Hetch Hetchy system.

water quality standards (it is disinfected with chlorine). Only a few cities in the nation are authorized to use unfiltered water.

Hetch Hetchy Valley, where that clean water is first stored, is about two-thirds the size of, and very similar in character to, the more famous Yosemite Valley. The Tuolumne River meandered through its meadows and trees, beneath towering granite cliffs and domes punctuated by waterfalls. The idea of building a dam inside a national park, and in that particular valley, infuriated John Muir. "These temple destroyers, devotees of ravaging commercialism, seem to have a perfect contempt for Nature, and, instead of lifting their eyes to the God of the mountains, lift them to the Almighty Dollar," Muir declared in 1912, as congressional hearings were about to start to consider the project. "Dam Hetch Hetchy? As well dam for water tanks the people's cathedrals and churches, for no holier temple has ever been consecrated by the heart of man" (1912, 181).

Muir argued that there were other rivers available to San Francisco, including the Mokelumne (which would be devel-

Plate 77. The dedication ceremony, in 1934, at the Pulgas Water Temple, above Crystal Springs Reservoir.

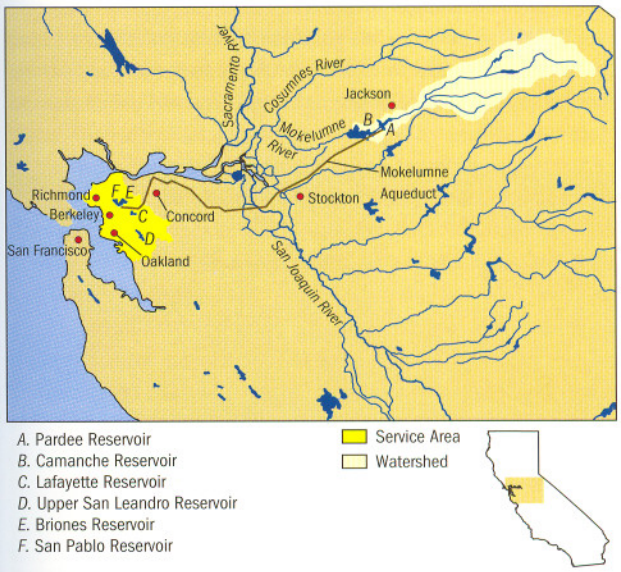
oped soon after for East Bay cities). Congress authorized the reservoir construction by passing the Raker Act in 1913. When President Woodrow Wilson signed the law, he stated that domestic water supply was the "highest use" of the river water, even though it originated in a national park.

Concerns about the old, deteriorating Hetch Hetchy Aqueduct system's ability to withstand earthquakes led to a $1.7 billion bond, approved by voters in the November 2002 election, to fund repairs and upgrades. Because two-thirds of the SFPUC's water customers had no say in its management decisions, some of their contracting agencies had also pushed for state legislation to require oversight of the repairs, and even for a new regional utility district something like the MWD to oversee water distributions.

Those who wanted to see the restoration of Hetch Hetchy Valley saw an additional possibility: that O'Shaughnessy Dam might actually be removed from Yosemite National Park. The Restore Hetch Hetchy organization proposed a project that would have developed alternative water storage as part of the capital improvement program and required no loss of water for San Francisco. They asked that a feasibility study be included in the bond proposal sent to the voters; that did not happen, but county supervisors did pass a resolution promising to (someday) consider the visionary proposal.

The Mokelumne Aqueduct

"East Bay MUD" is the nickname for the East Bay Municipal Utility District, which serves 35 communities in Alameda and Contra Costa Counties, including Berkeley and Oakland, and parts of the San Ramon Valley (map 20). It is an earthy nickname for an agency that supplies domestic water to about 1.2 million people.



Map 20. Mokelumne Aqueduct/East Bay MUD facilities and service areas. (Redrawn from Montgomery 1999.)

The Mokelumne River in the central Sierra Nevada is the source for virtually all of EBMUD's water. The watershed drains parts of Alpine, Amador, and Calaveras Counties. EBMUD built the Pardee Dam across the Mokelumne in the foothills northeast of Stockton. Pardee can hold a 10-month supply of water. Below Pardee is Camanche Reservoir, which helps regulate releases to serve downstream water rights holders and the fisheries and riparian habitat needs of the lower river.

EBMUD owns almost 30,000 acres in the Mokelumne River watershed and 25,000 acres of other watershed lands in the East Bay. After a 30- to 45-hour trip, water in the system has traveled 91.5 miles across the Central Valley via the Mokelumne and Lafayette Aqueducts to enter East Bay reservoirs or filter plants. Basins in the Berkeley and Oakland Hills contain the San Pablo, Briones, Lafayette, Upper San Leandro, and Chabot Reservoirs (pl. 78).

EBMUD also holds an American River entitlement that could be sent to the Mokelumne Aqueduct via the Folsom South Canal. This supplemental supply has only been tapped once, during the drought year of 1977 to 1978, when it was actually pumped from the Delta. This intake point generated controversy. EBMUD preferred the cleaner water taken from the American River, but environmentalists and the city of Sacramento were concerned about the impacts of such diversions on the river. A decades-long legal battle led to affirmation of EBMUD's water right, but modifications have been negotiated. The intake point was shifted to just downstream from Sacramento, to maintain minimum flows in the American until it merges with the Sacramento River.

Plate 78. EBMUD's San Pablo Reservoir, east of Tilden Regional Park.

The North Bay

Some cities north of San Francisco Bay, including Santa Rosa, Petaluma, San Rafael, and Mill Valley, are served by the Sonoma County Water Agency. Their primary water source is the Russian River, via the Santa Rosa, Sonoma, Petaluma, and North Marin Aqueducts and the Cotati Intertie. The agency also taps into the headwaters of the Eel River, diverting that water into the Russian River through a tunnel. The fast-growing cities of Vallejo, Fairfield, and Vacaville are served by the Solano County Water Agency, which captures Putah Creek water in Lake Berryessa and ships it south in the Putah South Canal. SWP water delivered by the North Bay Aqueduct adds to the Solano supply.

The state has thousands of water agencies and districts; 280 retail water agencies serve about 90 percent of California's users. The San Diego County Water Authority is an example of one of the intermediate layers in the water supply hierarchy. SDCWA is an MWD member that imports 84 percent of the county's water. It serves six cities, four rural water districts, three irrigation districts, eight municipal water districts, one public utility district, and a federal military base. The Colorado River provides 73 percent of its water; 27 per-

cent comes from the SWP (both sources are delivered, of course, by the MWD). In addition to SDCWA supplies, the county also relies on local sources (including surface water, groundwater, recycled water, and some water produced by desalination) that make up 16 percent of the total mix.

With so many agencies and many layers of decision making, coordination (or the lack of it) can be an obstacle to wise management of the resource. A Regional Water Authority established, in 2001, by 21 agencies in the Sacramento region was a hopeful sign that joint-powers agreements might be established elsewhere.

Because water is essential for life, every natural habitat and everything that lives in California has been affected by the redistribution of the state's water. (See table 3 for one way to look at this redistribution.) The aqueduct systems have fostered economic development and population growth. They have also generated a long list of challenges for Californians to face as they shape their future.

TABLE 2. State Water Project Contractors' Annual Entitlement and 2002 Allocation

Agency (headquarters location)	**Annual Entitlement, AF**	**2002 Allocations, AF (%)**
Upper Feather River		
Butte County, Board of Supervisors (Oroville)	3,500	1,575 (45)
Plumas County FC&WCD (Quincy)	1,630	865 (53)
Yuba City, Public Works (Yuba City)	9,600	4,320 (45)
North Bay Area		
Napa County FC&WCD* (Napa)	21,100	9,495 (45)
Solano County Water Agency (Vacaville)	46,296	20,833 (45)
South Bay Area		
Alameda County FC&WCD* Zone 7 (Pleasanton)	78,000	35,100 (45)
Alameda County Water District (Fremont)	42,000	18,900 (45)
Santa Clara Valley Water District (San Jose)	100,000	45,000 (45)
San Joaquin Valley		
Castaic Lake Water Agency	12,700	5,715 (45)
Dudley Ridge Water District (Fresno)	57,343	25,804 (45)
Empire/West Side Irrigation District (Stratford)	3,000	723 (24)
Kern County Water Agency (Bakersfield)	1,000,949	450,427 (45)
Kings County (Hanford)	4,000	1,800 (45)
Oak Flat Water District (Westley)	5,700	2,565 (45)
Tulare Lake Basin Water Storage District (Corcoran)	111,527	50,187 (45)
Central Coast		
San Luis Obispo County FC&WCD* (San Luis Obispo)	25,000	11,250 (45)
Santa Barbara County FC&WCD* (Santa Barbara)	45,486	20,469 (45)
Southern California		
Antelope Valley/East Kern Water Agency (Quartz Hill)	141,400	63,630 (45)
Castaic Lake Water Agency (Santa Clarita)	82,500	37,125 (45)
Coachella Valley Water District (Coachella)	23,100	10,395 (45)
Crestline/Lake Arrowhead Water Agency (Crestline)	5,800	2,610 (45)

continued ➤

TABLE 2. *continued*

Agency (headquarters location)	Annual Entitlement, AF	2002 Allocations, AF (%)
Desert Water Agency (Palm Springs)	38,100	17,145 (45)
Littlerock Creek Irrigation District (Littlerock)	2,300	1,035 (45)
Metropolitan Water Dist. of S. California (Los Angeles)	2,011,500	905,175 (45)
Mojave Water Agency (Apple Valley)	75,800	34,110 (45)
Palmdale Water District (Palmdale)	21,300	9,585 (45)
San Bernardino Valley MWD (San Bernardino)	102,600	46,170 (45)
San Gabriel Valley MWD (Azusa)	28,800	12,960 (45)
San Gorgonio Pass Water Agency (Beaumont)	4,000	1,800 (45)
Ventura County Flood Control District (Ventura)	20,000	9,000 (45)
Total State Water Project Entitlements/Allocations	**4,125,031**	**1,855,768 (45)**
(Over the years, SWP deliveries have averaged 2.3 million acre-feet)		

*FC&WCD = Flood Control and Water Conservation District.
Source: Compiled from Department of Water Resources reports.

TABLE 3. Where Does Your Water Come From?

Sources: **1.** Groundwater; **2.** Feather River/California Aqueduct/State Water Project; **3.** Colorado River/Metropolitan Water District of Southern California*; **4.** Owens and Mono Basins/Los Angeles Aqueduct/L.A. Department Water & Power; **5.** Tuolumne River/San Francisco PUC; **6.** Mokelumne River/East Bay Municipal Utility District; **7.** Russian and Eel Rivers/Sonoma County Water Agency; **8.** Lake Berryessa/Putah Creek/Solano County Water Agency; **9.** Central Valley Project (many Northern California rivers)/U.S. Bureau of Reclamation; **10.** local reservoirs/streams; **11.** ocean desalination

Agoura Hills 2, 3, 10
Alameda 6, 10
Albany 5, 10
American Canyon 2
Anaheim 1, 2, 3
Antioch 9, 10
Apple Valley 1*†
Arcadia 1, 2, 3
Arcata 10
Arroyo Grande 1, 10
Artesia 1, 2, 3, 10
Atascadero 1
Atwater 1
Auburn 10
Avenal 9
Azusa 1, 2, 3
Bakersfield 1, 2, 10
Baldwin Park 1, 2, 3
Banning 1
Barstow 1
Bell 1, 2, 3
Bell Gardens 1, 2, 3
Bellflower 1, 2, 3
Belmont 5, 10
Benicia 2, 10
Berkeley 6, 10
Beverly Hills 2, 3
Blythe 1, 10
Brawley 3
Brea 1, 2, 3
Buena Park 1, 2, 3
Burbank 1, 2, 3
Burlingame 5
Calabasas 2
Calexico 3
Camarillo 1, 2
Campbell 1, 2, 9, 10
Canyon Lake 1, 3, 10
Carlsbad 2, 3
Carpinteria 1, 2, 10
Carson 1, 2, 3
Cathedral City 1
Ceres 1
Cerritos 1, 2, 3
Chico 1
Chino 1, 2
Chino Hills 1, 2, 3
Chula Vista 2, 3, 10
Claremont 1, 2, 3
Clearlake 10
Clovis 1
Coachella 1
Colton 1*†
Commerce 1, 2, 3
Compton 1, 2, 3
Concord 9, 10
Corona 1, 2, 3, 10
Coronado 2, 3, 10
Costa Mesa 1, 2, 3
Covina 1, 2, 3, 10
Cudahy 1, 2, 3
Culver City 1, 2, 3
Cupertino 1, 2, 5, 9, 10
Cypress 1, 2, 3
Daly City 1, 5, 10
Dana Point 2, 3
Davis 1 (UC Davis 2, 8)
Delano 1
Diamond Bar 2, 3
Dinuba 1
Dixon 1
Downey 1, 2, 3
Duarte 1
Dublin 1, 2, 10
East Palo Alto 5, 10
El Cajon 2, 3, 10
El Centro 3
El Cerrito 6, 10
El Monte 1, 2, 3
El Segundo 2, 3
Encinitas 2, 3, 10
Escondido 2, 3, 10
Eureka 10
Fairfield 2, 8
Fillmore 1
Folsom 9
Fontana 1, 2, 10
Foster City 5
Fountain Valley 1, 2, 3
Fremont 1, 2, 5
Fresno 1, 9
Fullerton 1, 2, 3
Galt 1
Garden Grove 1, 2, 3
Gardena 1, 2, 3
Gilroy 1
Glendale 1, 2, 3
Glendora 1, 2, 3
Grand Terrace 1*†, 2
Grover Beach 1, 10
Hanford 1
Hawaiian Gardens 1, 2, 3
Hawthorne 1, 2, 3
Hayward 5, 6, 10
Hemet 1, 2, 3, 10

continued ➤

TABLE 3. *Continued*

Hercules 6, 10
Hermosa Beach 1, 2, 3
Hesperia 1*†
Highland 1, 2, 10
Hillsborough 5, 10
Hollister 1
Huntington Beach 1, 2, 3
Huntington Park 1, 2, 3
Imperial Beach 2, 3, 10
Indio 1
Inglewood 1, 2, 3
Irvine 1, 2, 3
La Canada Flintridge 1, 2, 3, 10
La Habra 1, 2, 3
La Mesa 2, 3, 10
La Mirada 1, 2, 3
La Palma 1, 2, 3
La Puente 1, 2, 3
La Quinta 1
La Verne 1, 2, 3
Lafayette 6, 10
Laguna Beach 2, 3
Laguna Hills 2, 3
Lake Elsinore 1, 3, 10
Lake Forest 2, 3
Lakewood 1, 2, 3
Lancaster 1, 2
Larkspur 7, 10
Lawndale 1, 2, 3
Lemon Grove 2, 3, 10
Lemoore 1
Livermore 1, 2, 10
Lodi 1
Loma Linda 1*†
Lomita 1, 2, 3
Lompoc 1
Long Beach 1, 2, 3
Los Alamitos 1, 2, 3
Los Altos 1, 2
Los Angeles 1, 2, 3, 4
Los Banos 1
Los Gatos 1, 2, 9, 10
Lynwood 1, 2, 3
Madera 1
Manhattan Beach 1, 2, 3
Manteca 1
Marina 1, 11
Martinez 9
Marysville 1
Maywood 1, 2, 3
Menlo Park 5, 10
Merced 1
Mill Valley 7, 10
Milpitas 2, 5, 9
Mission Viejo 2, 3
Modesto 1
Monrovia 1, 2, 3
Montclair 1, 2
Montebello 1, 2, 3
Monterey 1, 10
Monterey Park 1, 2
Moorpark 1, 2
Moraga 6, 10
Moreno Valley 1, 2
Morgan Hill 1
Mountain View 1, 2, 5, 9, 10
Murrieta 1, 2, 3, 10
Napa 2, 10
National City 1, 2, 3, 10
Newark 1, 2, 5
Newport Beach 1, 2, 3
Norco 1
Norwalk 1, 2, 3
Novato 7, 10
Oakdale 1
Oakland 6, 10
Oceanside 1, 2, 3, 11
Ontario 1, 2, 3
Orange 1, 2, 3
Orinda 6, 10
Oroville 1, 2, 10
Oxnard 1, 2
Pacific Grove, 1, 10
Pacifica 5
Palm Desert 1
Palm Springs 1, 10*†‡
Palmdale 1, 2, 10
Palo Alto 5
Palos Verdes Est. 2, 3
Paradise, 10
Paramount 1, 2, 3
Pasadena 1, 2, 3, 10
Paso Robles 1
Perris 2, 3
Petaluma 7
Pico Rivera 1
Piedmont 6, 10
Pinole 6, 10
Pittsburg 1, 9
Placentia 1, 2, 3
Pleasant Hill 6, 9
Pleasanton 1, 2, 10
Pomona 1, 2, 10
Port Hueneme 1
Porterville 1
Poway 2, 3, 10
Rancho Cucamonga 1, 2, 10
Rancho Mirage 1
Rancho Palos Verdes 2, 3
Red Bluff 1
Redlands 1, 2, 10
Redondo Beach 1, 2, 3
Reedley 1
Rialto 1, 2, 10
Richmond 6, 10
Ridgecrest 1
Riverbank 1
Riverside 1*§
Rocklin 10
Rohnert Park 1, 7
Rosemead 1, 2, 3
Roseville 9
Sacramento 1, 9, 10
Salinas 1, 10
San Anselmo 7, 10
San Bernardino 1*†, 2, 10

TABLE 3. *Continued*

San Bruno 1, 5, 10
San Carlos 5
San Clemente 1, 2, 3
San Diego 2, 3, 10
San Dimas 1, 2, 3
San Fernando 1, 2
San Francisco 5, 10
San Gabriel 1, 2, 3
San Jacinto 1, 2, 10
San Jose 1, 2, 5, 9, 10
San Juan Capistrano 1, 2, 3
San Leandro 6, 10
San Luis Obispo 1, 2, 10
San Marcos 2, 3
San Marino 1, 2, 3
San Mateo 5, 10
San Pablo 6, 10
San Rafael 7, 10
San Ramon 6, 10
Sanger 1
Santa Ana 1, 2, 3
Santa Barbara 1, 2, 10, 11
Santa Clara 1, 2, 5, 9, 10
Santa Clarita 1, 2
Santa Cruz 1, 10
Santa Fe Springs 1, 2, 3
Santa Maria 1, 2, 10
Santa Monica 1, 2, 3
Santa Paula 1, 10
Santa Rosa 7, 10
Santee 2, 3
Saratoga 10
Seal Beach 1, 2, 3
Seaside 1, 10
Selma, 1
Shafter 1
Sierra Madre 1, 10
Simi Valley 1, 2
Soledad 1
South El Monte 1, 2, 3
South Gate 1, 2, 3
South Lake Tahoe 1, 10
South Pasadena 1, 2, 3
South San Francisco 1, 5
Stanton 1, 2, 3
Stockton 1, 10
Suisun City 2, 8
Sunnyvale 1, 2, 5, 9, 10
Susanville 1, 10
Temecula 1, 2, 3, 10
Temple City 1, 2, 3
Thousand Oaks 2
Torrance 1, 2, 3
Tracy 1, 9
Truckee 1
Tulare 1
Turlock 1
Tustin 1, 2, 3
Twentynine Palms 1
Ukiah 1
Union City 1, 2, 5
Upland 1, 2, 10
Vacaville 1, 2, 8
Vallejo 2, 8, 10
Ventura 1, 10
Victorville 1*†
Visalia 1
Vista 1, 2, 3, 10
Walnut 2, 3
Walnut Creek 6, 9
Wasco 1
Watsonville 1
West Covina 1, 2, 3, 10
West Hollywoo, (east) 4; (west) 2, 3
West Sacramento 1, 9, 10
Westminster 1, 2, 3
Whittier 1
Windsor 1, 7
Woodland 1
Yorba Linda 1, 2, 3
Yuba City 1, 2, 10
Yucaipa 1, 2, 10
Yucca Valley 1*†

* MWD is also the largest customer for SWP water.

† Groundwater is replenished with State Water Project water.

‡ Riverside uses 99.9% groundwater; the rest is MWD's blend of SWP and Colorado River water.

§ Palm Springs groundwater is replenished with Colorado River water in exchange for SWP allotment.

Source: Water Education Foundation 1994 and numerous water district sources. Cities listed have populations greater than 10, 000.