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Historical Water-Use Priorities and Public Policies

ABSTRACT

The forces that created and maintain contemporary California's complex waterscape have exploited the Sierra Nevada for 145 years. Since the Gold Rush era, the development, manipulation, and use of its water resources has significantly modified the Sierra Nevada landscape, incalculably impacting the region's ecosystem. Focusing on selected episodes featuring the impoundment and conveyance of water and its various uses, this paper, emphasizing the historical evolution of water use priorities, seeks answers to the question: How have past public policies involving water resources—or their absence—impacted the Sierra Nevada ecosystem? Special attention is given to the scale and scope of landscape transformation in the last half of the 19th century, when technology and capital were largely unconstrained by public policies.

PROLOGUE

The constant quest for water—to use, control, and manipulate—has left deep imprints on California's history and environment. Californians have historically confronted water scarcity problems with strategies designed to augment existing supplies. Among the institutions that evolved to manage this scarce resource is a system of water rights peculiar to California (largely because it contains conflicting elements from so many traditional approaches to water rights), along with a commitment to construct large-scale storage and conveyance facilities—an attempt to physically conquer a physical problem. That problem being: plenty of water but not in the right places and the right times.

Since the Gold Rush era, the forces that created California's complex waterscape looked to exploit the resources of the Sierra Nevada, America's longest unbroken mountain range. For 145 years, the development, manipulation, and use of its water resources has significantly modified the Sierra Nevada landscape, thereby impacting the region's ecosystem. Providing prototypes for innovative hydraulic technologies, water law, water quality, and river preservation, the Sierra is where several seminal water management issues were played out, including the first conservation versus preservation battle in United States history: John Muir's vigorous attempt to prevent a dam in the Hetch Hetchy Valley of the Tuolumne River early in this century. Ever since, major Sierran rivers and lakes have commonly known controversy. The melodramatic struggle in the 1970s to "save" the Stanislaus from the New Melones Dam, for example, was America's most publicized river conservation dispute of its time. More recently, Mono Lake, at the dry eastern base of the Sierra, has symbolized the conflicts over the allocation and use of water.

The historical evolution of water use priorities for Sierra Nevada water extends far beyond the intense battles of the past 25 years between assorted water agencies and environmental organizations. Since the 1850s, development of the Sierra Nevada's water resources has mirrored prevailing values and objectives; often specific public policies have resulted.

Focusing on selected episodes featuring the impoundment and conveyance of water and its various uses, this paper implicitly seeks answers to the question: How have past public policies involving water resources shaped the current conditions of the Sierra Nevada ecosystem? This question is not easily answered. Indeed, it may be impossible to isolate the effects of public policies on Sierran water resources, at least with any precision. However, a better understanding of several benchmark events (appendix 8.1) could possibly provide fresh insights.

While policies have unquestionably been important, especially in this century, it could be argued that the Sierra Ne-

Sierra Nevada Ecosystem Project: Final report to Congress, vol. II, Assessments and scientific basis for management options. Davis: University of California, Centers for Water and Wildland Resources, 1996.

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vada waterscape actually experienced its heaviest impacts before the existence of explicit public policies. Large forces (political, social, economic) operating far from the mountains long have determined how the region's water resources would be used. And while these forces are clearly seen in a 20th century context, they were no less apparent 125 years ago, when the application of private enterprise and capital, much of it flowing from the East Coast and overseas, literally transformed the Sierra Nevada landscape. The literature on 20th century events is substantial; the cornerstone water resource issues—Hetch Hetchy, Owens Valley, the Central Valley Project and State Water Project, Mono Lake, the Stanislaus—are widely known. (They will be looked at subsequently, although not in detail). Much less known, possibly more intriguing, and therefore worthy of careful scrutiny here, is the scale and scope of landscape transformation—of waterscape impacts—in the last half of the 19th century, a time when technology and capital were largely unconstrained by public policies.

FASHIONING A HYDRAULIC LANDSCAPE

Perhaps no other area of our country of roughly equal size is so rich in the history of hydraulic engineering and technology as the northern and central Sierra Nevada. This region, bracketed by the Feather River in the north and the Merced in the south, gave rise to several hydraulic technologies that were not only the first of their kind in the West but the first of their kind anywhere in the world.

It was here that America witnessed the first large-scale development of reservoirs, ditches, and flumes for mining, irrigation, and power production. And here too was the birthplace of the Pelton Wheel (which revolutionized water power technology); the first facility in California for the generation of electric power under high heads; and the first long-distance, high voltage, power transmission line in the world.

Ditches and Flumes

Sometimes history seems unreasonably exclusive in its determination as to what shall be remembered and what largely forgotten. The extensive and elaborate water storage and transfer systems originally laid out to facilitate exploitation of California's placer gold deposits—the most widespread in North America—is an example of the latter.

More than a century ago on the summer-dry western slopes of the central Sierra Nevada more than 6,000 miles of ditches and flumes moved water from higher elevations to the foothills. Singly or in series, these man-made watercourses ran for miles along the broad east-west trending ridges, the major landform of California's Gold Country. The size of the ditches (or canals, as they were commonly called), ranging from four feet wide and two feet deep to double those dimensions, was usually dependent on the terrain traversed. In the rugged, broken country of the higher elevations, narrow and deep ditches with steep grades were preferred: initial excavation was less costly as were repairs due to damage from snow. Larger volume ditches were more common in the lower foothills, below 2,500 feet, where the grade is gentler and snow less frequent.

By the mid-1870s, mining ditches with carrying capacities as large as 80 cubic feet per second were in operation. Where it was not possible to excavate ditches, wooden flumes were built. It was often easier (and cheaper) to cross a canyon with a flume than to follow the contour of a mountain with a ditch. For a ditch of medium capacity the cost of construction was $500 per mile; there were, however, ditches that cost upwards of $5,000 per mile. Flumes were also built on or around solid rock where the cost of blasting for a ditch would have been prohibitive. Some of these canyon-spanning flumes, sustained in the air by trestles that rose to a height of 200 feet or more, were engineering marvels.

Flumes were generally built of 1 1/2-inch plank, with a framing of four-by-four and three-by-four scantling every three feet or so. Sugar pine was the favored construction material, though flumes were built of fir and spruce as well; the forest mix closest to the flume site usually determined the wood used. To protect against strong winds, high flumes were usually anchored to trestle towers with wire or wire rope. These suspension flumes were among the most spectacular structures of Gold Rush California.

The larger Gold Country ditch and flume systems derived their water supply from dams constructed near the Sierra summit to impound water from a melting snowpack. The dams held hundreds of thousands of acre-feet of water, primarily for summer mining activity. Cement was not yet a prime construction material at the apogee of California's gold mining era (except as a component of mortar for masonry) and reinforced concrete was unknown. Water and mining company engineers thus designed dams in stone, earth, and wood, building them with crews of displaced domestic and Chinese placer miners, many of whom would later lay the Central Pacific Railroad's line over the Sierra.

The earliest water transfer systems supplied alluvial placers in the lower elevations of the Sierra foothills. Generally modest structures, they were not built to endure. Yet in each of the Gold Country counties vestiges of these waterworks can be found, and some of the ditches are still in operation after 130 years. For example, direct descendants of these ditches form the main water supply for most of present-day Tuolumne County.

The Hydraulic Mining Era

Hydraulic mining—the application of water under pressure, through a nozzle against a natural bank (as defined by State

and Federal Statute)—was introduced in April of 1853. Little understood and largely ignored by historians and others, hydraulic mining, together with quartz mining, revived the declining California gold industry and set in motion the second major era of mining activity that, in terms of duration, industrial works constructed, and gold produced, dwarfed the early Gold Rush period. It was during the hydraulic mining era that water storage and transfer systems achieved a scale and scope theretofore unimagined. Water companies and mining concerns were often entwined: large ditch companies purchased claims and did their own mining, while heavily capitalized hydraulic operations eventually acquired (or built) their own reservoirs and ditch systems.

The hydraulic mining technique, a California invention and until the recent success of "heap-leaching" the greatest technological advance in the long history of alluvial placer mining, made possible economic extraction of gold from vast low-grade deposits buried deep in the earth. By the mid-1870s, giant hydraulic operations, not held accountable for reclamation, were washing gravels yielding less than five cents per cubic yard and making it pay! Without an immense water supply delivered to the mining pit by ditch and flume from sources many miles away, such results would have been impossible. When hydraulic mining was at its peak in the late 1870s single nozzles, up to nine inches in diameter, were discharging up to 25 million gallons of water in 24 hours! By the 1880s, in the watersheds of the Feather, Yuba, Bear, and American, where hydraulic mining achieved its greatest development, more than 150,000 acre-feet of water was stored in dammed alpine lakes and strategically located man-made reservoirs (figure 8.1).

In the 30 years hydraulic mining was actively practiced, more than $100 million was thought to have been invested; probably $30 million was expended in the construction of ditches, flumes, and reservoirs. Hydraulic mining yielded several billion dollars in gold. But it also produced a debris flow of tidal wave proportions that, after filling mountain canyons, spilled out onto the flat Central Valley to bury thousands of acres of farmland under infertile sand and rock. This initially unforeseen consequence of hydraulic mining, after a long and bitter regional conflict, led to its eventual stoppage; Judge Lorenzo Saywer's injunction in January 1884 effectively ended large-scale hydraulic mining operations on land drained by tributaries of the Sacramento and San Joaquin rivers. Legislation which resulted from Judge Saywer's decision ("Woodruff v. North Bloomfield Gravel Mining Company") enjoined the deposit of mining debris in streams to the detriment of agricultural interests in the Sacramento Valley; hydraulic mining was practically prohibited except under the most severe restrictions, involving the permanent impounding of the debris.

It has been estimated that in 1880 alone the Sacramento and San Joaquin rivers received in excess of 46 million cubic yards of debris from hydraulic mines in the mountains. During an 18-month period in the late 1870s, the quantity of mining debris dumped into the Yuba River drainage would have entirely filled the 363-mile-long Erie Canal. Nearly a quarter of a century after Judge Sawyer's decision, the distinguished government geologist G.K. Gilbert estimated that hydraulic mining operations in the basins of the Feather, Yuba, Bear, and American, the so-called "Northern Mines," had produced nearly 1.3 billion cubic yards of debris. Total mining debris from hydraulic mining for the entire Sierra Nevada likely exceeded 1.5 billion cubic yards, or 930,000 acre-feet, almost

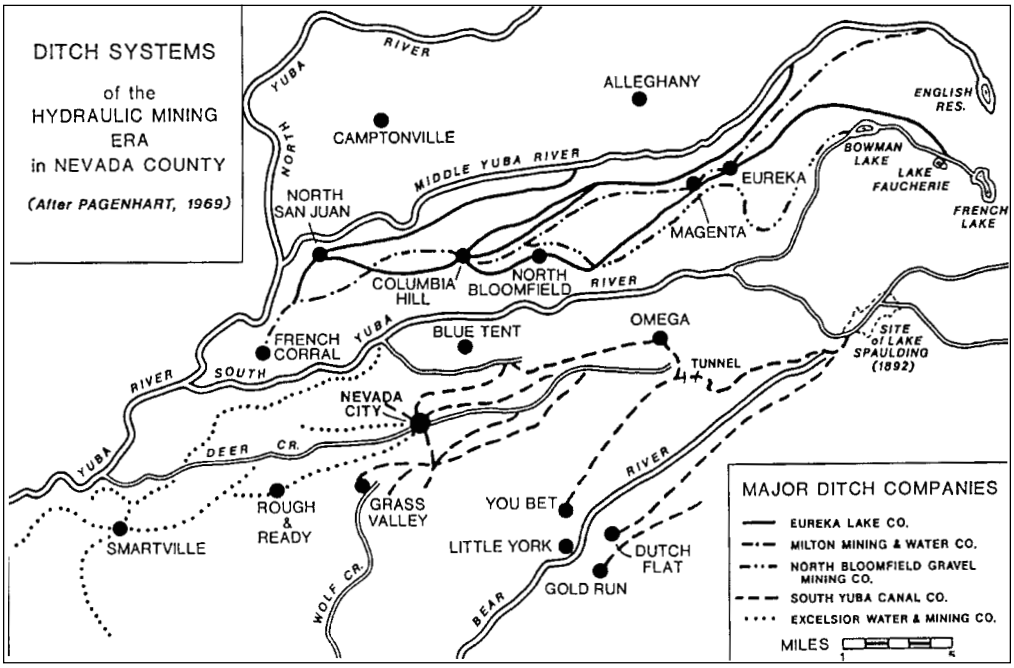


FIGURE 8.1

Ditch systems of the hydraulic mining era in Nevada County.

enough to completely fill Folsom Reservoir. Never in human history had man moved so much earth so quickly. Hydraulic mining was clearly responsible for a landscape transformation that was nothing less than geologic in nature and scope (appendix 8.2).

Why California?

Only in California, it appears, could large-scale hydraulic mining have evolved to such astonishing proportions. When gold was discovered California was a vast virgin territory without laws or precedents—or many people. The fantastically rich placer deposits happened, by chance, to be located in a region of mild climate with bountiful supplies of water and wood. The timing of the discovery of gold—roughly coincident with major social upheavals and economic reversals abroad—coupled with its universal allure, drew to California hardy, energetic, and industrious men of all nationalities who designed and maintained laws (if not policies, per se) ideally suited to an empty land. With California courts concluding that riparian rights did not exist on federal lands where there was no private riparian claimant, a doctrine of water use by appropriation quickly evolved. River diversion, reservoir construction, and rights of way for ditches and flumes required no formal possessory title; miners had only to drive stakes along the proposed route and post notices of their intentions. A popularly elected judiciary readily adopted these mining laws and made them the fundamental laws of the State. So the physical and legal prerequisites were nicely in place.

Large-scale hydraulic mining required at least one other essential element: enormous amounts of capital. It too would be put in place. The early 1860s witnessed the sudden emergence of various financial intermediaries that, in subsequent years, would channel huge sums of eastern and British capital into the Sierra Nevada. These new institutions—and the new rules under which they operated—were spawned by the enormous wealth derived from Comstock Lode in neighboring Nevada. Silver not only lined the pockets of many San Franciscans, but, more importantly, necessitated legislative modifications in California banking laws. The State Constitution of 1849, drafted by men with bitter memories of the disastrous nationwide financial panic of 1837, did not sanction incorporated commercial banks. Their experience led them to believe that nothing good could come out of a state-chartered banking system with its attendant bank notes substituting for the "hard money" (gold and silver) to which they had grown accustomed. Commercial banks, however, were not really needed until the arrival of Comstock silver wealth, which virtually demanded financial institutions whose primary function was extending credit to businesses. Consequently, state laws were amended; in 1862, incorporated commercial banks came into existence. They paved the way for foreign as well as domestic investment in hydraulic mining, particularly after 1870. In the post–Civil War period, America plunged into an era whose keynotes were industrialism and expansion. And hydraulic mining was one of several industrial ventures in the West that attracted the attention of American and British capitalists.

Although the first mining ditches antedated hydraulic mining, the evolution of the ditch and flume network largely reflected the changing fortunes of the hydraulic mining industry. As the hydraulic method became widespread, ditch and flume construction accelerated to meet increased water requirements. Many water companies consequently over-built their systems. Bankruptcies were common, as were consolidations. The number of ditch systems and their total mileage fell steadily throughout the 1860s. In the 1870s, however, ditch mileage stabilized, then expanded. Even more elaborate water storage facilities and distributions systems were planned for the 1880s (appendix 8.3). But then came the injunction. The story of how it came about may be of interest in the context of public policy analysis.

The Downstream Debris Dilemma: Choosing Up Sides

Devastated by repeated mining-caused flooding throughout the 1870s and disenfranchised from property and opportunity, Sacramento Valley farmers and townsfolk in 1878 launched a legal campaign that they hoped would result in nothing less than the complete abolition of hydraulic mining. Anticipating protracted litigation, their first step was to form a strong, well-funded grassroots organization: the Anti-Debris Association of the Sacramento Valley. Its mandate was to finance and prosecute lawsuits to challenge the miners' practice of filling rivers with debris. With an elected five-man board of directors, and the ability to levy assessments on members, the Anti-Debris Association was a necessary counterweight to the formidable coalition of mining interests that had organized two year earlier.

Prompted by a lawsuit from a Bear River farmer, the Hydraulic Miners Association was born in September 1876. The five-member Board of Council, the controlling arm of the association, was comprised of men of enormous wealth and power, a veritable who's who of California's mining elite. The association's roster, some 90 strong, represented virtually every important Sierra Nevada mining and water company. So with the formation of the Anti-Debris Association, each region had a powerful partisan coalition. For the next 15 years (ten of them after hydraulic mining had been permanently enjoined) these two associations would be engaged in almost continual judicial combat.

The initial battle appeared to be a victory for the farmers. In March 1879, Judge P.W. Keyser of the District Court of Sutter County ruled that hydraulic mining companies had no prescriptive right to dump their debris into the Bear River or any of its tributary streams. ("James H. Keyes v. Little York Mining Company," 53 California 724.) This was a stunning development, a blow to the mines that was entirely unex-

pected. The valley, jubilant, celebrated for weeks. Lawyers for the Hydraulic Minters Association quickly secured a stay of proceedings, then appealed Keyser's decision to the State Supreme Court, which issued a further stay. Angry and bewildered, farmers wondered just who had actually won the suit. Those in the bottomlands of the Bear River watched forlornly as the turbid river, displaced from its bed by an inundation of mining debris, ran riot over their fields. Then hope came in the form of crossfire from the Anti-Debris Association. In September 1879 the City of Marysville filed suite against the North Bloomfield Gravel Mining Company (and other Yuba River mining concerns) in Yuba County District Court, seeking a perpetual injunction against the company's practice of dumping debris into tributaries of the Yuba River ("The City of Marysville v. North Bloomfield Gravel Mining Co. et al.," 58 California 321).

San Francisco capitalists were outraged. The Stock Report, mouthpiece of San Francisco's financial community, vehemently voiced mining's position on the matter in its editorials. So too did the respected Mining and Scientific Press, a San Francisco weekly. Whether certain mining interests pressured the State Supreme Court is open to conjecture, but in November the district Court's injunction was overturned. The Supreme Court reasoned that it was not equitable to join all the mines of one watershed together in a single suit. The valley was stunned—while the mountains, a portrait of euphoria, rejoiced for days.

The final month of the decade wound down with the farmers deeply disappointed but not ready to give up. The abolition of hydraulic mining would simply require a broader realization that California had already passed an economic crossroads. The large loss of cropland resulting from the particularly devastating floods of 1878 brought into sharper focus the fact that agriculture, dominated by dry-farmed wheat, had become California's leading industry. Areas heavily slathered by mining debris where among the richest farmlands in the state. Thousands of acres of productive orchards and grain fields had been reduced to barren wastelands. Thousands more awaited a similar fate. History is rife with examples of short-lived societies built and based on precious metal mining; impermanence is their legacy. Was California destined to follow this path?

With the 1870s came a new vision of California's future. It lay not in gold from the Sierra Nevada, but in the splendid soils of the Central Valley. Able to produce a continuous stream of wealth, agriculture stood in sharp contrast to the hit-and-run nature of mineral extraction. And during the '70s it had replaced mining, statistically, as the leading sector of the state's economy. By late in the decade the annual value of the dry-farmed wheat crop alone had reached $40 million, more than double that of the dwindling gold output. The trend was clear and irreversible: the pivot of prosperity had shifted permanently toward the fields.

The Chess Match

As the California legislature began its 1880 session, the tension between agricultural and mining interests was almost palpable. Many lawmakers were therefore startled a few months later when the two factions jointly pushed for passage of legislation to save the Sacramento Valley. After a two-year study, the California State Engineer (an office created specifically by the debris dispute) had recommended a comprehensive flood control system consisting of brush dams in the Sierra Nevada foothills and extensive levees at key locations in the valley. The legislature subsequently passed the Drainage Act, a reclamation project to be funded by statewide taxation and the charge of one half cent on each miner's inch of water (a volumetric measure specific to Sierra Nevada mining operations) used by every hydraulic mining company. A Board of Drainage Commissioners, comprised of the governor, the state engineer, and the surveyor-general, would supervise the project. Work began almost at once as levees were thrown up along the banks of the Sacramento and dams built across the Yuba and Bear rivers. Debris-restraining dams, comprised of brush, wire, and logs, spanned canyon mouths at the edge of the Sierra foothills. Levees lined the Yuba from its junction with the Feather east to the Sierra; seven more miles of levees lined the Feather below where it is joined by the Yuba. The Bear was similarly hemmed in. Farmers and miners alike thought their debris problems were over.

The ensuing winter was wicked. Beginning in January 1881, a long parade of storms marched across northern California. By early February flooding was extensive and, according to at least one source, the most devastating ever. The integrated flood control system had failed miserably. Infuriated and frustrated, farmers and townsfolk in May revived the long-dormant Marysville v. North Bloomfield suit. Hydraulic mining, it was felt, had to be abolished. There could be no compromise solution.

In late June the Superior Court of Yuba County granted an injunction. Reluctantly, hydraulic operations in the upper Yuba basin ground to a halt. A month later, in the Superior Court of Sacramento County, the State Attorney General sought an injunction against the Gold Run Ditch and Mining Company ("The People v. The Gold Run Ditch and Mining Company," 66 California 138), whose property lay high in Placer County, on the North Fork of the American River. Two months later the California Supreme Court ruled that the Drainage Act was an unconstitutional assumption by the state of a private regional concern. All of California's citizens could not be taxed, the court reasoned, so that only the Sacramento Valley might benefit.

Throughout the winter and spring of 1882, hydraulic miners anxiously awaited the Gold Run decision. It came down in June. Judge Jackson Temple ruled that the Gold Run Company had to build restraining barriers at its mine to keep coarse debris (gravel and boulders) from entering tributaries

of the American River. Once they were built, mining operations could resume.

The Anti-Debris Association, which was given new life at the time of the revived Marysville v. North Bloomfield suit, was not pleased. Judge Temple's decision, it felt, was a weak echo of the Drainage Act. Dozens of flimsy brush dams clearly were not the answer; the floods of 1881 had graphically demonstrated their limited utility. Furthermore, only one mine at a time could be enjoined in this fashion, a time-consuming and basically ineffective approach. A more sweeping injunction remained the Association's aim.

What became the decisive suit was filed in the Ninth United States Circuit Court in San Francisco in September 1882. Edwards Woodruff, a Marysville landowner, brought a suit against the North Bloomfield Gravel Mining Company and all other mines in the Yuba River watershed ("Edwards Woodruff v. the North Bloomfield Gravel Mining Company et al.," cited as 9 Sawyer 441).

Checkmate: Victory for the Valley

An air of anxiety hung over the Sierra Nevada mining communities for most of 1883. The fate of Edwards Woodruff's suit weighed heavily on the minds of many. Some miners were convinced that Judge Lorenzo Saywer, a legitimate '49er who had spent time prospecting in the Nevada City district, would come down on the side of mining interests. Others were much less confident of a favorable ruling, as anti-mining sentiments in the Sacramento Valley had never been stronger. As 1883 wore on, the farmer cause quietly gathered momentum. Some of the best hydraulic engineers left for mining ventures elsewhere around the world. Perhaps they saw the writing on the wall.

On January 6, 1884, Marysville got word that Judge Sawyer would hand down his decision the following day. Confident townsfolk prepared for a grand celebration that included an enormous bonfire. On Friday the 7th, in his San Francisco courtroom, Judge Sawyer delivered his precedent-setting perpetual injunction: The hydraulic mining companies, "their servants, agents and employees, are perpetually enjoined and restrained from discharging or dumping into the Yuba River, or any of its forks or branches...tailings, bowlders, cobble stones, gravel, sand, clay, debris or refuse matter..." When word of the decision reached the Sierra via telegraph, whole towns became immobilized with abject disbelief. The valley, though, was a scene of unabashed celebrating. The long struggle was over. The farmers had won.

Aftermath: The End of an Era

Judge Sawyer's decision dealt a death blow to the hydraulic mining industry. No longer was there any legal justification for using the rivers of the Sierra Nevada as dumping grounds for mining debris. The question was that of nuisance: damage to private property and damage to public property—in this case the navigable waterways of the state. Free and open passage on them is guaranteed by the United States Constitution. There was never any question that mining debris posed an extreme menace to navigation. Judge Saywer wrote, "So long as hydraulic mining is carried on as now pursued it will continue to be an alarming and ever-growing menace..." (9 Sawyer 441).

Hydraulic mining interests passively accepted Sawyer's judgment. No plans were made for a retrial. The largest companies were the first to concede defeat. And the mountains began to empty, not of debris but of miners themselves.

In the wake of Sawyer's decision, several other suits were filed in federal courts. Combined, they effectively shut down all remaining operations in the northern and central Sierra, except those in remote locales far from the public eye. The Mining and Scientific Press reported that by the end of 1886 hydraulic mining in the Sierra Nevada was virtually nonexistent. Once-giant mining companies were having their properties and apparatus auctioned off at sheriff's sales to pay back fines and court costs.

Although the hydraulic mining era appeared over, there remained a glimmer of hope. The U.S. Army Corps of Engineers, which conducted a year-long investigation of the California debris problem, recommended to Congress in 1891 that hydraulic operations be allowed to resume if adequate restraining works first were constructed. Two years later, Anthony Caminetti, a congressman from California's 2nd District, introduced legislation in the House of Representatives to create a federal agency for the purpose of regulating hydraulic mining in the Sacramento–San Joaquin drainage system. Congress subsequently passed the so-called Caminetti Act. Under supervision of the Army Corps of Engineers, permits were granted to applicants who had already built debris dams below their mine sites.

Although well intentioned, this last-gasp legislative attempt to resuscitate hydraulic mining came up short. Heavy snows in the early 1890s (the 1890 snowpack was the deepest on record until 1952) ruined many miles of flume and ditch, essential elements in any hydraulic enterprise. Financially strapped mining companies simply could not afford to rebuild the damaged water systems and construct restraining dams. So in spite of the Caminetti Act, there would be no hydraulic revival, no hydraulic encore. The curtain had come down for good.

Legacies: Irrigation and Power Possibilities

As early as the 1860s, irrigated agriculture was seen as the logical successor to hydraulic mining. The contemporary historian John S. Hittell predicted that many of the mining ditches and flumes would eventually be "as indispensable to the farms, orchards, and vineyards of the dry uplands as to the placer diggings." This notion was echoed years later (six months after the Sawyer decision) by a large Sacramento Valley landholder who told the Sacramento Record Union that "by

showing that waters can be conducted anywhere, hydraulic mining has unwittingly solved a most important feature in the problem of irrigation."

Beginning in 1872, the California Legislature enacted several measures in support of local irrigation development. But these ultimately proved ineffectual in helping small farmers gain access to water resources dominated by large riparian landowners. In 1887, however, passage of the Wright Irrigation Act, authored by Senator C.C. Wright of Modesto, gave farming communities the authority to purchase, build, and operate their own irrigation systems. Irrigation districts could be created whenever a county board of supervisors approved a petition either from 50 landowners or from a majority of landowners in the area. For the first time in California history, water for irrigation was recognized as a "public use."

The complex water transfer systems abandoned by bankrupt mining companies were inherently well suited for another future use: the generation of hydroelectric power. Several years before hydraulic mining was judicially restrained, Hamilton Smith, Jr., the distinguished superintendent and chief engineer of the North Bloomfield Gravel Mining Company, foresaw hydroelectric power as an alternative use for ditch water. Yet by 1890, mining authority J.B. Hobson still could wonder "to what extent these expensive systems may yet be put in the way of furnishing water for power and irrigation cannot be very readily estimated."

The two decades prior to 1890 witnessed several important developments that, collectively, made the generation and long distance transmission of electricity possible. After discovery of the dynamo, or electric generator, in 1873, the electric motor was invented. And the generator, in conjunction with the electric arc lamp (devised by Thomas Edison in 1879) allowed a single system to light an entire city. This revolution in streetlighting was widely embraced; by the mid-1880s open arc lamps on tall wooden poles were common fixtures in America's larger cities.

While Edison and others were refining the incandescent lamp in 1880, there was an important advancement in waterpower technology: the Pelton wheel, developed by Lester Pelton of Camptonville in Yuba County. Pelton's contribution consisted of placing twin buckets with split centers closely spaced around the perimeter of an impulse water wheel. This design allowed a more effective flow of water than was possible with the crude, slow, hurdy-gurdy wheel, which had single buckets around its perimeter

Pelton, a former millwright, was immediately challenged by other inventors who insisted that his idea was really theirs. But Pelton's claim was ultimately upheld, and he alone received the U.S. patent for this invention. The Pelton wheel, which saw several refinements, was the crucial first step toward making the impulse wheel an efficient prime mover. With this technological improvement, hydroelectric power generation became as economical as thermoelectric power generation. There remained a major unresolved problem, however: electricity still could not be transmitted long distances without substantial loss.

History seems to have a way of arranging for important inventions to arrive on the scene just when they are needed most. And in the early 1880s two technological advances made electrical transmission over relatively long distances a reality: the development of transformers with the capacity to handle high voltage alternating current, and vastly improved storage batteries. The age of electric power was dawning.

Early Hydroelectric Power Generation

After the electric generator and motor had been made commercially useful, engineers looked for ways in which water rather than steam could be used to drive electric generators. And as the Mining and Scientific Press noted in an October 1887 editorial, the hydroelectric power potential of California was enormous and "there is no calculating the effect it will have on the industries of the State."

Two European experiments encouraged those with an eye on tapping the hydropower potential of the Sierra Nevada. In 1886 electricity was transmitted along a 2,000-volt line from a steam-driven plant in Tivoli to Rome, a distance of 17 miles. This was the first successful transmission of alternating current. Its significance to California, where transmission was a major problem, was that power finally had been carried a substantial distance. The second historic experiment took place in Germany in 1891. Electricity generated at a water-powered plant in Lauffen was sent to the International Electric Exhibition in Frankfurt, 81 miles away. Thirty thousand volts were transmitted, far more than had ever been attempted.

California's first application for water rights specifically for generating hydroelectric power was filed in 1891. Cornishman Alfonso Tregidgo, manager of a gold quartz mine in Grass Valley, was disturbed by the high cost and inefficiency of steam power for pumping and operating mining equipment. After learning of the successful application of water power and long distance transmission at a hydroelectric plant in Italy, Tregidgo decided to build a hydro plant on the South Yuba River and supply Nevada City, Grass Valley and nearby mines with power and light.

With water rights secured, the Nevada County Electric Power Company was incorporated in 1892. A powerhouse site and rights of way for transmission lines were purchased. Water diverted from the South Yuba about three miles above the powerhouse would be carried by flume to obtain a 200-foot drop to the Pelton wheels driving the electric generators. Numerous construction problems coupled with fallout from the nationwide financial depression of 1893 delayed completion of the plant, known as the Rome Power House, until February 1896, when the system was put into operation. It is of interest historically as the first plant of what came to be the Pacific Gas and Electric Company, the major utility serving most of northern and central California.

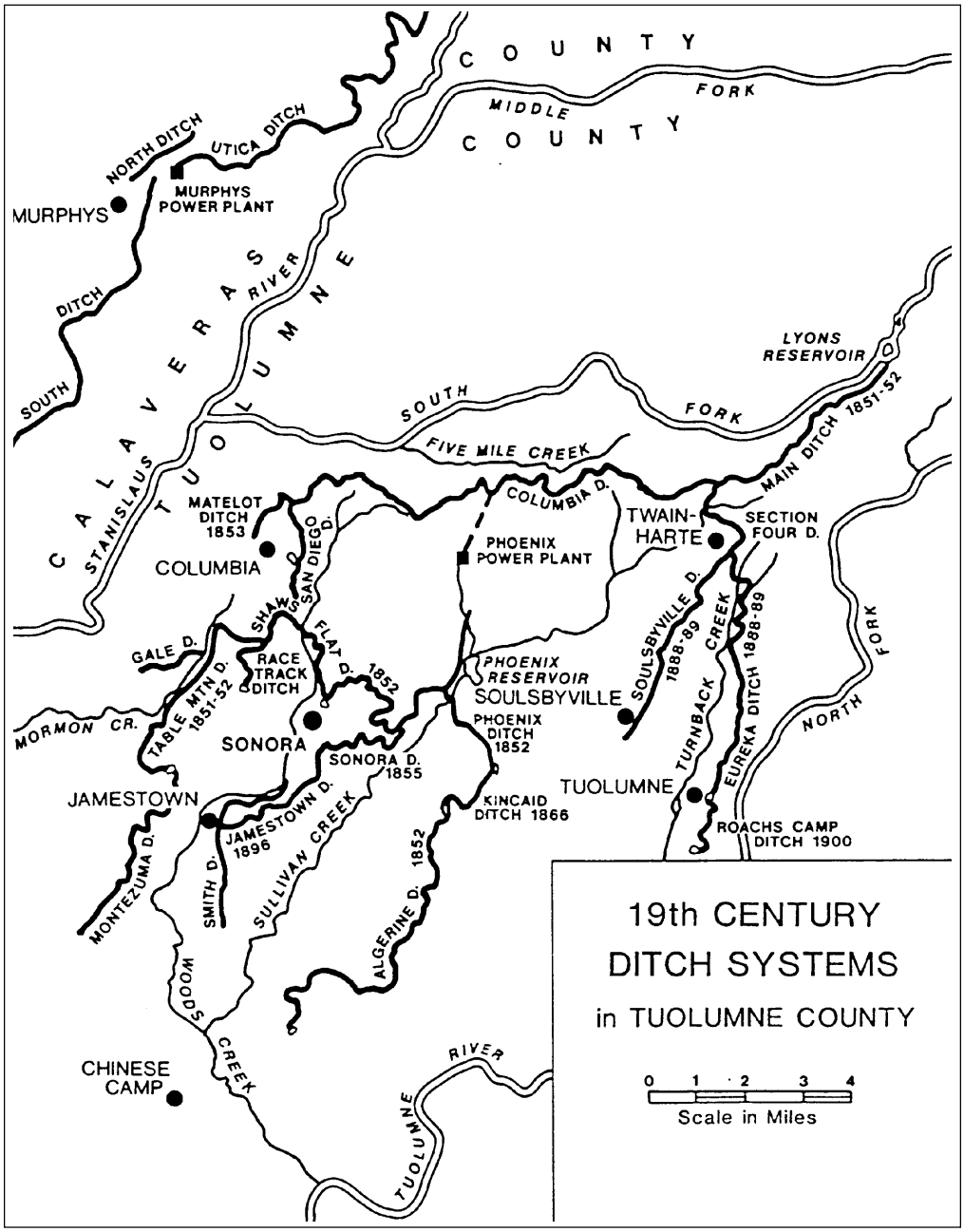
When the demand for electricity exceeded the capacity of the Rome plant, another facility, the Colgate plant, was built in 1899 on the north fork of the Yuba River. One of the most widely known plants in the history of civil engineering, the Colgate plant supplied a 60,000-volt line running out of the Sierra for 140 miles to Oakland. This was the world's first long-distance transmission line.

The unqualified success of the Nevada County hydroelectric plants spurred similar facilities throughout the Sierra Nevada. Within a few years, every major river draining the west slope of the Sierra could claim its own hydroelectric power plant. From Plumas County in the north to Fresno County in the south, the Sierra Nevada hummed from the generation of electricity by way of falling water. Most of these plants were located such that they could tap into abandoned, but still functional, ditch systems created in the heyday of hydraulic mining, or even earlier. The Phoenix Power Plant in Tuolumne County, which took water directly from the Columbia Ditch, and the Murphy's Power Plant in Calaveras County, which used the Utica Ditch, are two examples of hydroelectric plants built in the early 20th century that were essentially dependent on ditches excavated in the early years of the Gold Rush (figure 8.2).

The initial incentive to the rapid development of hydro-

FIGURE 8.2

19th-century ditch systems in Tuolumne County.



electric power in California was the high fuel costs existing around the turn of the century. Most of the electric plants in the state burned coal, which had to be imported from Australia and British Columbia. Not only was there a hefty transportation cost but an important customs duty had to be paid as well. The ability to generate electricity from falling water, clean and mechanically efficient then as now, attracted power companies, old and new, to the Sierra Nevada. The consequences for the Sierra's water resources, of course, was that an ever-increasing number of major rivers were given over to the storage of water for the purposes of hydroelectric power generation. The basins of the Yuba, Bear, American, and the eastward flowing Truckee River were especially endowed with attractive hydropower sites (figure 8.3). In most of these plants, water was used for irrigation after passing through the turbines, further underscoring the advantages of hydroelectric facilities.

Incorporated in 1905, the Pacific Gas & Electric Company was heavily capitalized by the sale of common and preferred stock. With this pool of ready capital, the utility bought most of the reservoirs, dams, ditches and flumes built by mining interests which were unable to remain commercially viable. Through its shrewd purchase of existing water storage and conveyance facilities, PG&E virtually monopolized the entire hydroelectric industry in northern California within a few years of its incorporation; however, smaller utilities such as Sierra Pacific Power Company, whose corporate roots extended all the way back to the El Dorado Canal Company, were able to maintain a niche (appendix 8.4). To this day, PG&E maintains several hundred miles of ditch and flume, whose waters turn turbines in Sierra powerhouses just as they have for nearly ninety years.

Epilogue to an Era

More than a century has passed since the roaring jets of water were turned off the high walls of the Sierra Nevada Tertiary gravels, ending an era of massive human alteration of the earth's surface. Today the cavernous hydraulic pits lie in eerie silence; their floors, studded with pines, are partially covered by rain-fed marshes. Still without a full vegetative cover, the deeply gouged walls have been further transformed by time and nature: wind and water have rounded the exposed edges, while oxidized minerals have tinted the gravels, producing multi-colored facades. The boldest landscape signature of the hydraulic mining era, these gaping red-dirt excavations endure as monuments to our unbridled assault on the earth in pursuit of precious metals.

Mining debris no longer encroaches on agricultural lands. Yet the effects of this debris and the present-day use of reservoirs, old ditch systems and other water diversions are still highly noticeable on the Sierra Nevada landscape, particularly with respect to channel morphology, channel forming processes and riparian vegetation. On steep, dry bluffs vegetation has been slow to assume control. Consequently, weathering processes have wasted these barren banks, forming graded talus slopes. Upland creeks remain laden with tailings, but larger streams now run clear as glass through rocky canyons.

All but forgotten as an economic enterprise, the hydraulic mining industry in California left valuable legacies. It hastened the development of scores of engineering techniques and innovations sophisticated beyond their time and useful beyond the realm of gold mining. Important, too, was the impetus given to the young sciences of geology and hydrology. Most useful, though, were the dozens of reservoirs and thousands of miles of ditch and flume, key components of the elaborate water storage and transfer systems ready-made to help meet northern California's needs for hydroelectric power generation, irrigation, and municipal water supply.

NEW WATER-USE PRIORITIES FOR A NEW CENTURY

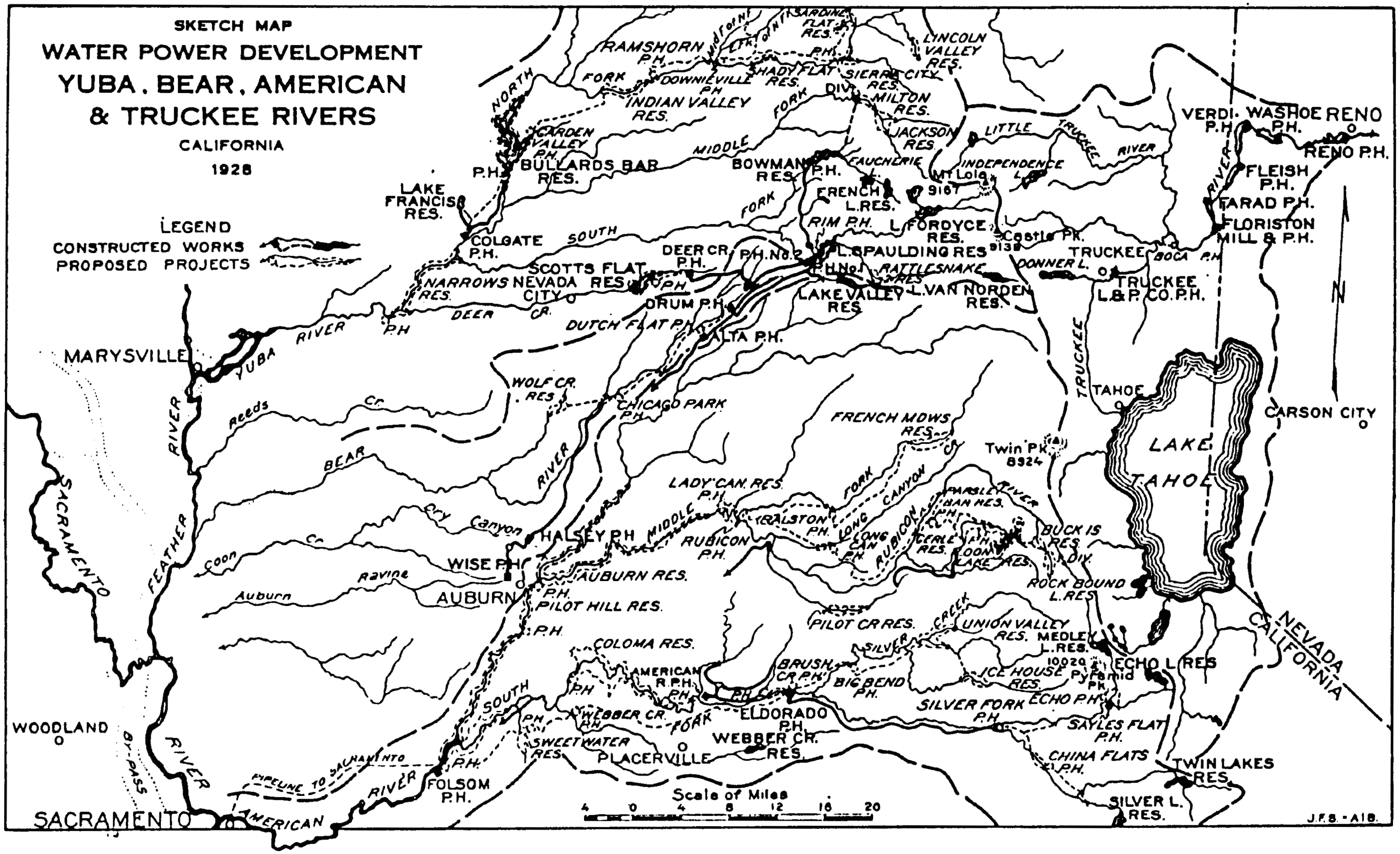
Private development distinguished 19th century water use in the Sierra Nevada. Beginning with the Gold Rush era and for nearly five decades, water developers supplied chiefly local needs, the mining companies and, later, irrigation districts being the principal users. In the early 20th century, however, the generation of hydroelectric power became the dominant private use of Sierra Nevada water, and electricity so generated for the first time was exported far beyond the mountains.

So too was Sierra water itself. Los Angeles and San Francisco, then California's two largest cities, effectively pioneered a water-based imperialism led by public—not private—entities with access to the public treasury. The success of these long-distance urban water grabs almost certainly opened the Sierra Nevada to exploitation by the enormous federal and state hydraulic projects of more recent decades. A better understanding of the 20th-century development of Sierra water resources requires a re-examination of the peculiar legal and legislative context out of which it grew.

Water Rights in Context

The first generation of miners were squatters on the Public Domain. Yet the federal government, preoccupied with the sectional strife that culminated in the Civil War, exerted no authority over the Sierra gold mining region until after the war. The first federal law that dealt with the disposition of mining property in California, enacted in 1866, simply recognized mining claims that the miners themselves had established.

Left to their own devices, the early miners devised a workable system of self-government to protect their property and mineral rights. Mining claims, which required "improvement"


SKETCH MAP
WATER POWER DEVELOPMENT
YUBA, BEAR, AMERICAN
& TRUCKEE RIVERS
CALIFORNIA
1928
LEGEND
CONSTRUCTED WORKS
PROPOSED PROJECTS
RAMSHORN P.H.
LINCOLN VALLEY RES.
DOWNIEVILLE P.H.
SHADY FLAT RES.
SIERRA CITY
MILTON RES.
INDIAN VALLEY RES.
JACKSON RES.
GARDEN VALLEY P.H.
BULLARDS BAR RES.
BOWMAN RES.
FAUCHERIE
FRENCH L. RES.
INDEPENDENCE L.
LITTLE TRUCKEE RIVER
VERDI P.H.
WASHOE P.H.
RENO
RENO P.H.
FLEISH P.H.
FARAD P.H.
FLORISTON MILL & P.H.
LAKE FRANCIS RES.
COLGATE P.H.
RIM P.H.
L. FORDYCE RES.
Castle Pk.
DEER CR. P.H.
P.H. No. 2
L. SPAULDING RES.
TRUCKEE
BOCA P.H.
DONNER L.
SCOTTS FLAT RES.
P.H. No. 1
RATTLESNAKE
NARROWS RES.
NEVADA CITY
DRUM P.H.
LAKE VALLEY RES.
L. VAN NORDEN RES.
TRUCKEE L. & P. CO. P.H.
DUTCH FLAT P.H.
ALTA P.H.
MARYSVILLE
YUBA RIVER
DEER CR.
TRUCKEE
TAHOE
WOLF CR. RES.
CHICAGO PARK P.H.
FRENCH MDWS RES.
CARSON CITY
LAKE TAHOE
Twin Pk. 8924
BEAR RIVER
Reeds Cr.
FEATHER
SACRAMENTO
LADY CAN. RES. P.H.
RALSTON P.H.
LONG CANYON
RUBICON RIVER
BUCK IS RES.
Dry Canyon
HALSEY P.H.
MIDDLE
RUBICON P.H.
WISE P.H.
AUBURN RES.
ROCK BOUND L. RES.
Coon Cr.
Ravine
Auburn
AUBURN
PILOT HILL RES.
PILOT CR. RES.
SILVER CREEK
UNION VALLEY RES.
MEDLEY L. RES.
NEVADA
CALIFORNIA
COLOMA RES.
AMERICAN R. P.H.
BRUSH CR. P.H.
BIG BEND P.H.
ICE HOUSE RES.
Pyramid Pk.
ECHO L. RES.
ECHO P.H.
SOUTH FORK
WEBBER CR.
ELDORADO P.H.
SILVER FORK P.H.
SAYLES FLAT P.H.
WOODLAND
SWEETWATER RES.
PLACERVILLE
WEBBER CR. RES.
CHINA FLATS P.H.
TWIN LAKES RES.
BY-PASS
RIVER
PIPELINE TO SACRAMENTO
AMERICAN RIVER
FOLSOM P.H.
Scale of Miles
4 0 4 8 12 16 20
SILVER L. RES.
SACRAMENTO
J.F.S.-A18.
N

as a condition of ownership, were dispensed on a first-come-first-served basis. The system that miners used to allocate, or "appropriate," water rights closely paralleled that of land use. After the intention was recorded in county offices, water could be diverted and carried long distances away from the source, used as desired, and abandoned without concern. The only stipulation was that the water be used "diligently." Water rights were forfeited with non-use. These mining customs, particularly useful in arid lands commonly without other sources of water, form the basis of the Western doctrine of prior appropriation. Miners could not have been aware of the full significance of the legal system they were creating and the degree to which it would conflict with widely accepted practices regarding the allocation of water rights.

Circumstantial as it may have been, the miners' system of water rights allocation would become embedded in the California legal system along with the older, established concepts derived from English common law—including riparian rights, which were assigned automatically with ownership of land adjacent to a stream and were not lost through non-use. When English common law was adopted by the first California Legislature at the time of statehood (1850), the riparian system was included as part of the unexamined legal baggage even though this system of water rights had not previously been used in California. The doctrine of prior appropriation, already the quasi-legal custom throughout the Sierra Nevada, had hastened the claiming of water resources and encouraged economic development. Riparian rights, recognized by the legislature in 1872, were reaffirmed primarily in the courts, particularly the landmark 1886 California Supreme Court decision in Lux v. Haggin. The legislature's response to this decision was the Wright Act of 1887: It provided the public with power to take water and land, by act of condemnation, to create community-controlled irrigation districts.

Thus California struggled along with two contradictory systems. The riparian system was never suited to California, and the appropriative system (before 1914) did not have an orderly and effective method of administration: the rights were too easily obtained and there was no centralized system of registration. Obviously needed was legislation to set up a fair and efficient system of water rights.

In 1900, a group of progressive citizens under the name of California Water and Forest Association convinced irrigation authority Elwood Mead, then chief of the U.S. Department of Agriculture's Office of Experiment Stations, to instigate an investigation of the water rights on selected California rivers. Mead's famous report, "Irrigation Investigations in California," was published in 1901. It revealed that conditions were, if anything, worse than anyone had imagined. Virtually every stream, especially those draining the Sierra's west slope, was legally choked with oversubscribed or useless water claims.

Consequently, a bill was drawn up for California's 1903 legislative session, embodying Mead's recommendations to alleviate the obvious legal problems. The bill included a general water code to systematize water procedures. But too much opposition was encountered, and the bill failed to pass. It would take another decade and much more effort before comprehensive legislation, which placed the recording and licensing power with the state rather than counties, would be passed.

In 1911, the California Legislature established the California Conservation Commission, with George Pardee, and ex-governor philosophically opposed to the monopoly of natural resources by corporations or individuals, as chairman. The Commission's purpose: to investigate and gather data on forestry, water, and use of water, water power, electricity, mines and mining, dredging, reclamation, and irrigation; and to revise, systematize, and reform the state laws concerning those subjects. Many Commission members had been active in the California Water and Forestry Association. Thus their recommendations, contained in a report submitted in 1912, echoed those proposed nine years earlier.

As an immediate consequence, a State Water Commission was established in 1912 to administer water rights for power purposes; a comprehensive Water Commission Act covering all uses of water was enacted the following year. Opponents of the Water Commission bill successfully delayed its passage by demanding a referendum on it. With public support, the act was approved at the next general election and became effective in December 1914.

The California Water Commission Act regularized appropriative procedure. Priority was given to the earliest permittee rather than the first applicant. For the first time in the state's history, it became possible to determine just how much unappropriated water remained in California. Now long-range planning of water resources, an essential prerequisite for the new water use priorities of the new century, could be pursued.

The Water Commission Act was emblematic of a new era for California's water resources: Local control, individual ingenuity, and private enterprise was giving way to centralized control, cooperative ventures, and the use of public funds and purview. How California's two largest cities went about securing water supplies for the 20th century underscored this shift. Acting independently and exclusively in their own interests, San Francisco and Los Angeles, through their massive public water projects, initiated a process that would in time fundamentally transform the Sierra Nevada waterscape and indeed that of the entire state.

Reaching Out to the Sierra Nevada: Urban Water Grabs

As the 19th century wound down, the problem of insufficient urban water supply stood as a substantial impediment to California's 20th century prosperity. America's transition from a predominantly rural to an overwhelmingly urban society occurred in California before the country as a whole. The accelerated growth of San Francisco and Los Angeles in the last

quarter of the 19th century pushed both cities up against the limits of their local water supplies. Without guarantees of additional water sources, continued prosperity would be problematic.

In 1900, San Francisco could boast of a population of 340,000, Los Angeles 100,000 and climbing rapidly; both cities had vigorous boosters, room to grow, and the transportation networks to facilitate growth; neither city, however, possessed the organizational structure required to reach far beyond city limits to tap a water source. In a departure from the national norm, California's largest cities did not control their own water franchises. Under California's riparian doctrine, water was viewed as a private resource, and private, not municipal, entities ran the water business.

Procurement and delivery of water from distant sources required substantial capital investments that private water companies were not prepared to make. Thus, municipalization of the urban water supply became the preferred solution to the "problem" created by continued urban growth: Cities were able to acquire capital through taxation and the sale of bonds. In the early 20th century, San Francisco and Los Angeles each moved to municipalize their water supplies, and each, acting independently, looked to the Sierra Nevada.

San Francisco struck first. By 1901, city leaders, moving to gain municipal control over the water franchise, commissioned an investigation of potential water projects on ten northern California rivers: the Eel, McCloud, Sacramento, Feather, Yuba, American, Consumnes, Mokelumne, Stanislaus, and Tuolumne, seven of which drain the Sierra's western slope. Reservoir sites, hydropower potential, water rights, water quality, routing considerations, and political concerns all favored a project on the Tuolumne River, but the premiere site for a reservoir in this scheme, the Hetch Hetchy Valley, lay inside Yosemite National Park.

Undeterred, San Francisco pushed for this ideal site. The city's struggle for permission from the federal government to dam Hetch Hetchy lasted a dozen years and spanned the administrations of two United states presidents and three secretaries of the Department of Interior. Advocates and adversaries were legion. Conservationists, led by Gifford Pinchot, argued that the project was an improvement upon nature: enormous water and power resources would come under municipal public control, and San Francisco would build roads and trails so visitors could enjoy easy access to the scenic splendors of Hetch Hetchy Valley. Preservationists, on the other hand, led by John Muir and the Sierra Club, took a jaundiced view of the dam, preferring to see it as the desecration of a natural temple. Additional attacks came from the Modesto and Turlock irrigation districts, which claimed prior rights to the Tuolumne. Despite resolute opposition, San Francisco ultimately won out.

In 1913, Congress passed the Raker Act authorizing construction of a dam across Hetch Hetchy Valley. To assure fiscal soundness while helping underwrite the project's considerable cost, the bill stipulated that a hydroelectric power system for municipal and commercial use be included. (Today, Hetch Hetchy electricity powers San Francisco's cable cars, electric trolleys and buses, and also lights and heats the airport and other municipal buildings). Confident that the dam was the best way to serve public needs without compromising the beauty of the public domain (Yosemite), President Woodrow Wilson, in December, signed the bill into law.

San Francisco's troubles were hardly over. Twenty more years of controversy, corruption, and escalating costs (to $100 million) plagued the project. O'Shaughnessy Dam was completed in 1922 but water from Hetch Hetchy Reservoir did not begin flowing into San Francisco until 1934. Hetch Hetchy quickly became a practical necessity for 20th century San Francisco: a dependable, if distant, source of water, power and revenue—a distinction it still holds. Subsequent expansion, including construction of New Don Pedro Dam in the Sierra foothills, has produced a water storage and conveyance system that delivers almost six times as much water as the original Hetch Hetchy project. Today San Francisco sells surplus water to suburban Bay Area communities and electricity to private utilities and Central Valley irrigation districts.

While San Francisco struggled for decades to secure and implement its Sierra-based municipal water system, Los Angeles, starting around the same time and eyeing a watershed adjoining the Tuolumne's, built a massive water project, a true engineering marvel, in one fifth of the time for only a quarter of the cost. In 1902, the city of Los Angeles, committed to the municipalization of the water franchise, purchased the water-distribution facilities of the private Los Angeles City Water Company following expiration of the company's lease. Spiraling population growth had convinced water department officials that local water supplies, once thought to be substantial, needed augmentation, especially if Los Angeles, as envisioned by boosters, was to become California's leading metropolis. Some 235 miles due north of Los Angeles, on the east side of the Sierra Nevada, the Owens River, fed by pristine snowmelt, seemed an ideal source for additional water.

To finance this ambitious project, whose centerpiece was a spectacular gravity aqueduct, Los Angeles floated two bonds, the first in 1905 for $1.5 million (covering the cost of surveying and land acquisitions), and the second in 1907 for $23 million (for construction). Between the two bond issues, which ran the city's legal indebtedness to the limit, Los Angeles sought and obtained from Congress in 1906 the required right-of-way for the aqueduct to pass over public domain land. Approval came with a stipulation: that no water from the project should ever be offered to private interests for resale outside the city limits. (Not coincidentally, between 1914 and 1923 Los Angeles nearly quadrupled in area as a result of annexations). Construction of the aqueduct began in 1908 and, astonishingly, was completed five years later. In November 1913, Owens River water, four times as much as the city of Los Angeles was capable of then using, arrived in the San Fernando Valley.

Like San Francisco's Hetch Hetchy, the Owens Valley aq-

ueduct project did not escape controversy. The focus of a long running dispute involving charges of deceit and duplicity by various public officials was the fate of the Owens Valley, whose modest farming communities were totally dependent on the local water supply. As Los Angeles grew—100,000 immigrants annually in the 1920s—so too did demand for water. The city responded by acquiring additional land and water rights in the agricultural heart of the valley, thus driving out longtime farmers and ranchers, some of whom reacted by repeatedly dynamiting the aqueduct. Eventually, Los Angeles wound up purchasing virtually all of the private land in the Owens Valley, thereby becoming the largest landowner and taxpayer of Inyo County. But it was still not finished.

Los Angeles voters, perhaps fearing the repercussions of a protracted drought on an exploding population, in 1930 approved a $40 million bond issue. With funding secured, the Los Angeles Department of Water and Power extended its eastside project 105 miles further north into the Mono Basin to tap eastward-flowing Sierran streams feeding Mono Lake. Completed in 1940, the so-called Mono extension could not be operated at full capacity: Los Angeles now held rights to far more Mono Basin water than the original aqueduct could carry. A second Owens Aqueduct, roughly paralleling the original, was begun 24 years later. By 1970 it was carrying Inyo-Mono water to Los Angeles, the two aqueducts collectively supplying 80 percent of the city's annual water requirements. The Owens Valley and Mono Basin, their water supplies controlled by an absentee metropolitan landlord, had effectively become water colonies of imperial Los Angeles, just as Hetch Hetchy Valley had for San Francisco.

Similarities abound in the way San Francisco and Los Angeles, two progressive, growing cities in the early 20th century, reached out to the Sierra Nevada for water. Both cities clearly understood that "progress" meant growth, that growth was largely dependent on the availability of abundant, inexpensive water supplies. Both cities early recognized that municipal control of water (and power) would be essential for guiding future development. And both relied on the federal government for cooperation and the public treasury for funding for their water empires.

So that no other remote, sparsely populated region would suffer as the Owens Valley had, the legislature in 1931 enacted the County of Origin Statute, which authorizes counties to recapture water later needed for their development. This policy would become embedded in the 1933 legislation that gave rise to the Central Valley Project.

Impacts on the Sierra Nevada environment traceable to the two major water transfer projects are clearly visible. In the Tuolumne River watershed, they range from clear cutting and drowning Hetch Hetchy Valley behind O'Shaughnessy Dam to the constant manipulation of the Tuolumne's flows, usually for hydroelectric considerations. Changes in the Owens Valley landscape, while more subtle, are no less apparent. Diversions into the aqueduct dried up Owens Lake, caused the valley floor to drop due to subsidence, and severely limited irrigated agriculture. Moreover, land purchased by the city of Los Angeles, amounting to several hundred thousand acres, has effectively transformed this slice of the eastern Sierra into a recreational suburb of Southern California. Mammoth Mountain, for example, is the most visited ski resort in the United States. Long is the list of impacts resulting from this land use. On the other hand, Los Angeles' ownership of the Owens Valley and interest in its groundwater has likely prevented urban development that otherwise might have occurred.

Most written accounts of the Hetch Hetchy and Owens Valley water projects tend to view them a morality plays: a pristine mountain valley (within a national park, no less!) and a promising agricultural landscape are violated by the forces of greed, fraud, deceit, and duplicity perpetrated by distant avaricious metropolises flexing their epic political muscles. Obviously, there is more to it.

Conceived during the Progressive Era, these projects, promising to deliver to their cities abundant supplies of inexpensive mountain water, were veritable paragons of progressivism. Each project required and received cooperation from the federal government, whose prevailing public policy of utilitarianism—greatest good for the greatest number over the longest time—certainly validated the water transfers. The success of Hetch Hetchy and Los Angeles' aqueduct system demonstrated the enormous benefits that could be gained through public water development. And in ways that embraced philosophy as well as engineering, created a template for the colossal federal and state water delivery systems unique to California. Their impact on the Sierra Nevada spanned nearly the length of the range.

Two Great Projects for the Great Valley

During the early 20th-century agricultural transformation of the Central Valley, the waters of the Sacramento, San Joaquin and their tributaries were used without a comprehensive plan for their conservation. Valley farmers and growers, dependent on year-to-year stream flow for irrigation, lived with the specter of drought; dry years, often in succession, were facts of life in the valley. So too was destructive flooding, commonly occurring at the close of a drought cycle. To ensure against these fluctuating extremes, farmers banded together to form irrigation districts, flood control districts, reclamation districts, and other mutual aid associations. They also came to rely on the valley's enormous groundwater resource: the alluvial sands and gravels which filled the Great Valley thousands of feet in places were permeated with moisture. But decades of pumping had lowered the water table to such depths that only the most powerful pumps could tap into it.

Then in the early 1920s, the situation got worse. Severe drought significantly reduced surface flows and excessive pumping caused an alarming drop in the groundwater table. Desperate agriculturalists sought help from the state legislature, which in 1921 had begun a comprehensive study of

California's watersheds, focusing on the flood control needs and irrigation potential of the Great Valley. This investigation, which stretched out over a decade and was ultimately titled the "State Water Plan," became the basis for the Central Valley Project (CVP), a massive water system that, by transferring water from the northern Sacramento Valley south to the San Joaquin Valley, would reshape the face and future of the Great Valley—along with that of the adjacent Sierra Nevada. Authorized as a state project in 1933, the CVP, which arrived on the scene in the depths of America's worst depression, could not find financing: No market could be found for the bonds to finance construction of the dams, canals, and associated infrastructure. Called on for a bailout, the federal government officially took over the Central Valley Project in 1935. The Bureau of Reclamation was placed in charge of construction and administration of this sprawling system.

In late 1937, the Bureau broke ground on the first unit to be completed (in 1940), the Contra Costa Canal. The next year construction of Shasta Dam, keystone of the system, began. Subsequently, the Central Valley Project effectively circled the Great Valley with a necklace of dams, large and small, wedged into the canyons of the Sierra Nevada and, to a lesser extent, the Coast Ranges. The spacious reservoirs behind Folsom Dam on the American River, New Melones on the Stanislaus, and Friant on the San Joaquin were intended to capture and hold Sierra runoff during the winter and spring for agricultural use in the long, dry summer. The dams had other effects as well: flood prevention, navigation maintenance, recreation, and, of course, hydroelectric power generation. The alteration of Sierra ecosystems caused by the construction of these large dams, though difficult to quantify, was undeniably massive. (And so too has been the impacts of reservoirs, streamflow diversions and streamflow regulations on regional landscape patterns, fisheries, wildlife, riparian vegetation, groundwater supplies, channel formation and channel maintenance.)

After numerous wartime delays, in 1951, some 14 years after construction had begun, water started flowing to the San Joaquin Valley from the Sacramento drainage. But already there was discontent. As a creature of the Bureau of Reclamation, the CVP was rooted in the government regulation known as the "160-acre limitation," which specified that no single farmer may irrigate more than 160 acres with the ultra-cheap water from a federally financed reclamation project. To receive CVP water, farmers and growers, hundreds of whom owned vast acreages, had to sign contracts which included the provision that they promise to divest themselves of "surplus lands"—those in excess of 160 acres (or various legal exceptions to this figure). For many powerful agricultural interests, especially the corporation-owned ranches, the acreage limitation was an absurdity to be challenged, fought vigorously, and, ultimately, avoided. The latter option took the form of persuading the people of California to underwrite a water plan that would not only serve agribusiness in the Central Valley but would also benefit the entire state. This movement would culminate in the world's largest water transfer system: the State Water Project.

By the middle of the 20th century most of the rivers draining the long western slope of the Sierra Nevada had been plugged by dams. Huge placid reservoirs backed them up. One large river that remained wild, due primarily to its remoteness and ferocity, was the Feather, the largest tributary of the Sacramento. Subject to devastating surges, most prominently the "Christmas floods" of 1955, the Feather carried an average annual runoff of 4.5 million acre-feet. Support for a mammoth state-controlled water system, whose centerpiece would be a giant dam on the Feather (at Oroville), gained momentum, slowly, through the 1950s. The Burns-Porter Act authorizing the project cleared the state legislature in 1959. In the general election the following year, voters narrowly approved the bond measure required to finance the State Water Plan. Voting patterns were conspicuous in their regional biases: wide-spread support for the project in Southern California, while only one northern county, Butte (site of the proposed Oroville Dam), voted in favor of the $1.75 billion bond measure.

Volumes have been written on the State Water Project, one of the most scrutinized and analyzed public projects in United states history. No insights will appear here that cannot be found in the vast literature on the subject. It is worth noting, however, that this colossal water project, so grand in scale and scope, so much a product of self-serving private interests and governmental bureaucracies, is likely the last of its kind. In the past twenty years Californians in growing numbers have risen up to stifle, scuttle, or otherwise re-evaluate water projects—proposed, planned, operating—like no time in the state's history. A new era, born of fiscal austerity and widespread public support for the maintenance of a more "natural" environment, had begun. In the Sierra Nevada, this clear shift in public opinion found expression in battles to save a free-flowing river and restore a saline lake.

The Fate of the Stanislaus and Mono Lake

There is no better illustration of the fierce clash between forces representing two eras of water policy than the protracted struggle to "save" a wild and scenic stretch of the Stanislaus River, which drains the watershed immediately north of Yosemite National Park. A dam on the Stanislaus had been a foregone conclusion to most. Approved in 1944 as part of the Central Valley Project, construction of the New Melones Dam finally got underway in the early 1970s. As the fourth highest dam in the United States, it would eventually flood 26 miles of the Stanislaus, including some of the nation's heaviest traveled white water rapids. The reservoir behind New Melones would also drown archaeological and historical sites, petroglyphs and wilderness areas. Wildlife, fisheries and water quality would be adversely impacted as well.

An initiative to halt the dam, drawn up by a consortium of environmental organizations spearheaded by the specifically

formed Friends of the River, appeared on the 1974 ballot as Proposition 17. Although the proposition lost, 53 percent to 47 percent, the battle had just begun. Moving to the courts, the Stanislaus case, through bureaucratic entanglements, ultimately pitted the state of California against the federal government (California v. United States). Meanwhile, construction of the dam continued throughout the decade as the controversy played out in more court action and finally in Congress. The House Interior Committee in September 1980 failed to endorse a bill that would have included the Stanislaus in the federal wild rivers system. Although the vote was close—the bill was defeated by two votes—the cause was all but lost. The extremely wet winters of 1982 and 1983, which flooded the Stanislaus Canyon behind New Melones, made any further protest moot.

On the other side of the Sierra Nevada, at the same latitude as New Melones Dam, a different kind of battle was being waged. Mono Lake, a starkly beautiful, 500,000 year-old roughly circular lake was the focus. Fed by creeks draining the Sierra's east slope, Mono Lake, with no natural outlet, had acquired a level of salinity that produced a unique ecosystem involving brine shrimp and flies and migratory waterfowl. Diversions of feeder streams by the city of Los Angeles, begun in 1941, had increased substantially after 1970 when the Mono extension of the city's Owens Aqueduct was completed. Larger diversions by Los Angeles accelerated the decline in the level of Mono Lake and increased the concentration of salts in the water, causing biologists to predict drastic consequences for the brine shrimp and flies as well as the resident visiting bird life.

Visible deterioration of the lake's ecosystem prompted the formation in 1978 of the Mono Lake Committee, which quite clearly had as its goal to "save" Mono Lake. With powerful economic and political forces lined up on the other side of the issue, the most formidable of which was the city of Los Angeles itself, environmentalists sprung an innovative offensive: In 1979, the National Audubon Society, Friends of the Earth, Mono Lake Committee, and others filed suit against the city of Los Angeles, claiming the Mono Basin diversions violated the doctrine of "public trust." Historically, this doctrine was associated with public access to navigable waters for commercial activity and for fishing. Now it was being invoked to protect an area that had documented scientific (ecological) and scenic value. The argument was that the state of California had an obligation to prevent Los Angeles from compromising the public's benefit and use of Mono Lake. The local superior court sided with Los Angeles but in 1983 the State Supreme Court, in the case of National Audubon Society v. Superior Court of Alpine County, ruled that no water can be taken from a stream, lake, or other natural source without assessing the impact on navigable waters. The public trust doctrine had been upheld.

Years of bitter engagements and legal maneuverings between the supporters of Mono Lake and the city of Los Angeles appears to have ended. In 1994, the State Water Resources Control Board voted to restore the level of Mono Lake to 6,392 feet, 18 feet above its level at the time of the ruling. Such an elevation, most studies have concluded, would preserve the ecological integrity of the lake. In a dramatic reversal of long standing policies and legal decisions favoring an ethic built around the notion that growth is good, that bigger is better, the Mono Lake case highlights the new era of limits and restrictions being imposed on a hydraulic society by a hydraulic society.

This new approach to water resources management presupposes that the status quo, especially in regard to climate, be maintained. No new large dams have been built in the Sierra Nevada in two decades and none, aside from Congressman John Doolittle's push to complete the mothballed Auburn Dam, are planned. But what happens if a prolonged cycle of drought returns? Not for six years, as in the late 1980s and early 1990s, but for 60 years, or 100? California has known them before. It will again.

SOURCE NOTES

Fashioning a Hydraulic Landscape

Ditches and Flumes

This truly astonishing aspect of Sierra Nevada history is surprisingly absent from the mainstream literature. Two unpublished works that give this subject its due are: Thomas H. Pagenhart, "Water Use in the Yuba and Bear River Basins, California," Ph.D. dissertation, 1969, University of California, and the author's own Master's thesis in geography, David J. Larson, "Ditch and Flume Systems of the Central Sierra Nevada: Evolution of a Water Transfer Network," University of California, 1982.

The Hydraulic Mining Era

Hydraulic mining as an enterprise and an agent of landscape transformation is covered in detail in the above two sources. See also the excellent monograph by Philip Ross May, Origins of Hydraulic Mining in California (Oakland, 1970). Another fine account of this phenomenon appears in Robert L. Kelley's Gold vs. Grain: The Hydraulic Mining Controversy in the Sacramento Valley: A Chapter in the Decline of the Concept of Laissez-faire (Glendale, 1959).

Two classic government reports detail the scope of damage to the landscape wrought by hydraulic mining: William H. Hall, Report of the State Engineer to the Legislature of California, 23 Session, 1880, Part III, The Flow of Mining Debris, (Sacramento, 1880), and Grove K. Gilbert, Hydraulic-Mining Debris in the Sierra Nevada, U.S.G.S. Professional Paper 105 (Washington, 1917).

Why California?

May and Larson, cited above, provide details on why California, more than any other 19th century locale, was the ideal stage on which the hydraulic mining drama could be played. Also, numerous issues of the Mining and Scientific Press, a San Francisco weekly newspaper, carried editorials addressing this question. Other papers consulted were the Sacramento Union, Nevada Daily Transcript (Nevada City), and the Daily Alta California (San Francisco).

The Downstream Debris Dilemma: Choosing Up Sides

The definitive account of this inter-regional conflict is Robert L. Kelley's Gold vs. Grain (1959), cited above, and his earlier "The Mining Debris Controversy in the Sacramento Valley," Pacific Historical Review, Vol 25 (1956), 331–346.

For an account of flooding and its effects, see: William T. Ellis, Memories: My Seventy-Two Years in the Romantic County of Yuba, California (Eugene, Oregon, 1939); Charles L. Brace, The New West: or, California in 1867–1868 (New York, 1869) weighs in with a first-hand view. See also Peter J. Delay, History of Yuba and Sutter Counties (Los Angeles, 1924) and Charles Nordhoff, California for Health, Pleasure and Residence (New York, 1872). Various newspapers provided material for my description of the debris dilemma, foremost among them: Mining and Scientific Press, Nevada Daily Transcript (Nevada City), Sutter Banner (Yuba City), Marysville Appeal, and two Sacramento papers, the Record-Union and the Bee.

The full text of Judge Keyser's decision in J.H. Keyes v. Little York Mining Company is reprinted in the Mining and Scientific Press, March 22, 1879. The Stock Report (San Francisco) provides acid commentary after the ruling.

The rise of a wheat culture in California is explained in detail in: Horace Davis, "Wheat in California," The Overland Monthly, Vol. 1 (November 1868); Rodman W. Paul, "The Wheat Trade Between California and the United Kingdom." Journal of American History, Vol. 45 (December 1958); Lawrence J. Jelinek, Harvest Empire, A History of California Agriculture (San Francisco, 1979), especially Chapter 5, "Bonanza Wheat Era: 1873–1902."

The Chess Match

See William H. Hall, Report of the State Engineer to the Legislature of California, 23rd Session, Part III, The Flow of Mining Debris, (Sacramento, 1880).

For background on the Drainage Act, see Statutes, Legislature of California, 23rd Session (1880).

The floods of 1881 were termed the most devastating ever by numerous valley newspapers, specifically (and predictably) the Marysville Appeal and the Bee and Union.

Checkmate: Victory for the Valley

Judge Sawyer's decision is variously cited as 9 Sawyer 441 and Federal Reporter, Vol. 18, No. 14, 1884, pp. 753–813. The full text of the judgment appears in the Mining and Scientific Press, January 19, 1884. Other San Francisco newspapers also provided detailed coverage. The celebration in the valley is chronicled by Peter Delay, The History of Yuba and Sutter Counties (1924).

Aftermath: The End of an Era

For the Army Corps of Engineers Report see Thomas L. Casey, Mining Debris, California 51 Congress, House Exec. Doc. No. 267 (Washington, 1891). See also W.W. Harts, "The Control of Hydraulic Mining in California by the Federal Government," Proceedings of the American Society of Civil Engineers, Vol. 32, No. 2 (1906).

Legacies: Irrigation and Power Possibilities

J.S. Hittell's prediction appears in J. Ross Browne, Report on the Mineral Resources of the States and Territories West of the Rocky Mountains (Washington, D.C. 1868), p. 606; Sacramento Record-Union, July 19, 1884.

The early innovations in electricity generation and water-power technology are discussed in Charles M. Coleman, P.G. and E. of California, The Centennial Story of Pacific Gas and Electric Company, 1852–1952, (New York, 1952) and Norman Smith, "The Origins of the Water Turbine," Scientific American, Vol. 242 (January 1980), especially 146–147.

Early Hydroelectric Power Generation

See two obscure but illuminating works by J.W. Johnson, a professor of mechanical engineering at the University of California, Berkeley: "Engineering Highlights of the California Mining Days," California Engineer (May 1949) and the more detailed "Early Engineering Center in California," California Historical Society Quarterly [California History] Vol 29 (September 1950), 193–209. See also C.M. Coleman, P. G. and E. of California (1952) for the role played by companies that would eventually become a part of Pacific Gas and Electric Company.

Epilogue to an Era

Observations are based on the author's own field work in the Sierra Nevada foothills.

New Water-Use Priorities for a New Century

Water Rights in Context

For an appraisal of the relationship between early gold miners and California government see Gerald Nash, State Government and Economic Development: A History of Administrative Policies in California, 1849–1933 (Berkeley, 1964), 38–41.

A summary history of appropriative rights is found in: Governor's Commission to Review California's Water Rights Law, Appropriative Water Rights in California: Background and Issues (1977), 4–5.

The hopelessly gnarled condition of water claims in turn-of-the century California is clearly presented in Elwood Mead et al, Irrigation Investigations in California, Bulletin 100, U.S.

Department of Agriculture Office of Experiment Stations (Washington D.C. 1901).

Mead's recommendations resulted in Assembly Bill 735: California Legislature. Assembly, Journal of the Assembly, 35th Session of the Legislature, Vol II (Sacramento, 1903).

For background on the California Conservation Commission, see California Legislature, California Statutes, 1911, Chapter 408 (Sacramento, 1911). The recommendation of the CCC is found in: California Conservation Commission, Report (Sacramento, 1912).

Reaching Out to the Sierra Nevada: Urban Water Grabs

For description and analysis of the Hetch Hetchy controversy, see Warren D. Hanson, San Francisco Water and Power: A History of the Municipal Water Department and Hetch Hetchy System (San Francisco, 1985); Roderick Nash, Wilderness and the American Mind, 3rd ed. (New Haven, 1982), Chapter 10. Also consulted was Kendrick Clements, "Politics and the Park: San Francisco's Fight for Hetch Hetchy, 1908–1913," Pacific Historical Review, Vol. 48 (May 1979).

The preservationist versus conservationist philosophies are eloquently presented in Michael L. Smith, Pacific Visions: California Scientists and the Environment, 1850–1915 (New Haven, 1987).

President Woodrow Wilson's views on Hetch Hetchy are found in: Congressional Record, 63 Cong. 2d Session (December 19, 1913), 1189.

An excellent overview of the entire Hetch Hetchy story is found in the William L. Kahrl (ed), The California Water Atlas (Sacramento, 1978).

The story of how the City of Los Angeles secured water rights in the Owens Valley and then engineered a transport system for that water has been the subject of many articles and several books, the latter being best represented by: William L. Kahrl, Water and Power, The Conflict over Los Angeles' Water Supply in the Owens Valley (Berkeley, 1982) and Abraham Hoffman, Vision or Villainy, Origins of the Owens Valley–Los Angeles Water Controversy (College Station, Texas, 1981). See also The California Water Atlas (cited above) for a fine overview of this classic case of abuses of power in the public interest. A popular history of this controversy is contained in Remi Nadeau, The Water Seekers (New York, 1950).

The County of Origin law (for watershed protection) is dealt with in California Statutes, Chapter 286 (1927). For a vivid description and analysis see Norris Hundley, Jr. The Great Thirst, Californians and Water, 1770s–1990s (Berkeley, 1992).

Two Projects for One (Great) Valley

An enormous volume of material has been written concerning every aspect of the Central Valley Project and the subsequent State Water Project, including numerous books devoted to either or both of these water projects. Without doubt the best source for an overview of the two projects as well as for the myriad details associated with them in Norris Hundley's The Great Thirst, Californians and Water, 1770s–1990s, a work of magisterial proportion. Everything else pales by comparison. But see also The California Water Atlas (1978) for its superb graphics on water storage and transfer data and associated water statistics. An earlier account of water development in California, colorfully written, is Erwin Cooper, Aqueduct Empire (Glendale, 1968). Also worth looking at for perspective and a "big picture" approach is Marc Reisner, Cadillac Desert, The American West and Its Disappearing Water (New York, 1986; 1993).

The Fate of the Stanislaus and Mono Lake

For the Stanislaus River New Melones dam controversy see: Tim Palmer, Stanislaus: The Struggle for a River (Berkeley, 1982) and the same author's Endangered Rivers and the Conservation Movement (Berkeley, 1986). The definitive analysis of the legal history of this river battle is W. Turrentine Jackson and Stephen D. Mikesell, The Stanislaus River Drainage Basin and the New Melones Dam (Davis, June 1979). See also Samuel P. Hays, Beauty, Health, Permanence: Environmental Politics in the United States, 1955–1985 (New York, 1987).

The pertinent governmental and legal documents are: California Water Resources Control Board, Decision 1422 (Sacramento: April 4, 1973); California v. United States, 438 U.S. 645 (1978); United States v. California Water Resources Control Board, 694 F. 2nd 1171 (1982); California Department of Water Resources, "Management of the California State Water Project," Bulletin 132–83 (Sacramento, November 1983) 155–156.

The Mono Lake story is told in Ron Bass, "The Troubled Waters of Mono Lake," California Journal, Vol. 9 (October 1979), 349–350; Daniel Chasan, "Mono Lake v. Los Angeles: Tug-of-War for Precious Water," Smithsonian, Vol. 11 (February 1981), 42–50; National Research Council, Mono Lake Basin Ecosystem: Effects of a Changing Lake Level (Washington, 1987); The California Water Atlas (1978); William Kahrl, Water and Power.

The legal scholarship on the Mono Lake case is best embodied in two works by Harrison C. Dunning: "The Significance of California's Public Trust Easement for California's Water Rights Law," U.C. Davis Law Review, Vol. 14 (Winter 1980), 357–398, and "A New Front in the Water Wars: Introducing the 'Public Trust' Factor," California Journal, Vol. 14 (May 1983); See also National Audubon Society v. Superior Court of Alpine County, 33 Cal. 3rd 419 (1983); denied 464 U.S. 977 (1983).

The question of whether California will experience another prolonged drought is addressed in Scott Stine, "Extreme and Persistent Drought in California and Patagonia During Mediaeval Time," Nature (16 June 1994).

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APPENDIX 8.1

Benchmark Events Impacting the Sierra Nevada Waterscape

19th Century

1848 Discovery of gold at Sutter's Mill near South Fork of the American River.

1849 Gold Rush begins in earnest. California Constitutional Convention meets at Monterey; adopts Common Law of England with its riparian rights provisions.

1853 First documented use of hydraulic mining--the application of water under pressure, through a nozzle against a natural bank--in Nevada County.

1877 Beginning of *Lux v. Haggin* suit, a legal test of riparian versus appropriative water rights.

1878 Legislature names William Hammond Hall first "State Engineer."

1884 Sawyer Decision: Judge Lorenzo Sawyer issues perpetual injunction against hydraulic mining in the Sierra Nevada.

1886 California Supreme Court rules in favor of riparian rights in *Lux v. Haggin* decision.

1887 Legislature passes Wright Act, laying the basis for irrigation districts.

1896 Rome Power House, using water diverted from the South Yuba, is first hydroelectric plant of what came to be the Pacific Gas and Electric Company.

1897 Wright Act revised and strengthened.

1899 Colgate power plant on north fork of Yuba River supplies electricity for Oakland via the world's first long-distance transmission line.

20th Century

1912 State Water Commission established to administer water rights for power purposes.

1913 The Raker Act authorizes the damming of Hetch Hetchy Valley, allowing the City of San Francisco to invade Yosemite National Park for municipal water and power.

Owens Valley Aqueduct, carrying eastern Sierra water to southern California, is completed.

1914 California Water Commission Act regularizes appropriative procedure.

1920 Federal Power Act paves the way for a vast number of small-scale hydroelectric dams to be built in Sierra national forests.

1922 O'Shaughnessy Dam is completed in Hetch Hetchy Valley, Yosemite.

1929 EBMUD completed Mokelumne Aqueduct from the Sierra Nevada to the East Bay.

1933 Central Valley Project approved by California Legislature and, after a referendum campaign, by California voters.

1935 Bureau of Reclamation takes over construction and administration of Central Valley Project.

1941 Owens Valley Aqueduct is extended north into the Mono Basin.

1945 State Water Resources Control Board created by Legislature.

1951 Central Valley Project becomes operational as water flows through the Delta-Mendota and Friant-Kern canals.

1957 League to Save Lake Tahoe is organized.

1959 State Water Resources Development Bond Act, known as the Burns-Porter Act, passes the Legislature; ratified by voters in 1960 General Election. These actions authorize State Water Project.

1962 Commercial whitewater rafting begins on the Stanislaus River.

1964 Wilderness Act passed by Congress; includes portions of the Sierra high country.

1968 Wild and Scenic Rivers Act (Federal). The Feather River is designated a wild and scenic river.

1969 National Environmental Policy Act (NEPA). A major element of this legislation is the requirement that an Environmental Impact Statement be prepared for any federal action having a "significant effect on the environment." This deals a serious blow to the dam builders.

1970 Completion of Owens Valley Aqueduct extension into Mono Basin; The Tahoe Regional Planning Agency is organized.

1972 Wild and Scenic Rivers Act (State); includes portions of the American River along with major north coast rivers.

1973 Friends of the River is organized; a statewide initiative against New Melones Dam on the Stanislaus loses; NMD floods canyon in 1982.

1975 Construction halted on Auburn Dam on American River.

1978 North Fork of the American added to the federal wild and scenic rivers system.

1980 The lower American River is added to the federal wild and scenic rivers system.

1983 The California Supreme Court rules on the Public Trust Doctrine in favor of Mono Lake.

1984 Mono Lake Scenic Area is designated; Tuolumne River is added to federally protected rivers system.

1987 Kings, Merced, and North and South Forks of the Kern are added to the national wild and scenic rivers system.

1994 State Water Resources Control Board votes to restore the level of Mono Lake to 6,392 feet, 18 feet above its current level.

APPENDIX 8.2

Estimates of Mining Debris Deposited, 1849–1909

	Million Cubic Yards
From Hydraulic Mining in the Basin of the:	
Upper Feather River	100
Yuba River	684
Bear River	254
American River	257
Streams tributary to lateral basins of the Sacramento River	30
Mokelumne River to Tuolumne River, inclusive	230
From Ordinary Placer Mining	60
From Quartz Mining (one-fourth in the Sacramento Basin)	50
From Drift Mining (three-fourths in the Sacramento basin)	30
Total Mining Debris:	
From Hydraulic Mining	1,555
From all Mining Tributary to the Sacramento River	1,390
From all Mining Tributary to Suisun Bay	1,665

Source: G.K. Gilbert, Hydraulic Mining Debris in the Sierra Nevada. U.S.G.S. Professional Paper 105 (Washington D.C., 1917), p. 43.

APPENDIX 8.3

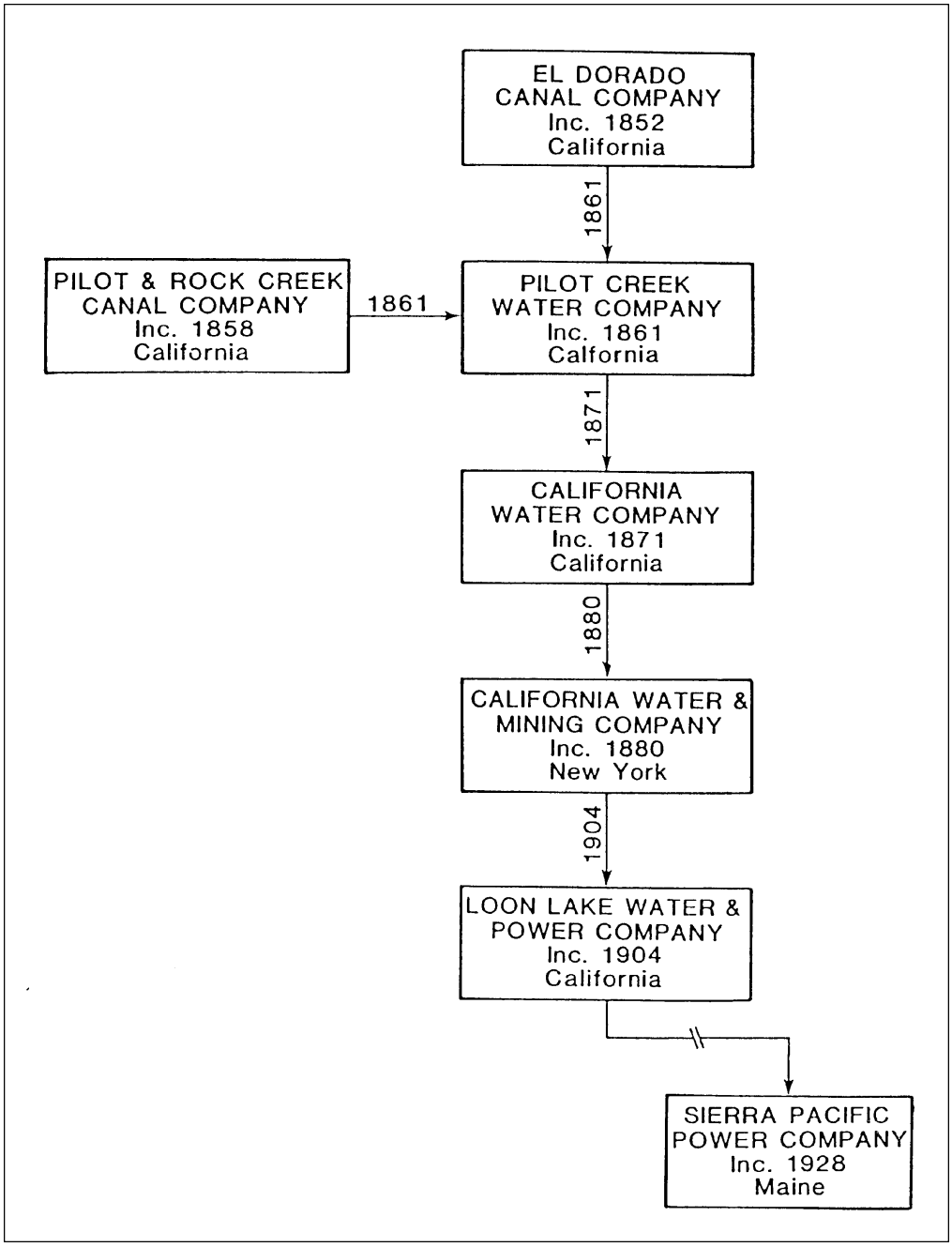
Water Storage Capacities of Water and Mining Companies in the Northern Sierra Nevada

COMPANY	STORAGE CAPACITY (Millions of cubic feet)
South Yuba Canal Company	1,800
Eureka Lake & Yuba Canal Company	1,130
El Dorado Canal Company	1,070
North Bloomfield Gravel Mining Company	1,050
Milton Mining and Water Company	650
California Water Company	600
Omega and Blue Point Company	300
Spring Valley Mining Company	300
Other small reservoirs in the watersheds of the Feather, Yuba, Bear, and American Rivers	700

Source: George H. Mendell, Report Upon a Project to Protect the Navigable Waters of California From the Effects of Hydraulic Mining Debris (Washington, 1882), p. 13.

APPENDIX 8.4

Sequence of Ownership: El Dorado Canal Company



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