WATER CONVEYANCE SYSTEMS IN CALIFORNIA

Historic Context Development and Evaluation Procedures

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JRP's excellent work constitutes the body of this report, with subsequent work by Caltrans staff to meet additional needs not foreseen in the original contract. Caltrans Cultural Studies Office staff Thad Van Bueren, Dorene Clement, Greg King, Gloria Scott, and Laurie Welch contributed to the revisions and preparation of supplementary material, while Kendall Schinke assisted with graphics production. Throughout the process, Meta Bunse and other staff at JRP Historical Consulting Services cooperated in the revisions and rendered invaluable assistance, particularly with regard to the conversion of electronic files.

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Any questions or comments on the study should be directed to the Chief, Cultural Studies Office, Caltrans Environmental Program, MS 27, P.O. Box 942874, Sacramento, CA 94274-0001.

Cover Photograph: Folsom Dam (courtesy of the California Room, California State Library)

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INTRODUCTION

This study began as an attempt to develop a statewide thematic approach to surveying the ditches and canals which are a commonly encountered, but previously little studied, property type in California. In the past, canals were not always recognized as a type of cultural resource that might need study, and furthermore, although highways and other transportation facilities often intersect artificial waterways, projects that merely cross linear resources typically have little potential to affect them. As a result, structures such as canals, railroads, or roads that were bridged by a transportation project were rarely included in cultural resource studies.

Now there is increased awareness that canals and other water conveyance facilities can be historically significant, and that when projects do have the potential to affect them, they need to be studied systematically. However, important water conveyance systems are frequently extensive and sometimes quite complex, while transportation project effects on them are typically limited to a small segment of the entire property. Under these circumstances, developing a basic historical context would allow researchers to work from a baseline of existing knowledge, thus helping to achieve a suitable balance between the need for adequate information and expenditure of a reasonable level of effort.

Because of California's unique combination of natural resources, climate, topography, history, and development patterns, the state has a variety and number of water conveyance systems possessed by few if any other states. Consequently, little guidance has been developed at a national or regional level, leaving California to develop its own statewide historic context and methodology. Sufficient research has now been conducted on California's water conveyance systems to provide this historic context and survey methodology for the appropriate consideration of water conveyance systems, especially the frequently encountered canals and ditches, in order to take into account the effect of transportation projects on historic water conveyance facilities.

It must be recognized that not all water conveyance properties encountered in the course of a project require study. No studies are needed when it can be reasonably concluded that an affected water conveyance facility lacks any potential for significance or when the project has no potential for effect on the property.

When there is potential for an effect on a water conveyance facility requiring study, the property should be incorporated within a project's Area of Potential Effect (APE). Undertakings that could have effects might include proposals that would modify a critical element of a significant system, concrete line or pipe an important earthen ditch, introduce visual intrusions that alter a canal's historic setting, reroute a critical component of an early system, obliterate a small mining ditch, or cause other changes to an important property's essential physical features. On the other hand, improving or replacing an existing bridge over a canal, including minor modifications in the vicinity of bridge footings, would have little potential to alter important characteristics of most water conveyance systems. In such circumstances, the project's APE would normally exclude the canal, and no studies would be needed.

Some level of research may be necessary to identify the possibility of historical associations and to reach a conclusion as to whether an evaluative study would be warranted, but certain types of water conveyance facilities are generally more likely than others to require study. Likely properties include any prehistoric or mission-era irrigation systems; gold rush-era mining ditches; early or major irrigation, reclamation, or hydroelectric systems; major multi-purpose systems; flumes, tunnels, or ditches that may possess engineering, construction, or design distinction; properties associated with important events, such as critical or precedent-setting litigation; and any early or prototype facilities. Other properties have minimal potential for significance and rarely require evaluative studies, although recordation and mapping during an archeological survey may be appropriate. Among properties normally unlikely to require further consideration are roadside drainage ditches; municipal water, sewer, and storm drain systems; most ordinary irrigation ditches; modified natural waterways; modern pipelines; isolated or unidentified ditch segments; and canals less than 50 years old.

Professional judgment should always be exercised before undertaking studies of most canals and ditches, particularly ordinary irrigation facilities that are ubiquitous in many regions and could easily generate a great number of unnecessary studies. In many cases, survey mapping and limited research to verify absence of any important associations will be all that is needed. Exceptions are possible, however, and careful consideration is needed to ensure that the level of effort is adequate and appropriate but not excessive.

When studies are called for, Caltrans cultural resources staff and consultants are encouraged to use the following historic context and survey methodology to help identify and evaluate water conveyance systems in an efficient, systematic manner. Consideration of such resources is part of the agency's general responsibilities to take into account the effects of transportation projects on properties that are eligible for listing in the National Register of Historic Places, responsibilities that derive from Section 106 of the National Historic Preservation Act and its implementing regulations, 36 CFR Part 800. Caltrans also has responsibilities for cultural resources under various provisions of state law, including the California Environmental Quality Act and Public Resources Code 5024 *et seq.*

This report offers a thematic approach to the identification and evaluation of the major types of water conveyance systems found in California. The term "water conveyance system" underscores two concepts that are central to this approach. First, structures designed to move water from one place to another are frequently part of a larger system and can be evaluated only by consideration of the entire system. Second, such systems delivered water that facilitated other activities, and thus their importance must be understood in relation to broader developments and the challenges that California's varied landscapes posed. Individual historic contexts are presented for the state's most common types of systems, those that conveyed water for irrigation, mining, hydroelectric power production, communities, reclamation, and large multi-purpose systems. Examples of each type of system are described in detail, but it should be noted that systems discussed in the text are selected examples, not a comprehensive survey or an identification of the most significant resources.

While this study focuses on ditches, canals, and similar features commonly intersected by transportation facilities, water conveyance systems can encompass a great range of other resources that may be worthy of consideration on a survey. It is hoped that the research and approaches developed here will also be useful for studies of other water-related resource types. For example, the scope of this study is limited to systems designed for the conveyance of water rather than for the movement of goods or people. However, the same or similar systems may have been used for other purposes, such as to transport logs or other materials. Existing water systems may also be used for related purposes, such as by ground water recharge facilities or by water treatment plants. While the current study does not extend to alternative uses of water systems, many of the survey considerations identified here will be similar for such properties.

During the preparation of this guidance, existing information and approaches to the subject were first reviewed, identifying both problems and general trends in the way information about water conveyance systems is presently gathered. Although a wide array of public agencies and private individuals generate records and documents pertaining to the identification, evaluation, and treatment of water conveyance systems, the absence of a centralized filing system and variable quality of available information continues to hamper comparative research. The dispersion of records is an issue that may eventually be surmounted by more consistent data sharing with the statewide inventory system managed by the California Office of Historic Preservation (OHP). At present, research at multiple repositories will continue to be a necessity. Some of the most important sources of inventory records are briefly discussed below. The variable quality of information may be addressed with more consistent and broadly scoped thematic approaches to evaluation, such as the one developed in this document.

OHP and affiliated regional Information Centers of the California Historical Resources Information System (ICs) can be important sources of inventory records and survey reports concerning water conveyance systems. While OHP and ICs each receive unique documentation, regular data exchanges are gradually creating duplicate libraries that will eventually result in improved access to information. Significant backlogs of unprocessed records and the fact that not all records reach the OHP inventory mean that research at other archives will remain necessary in the short term.

As part of this project, JRP Historical Consulting Services (JRP) inspected documentation at a number of locations to assess general trends in previous research about water delivery systems and to identify useful survey strategies. The sampled repositories included OHP, Caltrans headquarters and district offices, two of the 11 regional ICs (Northeastern and Eastern), five of the 17 National Forests located in California, the U.S. Bureau of Reclamation office in Sacramento, two of 15 Resource Area offices of the U. S. Bureau of Land Management (Redding and Folsom), and several private companies, including the Pacific Gas & Electric Company. Of 384 water delivery systems identified during that research, 64 were listed or had been determined eligible for the National Register, 62 appeared eligible or might become eligible, 162 were determined ineligible, and the remainder were not formally evaluated.

The records sampled indicate that water delivery systems have been most commonly found significant under National Register criteria A and C, with periods of significance spanning all eras of the state's history. No prehistoric water delivery systems had been evaluated to date. Themes identified with the 288 evaluated properties include irrigation (130 properties), hydroelectricity (43 properties), mining (30 properties), reclamation and drainage (nine properties), municipal and multi-purpose systems (seven properties), domestic water supply (one property), and systems associated with more than one use over time (13 properties). The functions of the remaining 55 properties are not specified in the electronic database.

The foregoing figures provide a reasonably comprehensive list of water delivery systems evaluated through mid-1995, but do not accurately reflect the total number of water delivery systems that have been identified. An electronic search of the OHP Archaeological Database in December 1995 revealed 1,132 recorded water delivery systems in that repository alone, of which only a fraction have been evaluated. Taking into account the data entry backlog at the ICs and records not yet submitted for inclusion to the statewide inventory, the total number of recorded water delivery system features in the state likely exceeds 1,500 properties. Those properties have been recorded on a wide variety of inventory forms, and in some cases, in a narrative format. Appendix A contains a comprehensive list of water conveyance systems identified in OHP's database as of July 21, 1997.

Survey approaches and recordation strategies have varied from evaluations of entire water conveyance systems to piecemeal identification of segments of such properties. This approach has created confusion and problems of correlation for evaluators. In some cases, several resource numbers have been assigned to a single water system. Both the Office of Historic Preservation's DPR 523 series of forms and the Stanislaus National Forest's recordation approach were developed to address the problem. Those strategies each involve the use of a "parent" record and master map for the resource as a whole and detailed records for specific segments. Nevertheless, duplicate numbering will likely continue because poorly documented or adjacent systems cannot always be identified without complete field inspection to verify alignments and relationships.

In the absence of a statewide historic context for water conveyance systems, previous evaluations also have covered some of the same ground each time the eligibility of a new water delivery system was considered. The context contained in this study was developed in part to address that problem by offering a comprehensive analytical framework that will permit more streamlined reporting and consistent approaches to recordation and evaluation.

HISTORICAL OVERVIEW

Water—too much, too little, in the wrong place, or at the wrong time—has shaped much of California's history. Rain falls unevenly and seasonally over the length of the state, and all too often California faces prolonged drought or flood cycles. The state has a generally Mediterranean climate, with little rain falling through the summer months. Although the amount of available water varies enormously from northern redwood regions of heavy rainfall to dry southern deserts, California as a whole is considered semi-arid, and much of the state relies on winter snow in the mountains to provide spring and summer runoff to water the valleys below.[1]

The effects of the erratic water distribution are magnified by the eccentric placement of population centers. Traditionally, civilizations develop their cities and towns from agricultural beginnings located adjacent to water sources, but California developed abruptly with the gold rush. The newcomers were miners, merchants, and adventurers, rather than farmers. Instead of following a gradual growth pattern along waterways based on traditional practices of agriculture, California became suddenly urban, with cities preceding farms.

In the gold rush and the years following, Californians rarely let planning for long-term water needs interfere with current enterprises, and many decisions were made without regard for an adequate supply of water. People set up business in locations that suited them in other ways. They built cities along the coast where shipping and commercial advantages outweighed the shortage of municipal water supplies; extracted gold from dry diggings using water carried in miles of mining ditches; planted crops requiring irrigation in fertile but arid valleys; and brought in the water to make desert housing developments bloom, at least until the lots were sold.

Shortage of water was one issue; excess was another. In Northern California, storm-fed rivers periodically rampaged down narrow gorges and spread floodwaters across coastal plains and inland valleys. Much of the interior Central Valley was a great seasonal wetland, receiving the bulk of the Sierra snowmelt and only partially draining the surplus water through the Sacramento-San Joaquin River Delta. Californians attacked these circumstances with typical vigor, by rearranging the landscape and redirecting the natural flow of water. Cities that were found to have been built on floodplains erected levees for flood protection. When its levees failed in the early years, Sacramento went even further by jacking up downtown buildings and raising the ground level of the business district to escape recurring floodwaters. Low-lying areas subject to seasonal inundation were drained by speculators and cattlemen who then claimed ownership of vast tracts of land through reclamation of “swamp and overflowed lands.” Later, large multi-purpose dams were built on major rivers to provide flood protection, as well as municipal and agricultural water supplies, hydroelectric power, or recreation.

Relocation of water for these varied purposes did not take place without controversy. In fact, conflict over water rights is a major theme of California’s history. This conflict was originally rooted in the existence of two mutually exclusive traditions for ownership of water, riparian rights versus prior appropriation, and perpetuated by the ongoing rivalry between Northern California, source of much of the state’s water, and Southern California, populous and thirsty.

The doctrine of riparian rights came to California with the English common law tradition. It gives landowners bordering waterways the exclusive and nontransferable rights to that water. In lands of abundant water, where rivers are seen as necessary for drainage, to remove water rather than deliver it, this doctrine works well. In drier lands, prior appropriation is the dominant doctrine. Coming from Spanish law, it allows the first users of the water to divert it from streams, a principle which is essential for communal uses of water such as for mining or irrigation. Under extreme political pressure, the California Legislature passed contradictory water rights laws which were upheld by the State Supreme Court and later confirmed by congressional action, creating a dual water rights system which has endured.[2] The lack of a single, clearcut system created endless scope for legal and political battles.

Rivalry between Northern and Southern California is only partly a competition between San Francisco and Los Angeles for urban dominance, and it does not rest solely on water issues, but it has been exacerbated by the discontiguity between southern population centers and northern water supplies. Southern Californians want to divert more northern water, now “wasted” in rivers that flow out to sea, to their thirsty cities, while northerners fear that insatiable southern needs will drain them of their own rights to those rivers. Periodically, the issue of splitting California into two states is raised, generally by northern politicians aware of their constituents’ distrust of the powerful south’s growing water needs. Political battles such as the bitter fight over the proposed Peripheral Canal seem inevitable as long as this disparity of supply and need remains.

Water development has shaped both land use and the landscape itself in California. Urban, residential, industrial, and agricultural land uses have been established in regions that lack adequate natural water supplies, in some cases at the cost of a corresponding drain on other well-watered but less populous or less politically powerful areas. Reshaping the land and relocating water has also caused widespread destruction of native vegetation and of fish and wildlife habitat. For example, over 90 percent of the Central Valley's once-vast wetlands have been destroyed at great cost to fish and bird populations, dams flood riparian habitat and impede salmon and steelhead spawning runs, and canals block wildlife migration routes. Few of these far-reaching political, social, and environmental consequences were foreseen when Californians began to move water from one place to another.

The development of water conveyance systems has been part of California's history beginning with the emergence of late prehistoric Native American agriculture. The spread of incipient agriculture in the southern and eastern portions of the state during the late prehistoric period led to important changes in some of the state's hunting and gathering societies. This process culminated in the development of the modern California landscape and communities. The history of water uses and ownership in the Owens Valley offers a prime example of the development and technological control of water resources.

During the late prehistoric period the Paiute began to divert water from streams such as Bishop Creek in order to promote the cultivation of various root and seed crops on adjacent alluvial fans. By the time non-Indian settlers arrived in the area, the Paiute had developed large-scale agriculture using diversion structures of brush, boulders, sticks, and mud and ditches up to several miles in length. Farmers later diverted water from the same creeks, adding control gates and other features to their hand-dug ditches to permit more careful allocation of the water. Such early pioneer water systems diverted limited quantities of water and required only a modest amount of work and limited knowledge of the science of hydrology. Surviving water supply systems from both periods can still evoke a strong feeling of time and place in such rural areas.

Following the west side of the Owens Valley and continuing for several hundred miles south, the Los Angeles Aqueduct provides strong contrast to the Paiute and pioneer irrigators' ditches. This municipal water conveyance system is a monument to modern technology. Its hard, clean, uniform geometry and complex system of canals, siphons, tunnels, gates, and other water control structures is clearly the work of engineers rather than pioneer farmers. The largest system of its kind in the western United States at the time it was completed in 1913, the Los Angeles Aqueduct came to symbolize the struggle for control of water in the arid West. As such, it also evokes a strong feeling of time and place.

From the simple structures created by Native Americans and early historic irrigators and miners, to the enormous edifices constructed by irrigation districts, hydroelectric engineers, and the US Bureau of Reclamation (USBR), water conveyance systems in California have grown from simple vernacular creations to elaborately engineered structures. Prior to 1860, few water conveyance systems in the state were designed by trained professionals and most were constructed to control modest quantities of water. As time passed and demands grew, older systems were often abandoned in favor of larger, more sophisticated structures designed by engineers. In the development of the civil engineering profession in California, hydraulic engineering for mining, hydroelectric power, and irrigation drew some of the state's most famous water engineers—William Hammond Hall, C. E. Grunsky, B. A. Echeverry, Walter Huber, J. B. Lippincott, John Eastwood, J. D. Schuyler, John R. Freeman, William Mulholland, M. M. O'Shaughnessy, Marsden Manson, and many others.

Canals are the dominant features of most water conveyance systems. These narrow linear structures can appear deceptively simple if observed in isolation, but they are only the most visible part of complex water systems. The complete layout of a water conveyance system may include diversion works, grade, alignment, cross-section, various types of conduits, and control structures joined in a complicated piece of engineering. Such systems must be seen as a whole to understand and appreciate the skills involved in their design and construction.

The generally accepted principles of hydraulic engineering, construction materials, and equipment used to build canals have all changed over time. Understanding the changing concepts of water conveyance system construction and the different materials and modes of construction, from vernacular to modern, can reveal the potential significance of different systems for their engineering qualities or the information they may reveal. Learning why the systems were constructed, public attitudes of the period toward the use and redirection of natural resources, and the events, people, and politics associated with their construction and operation can reveal the significance of these systems in California's history.

IRRIGATION

Native American Irrigation

For an unknown period before California was colonized by European settlers, some native tribes in the southern part of the state augmented their subsistence with agriculture. In certain cases, that practice included the irrigation of crops. By the time Europeans arrived, a few tribes had developed fairly extensive irrigation systems, which were duly noted in a variety of historical accounts.[3] Any surviving irrigation systems, as well as other evidence of native agricultural practices, are likely to have considerable historical significance for several reasons. First, as rare examples of the acquisition of new vernacular competencies, such systems may evoke a strong appreciation for the significance of prehistoric agriculture and irrigation. Equally important, the study of prehistoric water conveyance systems may address a variety of important questions regarding the design and antiquity of such structures, and when coupled with broader investigations of the cultures that built them, such studies may lead to better understandings of the origins and transformative role of agriculture and irrigation among hunting and gathering societies.

The near absence of prehistoric agriculture among California tribes has long puzzled scholars because crop irrigation was well established in the neighboring Southwest for nearly two millennia. Cultigens were first introduced in the Southwest about 2000 BC, with substantial irrigation adopted at places like Snaketown, a large Hohokam community on the Gila River Indian Reservation south of Phoenix, Arizona, as early as 300 BC.[4] A number of theories have been developed to explain why agriculture and irrigation took so long to spread and reached so few of California's prehistoric tribes. Those explanations include cultural factors such as seasonal population movements, the adequacy of gathered staples such as acorns, and environmental considerations such as the absence of adequate precipitation to grow cultigens.[5] Investigations of prehistoric irrigation systems in California may contribute to the explanation of such issues. While agricultural practices contributed to the subsistence regimes of several southern California tribes in the late prehistoric period, only a few of those groups are known to have used irrigation (Figure 1). Floodplain farming, supplemented by hand watering, was more common than irrigation with ditches. For example, the Mohave, Quechan, and Halchidoma grew corn, beans, and pumpkins in silts deposited by the flooding Colorado River. Other southern California tribes also may have planted in areas subject to seasonal flooding or springs during the prehistoric period, although the antiquity of such practices is less certain.[6]

Irrigation was practiced by at least two California tribes in the late prehistoric period. Both the Owens Valley Paiute and the Palm Springs band of Cahuilla diverted water from streams or springs. Other groups including some bands of Southern Paiute and various coastal southern California tribes also adopted crop irrigation, although the origins of such innovations may postdate historic contacts. Because current knowledge of prehistoric irrigation is based primarily on ethnohistoric data, the full distribution of the practice is not satisfactorily known and remains an important area for future investigation.[7]

The water conveyance systems constructed by the Owens Valley Paiute have received the widest attention to date. At least 10 systems between Independence and Bishop were reported by ethnographic informants. Those systems may have differed slightly in their design, but typically consisted of a main canal up to several miles in length and a latticework of smaller branch ditches to bring water to a collective plot. In one case, a series of parallel ditches west of Big Pine may have been operated with a separate diversion structure on each small ditch.

A new dam of boulders, sticks, and mud was built each year in the spring through the collective effort of the men in each local group. It was the job of the head irrigator (*tuvaijü*), elected each year by popular assembly, to turn water from the main canal into distribution channels using small mud or sod dams and a wooden pole

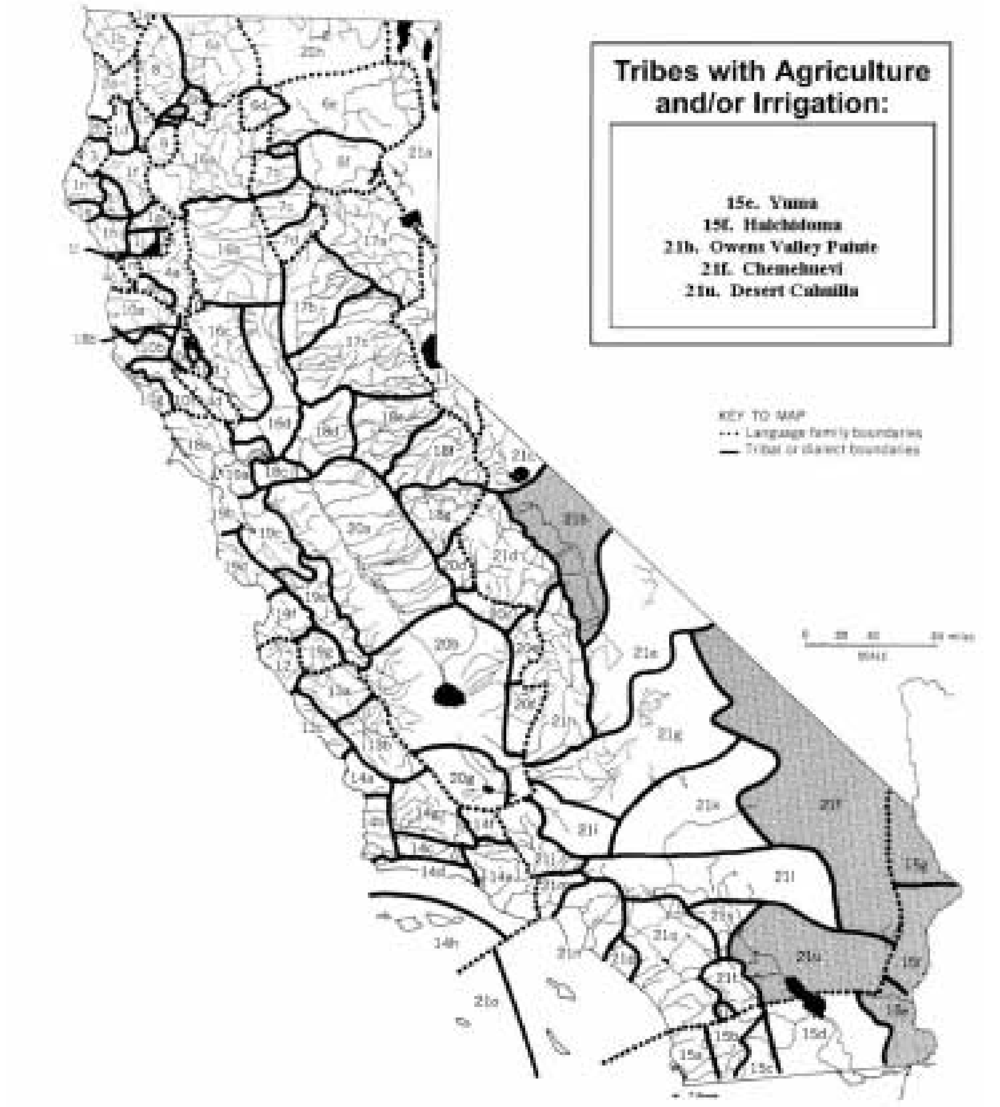


Figure 1. Distribution of prehistoric agriculture in California

called a *pavodo*. The main diversion dam was later purposely destroyed at harvest time. Women harvested tubers of yellow nut grass (*Cyperus esculentus*), wild hyacinth corms (*Dichelostemma pulchella*), and various seed crops. Destruction of the dam also facilitated the collection of fish stranded in the drying ditch channels. Plots were alternated every other year, allowing a regular fallow period. Excess water from the plots was allowed to continue downhill toward the Owens River.[8]

The absence of cultigens lends credence to the theory that irrigation originated independently among the Paiute, perhaps springing from observations of natural runoff and the widespread Great Basin practice of stream diversion for purposes of fishing and flooding rodents out of their burrows. Julian Steward's informants told him that irrigation was practiced on the west side of the Owens Valley from Rock Creek just north of Bishop to as far south as Independence.[9]

The Palm Springs Cahuilla also diverted water for agricultural purposes, although the prehistoric origins of that practice remain poorly known. In contrast to the indigenous crops grown by the Owens Valley Paiute, the Cahuilla grew cultigens such as corn, squash, and beans.[10] One Cahuilla irrigation system reportedly diverted the water debouching from Tahquitz Canyon (Dwight Dutschke 1996:personal communication).

Because prehistoric water conveyance systems are rare, poorly understood, and constitute the oldest examples built in California, extant examples are likely to be found eligible for the National Register. However, the integrity of such properties will influence the level of significance and range of applicable criteria. Most prehistoric water conveyance systems are likely to retain some significance regarding their ability to address important questions about prehistory (Criterion D). Details derived from the study of such systems may address important topics such as how these vernacular structures were designed, variability in those designs, their evolution and emergence, the scope and intensity of agriculture among particular indigenous groups, and what types of crops were grown, to name a few. The best preserved prehistoric irrigation systems may also be found eligible as vernacular constructions pursuant to Criterion C, particularly in cases where relict vegetation contributes to the appreciation of the system as a cultural landscape. For example, wild hyacinths continue to prosper in some areas previously subjected to irrigation by the Owens Valley Paiute.

Like most abandoned water conveyance systems, Native American irrigation works have likely suffered damage due to natural forces such as erosion and siltation, as well as the impacts of subsequent historic developments. Diversion structures probably have not survived, both because such dams were often purposely demolished and also due to erosion. There is no existing evidence for the use of control structures such as gates. Thus, main canals and branch ditches are likely to be the primary surviving elements of such systems, along with any associated relict vegetation. Where traces of such systems can be clearly detected, they may still evoke a sense of time and place connoting eligibility under both criteria C and D. Even systems that are largely obscured by siltation or have been partly destroyed may still provide important information about prehistory when studied with appropriate methods such as cross-trenching, aerial photography, mapping, and palynology.

Corroborating the age and Native American association of a water conveyance system is a crucial step in the evaluation of properties associated with this theme. Because no reliable methods are presently available to precisely date the year of construction or length of time a given system was in use, ethnohistoric data provide the most convincing grounds for demonstrating associations with the prehistoric irrigation theme. Historic documentation and ethnographic data may both render assistance in efforts to establish that a given system predates non-native settlement. For example, Government Land Office survey plats and notes for portions of the Owens Valley specifically identify Paiute irrigation or note multiple “stream” channels running parallel to elevation contours, not across them, in the same year non-native settlement of the area began. Ethnographic data collected in the early 1900s from informants who had direct knowledge of irrigation practices may also help establish associations for particular systems.

Spanish and Mexican Period Irrigation

Spanish colonists, among them missionaries and neophytes, were the first non-indigenous people to build irrigation systems in California. Beginning in 1769 at San Diego, the Spanish established missions along the California coast at roughly 30-mile intervals. They constructed irrigation systems at both the missions and the associated pueblos.[11] By modern standards these systems were not very extensive, but some portions were of such solid construction that they survive to the present day.

The agricultural tradition of the missionaries, by the time they reached California, was a hybrid of strategies and cropping patterns derived from two centuries of Mesoamerican occupation. California’s Mediterranean climate was familiar to the Franciscan priests who founded the missions. They applied traditions and technologies dating back to the Roman empire, including dry farming, runoff irrigation, flood water farming, and major irrigation projects requiring masonry dams, aqueducts, and tile-lined ditches.[12]

The Spanish established their settlements on the coast and in coastal valleys, leaving the interior largely to the Native Americans. While the Spanish occasionally entered and explored the Central Valley, they made no permanent settlement in the interior. For 50 years beginning around 1770, missionaries and rancheros raised cattle and farmed areas of southern and coastal California. Most of the missions had some kind of irrigation system, but the works were relatively small, although in one instance extending up to 20 miles. Size was limited by southern and coastal California’s irregular water supplies, which were subject to wide fluctuations, and by the necessary extensive investment in labor. Indian laborers built the missions' irrigation systems, using hand tools to construct earth and stone-lined channels.[13]

Spanish missionaries directed the planting of staple crops and brought water to irrigate small fields of maize and beans, but the largest areas of cultivation were in dry-farmed wheat and barley. Some of the mission gardeners also grew small quantities of lentils, peas, garbanzo beans, hemp, and cotton. As the settlements became more established they planted orchards and vineyards, including pears, peaches, apples, almonds, plums, oranges, lemons, limes, dates, cherries, walnuts, olives, and figs. The southern missions, like San Diego and Santa Barbara, fared better at raising fruit. San Gabriel, for example, had almost 200 acres of orchards and vineyards. Most of the missions, however, depended on wheat and cattle production. At peak development, scholars estimate that the missions cultivated, in the aggregate, only 5,000 to 10,000 acres, with most of that area in dry-farmed wheat.[14]

Evidence in secondary literature suggests that most missions founded during the Spanish period in California had some limited irrigation system to serve small gardens, vineyards, or orchards, as did their estancias and branch missions in outlying areas. At San Buenaventura, for example, the mission Indians were trained in horticulture, which implies farming and limited irrigation. At San Fernando Rey, the missionaries directed construction of a stone masonry dam in 1808, and by 1811 had a 1.3-mile aqueduct connecting it to the mission vineyard. This conduit was described as "clay pipe," and was depicted on the General Land Office plat of the mission in 1904. Dams and aqueducts of stone also were built at other missions (Figures 2 and 3). Mission San Jose in Alameda County was described as having developed an extensive system of wheat fields, gardens, orchards, and vineyards in 1826, also suggesting an irrigation system was in place. The garden and vineyard at Mission San Juan Bautista were served by a "*zanja* of water...in some years."[15]

In 1776, Mission San Luis Obispo installed a wooden aqueduct to connect the mission with San Luis Creek several miles away, and later installed two water-powered grist mills, one supported by a system of reservoirs and tanks. At San Luis Rey,

Figure 2. San Diego Mission Aqueduct
(California Room, California State Library)

between San Diego and San Juan Capistrano, the original mission was established at a marsh from which the missionaries got sufficient water for the Indians "and for irrigating a garden." To the north, the mission's outlying station at San Antonio de Pala had "a vineyard and orchard of various fruits and of olives, for which there is sufficient irrigation, the water being from the stream which runs in the vicinity." Other nearby wheat, corn, and bean fields also were irrigated. Even the struggling Mission San Miguel owned "a small spring of warm water and a vineyard distant two leagues." Finally, at Mission San Francisco Solano in Sonoma, the first actions upon siting the mission itself were described as cutting logs, putting up fences, and digging irrigation ditches.[16]

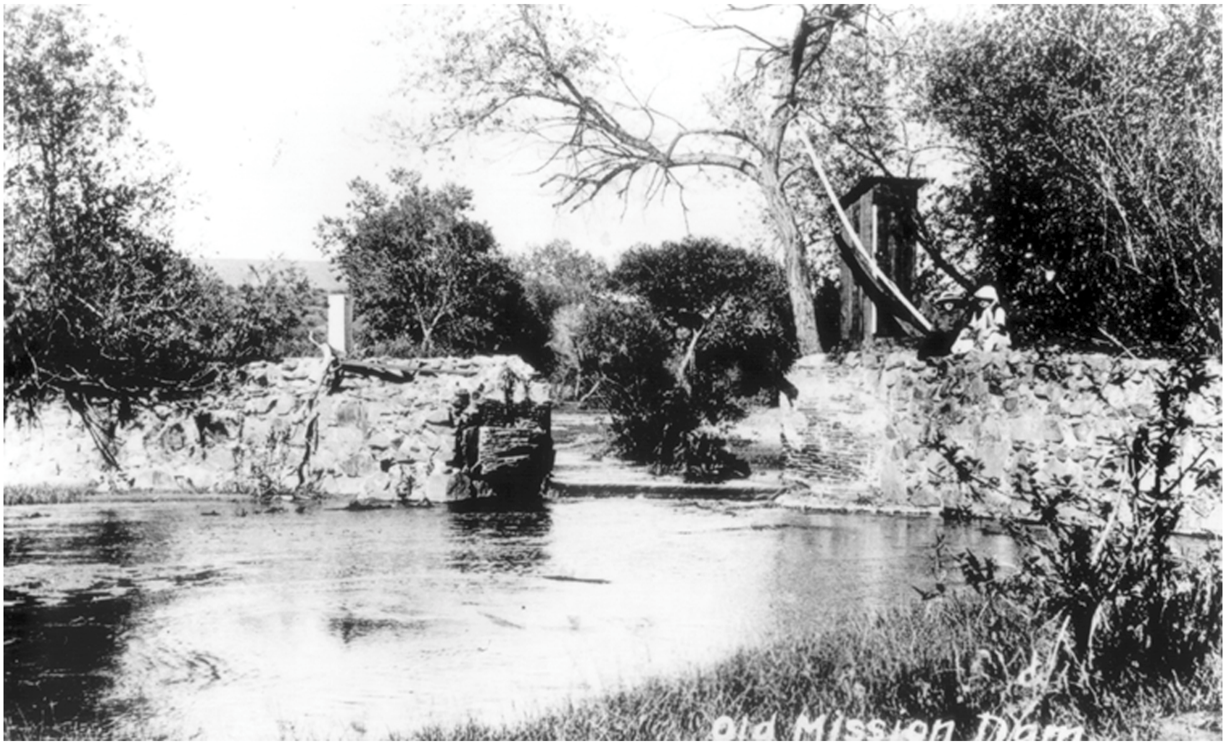


Figure 3: Remains of Mission San Diego stone dam
(California Room, California State Library)

Other missions had far more elaborate systems. The main canal that delivered water to the gardens at Mission San Antonio de Padua, for example, was about three miles long. Segments of this ditch were excavated into the sides of limestone cliffs, where others were masonry lined or earthen. The system employed a stone and mortar dam 150 feet long, 12 feet high, and tapering from five feet at the base to three feet across the top, to divert water from the Arroyo of San Miguel (Mission Creek) into the conveyance canal.[17] Mission San Diego's dam was 245 feet long and 12 feet high, with a stone-lined diversion canal six miles long. Indians at Mission San Gabriel built over 20 miles of aqueducts, and the missionaries at the San Bernardino branch mission directed the construction of the Mill Creek *zanja* between 1820 and 1830. As late as 1902, it was reported that "traces of an old irrigation ditch belonging to the Mission Soledad exist to this day."[18] Dams and aqueducts still exist at Mission Santa Barbara.

The pueblos, or towns, established during this period also constructed irrigation works. The canal known as the Zanja Madre in Los Angeles is probably the best known. In the 1770s, this canal diverted water by way of a temporary brush and wicker weir from the Los Angeles River for the little camp that became the Pueblo of Los Angeles. Beginning at a point across from present-day Elysian Park, two miles north of the pueblo, the channel followed natural contours to bring water to the community fields south of town. The Zanja Madre was used for both domestic and irrigation purposes, and the head of each household in the pueblo was "required to contribute a certain amount of time to its upkeep."[19] The pueblos at San Jose, San Diego, Branciforte (Santa Cruz), and San Francisco also were located around water courses, which in Spanish and Mexican legal tradition were held and controlled for the benefit of the pueblo inhabitants. These pueblo farmers irrigated crops similar to those grown by the missionaries, principally corn, beans, wheat, and barley. Several varieties of melons and squash, along with peppers and herbs augmented the settlers' diet, but most of the experimental orchards and vineyards planted before 1850 were put in at the missions.[20]

After successfully throwing off Spanish rule in 1823, Mexicans continued the general pattern of settlement in California established during colonial times. To a great extent the Mexicans left the Central Valley alone, and only late in their rule did the government grant ranchos, mostly to foreigners, primarily along the San Joaquin, Cosumnes, American, Feather, and Sacramento rivers in Sacramento and San Joaquin counties. By contrast, in both the Spanish and Mexican period the southern and central coast range was dotted with ranchos granted to settlers, or with missions and their *estancias*. Activities on these holdings centered around providing for self-sufficiency, sustaining the much reduced missions, but focused primarily on the hide and tallow trade.[21] Settlements established under Spanish and Mexican rule as missions, pueblos, and ranchos formed the basis for many modern towns and cities.[22]

Once Mexico won its independence from Spain, the new nation secularized the missions in California in 1833. Gaining control of the mission lands, the Californios retained some of the mission Indians as laborers but shifted their activity to center more on the hide and tallow trade. For the next 20 years or so agriculture, and especially irrigated agriculture, generally declined as rancheros focused on cattle raising.[23] Rancheros, both Mexican and foreign born, took advantage of large Mexican government land grants to develop huge herds of cattle for the hide and tallow trade; a limited trade in wheat, wine, and other goods formed an adjunct to this activity. The granting of ranchos increased dramatically after the secularization of the missions. Between 1835 and 1845 Mexico made almost 700 concessions of land, "many of which included the most fertile ex-mission tracts."[24] The ranchos encompassing former mission fields had some success with irrigated agriculture, as did the few who experimented with establishing citrus orchards and vineyards. Rancheros did not, however, invest time and labor in constructing irrigation works because their primary endeavor was in the relatively simple and highly profitable hide and tallow trade. Typically each rancho had a small house garden (and, in fact, establishing a garden was offered as proof of a valid title to a rancho grant), but even substantial rancho establishments often lacked an irrigating system of any size.[25]

The period of Mexican rule came to an end when Americans claimed California at the conclusion of the war with Mexico in 1846-47. By this time, almost half of the non-Indian inhabitants of California were Americans who had either settled in coastal towns or established farms in the Central Valley away from Mexican control.[26] In the decades that followed, Americans gained control of former mission and rancho land and developed more extensive irrigated agriculture in addition to stock raising.

American Period Irrigation

A diverse physical environment with inherent limitations faced the growing number of farmers at the beginning of the American period. In the generally dry climate, water for irrigation was often either unavailable or unreliable. Furthermore, 80 percent of the state's precipitation falls between November and March, missing the growing season of many crops. Although the porous soils, limited technical knowledge, high costs, scarce machinery, and conflicting concepts of water rights discouraged many early attempts to develop water supplies for irrigation, California's potential agricultural abundance spurred continuing efforts.

The nature of each region's geography and climate often dictated its rate of development. Southern California farmers dealt early with a limited water supply, low annual rainfall, and porous soil by building lined canals and pioneering storage facilities. Areas to the north, such as the Sacramento Valley, had sufficient rainfall for dry farming, so farmers were much slower to accept the expense and difficulties of installing irrigation works. In general, as local farmers learned about the limitations imposed by the climate and landforms of their own particular areas of the state, they constructed more successful systems. Because each area dealt with different variables, irrigation developed in different ways and rates throughout California.

The principal agricultural area of California is the great Central Valley, which lies between the Coastal Ranges and the Sierra Nevada. The entire valley is approximately 400 to 500 miles long, varies from 20 to 60 miles in width, and covers approximately 17,000 to 18,000 square miles. The southern half of the Central Valley, known as the San Joaquin Valley, declines gently in elevation from south to north. At the northern end, the Sacramento Valley slopes gradually from its higher northern end to the south. The southernmost portion of the San Joaquin Valley forms a closed basin with no outlet to the sea, where once great natural lakes have been drained for farmland. The Central Valley is bisected by its two major rivers, the southward-flowing Sacramento and northward-flowing San Joaquin, and is watered primarily by tributaries flowing west down from the Sierra Nevada on the east. The valley was gradually filled by flood plains and many compound alluvial fans of soft, rich earth, gently sloped, easily plowed, and easily irrigated. The configuration of the Sacramento and San Joaquin rivers in the historic period left at their confluence an oddity—an inland delta with deep, peat soils, influenced by the tides and faced more with problems of drainage than irrigation.

Outside of the Central Valley, irrigated acreage in California is scattered in coastal and mountain valleys and portions of the desert southeast. The next largest areas of irrigation, the Los Angeles Basin and the Imperial Valley, are much smaller than the Central Valley. Other smaller, more geographically isolated areas that irrigate crops include the Palo Verde, Salinas, Santa Clara, San Benito, and Napa valleys; bottom lands along rivers such as the Oxnard Plain; lands along the northern coastal rivers; and the drained Tule Lake area of the United States Bureau of Reclamation's (USBR) Klamath Project. Despite a smaller total acreage, these farms produce nationally important high-value vegetable and fruit crops. While the great majority of irrigation acreage lies in the Central Valley, Californians practice some irrigation in almost every other part of the state.

Development of Irrigated Agriculture

The gold rush greatly stimulated California commerce, agriculture, manufacturing, lumbering, and countless other economic pursuits. New incentives were created for transportation development and California's population underwent explosive growth. People in booming gold rush era mining towns like Grass Valley, Placerville, and Columbia, and expanding trade centers like Sacramento, Marysville, Stockton, and San Francisco, produced a market for agricultural products. This demand resulted in the steady spread of farms, ranches, and small towns along navigable waters and their tributaries all over the state.[27]

Cattle raising, the predominant agricultural pursuit of the 1850s and early 1860s, demanded little irrigation, and from the 1860s to the 1890s, dry-farmed wheat ruled the interior valleys of California. Wheat growers were slow to acknowledge the need for water distribution systems because dry farming provided such bountiful wheat crops that irrigation was seen as an unnecessary expense.[28] The lure of high returns from comparatively little investment in labor and equipment led many early farmers to try their luck without irrigation, but local water shortages and widespread droughts finally convinced many of the desirability of a secure water supply. The devastating drought and flood cycle of 1863-1865, unstable wheat market, soil exhaustion, and unreliable precipitation took their toll. Irrigation offered renewed hope in times of distress.

"Throughout the arid West during the last third of the nineteenth century," noted agricultural historian Donald Pisani, "support for irrigation grew out of immediate water shortages, not from a desire for comprehensive water resource planning or scientific farming; most farmers were not willing to commit themselves to agriculture as a long-term investment."[29] Wheat production in California began declining in the 1890s, and more farmers turned to irrigated crops. Once they began to see the benefits of investing time and money on irrigation systems, the number of systems increased. However, the long-term success rate for these early systems was low, and financial, legal, and legislative problems plagued irrigation organizations through the turn of the century.

The total irrigated acreage in the state grew from 60,000 acres in 1860 to nearly 400,000 acres by 1880, an increase of more than 650 percent. State Engineer William Hammond Hall's 1880 survey of the developed regions of irrigated agriculture (Table 1) showed that the San Joaquin Valley represented approximately 47 percent of the statewide total, with San Bernardino and Los Angeles counties accounting for almost 21 percent. On the other hand, the heavily dry-farmed Sacramento Valley had only limited irrigation.

Table 1. Hall's 1880 survey[30]

Location	Irrigated Acres
San Bernardino and Los Angeles counties	82,485
San Joaquin Valley	188,000
Sacramento Valley, on Cache Creek	13,400
Sierra foothills	9,000

Irrigation Institutions

Californians developed a number of institutions or communal arrangements to build extensive irrigation systems, which were normally beyond the financial capability of individual landowners. These institutions fell into four general types: private water companies, land colonies, mutual water companies, and irrigation districts. Of these types, the irrigation district represented the largest acreage and was crucial to the successful development of large-scale irrigated agriculture in California.

Private Water Companies

Beginning in the 1870s, private investors began to construct canals on a large scale, developing commercial irrigation companies that owned the canal system but not the irrigated lands. This system was often used in the early years of irrigation development in California for the development of lands under single ownership. By constructing an irrigation system and providing water at a specified rate, a developer or speculator could sell otherwise relatively valueless lands at irrigated land values. Profits were largely secured from the increase in land values rather than returns from operation of an irrigation system. Many commercial irrigation systems in California were later acquired by organizations of the local landowners, who would form an irrigation district in their service area and then purchase the canals serving it.[31] In a few cases in the twentieth century the USBR became involved in areas where private ventures had failed, such as the Stony Creek area in the Sacramento Valley or in the Imperial Valley.

Land Colonies

Land colonies are most often thought of as utopian, ideological, or ethnic institutions, where groups would join together to form a cohesive community. The long tradition of such colonies in California stretches from the Anaheim Germans of 1857, to a Polish utopian community that came to Anaheim almost 20 years after the Germans, to Thermalito in Butte County in the 1880s, to the Allensworth black settlement in Tulare County in 1908, and running through the modern communes of the 1960s and 1970s.

The original developers frequently sought homogenous social groups for each colony for an easier adjustment to the communal aspects of irrigated agriculture. Also, the colony offered social comforts to farmers, since small farms in close proximity to each other eliminated the isolation endured by so many pioneer farmers. Although settlers in such colonies obtained access to water through colony ditch systems as part of their land purchase agreements, ownership of the water system itself typically remained in the hands of the capitalist-developers of the tracts.[32] Because the colony company laid out the canal system and sold agricultural lands with irrigation works intact, the colony canal systems had a high degree of uniformity in canal shape, canal size, control structures, diversion works, and other engineering features.

In part related to a nationwide publicity campaign waged by the California Promotion Committee, the California Development Association, and the publicity departments of the Southern Pacific and the Atchison, Topeka & Santa Fe railroads,[33] land speculators and developers set up colony companies around the state, especially in the early twentieth century. Often linking their land and water systems in a structure similar to that used by mutual water companies, these land colonies of the 1900-1920s differed materially from nineteenth century efforts. Driven by the prospect of speculative profits, they emphasized the economic prospects of specialized farming on small acreage and were devoid of the "communitarian" spirit of the earliest colonizers. Customers were left to their own devices once contracts of sale were completed, and their survival often depended on their ability to exploit groundwater resources in the absence of surface irrigation systems.

Mutual Water Companies

Mutual water companies were cooperative organizations of landowners. They were started by a developer who transferred water company stock to each new purchaser in proportion to the number of acres to be irrigated. When all the land was sold, landowners held the water company stock and hence control of the water. In other cases, landowners wishing to develop an irrigation system bought stock in a water company, and that company used the capital from stock sales to acquire water rights and build a water system. Operating funds for the company were derived from assessments on the stockholders or charges for the water delivered. Ownership of stock was voluntary, and the company could not force others to be included.[34]

This marriage of land and water proved a powerful marketing tool for lands in arid California, most particularly in the south. Although usually considered a Southern California institution, mutual water companies were established in almost every region of the state around the turn of the century.

Irrigation Districts

Conflicts over control of agricultural water supplies under California water laws led to passage of the 1887 Wright Act, which provided for the formation of irrigation districts under the democratic control of the water users. The act, while not initially successful, survived several amendments in the years that followed, and after 1915, allowed the establishment of irrigation districts throughout the Central Valley and elsewhere in the state.[35] This achievement did not come easily.

Following the California Supreme Court's decision in *Lux v. Haggin*, in which the court upheld riparian rights, supporters of irrigation development had been forced to go to the legislature for relief. Assemblyman C. C. Wright introduced the Wright Act, to establish publicly controlled districts with sufficient legal powers to take land and water from powerful Central Valley riparian landowners. Wright and his supporters hoped that these vast tracts might be transformed into community-controlled irrigation districts. The Wright Act passed in 1887, and almost immediately on the heels of its passage came the organization of the Modesto, Turlock, and Tulare irrigation districts, followed soon thereafter by the Browns Valley and Alta irrigation districts.

Under the new law, irrigation districts were public corporations, empowered to issue bonds and condemn property, to levy and collect taxes, and to maintain and operate irrigation works. The districts were given the power to condemn in order to gain access to waterways that might otherwise be blocked by riparian owners. The law also provided for a board of directors to be elected from among the residents of the district.[36]

The Wright Act prompted the formation of numerous irrigation districts and led to increases in irrigated acreage in the late 1880s and 1890s. Forty-nine irrigation districts were organized between 1887 and 1896, most of them located between Stockton and Bakersfield. However, by the late 1920s, only seven of the original districts were still in existence, among them the Modesto, Turlock, and Tulare irrigation districts.

Farmers often found that irrigation districts faced formidable barriers. Unsympathetic large landowners and owners of riparian water rights fought district organization with a flood of costly law suits. For a time it seemed the enemies of the irrigation district law had won. In fact, John D. Works, a judge, US senator, and expert on California water law, declared the district idea dead by 1900: "The law of irrigation districts has ceased to be of general interest. The law has proved such a dismal failure, in its practical workings, that it is not likely that the formation of any new districts under it will ever be attempted."[37]

From 1897 to 1909, not one new irrigation district was formed. However, Works' dire prediction proved premature. After 1909, when the Oakdale and South San Joaquin Districts were formed, there was a general revival of irrigation district activity in California. One of the primary reasons the act was more successful after 1909 was the increased population, particularly in the Central Valley, finally large enough to support district formation. In addition, Progressive Era legislation passed in 1911-1913 increased state supervision over district organization and financing and made investment in irrigation district bonds more attractive.

The Wright Act created the Irrigation Bond Commission, composed of the attorney general, the superintendent of banks, and the state engineer. The duty of these officials was to pass upon the feasibility of proposed districts. If a favorable verdict were rendered, the bonds were registered at the office of the state comptroller and were considered legal investments for insurance companies, banks, or trust funds. Optimism regarding increased immigration and markets that would follow the opening of the Panama Canal contributed to a marked increase in district organization in 1915. New communities turned to irrigation development, and the only practical way of financing construction was through organization of irrigation districts.[38]

Under the impetus of increased demand during World War I, agricultural production reached a new peak in 1920. In each year from 1917 to 1925, five or more districts were organized; in 1920 alone, 18 districts were formed. Many of these districts found the required funding for construction of their systems by a marriage of convenience with private power companies. Companies like Pacific Gas & Electric and San Joaquin Valley Light and Power helped finance large irrigation reservoirs to feed district canals in return for the power generated. By 1930, there were 94 active districts in California, and the land watered by these agencies mushroomed to 1.6 million acres. Irrigation districts provided more than 90 percent of the surface water used for irrigation in the San Joaquin Valley before the Central Valley Project came on line in the 1940s.[39]

Among the most successful districts in the San Joaquin Valley were the Modesto, Turlock, Merced, and Fresno irrigation districts; and other examples can be found across the state. Success of the first three was based in part on development of storage reservoirs equipped with hydroelectric generation facilities which sold power within their districts or to local utilities. The increased demand for storage and coordination of interests on larger streams stimulated the development of water storage and conservation districts in the late 1920s. Plans for combining group interests under the sponsorship of state and federal agencies to manage basin-wide water resources became a characteristic of water management in California in subsequent decades.

In general, the heaviest concentration of irrigation districts was found in the San Joaquin Valley, followed by the Sacramento Valley. The largest single district in terms of acreage was the Imperial Irrigation District in the Imperial Valley. Scattered irrigation districts were located in Northern California, with much smaller and more isolated districts in Southern California. As Californians learned how to build, finance, and legislate for more successful irrigation, they brought more and more land under irrigation. Irrigation throughout the state grew rapidly through the first two decades of the twentieth century before slowing again as the amount of unclaimed water decreased and available land was utilized (Table 2).

Table 2. Growth of irrigated acreage in California[40]

Year	Irrigated Acreage
1870	70,000
1880	400,000
1889	1,004,000
1899	1,445,000
1902	2,644,000
1919	4,220,000
1929	4,720,000
1939	5,070,000
1950	6,599,000

By 1950, the Central Valley held two-thirds of the irrigated acreage in the state, and "no other hydrographic area [contained] as much as 10 percent of the total."[41] The area irrigated in the San Joaquin Valley grew further after the main canals of the Central Valley Project began deliveries in 1951-52, and after completion of the California Aqueduct in the early 1970s.

Regional Developments

Southern Coast

The Spanish and Mexican missionaries who were the first to build water conveyance systems in the south coastal area had constructed relatively small irrigation canals during the late 1700s and early 1800s. Later settlers sometimes incorporated these older systems into their own irrigation works. The Lugo family acquired San Bernardino's Mill Creek *zanja*, which they sold to Mormon farmers in 1851. Other Southern California settlers built the Duarte ditch in 1854, using some of the San Gabriel Mission's channel in the upper stretches of the works. Works built in 1841 on the San Gabriel River were still in use as late as 1960, as part of the Azusa water system.[42] These irrigation systems existed at the margin of an agricultural industry dominated by large-scale stock raising and dry farming of wheat during both the Mexican and early American period, from the 1820s until about 1870.[43]

Bordered on the north and east by rugged mountains and a formidable desert, and insulated by distance from the growth generated by gold discoveries of the Sierra Nevada foothills, with limited land transportation routes and an arid climate, the Los Angeles, Santa Ana, and San Diego river basins developed slowly. Spanish missionaries had planted small groves of oranges and other citrus fruit in this area in the 1770s, but without adequate transportation, there was little market for the crops. After the arrival of the Southern Pacific Railroad that linked Southern California with the rest of the nation in the 1870s, and the introduction of the Navel and Valencia oranges, citriculture boomed. Settlers were quick to develop irrigation systems once they identified profitable crops and markets. Beginning in the 1880s, Southern California farmers proved the value of irrigation when combined with marketable varieties of citrus fruit and railroad transportation.

The low rainfall necessitated development of irrigation systems, and porous soils stimulated farmers to line their canals when possible. While these canal systems were labor intensive and difficult to build, they were essential in this region where dry farming was uncertain at best. By 1880, State Engineer W. H. Hall listed more than 82,000 irrigated acres in Los Angeles and San Bernardino counties, about 23 percent of his statewide inventory. In the following decade southern Californians built the Bear Valley, Cuyamaca, Hemet, and Sweetwater reservoirs, developing the first extensive irrigation storage in the state.[44]

In order to develop these water systems, southern Californians organized colonies or turned to private water companies, mutual water companies, and irrigation districts. Private land and water companies, like those organized in San Diego and San Bernardino counties, built a number of systems to provide their service areas with water or enhance the value of lands they hoped to sell. The San Diego Land and Town Company built Sweetwater Dam in San Diego County and conducted water to its customers through a 58-mile network of iron pipes. State Engineer Hall noted that, "No water rights are sold by the company, but water is delivered to all who make application for it." Land without water sold for $100 per acre, as opposed to $300 per acre for land supplied with water.

The San Diego Flume Company had a system under development in 1888, with plans to serve the entire valley of the San Diego River, some 75,000 to 100,000 acres. The water would be delivered through a 36-mile-long flume, completed by 1888, and a set of pipes running nine miles from the end of the flume to the city. North of San Diego, near Hemet, the Lake Hemet Water Company provided irrigation to a 10,000-acre tract of land controlled by its parent, the Hemet Land Company. The land company gave one share of water company stock with every acre of land, providing irrigation water from May to December of each year, along with year-round domestic supplies. Shareholders had to pay $2 per share each year for their water, and could not sell shares without company approval.[45]

In San Bernardino County, the structure of valley soils led to development of a large number of systems. In 1888, State Engineer Hall noted that prehistoric torrents had created boulder and gravel ridges at the mouths of canyons, so that streams flowing out of the mountains percolated through the soil into buried river channels no longer visible on the surface. Often tightly capped, these channels gave rise to artesian fields covering 20 square miles of the lowest portions of the 100-square-mile valley and provided a substantial subsurface flow.

Further, the long gentle slope of the valley from both the north and south to its center made development of gravity-fed irrigation systems comparatively simple.[46]

Irrigation had been conducted in the area since the 1850s on a limited basis, but by the time of Hall's survey in 1887-88, a web of water companies and conveyance systems had grown up centered around San Bernardino, Ontario, Etiwanda, and settlements to the west and south. The North Fork Canal, which Hall described as having been an "insignificant, rough little earthen farm ditch" in 1858, by 1888 had evolved through relocation, enlargement, and rebuilding, into a "commandingly placed permanent structure and notable irrigation property." Other important systems included such conduits as the South Fork Ditch, the Sunnyside Ditch, Redlands Ditch, and J&B Ditch. Like other ditch systems in the area, they were controlled by the irrigators themselves who were also shareholders in Redlands, Lugonia, and old San Bernardino. Around Riverside were the Riverside Water Company, Gage Canal (Figure 4), and Vivienda Water Company, each with its own set of canals or canals and pipelines.[47]

Of irrigated land colonies in Southern California, the Anaheim Colony, organized in 1857 by Germans living in San Francisco, remains one of the most famous. Anaheim was chosen for its farming potential, and care was taken to obtain sufficient water rights. The colonists remained in San Francisco until 1860, investing regularly to pay for improvements. In the first years of the colony's establishment, the resident manager installed seven miles of main ditch, 25 miles of laterals, and 450 miles of subsidiary ditches to serve the 1,165 acres within the colony boundaries, and arranged for planting of vineyards and orchards. At the end of the development phase, 1857-1860, the colonists drew lots for parcel assignments and moved into the colony.[48]

Figure 4: Gage Canal, ca. 1900
(Mead 1902, Bulletin 119:Plate 16)

Beginning in 1882, George Chaffey used the system of linking land and shares in a mutual water company to develop Ontario and Etiwanda.[49] Ontario is perhaps the most noted example of mutual water company development. Chaffey, a Canadian-born hydraulic engineer and entrepreneur, adopted the concept of selling land in Ontario by including a mutual water company share with each acre purchased. Chaffey purchased existing water rights, a group of small water systems, and land in November 1882. He worked out an agreement with the San Antonio Water Company to purchase the company's works and water rights. The water company would provide one-tenth of a share for each "miner's inch" of water purchased, providing Chaffey with 3,500 shares to distribute. (Water delivered in ditches, canals, and flumes was measured in the miner's inch, which was eventually standardized to 1.5 cubic feet or 11.25 gallons per minute.) The water came from a tunnel driven into the hillside north of the company's lands. It was carried in a cobbled and cement-paved canal to a distribution chamber, then directed into a system of pipelines serving individual parcels.[50]

In Etiwanda, Chaffey acquired land and purchased existing water rights, then designed a system of flumes, short canals, and pipelines to the tract that allowed each landowner access to a ready supply for their lands. Hall noted in 1888 that "the landowners now control the Water Company." The water supplied was derived in part by tunnels driven into the *cienagas* (marshes), and into water-bearing gravels in the adjacent canyons. The Hermosa Water Company was a neighboring tract operated on much the same basis, taking its water from canyon springs and distributing it through iron pipe.[51] A number of these mutual water companies, such as the Fontana Mutual Water Company in San Bernardino County, can still be found in Southern California.

Farther to the west, private systems and mutual water companies led to development of irrigable lands in the Pomona, San Dimas, San Gabriel, San Fernando, Los Angeles, lower San Gabriel, and lower Santa Ana areas. Some of the systems being used in 1888, like the Old Settlement Ditch, dated to the early 1840s; in other areas land and water companies adapted existing systems or constructed new canals, dams, and tunnels. In these areas, the "new" systems of the 1880s tended to install, wherever possible, concrete pipe or lined irrigation canals. For example, the Pomona Land and Water Company, a combination of four smaller water companies, installed 240,013 feet of various-sized cement and iron pipe, delivering to 200 irrigation outlets.[52]

Southern Californians did not place as firm a reliance on irrigation districts as did irrigators in the San Joaquin Valley. By 1929, there were 82,096 acres served by 18 irrigation districts in Southern California; this total was roughly equivalent to that covered by the Modesto Irrigation District (81,183 acres) alone, and about a third of the 241,300 acres within the Fresno Irrigation District. Only one of the Southern California districts, Walnut, was established in the nineteenth century (1893). Of the remainder, four were established between 1911 and 1918, and 11 were established in the 1920s. The districts either acquired existing water company works and rights, erected pumping plants to exploit groundwater supplies, or purchased water directly from water companies or municipal works.[53]

Most of the south coastal counties (Ventura, Los Angeles, Orange, and San Diego) saw generally increasing agricultural growth for 60 years, from the 1880s through 1940.[54] Not until post-World War II suburban expansion began consuming cropland did the number of irrigated acres substantially decline. Los Angeles County is typical of metropolitan growth trends in Southern California. As the city and suburbs grew quickly eastward after World War II, encroaching on farm land, total agricultural acreage dropped correspondingly. In 1934, Los Angeles County reported a high of over 100,000 acres in fruit and nut orchards. That figure dropped by about 11,000 acres by 1944, another 11,000 acres by 1949, and totaled only about 46,000 acres in 1955.[55] As urban growth in Southern California has spread, a number of irrigation systems have been absorbed into suburban water supplies.

Sierra Nevada and Foothills

During the height of hydraulic gold mining in California, miners and ditch companies built hundreds of miles of canals, mostly in the Sierra Nevada foothills. Gold deposits in the northwestern part of the state, although not as extensive, also attracted many gold seekers who constructed systems in the Klamath, Trinity, and upper Sacramento River basins. One of the by-products of these systems was the development of local irrigated agriculture.

Even though the terrain and soils of the Sierra foothills were not as suited for large-scale irrigation as those in the great Central Valley, miners in the area created a strong demand for produce. The 1856 *Miners and Business Men's Directory, Tuolumne County* gave an example of this symbiosis between miners and a nearby farmer in the mining town of La Grange, Stanislaus County:

> Mr. J. D. Morely, who resides three miles below the village has within the last three years, by ditching and fencing, enclosed 700 acres of these rich agricultural lands. Last season his ranch produced 7000 bushels of wheat; 900 bushels of barley, and 60 tons of Hay; a quantity of stock and 500 fowls, for all of which he finds a ready market almost at his door.[56]

For the most part, farmers used water from mining ditches to grow crops for local markets. Limited by the low volume of crops produced, relatively limited agricultural areas, short growing season, and poor transportation facilities, foothill growers had a hard time competing with valley farmers.[57]

Although mining and agriculture shared a common need for water, the two activities were in fundamental conflict over land use priorities. Mining ditch superintendents considered selling water for irrigation a nuisance. Even though irrigators paid higher rates than miners, water for irrigation was distributed in such small amounts that water rates did not pay for maintenance and repairs of irrigation ditch extensions. Until the mid-1860s, foothill agriculture was "poorly developed, small-scaled, and merely tolerated by miners around the camps" because the search for gold was paramount. As the supply of easily mined gold diminished, agriculture grew modestly, assisted by federal legislation in 1866 that required miners to prove that the public land they wanted to mine was more valuable as a mining prospect than a farm. When the Comstock Lode was discovered in western Nevada, silver miners became the next market for foothill farmers, who took advantage of the improved trans-Sierra roads built during this period to deliver their produce to Nevada markets.[58]

The basic factor that restricted the expansion of irrigation in the foothill region was the cost of water delivered by systems originally designed for mining operations, not agricultural use. Miners and mining investors built their canal systems to carry water, often over long distances, to areas chosen for their mining potential, not for agricultural production. With high-maintenance systems delivering water to agricultural land only by chance, most farmers found profit only in small vegetable gardens and some orchards and vineyards.

Even though the mining ditches provided some water, the main historical agricultural activity of the Mother Lode region was cattle raising, with only limited orchard and vineyard development. State Engineer Hall estimated in 1880 only 9,000 acres were served by mining ditches. This number grew in later years, when the end of hydraulic mining brought a drastic decrease in mining use of water. Former mining ditches, like those owned by the Excelsior Water and Mining Company, served irrigation exclusively after 1896. In later state surveys, which included the foothills with statistics for the Central Valley, the foothills accounted for only about six percent of the valley's irrigation through 1960. Browns Valley Irrigation District was the only Wright Act era district to survive into the 1920s in the foothills. It did so primarily through a cooperative arrangement with Pacific Gas & Electric Company, by which the power company could run the irrigation district's water through its powerhouses in return for financial assistance.[59]

Although the region never achieved the kind of production and prosperity of other areas of California, the Sierra Nevada foothills have supported a small enduring agricultural population. This continues today with Sierra Nevada foothill vineyards and orchards. These are predominantly dependent upon groundwater supplies for irrigation; only in a few areas, such as around Grass Valley-Nevada City-Auburn (Nevada Irrigation District, 1921), and Placerville (El Dorado Irrigation District, 1925), have irrigation districts survived to the present. Like irrigation districts in the Central Valley, El Dorado Irrigation District purchased an existing canal and company, in this case based on mining canals, as the basis of its water system. The Nevada Irrigation District, on the other hand, filed water rights claims with the state and then worked out conveyance agreements with Pacific Gas & Electric Company to serve major portions of its area.[60]

San Joaquin Valley

Stimulated largely by arid conditions, settlers in the San Joaquin Valley were among the first American-era farmers in California to put in works specifically for irrigation. During the late 1850s and 1860s, their short, roughly made, earthen ditches diverted water by means of temporary brush dams constructed across the lower courses of the streams running west out of the Sierra. The earliest of these ditches were built in the vicinity of Visalia in 1852-1853; others spread out through the Kaweah River and Kings River deltas in the 1860s. Farther north in the valley where grain could be dry farmed, irrigation development was slower. The great floods of 1862 and 1868 destroyed most early ditch systems, but San Joaquin Valley farmers continued to experiment with irrigation. By 1870, most of the approximately 60,000 irrigated acres in California were small diversions in Southern California and irrigation from former mining ditches in the Sierra foothills. Farmers had also begun to irrigate bottom lands along the streams in the southern San Joaquin Valley.[61]

Like other Californians, most San Joaquin Valley settlers in the 1850s through the 1870s were not particularly interested in investing time and money in irrigation, preferring cattle raising and dry-farm cultivation of small grains to meet the economic opportunities created by the gold rush. The area was sparsely settled, and speculators like James Ben Ali Haggin and cattlemen such as Henry Miller and Charles Lux amassed large land holdings by acquiring swamp and overflowed lands and other public lands in the valley, on which they raised livestock. These holdings were typified by largely absentee ownership, seasonal labor demands, a high degree of mechanization, no crop rotation, employment of mostly dry-farming methods, and speculative returns from an unstable international wheat market. The San Joaquin Valley became the center of California's wheat belt in the 1870s. Wheat growing continued to expand, relying almost entirely on dry farming, and reaching its peak in the early nineties.[62] Although few wheat farmers were irrigating, some valley land barons, like Miller and Lux, invested in large-scale irrigation of pasturage for their primary business of stock raising. Miller and Lux watered large areas in the 1860s and 1870s, 150,000 acres of their 700,000 acres in California.[63]

The area around Fresno was the center of early irrigation in the San Joaquin Valley. The earliest attempts at irrigation development in Fresno County occurred at pioneer riverbank settlements, where water was readily available and easily transported. The earliest efforts occurred along the Kings River at Centerville, one of the oldest settlements in the county.[64] Centerville settlers could irrigate land with minimal effort by brushing the natural channels to serve as irrigation canals, beginning in 1868 or 1869, shortly after present-day Centerville was settled. Calling themselves the Centerville Canal and Irrigation Company, a group of local landowners cleared a natural channel, generally called the Centerville Channel, to provide dependable irrigation water. The headgate was simply the point of departure from the main stem of the Kings River, several miles upstream from Centerville.[65] In the fall of 1869, James B. Sweem built "Sweem's Ditch" to provide water power for his grist mill, located about four miles north of Centerville.[66] Sweem's Ditch was a branch, drawing its water from the Centerville Ditch.[67]

With these modest conduits—Centerville Ditch and Sweem's Ditch—the people of Centerville laid the basis for modern irrigation in the county. The energy and resources for extending canals to the Fresno plains came, however, not from the people of Centerville but from landowners to the west, especially A. Y. Easterby and Moses Church. During the 1860s, a group of San Francisco investors headed by Isaac Friedlander amassed tens of thousands of acres of Fresno County land. The key early settlers of Fresno, such as Thomas Kearney, A. Y. Easterby, and Frederick Roeding, purchased much of their original holdings from Friedlander's "German Syndicate." Easterby purchased 5000 acres on the Fresno plains. In 1870, he hired Moses Church to bring Kings River water to this acreage. Church, a Napa sheepherder, was residing in Centerville at that time, seeking pasturage for his flock.[68]

In mid-1870, Church purchased Sweem's Ditch with the intent of diverting its water to the essentially dry bed of Fancher Creek, which in turn connected with Easterby's acreage. Church and Easterby subsequently purchased the Centerville Canal and began constructing a connector with Fancher Creek. To continue this work, they and others organized the Fresno Canal and Irrigation Company.[69] They were successful in bringing water to Easterby's land, and it was the fertility of Easterby's crops that enticed Southern Pacific Railroad executives to locate a major railroad transfer nearby, at what would become the city of Fresno.

The arrival of the Southern Pacific Railroad in 1872, coinciding with completion of the first leg of the Fresno Canal, Easterby's Fancher Creek conduit, set in motion a great flurry of activity to develop and use the water of the Kings River. The modern canal system operated by the Fresno, Consolidated, and Alta irrigation districts was begun during the 1870s and 1880s, with a variety of private parties taking the lead (Figure 5). By the turn of the century, these smaller irrigation companies had been absorbed by a few large private parties, and in the case of Alta, by an irrigation district. By the early 1920s, essentially all irrigation works on the Kings River were controlled by local special-purpose districts.

The Kings River and Fresno Canal system was begun in 1872, shortly after the first leg of the Fresno Canal was completed. Investors in this system sought to irrigate land north of the Fresno Canal system, diverting through the Gould and Enterprise Canals. During the mid-1870s, this company fell under the ownership of Dr. E. B. Perrin, a major figure in land development in nineteenth century Fresno County. By the late 1870s, however, the company lost access to much of its water in an adverse court battle with the Fresno Canal and Irrigation Company (the Fresno Canal) which then bought Perrin's company.[70] These canals are now part of the Fresno Irrigation District and Consolidated Irrigation District. Conveyance systems like these were incredibly costly, and only a few early investor-speculators had the capital to fund them.

One arrangement for irrigating land was through communal land colonies. A number of these colonies were established in the area around Fresno in the San Joaquin Valley. In the 1870s, developers such as William Chapman and Moses J. Church created the prototype Central California Colony and its successors in clusters around the towns of Fresno, Selma, Dinuba, Kingsburg, and Reedley. Eventually, more than 20 important colonies were located in Fresno County, with over 800 miles of canals and over 2,000 miles in branches. Colony companies such as the Fresno Canal and Irrigation Company laid out roads and town centers, planted shade trees, established nurseries for the culture of raisins and wine grapes, and divided the agricultural land into 20-acre plots.

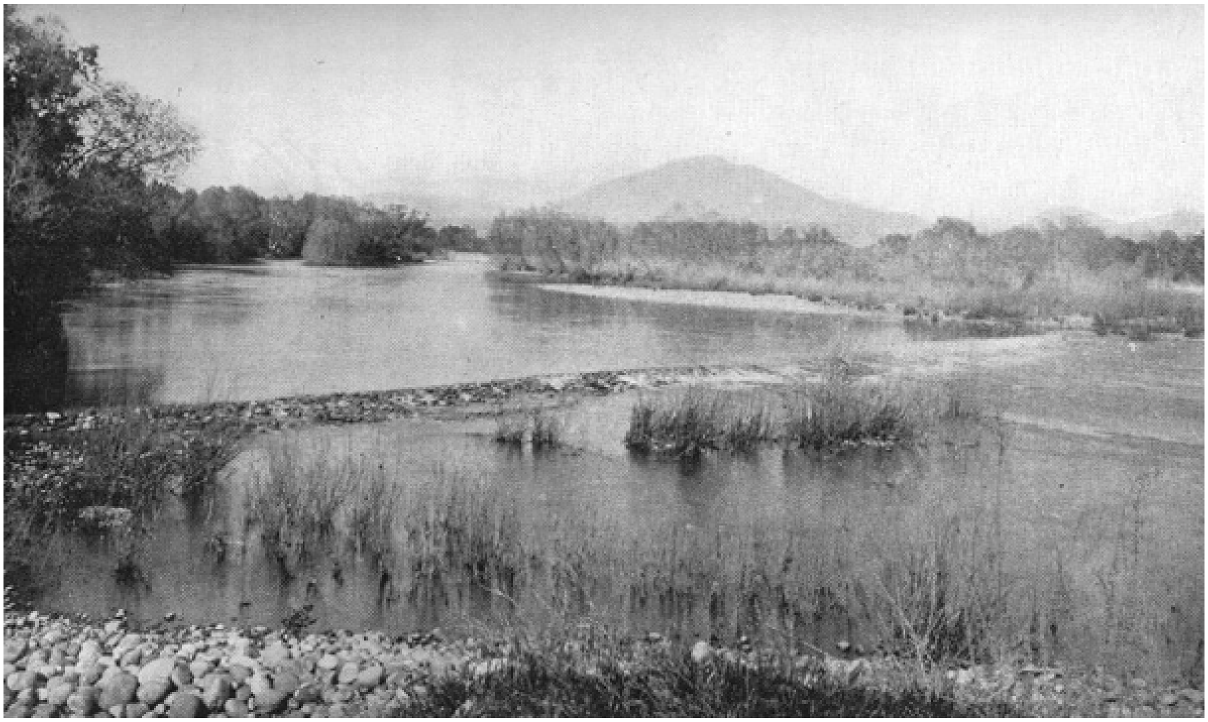


Figure 5. Cobble and brush dam, Fresno Canal, ca. 1898
(Grunsky 1898, Water Supply Paper No. 18:46)

In the first decades of the twentieth century, many private enterprise irrigation systems in the San Joaquin Valley, as in Southern California, were acquired by irrigation districts formed by local residents. The most common absorption occurred when local citizens formed an irrigation district covering the area served, and then purchased the commercial canals serving it. Among the examples of such changes in irrigation organization are several nineteenth century commercial irrigation companies that were later acquired by the Fresno, Consolidated, Madera, and Merced irrigation districts.[71] Some private enterprise irrigation and water companies have survived into the present, including the Lemoore Water & Irrigation Company, with its main Melga Canal, located in Kings County.[72]

The irrigation district remains the single most important institution for water conveyance in the San Joaquin Valley. It was in the San Joaquin Valley that the Wright Act was born, promoted by local irrigators, and the valley was home of the three original Wright Act districts. Some of the later districts formed after the turn of the century, particularly those in northwestern portion of the valley like East Contra Costa, Byron-Bethany, Westside, Banta Carbona, and West Stanislaus, used canals and lift pump systems that were later built on a far grander scale by the Central Valley Project and State Water Project on their aqueduct systems. San Joaquin Valley irrigation districts, along with more modern counterparts like water conservation districts and groundwater management districts, provided a powerful measure of public control over water use. Department of Water Resources records show that in 1995 there were 122 agencies providing water in the counties forming the San Joaquin Valley.[73]

After irrigation districts took over in the 1910s and 1920s in the San Joaquin Valley, they typically replaced the wooden headgates, control structures, and diversion works with concrete structures.[74] Many canals remain earth lined, however, although areas with high seepage losses or problems with high groundwater tables installed linings in their originally earth-lined conduits. For example, even some of the largest canals of the Fresno Irrigation District, passing though urban Fresno, remain unlined except where washouts or seepage problems require repairs. On the other hand, canals and laterals in the Modesto and Turlock irrigation districts have been lined since the 1920s.[75]

Sacramento Valley

The Sacramento Valley, the northern part of the California's Central Valley, receives substantially more rainfall than the San Joaquin Valley. Consequently, Sacramento Valley farmers continued to dry farm wheat much longer than their counterparts in the San Joaquin Valley, and development of irrigation systems was slower than on farms to the south. The Sacramento Valley was not, however, immune to drought. Farmers there suffered the same basic dilemma that faced California agriculture in general—even when there was enough water, it did not fall during the season most crops needed it. Nevertheless, few attempts at irrigation went forward between 1850 and 1870.[76]

Yolo County farmers were among the first to build irrigation canals in the Sacramento Valley, beginning in the 1850s. Jerome Davis supplied water to his orchards and vineyards at present-day Davis, and James Moore built an irrigation ditch in 1856 in Capay Valley. The original Moore ditch measured eight feet wide on the bottom, had a depth of eight feet, and side slopes of 1.5 to one. In 1863, the ditch was enlarged to 16 feet on the bottom with the same depth and side slopes. The ditch had no permanent diversion dam. Each year the first freshet washed out the previous year's brush and gravel dam, which was replaced as the creek subsided. Other engineering features were crude wooden structures, such as the headgate described by the state engineers as "a ponderous box with posts of hewn oak and gates...requiring 2 to 3 men to handle them" (Figure 6). Moore owned 1,000 acres of riparian land adjacent to Cache Creek, and by the early 1870s, his system served about 15,000 acres. The ditch was managed by a *zanjero* who attended to the necessary repairs, divided the waters among irrigators, and collected water fees. The ditch originally cost $10,000-$12,000 and brought in annual receipts between $3,000 and $7,000.[77]

Figure 6. Headworks and dam, Moore Ditch, ca. 1900
(Chandler 1901:22)

Other Sacramento Valley farmers were not so successful during the first few decades after the gold rush. Will S. Green, who owned thousands of acres near the Sutter Buttes, promoted a large-scale irrigation scheme during the 1860s which would have watered 600,000 acres between the Tehama-Colusa county border and Cache Slough in Solano County. He secured little public support and was unable to finance the huge undertaking.[78] In his 1880 irrigation survey, State Engineer Hall noted only 13,400 irrigated acres in the Sacramento Valley, on Cache Creek in Yolo County.

The Stony Creek area on the dry northwestern side of the Sacramento Valley illustrates the struggling and limited nature of irrigation efforts in the late nineteenth century. W. T. Clarke and C. W. Landis, of the United States Department of Agriculture (USDA), described a total of 39 canals taking water from Stony Creek in 1902. The ditches were located mostly in Glenn County, with a few in Colusa and Tehama counties. The irrigation works were mostly relatively short, earthen channels, a mile or two long. A few, like the Lemon Home Ditch, Orland Canal, and Fruto Land and Water Company Ditch, were more substantial, running from five to 10 miles long.

The Stony Creek Irrigation Company constructed the Orland Canal as a private enterprise in 1891-1892. Clarke and Landis reported in 1902 that its average cross section was 10 feet by two feet, with a grade varying between 3.2 feet and five feet per mile. At the time of this survey, the ditch was capable of serving 20,000 acres, but only 225 acres of alfalfa and fruits were being irrigated. At the same time, four of the 39 ditches using Stony Creek were not in use in 1902. Orland area farmers formed the West Side Irrigation District in 1888, but as was common with most other districts of the period, its organizers could not sell the bonds to finance its activities and the district failed.[79]

Despite such financial concerns, more Sacramento Valley farmers were planning irrigation projects by the 1880s, particularly once the Wright Act passed. The Central Irrigation District, organized several months after passage of the Wright Act, sought to irrigate a large tract in Glenn and Colusa counties on the west side of the Sacramento River. The district failed after completing several miles of main canal. In 1903, the Central Canal and Irrigation Company purchased its works, with plans to irrigate a more limited area, and intending to build new works to increase deliveries. This company passed through several hands and became embroiled in substantial legal controversy until it was finally absorbed into the 121,592-acre Glenn-Colusa Irrigation District, organized in March of 1920.[80]

By 1929, there were 15 irrigation districts in the valley between Redding and Sacramento. Of these, eight were established between 1916 and 1919, a period of great expansion of the California rice industry, and the remainder between 1920 and 1926. Some districts served large areas, particularly those contiguous with the massive Glenn-Colusa district, while other small districts served essentially suburban areas like Fair Oaks and Carmichael near Sacramento. In most cases, the districts absorbed existing works and systems, or were successors to land and water companies. The suburban systems, in particular, were related to suburban "colony" development. They generally had the majority of their systems in pipe at an early date.[81]

Shortly after the USDA's survey of Stony Creek and the Orland area, the US Reclamation Service, predecessor of the US Bureau of Reclamation (USBR), began studying the feasibility of plans for an irrigation system for the same area (Figure 7). This irrigation system was one of the first 25 reclamation projects selected for construction by the newly created service as part of its mission to help Westerners improve their land.[82]

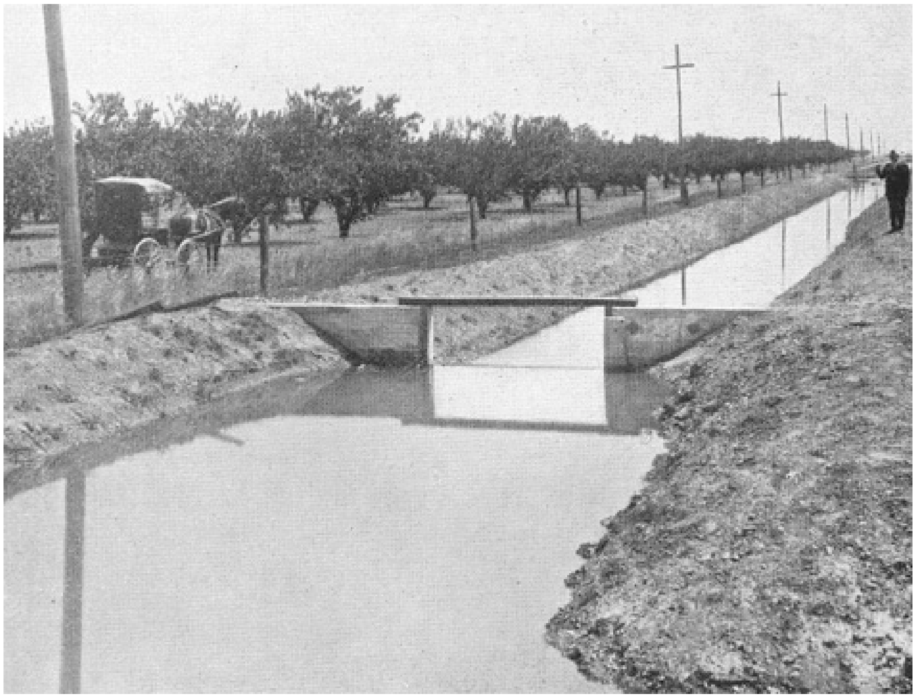


Figure 7. Orland Project lateral, ca. 1914
(US Reclamation Service 1914:Plate 20)

Farmers served by the earthen ditch system of the USBR's Orland Project began irrigating some crops in 1911, and by 1916, the initial system was largely complete. The biggest problem faced by project farmers was seepage loss, so in 1917, landowners agreed to increased project charges in exchange for an additional agreement with the USBR for lining the canals. Day labor directed by the USBR lined 64 of the 146 miles of canal in the Orland Project by early 1922.[83]

During this time, irrigation from wells also played an important role in Sacramento Valley agriculture. Wells were often the source of water for small ditches serving individual farms. Irrigation districts continued to be important after 1930, and today there are approximately 70 agencies providing irrigation water in Sacramento Valley counties.[84]

Central Coast, Sonoma to Ventura Counties

Spanish and Mexican settlement had a lasting effect on the settlement of California's central coastal area. Many of the ranchos were located along the coast, strung along between the missions in the valleys on or near El Camino Real. The early rancheros, like the missionaries, raised stock and dry-farmed agriculture in these areas. After secularization of the missions, petitioners quickly filed to obtain vast tracts of mission rangeland in coastal counties and on fertile river bottoms like the Salinas Valley. About half of the 70 ranchos granted in Monterey County were located to take advantage of the rich lands in the Salinas Valley. At the southern end of the coastal region, cattle country took up half of Santa Barbara County, and former rancho land in the rolling hills of western and central San Luis Obispo County still supports huge herds of cattle. Extensive irrigation systems were not needed for this type of agriculture based on large-scale stock raising and dry-farmed grains.[85]

Agriculture along California's central coast developed in adaptation to each local area's unique climate, geography, and hydrography. The vineyards in the counties north of San Francisco Bay utilized soil considered poor quality for other crops and often received enough rain to go unirrigated. The Salinas Valley and other humid coastal zones supported crops that benefited from dense ocean fogs. While foggy weather does not extend very far inland, farmers in this zone could grow unirrigated crops that were able to use airborne moisture, such as artichokes and strawberries in the Salinas Valley and tomatoes and lima beans in Santa Clara and Santa Barbara counties.[86] Another characteristic of central coast agriculture was the prevalence of groundwater obtained from wells and delivered through pipelines, subsurface irrigation, and sprinkler systems. Because this unique system of specialty crop agriculture did not rely on surface irrigation conveyance, canals were comparatively rare in this region.[87]

Early viticultural development came to Sonoma, Napa, and Santa Clara counties in the 1860s and 1870s, as experienced European wine makers arriving in California began planting vineyards in the central coast area. Missionaries and gold rush farmers had established vineyards of mission grapes, but this variety was susceptible to pests and did not produce very good wine. Ironically, viticulture in the cooler central coast counties produced higher quality wines in poorer soil, unirrigated in some areas, than the more established southern vineyards.

California's most famous wine grape grower, Colonel Agoston Haraszthy, experimented with many locations before choosing 560 acres in Sonoma County for his Buena Vista Ranch. Haraszthy invested time and effort in early California viticulture by importing 200,000 samples representing 1,400 varieties of European grape vines in 1860. French vintners Etienne Thee and Charles Lefranc founded Almaden Vineyards in the Santa Clara Valley, and other French growers located their operations in San Jose. Northern European wine makers such as Charles Krug made names for themselves in the Napa Valley. Many of these pioneering wineries were successful ventures that have survived and expanded into other coastal areas.[88]

Following a statewide trend during the last quarter of the nineteenth century, farmers along California's central coast also turned to various specialty crops. Small plum, prune, peach, apricot, and pear orchards had been planted at the missions and set a precedent for later orchardists. Santa Clara and San Benito farmers put in orchards of many varieties, but by the end of the 1920s, other nationally important specialty crops took the place of deciduous fruit in these areas. Salinas Valley became the largest supplier of lettuce in the nation, along with substantial production of broccoli, artichokes, strawberries, celery, and other row crops. The transformation of Monterey County, from 60 acres of lettuce and 95,000 acres of grain in 1920 to the nation's

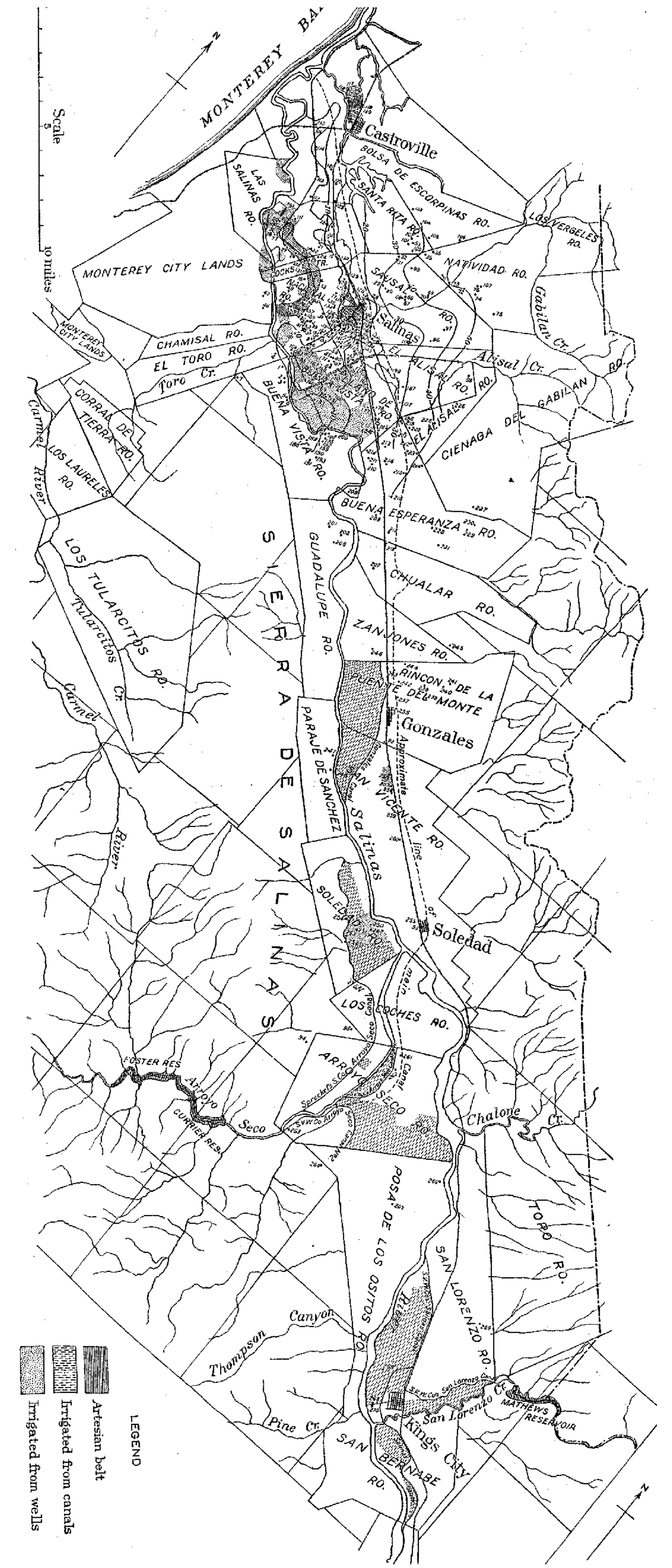


Figure 8. Salinas Valley irrigation (Hamlin 1904:Plate 2)

specialty vegetable center two decades later, illustrates the basic trend of coastal valley agriculture. Farmers quickly accepted these profitable new crop types and turned away from dry-farmed grain.[89]

These farmers, however, relied more upon groundwater than surface diversions for their irrigation supply. In 1900, Charles Marx with the Reclamation Service reported that among his observed instances of irrigation in the Salinas Valley, 15 were from wells, nine pumped from the river, and four employed canals. The canals irrigated an aggregate of only 4,860 acres. They were earthen, ranged from 25 to 40 feet across at the top and 20 to 30 feet across at the bottom. The three Marx observed carrying water were five feet deep; one canal did not irrigate that year. In Marx's view, of the 70 water rights filings made in Monterey County for the Salinas River, only 10 actually appropriated water. Homer Hamlin confirmed these findings when he surveyed the Salinas Valley for the US Geological Survey a few years later in 1902. Hamlin listed 270 wells. His water supply report also included a map illustrating lands irrigated by canals and showing that this land was located solely within the boundaries of various Salinas Valley ranchos (See Figure 8 and Table 3).[90]

The coastal range county of San Benito illustrates the general progression from dry-farmed grains to more specialized agriculture. By 1920, farmers there were beginning to recognize the possibilities of diversified agriculture, but most still depended heavily on dry-farming. Those who did irrigate obtained water from wells, bringing the pumped water to crops through either temporary flume and pipe systems or in permanently installed underground pipe systems. San Benito County communities advertising surface irrigation systems included:

Ausaymas: "Some orchardists irrigate

by damming [Pacheco] creek."

Union: "Irrigation is by gravity ditch system" and pumping.

Tres Pinos: Other than "irrigation canals which flow along the west side of the Tres Pinos Section, irrigation is from wells."

County officials were eager to point out the area's production of specialty crops like cherries, blackberries, strawberries, grapes, nuts, sugar beets, and tomatoes, but they could not have forecast the explosive growth of vegetable crops that began in the mid-1920s.[91]

Even with the turn to production of vegetable crops, surface irrigation development in San Benito County remained small compared to Central Valley or Southern California systems. The San Benito Land and Water Company, for example, began serving farmers in the vicinity of Paicines from their concrete diversion dam, main canal, storage reservoir, and approximately 20 miles of distribution laterals in the 1890s. When water supplies were low, the company conveyed the stored water into the natural channel of the stream, diverting it back into a system of laterals for conveyance on either side of the San Benito River. According to a 1919 promotional pamphlet, this service "changed hay and grain land into orchard, berry, and alfalfa land." What the promoters failed to note was that a large area of the county still depended on dry farming. Furthermore, the company's system could not meet the demand for water, and irrigators supplemented their supply with many private pumping plants. A subsequent drop in groundwater levels led local farmers to approve the formation of the Hollister Irrigation District in 1923. The engineer hired by the new district found that the area would be better served by a water storage district and underground water management, rather than a surface system. The district, however, apparently failed to survive.[92]

Table 3. Salinas Valley irrigation canals ca. 1902*

Canal Name	Statistics (Built / Length / Dimensions)
Salinas Canal	1896-1897 / 9 miles long / 40' top, 30' bottom, 5' deep. Diverts winter and spring only; irrigates 3,500 acres on San Bernabe Rancho; crops mostly sugar beets and barley.
San Lorenzo Canal	1896 / 8.5 miles long / 30' top, 20' bottom, 5' deep. Diversion point is temporary dam, diverting during winter only; roughly 800 acres irrigated.
Arroyo Seco Canal No. 1	1897 / 4 miles long / 35' top, 25' bottom, 5' deep. Serves about 300 acres east of the Arroyo Seco channel on the Arroyo Seco Rancho.
Arroyo Seco Canal No. 2	1899 / 4 miles long / 27' top, 17' bottom, 5' deep. Diversion point is temporary dam; canal serves 4,000 acres of the Arroyo Seco Rancho.
Arroyo Seco Canal No. 3	1901-1902 / 14 miles long / 28' top, 20 bottom, 4' deep. Irrigates about 2,000 acres on the Soledad Rancho south of the Salinas River.
Gonzales Canal	1899 / 7.5 miles long / 32' top, 16' bottom. Temporary diversion dam constructed of sand and brush; irrigates 2,700 acres; primary crop is grain, but last season irrigated about 500 acres of alfalfa, beets, and beans.
Brandenstein Ditch	Abandoned by the time of Hamlin=s field research in 1902; six-mile-long main canal (originally surveyed as 50' wide and 3' deep); eight to 10 miles of laterals unidentified; not on map.

*Total acreage irrigated by canals reported by Hamlin in 1902: 12,800.[93]

The limited development in this area of the state is reflected in the small number of irrigation agencies existing today. In the area between Sonoma on the north and Ventura on the south, there are only 20 agencies providing irrigation water; of these, eight are in Ventura County alone. Santa Clara and Marin counties reported only one each; Napa, Monterey, San Benito, and San Luis Obispo counties reported none.[94]

Northern California

Northern California supports relatively little irrigation outside of the Sacramento Valley and the Sierra Nevada foothills, because the terrain is generally too rugged for large-scale irrigated agriculture. This portion of the state is mountainous, with the Coast Range, Klamath Mountains, Cascade Range, and Sierra Nevada crowding around the northern end of the Sacramento Valley. The Modoc Plateau fills the northeastern corner of the state with lava beds and hills, at an average elevation of 4,500 feet. Any need for irrigation is further reduced by the fact that this area is, overall, the wettest in the state. The rainfall feeds the Klamath, Trinity, Mad, and Eel rivers which drain to the Pacific Ocean; the McCloud, Shasta, and Pit rivers draining to the Sacramento Valley; and the Susan and Truckee rivers draining into the Great Basin.[95]

Nonetheless, some irrigated agriculture has developed, especially on the Modoc Plateau where there is more tillable land and less annual precipitation, about 15 inches per year. Irrigation has also been employed in a few Northern California valleys. Pit River ranchers have been irrigating small acreages since the late 1800s, and Shasta Valley farmers in Siskiyou County brought water to about 43,000 acres by the early 1920s. In the area around Macdoel, Yreka, and Scott Valley, irrigation systems composed of long main canals and complex lateral systems irrigated local pasture and farm land. Several irrigation districts, such as the Grenada and the Big Springs, were formed to take over unsatisfactory private water systems. In the Hot Spring Valley Irrigation District, on the other hand, the only works owned by the district was Big Sage Dam. This dam served to regulate and augment flows on the Pit River; local ranchers built simple timber diversions in the river to flood their fields.[96]

The northern irrigation districts were organized to irrigate alfalfa, grain, and pasture land, which they still do today. As support for stock raising, and not in high-value crops, their basic organization appears to be more informal in this region. For example, the Big Valley Irrigation District (Lassen and Modoc counties) has been largely inactive since its organization in 1925, and the Tule Irrigation District (Lassen County) has been inactive since 1941.[97]

In the Coast Range, Mendocino County public utility or water districts provide irrigation water. The only exception, the Potter Valley Irrigation District, was organized in 1924 to take water from the tailrace of the Potter Valley Powerhouse and distribute it through a 35-mile-long system of unlined main canals, laterals, flumes, and culverts.[98]

After attempts at larger ventures, most of the agricultural development in Northern California eventually centered around small private holdings and individual or small private irrigation works. In Modoc and Lassen counties, settlers planned large-scale irrigation projects with varying degrees of success since the late nineteenth century. As is true throughout the state, irrigation in these counties passed from a private to a public phase, but unlike other areas, small private irrigation systems enjoyed the most long-term success. Private efforts began the cycle. They date to the earliest period of settlement, when individual landowners and small associations built minor diversion structures to take water from streams to adjacent lands. More intensive efforts were first undertaken by private corporations in the late 1800s, although with little success except on the South Fork of the Pit River. Beginning in 1905, the Reclamation Service worked on the Klamath Project to drain Tule Lake for irrigated farm land in both Oregon and California.[99]

While irrigation schemes in this area often failed, failures were not due to lack of effort. Many individuals and organizations tried to construct a tunnel and conveyance system using Eagle Lake in Lassen County as a source for watering land in the Honey Lake Valley. Attempts in the 1870s through the 1890s did not succeed, and ultimately, neither did the Baxter and Tule Irrigation districts, which were organized to use the system in 1923. The tunnel last supplied irrigation water in 1935, and the irrigation districts struggled to obtain other water sources. The Baxter Irrigation District officially dissolved in 1954, and although the Tule Irrigation District remained on the books, it ceased activity in 1941. Other unsuccessful irrigation projects in Lassen County included attempts to irrigate the Madeline Plains, and the Standish Water Company's efforts to use pumped Honey Lake water from about 1909 to 1912. These endeavors left many visible canal segments in the area as proof of their efforts.[100]

The Pit River cattle ranchers learned as early as the 1880s to exploit the river's meanders to provide flood irrigation for meadow pasture land and hay fields. Settlements along the spring-fed Pit River relied on smaller reservoirs and individualized canal systems, the entire works generally owned and operated by individual landowners. Temporary dams in the river and its channels diverted water into short canals, flooding land away from natural water courses. By the turn of the century, these primitive but effective irrigation works were augmented by dozens of small reservoirs which could store water for delivery to more distant acreage and extend irrigation through the dry summer months. The California Division of Water Resources reported that there were 53 small reservoirs (generally less than 500 acre-feet capacity) along the Pit River in Modoc County in 1933.[101]

Figure 9. Lateral of the Klamath Project, under construction in 1949
(USBR Canal Linings and Methods of Reducing Costs, 1952: 62)

In 1905, the Secretary of the Interior authorized the Reclamation Service to build the Klamath Project, an irrigation system serving land in both Oregon and California (Figure 9). The project design included draining Tule Lake, located mainly in Siskiyou and Modoc counties, to create agricultural land that could be irrigated by water from the upper Klamath River in Oregon. Some irrigation began soon after construction started in 1909, but progress was slow, and the project faced various problems including legal issues of state jurisdiction, poor soil, and long transportation distances. Settlement and successful irrigation did not pick up until World War I. The federal government offered the newly drained lakebed land in several stages beginning in 1917 and continuing through the 1940s. After nearly 50 years of federal management, residents voted in 1952 to form the Tulelake Irrigation District and began the process of repaying construction costs incurred by the government. Currently, most of the district's acreage receives water for cereal grains, alfalfa hay, irrigated pastures for beef cattle, onion, potatoes, and grass seed.[102]

Eastern Sierra

Although higher in elevation and more mountainous than the Mojave Desert, the eastern Sierra region receives relatively little precipitation. Lying in the Sierra Nevada rain shadow and averaging between five and 10 inches of annual rainfall, the eastern slopes of the Sierra Nevada, the Owens Valley, the Panamint Range, and Death Valley form a sparsely populated high desert area in Mono and Inyo counties.[103]

Most of the irrigable land in this region lies in the fertile Owens Valley. American settlers first recognized the agricultural potential of this long, narrow basin, drained by the Owens River, in about 1860. Cattlemen entered the area in search of water and forage in 1861 and began to build cabins. By the 1870s, cattle herds were regularly wintering in the valley. During the same period, private ditch companies engineered early irrigation development with canal systems in the Bishop, Laws, and Big Pine areas of Inyo County (Table 4). At the turn of the century, there were about 200 miles of canals watering over 40,000 acres of land in the Owens Valley. The major crops were cereal grains and forage, but some farmers began to set out apple, peach, pear, and plum orchards, as well as corn fields and vineyards. Irrigated agriculture did not progress much further because the City of Los Angeles had other plans for the water of the Owens River.[104]

Table 4. Owens Valley canals, 1904 [105]

Canal	Maximum Discharge	Comments
Owens River Canal	46 cubic feet per second (cfs)	Highest diversion on river
Bishop Creek Canal	121 cfs	Uses channel of creek
Hillside Ditch	8 cfs (est.)	
Loves Ditch	4 cfs (est.)	
Farmers Ditch	32 cfs	
McNally Canal	120 cfs	Highest diversion east side
Rawson Canal	35 cfs	
Geo. Collins Canal	15 cfs	
A. O. Collins Canal	50 cfs	Very overgrown
Dell Ditch	24 cfs	
Owens River & Big Pine Canal	104 cfs	
Sanger Canal	24 cfs (est.)	Overgrown, partial records
Stevens Canal	29 cfs (est.)	Partial records
Eastside Canal	94 cfs	Also hydro-power canal
Powers Ditch	18 cfs	
North Hillside Canal	13 cfs	
South Hillside Canal	5.7 cfs	

Los Angeles city planners looked to this source some 230 miles away as the solution to their municipal water supply shortage. The growing metropolis bought land and water rights in the valley to secure the supply, and by 1913, began delivering water to Los Angeles residents through an aqueduct that was an unprecedented engineering feat. At first, the city owned land around its diversion point on the Owens River and in large tracts in the southern part of the valley, leaving northern valley farms largely intact. However, irrigators used up the river supply during drought conditions in the 1920s, spurring Los Angeles to buy out the most of the remaining irrigated area. As a result, Los Angeles today owns "virtually the entire floor of Owens Valley."[106]

During the planning for the Los Angeles water project, engineer J. C. Clausen reported on the existing irrigation systems in the Owens Valley. According to Clausen, the canals were almost all built and owned by the private landowners who used them. Speculators had tried to establish colonies, but these efforts were failures or "met with only partial success due to the inefficient development of the water supply." Clausen listed 17 active canals and their capacities in his 1904 report. In the 1920s, the state listed no irrigation districts in the region, and only 3,000 acres in the Mono basin were irrigated.[107] Currently, two agencies provide irrigation water in Alpine County, one in Mono County, and none in Inyo County.[108]

Mojave Desert/Colorado Basin

The open, arid plain of the Mojave Desert is broken by few mountains and no major rivers. The Mojave River is the area's largest stream, but its surface flow is intermittent and the majority of its course subterranean. Lacking a natural outlet to the sea, the desert is dotted with dry lakebeds that collect seasonal runoff which soon evaporates in the desert heat. Southern California coastal basins catch most of the precipitation from storms that pass over this area of the state, leaving the southeastern desert with less than five inches of rain per year.[109] Because of the extremely arid nature of the Mojave Desert, irrigation has succeeded only in areas near the Colorado River, the one viable source of water for the region. Extensive irrigation systems using Colorado River water have been successful in both the Palo Verde Valley and the Colorado Desert (Imperial Valley).

Native Americans had used Colorado River water in a limited fashion in prehistoric times for growing crops such as beans and melons. Explorers also recognized that it could be an excellent water source for irrigated agriculture. Some early California immigrants tried to establish irrigated agriculture in the region, but their attempts were unsuccessful. In addition to the unstable soils that made canal construction technically difficult, settlers were unwilling to endure the harsh climate. The newly named Imperial Valley begin to develop widespread irrigated agriculture only after 1898-1899, when C. R. Rockwood and George Chaffey took an interest in the area.[110] Even Chaffey's efforts in the Imperial Valley did not succeed totally until the federal Reclamation Service became involved.

Chaffey and Rockwood's California Development Company built a canal to serve the Imperial Valley in 1900-1902. Because of unstable sandy soil west of the Colorado River, part of the canal alignment had to be constructed south of the border, and it ran through Mexican land before turning north into the Imperial Valley. Farmers irrigated 25,000 acres the first season, and 100,000 acres by the next. In an effort to avoid water rights issues raised by a hostile federal Reclamation Service, and to get around large accumulations of silt at the out-take on the Colorado River, on the American side of the border, the California Development Company cut a wide outlet with no headgate in the riverbank inside Mexico. Unusually high flood waters tore open this outlet in the winter of 1905, overwhelming the main canal. On and off for the next two years, the Colorado River flowed through the main canal, flooding large areas of the Imperial Valley, destroying many farms and parts of some communities, and ultimately filling the Salton Sink, creating the Salton Sea.

As work developing the valley went ahead, the company organized smaller mutual water companies to build ditch systems drawing off the main canals. By 1906, over 130,000 acres were under irrigation, growing to 180,000 acres in 1910, but Chaffey and Rockwood's company had gone into receivership in 1909. As demand for an irrigation district grew among remaining settlers, the Imperial Irrigation District was created in 1911. It encompassed more than 600,000 acres, by far the largest in the state. The Southern Pacific railroad purchased the California Development Company's works in February 1916, and then sold them in turn to the Imperial Irrigation District in June. By 1919, total irrigated acreage in the valley reached 400,000 acres, dropping to 300,000 at the beginning of the Great Depression, and in 1960 climbed to 565,000 acres.[111]

The massive works of the Imperial Irrigation District encompass an elaborate 75-gate heading on the Colorado River, a main canal running through to Calexico, and a web of over 2,400 miles of canals and laterals, with attendant gates, checks, drops, and miscellaneous structures. In the 1920s, the canals were unlined. Until most of the district's canals and laterals were straightened and lined with concrete beginning in the 1950s, they were plagued by silting problems. For example, in 1927, the district cleaned sand and silt from 3,274 miles of canals and surface drains.[112]

Among the reasons for the USBR's involvement in irrigation development in the Imperial Valley was the constant danger of the canal system's being washed out during high water stages in the Colorado River. In addition, the canal alignment located partly in Mexico left the system vulnerable to international disputes. During the late 1930s the USBR headed the All-American Canal project to construct a new canal north of the border. When completed, the All-American Canal brought water to the Imperial Valley south of the Salton Sea, and a branch called the Coachella Canal irrigated the Coachella Valley north of the Salton Sea.[113]

The Palo Verde Valley, in the extreme southeastern corner of Riverside County, bordered on the east by the Colorado River, is another important example of Californian desert irrigation. In 1877-78, Samuel Blythe obtained 40,000 acres of swamp and overflowed land in the valley and began raising cattle in the valley. Floods in 1905 and 1922 destroyed most of the existing irrigation system. In 1908, the Palo Verde Mutual Water Company acquired what remained of the water works after the first flood and improved the system; however, the company was not strong enough financially to survive the second flood in 1920.

In 1923, local landowners organized the Palo Verde Irrigation District. With special legislation providing for flood protection, irrigation, and drainage, this district was ultimately successful. By 1926, it delivered water through a concrete headgate built into the Colorado River, four miles of main canal, and 20 miles of main laterals. Along with the canals were installed 150 canal headings, 270 checks, 300 canal bridges, 700 conveyance outlets, a spillway, and 25 flumes. The district also controlled 68 miles of drainage canals and 34.5 miles of river levee protecting it from the Colorado River. In all, its canal system stretched over 200 miles. Although agriculture in the area struggled financially during the Great Depression, it expanded in the growing post-World War II economy.[114]

The Legacy of Irrigation Canals

Techniques used to construct irrigation canals have varied widely during the various periods of California's history, from the relatively short, hand-dug, early masonry and tile ditches, to horse-scraped and hand-dug earthen irrigation ditches, to the large concrete-lined, machine-formed irrigation canals of the middle decades of the twentieth century. Evidence of these changes in scale, methods of construction, and knowledge of engineering are reflected in the remaining physical resources found on the landscape today. Substantial regional variation exists with respect to the adoption and dissemination of the new technologies, such as where and when concrete replaced wood in the engineering works of major irrigation canals. These regional differences can be explained in part by cultural traditions with respect to water management, ownership of water rights, and environmental factors, but economics, politics, and the formation of particular types of irrigation institutions also played a significant role.

Older canals were often subject to substantial change over time. A common change was to expand the system in order to serve more acreage. Unless pumps are used, irrigation canals rely on gravity to move water, and they can provide service only to land lying below the canal's water level. As irrigated acreage expanded, water companies frequently consolidated smaller ditch systems, moved the point of diversion upstream, and built a high-line canal to service new acreage. In this manner, pioneer canals were often absorbed into larger systems, frequently by irrigation districts, to pull in more potentially irrigable lands. Segments of earlier irrigation systems might remain largely intact within the larger framework of a new irrigation system, or the changes could be such that the old separate irrigation system would become, in essence, a typical component of a new 1920s irrigation district canal.

Another important factor is that water is notoriously difficult to control; it can be, and frequently is, an engine of destruction. Flood waters, for example, repeatedly overwhelmed the flimsy wooden control structures built on nineteenth and early-twentieth century irrigation systems in the San Joaquin Valley. Canals were also often altered as a result of improvements designed to counteract the normal erosion that occurs from water moving through earth-lined canals. Improvements to stabilize canals ranged from realigning segments of the channel, to lining ditches or putting them in pipe, to replacement of checks, drops, culverts, or other regulation structures. These improvements were sometimes carried out systemwide, sometimes on a piecemeal basis. In light of the proclivity for change and the wide diversity of canal materials and modes of construction, adequate documentary research is essential to understand the evolution of an important irrigation canal and to assess its integrity.

MINING

Gold and gold mining had an overwhelming impact on California during the mid- and late-nineteenth century. A limited amount of gold mining had been done in the late eighteenth and early nineteenth century, but it was the 1848 discovery of gold at Sutter's Mill on the American River that turned gold production into California's major industry. Prior to 1848, the primary locations of gold mining were the Potholes, Cargo Muchacho, and Picacho districts in the southeastern corner of Imperial County (1775-80), San Ysidro in San Diego County (1828), San Francisquito Canyon in Los Angeles County (1838), and Placerita Canyon in Los Angeles County (1842). After 1848, gold was found throughout California, with the most productive areas in the northern and central parts of the Sierra Nevada.

William B. Clark, a geologist for the California Division of Mines and Geology, noted that most of California's gold production came from four of the state's 11 geomorphic regions: the Sierra Nevada, Klamath Mountains, Basin Ranges, and Mojave Desert.[115] In the Sierra, productive lode districts existed throughout the Mother Lode belt and in the southern end of the range. Placer deposits in the Sierra were found principally in Butte, Plumas, Nevada, Placer, Calaveras, and Tuolumne counties. In the Klamath Mountain region of Klamath and Trinity counties, large amounts of gold were taken by hydraulic mining. The Basin

Ranges and the Mojave Desert also produced significant amounts of gold, notably at Bodie in Mono County and in scattered areas throughout the Mojave Desert.

The Gold Rush

California's gold rush began with the discovery of gold at Sutter's Mill on the American River in 1848. By 1849, the gold discovery had ignited a world-wide frenzy, as 100,000 "forty-niners" dashed to the California gold country. The rush lasted only a few years, but it brought a major influx of people to California. Seeking quick fortunes, prospectors came from all over the world in search of California's gold. Many of the forty-niners arrived by ship and disembarked at San Francisco before heading to the Sierra gold fields. In 1849, most miners were working the area between the Yuba River and Mariposa County, the area known as the Mother Lode. The Mother Lode is a strip of land in the Sierra Nevada foothills, varying in width from 10 to 20 miles, and in elevation from 1,200 to 2,000 feet.[116]

The earliest forms of mining required water to wash lighter sands and gravels away from the heavier gold. From 1848 to 1850, miners could profitably work the easiest and most accessible diggings in or adjacent to water sources, along creeks, gulches, river bars, and river banks. During this early period, simple forms of mining predominated. Most of the miners worked independently of each other and were concentrated in the Mother Lode region of the Sierra Nevada foothills. They used implements including pans, picks, shovels, rockers (Figure 10), long toms (Figure 11), and sluices. The miners first used the pan, or *batea*. They mixed water and gravel in the pan, then with circular flipping motions, washed the lighter soil over the side until only the heavier gold-bearing residue remained. Experienced Mexican miners, from Sonora, Mexico, may have introduced the first pans.[117]

Figure 10. The rocker or cradle.
(Egleston 1887:18)

Other simple, hand-operated implements were introduced over the next few years. The rocker, long tom, and sluice all required water to wash over the auriferous gravel to extract the gold. Because of its high specific gravity, gold settled in the bottom of these devices as other lighter material was washed through it. The rocker, or cradle, was developed in 1848, probably by miners with gold mining experience in Mexico or Georgia. The rocker washed gravel on a perforated plate as auriferous dirt was poured into the oblong box through a sieve. Water carried away the lighter dirt, and the gold remained in the bottom of the rocker. The machine was "rocked" side to side to speed the washing.[118]

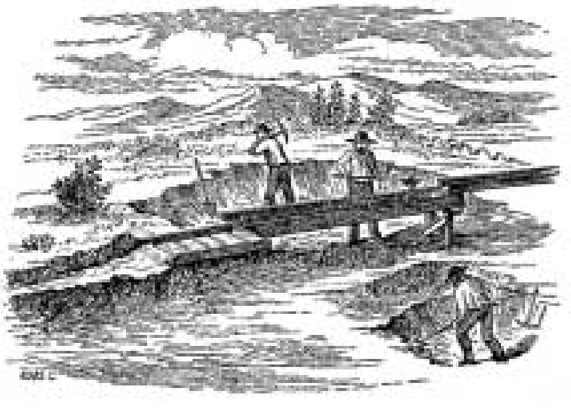


Figure 11. The long tom.
(Egleston 1887:19)

Another innovation of the early miners was the long tom, a short washing sluice with a perforated iron plate at the lower end to catch gold particles. At the upper end, gravel and water were mixed together as they entered the tom, usually through an inverted funnel to employ a greater force of water. The wider lower end slowed the water so that more gold would be caught. As water flowed through the tom, miners shoveled dirt in with the water. This operation usually required three or more men. Through working together on the rocker and long tom, miners first began cooperative efforts in retrieving gold.[119]

The practice of river mining also developed during this period. The early miners built dams, ditches, and flumes to divert rivers and streams from their natural channels in order to work the ore-bearing soils at the bottom of the streams. As early as 1849, companies of miners on the American River planned to turn that river from its channel. This type of mining was heavily dependent upon the weather, and river miners wanted a long, dry season that would keep the rivers' flow low. The dams, flumes, and canals used to divert the stream were temporary engineering works, typically built for one season, with a new structure planned for the following year. A variety of diversion structures were used: L-shaped wing dams, wooden flumes, and diversion canals were all used to expose the riverbed. Later companies captured entire streams and diverted them from their channels in large ditches, mammoth wooden flumes, or through bedrock tunnels. Dams diverted water from the rivers' natural course, while the flumes, canals, or tunnels channeled water away from the river beds. Below the area being worked, the water was dropped back into the natural streambed. These techniques continued in use until the late 1850s.[120]

On the Feather River, the Cape Claim Company conducted one of the largest river mining operations. In 1857, the company spent over $175,000 to build a river flume that was three-quarters of a mile long and 40 feet wide. The company profited by removing $75,000 worth of gold in 1857, but the next year they lost $40,000 and ended their operation.[121] Extensive river mining also occurred on the North Fork of the American River throughout the 1850s.

River mining influenced future mining development in California because it was the first time miners began to pool their resources and to work in large numbers together. Because of the high cost of labor and a lack of men willing to work for wages, anyone trying to build a ditch or dam found it difficult to hire laborers. Miners instead formed joint stock companies with each person having a share of the company and potentially its profits. Each member of the association worked on the project in order to "pay" their subscription to the company. In this way, the project could be completed with all members having a stake in the final outcome.[122]

Development of Large-Scale Mining

During the period 1850 to 1865, the era of the single prospector working a successful placer operation ended. Throughout the state, mining moved toward larger-scale production. By the early 1850s, the easily mined placer deposits along and in streams had played out, and miners had to look for gold in other locations, away from rivers. Miners had only two methods of retrieving gold from soil and sand: by winnowing or by washing. Winnowing used wind to blow away lighter material, as gold-bearing soil was tossed in the air, leaving the heavier gold behind. Washing was more efficient, but it required a substantial water source. The miners therefore had to either transport the dirt to a water source or bring the water to their "dry diggings."

Getting water to their dry diggings led miners to dig the first ditches used for mining. Because of the cost and effort to dig a ditch, miners pooled their money and labor to form water companies that could afford the cost of construction. Later some of these companies began to concentrate solely on selling water and not on mining. The water and ditch companies had a large impact on mining through the 1880s. In the early 1850s, new forms of mining, including quartz, drift, and hydraulic mining, began in an effort to expose and extract gold-bearing gravels and veins buried deep below the surface of the earth. Each of these industries had its own peculiar water demands.

In the early 1850s, miners began to build ditches to bring water to dry diggings. The first notable attempt to convey water to an area away from a stream took place at Coyote Hill in Nevada County in March 1850. In the spring of 1850, miners dug ditches along Coyote and Little Deer creeks near Nevada City to carry water to nearby long toms. The success of this 1.5-mile-long ditch led quickly to the digging of many other ditches in the state.[123] Other projects of a similar type began later that season when water was turned from the American, Feather, Yuba, and other rivers. In El Dorado County, the first ditch built for this purpose was the

Coloma Ditch, which had a length of three miles. Believed to have been completed in mid-1850, it carried water to the Coloma Valley at an estimated cost of $10,000.[124]

As early as 1850, the first water companies in the Sierra Nevada were also planned. The purpose of these companies was to build ditches and flumes to bring water to dry diggings, providing miners with water for washing gravels in long toms or sluices. Such ditches carried water to all the principal placer districts. The water companies, like river mining companies, were joint stock companies formed by miners and local merchants to bring water to an area that had previously been dry. The companies used their pooled funds and resources to hire laborers to construct water conveyance systems of ditches, canals, and flumes. Some miners left their gold claims to work digging ditches and building flumes for water companies.[125]

The first ditches dug by water companies were short and relatively easy to construct. One visitor to the gold country in 1850 wrote that miners working near rivers dug ditches to supply water to long toms located on the upper river terraces. The miners diverted water through a ditch “some two or three feet wide and about the same depth, with a sufficient fall to give the water a rapid current.”[126] The greatest expense in ditch digging came when the miners had to use pick and shovel to cut ditches through granite. Because there were few sawmills in the state and construction sites were frequently in remote locations, wood often had to be sawed and hewn by hand on site when building diversion dams and flumes. By pooling resources, the water companies could make these efforts possible.[127]

A large supply of water was a necessary requirement for working low hill gravels away from the rivers. As surface diggings played out and miners turned to deeper auriferous beds, sluicing revolutionized gold-washing. Hundreds of simple ditches carried water to the state’s placer districts, including the rich placer deposits in El Dorado, Nevada, Placer, Butte, and Tuolumne counties. The earliest ditches were used for only a short duration. Because water and mining companies had no water storage facilities, and streams often went dry during the summer, placering or sluicing operations ceased several months of each year.[128]

Among the most prominent of the early placer and ground sluicing mining water systems was the Natoma Ditch in Placer and Sacramento counties. Built by the Natoma Water and Mining Company in 1852-1853, the canal diverted water from the left bank of the American River, 1.5 miles above Salmon Falls. The main canal and its branches were constructed by miners who proposed using the water themselves. The canal was then turned over to the water company in lieu of water scrip, which in turn was redeemed by the company in the form of conveyance of water at certain rates. The main canal conducted water to the placer mines at Browns Hill, Red Bank, Richmond Hill, and Mormon Island, ending in a large storage reservoir two miles east of Folsom. Water from the reservoir was distributed by branch lines to mining ground owned by the Natoma Company and to Bunker Hill, Folsom Flat, Alder Creek, and the Texas Hill camps in the immediate vicinity of Folsom. The main canal was 15 miles in length with an average grade of three feet per mile. The canal measured eight feet across the top, six feet on the bottom, and was four feet, seven inches deep. There were four principal distribution ditches, averaging about two feet in width and 1.5 feet deep: Mormon Island Branch, 2.5 miles long; Bunker Hill Branch, 5 miles long; Rhodes Branch, 12 miles long; and Alder Creek Branch, 3.5 miles long. Numerous other smaller branch ditches totaled some 12 miles.[129]

Beginning in the early and mid-1850s with the development of hydraulic mining operations, water companies were created—not just by groups of miners to bring water to their own diggings, but by those who built ditches to deliver water to other mining operations for a fee. Many of the companies did not mine at all; instead they made their profit through the sale of water to mining districts.

Hydraulicking had increased the demand for water 50-fold during the 1850s, which raised the price that water would bring. The cost of building ditches and flumes for hydraulic mining operations could be enormous yet lucrative as long as demand held. For example, in 1852 or 1853, the Mokelumne Ditch Company in Calaveras County constructed a line of flumes and ditches 18 miles long at a cost of $250,000. At the same time a 16.25-mile-long canal was built in El Dorado County for $275,000. Still, for a private company, water systems could be extremely profitable because of the scarcity and high price of water during California’s dry summer months.[130]

Conflicts between ditch companies and miners often arose when the companies attempted to force miners to pay what the latter perceived as excessive rates. In 1855 near Columbia in Tuolumne County, the miners began protesting against the Tuolumne County Water Company, a ditch company, and its water rates. Most of the community joined in the struggle. Supporters of the protest invested their money in a competing ditch company, the Columbia and Stanislaus River Water Company. Such conflicts occurred throughout California between miners and ditch company owners, eventually leading the ditch owners to try to unite.[131]

The miners of Butte County rebelled against a Marysville speculator who sold water to the diggings in Kimshew Township, above present day Paradise, between the West Branch Feather River and Butte Creek. Gold had been discovered in the 1850s, and Dogtown (now Magalia) became a town of 500 miners by 1852, growing to be one of the most important mining regions in the county by the mid-1850s. In the summer of 1858, three local residents organized a ditch enterprise to bring water from near the headwaters of the West Branch to some newly discovered mines at Inskip. As with many locally financed water projects, the Butte County backers of the project soon found themselves in debt and were forced to sell their property to their suppliers, Marysville merchants Samuel L. Dewey and Stephen A. Faulk. Dewey immediately raised water rates to make the ditch venture profitable. Friction quickly developed between the outside ditch owners and local miners. In early 1860, a group of miners who held claims at Blowhard Hill organized a ditch company to channel water by a second ditch to their diggings. The Miner’s Ditch Company built diversion work on the West Branch 1.5 miles below Dewey’s head dam and conveyed water in a parallel ditch to the town of Inskip.

Within a year, James R. Dickey, the Inskip mill owner who had supplied the Miner’s Ditch Company with lumber for their long flumes, owned the ditch, which he promptly sold to Dewey. Thus, by 1861, Dewey possessed the entire rights to the only two diversions on the West Branch, along with Dickey’s Union Saloon and the only saw mill in Inskip. Dewey planned to construct a dam on the West Branch above Sailor Ravine and conduct 2500 miner’s inches to the diggings in the vicinity of Inskip with branch lines to other ravines. He held onto the ditch through the depressed 1860s, and when the discovery of the ancient river channel at Gold Hill was made in 1869, he finally cashed in on his investment. In 1871, he accepted an offer from the Spring Valley Canal & Mining Company, owners of the productive hydraulic mines at Cherokee Flat, to purchase his entire water system for $15,000. Through consolidation of several other small ditch systems like Dewey’s, Cherokee Mine became one of the largest hydraulic mining operations of the 1870s.[132]

Ditches constructed in the 1850s, like the Dewey and Miner’s ditches, generally were short, often less than 20 miles in length, as shown in forest historian Carmel Barry Meisenbach’s study of the ditches on the Tahoe National Forest. Meisenbach listed 34 ditches, most completed in the 1850s, in the San Juan Ridge district, located between the Middle and South Yuba rivers from the crest of the Sierra to North Columbia, where hydraulic mining was practiced extensively. Of the 34 ditches, only six were longer than 20 miles; 15 were 10 miles or shorter; eight were 11 to 20 miles in length; and five had no length given. The longer ditches, including the Milton Ditch, North Bloomfield Mining Ditch, and the Miner’s Ditch, were constructed by major mining companies. Three major ditch companies, the Milton Mining and Water Company, the North Bloomfield Gravel Mining Company, and the Eureka Lake and Yuba Canal Company, were located in the San Juan Ridge region. Only one of the three companies, the Milton Mining and Water Company (1853), was formed in the 1850s. The Eureka Lake and Yuba Canal Company was incorporated in 1860, and the North Bloomfield Gravel Mining Company was formed in 1866. These companies bought many of the existing ditches and enlarged them, along with building new ditches to bring water to their mines or to sell to other miners and mining districts.[133]

The Eureka Lake Water Company provides an example of how a ditch company would consolidate smaller ditches along with building their own. When the company incorporated in 1860, it brought together many of the small mining ditches in the San Juan Ridge area. It acquired the Grizzly Ditch, Irwin Ditch, Poorman’s Ditch, McDonald Ditch, Memphis Race, Spring Creek Ditches, and the Miner’s Ditch. Most of these ditches had been constructed by water and ditch companies in the early and mid-1850s to serve a single mining area. The Miner’s Ditch, for example, was completed in 1856 by a group of local miners, frustrated with the high cost and inadequacy of water at their diggings at Woolsey’s and Moore's flats. The total cost of building reservoirs, ditches, and feeder branches was $175,000. The Miner’s Ditch took water 20 miles from the

Middle Yuba River through a 750-miner's-inch-capacity canal that was five feet wide and three feet deep. In 1859, the Miner's Ditch company merged with the Eureka Lake Company.[134]

The Middle Yuba Canal Company was another typical ditch company that operated over a large region. In 1852, Charles Marsh, Mr. Pettibone, and Mr. Stewart began construction on the Grizzly Ditch, which took water from Grizzly Canyon to San Juan and Columbia Hill. The ditch had to be enlarged in 1855 to increase water supply. By the 1860s, the Middle Yuba Company owned the ditch. Grizzly Ditch served as a main trunk canal to distribute water to miners along the way to Columbia Hill. Four receiving reservoirs held water along the path of the canal, and branch ditches from these reservoirs or from the main canal supplied the miners. Where valleys had to be crossed, trestle flumes were constructed. The main part of the canal was seven feet wide at the top, four feet at the bottom, and three feet deep. The branch ditches were smaller, with dimensions of four feet at the top, 2.5 feet at the bottom, and two feet in depth.[135]

Of the early ditch companies, the South Yuba Water Company proved the most successful in the long run. It consolidated smaller companies as well as building its own ditches and canals. The company was unusual in that it had high mountain storage reservoirs as early as 1857, mostly small natural lakes that the company had dammed. The South Yuba supplied water to be used by hard-rock quartz miners, placer miners, and hydraulic operations. During the hydraulic mining period, the South Yuba Water Company emerged as the pre-eminent ditch company in Placer and Nevada counties.

The South Yuba Water Company originated with the 1850 construction of the main South Yuba Canal in Nevada County by the Snow Mountain Ditch Company. Snow Mountain, after merging with two other companies, began construction of the canal under the name of the Rock Creek, Deer Creek, and South Yuba Canal Company, which was later shortened to the South Yuba Water Company. By 1857, this company had completed the ditch from above Bear Valley (near modern day Lake Spaulding, originally constructed in 1892) to Big Tunnel (in sections 31 and 32 of T 17 N, R 11 E, MDM). The canal was 16 miles long before it branched into smaller systems, and it ran six feet wide at the bottom, eight feet wide at the top, and five feet deep, with a capacity of 7,500 miner's inches. By 1857, the company had built distributing reservoirs along the route and dammed 20 small headwater lakes to increase dry-season storage. The company continued to improve its operation through the 1850s and 1860s, including building a dam at Meadow Lake which increased by 10 times the capacity of the lake. By 1865, the South Yuba Water Company began inter-basin transfers of water between the Yuba and Bear river basins through the Yuba South Canal and its tributaries.[136]

From about 1858 through the mid-1860s, mining ditches decreased in value, corresponding to the decreasing value of placer and hydraulic mining throughout the region, and some ditches were sold or abandoned. Many ditches had been built during the 1850s, when water rates were high enough to cover the high cost of labor. In the depression of the late 1850s and early 1860s, ditch owners no longer commanded high rates for water as miners left the area for new mining strikes elsewhere. Many ditch owners either abandoned or sold their ditches during this period. For example, at Columbia, 40 miles of new ditch were abandoned in the 1860s. The Amador Canal Company built a 31-mile-long flume system in the 1850s, but when the upper 11 miles were damaged in 1862, the company chose not to rebuild because of the expense. The earliest ditches had been very profitable because they were short, small, and inexpensive to build and maintain, while the companies could sell the water at a high price or use it themselves to work rich placers. The small ditch companies avoided expenses incurred by larger companies because their ditches were normally short, intra-basin diversions, constructed over favorable terrain which did not require expensive, easily damaged engineering structures such as high flumes on trestles.[137]

Mining ditches reached their peak of development during the initial construction phase in 1858, but with the discovery of gold and silver at the Comstock Lode in Nevada, miners began leaving the area. Water rates dropped, and ditch owners could no longer afford to maintain their ditches and still sell water at a profit. Furthermore, until the federal government clarified the rights to use water and mineral resources on public lands with passage of the Mineral Act of 1866, and the state adopted procedures to record appropriative water claims in the Water Code of 1872, ditch owners invested at great risk because of uncertain legal title to water rights, mining rights, and rights-of-way for their canals on public lands.[138]

In the early 1860s, new mining rushes drained miners and investors to the Comstock and other territories, and hydraulic miners who remained in California fell into debt to the ditch companies upon which they depended. However, by the mid-1860s, hard times hit the Comstock Lode, causing men and money to slowly return to the western side of the Sierra. Comstock Lode mining had required heavy investments in labor, tunneling, and mining equipment, and the money was raised by selling stock in the San Francisco exchange. One important result of this financing was that it set off a stock exchange boom out of which emerged a group of entrepreneurs who began looking afresh at the California mines. By the late 1860s, capitalists were once more searching out promising investment opportunities in the hydraulic mines of the northern Sierra Nevada, and hydraulic mining began to regain the high promise it had shown briefly in the late 1850s.[139]

By 1865, water development for mining in California was conservatively estimated at 5,328 miles of conduit, built at a cost of over $15,000,000 (Table 5). That tabulation did not include numerous branch ditches, estimated to have an aggregate length of about 800 miles, nor were uncounted miles of smaller ditches added to the figure. In addition, 30 listed ditches had no defined length. Thus, the actual number of water systems developed to support mining activities and the aggregate ditch length were both considerably greater.

Two hundred and ten ditches were from one to 10 miles in length; 62 were 11 to 25 miles long; 14 were from 25 to 50 miles; and 16 were greater than 50 miles. The numbers for the last two categories may be exaggerated because a few listings reflected a company's total miles of ditches, not separate canals. For example, in Nevada County, J. Ross Browne gave the total aggregate length of ditches owned by the Eureka Water Company as 150 miles and the South Yuba Canal Company as 200 miles. As one would expect, the greatest number of ditches existed in the heart of the Mother Lode region, in the counties from Amador on the south to Nevada County on the north, where there were 2,521.5 miles of mining ditches listed.

Table 5. Mining ditches and canals by length, per county ca. 1865[140]

County	1-10 miles	11-25 miles	26-50 miles	over 50 miles	no length listed	Total Miles
Amador	15	8	3	1	1	412.75
Butte	9	2	0	0	1	64.5
Calaveras	5	6	4	0	0	291
Del Norte	13	0	0	0	0	35
El Dorado	12	9	1	2	1	832.25
Inyo	0	1	0	0	0	15
Klamath	5	0	0	1	0	91.25
Lassen	4	0	0	0	0	18.25
Mariposa	1	1	0	0	0	25
Mono	0	1	0	0	0	20
Nevada	2	6	0	4	0	577
Placer	11	11	2	3	0	699.5
Plumas	17	2	1	0	0	136
Sacramento	2	1	1	0	0	58
Shasta	8	6	0	1	0	201
Sierra	24	2	0	0	1	115.5
Siskiyou	18	4	0	1	1	223
Stanislaus	4	1	0	0	0	42
Trinity	41	1	0	0	0	139
Tulare	17	0	0	0	0	70.5
Tuolumne	2	0	2	2	0	242
Yuba	0	0	0	1	25	150

Hydraulic Mining

During the early 1850s, California developed one of its unique contributions to the world-wide mining industry—hydraulic mining. By the mid-1860s, nearly all of the placer gold taken in the state was extracted by the hydraulic method. One early mining observer noted that the most profitable placer claims were those worked by the hydraulic process and that the most prosperous mining counties were those with the largest areas suitable to hydraulic mining.[141] This method had a great impact on mining technologies in California. It also helped to transform the California mining industry from a highly individualistic business of small partnerships to a complex capitalistic endeavor with mine foremen and managers, mining and water engineers, financiers, and many mine laborers with specialized skills. Further, the hydraulic mining industry had an enormous impact on the California landscape and environment, by rearranging everything in touched. Hydraulic mining depleted fresh water supplies in natural channels, destroyed mountainsides, and returned debris-laden run-off to the rivers to be deposited in the Central Valley.

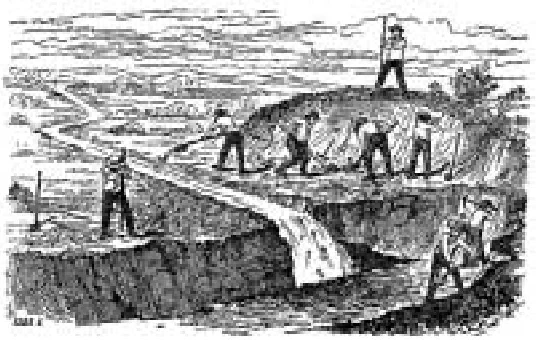


Figure 12. California ground sluicing (Egleston 1887:27)

Hydraulic mining evolved out of the ancient practice of ground sluice mining, which in its simplest form involved running water and gravel through a ditch to precipitate out gold-bearing gravel deposits. The heavier gold and sand would settle in the bottom of the ditch, and the gold could then be removed by panning. A more advanced method of sluicing employed a wooden trough with a rippled bottom that would catch the heavier gold as the clay, sand, gravel, and stones were washed out the tail end of the sluice. Usually a group of sluice boxes were arranged in a string with the lower end of one attaching to the upper end of the next. The technique of ground sluicing went back as far as the first century, AD; Pliny the Elder wrote about a form of mining being done in northern Spain at that time that resembled ground sluicing. By the sixteenth century, this method was being used in Europe, and was described by Agricola. Sluicing was widely used in California by 1850 and 1851 (Figure 12). With the development of advanced sluicing technologies, the state entered a new phase of gold mining, with miners less concerned with collecting every particle of gold than with washing vast quantities of earth and thus capturing more gold in the same amount of time. Volume rather than efficiency became the rule.[142]

Hydraulic mining quickly became the principal method of deep mining in California. It can be broadly defined as “that method of gold-mining in which the ground is excavated by means of water discharged against it under pressure.”[143] It basically involved the employment of large quantities of water shot through a hose and nozzle against a mountainside to wash ore-bearing ground (Figure 13). Sluices were then used to capture the gold. Hydraulic mining effectively removed gold from ancient river channels where much of it was buried. Miners brought water from sources several miles away through ditch, tunnel, or flume, keeping the water well above the elevation of the mining site. When the water reached the mine, it was conveyed into a hose and dropped to build up pressure. The water was then shot out of the hose

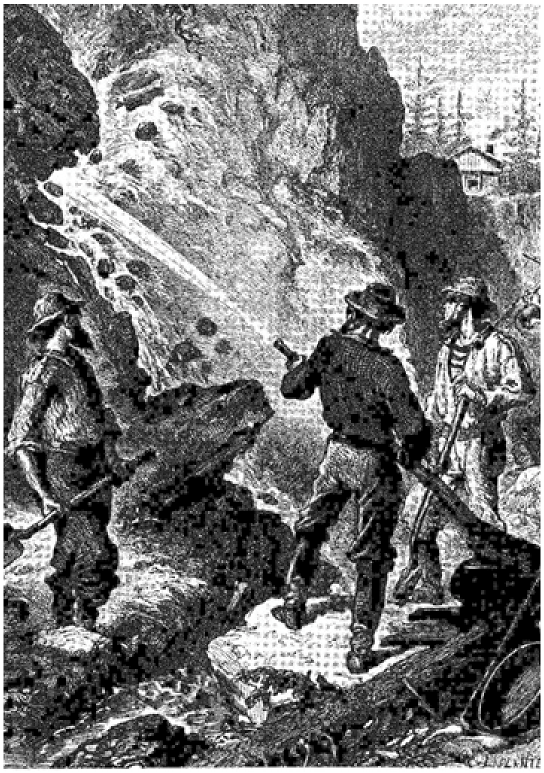


Figure 13. Early hydraulic mining operation. (Simonin 1836:444)

through a nozzle, or monitor. Employing water under pressure, a miner could quickly wash away much greater amounts of gravels than was previously possible. J. Ross Browne and James W. Taylor estimated in 1867 that a miner with a rocker could wash one cubic yard of earth a day, with a long tom two yards a day, with a sluice alone four yards a day, and by hydraulicking 50 to 100 yards per day.[144]

Two individuals are credited with having the most influence on the development of hydraulic mining in California: Anthony Chabot and Edward E. Matteson. In the spring of 1852, Anthony Chabot improved his ground sluicing operation by attaching a canvas hose to the flume that brought water to his claim at Buckeye Hill, east of Nevada City. The canvas hose greatly increased the range that water could be run over a sluicing area. Chabot, a French-Canadian who had come to California in 1849 in search of gold, made his mark on California's water history in other ways as well. Through the 1850s he built, or secured interest in, mining ditches in Yuba and Sierra counties. Then in the late 1850s and early 1860s, Chabot and two partners formed the San Francisco City Water Works, which merged in 1865 with the Spring Valley Water Company. These companies supplied San Francisco with its municipal water. Chabot was also involved in the development of pioneering municipal water systems for Vallejo, San Jose, and Oakland.[145]

Edward E. Matteson is most often regarded as "the father of hydraulicking." Matteson operated a ground sluicing claim at American Hill near Nevada City in the spring of 1853, with water supplied by the Rock Creek Water Company. Here he first experimented with hydraulic mining. Matteson ran water through a rawhide hose down a 30-foot drop from a supply ditch and attached a brass nozzle to the end of the hose. The resulting advantages, noted in a newspaper of the day, included the reduction of manual labor and extension of mining operations to new locations. Matteson continued hydraulic mining through the 1850s and 1860s. In 1860, while working on the south fork of the Yuba River at the Omega Diggings, Matteson made his second contribution to California mining by devising a hydraulic derrick that could move the heavy boulders that sometimes hindered hydraulic operations.[146]

Hydraulic mining spawned many other early technical advancements in water engineering. By the end of 1853, light sheet iron was introduced by R. R. Craig on American Hill, Nevada County, to replace Matteson's rawhide hoses. Three years later, a San Francisco manufacturer began to produce wrought iron pipes for hydraulic mining locally. By 1857, sheet iron pipe up to 40 inches in diameter was being used in a conduit to cross a ravine at Timbuctoo in Yuba County. Before the end of the 1860s, these experiments with wrought iron water conduits led hydraulic mining engineers to lay the first inverted siphons (pipes with a section lower than both ends; "sag pipes") in the mining regions.[147]

Hydraulic mining offered many advantages over other forms of placer mining. As sluicing developed, miners learned that a significant amount of water ran to waste as they shoveled dirt into the sluice. Hiring more men to work on a sluice was expensive, at rates of six to eight dollars per day. Hydraulic mining accomplished the same or more work with fewer men. It was also a marvelously cost-effective method of exposing the richest gold-bearing gravels for processing. Other forms of deep gravel mining were more dangerous than hydraulic mining. Experience quickly proved that the top gravel of deep alluvia was not rich enough to repay investment of large amounts of capital. "Pay dirt" was almost always obtained in the eight-to-10-foot strata above bedrock. By 1853, miners had begun to dig down and retrieve these auriferous deposits that were buried in the bottom of ancient riverbeds. The tunnels down to the gold-bearing gravels, known as coyote holes, were dangerous because of possible collapses. However, with hydraulic mining, the whole mountainside was washed away, exposing the gold-bearing strata without threatening the mining crews who worked at a distance from the ground being washed.

The need for larger outlays of capital grew as mining sites further away from water sources were developed, requiring new methods of mining and of raising capital. The most common technological improvement was lengthening and/or enlarging existing ditches, canals, and flumes.[148]

With the exhaustion of the rich and shallow dry placer diggings close to rivers and streams, canals were expanded to reach relatively lower-grade deposits at a greater distance from water sources. These longer canal systems employed more elaborate engineering, including massive flumes and permanent diversion works. Technical advances in mining, by reducing the cost per unit in raw materials handled, extended work progressively to comparatively low-grade mines. The evolution of hydraulic mining procedures reduced the costs of extraction of gold to less than a cent per cubic yard of gravel, while using the old rocker method, the same unit cost soared to $5.00. However, hydraulic mining in every case required large amounts of water.

During 1855 alone, miners and water entrepreneurs built more than 1,159 miles of mining ditches in California. By 1857, they had placed 4,405 miles of mining canals and ditches in operation statewide. The most extensive ditch systems were concentrated in the primary hydraulic mining regions where big companies had consolidated individual claims and invested capital on a long term basis—in El Dorado, Nevada, Placer, and Tuolumne counties.

The builders of hydraulic mining canals required a small army of laborers to dig earthen ditches, drill and blast obstacles, and build rock retaining walls and flumes. With the completion of the transcontinental railroad in 1869, 25,000 laborers of various ethnic groups, including Chinese, Cornish, and Irish, who were experienced in tunneling, railroad and road construction on a massive scale, became available to work on other construction projects. The East was experiencing a depression in the aftermath of the Civil War and Reconstruction, and hopes for boundless opportunity in the West following completion of the transcontinental railroad drained off excess labor supply in the East and aggravated the condition of the labor market in the West. The 1870s was an era of economic consolidation for big businesses and of chronic underemployment for wage laborers in California.

Chinese immigration reached a peak in California from 1868 to 1876. These newcomers joined other Chinese, former miners and transcontinental railroad workers, on the pick-and-shovel brigades that built irrigation and reclamation canals, levees, railroads, and harbor improvements. In 1867 the North Bloomfield Company employed 800 Chinese and 300 white workers on its canal (Figure 14).[149] In Tuolumne County, an ethnically mixed group of 1,500 workers, including 600 Chinese along with French, Italians, Portuguese, Irish, and Americans, constructed the La Grange Canal in 1871-72.[150] Because wage labor on typical canal projects ran about 55 percent of the total cost, labor costs were of paramount importance to water and mining companies contemplating an expansion of their water supply.[151] In the early 1870s, a large, underdeveloped, mobile, and experienced work force became available to canal companies, a source of cheap labor unavailable in the gold rush decade and lost again following the anti-Chinese agitation of the late 1870s.

Figure 14. North Bloomfield Mining Company's Malakoff Mine.
(California Room, California State Library)

The ditch companies required more than a larger labor force to complete their projects in the 1860s and 1870s. They also needed greater technical skill, as water conveyance systems became more sophisticated and required progressively greater engineering knowledge. The earliest water conveyance systems were often poorly engineered and inefficient. Carpenters skilled in working with wood constructed many of the longer early systems, building wooden flumes even where ditches may have cost less.[152] Early water companies were also less concerned about the durability of canals or ditches, where pay dirt might last only a few years at a given location and new ditches could easily be dug.[153]

In the 1870s, the systems that delivered water to the main hydraulic mining districts of California were far more difficult and complicated to build than the small mining ditches scratched out between a creek and claim in the early days of the gold rush. The earliest ditches were constructed "without regard to the loss of head, the only object being to keep the location where the digging was easiest."[154] Hydraulic mining canals with their storage reservoirs and extensive ditch systems called for skills and techniques of construction beyond the capability of most practical miners.

One of the principal concerns of hydraulic mining companies was to have a sufficient water supply to extend operations through the dry summer months. To accomplish this, they began constructing storage reservoirs in the mountains at elevations of 5,000 to 7,000 feet. Reservoir sites were constructed to obtain the largest supply from a catchment area, but at a high enough altitude to construct a ditch at proper hydraulic gradient to deliver water under pressure to mining locations along the canal system. Thus, these reservoir and ditch systems had to be carefully investigated and surveyed before large sums of capital were invested on construction.

Mining and mining investment capital followed one mining rush after another, returning to California in the 1860s and 1870s after the Comstock rush played out. New investments provided a financial infusion for the mature phase of hydraulic mining in the post-Comstock era. During this period, hydraulic mining dominated the California mining industry. Investment from San Francisco, the East Coast, and Europe led to the consolidation of many of the ditch and hydraulic mining companies. Complex operations that utilized vast ditch and reservoir systems to supply large hydraulic operations were founded throughout the state. These large operations included major canal systems on the South Yuba-Bear River serving the mines at Gold Run in Placer County and at North Bloomfield in Nevada County; the North Fork of the American diversions serving the Iowa Hill Ditch and the Cedar Creek Ditch in Placer County; and the complex Butte Creek and Feather River canals that provided water to the Cherokee system in Butte County. Substantial new investments in water conveyance systems were made to support the revitalized hydraulic mining industry. Good examples of some typical construction features that characterized canals from this period can still be found on the La Grange Ditch of Tuolumne County and the El Dorado Ditch in El Dorado County.

In the late 1860s and early 1870s, many of the smaller ditch companies were acquired by larger companies that took control of whole watersheds. Investment came from San Francisco, the East Coast, and England. For example, San Francisco capitalists formed the Little York Mining and Water Company. This group bought hundreds of acres in the Bear River Basin along with almost 50 miles of ditches. English investment in California began to increase, especially in Nevada and Placer counties. English capitalists invested an estimated one million dollars in hydraulic mines in 1871 alone. The increased investment allowed companies to construct larger, more complex systems with ditches and reservoirs of increased capacity.[155]

The North Bloomfield Gravel Mining Company's works provide an example of one of the systems of reservoirs and ditches that impounded and delivered water for hydraulic mining. Lester L. Robinson led a group of San Francisco investors who formed the company in 1866, but he had been a successful engineer prior to the North Bloomfield venture. Robinson came to California in 1854 and worked on building the Sacramento Valley Railroad, the first railroad on the Pacific Coast. Robinson also helped to build the Freeport road on the Sacramento River levee and the Sacramento, Placer and Nevada Railroad. In 1865, he bought the Market Street Railroad in San Francisco, which he converted from horse to steam power. Through his earnings from these works and others, he became a major investor in San Francisco, purchasing interests in mining, land, and irrigation companies in California and Mexico. Robinson and other San Francisco investors began purchasing land claims on Humbug Creek in Nevada County, including the famous Malakoff Mine.[156]

Operations at Malakoff began in 1866 with water from the Eureka Lake and Yuba Canal Company. In 1868, the North Bloomfield Company employed an engineer to build a ditch from Poorman's Creek to their operation near North San Juan in Nevada County. Almost immediately after completion of the ditch that same year, the company began looking for a larger and continuous supply of water. One suggestion was to bring water from Little Truckee River by ditch. Instead, the company's directors purchased Bowman's Ranch at Big Canyon Creek as a storage reservoir site.[157]

At a narrow channel in the hills surrounding Bowman's Ranch, the North Bloomfield Company constructed Bowman Dam in 1869, creating a huge reservoir that could retain 400,000,000 cubic feet of water (Figure 15). The original dam was described as being 65 feet high and 215 feet in length. A quarter mile below the large dam was a small diversion dam that was used to turn water flowing from the reservoir into a ditch. In 1872, the company rebuilt the main dam as a timber crib structure with a watertight pine-plank lining. Four years later, they decided to rebuild the dam again, only this time with stone, and raised it to a height of 100 feet. By 1880, the North Bloomfield Gravel Mining Company had a vast network of lakes, reservoirs, and ditches. The Nevada County tax assessment for the North Bloomfield company that year listed the Bowman Dam, 43 miles of ditch from Bowman Dam, a branch ditch from the main ditch, ditches from Humbug Creek, a ditch in Missouri Canyon, claims to seven small lakes and reservoirs, and three other distributing reservoirs. The North Bloomfield system eventually had an aggregate capacity in their reservoirs of 23,000 acre-feet.[158]

The Iowa Hill Ditch in Placer County was a smaller system that also delivered water to mines during this period. Gravel deposits in the area around Iowa Hill had not been mined for several years when construction of the main canal began in 1873, and the ditch opened in 1874 to great enthusiasm. Before the canal was constructed, miners received water for only three months of the year. This main canal tapped all the side creeks along the North Fork of the American River and distributed the water to mines in the Iowa Hill district. The Iowa Hill Ditch was linked to several reservoirs: one at Sailors Canyon, covering 25 acres; a second at Big Canyon, also 25 acres in extent; and several others at its head, covering 500 more acres. With this supply from the canal and storage reservoirs, ditch owners hoped they could provide water to miners nearly year around. If not, they projected construction of a 2,500-foot tunnel to tap the waters of the Middle Fork of the American River. Soon after construction of the trunk line, branch ditches were built to convey water to Indian Canyon, Iowa Hill, Wisconsin Hill, Prospect Hill, and Sucker and Grizzly flats. Typically, the citizens of Iowa Hill considered their canal system to rank "as one of the foremost works of its kind in the state."[159]

In the late 1860s, using investment funds derived from British speculators in the London financial market, the Spring Valley Company began purchasing older ditches for hydraulic mining use. The Spring Valley system took water from the Dewey, Miners, and other ditches on Butte Creek and the West Branch of the North Fork Feather River, ran it down the ridge top between the two streams, and delivered it to the hydraulic mines at Cherokee Flat, north of Oroville in Butte County. By 1870, the company had its plan well underway to unite these systems to deliver water to Cherokee. In the spring of that year, millionaire steel magnate Egbert Judson of San Francisco incorporated the Spring Valley Company under New York law with capital assets of $4,000,000. Judson hired Herman Schussler, engineer of the San Francisco Water Works, to draw up plans for the water project. Crews of up to 250 men were at work on the system by the end of 1870. The ditch systems when combined had a capacity of over 1000 miner's inches, and used earthen ditches, wooden flumes on trestles, and pipes to bring water from the headwaters near Round Valley Lake to the mines.

In 1873, the Spring Valley Company merged with the Cherokee Mining Company, bringing some 900 consolidated mining claims at Cherokee and two major mining canal systems into one ownership. The consolidated enterprise made Spring Valley one of the largest hydraulic mining operations in the state. George S. Davison and James D. Schuyler, two prominent hydraulic engineers, surveyed the system in 1899. They pronounced it one of California's most important mines because of its production and because of "its costly and comprehensive water system, involving many miles of ditches to gather water from various distant sources, and the use of inverted siphon pressure pipes of unusual size and high pressure for crossing deep canyons, displaying high class of engineering skill and boldness in execution and design."[160]

Table 6. Comparison of ditch dimensions of three companies

Ditch Name	N. Bloomfield Main Ditch	Iowa Hill Ditch	Spring Valley and Cherokee
Year	ca. 1885	ca. 1874	ca. 1885
Length	55 miles	25 miles	52 miles
Capacity	3,200 miner's inches (80 cfs)	7,000 miner's inches (175 cfs)	2,000 miner's inches (50 cfs)
Grade	12 to 16 feet/mile	Unknown	9.6 feet/mile
Top width	8.65 feet	Unknown	8 feet
Bottom width	5 feet	7 feet	5 feet
Depth	3.5 feet	4.5 feet	3.5 feet

After consolidating smaller systems, the Cherokee company had a series of reservoirs and ditches connecting the previously constructed ditches to the hydraulic mine at Cherokee. The system eventually had a series of four reservoirs on the ridge top above and adjoining the mine, from which the company could deliver water under pressure to their hydraulic giants. Their main source of water came from Butte Creek. The water was diverted through Butte Creek Ditch, which had a carrying capacity of 27 cubic feet per second, and conveyed water from Concow Reservoir 14 miles to the mine. The system supplied water to the mines nearly year-round. The rest of the company's water came from the West Branch of the Feather River through the Dewey Ditch and Miner's Ditch. One innovative feature of this system, from an engineering viewpoint, was the use of iron pipe in an inverted siphon to bridge the gap between Paradise Ridge and the mines on Table Mountain.[161] The dimensions of the Cherokee, Iowa Hill, and North Bloomfield systems are compared in Table 6.

By the early 1870s, miners had worked out many of the techniques for constructing elaborate ditch systems. The importance of mining ditches at this time was emphasized by one authority, who in 1873, wrote that, "[T]he ditches of California are the great arteries which bring life to the mines. Their even and constant flow secures a healthy and vigorous state of industry, while the dearth of water in the mines throws a pall over the business world of California, money becomes tight, and hard times are the consequence."[162] The author further noted the exceptional engineering skill used for building the vast network of flumes, ditches, and canals throughout the mining region, giving as an example, that miners had used iron pipe since the late 1850s to cross valleys and ravines. As noted above, the Spring Valley Canal and Mining Company of Cherokee applied this engineering skill in the 1870s to lay a 30-inch iron pipe across a nearly thousand-foot gorge.[163]

Water delivered in ditches, canals, and flumes was measured in the "miner's inch." Originally the size of a miner's inch varied from location to location, but in 1905, this measurement was standardized to 1.5 cubic feet per minute, or 11.25 gallons per minute. Miner's inches were measured by water flowing from a ditch or flume into an opening that could be from one to 12 inches in width and from a few inches to several feet in length. The head was varied from 4.5 to 12 inches above the opening.[164] "A miner's inch of water which sold for 25 cents per ten-hour flow in the early years dropped to as low as eight cents per ten-hour flow. By the early 1870s the price leveled off to ten to fifteen cents per ten-hour flow."[165] The boom-bust cycle of mining was thus mirrored in the cost of water and the financial health of ditch and water companies.

Certain rules and conditions governed building hydraulic mining ditches by the early 1870s. The ditches needed a sufficient supply of water during all seasons of the year. It was preferable to spend great amounts of money constructing a ditch if it could supply hydraulic mining companies with a year-round supply of water. Being able to supply water in the summer offered the advantage of longer work days, milder weather, and warmer water, which helped in the amalgamation of quicksilver (mercury) and gold. Ditches also needed to be located at a much higher elevation than the mine. The drop in elevation produced greater water pressure at the mine, and once a mine was exhausted, the lower end of the ditch could be rerouted to supply other locations. The ideal place to start a ditch was as close to the snowline as possible, because this would give the greatest height without risking damage to the ditch during winter. In certain circumstances, some mine operators built costly snow sheds over a ditch. Along the course of a main canal, engineers designed side ditches and flumes to capture the flow of all available small water courses and divert them into the main canal.[166]

Construction of a ditch began with conducting a careful survey, which tried to establish a gradient whereby water would drop about 10 feet per mile. The engineers and surveyors of that time had determined that this grade provided a convenient conveyance of water, secured the best flow, and limited damage by erosion to the ditch. For the water to flow smoothly through the ditch, the grade needed to be consistent over its entire length. Problems with slowing and backing up of the flow would occur when the grade leveled out, and in those instances, the ditch would need to be widened to enhance capacity or lined to increase flow.[167]

Once a survey was completed, excavation of the ditch began. Charles Waldeyer, a mining expert from Butte County, believed that, "[N]o operation connected with hydraulic mining needs greater care and foresight than the building of the ditch." A well-constructed ditch, while costing more initially, would cost far less over its life than a poorly constructed one. The preference of engineers in building ditches was for deep as opposed to shallow ditches. A deep ditch allowed less evaporation during the dry summer months and less danger of freezing in winter months. However, soil conditions often dictated ditch design. Because of the shallow depth to bedrock through the gold country, ditches were often only two or three feet deep and correspondingly wider. The forms most commonly adopted for earthen canals and ditches were trapezoidal or rectangular, while circular and square profiles were used only in stone, wood, or iron construction.[168]

Since mining ditches were located throughout the mountains and foothills of California, they were necessarily often built on steep slopes. One of the concerns of engineers in surveying ditch routes was that ditches located on mountainsides could wash out, especially during rainy seasons. In attempting to reduce damage potential and maintenance costs, engineers built them with slopes that would minimize such breaks in the line. The body of a ditch also needed to be far enough into the side of the mountain to leave a wide, level berm on the outside or lower edge for a protective bank.[169]

The great majority of ditches were lined with dirt, as the least expensive and easiest material to work with. Material removed during excavation was piled on the sides of a ditch to form a dirt berm. The flow of water in a dirt-lined ditch was influenced by factors including absorption, percolation, evaporation, and leakage. In some areas, dry-laid rock was used to line one or both of the walls of a canal. Dry-laid rock was used under a variety of circumstances: 1) where the composition of the soil was conducive to easy erosion; 2) where ditch lines transitioned to flumes, and the integrity of the connection was susceptible to damage from turbulence; 3) where the material of the side hill was unstable and unsuited to ordinary forms of an earth ditch; and 4) in hydraulic mining canals, which often had steep grades, up to 16 feet per mile, and were sinuous. Hydraulic mining canals curves were also sometimes lined with rock to minimize erosion.[170]

Canals and ditches could not convey water across streams, ravines, gorges, or valleys, so wooden flumes were often built to bridge the gap. Experienced engineers avoided building flumes whenever possible, however, because wooden flumes were expensive, subject to fire, and did not last long, usually only 10 to 25 years (Figure 15). Flumes were generally constructed with one-and-one-half inch plank, with a framing of four-by-four and three-by-three scantling at intervals of every two-and-one-half or three feet. The scaffolding for the flume needed to be well planned. An ideal foundation rested on solid, dry ground, for stability and to avoid rotting at the base. Flume builders removed any undergrowth and

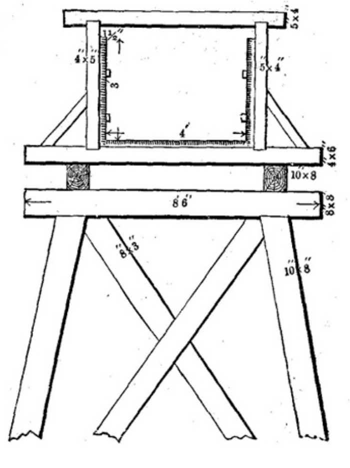


Figure 15. Trestled flume.
(Bowie 1905:143)

timber below the flume to reduce fire dangers. Flumes were built slightly smaller and with less of a grade than the rest of the ditch, because water traveled faster in a flume with its relatively smooth interior surface. Flumes built high off the ground were anchored by wire or wire rope to secure them during strong winds. By the turn of the century, engineers seeking to avoid extensive flume construction used iron pipe as an inverted siphon. Pipe came to replace many flumes because it was more secure and lasted much longer.[171]

Besides flumes carried on wooden trestles, other types of flumes were constructed in the late 1860s and early 1870s. In Butte County, the Miocene Gold Mining Company constructed the Miocene Ditch with a unique flume system (Figure 16). The ditch was built with a hanging flume on the side wall of a steep canyon. Designed by W. H. Bellows, the bracket flume allowed the company to avoid building a trestle over 100 feet high. The horizontal end of the T-shaped metal brackets were formed of 30-pound railroad iron bent to the shape of an "L," and attached to the side of the cliff. Laborers lowered down the 350-foot canyon wall drilled the holes for the brackets. The vertical end was fastened to a three-quarter-inch iron bar secured in the rock above by means of a ring bolt drilled into the face of the cliff. The brackets were set on eight-foot centers and were capable of sustaining a weight of 14.5 tons. The four-foot-wide and three-foot-deep flume built on top of the brackets ran for 486 feet at a height of about 118 feet above the canyon floor.[172]

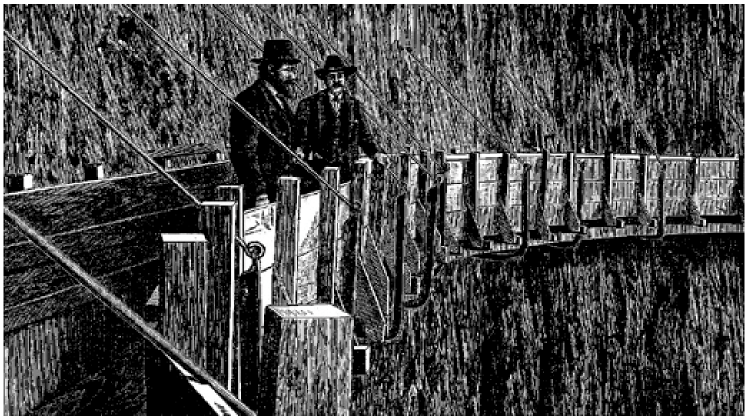


Figure 16. Miocene bracket flume. (Bowie 1905:152)

Among the most common forms was the bench flume, supported in full or part on a shelf or cut in the hillside (Figure 17). Bench flumes were constructed in locations where a ditch could not be fully excavated because of topography or because the soil was either porous or rocky. Bench flumes required less lumber than flumes and restles, especially less of the long, heavy, expensive pieces needed for substructures in crossing small drainages and steep slopes. On steep hillsides, the uphill side of the flume could be supported on a narrow shelf and the downhill side held up by posts. The shelf was excavated in the hillside by pick, shovel, or in some cases, by blasting. The excavated material was then used to form a ledge, and the flume was placed on the ledge close to the bank. In El Dorado County, the El Dorado Canal, constructed in 1870s, utilized many miles of bench flumes, as did the South Yuba Canal and Milton Ditch in Nevada County.[173]

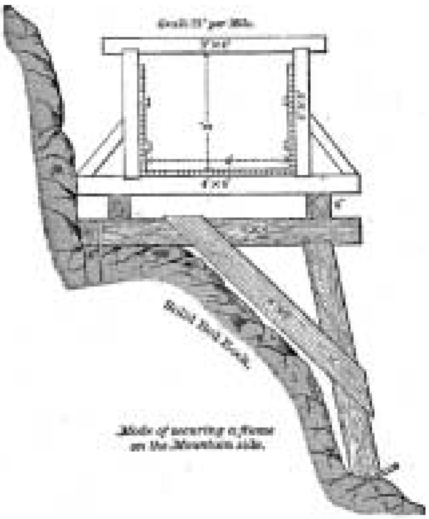


Figure 17. Milton bench flume. (Bowie 1905:156)

Riveted iron pipes also served to convey water in certain locations. Miners used iron pipe in limited quantities as early as the mid- and late 1850s to carry water across minor geologic depressions, although flumes were much more common. Mining companies used wrought-iron pipe because of its low cost, adaptability to the topography, ease in moving to new locations, and lightness compared with its tensile strength. Iron pipe was also used for inverted siphons by the La Grange Hydraulic Mining Company in Stanislaus County, the North Bloomfield Company in Nevada County, and San Francisco's Spring Valley Water Company in the 1870s and 1880s.[174]

Pipe could also be used in other parts of a water conveyance system. Supply or feed pipes were used to carry water from a ditch's termination point to a claim, and distributing pipes took water from the supply pipe to a nozzle or discharge pipe. In general, the builders bent thin sheet metal for the large pipes they made themselves, and used thicker, prefabricated iron pipe for smaller conduits that had higher water pressure. Pipes often had a sand trap, a receptacle similar to a cistern, that removed sand and gravel at the point water entered, and they dipped near the receiving point to prevent air from entering the pipe. Later, stand pipes and air valves were added to exclude air.[175]

Three basic types of tunnels were used in ditch and hydraulic mining operations. Diversion tunnels were among the most common. At the location where a river was diverted into a canal or ditch, such as at a narrow spot on a river flowing through a steep-walled canyon, a diversion tunnel would be dug through the canyon wall. A dam would then be constructed across the river and water diverted into the tunnel. A second common type of tunnel was the drainage or waste tunnel found at the end of hydraulic or sluicing operations. Waste tunnels were drilled or blasted to provide a drainage route for water to be removed from a mine after it had been used. The tunnels usually led to a major watercourse where the water and sluice debris could be drained away. Third, tunnels had to be dug to carry canals through terrain that was otherwise impassable. While water companies generally preferred to build flumes, it was sometimes necessary to blast tunnels through difficult spots.

In tapping a water source, engineers often had to construct a head dam to either divert or store water. Because California's streams can rise rapidly, the need for strong dams was evident from the first. The earliest dams constructed to divert water for river and placer mining were simple structures. In the late 1870s, water and mining companies built more extensive earth, timber, and stone dams to store water for hydraulic mining operations. In remote locations of the mining country, rockfill dams were often constructed, using locally obtained rock as the main structural material, although wood was often used as cribbing or to line the dam's upstream face.[176]

In the late 1870s, two main types of dams existed: dry rubble stone and timber crib. The most significant dry rubble-stone dams in 1878 were Bowman Dam, operated by the North Bloomfield Gravel Mining Company; English Reservoir of the Milton Mining and Water Company; Fordyce Dam of the South Yuba Canal Company; and Eureka Dam of the Eureka Dam and Yuba Canal Company. The Tuolumne County Water Company by 1878 had also built many large timber crib dams.[177] According to Charles Waldeyer, the strongest dams were timber crib dams that were "constructed by throwing the trunks of pine trees from shore to shore across a river, putting the first layer, or foundation, from 6 to 8 feet apart, for a width of 40 or 50 feet, then placing another layer of pine trees at right angles and at the same length across the first layer, and alternating this way until the dam has reached to proper height." After the builders completed this part of the dam, they filled the open places with stones, earth, gravel, sand, and pine branches. On one side of the dam was constructed a head gate for the ditch. The engineers installed the best gates in a solid bedrock tunnel which floods could not destroy. The gate itself was built with iron or strong wood and could be controlled by a lever or screw.[178]

In addition to high-elevation storage reservoirs, ditch companies built temporary storage, or regulating, reservoirs near the point of use. The main storage reservoirs would catch the water high in the Sierra Nevada during winter and spring and distribute the water throughout the rest of the year. Nearer to the mining area, companies had smaller distribution reservoirs. From these reservoirs, water could be easily conveyed to mining claims even if the canal system was out of service, or the reservoir could be used to retain surplus water coming from the main ditch when the claims were shut down.[179] By 1882, all of the large hydraulic mining companies had adopted systems of large storage reservoirs and smaller regulating reservoirs. Several of the largest water companies utilized multiple drainage basins for collecting and storing water, which allowed the companies to continue working into the late summer.[180]

The La Grange Ditch in Tuolumne County is an example of one of the post-Comstock ditches constructed during the second, or consolidation, phase of hydraulic mining in California. In 1871-1872, the La Grange Ditch and Hydraulic Mining Company, headed by San Francisco attorney Edmund Green, built a timber crib dam to tap the Tuolumne River for a ditch system serving the hydraulic mines in the area south of La Grange in eastern Stanislaus County. Chinese laborers made up a large portion of the 1,500-man work force that built the ditch. It was 17 miles long, carried 4,000 miner's inches, and cost $200,000. Much of the ditch was dug through granite with rock walls on the sides of segments of the ditch (Figure 18).[181] According to Augustus Bowie, a mining engineer, there were "stone walls 50 to 70 feet high."[182] The materials used varied from cobblestones, to shaley rock, to granite set in rough courses. The kind of rock utilized was that which was readily at hand. By the late 1880s, the ditch had fallen into poor condition.

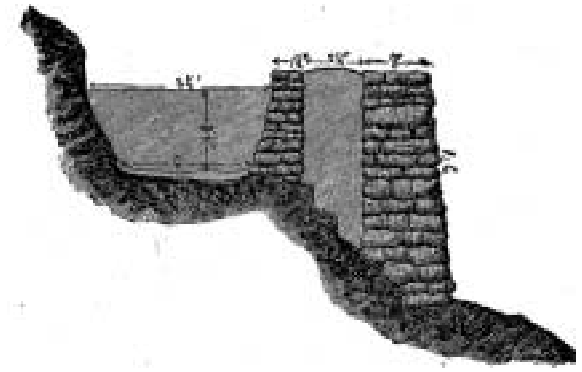


Figure 18. Section of La Grange Ditch. (Bowie 1905:141)

Another representative example of a post-Comstock canal was the El Dorado Canal, a ditch constructed between 1873-1876 to take water from the South Fork of the American River to hydraulic mines in the vicinity of Placerville. John Kirk, an engineering contractor who had built navigation canals, roads, and railroad bridges in the eastern United States, first proposed building a canal to serve the Placerville area in 1856. Kirk came to California in the winter of 1849-1850 and settled in Sacramento. He was responsible for some of the major pioneer engineering works erected in that city, including the first municipal water works and planking of the principal commercial streets. Kirk moved to Placerville in 1853, and later, with Francis A. Bishop, organized the South Fork Canal Company to bring water to the mines near Placerville. The project stalled with the general depression in hydraulic mining during the early 1860s, but the idea was revived in the early 1870s by Placerville business leaders. In 1873, Kirk sold his share to all of his ditches and water rights on the South Fork of the American River to a group of prominent San Francisco investors (including Bishop) that formed the El Dorado Water and Deep Gravel Mining Company. The company bought 750 acres of choice hydraulic mining property in the vicinity of Placerville, along with the Gold Hill, Iowa, and Weber Ditch Company properties, including 114 miles of ditches and flumes valued at nearly $1,000,000.

Construction on the El Dorado Canal began in 1874 under the supervision of Bishop, who was a trained surveyor and engineer. The canal had a capacity of 5,000 miner's inches, headed on the South Fork near Kyburz, and included some 18 to 20 high Sierra reservoirs. The company anticipated that the ditch would be completed in one season, but that expectation collided with rough reality. The effort required over 1,000 laborers, with Chinese gangs performing much of the manual labor. Experienced "wall surveyors" who had built flume bench walls on the Natoma Canal, blasters and tunnelers from the deep rock mines in Nevada County, and experienced stone masons and quarry men from Placer, Sacramento, and Plumas counties rounded out the work force. Progress was slow on the canal because of the vast amount of granite (200,000 cubic yards) through which they needed to cut or blast. The canal was completed in 1876, and was the most expensive ditch, mile for mile, built in California during the hydraulic mining era.

Figure 19. El Dorado Canal bench flume showing side drainage notch (JRP Collection)

The canal contains many long sections of bench flume resting on dry-laid granite block and rubble bench walls 15 to 20 feet high (Figure 19). The El Dorado Canal served various mining areas in western El Dorado County, such as the Excelsior hydraulic mine which operated six hydraulic giants with water from the ditch.[183]

The South Yuba Water Company had installed an extensive water conveyance system by the end of the hydraulic mining period. The company, as noted earlier, began to supply local miners in Nevada County in the 1850s. By the hydraulic mining period, it was also one of the largest operations in the state. The company had a watershed of 150 square miles at the source of the South Yuba and numerous storage reservoirs in the high Sierra, ranging in elevation between 4,500 feet and 7,500 feet. These reservoirs supplied a vast network of canals in Nevada and Placer counties.

The main canal received water from high Sierra reservoirs. From there, the conduit continued down toward the mines through flumes and ditches. At the point where one of the flumes crossed the divide between the South Yuba and Bear rivers, the canal split into two systems, one that supplied the Bear River mines and Nevada County and the other that supplied Placer County. The Nevada County system passed through a mile-long tunnel before it reached Grass Valley and Nevada City, serving quartz and hydraulic miners there. Diversions from the ditch were also made along its length to serve mining districts, including Little York, Yankee Jim's, and Red Dog. The Placer County system also delivered water to mining districts as it moved west. The system, after the end of hydraulic mining in 1884, served an agricultural base in Placer and Nevada counties, primarily orchardists in the 1890s. The system also became the basis for one of the first hydroelectric power systems in the state, and by 1903, it took water to three powerhouses in Placer County.[184]

By the end of the hydraulic mining era in 1882, there were several hundred mining ditches in California (Table 7). Mining ditches generally fell into three functional types: main or trunk lines that diverted water from a creek or river; branch or lateral lines that took water from the main trunk to a mining operation; and finally waste channels that carried water away from various points on the individual mining claims. Ditches serving hydraulic mines were the largest, ranging in carrying capacity from about 500 miner's inches (12.5 cubic feet per second—cfs) to 7,000 miner's inches (175 cfs). Relatively few ditches, probably no more than 24 in the state, can be classified as "large" mining canals, i.e., those carrying 2,000 miner's inches (50 cfs) or more. However, those 24 ditches alone totaled about 1,750 miles and represented an investment of more than $11,500,000. The ditches diverted their water from the principal streams that drain the west slope of the north central Sierra Nevada: the Feather, Yuba, Bear, American, Mokelumne, Cosumnes, Stanislaus, and Tuolumne rivers. A few large ditches also appeared on the Trinity River in northwestern California.

The ditch systems varied greatly in length, some only three or four miles long, but others complex mazes totaling up to 250 miles. The entire cost of all the mining ditches in California in 1882 was estimated at $30 million, which did not include the value of abandoned and unused ditches. Their aggregate length was around 6,000 miles, aside from an estimated 1,000 miles of subsidiary branches and small distributor ditches used to take water from larger ditches and reservoirs and carry it to points on the mining claim.[185] None of the other western states approached the magnitude of water development that took place in California's mining regions, but the overall pattern of development elsewhere generally followed that of California.[186]

Effects of the Sawyer Decision

In 1884, a federal court ruling known as the Sawyer Decision ended large-scale hydraulic mining in the Sierra Nevada. As the industry grew, the debris from hydraulic mining had increasingly damaged downstream farms and waterways. Sacramento Valley farmers protested loudly when the torrential rains of 1862 washed mud, sand, and gravel tailings from hydraulic mines onto unprotected farms. However, the drought that followed closed down many of the water-dependent hydraulic mines, and little debris was washed into the valley from 1862 to 1864. Then in the late 1860s, the hydraulic mining industry boomed, and vastly expanded hydraulicking operations washed unprecedented amounts of soil, creating massive debris streams. Via tunnels and sluices, tailings were emptied directly into major tributaries of navigable rivers, causing tremendous damage to the rivers and the valley.[187] By 1868, mining debris had silted in the beds of the Yuba and Feather rivers, raising the riverbeds higher than the town of Marysville. Over the next 10 years, Marysville spent hundreds of thousands of dollars building levees around the city to avoid being flooded.[188]

Table 7. Major hydraulic mining ditches of the Sierra Nevada region in 1882[189]

[1]Canal name	Source	Length (miles)	Capacity (miner's inches)	Post-1884 use
Bear River & Auburn	Bear	75	3,000	power/irrigation
Amador (Standard)	Mokelumne	66	2,000	power
Blue Tent	Bear/SF Yuba	32	2,000	abandoned
Brandy City	NF Yuba	17	2,200	abandoned
Cedar City	Bear	50	4,500	power
California Water Co.	SF American	125	4,500	irrigation
Dardanelles	NF American	17	3,000	abandoned
Eureka Lake & Yuba	MF Yuba	163	5,800	abandoned
Excelsior	SF Yuba	110	5,300	irrigation
El Dorado	SF American	26	5,000	power
Eureka	NF Cosumnes	170	2,000	irrigation
Gold Run D & M	Bear	26	2,500	abandoned
Hendricks	WB NF Feather	46.5	2,000	irrigation
Iowa Hill	NF American	27	4,500	abandoned
Little York/Liberty	Bear	35	3,500	abandoned
La Grange	Tuolumne	20	2,700	abandoned
Milton	MF Yuba	100	3,000	abandoned
North Bloomfield	SF Yuba	157	3,200	abandoned
Natoma	SF American	16	3,500	irrigation
Phoenix	SF Stanislaus	100	4,000	power
Powers	Butte Creek	30	2,000	irrigation
South Yuba	SF Yuba	123	7,000	power
Spring Valley/Cherokee	WB NF Feather	52	2,500	power
Tuolumne Co. Water	SF Stanislaus	75	3,600	power/domestic

As their resentment grew, farmers protested more vigorously in the 1870s. Miners and farmers both organized variously into groups that either supported or opposed the mining, such as the Hydraulic Miners Association and the Anti-Debris Association of the Sacramento Valley. Navigation interests also joined with the farmers as a result of the debris clogging valley rivers that made travel more difficult, and valley counties formed groups to protest against hydraulic mining. The state legislature attempted to please both sides through legislative acts, but they did not succeed. Farmers turned to the courts in their attempt to end hydraulic mining.

The virtual end of large-scale hydraulic mining came with the Sawyer Decision in 1884. In that year, the Ninth U. S. Circuit Court in San Francisco issued an injunction that essentially ended the practice of hydraulic mining in the Sierra Nevada. In the case *Woodruff v. North Bloomfield,* Judge Lorenzo Sawyer, a former forty-niner, ruled that hydraulic mining could be shut down on the grounds that dumping debris into rivers was injurious to the property of others, in that it practically ended navigation on the Feather and Upper Sacramento rivers. Not only were mining companies forbidden to allow any of their tailings to enter rivers, but ditch companies could not sell their water to hydraulic miners.[190]

While the act did not affect other types of mining such as quartz and drift mining, it had a tremendous impact on California. It is estimated that during the first year after the decision, gold production in the state dropped by $10,000,000. Mining areas such as Red Dog and You Bet nearly turned into ghost towns overnight, and other towns including Gold Run, Dutch Flat, and Foresthill had thousands of unemployed residents. In certain areas, the value of mines, ditches, and other related property decreased by 75 percent. Some miners ignored the decision and continued hydraulic mining where they could, while others looked for ways to operate a hydraulic mine within the limits of the injunction. For example, a few companies constructed tailing storage dams and continued to operate. California legislators from the gold country attempted to restart hydraulic mining with the introduction of bills authorizing the construction of large debris dams. In the late 1880s, a federal commission was set up to investigate the debris problem and the possibility of river reclamation. The Briggs Commission recommended in 1891 that hydraulic mining could resume if debris dams were constructed, renewing miners' hopes. Many of the commission's recommendations were contained in a bill introduced by Anthony Caminetti to the U. S. House of Representatives in 1892.[191]

President Grover Cleveland signed the Caminetti bill into law in 1893. The act set up the three-member California Debris Commission to oversee hydraulic mining in the area drained by the Sacramento and San Joaquin rivers. The commission had the authority to license hydraulic mining operations if it could be proven that the mining would not affect farming or rivers. Before beginning operation, miners had to apply to the commission for permission, and because their equipment had not been used for nearly 10 years, most miners could not begin immediately in any case. The heavy restrictions ensured that hydraulic mining never regained the volume or the influence it once had in the Sierra Nevada.[192]

Not all of California's hydraulic mining areas were affected by the Sawyer Decision. In the northwestern part of the state, hydraulic mining operations continued through the 1880s and into the twentieth century. The tailings from these mines flowed directly to the Pacific Ocean and thus did not impair navigability of Central Valley rivers, which was the basis for the Sawyer Decision. In Trinity County, one of the world's largest hydraulic mines operated into the 1910s. Mining had begun in Trinity County in 1851, and in 1873, several of the mining claims were consolidated into the Weaverville Ditch and Hydraulic Mining Company. Part of this company's property was purchased in 1879 by a Frenchman, Baron La Grange, for $250,000. The La Grange Mine originally obtained water for its operation through ditches from Weaver Creek, but when more water was needed, the company acquired water rights on the East Fork of the Stuart Fork. This mine remained one of California's most important until its closure during World War I.[193]

In the 1880s and 1890s, Sierra miners continued to push for a reduction in the Sawyer Decision's restrictions. The most practical idea remained the construction of impounding dams to keep tailings from entering rivers. A few of these dams were built in the 1910s and 1920s. In the early 1920s, the California Debris Commission constructed small dams across the Yuba River, as well as protecting walls to guide the river through debris deposits.[194] A state investigation in the 1920s into the potential for hydraulic mining found that hydraulic mining could be resumed if impounding dams were constructed at strategic locations. For an estimated cost of $2,405,000, dams could be constructed on the American, Bear, and Yuba rivers that would allowed for the resumption of hydraulic mining in those areas.[195] The Englebright Dam on the Yuba River was authorized by the US Congress as a hydraulic mining debris storage dam in 1935; it was completed in 1941.

Even with the general decline in gold production, some other forms of gold mining began or increased after the Sawyer Decision. After 1884, three types of gold mining dominated California's production. Quartz mining, centered in Nevada and Amador counties, received the first great burst after the Sawyer Decision. Dredge mining at the turn of the century also became a major producer of gold in the state, with the primary dredging fields along the Feather, Yuba, American, and Tuolumne rivers. Thirdly, small-scale placer mining had a small boom in the 1930s as unemployed urban residents moved to the country, mainly Mother Lode counties, seeking income from prospecting during the Great Depression. They used techniques such as the pan, rocker, and sluice to work the gold-bearing gravels, just as prospectors had done nearly 100 years earlier.

After the initial decline following the Sawyer Decision, gold production gradually increased in California. The number of fine ounces taken from California fell from 1,176,329 in 1883 to 657,900 in 1884, then remained relatively steady through the rest of the decade. In the 1890s, production increased from 595,486 fine ounces in 1890 to 767,390 in 1900. Gold production continued to increase through World War I, rising to 953,734 by 1910 and to over a million fine ounces in 1915 and 1916, then declined for the next 15 years. Production was down to 692,297 fine ounces in 1920 and 457,200 in 1930. Gold production rose again with the coming of the Great Depression and an increase in the price of gold. Between 1936 and 1941, production passed one million fine ounces every year. The federal government shut down gold mining during World War II, and even after the war ended, the renewed production continued a steady decline. By 1960, production stood at 123,713 fine ounces, and by 1968 it was at 15,682.[196]

Quartz Mining

Quartz, or hard-rock, mining began in 1849 with the discovery of a gold-bearing quartz vein in Mariposa County. Quartz mining required application of a different type of extraction and processing technology than placer mining. Miners had to blast or hew the quartz from the surrounding rock, pulverize it into fine grains, and finally separate the gold from the rest of the rock. Stamp mills and arrastres, or circular rotating grinding stones, were built to crush the rock. The early equipment was powered by either animals or water. At first, water-driven milling equipment used overshot water wheels that received water from canals. Later, mining engineers created various devices to direct water under pressure against a water wheel which then turned the milling machinery. New developments in water wheels continued through the 1870s and 1880s. Water was used at quartz mills in conjunction with riffles, sluices, and amalgamating boxes in much the same way it was utilized in placer operations.[197]

Through the 1860s, quartz mining operations often depended on the experience of Mexican miners who had worked in gold, silver, and copper mines in northern Mexico. Other miners learned their techniques and developed improvements through the 1850s and 1860s. Quartz mining gained in production after the end of the Comstock Rush as miners experienced in blasting and tunneling returned to California's deep, hard-rock mines. The end of the Comstock also brought a return of capital to California quartz mining. Outside investment allowed California miners to construct large operations with larger, more productive stamp mills.[198]

Quartz mines and stamp mills produced the majority of California's gold output after 1884. Advancements in quartz mining production included the development of the California Stamp Mill, which had strong and durable stamps. Water powered many of the stamp mills, hoists, pumps, and drills, requiring ditches and canals to be dug to a mill's location. For example, Amador County had 19 stamp mills in 1888, of which 16 were operated by water power and the other three by either water or steam power. To the south in Tuolumne County, 10 of that county's 12 mills were operated by water power, and in Siskiyou County, 11 of their 16 ran by water only. Miners and mining engineers returning from the Comstock in the 1860s brought with them new knowledge about quartz mining, including information about sinking deeper shafts, underground ventilation, blasting rock, timber cribbing, better hoisting equipment, and the use of steel and iron cable instead of hemp rope. Some of this knowledge was directly transferable to canal construction, especially in rocky terrain that required extensive blasting and tunneling.[199]

The locations for quartz-bearing operations were scattered throughout the Mother Lode region, including Mariposa, Amador, and Nevada counties. One of the first and largest of the quartz operations was on the Las Mariposas Rancho, John C. Fremont's Mexican land grant.[200] Principal quartz lodes were located in the Grass Valley-Nevada City and Allegheny areas in Nevada County, the Jackson-Plymouth region in Amador County, Carson Hill in southwestern Calaveras County, Bodie in Mono County, Jamestown in Tuolumne County, and the Mojave District in southeastern Kern County. Quartz mining in the Jackson-Plymouth district lasted from the 1850s through the 1940s, but it was not until the end of hydraulic mining that two of the most productive mines began to operate on a large scale. These two mines, the Argonaut and the Kennedy, each produced over $25 million dollars' worth of gold. At the Argonaut Mine, gold was brought up from over 5,000 feet below the ground surface, making it one of the deepest gold mines in the world.[201]

Lode mining required more capital and greater geologic knowledge than any of the forms of placer mining, and it utilized water-driven machinery in the quartz mills and mines. In California where high volumes of water were not available, low-head turbines could not be used. As a result, highly engineered water wheels became the standard in the state for running the machinery. These wheels, powered by the force of high-head water striking and turning them, included the Hurdy-Gurdy, Pelton, Knight, and Donnelly wheels (Figure 20). In Amador County, the Amador Canal Company supplied water to 20 quartz mines or mills using water wheels at Plymouth, Drytown, Amador City, Sutter Creek, and Jackson by 1888. Fourteen companies used the Knight, the most common wheel type; seven companies used the Donnelly wheel; five used the Pelton wheel; and some used more than one type. The major ditch companies delivered most of the water used by quartz mining companies. In addition to the Amador Canal Company, ditch companies serving quartz mines in 1888 included the El Dorado Water and Deep Gravel Company, the Tuolumne Ditch Company, the South Yuba Canal Company, and the Milton Ditch Company.[202]

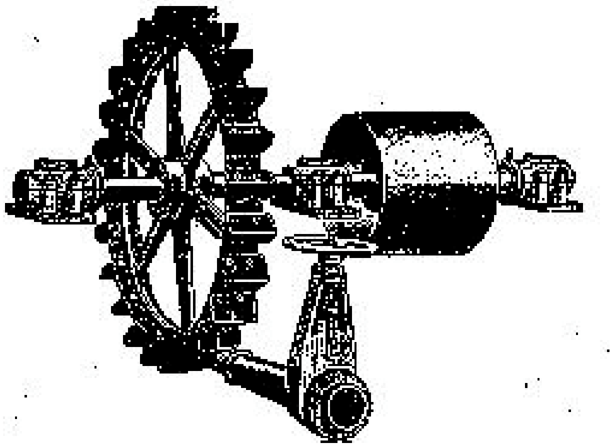


Figure 20. Pelton wheel.
(Bowie 1905:193)

Dredge Mining

The practice of dredging for gold began in California just prior to 1900. Developed in New Zealand in the early 1880s, dredging was first used in the United States in Montana in 1897. A dredge was a large flat-bottomed boat equipped with excavating and gold-washing machinery. Continuous lines of buckets scooped riverbed gravels onto the barge for processing with riffle sluices and quicksilver. W. P. Hammon and Thomas Couch pioneered the first successful use of dredges in the state in 1898 with a bucket-line operation at Oroville on the lower Feather River. Their dredge had open-link buckets with just over one cubic foot capacity. The Colorado Pacific Gold Dredging Company began dredging near Folsom in Sacramento County in 1899 and continued until the mid-1960s. The Folsom dredges were much larger than those in Oroville, and by 1907 they had steel dredge buckets with a 13-cubic-foot capacity.

Most dredging operations were located adjacent to rivers or streams, and the primary dredge fields were along the Feather, Yuba, American, and Tuolumne rivers. In these locations, dredges could be floated without requiring supply ditches or canals to fill dredge ponds. In Yuba County, for example, the Yuba Consolidated Gold Fields and the Marysville Dredging Company both worked dredges beside the Yuba River in 1908. These companies worked the old gold-bearing river gravels that had been buried by hydraulic tailings. Dredging also took place in large dredge fields on the Trinity River in the north, and some minor dredging was undertaken on the Stanislaus River near Oakdale. An exception to the usual type of dredging operation was near Folsom in Sacramento County. There, the previously existing Natoma ditch system was used to supply water to float dredges some distance away from the American River.[203]

During World War II, War Production Limitation Order L-208 ended gold mining for the duration of the war. California’s last major dredging operation, the Hammonton district (named after W. P. Hammon) on the Lower Yuba, closed in 1967-68.[204]

Return of Small-Scale Placer Mining

Small-scale placer mining operations were revived during the Great Depression of the 1930s. Thousands of the urban unemployed migrated to the gold districts that had been worked during the nineteenth century, and the number of placer gold mines more than doubled, from 478 in 1929 to 892 in 1930. From 1933 to 1935, the increase in the price of gold from $20.67 to $35 per fine ounce attracted greater numbers of prospectors. In areas such as Placer, El Dorado, and Calaveras counties, individuals and small groups of miners returned to many of the earlier techniques of gold mining, including the use of pans, rockers, sluices, and even hydraulicking. The greatest concentration of small-scale placer miners, or “snipers” as they were known, occurred on the Stanislaus, Mokelumne, Cosumnes, American, Bear, Yuba, Feather, Trinity, Salmon, and Smith rivers. An estimated 10,000 people were engaged in “hand-mining,” or small placer operations, as early as 1932. This mass migration of miners amounted to fully one-fifth the estimated mining population in those districts at the time.[205]

As placer mining revived in Placer County in the 1930s with the rise in the price of gold, numerous gold mining operations began or increased production. The Bake Oven Placer Mine on the North Fork of the American River was leased to two prospectors named Woodruff and Morgan, who worked some of the gravels there by hand. Like miners in the nineteenth century, they envisioned greater production if they could just bring water to the site. At Wisconsin Hill, an area worked by hydraulicking into the 1880s, the Goodman Mining Company began producing gold in 1933 from drift mining. Employing four to five men, the company continued operating throughout the 1930s and realized substantial returns.

Small-scale hydraulic mining also returned in Placer County where companies could erect dams to impound their debris. The Paragon Mine, located two miles from Foresthill, returned to drift and hydraulic mining in 1932. The mine's history followed a typical pattern. The area was first worked by sluicing in 1852 to 1862, followed by drift mining, which was then replaced by hydraulic mining in 1874. Drift mining returned after the Sawyer Decision, but little production took place until the 1930s. Similarly, the Lost Camp Hydraulic Mine near Blue Canyon prepared to restart hydraulic mining during 1934-1935 by claiming water rights on Blue Ravine Creek, completing a sluice tunnel, and securing storage for tailings in Blue Canyon Creek.[206]

Both Calaveras County and El Dorado County followed a pattern similar to Placer County. Placer mining had a rebirth in Calaveras starting in 1933, although it was confined mainly to river gravels along the western edge of the county. Dredging and drift mining production increased in Calaveras in the 1930s. Near Mountain Ranch, one operation began rehabilitating old canals for use in their use in hydraulic mining. Five miles of a 12-mile ditch were rehabilitated to furnish the water supply. Other mining companies built washing plants and sluices along the Mokelumne River and pumped water from the river to their works to wash the gravels.[207] In El Dorado, production also increased during the 1930s. Numerous mines were opened, but prospectors also worked river pockets and seams, along with small placer mines. The Wulff Placer Mine near Rescue was worked in the late 1930s by two men who removed a few cubic yards of material each day and washed it at a nearby sluice.[208]

The Legacy of Mining in California

Mining and mining ditches have had a significant impact on California history, extending beyond service to the mining industry. Mining's impact on the landscape represents one of the first great environmental issues confronted in the state, and at a national level as well. The ditches and canals that supplied the miners altered California's landscape. Remnants from the early mining period are still visible in shallow placer tailing sites and in ditch fragments found in many parts of the state. Dredging operations have left herringbone-patterned remains along or near many of the rivers of the Central Valley. Perhaps the most visible marks on the landscape are the hydraulic mining tailings and the scarred mountainsides where hydraulic mining operations once took place. The damage done to the landscape by hydraulic mining led to one of the most important environmental judicial decisions ever in the United States, the Sawyer Decision.

The mining ditches also had positive impacts on California. The ditches and the mining operations they served help California become one of the most populous and prosperous states in the nation. The ditch systems of some mining operations were engineering marvels, with an elaborate use of dams, canals, ditches, flumes, and pipes. The canal systems in some cases extended over hundreds of miles, taking water from one drainage basin and delivering it to another. Many of the ditches and ditch systems continued to be used after their initial mining purpose ended, supplying agriculture, municipal water services, and hydroelectric power systems.

Today, mining canals and ditches are found in various conditions. Many of the branch or lateral lines served no further purpose after mining ended. These ditches are often overgrown or silted in, or they have been destroyed by natural conditions, such as landslides, or by the human hand operating a bulldozer. Trunk line ditches are more likely to have intact segments and may possess integrity of location, materials, workmanship, design, setting, feeling, and association. It is unlikely, however, that many associated elements, such as dams, control structures, diversion works, or original wooden features, such as flumes, remain on these systems. Nevertheless, mining canals and ditches remain important features of the state's cultural landscape.

HYDROELECTRIC SYSTEMS

Since the late nineteenth century, California has been a world leader in the development of hydroelectric power. Beginning in the 1890s, Californians, who lacked the rich coal resources found in other regions of the country, looked to hydroelectricity as a principal power source for municipal, industrial, and agricultural uses. The development of water power and its dissemination throughout the state were central factors in the tremendous expansion of the state's economy in the early twentieth century.

The history of the hydroelectric power industry in California can be broken into three main periods or phases. In the pioneer period, lasting from the 1890s through the early years of the twentieth century, entrepreneurs organized small independent power companies that found eager markets for inexpensive electricity. Technological improvements allowed for expansion of the radius of their economical service areas, increased generating capability, and promoted a proliferation of small power companies. During the second phase, lasting from about 1905 to World War II, small power companies were consolidated into large corporations that planned and built integrated power generating systems that maximized the power possibilities of entire watersheds. This consolidation of ownership of power facilities prompted a movement by municipalities and state and federal government to regulate private power companies as quasi-public utilities. The third major phase in California's hydroelectric power history began in the 1920s with the rise of government regulation and the development of power generation facilities by public entities.

The pioneer period of hydroelectric development, from the 1890s to 1910, was experimental in nature. The owners of the state's first plants had to experiment with different, relatively untested, systems to generate and transmit electricity. California's first powerhouses were different from those in the East because they utilized high head and low volumes of flow, and they stored water at elevations far above the penstock. This type of system was suited to California's prevailing weather pattern, which was characterized by long periods of little or no rain. Typically in this period, only one power plant was constructed on any given watershed, and electricity was transmitted to a single location. These two characteristics were reflected in the Pomona and Redlands hydroelectric power plants in Southern California, the Folsom powerhouse in Sacramento County, the Colgate plant on the Yuba River, and the Bishop Creek powerhouse on the east side of the Sierra Nevada.

The second stage of development began in 1905 and continued through World War II. During this period, California's reliance on electric power increased greatly. First, long-distance transmission of high-voltage alternating currents was made possible, which allowed power-generating sites located high in the mountains to deliver electricity to California's coastal population centers. To meet increased demands, hydroelectric power companies began to develop entire watersheds. Instead of utilizing a single plant on a river, companies began to plan and build stepped systems. These stepped systems utilized multiple high-mountain storage reservoirs, blasted long tunnels to maximize head, and sought to increase the number of powerhouses that could be stationed along the river. Designed by some of the most notable engineers of their era, these monumental works represent major achievements in civil engineering.

Construction of these stepped hydroelectric systems was undertaken not by the small pioneering companies, but by larger corporations that absorbed those companies, and that were in turn taken over by two companies that established dominance in their field by the 1920s—Southern California Edison and Pacific Gas & Electric. Examples of corporate-built stepped hydroelectric systems include San Joaquin Light & Power Company's Big Creek development on the San Joaquin River, the Battle Creek development of the Northern California Power Company, the North Fork of the Feather River power system of the Great Western Power Company, and the South Yuba-Bear hydroelectric power system developed largely by Pacific Gas & Electric Company.

Another separate type of hydroelectric power development took place during the second period: development by public agencies, from the municipal through the federal level. In California, the movement towards public ownership of power began in the 1910s, with debates over the threat of monopoly in the hydroelectric power industry and over the relative merits of public versus private ownership. Municipalities, including Los Angeles and San Francisco, built their own hydroelectric plants during this period, and some irrigation districts generated hydroelectric power as an additional use of the water held in their storage reservoirs. The federal government played a major role in building hydroelectric facilities in California, notably with the construction of the Central Valley Project's Shasta Dam. Generally, these public projects developed hydroelectric power as a side benefit, while their primary purposes were irrigation, flood control, or municipal water supply. They did not develop watersheds exclusively for power generation, nor did they build the large transmission systems produced by private companies of the same period.

California's topography has been the critical factor in influencing the development of high-head, low-volume hydroelectric systems. Most of the state's hydroelectric plants were built in the Sierra Nevada and Transverse Range, chains of high, steep mountains that receive enough precipitation to build a substantial snowpack. At their high elevations, these mountains hold water in the form of snow, often well into summer, providing a large runoff that helps feeds the streams flowing to power plants. To keep plants operating throughout the dry summer and fall, water was impounded in mountain reservoirs and released to maintain a steady flow. Hydroelectric companies either built their own reservoirs, or as in the northern and central Sierra, used reservoirs that had been constructed for hydraulic mining operations.[209]

The hydroelectric industry has benefited greatly from technologies and water systems developed for mining, in particular hydraulic mining. Miners had depended upon water to provide power to operate hoisting and ore-crushing equipment. Among the first of these developments was the "hurdy-gurdy" wheel, operated by a stream of water hitting buckets mounted on a horizontal axis wheel, which then turned the hoisting or milling equipment. California millwrights and blacksmiths made a number of improvements on these "impulse wheels," as they came to be known. Lester Pelton introduced a new type of wheel, the Pelton wheel, around 1880. One of the most significant improvements, the wheel was more efficient because a smaller amount of water would turn it. With the Pelton wheel and similar inventions, California miners and later hydroelectric power producers were able to utilize California's low-flow waterways.[210]

The presence of mining ditches throughout the Sierra Nevada and its foothills greatly aided the development of the state's hydroelectric industry by providing a network of existing water storage and delivery facilities. Mining and ditch companies had constructed large systems to supply water for mining from the 1850s through the 1880s, and by the end of the hydraulic mining era, there were hundreds of mining ditches throughout the state, with an aggregate length estimated between 6,000 and 8,000 miles. Companies producing hydroelectric power had similar needs for water systems. For year-around operation, both mining and hydroelectric power companies needed mountain reservoirs to hold the water that would carry them through the dry seasons and conveyance systems to deliver the water to its terminus, whether a mine or a power plant. Both industries also designed their systems to begin at the highest possible altitude in order to maximize the head above the mine or power plant, and they utilized the fall of water under pressure in penstocks.

Many abandoned or deteriorated hydraulic mining water systems were acquired by power companies in the late 1890s and early 1900s. The De Sabla hydroelectric plant (1904) on Butte Creek used the old canal network of the Cherokee Mining Company; the PG&E power plants on the South Yuba Bear River were dependent on a host of hydraulic mining canals including the Bear River Canal, the Boardman Canal, and the South Yuba Canal; and the Phoenix hydroelectric plant in central California obtained its water supply from an old mining ditch.

The development of hydroelectric power came as one answer to California's energy needs. In the late nineteenth century, Californians relied upon wood, imported coal, kerosene, and gas made from coal or crude oil as their main energy sources, but fuel scarcity was a major problem. The early fuel sources were expensive and not always readily available. By the 1890s, Californians were beginning to look for new methods to generate electric power as a result of the rapid increase in population and industrial growth. In the early twentieth century, the population of California increased from 1,485,053 in 1900 to 3,426,861 in 1910 and 5,677,883 by 1930.[211]

The use of electricity in homes and industry increased sharply beginning in the 1890s. Electric lighting, developed in the late 1870s, soon arrived in California. In 1879, Charles Brush, an early experimenter with dynamos, established a system to supply 22 street lights and electricity for lighting several business on behalf of the California Electric Light Company in San Francisco. Originally, communities that did illuminate used steam-generated electrical systems.[212] As advances in technology led to the design and construction of motors and pumps that used electricity, the number of electric motors in California increased from 23,745 in 1914 to 133,875 in 1929. The amount of electricity needed to operate these motors increased from 258,734 horsepower to 1,230,457 horsepower over the same period. Engineers sought additional power sources to meet the needs of the general population and industry. Until the great oil discoveries were made in the southern San Joaquin Valley and on the coast of Southern California, California had few options to meet the power need except development of its water power resources.[213]

The first hydroelectric power plants produced direct-current, or DC, power. As early as 1881, direct-current plants had been built in the eastern United States, but the plants were small and the service was highly localized, as direct current could be transmitted profitably only at distances of up to seven to 10 miles. In 1887, the San Bernardino Electric Company was the first company in California to create direct-current electricity using water. The company took water from a Riverside Water Company irrigation canal, with a drop of 50 feet, to drive three dynamos. The success of this experiment led to the construction of other direct-current plants in the state.[214]

One example of a direct-current hydroelectric facility was constructed in 1892 on the Sacramento River to serve the town of Dunsmuir. Herman Scherrer, an emigrant from Switzerland, had visited the town of Ashland, Oregon in the late 1880s, and decided that because Ashland had installed electric lights, Dunsmuir should do the same. He installed a 117-volt, direct-current generator in a wooden building behind his house. Scherrer built a log dam and diverted water from the Sacramento River into a two-foot-square wooden flume that stretched about one-half mile to his property and the generator. The water then fell 27 feet over a water wheel that turned a turbine to run the generator. In 1899, Scherrer decided to construct an entire new system, replacing the wooden flume with an open ditch and adding a new water wheel and generator. The electricity ran electric lights in Dunsmuir.[215]

Alternating-current (AC) hydroelectric plants took over from direct-current plants in the 1890s. Direct-current transmission lines lost voltage at such a rate that it was unprofitable to transmit electricity for any distance. To establish power plants farther away from their ultimate markets, it became necessary to either develop more efficient lines or create a new system for conveyance. By the late 1880s, experiments with alternating-current lines showed that they could transport electricity with only minor line loss over longer distances. The alternating-current systems developed by George Westinghouse's company and the General Electric Company became the standard systems used in the West. With AC, California was finally able to build long distance transmission systems.[216]

Pioneering Development, 1890s-1910

A lack of readily available cheap fuel such as coal had handicapped California's economic development until the 1890s, when enterprising power companies began to build commercial hydroelectric power plants throughout the state. Since then, California has developed into one of the world leaders in the development and production of hydroelectric power. Only two western states' plants, one in Oregon and one in Colorado, predate California's first long-distance, alternating-current, hydroelectric transmission stations. California's early power plants were scattered throughout the state, but they faced similar problems of generation and transmission of their electricity.[217]

By the turn of the century, California had become the nation's leading state in the practical application of electrical transmission engineering. California's first alternating-current station was the Pomona Plant of the San Antonio Light and Power Company, a company organized by Dr. E. G. Baldwin, who was president of the Congregational Church-run Pomona College and chairman of the local water and power committee (Figure 21). This company began operating the plant in 1892 and transmitted electrical current 15 miles to Pomona for lighting. It used single-phased alternating current generators to produce the electricity. Single-phase AC was only a small improvement over DC because it also did not transmit electricity efficiently. It carried electricity over a single line of alternating current and was good for lighting systems, but it did not provide a good source of electricity for motors.[218]

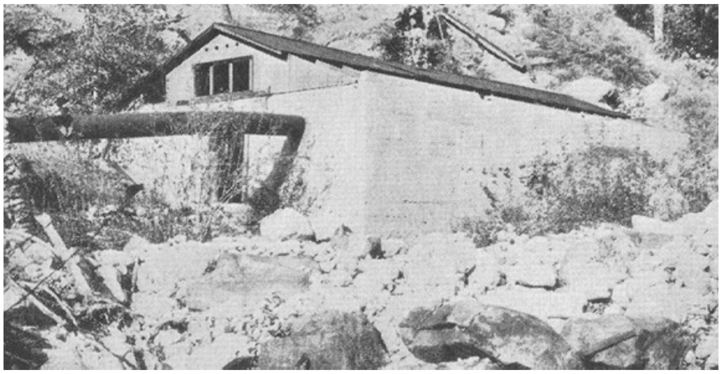


Figure 21. Old Pomona Plant, ca. 1920
(Fowler 1923:Plate LIV)

The production of electricity on the Pomona system was elementary. A dam on San Antonio Creek diverted water into a pipe 2,370 feet long. A short distance below the dam, the pipe was carried in a 1,300-foot tunnel blasted through a hillside to cut off a large horseshoe bend in the river. While the river wound around the hillside losing elevation, the pipe emerged from the tunnel some 400 feet above the floor of the canyon and dropped its water into a penstock that descended to a small wood-roofed concrete powerhouse. Electricity was transmitted originally only to Pomona, but within a month, transmissions began to San Bernardino, a distance of 28 miles. The transmission system was quickly upgraded to carry greater voltage, and by February 1893, the voltage carried was doubled to 10,000 volts. The plant was successful, and a second unit was added to the powerhouse in 1893. The capacity was doubled again the following year by the addition of two more units.[219]

The next advancement in long distance transmission of current, the polyphase system, followed quickly. Polyphase systems, which transmitted two or more lines of current at the same time, allowed electricity generated at remote locations to be transmitted many miles without a significant loss during transmission. Germany led the way in developing this technology. In 1892, German firms put the first commercial polyphase AC system into production. In the United States, General Electric and Westinghouse battled over the introduction of polyphase technology. The multiphase system that eventually prevailed was the three-phase system that did not require wires to run back from the load to the generator. With the introduction of this new transmission technology, it became feasible for generating plants in the Sierra Nevada to reach the large markets in the Bay Area and Los Angeles basin.[220]

The Redlands Electric Light and Power Company put the first three-phase transmission into operation at Redlands, San Bernardino County, in September 1893. In 1892, Southern California businessmen George Crafts, George Ellis, F. G. Feraud, and H. H. Sinclair had conceived the plan to bring electricity to the city of Redlands, a promising new settlement of 4,500 residents. The plan was hatched in part to induce the Union Ice Company, one of the largest handlers of ice in the western United States, to locate a plant at Redlands in the center of the Southern California orange belt. After entering into a 25-year contract to supply power to the ice company, Sinclair and his associates hired one of California's leading hydro-electrical engineers, William Decker, to design and construct the Redlands plant on Mill Creek. Decker, who had worked on the Pomona plant and was chief electrical engineer of the Mount Lowe Railway, seized the opportunity to build California's first polyphase facility. Whereas the single-phase system at Pomona supplied power only for lighting, the town of Redlands was able to use its electricity for heating, manufacturing, and even operating street cars. The polyphase system was installed by the General Electric Company.[221]

The power market increased so remarkably that by 1896 an expansion of the Redlands plant's generation system was necessary. Originally, the plant was supplied by a head of water obtained by a 377-foot drop, soon increased to 530 feet. This improvement was followed by expansion of the company's transmission lines from Redlands to Colton and Riverside. When the Mill Creek No. 2 powerhouse was completed upstream from the first plant in 1899, an iron pipe was constructed to take water from the newer plant to the older plant. The water for the second plant was diverted from Mill Creek by a 400-foot-long tunnel. From the tunnel, the water passed to the powerhouse through concrete pipe and wooden flumes. The two-inch-thick concrete pipe was constructed in two-foot sections. The pipe was placed in trenches dug to minimize curving in the line, while manholes located 500 feet apart along the route allowed for easy maintenance. Twenty-three flumes were also constructed across ravines and along the sides of rocky cliffs to take water from Mill Creek to the plant. The flumes, ranging from 22 to 400 feet in length, were three feet wide and 26 inches deep.[222]

Mill Creek No. 2 was the last powerhouse completed by the Redlands company before it was absorbed by Edison Electric Company of Los Angeles. Edison had already acquired Southern California Power Company with its Santa Ana River No. 1 plant (1898) east of Redlands and 83-mile transmission line to Los Angeles. The watercourses and tunnels were some of the most interesting engineering features of that early plant. In total, there were 18 tunnels, the longest 2,000 feet long, and 16.5-feet-high by 5.5-feet-wide wooden flumes totaling 2,697 feet in length on the waterway which was almost 2.75 miles long overall. By 1902, Edison Electric had acquired several more small independent power companies owning hydroelectric power plants and local distribution systems, such as Pasadena Electric Light & Power Company, Santa Ana Gas & Electric Company, Mountain Power Company, Lytle Creek Light & Power Company, and the California Power Company. Edison proceeded to tie its power plants into its 33,000-volt transmission line serving Los Angeles and constructed feeder lines to cover the San Gabriel Valley and Orange County.[223]

The first hydroelectric plant in Central California was the Folsom Powerhouse on the American River in Sacramento County. The plant began service on July 13, 1895. The Folsom plant was unique for California because it relied on a low-head, high-volume flow of water, not the high-head, low-volume flow common to almost all of the state's other hydroelectric power plants. The Sacramento Electric Power and Light Company, under the guidance of Horatio P. Livermore, designed its plant and dam to supply Sacramento with an alternating current for running the machine shops of Southern Pacific Railroad Company, as well as breweries, printing offices, flour mills, and elevators. A 1.67-mile-long canal on the south side of the American River diverted water just below the confluence of the North and South forks of the American River and conveyed it to the powerhouse. Although short, the canal was one of the largest used for power generation in California, with a maximum section measuring 53 feet wide on top, 45 feet wide on bottom, and eight feet deep.

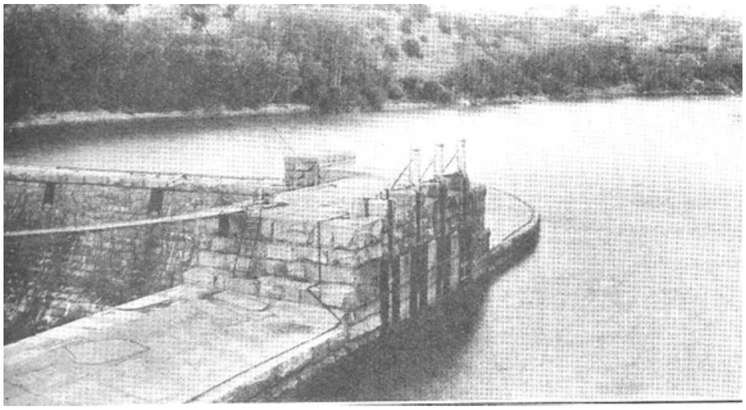


Figure 22. Folsom dam and intake structure
(Fowler 1923:Plate XXI)

The head dam, a massive granite structure laid in cement mortar, crossed the American River above Folsom State Prison (Figure 22). Convict labor was used in the construction of the dam. Water was diverted at the dam through three head gates, each measuring 16 feet high and 14 feet wide. The canal ran close to the river and was walled or riprapped with rock on the inside and on most of its outer bank. At its lower end, the canal made an abrupt turn into a 150-foot-long forebay where the water was divided into two sections by a longitudinal wall running down the center of the forebay. Each of these two sections was divided again before the water reached the penstocks of the upper powerhouse. The upper powerhouse developed a head of only 55 feet. The lower powerhouse received water from the tailrace of the first under a head of only 25 feet. By 1923, Pacific Gas & Electric owned and operated the powerhouse.[224]

The first high-head hydroelectric plant to operate in Northern California was developed by the Nevada County Electric Company at a small plant on the South Yuba River near Nevada City. The promoters of the project, including Eugene J. De Sabla and John Martin, who later organized PG&E, and Fred Searles, a prominent Nevada City attorney, intended to generate power and transmit it to Nevada City and Grass Valley for lighting and power purposes. Other power plants built during this period in the mining region were constructed to serve mining operations only.[225] The company initiated construction of a dam across the South Yuba River in 1892, but the dam failed in the first freshet. A second dam, 28 feet high and 107 feet long at the crest, was started in August 1895 and completed in November; the plant began operation in February 1896. Water was diverted at the dam by a wooden flume 4.5 feet deep and carried by flume 18,400 feet to a pressure pipe where it was dropped 206 feet to the powerhouse on the South Fork. The operation was successful, and three years later, the Nevada County Electric Company built a 54-foot-high timber crib dam on Rock Creek, forming Lake Vera. The pressure pipe from the new reservoir to the power plant developed a head of 785 feet, nearly four times the initial unit. Despite the expansion, the local market for electricity outstripped demand, and in 1899, lines had to be extended from the nearby Colgate plant, which was owned by some of the same people who had organized Nevada County Electric.[226]

John Martin and Eugene J. DeSabla organized the Yuba Power Company in October 1897. They began construction of a second plant on the Yuba River later that year to supply electricity for general use in the town of Marysville and to supply mines in the Browns Valley region. The plant utilized a ditch system that diverted water from the North Fork of the Yuba River for irrigation purposes in Browns Valley. The canal system consisted of eight miles of flume and some 21 miles of open earthen ditch. The canal was nine feet on top, five feet on bottom, and 2.5 feet deep, and it ran on a grade of 9.6 feet per mile. The canal discharged into a head box and was sent by pressure pipe a distance of 850 feet to the powerhouse. The system developed an effective head of 292 feet.

As soon as the Yuba plant was completed, Martin and DeSabla reorganized their corporation, forming the Yuba Electric Power Company, and began construction on a third hydroelectric power plant. A drought in the summer of 1897 and 1898 reduced the flow of the American River, causing the Sacramento Electric Power and Light Company, owners of the Folsom Powerhouse, to look elsewhere for electricity to supply Sacramento. They contracted with the Yuba Electric Power Company to receive power from the partially completed Colgate plant 61 miles away. The two men received much of their advice on how to transmit their electricity to distant Sacramento from William Stanley, who had helped develop Westinghouse's alternating current system.

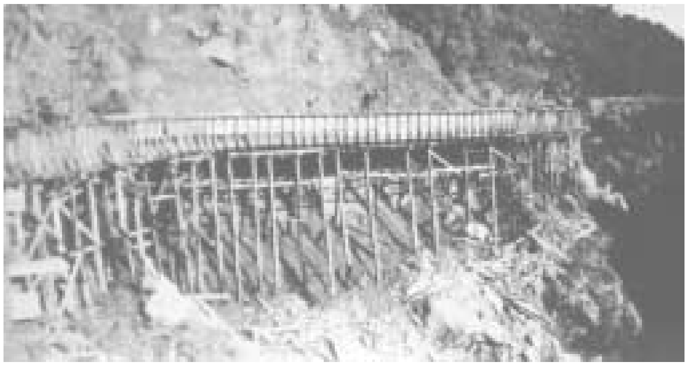


Figure 23. Flume on Colgate system, 1910
(PG&E Archives)

The Colgate System took water from two different watersheds and conducted it some 10 miles to the power site without any portion of the water conveyance system running in an excavated ditch. Although located on the Middle Fork of the Yuba River, the Colgate plant derived its main water supply from the North Fork. The Middle Fork provided a supplementary supply for dry seasons from Lake Francis, a reservoir formed by a 70-foot-high, earth-filled dam on Dobbins Creek. The main water supply was diverted above the North Fork's junction with the Middle Fork. Here, a five-foot-wide and seven-foot-deep wooden flume (Figure 23) diverted water from a rock-filled, timber-crib head dam and carried the water 7.6 miles by flume through the river canyon to a small masonry forebay at the powerhouse. The supply from Lake Francis was delivered to the Colgate forebay through a conduit originally composed entirely of flume. The flume was poorly engineered with an irregular and steep grade. As early as 1899, Yuba Electric began replacing flume sections with wood-stave pipe. By the early 1920s, the conduit contained only 0.5 miles of flume, while the remaining 1.65 miles was 36-inch wood-stave pipe. The fall from the forebay to the power plant was an impressive 702 feet through two, later five, 30-inch penstocks. When the plant began operation in 1899, it supplied electricity to local mines in the vicinity of Nevada City, as originally intended, and also sent power to Sacramento.[227]

This Colgate project placed Yuba Electric Power among the state's leaders in long-distance power transmission. In 1901, Martin, De Sabla, and their financier, Romulus Riggs Colgate, now operating as Bay Counties Power Company, decided to construct a transmission line from the Colgate plant to Oakland. The line would be 140 miles long, the longest in the world at that time. The electricity was used to operate Oakland's street railway system. Two transmission lines began operating on April 27, 1901, when electricity was taken from the Colgate plant through Wheatland, Davis, and Suisun and over the Carquinez Straits to Oakland. In the years after 1900, the Bay Counties Power Company, with De Sabla as its president, began interconnecting their plants to supply electricity to other areas in California. The Colgate and Yuba plants, along with the Nevada plant of the Nevada County Power Company, were tied together to reach counties north and south of Oakland and San Francisco. They provided power for street railways, manufacturing, and agriculture.[228]

The South Yuba Water Company, one of the Sierra's pioneer mining water and ditch companies, had emerged from the gold rush and hydraulic mining frenzy with one of the most extensive systems of mining ditches and reservoirs in the state. During its peak hydraulic mining operation, the company had 450 miles of conduits in Nevada and Placer counties, constructed over uncertain, porous, sliding, and difficult terrain. The long canal lines, some in use since the 1860s, were a monument to the engineering skill of those who built them. The company also owned 20 storage reservoirs in the Sierra with a storage capacity of 14.5 billion gallons, which did not include the 15 smaller distributing reservoirs along their system. The vast majority of the company's ditches and canals were constructed in the 1860s and 1870s for hydraulic mining. After hydraulic mining was curtailed in 1884, the South Yuba Company needed to find a new market for its water. It first turned to the boom in irrigation in the foothills. Old canals were repaired, and the South Yuba Company acquired the Bear River Canal at the lower end of Placer County to sell water to foothill fruit growers (Figure 24). By the late 1890s, the company realized that the natural fall in its canal lines could also be developed profitably for hydroelectric power.[229]

Figure 24. Bear River Canal, 1908
(PG&E Archives)

The South Yuba Company, under the management of John Spaulding, owned and operated 46 canals on the South Yuba and Bear rivers that covered the better part of Nevada and Placer counties from the summit of the Sierra Nevada to the foothills. The company had the oldest water rights on South Yuba River, Bear River, Deer Creek, and Rock Creek, and rights also to much of Steep Hollow, Fall Creek, and Bowman Creek. In 1895, the company organized a subsidiary, Central California Electric Company, to utilize several power sites on the South Yuba Water Company's system. The first of these was the Newcastle Powerhouse, located 1.5 miles southeast of Newcastle, at the foot of a drop in the Bear River Canal. At a second 206-foot drop in the Bear River Canal one mile northeast of Auburn, Central California Electric built the Auburn Powerhouse to meet peak loads at the Newcastle plant. In 1901, a third plant at Alta was opened by running a pipeline one mile down the Little Bear River Canyon from an abandoned reservoir. By the 1910s, these rights were controlled by PG&E. The miles of interconnecting ditches allowed them to deliver water to many new powerhouses.[230]

Early power development on the eastern side of the Sierra Nevada followed a similar pattern. The discovery of gold in the Nevada towns of Tonopah and Goldfield in 1904 drove mining companies to find sources of electric power to operate their equipment. The price of desert production of electricity fueled by steam or gas was prohibitive. Instead, with the possibility of long distance transmission of electricity, mining companies looked to mountain streams and the Sierra's steep eastern escarpment for a potential power source.

Investors from Denver and Pittsburgh organized and formed the Nevada Power, Mining & Milling Company in 1906, one of the first hydroelectric companies in eastern California. After conducting a quick survey, they chose Bishop Creek in Inyo County as the best place to build a power plant. The Nevada Power, Mining &

Milling Company began operation of their first plant on the creek in 1905, with power conveyance to Tonopah starting on September 21, 1905. Like many other early power plants, the first Bishop Creek plant delivered electricity from a single plant to a single location. The original conduit consisted of 1.22 miles of 42-inch wood-stave pipe and a 30-inch wood-stave penstock. As power demands grew, the company increased the plant's production capacity by doubling its kilovolt-ampere units the next year. By 1908, they had again doubled their capacity. Development of the entire watershed commenced with the construction of a second power plant on Bishop Creek that began operation in 1907.[231]

A total of 25 hydroelectric plants were constructed in California through 1900 (Table 8). Of these, nearly three-quarters (18 plants) were located in the Sierra Nevada, all but two of these on the western slope of the mountain range. The remaining seven plants consisted of five in the Transverse Ranges, one in the Coast Range, and one in the Southern Cascades. By 1923, 28 percent (seven) of the plants constructed before 1900 were no longer in operation.

Table 8. Pioneer period hydroelectric water conveyance systems, as of 1923[232]

Name	Year	Length	Canal	Flume	Pipe	Tunnel
Pomona *	1891	1.3 miles (estimate)			lap-riveted steel	
Mill Creek #1	1893	2.0 miles			lap-riveted steel	
Bodie *	1893	0.84 miles	earth			
Utica *	1895	18.35 miles	earth	trestled wood		
Folsom	1895	1.67 miles	rock-lined and earth			
Yreka *	1895		rock-lined and earth	lap-riveted steel		
Nevada *	1896	3.5 miles		wood		
San Joaquin *	1896	6 miles (estimate)	Earth		riveted steel	
Big Creek	1896	2.0 miles		wood		
Newcastle *	1896		Earth	wood	single-riveted steel	
Knight's Ferry *	1896		Earth			
Kern River	1897	1.6 miles				concrete-lined
Blue Lakes *	1897					
Yuba *	1898	29.3 miles	Earth	wood (5'x3')		
Azusa	1898	5.9 miles		concrete/ masonry	wood stave	concrete-lined
Auburn *	1898	0.63 miles			lap-riveted steel	
Santa Ana	1898	3.3 miles		unknown	steel	concrete
Phoenix *	1898		Earth	wood (cedar)		timbered
Centerville	1898	19.0 miles	Earth?	concrete	lap-riveted, butt-riveted steel	
Utica (new)	1898	18.3 miles ft	earth, rock	trestled wood	riveted steel	unknown
Farad	1899	1.76 miles		wood	wood stave	
Kaweah #1	1899	6.45 miles		trestled wood	riveted steel, lap-welded	unlined
Mill Creek #2	1899	3.15 miles	Open	wood	concrete, lap-riveted steel	concrete pipe
Colgate	1899	10.0 miles		trestled wood	wood stave, cast iron, riveted steel	
Kitteridge	1900			unknown		

*Hydroelectric plants either abandoned or replaced by 1923.

Each of those early systems used conduits possessing certain similarities in materials and methods of construction. Their length ranged from approximately 30 miles at the Yuba Powerhouse to a low of less than a mile at the Auburn and Bodie powerhouses. The average length was slightly more than six miles. Most of the canals were originally earthen. Of the 11 for which detailed information was found, all included some unlined segments and three also reported rock lining. Out of 13 canals reporting flumes, 11 were described as wooden, one as concrete/masonry, and one as concrete. Six of the canals possessed tunnels, and of these, three were concrete lined, one was timber lined, and apparently the other two were unlined bedrock tunnels. Pipe material was almost uniformly lap-riveted steel, but two systems (Azusa and Farad) reported wood-stave piping and a third (Colgate) made use of cast iron, wood-stave, and riveted steel pipe.

Consolidation and Watershed Development, 1905 to Present

Hydroelectric power generation since 1905 has been characterized by the consolidation of smaller companies into a few large companies that controlled whole regions and watersheds. In 1900, there were dozens of small independent power companies in California, but these companies were absorbed in the early years of the twentieth century by moderate sized corporations, such as California Gas & Electric Corporation, which operated plants on the west slope of the Sierra from Mokelumne River northward to Butte Creek. In turn, these companies were absorbed by larger companies, and by 1915, only about 23 companies operated hydroelectric plants in California.[233] By 1928, this number had fallen to 14, with the vast majority of power plants being owned by the two giant corporations, Pacific Gas & Electric (PG&E) and Southern California Edison. In 1990, these two electrical utilities owned and operated 74 pre-1940 hydroelectric powerhouses, 10 percent of the nation's total.[234]

A second trend was a move toward developing the water sources of an entire watershed. Instead of having just one powerhouse, companies started to design systems that would take advantage of all the potential hydroelectric power of a river and its tributaries. Companies built stepped systems, which generated power at one point on a watershed then returned the water to the watershed, picked it up again in a conduit to develop a sufficient head, then dropped it again to generate electricity at another plant. In this way, the watershed's power potential was maximized. The third trend was a move away from single terminus distribution to a broader grid that could include both rural and urban customers.

The company that probably best illustrates these three trends was PG&E. The previously discussed Bay Counties Power Company was one of the companies to come under control of PG&E in the 1900s. The owners of Bay Counties, De Sabla and Martin, in 1903 organized the California Gas and Electric Company to form and merge power companies. Their company became one of the main components of PG&E when it incorporated in October 1905. PG&E was formed as a holding and operating company that took over for California Gas and Electric Corporation and San Francisco Gas and Electric Company.[235]

PG&E's Butte Creek/West Branch hydroelectric power development illustrates how power companies relied on mining water systems and water rights to supply their power plants. Between 1898 and 1908, four powerhouses were constructed: Centerville (1898), De Sabla (1903), Lime Saddle (1906), and Coal Canyon (1907). The four plants made use of many mining ditches, including Butte Creek Canal (1871), Hendricks Canal (1869), Toadtown Canal, Dewey Canal (1858), Miner's Canal (1860), Inskip Canal (1860), Centerville Canal (1875), Hupp Canal (1859), Miocene Ditch (1875), Nickerson Ditch (1850s), and Powers Ditch. Many of these ditches were enlarged by the power company. The1903-1904 enlargement of the Butte Creek Canal (Figure 25) necessitated construction of notable dry-laid rock retaining walls on its outer bank. Similarly, the old Hendricks flume system, one of the longest in the region, had to be rebuilt and portions were abandoned.[236] These power plants and canals came under the ownership of PG&E in 1908.

Figure 25. Lower end of Butte Creek Canal in 1908 (PG&E Archives)

Another watershed that eventually came under control of PG&E in 1919 was the Battle Creek System in Shasta County. Terry S. Reynolds' Historic American Engineering Record fully described the system's construction history, including its ditches, as follows:[237] The Battle Creek system was constructed by Northern California Power Company between 1900 and 1912. From a technological and engineering viewpoint, the system was one of the most notable early-twentieth century power developments in the state. As with many power projects in this era, Battle Creek began with the development of a single powerhouse and soon thereafter evolved into an integrated generation system with several power plants on the watershed. Plans to develop Battle Creek in Shasta County began in the late 1890s. Rising copper prices encouraged some mining entrepreneurs to turn away from gold and silver production and look toward exploiting Shasta County's mineral resources on a large scale. Expansion of mining and its associated industries coupled with increased population strained the region's fuel resources and created an incentive for hydroelectric power companies to explore the power possibilities of the region. As early as 1899, Mt. Shasta Power & Light Company began surveying the hydroelectric possibilities on the Pit and McCloud rivers, but a smaller tributary of the Sacramento River, Battle Creek, became the site of the initial power development in the region.

The Keswick Electric Power Company built the first hydroelectric plant on Battle Creek at Volta in 1901 to deliver electricity to copper mines in the region. The Volta powerhouse on the North Fork of Butte Creek utilized an existing complex ditch system, which was composed of several irrigation ditches which Keswick had acquired at various times on North Battle Creek and its tributaries, and the new Keswick Canal, which was dug by hand a distance of 3.5 miles to the top of the ridge overlooking the powerhouse. It diverted water by means of a rubble dam and withdrew water from several side creeks along the way, while developing a head of 500 feet. The water system was conservatively engineered without any flumes, trestles, tunnels, or steep hillside ditching because the company wanted to avoid any problems that could possibly shut down the powerhouse, its only source of electricity. Since it had only a single plant, the young company could not afford to lose its reputation as a reliable energy source or to discourage potential customers from acquiring electrical equipment. For similar reasons, the company erected a forebay storage reservoir of sufficient size to permit the plant to operate for six to 10 hours with the ditch system shut down.

In 1902, Keswick Electric Power incorporated as the Northern California Power Company. This company continued to generate power through the first decade of the 1900s. After completing the Volta plant, Northern California Power Company planned a back-up plant. The Kilarc plant, completed in 1904, was 20 miles north of Volta on Old Cow Creek, a tributary to the Sacramento River. Kilarc helped supply electricity to a growing market that included a smelter at Kennett, the Trinity River mining district, the Belle Vue Irrigation Company at Anderson, the interurban electric railways of Northern California, and the gold dredges on the Feather River. Then in December 1905, the company signed a power contract with PG&E that gave it rights to link with PG&E's transmission grid, giving Northern California Power access to the growing power market in the Sacramento Valley and the Bay Area.

In 1906, the company expanded the Volta powerhouse by adding a new generating unit. To accommodate the expansion, the company had to build a new water system with a second forebay reservoir, named Grace Lake, a new penstock, and an expanded ditch and flume system tapping the waters of Bailey, Deer, and Manzanita creeks. Northern California Power also elected to build its first major storage reservoir at Macumber Flats, nine miles northeast of Volta. The massive earth and rock dam was completed in 1907. At about the same time, the company began to envision a series of four powerhouses, including Volta, on Battle Creek. Expansion of the single plant system was foreseen to meet the still increasing market for electricity and to keep rival companies from building on Battle Creek downstream from Volta.[238]

Northern California Power had managed to avoid expensive flume, tunnel, and siphon construction on its Volta plant, but the rugged terrain on its future developments required expensive hydraulic engineering structures. The other three powerhouses of the Battle Creek system were completed between 1909 and 1912. The location of the three plants, the South, Inskip, and Coleman, were determined after a survey in 1907 showed where the plants could be built to utilize the entire fall available in the watershed. All three required extensive ditch systems that could convey the water from plant to plant.

The South plant, completed in 1909, required construction of ditches, tunnels, and flumes through rugged terrain where steam shovels could not be used. Work was completed by hand using air drills, picks, shovels, and dynamite. Rock blasted out for the ditch and tunnels was used to construct the powerhouse and to build retaining walls, intakes, diversion dams, and waste weirs for the canal system. A number of tunnels were driven to shorten the proposed ditch line, which required difficult excavation through solid lava rock. The tunnels, measuring approximately eight feet by eight feet, were driven from portals only.

The powerhouse received water through two ditch systems that joined about three-quarters of a mile above the forebay. The first diverted water in a canal from Volta Powerhouse to the edge of the canyon where it was dropped through a timber chute and then delivered to the south side of Battle Creek Canyon in a wooden flume. Here it joined with another flume carrying water from North Battle Creek. It then followed the south side of the canyon until it joined the South Battle Creek Ditch. The South ditch, diverted by a masonry dam, had a total length of 6.3 miles and was constructed through the most difficult rocky terrain. A total of 10 unlined tunnels were completed on this ditch, the longest being 4,258 feet long. The laborers who built the canal system were a diverse lot of Anglo-Americans, Greeks, Irish, Portuguese, Mexicans, and Italians. Most of the skilled rock work was carried out by Italian stone masons. To avoid a large expense for excavation and embankment work, the forebay at South Powerhouse was a simple rectangular masonry head box with a trash rack to screen the water and a trap to discharge sand.[239]

The third powerhouse on the Battle Creek System, completed at Inskip in 1910, supplied water to its penstocks through two main canals—the Inskip Canal and the Eagle Canyon Canal. The Inskip Canal was the larger of the two and headed at a 32-foot-high rubble masonry diversion dam below South Powerhouse. The 4.5-mile-long Inskip canal paralleled the course of South Battle Creek and had 11 separate sections of open ditch, eight sections of tunnel totaling almost one mile, and one short section of flume over Ripley Creek. The Inskip Canal had a typical cross-section of eight feet wide at top and a depth of five feet, and was somewhat novel in that excavation was hurried to completion by the use of steam shovels. The company, now well established in the power market, chose to construct costlier tunnels rather than building timber flumes because of the permanence of tunnels and their low cost of maintenance. The supplemental water supply was diverted at a masonry dam near where North Battle Creek entered Eagle Canyon. The canal was about 2.6 miles in length, with most of it being ditch excavated by hand. The canal also contained six tunnels and six flumes. The flume box on the north wall of Eagle Canyon was set on timber bents spaced at three-foot intervals, resting on a bench cut into the side wall of the canyon. The difficult and costly bench and flume construction delayed completion of the canal until 1919. As at South Powerhouse, the Inskip forebay was a simple three-chamber masonry header box that screened debris and sand from the system before water entered the penstock. The Inskip penstock was constructed of redwood-stave pipe where water moved down a gentle incline at low pressure, and with steel riveted pipe where it dropped sharply to the powerhouse.[240]

Even with Inskip and South powerhouses on line, seasonal demand for power from irrigators and the growing demand for power by the copper industry in Northern California Power’s territory exceeded the generating capacity of the company’s hydroelectric system. Construction began on the Coleman plant, named after Edward C. Coleman, one of the directors of Northern California Power Company. It was the largest powerhouse ever built by the company.

The plant received its water primarily from South Fork of Battle Creek, below the Inskip plant, where it was diverted by means of a 15-foot-high ogee-shaped rubble dam. Because there were no conflicting water rights between Inskip and Coleman, nearly all of water in Butte Creek was diverted into the Coleman Canal. There were no long tunnels or flumes on the canal. It ran 10 miles through gently rolling hills, which made excavation by a steam traction engine and steam shovel possible. In crossing the North Battle Creek Valley, Northern California Power’s engineers constructed a 1,270-foot-long, 76-foot riveted-steel inverted siphon, a construction technology not utilized on any of the earlier canal systems. The siphon was carried across the floor of the valley on masonry piers and actually crossed the creek bed on a 55-foot-long Howe truss. A second, smaller siphon was constructed to cross Baldwin Creek. Branch flumes from Baldwin Creek and Darrah Creek constructed in 1912 and 1913 discharged the water of those streams into the Coleman Canal. Along its course, the canal had nine rubble spillways and was mostly unlined except where dry-laid rubble walls buttressed up weak banks. The canal had a cross section 11 feet wide and 5.5 feet deep and a carrying capacity of 275 cfs, making it one of the largest power ditches in the state. At its lower end, the canal emptied into the Coleman forebay reservoir, formed behind an hydraulic-filled earthen dam composed of material excavated from the reservoir by steam shovel. The two 3,700-foot lap-riveted steel penstocks, formed on the site from plates, were ballasted by a dry-laid lava wall and anchored in concrete blocks.[241]

At about the same time the Battle Creek system was being built, a competitive race began between two companies to establish a toehold on the upper North Fork of the Feather River. Both companies sought to file for appropriative water rights at the Big Meadows reservoir site and thereby to tie up water rights on the entire river. Edwin T. Earle, owner of the largest fruit packing and shipping business in the state, and his brother, Senator Guy C. Earle, of Oakland, allied themselves with California engineers James D. Schuyler and Julius M. Howells and won the race to file for water rights. The group that would eventually form the Great Western Power Company began steps to develop power in 1902.

In 1905, the Great Western Power Company contracted with John R. Freeman, one of the most prominent hydraulic engineers of his era, to conduct surveys and file a report on the potential of the Feather River. Freeman's report became the basis for one of the first plans for a comprehensive hydroelectric power development in California. The plan included a huge storage reservoir (Lake Almanor) at Big Meadows, elevation 4,480 feet, on the headwaters of the North Fork; two off-stream storage reservoirs; seven power plants; and four diversion dams on the North Fork of the Feather River.

Great Western began building its first powerhouse at the lowest possible site on the proposed system, the base of an old mining tunnel formerly used to divert the Feather River for river mining. The Big Bend Plant above Oroville was completed in 1908. By 1911, construction on an Eastwood multi-arch dam at Big Meadows had begun; it was completed as an earthen dam in 1913. The second powerhouse at Caribou was completed in 1919, but the last plant on the river at Belden did not go into operation until 1968. The conduit system for the development represents a remarkable engineering feat in that the entire water conveyance system is composed of either bedrock or concrete-lined tunnels or steel pipe. There are no open canals.[242]

As Great Western worked on its dam at Almanor, the company was also busy acquiring a distribution system in San Francisco. In 1912, it laid a transmission cable under the San Francisco Bay from Oakland to San Francisco. This potential threat to PG&E's status as the wholesale power distributor caused PG&E to unleash a major program to develop the hydroelectric potential of the South Yuba and Bear rivers. The scope of this project dwarfed the earlier efforts of Martin and De Sabla.

PG&E had acquired the water rights and facilities of Central California Power Company in the South Yuba-Bear River watersheds in 1905. The company assigned two bright young civil engineers, J. H. Wise, a recent graduate of Stanford, and Frank Baum, of Berkeley, to plan the development. Like Great Western's development on the North Fork Feather River, the comprehensive plan for this watershed included utilization of the entire fall of 4,600 feet between an enlarged Lake Spaulding on the upper South Yuba to the final plant near Newcastle, 50 miles downstream. The system relied greatly on the old hydraulic mining canals of the region; however, completion of the enlarged Lake Spaulding Dam necessitated an increase in the capacity of the main canals. For example, Bear River Canal's capacity of only 43 cfs was enlarged to 350 cfs. The inside banks of the canal were carefully protected while material from the outer bank was piled up above the old surface. The canal was then run full to the top, with the outside bank of the hillside ditch stabilized by dry-laid rock for its entire length. Of course, increasing capacity by a factor of eight also meant completely rebuilding the old flumes.

Construction on the comprehensive power plan of the South Yuba-Bear River system was begun in 1912 with construction of the new dam at Lake Spaulding and the first powerhouse at Drum.[243] The new Lake Spaulding, which was first dammed in 1892 by the South Yuba Water Company using a rock-filled, dry-rubble dam, held a capacity of nearly 75,000 acre-feet by 1923. Its water supply was supplemented by 22 other reservoirs throughout the watershed, including Lake Van Norden and Fordyce Lake, which served as storage reservoirs higher in the Sierra.[244]

Figure 26. Drum Canal showing rock wall, 1914
(PG&E Archives)

Construction on the first of the six proposed plants, the Drum powerhouse, began in July 1912. With the 1913 construction of the dam, PG&E also built a 4,400-foot headgate tunnel to connect the reservoir with the intake of Drum Canal. The canal had a length of 8.76 miles, mostly in sidehill canal reinforced with dry-laid rock masonry on the inner wall and rock laid in mortar on the outer walls (Figure 26). Like the Coleman Canal on Battle Creek, the Drum Canal was constructed with steam shovels, with dimensions of 18 feet at top, 11 feet at bottom, and an average depth of seven feet. It made minimal use of flumes and possessed two siphons, one designed to avoid construction on National Forest land. Before the Drum Canal was completed, 40 percent of the water stored in the two basins was spilled into Bear River and diverted at the Boardman head dam where it was carried to Alta Powerhouse. After 1913, the Drum Canal became the principal diversion from the South Yuba, while only a small amount of water was diverted into the upper Boardman to service existing water rights.[245]

Following the construction of the Drum, other plants quickly followed at Halsey, just below Drum (1915), at the Spaulding Reservoir (1917), and the Wise Powerhouse, near Newcastle (1917). The Wise powerhouse was the lowest plant on the system, and it received its water through a complex system of canals, tunnels, and flume. The Wise canal was an open ditch which took water from the Halsey powerhouse to the Wise powerhouse. Three tunnels were used along the length of the conduit, as well as 300 feet of steel flume. Eventually, the South Yuba-Bear River system had eight plants: Spaulding Nos. 1, 2, and 3; Drum; Alta; Dutch Flat (conceived of as part of PG&E's original system); Wise; and Halsey. After passing through the power plants, the water was picked up for irrigation. The South Yuba-Bear River power system was one of the preeminent hydroelectric power developments of its era.[246]

From 1905 through the 1920s, the Great Western Power Company competed with PG&E in Northern California for the Oakland and San Francisco markets. The two companies finally merged in 1930. The Southern California market likewise was dominated by a few giant power companies. Pacific Light & Power Company owned the Big Creek power system in the upper San Joaquin River watershed and sent its electricity 240 miles to Los Angeles where it powered the largest interurban railway in the United States. Southern California Edison owned the pioneering systems on Mill Creek and the Santa Ana River and transmitted electric power 120 miles from its Kern River plants to Los Angeles. San Bernardino and Riverside counties were supplied largely by Southern Sierra Power Company (later California Electric Power Company) from its Bishop Creek plants. Thus, the three major private hydroelectric power companies in the Southland (as well as the Los Angeles Department of Water and Power) all developed power plants in the Southern Sierra to utilize the fall available from the lofty mountain range and transmitted the electricity a great distance to Southern California.

The steep topography of the Big Creek and San Joaquin River region of the Sierra Nevada made it a prime natural location for large-scale hydroelectric power generation. The many meadows and natural mountain lakes provided good locations for water storage, and the steep ridges and deep canyons allowed for high-head power development. The story of the development of the Big Creek System has been told by David H. Redinger in *The Story of Big Creek* (1949) and by Laurence H. Shoup in *"The Hardest Working Water in the World:" A History and Significance Evaluation of the Big Creek Hydroelectric System* (1988).

By all accounts, the Big Creek story is one of the great accomplishments in civil engineering. Big Creek was at the leading edge of each technological field it represented—turbine design, long distance electrical transmission, dam building, and tunnel construction. John S. Eastwood, one of the pioneer hydroelectric engineers and dam designers of his era in California, planned the development over a number of years. Each summer, he ascended the canyon and for months performed surveys and calculations upon which the entire development would proceed. One of the greatest of the many technological achievements of Big Creek was the innovative coordination of the many power generating stations and the heroic efforts of the army of workers who blasted miles of tunnel to connect those power plants. Among the many tunnels constructed, the key project was the Ward Tunnel, a 15-foot-by-15-foot tunnel driven through 11 miles of solid granite on Kaiser Ridge to tap the South Fork of the San Joaquin watershed.[247]

After the initial construction of a single powerhouse in 1905 on Bishop Creek, a progressive development of the entire watershed took place. Between 1905 and 1913, the Nevada-California Power Company and its subsidiaries completed five powerhouses on Bishop Creek. The first plant, powerhouse No. 4, discussed earlier, was completed in 1905 by the Nevada Power Mining and Milling Company, which was reorganized in 1907 as the Nevada-California Power Company. This company then progressively developed the entire watershed. By the time they had completed their construction in 1913, the plants utilized the entire available head from an elevation of 8,050 feet down to 4,459 feet. The system consisted of five independent power generating plants, 10 flowlines, 10 intakes, seven penstocks, four diversions, four dams, and associated buildings. The plants were spaced so close together that Frederick Fowler, a leading authority on hydroelectric plants in the 1910s and 1920s, noted that "barely enough space intervenes for the discharge from one to clear the intake pond of the next below." One of the unusual features of the Bishop Creek power system was the extensive use of redwood and Douglas fir wood-stave pipe for all its flowlines built between 1905 and 1913. Apparently, this pipe was all replaced between 1949 and 1983. In contrast, much of the original riveted-steel penstock pipe is still in place.[248]

The most southern of the major Sierra Nevada streams is the Kern River. Because of its location, Southern Californians began looking to it in the 1890s as a promising site for hydroelectric power development. Companies began to build small powerhouses on the Kern River in the late 1890s, and by the early 1920s, there were four plants on the river. Three of these were owned by Southern California Edison. Their two major plants on this watershed were Kern River Plant No. 1 and Kern River Plant No. 3. Kern River No. 3 was the largest plant and the one farthest upstream. The conduit for this plant was nearly all tunnel with short flumes connecting the tunnel and a 1,170-foot-long steel inverted siphon. The entire length of the conduit was over 68,000 feet. Kern River Plant No. 1 was constructed in 1907 by the Edison Electric Company. This conduit also relied heavily on tunnels, with 42,000 feet of its 44,000-foot conduit in tunnels.[249]

By the 1940s and 1950s, hydroelectric powerhouses had been built on nearly all the prime locations in California. Companies then began to replace the older plants. Modern, more efficient equipment led many companies, PG&E among them, to replace plants built 40 or 50 years earlier. PG&E's plant that first went into operation in 1899 was replaced 50 years later by a new plant at the same location. The new facility had a single 35,000-horsepower reaction turbine that replaced seven impulse turbines and the aggregate 20,000 horsepower of the original plant. By one estimate, 27 plants built before 1940 had either been retired or replaced by 1991.[250]

Public Development of Hydroelectric Power

Beginning in the 1900s, there was a move by some Californians toward government control and production of electricity. This was found on all levels of government, from municipal to federal. The first government regulation and control over hydroelectric power facilities had begun during the first decade of the 1900s. Two congressional water power acts, in 1901 and 1910, gave the Secretary of the Interior the power to grant rights-of-way for dams, reservoirs, power plants, and transmission lines over public lands. Most of the power plants in the state were on or had rights of way across public land. Permits were granted for 50 years and could be revoked only if there were cause. The two acts were suppressed by the Federal Powers Act of 1920 which created the Federal Power Commission. The Federal Power Commission had the authority to issue licenses for hydroelectric power development on all public lands except National Parks. These permits were also not to exceed 50 years. The act was one of the major steps to regulate hydroelectric power.[251]

In California during the early 1920s, two initiatives appeared on the ballot that would have had a large impact on the hydroelectric development in the state. The Water and Power Acts of 1922 and 1924 would have created a Water and Power Board to build or buy hydroelectric facilities which the board would operate. The acts would have authorized the board to borrow up to $500,000,000 for these projects and would have given it broad powers to buy generated electricity, build distribution systems for municipalities, and reserve the water from others for their own use. Both initiatives were soundly defeated, but the effort was one of the first steps in the debate over public versus private ownership of power in California.[252]

The idea of publicly owned hydroelectric plants had begun as early as 1906 in California. The first public groups to begin to develop hydroelectric power in California were municipalities. Los Angeles in its 1905 plan for the Los Angeles Aqueduct, which took water from the Owens Valley to Los Angeles, determined that three locations on the main line could be used to develop hydroelectric power. Led by city engineer William Mulholland, and with the approval of Los Angeles voters, the city began to build the first plant on the aqueduct mainline in 1911. By 1913, the plant was ready to go on line, but a controversy over distribution of the electricity in the city delayed its opening until 1917.[253]

The first plant, San Francisquito No.1, went on line in April 1917. The plant received water from a tunnel on the aqueduct line and delivered it to Fairmont Reservoir just above the power plant. From the reservoir, water entered the 40,000-foot-long Lake Elizabeth Tunnel. The tunnel had a head of less than 200 feet before it reached the penstocks. Construction on a second San Francisquito plant was begun at the same time as the first, but it was not completed until 1920. The second plant received its water through a conduit leading directly from the first plant, consisting of a series of eight concrete-lined tunnels.[254]

Earlier, Los Angeles had built three small hydroelectric facilities utilizing small drainage basins in the Owens Valley. The plants, two on Division Creek and one on Cottonwood Creek, were built in 1908 and 1909 to supply power for construction of the aqueduct. Like the hydroelectric systems of private companies of the period, the plants were envisioned as part of large, integrated power development, but instead of watershed development, this power would be generated along the line of the aqueduct.[255]

The other notable municipal production of hydroelectric power came from the City of San Francisco. San Francisco, like Los Angeles, sought a permanent, reliable water supply for its citizens. Both cities looked to the Sierra Nevada for this source, Los Angeles in the eastern Sierra and San Francisco on the western side. San Francisco’s eventual choice was the Hetch Hetchy Valley in Yosemite National Park. After a battle with environmentalists led by John Muir, the city built a reservoir in that valley. San Francisco constructed a small powerhouse, known as Early Intake, on the Tuolumne River to power equipment for constructing the O’Shaughnessy Dam, which formed the Hetch Hetchy reservoir. Eleanor Creek was dammed to supply water for the powerhouse, and water taken from Lake Eleanor was transported through a three-mile-long system of flumes, pipes, tunnels, and concrete-lined ditches. A second, larger power plant was constructed by the city at Moccasin Creek. From Early Intake, a 19-mile-long tunnel was drilled to Priest Reservoir above the Moccasin powerhouse, and penstocks took the water from that reservoir down to the powerhouse. Electricity generated by this system was delivered to San Francisco and distributed over PG&E’s transmission lines.[256]

Irrigation districts, organized locally to centralize water management and distribution, also built publicly owned hydroelectric plants. A few districts, including the Modesto, Turlock, and Imperial districts, produced and distributed hydroelectric power. The Modesto and Turlock irrigation districts, both organized in 1887, jointly owned Don Pedro Reservoir and powerhouse. They used the reservoir primarily to hold water for their customers to use in irrigation, but they also used the water to generate electricity. The powerhouse, which was installed in 1923, generated electricity that was distributed within the districts. The Modesto Irrigation District encouraged the use of electricity on farms by installing power lines and offering low rates. The Turlock Irrigation District also operated an additional hydroelectric facility below the La Grange dam on the Tuolumne River.[257]

During the first years of the Great Depression, the need for hydroelectric power decreased, and construction by private companies slowed. By the 1930s, it became much more expensive to build private hydroelectric plants, and most of the best locations had already been taken. However, nationally, construction of federal projects increased during the Depression of the 1930s, and in California, the total percentage of power that was produced by publicly owned plants increased from the 1920s through the 1940s. In 1923, this type of power was six percent of the state's production; by 1927, it had increased to 14 percent; and in 1945, it was 25 percent. These figures did not include power produced by federally owned plants.[258]

One of the largest New Deal projects was the Tennessee Valley Authority (TVA), which constructed many hydroelectric plants in the Midwest. In California, the Central Valley Project (CVP) began construction in 1937, rivaling the TVA in size. CVP, originally conceived of as a state, not federal, project, had many purposes, including controlling floods, improving navigation, providing water for irrigation, and generating hydroelectric power. The most noted hydroelectric plant on the CVP was the Shasta power plant at Shasta Dam on the Sacramento River. The Shasta Dam was the focal point of the CVP, as it was the largest storage reservoir on the project. The powerhouse at Shasta came on line in 1944, delivering electricity to the CVP's Tracy pumping station, where it could be distributed cheaply to customers, including farms, cities, and industries in the Sacramento Valley and along the Delta, and to pumping stations.[259]

The Central Valley Project built its largest hydroelectric facility, the Shasta power plant, just below the Shasta Dam. It received water directly from the dam through five 15-foot penstocks. By the 1980s, the plant had a generating capacity of 539,000 kilowatts. Nine miles downstream from the Shasta powerhouse, the Keswick Reservoir was used as an afterbay and reregulating reservoir for Shasta Lake and the Trinity River Division section of the CVP. The Keswick power plant, another of the hydro-generating facilities, was built into the dam. Throughout California, other power plants related to the CVP were constructed, including the Nimbus facility on the American River and the Lewiston power plant on the Trinity River.[260]

Controversy over the benefits of public versus private power continued with the construction of the hydroelectric facilities on the CVP. PG&E, with support from valley farmers, led the fight against the CVP's public power provision. The farmers believed that the Bureau of Reclamation's low-cost power policy would not generate enough money to help pay for the CVP, leaving the farmers with a greater share of the cost.

While PG&E was moving to limit the Bureau's role in power distribution, the Bureau fought for an integrated system of hydroelectric plants, steam plants, and transmission facilities. In 1951, a settlement was reached between PG&E and the Bureau whereby the Bureau would generate power and maintain high-voltage transmission lines that would link its plants together and deliver power to pumping stations. The Bureau, though, would not build low-voltage lines for public customers; instead, PG&E would distribute the power to customers.[261]

The Legacy of Hydroelectric Power

California became an early world leader in the development and long-distance transmission of hydroelectric power, creating elaborate systems to take full advantage of entire watersheds. During the pioneering period of development from 1890 to 1910, individual plants were constructed throughout California. As the basic technology advanced, more sophisticated systems were established in the Sierra Nevada watersheds. Beginning in 1905 and continuing to the present, the industry has shifted in focus to multiple plant systems that encompassed entire watersheds with increasingly complicated electric power conveyance systems. During both periods, companies used water conduits based on location and the company's needs. In the Sierra, companies utilized existing mining ditches and canals but often added tunnels, flumes, pipes, or more ditches to reach their power plants. The later federal projects often either built production facilities into a dam or had penstocks that connected reservoir to powerhouse. Ditches, flumes, pipes, tunnels, and penstocks were all essential for the operation of hydroelectric generation plants, especially important to the high-head type of development in California.

COMMUNITY WATER SYSTEMS

Early towns and cities relied on a combination of private and public water systems to solve their water supply problems. The more sophisticated early municipal water systems were designed for large urban areas, primarily the quickly populated Los Angeles and San Francisco Bay areas. However, despite common themes and shared technologies, California communities developed water systems in a number of different patterns.

In the Sierra foothills, for instance, joint stock water companies owned water systems consisting of timber flumes and iron pipes, dams and storage reservoirs. While generally constructed to meet the needs of mining interests, these systems nevertheless also eventually served farmers and ranchers who needed a reliable source of water. One of the earliest systems was built for the town of Columbia, where in 1853, the New England Water Company brought water to the community in a wooden water pipe, replaced in 1856 with iron. Water works and other infrastructure were constructed before 1900 in several San Joaquin Valley towns, largely by private companies. The Modesto Water Company was organized in 1876, and a water system was built for Hanford in 1881 and for Tulare in 1885.[262]

In Sacramento, citizens voted themselves a tax increase for the first municipally owned water works, which went into operation in 1854. Over the next several years, pipelines were extended from the Sacramento River. As the river was used for any number of other local activities, including industrial waste, citizens waged a campaign from 1895 until 1915 to purify the water supply. Only after 20 years' effort was a decision made to chlorinate the water taken from the Sacramento River, and in 1924, a filtration plant was put in operation.

Many other growing communities relied on privately owned water services. Enterprising individuals, such as Anthony Chabot, who developed water supplies for San Jose, Oakland, and Vallejo, and private companies, such as San Francisco's Spring Valley Water Company, brought water systems to California communities.

Before 1865, San Francisco residents drew water from nearby streams such as Lobos Creek and Islais Creek, and ships brought fresh spring water across San Francisco Bay from the "Saucelito." These early urban water projects generally dug open ditches that tapped nearby streams, and then delivered the water to residents in barrels and wagons, or they drew underground water from local wells. It soon became apparent that burgeoning San Francisco would require a water supply beyond the capacity of local water sources and private enterprise. However, in the late nineteenth century, local governments themselves rarely engaged in water development. It was not until the 1930s that the city finally selected a water supply from the distant Tuolumne River, using storage at Hetch Hetchy Valley and Lake Eleanor. Lawsuits and construction obstacles delayed delivering water to San Francisco until 1934.[263]

In Southern California, rivers, surface streams, and artesian wells supplied adequate water for most small communities during the first few decades after California's admission into the Union. In Los Angeles, water initially continued to be distributed through publicly owned *zanjas*, open ditches established by the residents' Mexican predecessors. By the 1860s, however, pipes were installed for safer water distribution, and in 1868, the city signed a 30-year lease with a private firm to provide the city with water. In 1886-87, Elias J. "Lucky" Baldwin, owner of the Rancho Santa Anita in Los Angeles County, constructed a pipeline far up in the reaches of Santa Anita Canyon to transport cool stream water to his semi-arid acreage. Without it, the subdivision of his vast land holdings would have been problematic at best.

In Riverside, an uncertain future over water resources, along with conflict between land promoters, water companies, and residential users, prompted city incorporation in 1883.[264] Indio in the Coachella Valley relied on irrigation from artesian wells as it began to develop in the 1890s, but rapid depletion of the groundwater in the desert town led to the organization of the Coachella Valley Water District in 1918. Over the next several decades, the agency built infrastructure to trap local seasonal streams and eventually constructed a branch line extending around the northern side of the Salton Sea from the All-American Canal.

By 1902, after a bitter legal battle, the Los Angeles municipal government took back jurisdiction of its own water needs and purchased the existing water system, then consisting of seven reservoirs and 337 miles of pipe. The city's leaders knew future growth would be limited without an adequate supply of water. How Los Angeles secured its water is a familiar story and has been well documented. City voters passed bond measures in 1905 and 1907 for the purposes of procuring water from the Owens Valley via a 250-mile aqueduct. Two decades later, the aqueduct was extended 100 miles farther north to the Mono Basin watershed.

Even then, the Southern California region's water needs were seemingly insatiable. By the end of the 1920s, the coastal plain and the inland valleys of Los Angeles, Orange, Riverside, and San Bernardino counties had become home to more than 2.5 million residents. The collaboration of Los Angeles with other nearby cities, including Glendale, Pasadena, San Bernardino, Colton, and Long Beach, in the formation of the Metropolitan Water District and in gaining access to waters of the Colorado River opened still another significant phase in the development of Southern California.

By the 1920s and 1930s, Southern California communities approaching full use of their existing municipal water supplies took different responses to the perennial problem of water shortage. Until the waters of the Colorado could be tapped, Pasadena and other nearby cities had flood control districts and other water agencies construct works along the San Gabriel and Santa Ana rivers and their watersheds to capture the precipitation that fell during the short rainy season. The problem was perhaps more severe in coastal areas, where saltwater intrusion and declining groundwater indicated a serious shortage.

Santa Monica, like many other cities in the Los Angeles basin, relied on its own water supplies before becoming one of the 13 charter members of the Metropolitan Water District (MWD) when it was organized in 1928. After the Colorado River Aqueduct was completed in 1941, Santa Monica became eligible for conveyance of softened, filtered Colorado River water, conveyed 266 miles through conduits that included 93 miles of tunnel and 19 miles of pressure pipe. By 1960, 98 percent of the city's water came from that source.

Other Southland cities eventually joined the Metropolitan Water District to ensure adequate access to water during droughts. The city of Arcadia, for instance, located at the base of the San Gabriel Mountains, had its own ample ground water supply. In the heart of Lucky Baldwin's home tract and a scant 15 miles northeast of downtown Los Angeles, Arcadia lies over three natural underground basins, which still provide most of its water. Indeed, through the early 1990s, 90 percent of the water supply for the more than one million San Gabriel Valley residents was derived from the valley's ground water basins. However, to guarantee supplemental water supply when local ground water sources were insufficient, the city was required to sign on to the MWD, which it did in 1959.

Early in its history, the city of San Diego had given private citizens permission to drill wells and to take water from the San Diego River. The city also contracted with the privately financed San Diego Water Company to lay pipe to bring water from the San Diego River to Old Town. Elsewhere in the region, as the land boom brought settlers and land speculators, it became clear that water was essential to future growth and development. In the 1886-89 period, the San Diego flume company constructed 35 miles of flume, tunnels and dams to bring water to the greater San Diego region, including Chula Vista and National City.

By 1901, San Diego had purchased back some of the river rights it had given to private interests, but it was soon forced to look for additional water sources. Farsighted local policy-makers had identified and legally secured a right to Colorado River water and planned to eventually tap into the All-American Canal. However, the arrival of Navy personnel and civilian defense contracts brought growth that induced San Diego to eventually connect to the Colorado River water by constructing a conduit from the Metropolitan Water District system at the western end of San Jacinto Tunnel.[265]

RECLAMATION SYSTEMS

Usage of the term "reclamation" in California has historically varied from that of other arid western states. In California, reclamation generally referred to draining "swamp and overflowed lands," or low-lying areas inundated by seasonal wetlands, while in other western states, the term commonly applied to irrigating arid or semi-arid land. In California, Reclamation Districts (RDs) are special districts, primarily levee districts, organized for flood control or for drainage of surplus water to allow the land to be farmed. Ironically, much of the farm land within RDs does require irrigation, but irrigation activity is generally subordinate to flood control.

The opening of the twentieth century marked a turning point in reclamation in the United States. Heretofore, private capital, sometimes partnerships or settlement colonies, undertook reclamation work. However, privately financed projects met with mixed success, and the scale necessarily was limited. Development of larger projects involving substantially more acreage required the financial involvement of both the state and federal governments.

Reclamation began as early as 1849 on the Sacramento-San Joaquin Delta with the construction of levees around Grand Island. Many of the first efforts of reclaiming land in California were private enterprises, such as the Kern Valley Water Company's construction of a canal 125 feet wide and 24 miles long to carry the floodwaters of the Kern River and the overflow of Buena Vista Lake.

The 1902 Reclamation Act established the US Reclamation Service (later the Bureau of Reclamation) within the Department of Interior. Reclamation policies were initially designed to foster construction of irrigation systems, with the larger purpose of promoting the occupation of western lands by family farmers and ensuring an equitable distribution of water. The development of hydroelectric power became an additional goal as early as 1906. Often, the remoteness of the project sites required the Bureau to build its own hydroelectric plants and transmission lines.

Under the 1902 Act, and in response to the perceived inequities of earlier land grabs such as the Homestead Acts of the 1860s, no water in excess of that needed to irrigate 160 acres (or 320 acres held jointly by husband and wife) could be delivered to a single farm operation. However, wholehearted enforcement of these provisions apparently never materialized, at least in some parts of California.[266] Within five years of the Act's passage, a total of 24 projects were authorized, spread throughout the western United States. Notably, several projects extended beyond the bounds of a single state.

Early federal reclamation projects in California (prior to World War I) included the Orland Project, in Glenn County in the northern Sacramento Valley; the Truckee-Carson project near the northern Lake Tahoe Basin; the Klamath Project, encompassing portions of Modoc and Siskiyou counties, as well as parts of southern Oregon; and another project involving the Colorado River. These projects commonly involved building storage and diversion dams, canals, and feed laterals that would distribute water from a reservoir to the privately held lands to be irrigated, and some of the projects incorporated earlier, privately built ditches within the new systems. (See the section on Irrigation, above, for further discussion of these reclamation projects.)

MAJOR MULTI-PURPOSE SYSTEMS

Government interest in comprehensive development of California's irrigable land began in the 1870s and focused on the Central Valley area. A federal irrigation commission, headed by Colonel Barton S. Alexander of the Army Corps of Engineers, issued a report on nascent irrigation development in California in 1873-1874. Interest in the report, in part, generated creation of the State Engineer's Office in 1878. Through that office, the state initiated investigations into a potential system of irrigation canals for the Central Valley and explored forms of organization for irrigation development. William Hammond Hall, who headed the office, and his assistants—James Dix Schuyler, Marsden Manson, and Carl Ewald Grunsky—became leading engineers in the early development of the state's water resources.[267]

By 1880, the total number of acres irrigated in the state had jumped to 292,885 acres, almost a five-fold increase in 10 years. Nevertheless, dry farming of wheat on huge estates still dominated Central Valley agriculture. It was not until the end of the century that soil exhaustion, lower yields, and competition from the Mississippi Valley and Russia brought about the collapse of California's wheat empire. In the meantime, irrigated agriculture made steady, if modest, progress.

The turn of the century marked the end of a prolonged economic depression that had affected agriculture throughout California and the American West. For the next two decades, California farmers enjoyed high prices for their products, especially during World War I. With prosperity came a flood of new immigrants, and between 1900 and 1920, approximately 45,000 new farmsteads were established in California. Most of the new farms were created from the subdivision of former large grain farms and cattle ranches. The subdivision phenomenon produced farms smaller than the typical 160-acre American quarter-section farm. Of the 45,000 new farms, 37,600 were less than 50 acres in size. The San Joaquin Valley surpassed other regions of the state in the growth of its rural population during this period. One-third of the state's overall growth in farm population occurred there, tripling the valley's population in only two decades.

These figures, while impressive, did not signify the disappearance of large landowners. Rather, while the number of farms did increase, the percentage of land in larger or consolidated holdings also rose dramatically. Floods, drought, and increasing operating costs took their toll on smaller farmers following the boom years of World War I. Larger farmers took advantage of economies of scale and the availability of an inexpensive, mobile labor force to harvest their crops. They relied on a series of ethnic groups to provide low-cost labor, starting with the Chinese in the nineteenth century, followed in waves by Japanese immigrants, people from India, Filipinos, Mexicans, predominantly white Dust Bowl migrants, and Mexican Americans.[268]

California's growing metropolitan areas also needed increased water supply systems. Like proponents of comprehensive basin-wide or statewide systems, California's cities adopted the concept of inter-basin water transfers to supply their growing needs. First, Los Angeles in the Owens Valley (1906-1913), followed by San Francisco at Hetch Hetchy (1913-1935) and Oakland on the Mokelumne River (1924-1928), the state's major urban areas reached beyond their local and increasingly inadequate watersheds to secure ample supplies of high-quality water for municipal and domestic uses. Los Angeles even extended its reach to a second system, connecting to the Colorado River in the 1930s.[269]

The nation's agricultural depression of the 1920s did not reach California until 1930, but trouble was already on the horizon. From 1917 to 1924, water shortages in the Sacramento and San Joaquin valleys stimulated construction of a half-dozen major reservoir projects. Irrigation became increasingly expensive; speculation inflated land prices; and the costs of ground leveling and ditching and the charges for water rights also escalated. This situation set the stage for rekindled interest in the earlier federal and state feasibility studies of large-scale water transfer systems.

After World War I, farmers, city-dwellers, and industrialists increased pressure on government officials to provide a larger and more secure supply of water. This prompted water planners to return to inter-basin concepts introduced in the 1870s and 1880s in state and federal government irrigation investigations. The first substantive blueprint for a comprehensive water plan came in 1919 when increased population and declining water tables in the valley prompted former USGS Chief Geographer Robert B. Marshall to suggest a system of immense scope. The "Marshall Plan" included a huge dam on the upper Sacramento River upstream from Redding at Kennett as the capstone of his project. Two grand aqueducts on either side of the Central Valley would reclaim arid portions of the southern San Joaquin Valley, provide water to Bay Area cities, improve the navigability of the Sacramento River, and prevent salt water intrusion into the Sacramento-San Joaquin Delta.[270] While Marshall's idea fired popular imagination, it was rejected three times by the state's voters in the 1920s. The concept, however, carried forward to the 1930s, and it was among the proposals providing a starting point for a statewide plan.

The Central Valley Project

The story of the development, planning, political background, and construction of the Central Valley Project (CVP) has been well told elsewhere. The CVP represents one of the most ambitious and successful water development projects ever undertaken. Within the contexts of hydraulic engineering, the politics of public works, state-federal conflict over reclamation policy, and the economics of large-scale irrigation, the CVP is recognized as a great achievement on a national, even international, scale. Although finally built by the federal government, CVP was a concept devised by the State of California to resolve chronic intra-state water shortage problems. The history of the project may be traced back as far as the 1870s, but it was not until the late 1920s that the California Legislature recognized that the state's water problems were so severe and systemic as to require government intervention.[271]

The key building block in development of the CVP was a series of studies undertaken by California's State Engineer Edward Hyatt between 1927 and 1931. Hyatt borrowed aspects of the Marshall Plan, but also made substantive changes. Released in 1931, his plan called for a huge system of canals and reservoirs throughout the state, including most of what became the CVP, as well as a transfer system to bring Colorado River water to Southern California.[272] In 1933, California voters approved by initiative the Central Valley aspects of Hyatt's proposal, called the Central Valley Project in the initiative. However, construction was delayed because the state was unable to market bonds during the economic depression.

The state then turned to the federal government, suggesting a role for construction of the CVP in President Franklin D. Roosevelt's New Deal. Through a complicated series of negotiations, California officials were finally able to secure federal funding for the project, in part by promoting the project as a major job-creation undertaking—a convincing selling point during the early years of the Great Depression. Throughout these negotiations, state and federal officials wrangled over whether the project should be built by the Corps of Engineers or the US Bureau of Reclamation (USBR), the two major dam-builders within the federal government, and whether the system would ultimately be controlled by the state or federal government. In time, the federal government decided to proceed with the undertaking as a federal reclamation project, a decision which ensured that the USBR would be the constructing agency and that the system would remain in federal ownership for the foreseeable future.[273] This also meant that federal reclamation laws would apply to the CVP, most importantly the 160-acre limitation on water deliveries.

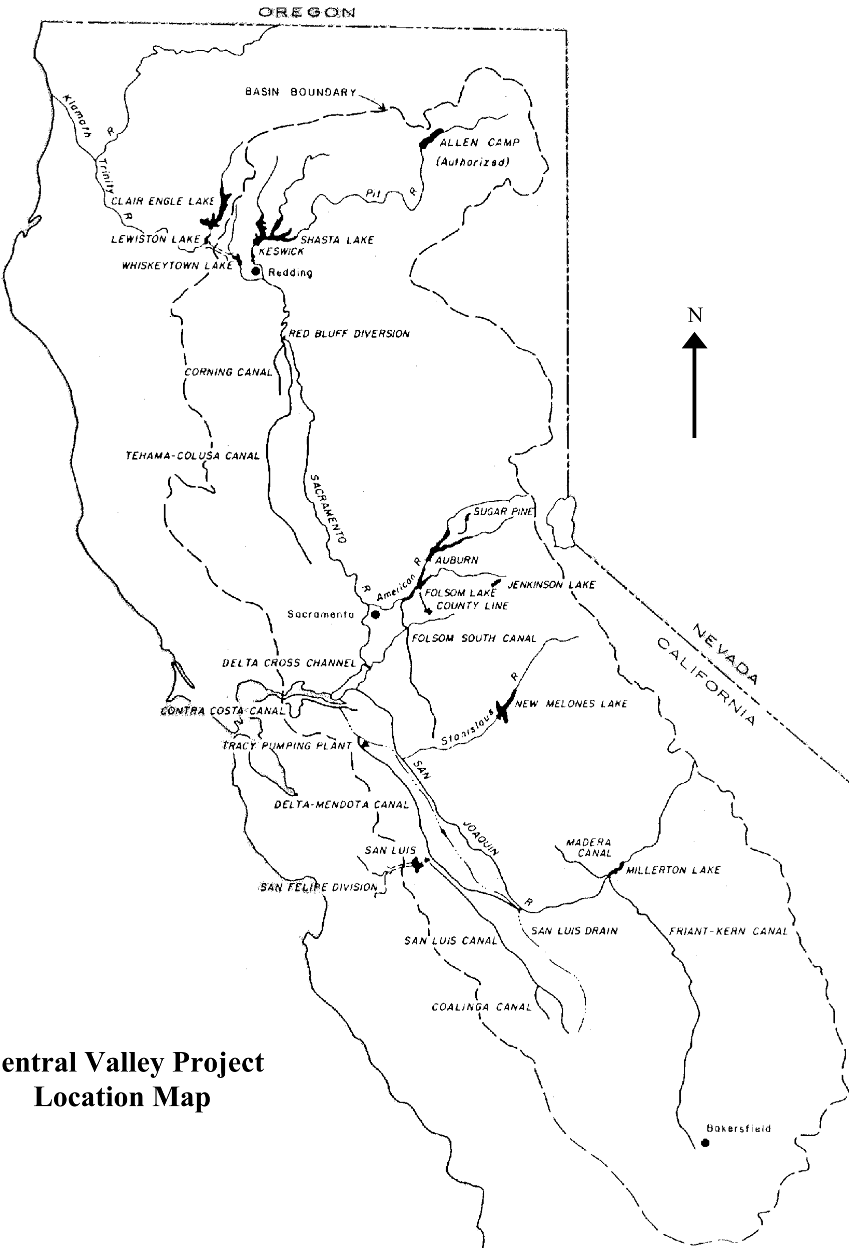
In 1935, President Roosevelt released emergency funds so that construction could begin, with water thus developed subject to the reclamation law's acreage limitation. Two years later, Congress gave the USBR authority to take over the project. Construction of the project proceeded on a piecemeal basis.[274] From the outset, federal officials looked at the CVP in both the short and long term. In the long run, USBR officials regarded the CVP as including essentially all elements devised by Hyatt in the late 1920s. In the short run, however, the CVP was restricted to five fundamental units, operating as an integrated system (Figure 27). They consisted of Shasta Dam, the Delta-Mendota Canal, Friant Dam, the Friant-Kern Canal, and the Contra Costa Canal. The Contra Costa Canal was the smallest segment, and unlike the other major canals, it was a relatively small conduit, designed to deliver water to industries, farms, and homes in eastern Contra Costa County. In replacing Suisun Bay water, it also served, to a limited degree, to mitigate the effects of pumping water from the Delta which was further degrading water quality in Suisun Bay. The core of the CVP system, however, involved the coordinated operation of the other four units for the purpose of delivering Sacramento River water to the arid San Joaquin Valley.

The USBR designed the four units to operate in two groups of works. Shasta Dam and the Delta-Mendota Canal operated together to store and deliver Sacramento River water as far south as Fresno County, to irrigate new acreage and supply replacement water for San Joaquin River diversions. Friant Dam and the Friant-Kern Canal worked together to store and divert San Joaquin River water as far as the southern extremes of the San Joaquin Valley near Bakersfield. Working in conjunction with one another, the Shasta/Delta-Mendota system replaced water that was diverted by the Friant/Friant-Kern system.[275]

Power generated at Shasta Dam was transmitted to CVP pumps, providing electricity to the lift pumps that raised water into the main canal system. The system utilized the natural channels of the Sacramento River and Sacramento-San Joaquin Delta to move water from Redding to Tracy, the head of the Delta-Mendota Canal. The USBR later added the Delta Cross Canal to direct flows more efficiently across the Delta to the Tracy pumps.[276]From the outset, the CVP did more than supply irrigation water. Shasta Dam generated surplus power for sale, which helped fund the project, and water releases from the dam were intended to facilitate more dependable navigation on the Sacramento River. Among other benefits were recreational opportunities and enhancement of fish and wildlife habitat. As a reclamation project, however, the system was at its heart designed to deliver water to farmers.[277]

Although the initial units were finished in the early 1950s, the USBR greatly expanded the system in subsequent decades, adding or absorbing reservoirs, canals, pipelines, pumping plants, and other units. Since the 1970s, the State of California's State Water Project has been operated in conjunction with the CVP, the state project drawing from the same Delta pool as the CVP and the stored water mingling in the Sacramento River flows.[278]

The great dams at Shasta and Friant are the linchpins of both the original and current system, providing the water that flows through the CVP canals. The main canals are radically different in design from any of their predecessors in California, being built to carry enormous amounts of water and built to last.[279] The largest of the canals, such as the Friant-Kern Canal and Delta-Mendota Canal, rival natural rivers in capacity and length. Other canals in the system are more modest in size. For example, the Madera Canal, a relatively minor part of the original CVP units, is the shortest and second smallest canal in terms of flow; only the Contra Costa Canal is smaller.



**Central Valley Project
Location Map**

Figure 27. Central Valley Project features, 1981 (Christiansen 1981:v)

The CVP has had a profound impact on Central Valley agriculture in the years since its water first reached San Joaquin Valley farms in 1951, some 14 years after the Bureau began construction on the project.[280] The USBR has called the CVP "one of the most extensive artificial water transport systems in the history of the world."[281] Furthermore, the CVP was seen as an integrated unit. "From its inception and formulation," wrote former USBR senior official L. B. Christiansen, "the Central Valley Project has been a single project in concept, design, and operation; it functions as an integrated whole, not as a grouping of separate or independent units." Congress made this explicit in the CVP authorizing legislation.[282]

In the years after its initial period of construction, roughly through 1951, a number of major dams constructed by the Corps of Engineers (Folsom, New Melones, Hidden, Buchanan, and Black Butte) have been incorporated into the CVP by their authorizing legislation, although they were not part of the original plan. Other major units, like the Trinity River Division's Trinity and Lewiston dams, and Clear and Spring creek tunnels, were part of a second wave of authorizations in 1955 and not completed until 1964. Even later were completed units like the Tehama-Colusa Canal. Similarly, in 1960, the CVP and State of California jointly developed the San Luis Unit (45 percent CVP, 55 percent State) as an off-stream storage facility in the Los Banos area to augment supplies to both systems and provide water to the San Luis Canal. Other segments remain authorized but not yet completed, such as the Auburn-Folsom South Unit.[283] While the dams are integral parts of the CVP, the canals they feed are the focus of the following discussion.

Contra Costa Canal

The USBR initiated construction of the CVP's first canal, the 46-mile-long Contra Costa Canal, in November 1937. This canal was designed primarily to provide water for industries threatened by salinity intrusions into Suisun Bay. It was included in the CVP at least in part as a concession to politically and economically powerful industries which might have otherwise opposed the CVP on the grounds that the project would have increased their salinity problems. These influential companies promoted the "Contra Costa County Conduit" concept, which was supported by the State Water Plan Authority.[284]

Figure 28. Typical unreinforced concrete section of Contra Costa Canal (USBR 1952:frontis)

The USBR opened an office in Antioch in 1936 and began surveys of the proposed route. Over the next two years, studies settled on a canal design with a capacity of 350 cfs. As this volume exceeded the USBR's design, the Contra Costa Water District agreed to pay the extra $500,000 to expand the canal.[285] Construction was underway even before the canal's final capacity had been set. By 1940, the facility had reached Pittsburg, and test pumping began that July (Figure 28).[286]

The canal had reached 38 miles west of the Rock Slough intake when the entire CVP was classified as a "limited defense activity," and in May 1942, work was suspended for the duration of World War II. Construction resumed after the War Production Board returned control of the CVP to the USBR in September 1945, and the Contra Costa Canal system was completed in 1948.[287]

According to the USBR, the purpose of the Contra Costa Canal within the CVP was to deliver water to "an upland agricultural area, many industrial plants in the upper Bay region, and a number of Contra Costa County municipalities." The Contra Costa County Water District purchased the water from the USBR and sold it to local retailers. It has continued to do so since the first "interim contract" with the Bureau between 1948 and 1951, and by a finalized agreement since that date.[288]

The Contra Costa Canal gradually diminishes in size as it wends its way west from its intake at Rock Slough in the Delta to its terminus in Martinez. It is predominantly open and concrete lined, with occasional piped segments laid underground. Siphons, like that on Kirker Creek, carry the canal across major drainages, while small or intermittent waterways pass beneath the canal in culverts. Wasteways and turnouts are provided at regular intervals to drop water to consuming industries along the margin of Suisun Bay. At Port Chicago, the canal swings south and passes through Concord and Pleasant Hill before swinging north to Pacheco and terminating in Martinez Reservoir.[289]

Delta-Mendota Canal

The Delta-Mendota Canal was built between 1946 and 1952, its construction delayed by wartime allocation of resources to military projects. The canal carries water from the Tracy Pumping Plant in the southern Delta roughly 113 miles south to a point on the San Joaquin River 30 miles west of Fresno. Besides some releases made along the canal on its way south, water from the canal collects in the Mendota Pool, then flows north through the San Joaquin River channel where it is diverted for use by local farmers and irrigation districts. The water provided through the canal replaces San Joaquin River water stored behind Friant Dam, which is used on the eastern side of the San Joaquin Valley after diversion into the Madera and Friant-Kern canals. The Delta-Mendota Canal receives 4,600 cfs from the Tracy Pumping Plant, and it delivers 3,210 cfs to Mendota Pool; the remainder is diverted from the canal or lost to evaporation and seepage.[290]

Most of the way, roughly 95 miles, the canal is concrete lined; only 18 miles are earthen. The canal's bottom width in concrete sections is 48 feet; earthen sections are wider, running 60, 62, and 80 feet, depending on location. Concrete sections have steeper sides (1.5 to one) and have deeper water (15 feet) than earthen sections (2.5 to one and 13.9 feet). Besides the canal itself, canal-related structures include concrete check structures at five-mile intervals; four major wasteways; a control structure at the Mendota Pool; seven siphons to carry the canal beneath roads, railroads, natural streams, and other obstacles; state and federal highway bridges, more than 50 county road bridges, and farm and service road spans; 10 siphon crossings, carrying irrigation laterals or drains under the main canal; five major turnouts; and a variety of pipeline and powerline crossings, drains, and other structures.[291]

Walking draglines, some with 13-cubic-yard capacity buckets, were used to excavate the main canal (Figure 29). The Morrison-Knudsen Company, Western Construction Corporation, H. H. Everist Sr., and M. H. Hasler Construction Company employed large movable canal trimmers and movable slip forms to install the linings on concrete-lined portions of the canal, resulting in a uniform design and appearance. All canal sections, whether lined or not, are a standard trapezoidal configuration, varying in overall dimension. Teams of concrete finishers also installed linings for wasteways and other facilities.[292]

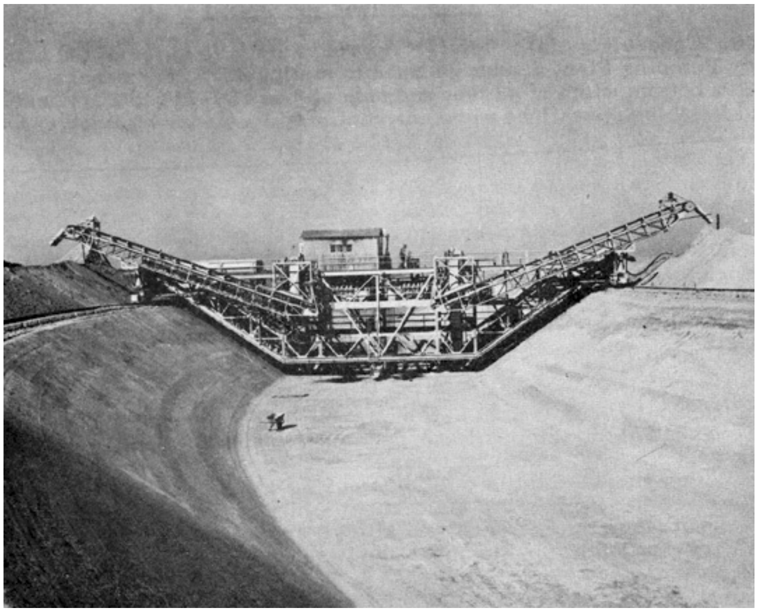


Figure 29. Delta-Mendota Canal under construction, 1947
(USBR 1959:132)

Friant-Kern Canal

The Friant-Kern Canal is a part of the Friant Division of the CVP, constructed as an initial segment of the CVP. Water from the San Joaquin River is stored behind Friant Dam in Millerton Reservoir east of Fresno on the Fresno-Madera County line. The Friant-Kern Canal and the smaller Madera Canal receive water through outlets at either side of the dam, and the Friant-Kern Canal carries San Joaquin River water more than 150 miles south to the Bakersfield area.

Like the Contra Costa Canal and Delta-Mendota Canal, the Friant-Kern Canal was authorized for construction by Congress in the Central Valley Project Act of 1937. The overall object of the project was to take water from the Sacramento Valley, where there was a "surplus," and shift it to the water-deficient San Joaquin Valley. Water stored at Millerton Reservoir would be sent south as far as Bakersfield; these flows were to be replaced by water supplied through the CVP's Delta-Mendota Canal.

As its name implies, the Friant-Kern Canal connects Friant Dam with Kern County, covering a total distance of 152 miles. USBR contractors built the Friant-Kern Canal between 1945 and 1951, once wartime water restrictions had been lifted. Work on the canal proceeded in a generally downstream direction, so that the final sections near Bakersfield were built during 1950 and 1951. In its concrete-lined sections, the canal has a bottom width of 36 feet and a water depth of 15.5 feet, with steep side slopes of 1.25 to one. It has a maximum capacity of 5,000 cfs, with a normal diversion capacity of 4,000 cfs.[293] In terms of its geometry and dimensions, it is nearly identical in appearance and configuration at all locations.

The canal was dug by crawler tractors towing an endless belt to remove dirt, which also created an embankment along the canal. As with the Delta-Mendota Canal, a machine that was a combined shaper and concrete layer placed the lining. These machines were moved on tracks laid temporarily at the edge of the canal and shifted as the crews finished each portion. The machines for cutting, shaping, and lining the canals were referred to as "jumbos." The builders poured concrete into a slow-moving slip form which followed the canal-shaping jumbo. Men working as concrete finishers worked on scaffolding attached behind the concrete-laying jumbos. They had to use ice in summer months to keep the concrete at proper temperature.[294] Of course, one effect of the use of such machinery was uniformity in the canal's design, dimension, and appearance.

The USBR's locational surveys in the late 1930s had been based on a planned canal capacity of 3,500 cfs, but when the project took shape in the 1940s, a larger capacity was called for. Because some right-of-way had been acquired in the 1930s, the path adopted was somewhat more sinuous than it would have been had a larger canal been contemplated from the outset, particularly at the upper end. When the canal began conveying water in 1951, 127 miles of its 152-mile length were concrete lined, including the last 30 miles upstream of Bakersfield, and the remaining 25 miles were lined with compacted earth. The earthen sections were considerably wider (64 feet as opposed to 32 feet) than the concrete section, with gentler side slopes. As the canal moved south, it grew smaller as diversions reduced flows. By the time it reached Bakersfield, the canal's capacity was reduced to 2,000 cfs.

The USBR granted construction contracts for various segments to different contractors. Among these were Morrison-Knudsen (also working on the Delta-Mendota Canal), Arizona-Nevada Constructors, Bent Construction Company, and Otto B. Ashbach and Sons, Inc. The contract for construction in the vicinity of Bakersfield went to Peter Kiewit Sons Co., of Omaha, Nebraska, for "earthwork, concrete lining, and structures." Kiewit in turn used a number of local subcontractors to aid in this effort, mostly to provide supplies. Kiewit performed construction on other segments of the canal as well. The company completed the work on June 29, 1951, having employed as many as 460 workers in January 1951, down to 60 in June of that year.

At the time it was completed, the canal was equipped with a variety of control structures: 29 major canal siphons, eight wasteways, five checks, 11 overchutes, 49 culverts, and 51 turnouts to local distribution laterals. It also had a large number of bridges of various types: one railroad bridge, 19 state highway bridges, 100 county road bridges, 91 farm bridges, and one "miscellaneous road bridge." The USBR used standard plans from various organizations for the bridges. Types included timber farm bridges, timber county bridges, highway bridges with steel girders, and concrete state and county road bridges. The timber bridges were "designed in accordance with their appropriate listed standard specifications," drawn from either the American Association of State Highway Officials or the American Railway Engineering Association.[295]

The Friant-Kern, like other segments of the CVP, provided water for others to distribute. Once this federal water was available, new irrigation districts were formed in the San Joaquin Valley, including the Porterville Irrigation District (Tulare County), Rosedale-Rio Bravo Water Storage District (Kern County), Ducor Irrigation District (Tulare County), and Pixley Irrigation District (Tulare).[296] The Friant-Kern Canal's effect on local canal systems can be seen in the establishment of the Porterville Irrigation District (PID).

The PID was not one of the original Wright Act districts of the 1880s, nor was it organized during the second phase of Wright Act district establishments in the early twentieth century. Instead, the PID was established to take advantage of the new water available from the CVP Friant-Kern Canal, which reached the Porterville area in 1949. The new supply augmented the meager flows from small ditch systems tapping the Tule River since the mid-1870s. Before the arrival of Friant-Kern water, the total area irrigated around Porterville was relatively small, encompassing only about 5,000 acres by 1901, and with the use of groundwater, 13,000 acres by 1949.[297] In August 1949, the new district was organized to contract with the USBR for water from the new Friant-Kern Canal. Negotiations continued through 1951, and on January 28, 1952, the PID and USBR signed a contract for a substantial irrigation supply. PID installed additional earth-lined distribution laterals, with headings at a turnout structure on the main canal, to deliver Friant-Kern water to farmers in the district.

Madera Canal

The Madera Canal, also known as the Friant-Madera Canal, runs north from Friant Dam toward Madera. The canal is a lesser component of the USBR Friant Division, which also includes Friant Dam and the Friant-Kern Canal (Figure 30). The Madera Canal carries water into Madera County, a total distance of about 36 miles.

Like most other components of the Central Valley Project, the Madera Canal had its origin in local and state plans before being adopted by the federal government. The Madera Irrigation District, organized in 1914, began planning to build a dam on the San Joaquin River during the late 1920s. Various financial and water rights issues delayed implementation of these plans, even though the district had acquired the site for a dam at Friant.[298]

Figure 30. Madera Canal and Friant Dam
(Water Project Authority 1952:28)

The Friant Division was authorized by Congress in 1936, and construction of Friant Dam began in November, 1939, with canal construction starting the next year. The project was delayed by World War II, although construction did proceed at a diminished rate, and the dam was completed in 1944. Construction on the two canals moved more slowly. Some test diversions were made into the Madera Canal in 1944, but the full canal was not completed for several more years. It was marginally operational during the late 1940s, in part because laterals were not constructed, and in part because local and federal officials could not agree on how to implement the acreage limitations imposed by federal reclamation law.[299] The canal reached its capacity around 1950.

The Madera Canal is a strictly bulk conveyance canal; irrigation district canals handle all distribution through laterals.[300] It is 36 miles long, beginning at Friant Dam on the San Joaquin River and terminating at a slough on the Chowchilla River. Over most of its length, the canal is concrete lined, although it is earthen on its downstream reaches. The concrete-lined sections are deep and narrow, with a bottom width of 10 feet, a nine-foot depth, and a crest width of about 24 feet. In the earthen-lined sections, the bottom width is 20 feet, while the depth is nine feet.[301] The canal's designed flow capacity is 1,000 cfs, compared with 3,500 cfs for the Friant-Kern Canal. Despite its rigorously uniform design, the canal includes some interesting features to deal with strictly local conditions. In some locations, to prevent erosion and introduction of debris into the canal, box flume overchutes were constructed to carry small and intermittent streams across the canal.

Later CVP Units

The Sacramento Valley Canals Unit consists of the Red Bluff diversion dam, Corning Canal and Pumping Plant, Tehama-Colusa Canal, fish spawning facilities, and irrigation distribution systems. The unit was authorized in September 1950. The Corning Canal was completed by 1961, taking water from a temporary intake before the Red Bluff diversion facility and desilting basin was finished. Construction on the almost 119-mile-long Tehama-Colusa Canal began in 1965 and was completed by 1980. The canal, running from the Sacramento River below Red Bluff to a point near the Yolo County town of Dunnigan, employs 21 siphons, with a maximum diameter of 18 feet, to carry water under the easterly flowing small creeks emerging from the Coast Range. The canal is composed of eight reaches, gradually decreasing in capacity from 3,030 cfs to 1,700 cfs. At its widest, the canal is 79 feet across; at the final reach it is 14.2 feet wide. Depths run from 18 feet at Reach 1 to 14 feet at Reach 8.[302]

Other portions of the system, like the Folsom South Canal, were partially constructed but have not yet been completed. Authorized in September 1965, this canal runs from Nimbus Dam on the American River below Folsom Dam, south toward the Mokelumne River. Uncertain financing and legal challenges caused the federal government to stop its construction before the canal connected with the Mokelumne River. The completed portions are similar in geometry to the Friant-Kern and Delta-Mendota canals. Portions of the Folsom South Canal run in an embankment substantially above natural grade. A siphon carries the canal beneath the Cosumnes River.[303] Likewise, the proposed Auburn Dam, part of the Auburn-Folsom South Unit of the CVP, has been entangled in legal and political controversies and has not gone beyond planning stages.

The State Water Project

The massive State Water Project (SWP), which includes the California Aqueduct, Feather River Project dams at Oroville and Thermalito, pumping plants, tributary reservoirs, and branch canals stretching from the northern foothills of the Sierra Nevada to San Diego County, represents one of the most ambitious public works projects undertaken by the State of California. It rivals the CVP in its role in the state's water conveyance system (Figure 31).[304] By 1955, about 4.5 million acres of land in the valley were irrigated with deliveries through the federal canals—a little more than half the irrigated land in California and about one-seventh of that in the continental United States.

Expansion of irrigation required coordination in the use of direct diversion and pumping of groundwater. Slightly more than half of the irrigated area was supplied by groundwater from some 50,000 wells by the mid-1950s, a 30-fold increase over the amount withdrawn in 1905. The groundwater supply, like streams, was limited, and in some regions of the valley, the supply was being depleted as early as the 1920s.[305]Through the CVP, the federal government had accomplished much of what the State of California had proposed in the original State Water Plan put forward by Hyatt in the late 1920s. As a reclamation project, however, it posed problems for many potential customers. Most notably, primarily because southern Californians objected to inclusion in the system, the CVP did not extend to Southern California. However, during and after World War II, the population of Southern California had grown enormously. The CVP also did not serve some potential customers among the farmers of the San Joaquin Valley who were either outside the CVP service area or could not qualify for water under the terms of the acreage limitations associated with federal reclamation projects. In addition, many state leaders, although agreeing to federal funding, had never intended that the CVP should remain a federal project and hoped that the state would obtain the project works after they had been completed. For these and a host of other reasons, the State of California began planning its own massive State Water Project, even before the initial units of the CVP had been completed.[306]

Figure 31. Major facilities of the State Water Project, 1993.
(California D.W.R., Bulletin Nos. 160-193, 1994:62)

The California legislature responded to the growing number of water consumers and the southern San Joaquin Valley farmers outside the CVP area by passing the State Water Resources Act of 1945. The act gave the state the authority to organize water development by creating the Water Resources Board to survey the state's water resources and produce plans for solving its water problems. After six years of study, the board reported that much of the water of northern rivers was flowing into the ocean, while the southern, higher-populated portion of the state suffered from water scarcity. In the same year, State Engineer Arthur D. Edmonston presented a plan which would use water from the Feather River in Northern California to supply the southern San Joaquin Valley and the greater Los Angeles area. The legislature authorized this project and funded feasibility studies later in 1951.[307]

Deadly and devastating widespread flooding hit in the Sacramento Valley in 1955, with damage particularly severe around Yuba City. Many believed it might have been minimized if the Feather River had been controlled. Following the 1955 floods, the legislature created the Department of Water Resources (DWR) to oversee all state agencies involved in water development. It was not until 1959 that the Burns-Porter Act allowed for sale of $1.75 billion in construction bonds for the first phase of the Feather River Project (later renamed the State Water Project). Because of the unprecedented high cost, the legislature put the plan on the November 1960 ballot for public approval.

Governor Edmund G. Brown, Sr., wholeheartedly supported the project, but he faced fierce opposition. Northern Californians, who had strongly supported the CVP, generally disliked the idea of sending “their” water south, and they were concerned with the project’s cost. Strong resistance also came from the south, from the Metropolitan Water District (MWD) of Los Angeles. MWD members feared becoming beholden financially to the counties where the water originated. While the initial construction phase would be funded from other sources, water consumers would pay northern counties for the actual water used. In addition, the state-controlled imported water would end the MWD’s monopoly on Southern California water. After a spirited campaign, the plan passed by an extremely narrow 0.3 percent margin.[308]

The SWP called for construction of Oroville Dam on the Feather River for flood control and storage of runoff. The stored water would then be conveyed by way of the Feather and Sacramento rivers to the Sacramento-San Joaquin Delta. From the Delta, water would be sent on to “areas of need” through an aqueduct system nearly 700 miles long. The California Aqueduct, the main conduit of the SWP, runs 444 miles along the west side of the San Joaquin Valley, over the Tehachapis, terminating in Riverside County.[309] The plans for the SWP also included 16 dams, nine power plants, and 18 pumping plants to lift the water along the aqueduct’s alignment.[310]

Figure 32. Typical State Water Project canal (DWR, Bulletins 132-193, 1994: cover)

The SWP’s first phase of construction completed all initial features between 1961 and 1972. Because the Aqueduct was by far the largest and most vital element of the system, contractors worked on the canal throughout that entire period. The trapezoidal aqueduct, similar in geometry to the CVP’s main canals, was lined California with “unreinforced concrete except in special areas where reinforced concrete was essential.”[311] As the aqueduct carried water south, making deliveries along the way, it became narrower (Figure 32). At the northern end of the project, the canal’s bottom width was 40 feet; after it crossed the Tehachapis into Southern California, that width was reduced to 24 feet.

The SWP began delivering water to Alameda County in 1962 through the South Bay Aqueduct, and in 1968, the project began irrigating land in the San Joaquin Valley through the northern half of the California Aqueduct.

Northern water reached areas south of the Tehachapis by 1972.[312]

In all, 31 agencies subscribe to the over four million acre-feet of State Water Project water. Of this, 30 percent provides additional irrigation water, but fully 70 percent of the total is aimed at municipal and industrial use in Bay Area and Southern California cities.[313]

The SWP's branch canals, which carry water to areas off the main California Aqueduct, include:

- North Bay Aqueduct, 27.5 miles long, carrying water to Napa and Solano counties;
- South Bay Aqueduct, 42.9 miles long, providing a maximum of 188,000 acre-feet per year, primarily for industries and municipal uses in areas of Alameda and Santa Clara counties;
- Coastal Branch Aqueduct, 100.8 miles long, branching from the California Aqueduct at Las Perillas-Badger Hill pumping plants, serving portions of San Luis Obispo and Santa Barbara counties. This system remains uncompleted.[314]

The Cross Valley Canal (CVC), a recently constructed canal of the SWP system, illustrates the integrated nature of the system. The CVC connects the State Water Project's California Aqueduct with Bakersfield and western Kern County, taking water from the aqueduct at Tupman and moving it uphill to Bakersfield. The canal runs 22 miles, primarily west to east, turning north along the Kern River. It is composed of a series of three "reaches" and a set of seven pumps (pumping stations 1 through 7) that lift water into each segment.

The CVC was built between 1973 and January 1976, when it began full operation, providing water for irrigation and domestic use and recharging depleted aquifers. The Kern County Water Agency (KCWA) is the controlling entity for the CVC. The agency undertakes exchanges of water through the system and delivers State Water Project water to irrigators along its western end, in lieu of water that would otherwise be delivered through the canals or river farther upstream.[315] "Construction of the canal," noted the KCWA, "enabled federal east side contractors who were unable to bring Central Valley Project water to their lands in eastern Fresno, Tulare, and Kern counties to exchange their water from the Delta through the California Aqueduct and the Cross Valley Canal by contracting with the Arvin-Edison Water Storage District."[316]

Integration of the Major Multi-Purpose Systems

Over the years, the two major systems have integrated their planning and operations, working together to manage the huge proportion of California's water they control. For example, recent agreements between the CVP and SWP have established joint use of San Luis Reservoir's off-stream storage capacity, and in November 1986, the two projects signed the "Coordinated Operation Agreement," which included an important component for management of Delta water quality standards.[317] Through state jurisdiction over irrigation districts and post-1914 water rights, joint operating agreements, and contractual control of water supplies, the integration of major water systems in California has profoundly altered the distribution of this scarce resource across the state.

TYPICAL COMPONENTS

While California's prehistoric and historic water delivery systems vary considerably in complexity, their common purpose produced many similarities in structures and associated resources. Comparison of these similar design elements, regardless of the system's original purpose, can help in evaluating these systems, particularly for eligibility under criteria C and D. For purposes of evaluation, it can be very important to identify the full array of components that were historically associated with a given water delivery system and note any missing components that may diminish the integrity of the entire system. However, the identification of all major components may not always be necessary when evaluating only a portion of a system.

The following general typology of water delivery system components has been developed for comparative study. Major elements are briefly discussed below, with important types of designs and associated minor features identified (Table 9). Examples of various design components are described and illustrated in Appendix B.

Table 9. Typical components and features*

Component	Major Types and Subcategories	Related Elements/Features
Diversion Structures	**Weirs** (brush; loose rock; log crib; framed wood; mortared stone; concrete)	Intake structures with trash grates Head gates/flow control devices
	Dams (earth; earth face with rubble or log core; cribbed wood with plank face; mortared cobbles or blocks; concrete)	Reservoirs Intake structures with trash grates Head gates/flow control devices Spillways and/or other wasting outlets
	Natural lakes tapped by tunnel	Intake structures with trash grates Flow control devices
	Pumping station	Intake structures with trash grates
Conduits	**Open canals** (earth; rock; earth with concrete/gunite lining; mortared rock; concrete)	Gauges/measuring boxes Division structures Flow control devices/waste outlets Sand traps/trash grates Drops and chutes
	Flumes (framed wood box; metal; masonry bench; concrete)	Wood, steel, or concrete trestles Sidehill cuts Bench walls/foundations Suspension systems
	Tunnels (solid rock; earth with timber cribbing; earth with wood box flume inserted)	Intake structures/portals Trash grates Vents/waste outlets
	Pipelines (hollowed logs; wood stave; riveted iron; welded steel; concrete)	Intake structures/forebays Trash grates Flow control devices
Flow Control Devices	**Gates, gauges, valves, distribution boxes** (wood; steel; concrete)	
	Head boxes, forebays, and intake structures (concrete; mortared stone; wood frame)	
	Waste outlets and spillways (wood; mortared stone; concrete; steel)	
	Drops and chutes (concrete; wood)	
Cleansing Devices	**Sand traps, trash grates**	
Associated Resources and Setting	**Habitation sites** (construction camps; ditch tenders' camps; other opportunistic occupation)	Archaeological deposits/features Buildings and structures Entire communities
	Mines (placer mines; hydraulic mines; hard-rock millsites)	Mined landscapes and mills Habitation sites (see above)
	Hydroelectric power plants	Operators' housing (see habitation)
	Agricultural landscapes (orchards; vineyards; field crops)	Farms (see habitation) Houses and outbuildings
	Telecommunications and power lines	Poles
	Access roads	Bridges and culverts

*See Appendix B for examples and illustrations of components.

Certain kinds of components are common to all systems, while other features are restricted to particular kinds of water systems. All water delivery systems consist of a diversion structure, some type of conduit, and a functional association with one or more activities, whether agriculture, mining, domestic water supply, hydroelectric power generation, or other uses. Some provision for disposing of excess or waste water will also be present. These basic attributes were often augmented in more complex systems with control structures to regulate flow and elements designed to remove foreign objects. The specific design and materials used to build a given system were influenced by many factors, including the purpose and desired longevity of the system; geographic constraints such as topography, geology, and climate; the builders' knowledge and skills; and economic means. As knowledge of hydraulic principles improved and experience with different geographic settings accumulated, designs evolved. Both innovative designs and systems with well-preserved examples of the major types of components may be found eligible for the National Register. Appreciating the significance of water delivery systems may also entail identifying associated resources and contributive aspects of setting. Associated resources may include agricultural fields, mines, hydroelectric power plants, caretakers' or construction crews' housing, and perhaps even entire communities. A system's setting may also contribute to its significance.

DIVERSION STRUCTURES

The diversion of water was accomplished by three principal methods. Weirs were used to divert a portion of the water in a stream or river, with the residual flow passing over or through the structure. Dams were constructed to divert the entire flow of a watershed or create pondage where flows were inadequate during some portion of the year. More rarely, the water in natural lakes was diverted through tunnels or other conduits set at some depth below the natural pool. All three types of diversion structures typically incorporated a device for regulating the amount of water passing into the conduit. However, for some rudimentary systems, like prehistoric irrigation networks, no regulation was attempted.

Weirs were made of a variety of materials, including brush, loose rock, wood, mortared rock, and concrete. The purpose of these diversion structures was to elevate the water level just enough to divert adequate flows into a conduit without completely blocking the natural flow in a moving body of water. They were usually placed perpendicular to the stream or river. Both permanent and temporary weirs were constructed, with adjustable elements sometimes incorporated in the more durable structures. Brush and loose rock weirs allowed flows to pass directly through them. They were easily erected, but required frequent upkeep and had to be rebuilt annually. Such temporary structures were most common on smaller water delivery systems developed prior to the late nineteenth century. It is unlikely that examples of this type have survived the ravages of time. Wood and masonry weirs required more substantial investments, but are more likely to survive as identifiable elements of historic water delivery systems. Wooden weirs were commonly framed with milled lumber or made of cribbed logs. Masonry structures were most often made of mortared cobbles, concrete, or mortared blocks. Stream flows through masonry and framed wood weirs were typically accomplished through a series of notches.

Dams were generally made of earth, earth-covered rubble cores, wood, masonry, or some combination thereof. Because California's precipitation falls mainly between October and April, the size of a dam often depended on the pondage required to achieve steady and adequate supplies of water. Reservoirs, intake and control devices, trash grates, spillways, waste gates, and other features are typical elements of this type of diversion structure. In some cases, forebays or even entire reservoirs may be masonry lined.

Where natural bodies of water, such as Eagle Lake in northeastern California, were tapped, pondage was limited by the rate of natural recharge in such watersheds. In rare cases, artesian springs were also diverted. With the advent of twentieth-century multi-purpose systems, water has also been diverted by means of pumping plants placed in rivers.

CONDUITS

Water was conveyed through four basic types of conduit: open canals, flumes, tunnels, and pipelines. Systems that traversed diverse terrain often used several different types of conduit in combination, particularly in mountainous country.

Open Canals

Perhaps the most common canal type in California is the irrigation canal. These conduits carry water for pastures, row crops, orchards, and vineyards, and vary widely in size, shape, and construction materials. As with other canals, they are typically part of a larger system. Beginning from a storage dam or diversion weir, water is diverted through a main canal, into laterals, and then through outlet gates or other control structures into individual farm distribution ditches. In places like Southern California, much of the distribution system has been placed in underground pipe, often only leaving the main canals, or trunk lines, above ground. In many areas, the main canals have remained unlined, while in others, aggressive programs of canal lining have been undertaken in this century to minimize seepage losses.

The cross section or profile of open canals varied with the material through which the conduit was constructed and with the method of construction employed. If constructed in rock, the canal tended to be more rectangular with side slopes as steep as 1:0.5; in earth, the canal shape became more trapezoidal, with side slopes varying from 1:1 to 1:5, depending on material. Early canals that were built with scrapers in the alluvial soils of the Central Valley had rounded bottoms and long side slopes, with rounded berms mounded up on each side of the cut. In similar locations, irrigation channels cut with modern machinery and blades have a V-shape, with steep side slopes and flat broad berms.

In terms of the ratio between width and depth, the most hydraulically efficient canal would have a hydraulic radius one-half the water’s depth. Therefore, the canal’s width would be twice the depth. However, in sidehill locations, is it more economical to construct a narrower, deeper canal, and in practice, canal builders often adopted a design based on economy, rather than the most hydraulically efficient one. A 1934 study noted that in California the hydraulic radius on hydroelectric canals varied from 0.5 to 0.8 the water depth, with the average being about 0.6. Figures for hydraulic mining canals and irrigation canals seem similar. The reason for any substantial variation from this ratio should be investigated. For example, a different ratio might be used to reduce ice formation in a cold climate, where narrow, deep canals are less subject to freezing over than wide, shallow ones of the same capacity.

In general, in any arid or semi-arid climate, water systems operators and managers try to minimize losses due to evaporation and seepage. In California, hundreds of miles of previously earthen ditches have been lined with some less permeable surface or placed in pipe. Lined canals can also carry more water by moving it faster, and the lining can prevent scour of banks and bottom from running water at high velocity.

In the nineteenth century, canals were lined with randomly coursed stone paving or cobblestone, usually dry-laid, 12 to 18 inches thick. In the twentieth century, concrete and shotcrete (gunite) linings averaging between two and four and one-half inches in thickness have been standard. Concrete canals have a greater carrying capacity than a rough stone or earthen canal, carrying about twice the water in the same space. Thus, if an irrigation company or agency had sufficient capital, lining canals in concrete achieved many potential goals: it decreased maintenance costs, lessened loss by seepage, and increased carrying capacity.

Flumes

Impressive wooden flumes on high trestles were a picturesque and frequently necessary component of nineteenth-century water delivery systems. Nevertheless, they had a number of drawbacks and were used primarily where low initial cost was of prime importance. From the 1850s onward, open flumes were often used in connection with canals to avoid ditch excavation in solid rock or meandering canal journeys along hillside contours. Flumes mounted on tall timber trestles were also used to cross valleys or ravines. Whether constructed of wood, steel, or concrete, flumes often had less frictional resistance than adjoining unlined open canals and were therefore usually smaller to carry the same volume of water. Differences in the water velocity where flumes met open canals, however, was a pesky problem for early hydraulic engineers. Poorly designed transitional sections led to flume failures or canal washouts. Flumes were also subject to damage from slides, winds, and fire, which eventually led engineers to replace them with tunnels, bench canals, or inverted siphon pipelines, whenever possible.

The early rectangular box flumes were designed with a width approximately twice the normal water depth. In the late nineteenth century, wood-stave flumes, semicircular forms with diameters ranging from about two to 20 feet, also came into general use. Wooden flumes did not have a long life, perhaps 10 to 15 years for a pine flume, and 15 to 25 years for redwood, unless creosoted. Semicircular riveted metal flumes were introduced in the late nineteenth century. By the early years of the twentieth century, non-riveted galvanized steel flumes were introduced, with smooth joints that gave a relatively unobstructed flow line. Semi-circular steel flumes were developed for faster and easier construction. Several patented types were on the market by the 1920s, manufactured in sizes ranging from one foot to 20 feet in diameter.

In the 1920s, concrete flumes began to replace older wooden flumes, especially on irrigation and power systems that were converting from earthen to lined ditches. At about the same time, the U. S. Bureau of Reclamation began to contract for the manufacture of precast-concrete flumes for some of its projects, like the Klamath Project. Reinforced concrete flumes were the most expensive but also the most permanent. Concrete flumes were typically carried on reinforced concrete trestles with the side walls of the flume acting as girders to support the flume between trestle bents.[318]

Tunnels

Tunnels were often constructed to shorten water delivery systems, by cutting across a river's bend or going through hills instead of around them. To a large degree, geologic conditions dictated whether tunneling was an appropriate engineering solution. Solid rock was the best material for tunnel construction, as opposed to the softer materials desired for canal excavation. In solid rock with little ground water, the cost of tunnel construction could be estimated with some accuracy. In contrast, tunnels had to be lined with concrete, brick, or timber in unstable rock where water was encountered, and the cost of construction could not be determined at the outset.

As a practical matter, a tunnel's minimum size was about five to six feet high and six to eight feet wide. Any larger size was determined by the amount of water the tunnel needed to carry. The tunnel's shape through absolutely stable material could be whatever proved most economical. In fact, a profile was usually adopted that allowed for the best resistance to external pressures. It varied with the nature of the material through which the tunnel was to be driven, but in general, the tunnel had a semi-circular arched roof, more or less vertical sides, and a horizontal floor. Tunnels through firm earth or soft rock might adopt a more horseshoe shape, whereas tunnels through soft earth could be nearly circular. A long tunnel was usually broken into sections and worked simultaneously from several headings, either shafts sunk from above or adits or drifts coming in from the side, to avoid the cost of hauling materials long distances underground.[319]

Pipelines

Many water delivery systems used pipe somewhere. In the early years, municipalities and farmers used wooden pipe for their distribution lines, fashioned by hollowing out the core of logs. Wood stave pipes soon replaced the older log pipes. Ranging from a few inches to 16 feet in diameter, wood stave pipes were used by miners and irrigators and in early hydroelectric power systems into the early twentieth century. Among these users, the hydroelectric power industry perhaps made the most use of wood stave piping. Wood stave pipes were frequently assembled on site. The staves, commonly redwood, were arranged in a circle to form the pipe's diameter, then hoop tension bands were put around the outside and tightened to hold the staves together. The number and type of bands could be modified to fit particular circumstances. Wood stave piping was used both in hydroelectric flowlines (most extensively on the Bishop Creek system) and for low-pressure penstock where steel pipe was not economical. Wood stave pipes could be buried in trenches, run on the surface of the ground with bracing, or placed in heavy timber trestles.[320]

During the nineteenth century, riveted iron pipe was preferred in California's mining regions, where most applications involved relatively low pressure. For pressures above 150 feet of head, such as in California's high-head hydroelectric power plants, steel pipe was almost always used. Of the types of steel pipe available, most power plants chose lap-riveted steel pipe. The pipe could be delivered pre-assembled in sections, or to reduce transportation costs to remote mountain regions, it could be transported in flat sheets and rolled on site. Due to manufacturing improvements, use of forge-welded steel pipe rapidly increased by the 1930s.

Reinforced concrete pipe was not used in California for penstocks because it was useful only for heads under about 60 feet. However, concrete pipe was used extensively in irrigation water systems, especially in farm distribution networks. Mutual water companies in Southern California used both metal and concrete pipes as early as the 1880s. Where pressures precluded the use of concrete, the companies resorted to iron, and later steel, pipes. Although these piped systems were costly, they could be used because of the permanent nature of the plantings and the high value of crops such as oranges and grapes. During the same period in the San Joaquin Valley, where different row crops might be planted from season to season, earthen ditches provided greater flexibility than pipes. However, in recent decades, pipes have been used in the Central Valley to reduce water loss by evaporation and seepage, conserving precious and expensive water resources.

FLOW CONTROL AND CLEANSING DEVICES

Most water delivery systems included water control and cleansing devices. A variety of structures were developed to measure and regulate flow rates, dispose of excess water, and trap sediment and debris. Gates, valves, checks, and gauges could adjust the volume of water passing a particular point in the system, and drops and chutes reduced the velocity of the water at abrupt changes in gradient. Gates could be as simple as sliding wood slats, while drop gates of wood, metal, and even concrete were also common. Smaller gates were typically adjusted by hand; large gates were either counterweighted or mechanically assisted. A variety of valves, air vents, and other specialized equipment was also employed on penstocks and other pipelines subject to high pressure.

In most systems, provision had to be made for disposal of excess water to prevent erosion. Spillways, wasteways, and other overflow devices were important at transition points—from diversion structures to conduits, from one type of conduit to another, and particularly at the terminus of the system. The most effective and lasting wasteways were made of durable materials, such as bedrock, masonry, metal, or wood.

Drops and chutes were designed to change the water’s elevation while reducing its velocity. Drops consisted of a small adjustment in the elevation of an open canal, by constructing a breast wall across it. The floor and walls on the downstream side were made of durable materials such as masonry or wood to prevent undercutting and to cushion the falling water. Chutes were used to make more substantial changes in elevation. They were also typically made of durable materials and used riffles or other irregularities to slow the descent of the falling water.

Trash grates, floating booms, and filtration devices were commonly used to keep debris out of water delivery systems or to trap it as it passed through. To keep large debris from entering water systems, trash grates, or “grizzlies,” which were commonly used, required regular maintenance to prevent them from plugging up. Near dams, floating booms helped keep buoyant debris from entering intake structures. On some systems, sand traps and other filtration devices were used to reduce sediment loads. While sediments tended to be a problem for all water supply systems, they were particularly troublesome for hydroelectric and other mechanical systems where fine debris caused rapid degradation of equipment such as Pelton wheels and impellers. Sediments also reduced the capacity of many open canals that consequently required regular mucking.

ASSOCIATED RESOURCES AND SETTING

Resources that are structural elements of water delivery systems can usually be easily identified. They include integral structural features like dams, canals, flumes, pipes, pumps, and gates—the physical features that are components of a water delivery system itself. Other resources, including setting, can also be associated with such systems, but are not always so clearly identified or may not be visible on the ground. Associated resources can be either directly related to the system or incidental to it.

Directly related associated resources are those that played a role in the construction, operation, or maintenance of the system. They could include construction camp sites, construction or maintenance access roads, maintenance crew housing, hydroelectric facilities, power lines, and landscaping of the system itself or of any of its associated features. These associated resources are normally found in close proximity to the system and they date from the system's period of construction or use.

Incidentally associated resources consist of features that were built or function in response to a water delivery system. These resources could include bridges that cross a canal or a road network built in a pattern to go around it. Associated resources could also include Native American habitation sites along mining ditches, towns served by a piped municipal water system, farms dependent upon irrigation, mines, mills, factories, and other water users that owe their existence or growth to water conveyed through such a system. These associated resources may also be found near water delivery systems, although they can postdate the system's period of significance.

The setting for a water delivery system can also be associated with that system. The environment in which a system is located, whether rural or urban, natural or cultural, can contribute to an understanding of the resource. Because of engineering considerations and the gravity-based nature of water delivery systems, the design and function of a water system are especially closely linked with and reflect an area's topography. Both the aspects of setting that influenced the system's development and those aspects that constitute the past and present environment of the system should be examined.

SURVEY METHODOLOGY

Surveys undertaken to identify, record, and evaluate water conveyance systems should be conducted in accordance with the directions provided in Volume 2 of the Caltrans *Environmental Handbook* or *Guidance for Consultants*. The following discussion provides supplementary guidance focusing on survey requirements specific to water conveyance systems.

RESEARCH

When a water conveyance system requiring study has been identified within a transportation project's Area of Potential Effects, research should begin with an examination of the historic context presented in this report. Information and sources identified in the bibliography, tables, and text of this report can provide a point of departure for further documentary research.

Preliminary research should seek to identify basic information about the alignment, key elements, and potential significance of the water conveyance system, as well as any directly related associated resources. That research should build on the context presented in this report, starting with the identification of the theme or themes with which the property is associated. From that point, the research should delve further into details specific to the water system and the historical developments and persons with which it was associated. Particular attention should be devoted to locating historic maps, plans, and other specifications that could reveal the original construction and appearance of the system. Dates of construction, alterations, and the period of operation should be identified where possible as a basis for ascertaining the property's period of significance and assessing its integrity. Sources most likely to contain relevant information will vary, depending on the type of water conveyance system. The following list identifies some sources worth examination:

- US Bureau of Land Management (Government Land Office plats and survey notes)
- County Recorder/Surveyor/Assessor (maps and records of water districts)
- US Bureau of Reclamation (various records on reclamation districts and projects)
- US Forest Service (maps, records, and evaluations of water conveyance systems)
- California Department of Water Resources (records of state water projects)
- US Geological Survey (Water Supply Papers and topographic maps)
- California Water Resources Control Board (post-1913 water rights mapping and records)
- Water Resources Library, University of California, Berkeley
- Engineering Journals (e.g., *Engineering News Record, Southwest Builder and Contractor*)
- MELVYL or other electronic library search routines

FIELD INSPECTION AND RECORDATION

The scope of required field inspection and recordation will depend on a water conveyance system's probable areas of significance; the degree of difficulty in determining whether or not it appears to meet eligibility criteria; the integrity of the segment in the project area; the complexity of the property; and the magnitude of anticipated project effects on the system.

Evaluations must consider the entire property, although it is not always necessary to physically record the whole system. Visual inspections, recordation of components within the project APE, and perhaps recordation of sample points outside the APE are often adequate for an evaluation, particularly when a water conveyance system is simple, easily understood, or clearly lacks integrity, or when substantial documentation already exists. Otherwise, at a minimum, observations should be made of key components of the system, which typically include the diversion structure (the beginning—where water enters the system), the terminus (the end—where water is delivered to the user), and the main conduit between them. The portion of the water system in the APE of a project should always be recorded.

The complexity of water conveyance systems and the presence or absence of associated resources should be considered when making decisions about whether to define particular systems as individual properties or as historic districts. Simple systems that lack branch conduits or directly associated resources such as construction or maintenance camps are normally treated as single properties, while more complex systems possessing such features are often best treated as districts. In some cases, the significance of a water system may be inextricably linked to larger developments of which it is a part. Under those circumstances, it may also be appropriate to consider the water system as a potential contributor to a district. For example, water systems that were designed to supply a single activity such as a farm, mine, mill, or community, or hydroelectric power plant should generally be evaluated as integral parts of the larger properties (districts) with which they are associated.

The decision to treat canals individually or in groups must take into account both the nature of the resource and the nature of the project. Ordinarily, the practical solution will be to treat canals individually, while giving some attention to the larger context within which they function to determine if there is a need to consider them as part of a potentially eligible district. On occasion, a group of individual canals, formerly separate entities, may have been consolidated into a larger network. In that case, their potential significance and especially their period of significance, will play the key role in determining whether to treat them as individual resources or elements of a district.

Water conveyance systems may constitute elements within a historic landscape, but are unlikely by themselves to constitute a landscape. The need to evaluate a water system in relation to a potential landscape or other district should be based on the presence of a wide range of characteristics such as evidence of land uses and activities, retention of patterns of spatial organization, responses to the natural environment, cultural traditions, circulation networks, boundary demarcations, distinctive vegetation, and associated buildings, structures, objects, sites, and small-scale elements associated with the importance of the larger property.

Consult the "General Guidelines for Identifying and Evaluating Historic Landscapes" (February 1999) for further guidance if it appears that a potential historic landscape could be present within a project area.

In defining a beginning and end for a water conveyance system, the diversion point is ordinarily easy to locate; it is the terminus that must sometimes be assigned arbitrarily. The Hansen Ditch near Fresno is instructive as an example. It diverts water from the larger Fresno Canal at a known point, which serves as the beginning point of the canal, and for most of the year, the Hansen Ditch simply terminates in farmers' fields. A physical connection was made, however, to allow excess flows from the Hansen Ditch to spill into the Briggs Canal. The Briggs is otherwise unrelated to the Hansen Ditch, diverting its water from a completely different main canal. The connection between the Hansen Ditch and the Briggs Canal appears to represent a logical if somewhat arbitrary terminus for the Hansen Ditch. The problem would be more pronounced if a canal breaks into a series of smaller branches. The terminus may then be the point where the smaller branches divert, but it will need to be evaluated on a case-by-case basis.

Two kinds of documentation are normally required for surveys of water conveyance systems: **Inventory Records**, which present property-specific information about the location, physical characteristics, and significance of the property; and a **Survey Report** that summarizes the property-specific information, describes survey methods, and provides historic context and comparative analysis. To the extent possible, survey reports should summarize rather than duplicate information contained in this historic context and on inventory records submitted as supporting data.

The DPR 523 series of inventory forms, adopted by the State Historical Resources Commission in 1995, should be used to present inventory data. Refer to the Instructions for Recording Historical Resources (California Office of Historic Preservation, 1995) for guidance on selecting and preparing the appropriate forms. The approach suggested in this report does not specify a particular set of records or reporting format, but instead offers checklists of appropriate information (Tables 10 and 11 below), incorporating details included in *National Register Bulletin* 16A, Appendix VI, checklist for canals and waterways.

Table 10. Inventory record checklist*

Locational data
County and state (P2a)
UTMs for diversion structure and terminus (P2d)
Property boundaries (P3a or D4 and D5)
Location map showing entire system with inspection points depicted (DPR 523J)
Historic maps (DPR 523L)

Descriptive overview
Description of the entire system and its key elements (P3a)
Identification of relevant historic context(s) from this report (P3a and B10 or D6)
Length of entire system (P3a)
Elevations at diversion structure and terminus (P2e or P3a)
Overview of design and materials (P3a)
Overview of setting (P3a)
Description of associated resources (P3a and L5 or B8)

Integrity
Integrity/modifications at inspection points (L7)
Integrity of entire property (B10 or D6)

Evaluator and date
Evaluator and address (B14 or D10)
Date of evaluation (B14 or D10)

Project reference
County, route, and postmile limits (P1)

Photographs
Overview of resource in APE (P5a)
Detail photographs of inspected points (L8a)
Other current or historic photos (DPR 523L)

Descriptive details
Date or period of construction (P6)
Engineer or designer (P3a or B9a)
Builder (P3a or B9b)
Description of diversion structure (type, materials, dimensions) (L3, L4, and L5a-d)
Description of conduit (type, materials, dimensions) (L3, L4, and L5a-d)
Description of terminus (type, materials, dimensions) (L3, L4, and L5a-d)
Cross sectional sketch of conduit (L4e)
Historic plans, elevations, and cross sections (DPR 523L)

Significance evaluation
Theme and subtheme (from this report) (B10 or D6)
Period of significance (B10 or D6)
Applicable National Register criteria (B10 or D6)
Level of significance (B10 or D6)
Contributors and noncontributors to districts (D6)
Properties used for comparison (B10 or D6)

*Alphanumeric designations in parentheses refer to appropriate fields on the DPR 523 forms.

Table 11. Survey report checklist

Project description
Research methods
Focused historic context
Description of survey methods
Findings/conclusions regarding NRHP eligibility
Bibliography or references cited
Qualifications of preparer(s)
Inventory records, in appendix
Project location, vicinity, and detailed project maps

SIGNIFICANCE EVALUATION

When a property is evaluated for its significance, it may be found either eligible or ineligible for the National Register of Historic Places. The evaluation may apply to an entire water conveyance system, or it may apply only to the portion of the water conveyance system in the project APE.

In a system which has potential for eligibility that can be documented, a segment may be found eligible as a contributing element of that system, and it would then be treated as eligible for the purpose of the project. If the segment lacks integrity, was not present during the period of significance, or otherwise has no potential to contribute to the significance of the larger property, it may be found ineligible. A segment may also be found either eligible or ineligible based on its own significance and integrity as an individual property.

If an evaluation applies to a segment or feature only, and not to the entire water conveyance system, the name of the resource should clearly convey that information so that evaluation of the whole system is not implied. Existing names may be used or descriptive names may be coined to identify the exact property being studied, e.g., “Clear Creek segment of Crawford Ditch,” “Big Gap Flume at State Route 120,” “Main Canal between Miller Road and Lux Drive,” or “Intake No. 3, Powerhouse No. 2, of Bishop Creek Hydroelectric System.”

Whether examining an entire system or a segment, consideration must be given to all potential areas of significance. Potential significance should be examined in relation to the contextual themes developed in this report, in the application of the National Register Criteria, and in assessing aspects of integrity. At any point in the future, passage of time, changing perceptions of significance, or new research may warrant reconsideration of a property’s eligibility and may require reevaluation in the light of new or changed circumstances.

Application of the NRHP Criteria

An eligible water conveyance system must meet one or more of the National Register criteria, and it must retain integrity. To meet the National Register criteria, it must: (A) be associated with events that have made a significant contribution to the broad patterns of our history; (B) be associated with the lives of persons significant in our past; (D) embody the distinctive characteristics of a type, period, or method of construction, or represent the work of a master, or possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction; or (D) have yielded, or may be likely to yield, information important in prehistory or history.

Water systems may be found eligible to the National Register of Historic Places under any of the National Register criteria, although some criteria are more commonly relevant than others. Of 22 eligible water systems identified with one, or more than one, specified criteria in OHP’s statewide inventory as of mid-1995, 21 systems (95%) were listed under Criterion A; 14 (64%) were listed under Criterion C; while only one each (5%) came under criteria B and D. It appears that water conveyance systems are most likely to be found eligible for the National Register of Historic Places under Criterion A (events) or C (type or style of construction, district), and fewer will be found eligible under B (people) or D (information potential).

More than one of the National Register criteria may apply to water conveyance systems, such as when a system is eligible under both A and C, for its association with important events and its engineering values. A system may also contain individually eligible properties, such as associated archeological sites that may be eligible under D or structures eligible under C. Each system should be examined for eligibility under each of the National Register criteria, as described below.

Criterion A

Like other kinds of public works facilities, water conveyance systems are inherently important to the communities they serve, providing infrastructure essential for community development. Water supply has been particularly pivotal in the development of California and other parts of the arid West. Irrigation and reclamation canals provide the lifeblood of farming communities; municipal water canals are of critical importance in city development; hydroelectric canals serve a very specific purpose, but their benefits are widely distributed; mining canals also served a focused purpose, but nonetheless played very key roles in the economies of mining-based communities; and major multi-purpose systems provided far-reaching benefits to many sectors of the state's population. Thus, it is not surprising that water conveyance systems have been found eligible for the National Register of Historic Places under Criterion A for their association with important events.

For a water conveyance system to be eligible under Criterion A, it must be found to be associated with specific important events (e.g., first long-distance transmission of hydroelectric power) or important patterns of events (e.g., development of irrigated farming). This document has established historic contexts for many of these themes, but other events may also be found significant, and assessing local significance may require further research.

A system must be adequately documented, through accepted means of documentary or archeological research, as being associated with the important events; speculative associations cannot confer eligibility. The significance of the documented association must then be demonstrated. In other words, the system's association with the important event must also be an important association, not mere coexistence. For example, an 1850s mining ditch evaluated for its association with the gold rush would normally not be found eligible under Criterion A if it served only unimportant mines that produced little gold, and it possessed no other associations.

Criterion B

For eligibility under Criterion B, a property must be associated with an important person's productive life and must be the property that is most closely associated with that person. For instance, the office in which a prominent engineer prepared his/her most important designs could be eligible under Criterion B and would be more closely associated with his/her work than would the place where that person was born. On the other hand, a property such as a dam that represents the work of a master engineer would be eligible under Criterion C, as the work of a master, rather than B, as representing an important person. Water conveyance systems will rarely be found eligible under Criterion B. There may be instances, however, when a water conveyance system would be eligible under Criterion B, notably when the person's association with the system is very strong and no properties more intimately associated with that person remain. Researching associations with people important in water history should include a careful evaluation as to whether the water system under investigation is the property that best represents that association.

In California notable names for which there might be associations with water planning, construction, or engineering include: Anthony Chabot, George Chaffey, Frederick Eaton, William Mulholland, George Maxwell, Robert Marshall, Elwood Mead and C. E. Grunsky.

Criterion C

Water conveyance systems have been found eligible for the National Register of Historic Places under Criterion C for their engineering or design values. Examples of different types, periods, or methods of construction; the works of a master; properties with high artistic merit; and properties which together constitute a historic district may be eligible under Criterion C. Properties eligible under C may have unique values or they may be the best or good examples of a type of property. The earliest, best preserved, largest, or sole surviving examples of particular types of water conveyance systems or a property that introduced a design innovation may be eligible as examples of evolutionary trends in engineering.

To be considered a good representative of that type, period, or method of construction, a water conveyance system must possess "distinctive characteristics," the common features or traits of that type, period, or method of construction. Through those distinctive characteristics, a property must clearly illustrate one or more of the following: the pattern of features common to a particular class of resources; the individuality or variation of features that occurs within the class; the evolution of that class; or the transition between classes of resources. When water systems are examined as good examples of a particular class of property, it is necessary to establish a comparative framework in order to understand how they relate to other properties with similar characteristics.

Water conveyance systems can be eligible as the work of a master when designed by a figure of acknowledged greatness in the field or by someone unknown whose workmanship is distinguishable from others by its style and quality. However, the system must be a good example of the designer's work, and not all works of a master will be eligible. Systems designed by individuals identified in the Criterion B discussion above should be examined for the possibility of their eligibility under Criterion C as the work of a master. High artistic values can also be found in properties that articulate a particular concept of design so well that it expresses an aesthetic ideal. To be eligible for its artistic value, a property must express the aesthetic ideal or design concept more fully than other properties of its type.

A large water conveyance system with multiple components will often be evaluated as a district rather than as a single property. An eligible historic district must possess a significant concentration or linkage of resources that are united historically or aesthetically by plan or physical development. It should be a significant and distinguishable entity, although its components need not possess individual distinction.

Criterion D

Water conveyance systems may be eligible for the National Register if they may be likely to yield information important in history or prehistory. These properties must be studied within an appropriate historic context and they must possess the potential to answer specific important research questions. Once the research value of a property is realized, it is no longer eligible under Criterion D. However, properties that have yielded important information may in rare cases also be found eligible under Criterion A when that data has proven seminal to research in that field.

The properties most commonly found eligible under Criterion D are archeological sites, but buildings, structures, and objects can also, if infrequently, be found eligible for their information potential. In order for these other property types to be eligible under D, the physical properties themselves must be or have been the principal source of the important information. Because water conveyance systems are often complex properties that may be composed of both structural elements and directly associated resources, eligibility under Criterion D may derive from both the research value of individual elements and/or relationships among those parts.

The information value of water conveyance systems has not been widely recognized to date, and few water conveyance systems have been found significant for their research potential. Attention has generally focused on the ability of water conveyance systems to yield important information about vernacular competencies and construction methods. That work has examined the traditional models water conveyance systems were drawn from, how such models were modified to meet new situations, and the factors that influenced the success or failure of those constructions. Prehistoric irrigation systems, Spanish irrigation systems, and early mining and irrigation systems of the American Period all have the potential to provide such insights.

Certain water conveyance systems also may possess research value stemming from their associations with other types of resources. When documentary sources fail to reveal the precise alignment of a water system, field verification of the route may help locate associated properties both directly related and incidental to those systems. Knowing the period during which the water conveyance system operated may also guide the interpretation of associated resources. Mining ditches in the foothills of the Sierra Nevada are particularly likely to possess this kind of limited value. While unlikely to be individually eligible, systems that possess incidental information may require consideration within the larger context of any important information they can generate as a group. With that said, their aggregate value may be fully realized through appropriate survey efforts, rendering such properties ineligible after their alignment and period of use are verified.

Associated archeological sites that are either directly related to the construction and maintenance of water conveyance systems or linked by dependence on their water also may be eligible under Criterion D. Occupation sites directly associated with the construction and operation of water conveyance systems, such as construction camps, ditch tenders' cabins, and operators' housing compounds, may contain archaeological deposits and features with the potential to provide important information. Other types of incidental habitation sites also may contain such information. For example, Native Americans commonly relocated near mining ditches after they were displaced from traditional occupation sites, and miners also situated their camps near ditches when other sources of potable water were not readily available.

Detailed descriptions and evaluations of associated archeological sites are normally undertaken only when those properties will be directly impacted by a project. Unevaluated occupation sites should be treated as potentially eligible for the National Register until they are formally evaluated.

Integrity

Water conveyance systems that appear to meet the National Register criteria must also retain integrity, which is the ability of a property to convey its significance. To retain historic integrity, a system must possess at least several, and usually most, of the seven aspects of integrity: location, design, setting, materials, workmanship, feeling, and association. The property's essential physical features, important elements that were present during the historic period, must be present and visible.

To address integrity, the appearance of the water system and its setting during its period of significance must be known and the following questions should be asked: Does the system follow the alignment of its period of significance? Have the significant elements of design, materials, and workmanship been retained? Does the setting still evoke the important qualities of the water system? And does the property retain the feeling and associations needed to convey its significance? For water conveyance systems or features within a system that may be eligible under Criterion D, an evaluation will normally focus on whether the property retains the potential to yield important information. That consideration will usually focus on location, design, and materials, although it is possible that other elements of integrity may sometimes apply.

As with other types of historic properties, the fundamental test of the integrity of a water conveyance system consists of the relationship between its current appearance and its appearance during the period of significance. Integrity will not be lost as the result of modifications that were undertaken during the system's period of significance, and modifications made within that time may actually contribute to the importance of the property. Subsequent repairs or modifications may have greater effects on the system's integrity than abandonment and deterioration of the system. An abandoned system that has deteriorated in place can retain integrity despite erosion or sedimentation, while systems that continue in use may have lost integrity because they have been substantially modified in the course of maintenance and repairs.

Eligibility Details

If a water conveyance system appears to be eligible, then the following details of boundaries, level of significance, period of significance, and contributors and noncontributors must be specifically identified and listed.

Boundaries

A historic water conveyance system's boundaries should be selected to encompass but not exceed the full extent of contributing elements. Generally, a water conveyance system's boundaries will begin with a water source, such as a river or reservoir, and progress in a linear fashion to terminate with the end user(s) of the water, such as a hydroelectric power plant, a mill pond, or irrigated fields. The water system will typically present a long, thin shape, perhaps with multiple branches or bulges. The boundaries should include any associated elements, such as maintenance roads, berms, weirs, or habitation sites, and may extend beyond visible surface features to include subsurface deposits or sites of important events. The boundaries should be drawn to exclude major noncontributing elements or areas with a concentration of non-historic features. While the water system's setting can contribute to the property's integrity, the setting is by definition outside the boundaries and should not be included within them.

Level of Significance

Water systems may be associated with events defined as important at the local, state, or national level of significance. The level of significance can reflect the system's association with local, state, or national history, or it can apply to the geographic area within which the historic context was developed. For example, a mining ditch constructed during the gold rush could be associated with that event, which would be significant at the state or national level, but if the ditch's greater significance is its effect on the location and establishment of a town, the property should be found significant at the local level.

Period of Significance

The period of significance will encompass the span of time when the property was associated with its important events, activities, persons, groups, or land uses, or when it attained its important physical qualities or characteristics. Care should be taken in assigning a period of significance because it becomes the benchmark for measuring whether changes are part of the property's history or whether they constitute loss of integrity.

The period of significance begins with the construction date or the date of the earliest important land use or activity of which tangible historic characteristics remain today. It ends with the date when the important events, activities, or construction ended. The period of significance must reflect dates of the property's important associations. For example, systems eligible under Criterion A will have a period of significance tied to the dates of the important events, while systems significant under Criterion C for engineering will generally use the date of construction.

In most cases, a single period of significance should be established for the entire water system. If a segment is evaluated within the context of the system, the segment's period of significance should fall within the system's period of significance but should commence no earlier than the segment's own construction date. A different period of significance may apply, however, when the segment is evaluated as an individual property that possesses values dating from a separate period. On occasion, more than one period of significance may be appropriate when a system contains resources dating from substantially different periods, such as when two formerly separate water systems have been consolidated into a single system.

To be eligible, a water conveyance system must normally be over 50 years old and have achieved significance within a period that ended over 50 years ago. If a system is less than 50 years old or if its period of significance extends into the last 50 years, the property must meet the National Register's criteria for exceptional significance. Exceptional significance could apply if a water conveyance system were associated with an event of extraordinary importance, or if it were a good or rare example of a type of system that is fragile and rarely attains 50 years of age.

Contributors and Noncontributors

When a water conveyance system is evaluated as an eligible district or as an individually eligible property with multiple components, contributing and noncontributing elements must be identified. Contributing structures, buildings, objects, and sites are those elements associated with the property's period and area of significance which also possess an adequate level of integrity. Noncontributing elements were either not present during the historic period, or they were not part of the property's documented significance, or they have lost integrity and no longer reflect historic character. When considered as a historic district, a water conveyance system must contain a high proportion of contributors to noncontributors.

PROFESSIONAL QUALIFICATIONS

The diverse qualifications of professionals who may be called upon to assess the significance of water conveyance systems reflect the array of areas of significance associated with such properties and the potential for effects upon them. Historians, architectural historians, historical archaeologists, prehistoric archaeologists, and other cultural resource specialists may be qualified to address particular types or aspects of California's diverse water conveyance systems. The Secretary of the Interior's *Professional Qualifications Standards* provide the basic guidelines for determining professional qualifications. While it is preferable for resources to be evaluated by specialists in the discipline mostly closely related to the potential resource values, specialists in more than one discipline may be qualified to evaluate water conveyance systems.

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[31] Frank Adams, *Irrigation Districts in California*, Bulletin No. 21, California Department of Public Works, Reports of the Division of Engineering and Irrigation (Sacramento: California State Printing Office, 1929), passim; Wallace Smith, *Garden of the Sun: A History of the San Joaquin Valley, 1772-1939* (Los Angeles: Lymanhouse, 1939), 463-464.

[32] Mead, *Report of Irrigation Investigations in California,* 218; Ingvart Teilman and W.H. Shafer, *The Historical Story of Irrigation in Fresno and Kings Counties in Central California* (Fresno: Williams & Son, 1943), 12-13; Virginia E. Thickens, "Pioneer Agricultural Colonies of Fresno County" *California Historical Society Quarterly,* 25:1 (March 1946) and 25:2 (June 1946): 17-37, 169-177.

[33] Merle Armitage, *Operations Santa Fe: AT&SF Railway System* (New York: Duell, Sloan, & Pierce, 1948), 111-116; Passenger Department of the Santa Fe, "Central Valley of California," Promotional pamphlet (1901).

[34] T. E. Malone, "The California Irrigation Crisis of 1886: Origins of the Wright Act," Ph.D. diss. (Stanford University, 1965), 27-33.

[35] Jelinek, *Harvest Empire*, 47-60; William L. Preston, *Vanishing Landscapes: Land and Life in the Tulare Lake Basin* (Berkeley: University of California Press, 1981), 136-137; Norris Hundley, Jr., *The Great Thirst: Californians and Water, 1770s-1990* (Berkeley: University of California Press, 1992), 97-102.

[36] Malone, "The Irrigation Crisis," 182-211; Adams, *Irrigation Districts in California*, 119-121, 180-190, 214-217.

[37] John D. Works, "Irrigation Laws and Decisions in California," *A History of the Bench and Bar in California* (Los Angeles: Oscar T. Shuck, 1901), 164; Pisani, *From The Family Farm*, 252-282; Hundley, *The Great Thirst*, 97-102.

[38] Harmon S. Bonte, *Financial and General Data Pertaining to Irrigation, Reclamation, and Other Public Districts in California*. Bulletin No. 37. California Department of Public Works (Sacramento: State Printing Office, 1931), 27; California Division of Water Resources, Bulletin 21-A (1930), 12; Cal. Stats. 1911: 322 and 1913: 778.

[39] Bonte, *Financial and General Data*, 27; California Division of Water Resources, Bulletin 21-A, 12; Cal. Stats. 1911: 322 and 1913: 778.

[40] Pisani, *From the Family Farm*, 83-91, or Smith, *Garden of the Sun*, 448; William Hammond Hall, *Annual Report of the State Engineer to the Governor of the State of California* (October 1880); Harding, *Water in California*, 80.

[41] Harding, *Water in California*, 81.

[42] Harding, *Water in California*, 2-3.

[43] Paul, "Beginnings of Agriculture," 16-27.

[44] Harding, *Water in California*, 80; Durrenberger and Johnson, *Patterns on the Land*, 91.

[45] William Hammond Hall, *Irrigation in California*. Vol. II. (Sacramento: 1888), 55-75, 85-97.

[46] Hall, *Irrigation in California*, 114-126. Among the streams that Hall noted as sinking into the valley floor were the Santa Ana River, Mill Creek, San Gorgorio Creek, Temescal Creek, City Creek, Twin Creeks, Devils Canon, Cajon Pass Creek, Lytle Creek, Cucamonga and Days canons, San Antonio Canyon, Warm Creek, Chino Creek, and Rincon Mill Creek.

[47] Hall, *Irrigation in California*, 154-176, 198-258.

[48] For an uncritical account of the founding of the Anaheim Colony, see Charles Nordhoff, *California for Travelers and Settlers* (1873, reprinted in 1973 by Ten Speed Press), 174-177.

[49] Walton Bean, *California, an Interpretive History* (New York: McGraw Hill, 1978), 234-235.

[50] Hall, *Irrigation in California*, 353-363.

[51] Hall, *Irrigation in California*, 332-338.

[52] Hall, *Irrigation in California*, 365-646 passim. For the Pomona system, see 406-409. This section of Hall's report runs 15 chapters in length.

[53] Adams, *Irrigation Districts in California*, 180, 204, 277-334. Of the 18 Southern California irrigation districts in 1929, Vista ID had 18,161 acres; La Mesa, Lemon Grove and Spring Valley ID had 18,000 acres; and Fallbrook ID had 10,216 acres. The three represented 56.5% of the total area; the remaining 15 districts ran from 320 to 9,815 acres, averaging 2,381 acres each.

[54] San Bernardino and Riverside county boundaries encompass both the south coastal and desert regions. San Bernardino seemed to follow the trend of diminishing agricultural land after the 1940s; Riverside's acreage grew with increased development in the Coachella and Palo Verde valley areas. [Los Angeles County Chamber of Commerce, "Crop Acreage for Los Angeles County and Southern California," (Los Angeles: Board of Supervisors, 1956), 6.]

[55] Los Angeles County Chamber of Commerce, "Crop Acreage," 6, 10.

[56] Thorne Gray, *Quest for Deep Gold: The Story of La Grange, California* (La Grange: Southern Mines Press, 1973), 4.

[57] California Department of Public Works, Division of Water Resources (1955), 21, 23; State Engineering Department Field Notes, Book 32, Box 7, California State Archives (Sacramento).

[58] Larry M. Dilsaver, " After the Gold Rush," *The Geographical Review,* 75 (January 1985): 8, 15; Paul, "Beginnings of Agriculture," 16-19.

[59] Mead, *Report of Irrigation Investigations in California*, 131-133, 148-149; Adams, *Irrigation Districts in California,* 119-121.

[60] Jelinek, *Harvest Empire*, 35-37; Paul, "Beginnings of Agriculture," 16-27; Harding, *Water in California*, 82, 106.

[61] Pisani, *Family Farm to Agribusiness*, 83-91; Smith, *Garden of the Sun*, 448.

[62] Jelinek, *Harvest Empire*, 23-38; Paul, "Beginnings of Agriculture," 16-27.

[63] Walter Ebeling, *The Fruited Plain: The Story of American Agriculture* (Berkeley: University of California Press, 1979), 337; Jelinek, *Harvest Empire*, 31-32.

[64] C. L. Kaupke, "State Water Commission, Engineers Report on Kings River Investigation, 1920" (Sacramento, March 1921).

[65] Paul H. Willison, "Past, Present, and Future of the Fresno Irrigation District," California State University, Fresno, Special Collections (August 1, 1980), 78-9; Teilman and Shafer, *Historical Story of Irrigation in Fresno and Kings Counties*, 6.

[66] *Sanger Herald*, Centennial Edition (December 1988), p. 24.

[67] Willison, "Fresno Irrigation District," 79.

[68] Teilman and Shafer, *Historical Story of Irrigation in Fresno and Kings Counties*, 9-12; Willison, "Fresno Irrigation District," 70-76.

[69] Willison, "Fresno Irrigation District," 68-70.

[70] Arthur Maass and Raymond L. Anderson, *...And the Desert Shall Rejoice* (Cambridge, Mass: MIT Press, 1978), 160-161.

[71] Adams, *Irrigation Districts in California*, passim; Smith, *Garden of the Sun*, 463-464.

[72] JRP Historical Consulting Services, Field survey forms, Mojave Natural Gas Pipeline Northern Extension Project (1993-94).

[73] California Department of Water Resources, "Interim Statewide Alpha Listing of Water Service Agencies," revised (Sacramento: 1995); Adams, *Irrigation Districts in California*, 149-168. These counties include San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare, and Kern.

[74] Jelinek, *Harvest Empire*, 29.

[75] JRP, Mojave Pipeline Project field survey.

[76] Durrenberger and Johnson, *Patterns on the Land*, 22-24, 30; Harding, *Water in California*, 89; Jelinek, *Harvest Empire*, passim.

[77] State Engineering Department Field Book 47, Box 7, California State Archives (Sacramento).

[78] Pisani, *From the Family Farm*, 83, 93-97. Green's plan would not be realized until the state and the USBR cooperated in building the CVP's Tehama-Colusa canal.

[79] United States Department of Agriculture, "Report of Irrigation Investigations for 1902," (Washington, DC: GPO, 1903), 151-152, 154, 158-165. This "West Side Irrigation District" should not be confused with the later and more successful San Joaquin County district of the same name.

[80] Adams, *Irrigation Districts in California*, 80-89; Harding, *Water in California,* 88-89.

[81] Adams, *Irrigation Districts in California*, 73-77, 92-98, 105, 110, 115, 133, 139-140, and 143.

[82] Michael C. Robinson, *Water for the West: The Bureau of Reclamation, 1902-1977* (Chicago: Public Works Historical Society, 1979), 20-21.

[83] R. C. E. Weber, "Thin Concrete Lining Successful in Irrigation Canals," *Engineering News-Record* 88 (March 16, 1922), 436-437; Gloria Scott, "Historical Architectural Survey Report and Historical Resources Evaluation Report for Shoulder Widening and Left-Turn Channelization Project," California Department of Transportation, Orland, 03-Gle-32, 1.3/4.1, 03209-339600 (January 1991).

[84] California Department of Water Resources, "Interim Statewide Alpha Listing," 1995. The counties of the Sacramento Valley include portions of Shasta, Tehama, Glenn, Butte, Colusa, Sutter, Yuba, Yolo, Sacramento, and Solano. It should be noted that some of the agencies listed by the DWR provide irrigation water for open space uses like parks and golf courses.

[85] Durrenberger and Johnson, *Patterns on the Land*, 83-85, 88; George G. Mader, "Planning for Agriculture in Urbanizing Areas: A Case Study of Santa Clara County, California," MA thesis, (University of California, Berkeley, 1956), 3; Hoover and Rensch, *Historic Spots*, 378-388.

[86] For example, of the 7,750 acres of lima beans planted in Santa Barbara County in 1927, only 250 were irrigated. Clifford Zierer, "The Lima Bean Industry of the Southern California Coastal Region," *Bulletin of the Geographical Society of Philadelphia,* 27 (January 1929), 85.

[87] US Geological Survey, *Geology and Water Resources of the Santa Ynez River Valley*, (1947), 26, 29-30; Zierer, "The Lima Bean Industry," 70; Mader, "Planning for Agriculture," 1-12; Jennie Dennis Verardo and Denzil Verardo, *The Salinas Valley: An Illustrated History* (Chatsworth, CA: Windsor Publications, 1989), 85, 131, 135; California Development Board, *Agricultural Survey of San Benito County, California* (San Francisco: 1919), passim.

[88] Jelinek, *Harvest Empire*, 35-36, 47-49; Verardo and Verardo, *The Salinas Valley*, 135.

[89] Peter J. Lert and W. W. Wood, *Santa Clara County Agriculture: A Look at Its Future* (Agricultural Extension, University of California, 1972), 1, 4-8; Verardo and Verardo, *The Salinas Valley*, 80-85.

[90] Mead, *Report of Irrigation Investigations in California*, 195, 201-204; Homer Hamlin, AWater Resources of the Salinas Valley," *Water Supply Paper No. 89*, US Geological Survey (Washington, DC: 1904), 22-30.

[91] California Development Board, *Agricultural Survey of San Benito County*, 17-40, 64-68, 76-77, 82; Verardo and Verardo, *The Salinas Valley*, 84.

[92] California Development Board, *Agricultural Survey of San Benito County,* 14-15, 59; Adams, *Irrigation Districts in California*, 357-359.

[93] Hamlin, ASalinas Valley," 78-80.

[94] California Department of Water Resources, "Interim Statewide Alpha Listing," 1995.

[95] Durrenberger and Johnson, *Patterns on the Land*, 12, 14-15.

[96] Durrenberger and Johnson, *Patterns on the Land*, 30; Harding, *Water in California*, 105; California Department of Public Works, Division of Engineering and Irrigation, *California Irrigation District Laws* (Sacramento: State Printing Office, 1921), 56; Adams, *Irrigation Districts in California*, 53-65. The Montague Water Conservation District was originally organized as the Montague Irrigation District in 1925. California irrigation district law provides for the words "water conservation" to be used instead of "irrigation" and the district chose to adopt this wording in 1926.

[97] Adams, *Irrigation Districts in California*, 389-390; California Department of Public Works, Division of Water Resources, "Irrigation and Water Storage Districts in California, 1961," Bulletin No. 21 (Sacramento: State Printing Office, 1963); California Department Of Public Works, Division of Water Resources, "Report on Irrigation Districts in California," Bulletin No. 21 (Sacramento: State Printing Office, various years 1938-1950); California Department Of Public Works, Division of Water Resources, "Report on Irrigation and Water Storage Districts in California for 1956-1958," Bulletin No. 21 (Sacramento: State Printing Office, 1960).

[98] Adams, *Irrigation Districts in California*, 102-103.

[99] Pisani, *From the Family Farm*, 322-324; Stan Turner, *The Years of Harvest: A History of the Tule Lake Basin* (Eugene, OR: 49th Street Press, 1987), 159.

[100] California Department of Public Works, "Report on Irrigation, 1956-1958"; Michael G. Delacorte, et al., *Report on the Archaeological Test Investigations at 209 Sites along the Proposed Tuscarora Pipeline, From Malin, Oregon to Tracy, Nevada,* Vol. III, *Historic Site* (February 1995), passim; Mead, *Report of Irrigation Investigations in California*, 71-111.

[101] California Department of Public Works, Division of Water Resources, "Pit River Investigation," *Bulletin No. 41* (Sacramento: State Printing Office, 1933), 42-45; Delacorte, et al., *Tuscarora Pipeline*, passim.

[102] California Department Of Public Works, "Report on Irrigation, 1956-1958," 19-20; US Bureau of Reclamation, "Factual Data on the Klamath Project," pamphlet (Washington, DC: GPO, 1994); Pisani, *From the Family Farm*, 322-324.

[103] Durrenberger and Johnson, *Patterns on the Land*, 30-32.

[104] Robert A. Sauder, "Patenting an Arid Frontier: Use and Abuse of the Public Land Laws in the Owens Valley, California," *Annals of the Association of American Geographers* 79 (1984), 557-559; Kahrl, *Water and Power*, 33-39; Hoover and Rensch, *Historic Spots*, 115-116.

[105] Hoover and Rensch, *Historic Spots*, 120; J. C. Clausen, "Report on the Owens Valley, California" (1904), 19, 28-47.

[106] Sauder, "Patenting an Arid Frontier," 565-566.

[107] Kahrl, *Water and Power*, 331.

[108] California Department of Water Resources, "Interim Statewide Alpha Listing," 1995. Statistics for El Dorado and Placer counties are countywide, so it is possible that there are others in this region; however, the numbers in those counties (two in El Dorado, for example, of which one is the El Dorado Irrigation District in the foothill region) are low.

[109] Durrenberger and Johnson, *Patterns on the Land*, 15-17, 30-33.

[110] Harding, *Water in California*, 3-4, 113-115. Rockwood and Chaffey reasoned that "Imperial Valley" was a more inviting and marketable name for their project than "Colorado Desert."

[111] Harding, *Water in California*, 81, 113-115; Los Angeles County Chamber of Commerce 1956, 6; Adams, *Irrigation Districts in California*, 334-341.

[112] Adams, *Irrigation Districts in California*, 340-341. The Imperial Irrigation District has in the past several years begun a cooperative agreement with the Metropolitan Water District, whereby the MWD will line the district's canals in return for the water thus saved.

[113] Harding, *Water in California*, 115.

[114] Harding, *Water in California*, 3, 84, 115; Adams, *Irrigation Districts in California*, 327-331.

[115] The 11 geomorphic zones he listed were: Klamath Mountains, Cascade Range, Modoc Plateau, Coast Ranges, Great Central Valley, Sierra Nevada, Basin Ranges, Mojave Desert, Traverse Ranges, Peninsula Ranges, and Colorado Desert. William B. Clark, *Bulletin 193: Gold Districts of California* (Sacramento: California Division of Mines and Geology), 11.

[116] Bean, *California*, 95.

[117] Owen G. Stanley, "Brief History of Hydraulic Mining, Gold Dredging, Creation of the California Debris Commission, and Birth of the Sacramento District of the Corps of Engineers," (October 1965), 6; Rodman W. Paul, *California Gold: The Beginning of Mining in the Far West* (Lincoln: University of Nebraska Press, Bison Books, 1967), 50-51.

[118] Jackson Research Projects, *History of the Tahoe National Forest, 1840-1940: A Cultural Resources Overview History,* Tahoe National Forest Cultural Resources Report No. 15 (Nevada City: 1982), 25-26; Paul, *California Gold*, 52-53.

[119] Paul, *California Gold*, 61-62; Jackson Research Projects, *Tahoe National Forest*, 26.

[120] Paul, *California Gold*, 59-60, 124-29; Hundley, *The Great Thirst*, 67-68.

[121] J. Ross Browne and James W. Taylor, *Report upon the Mineral Resources of the United States* (Washington, D. C.: GPO, 1867), 23; Paul, *California Gold*, 128.

[122] Paul, *California Gold*, 60; Douglas R. Littlefield, "Water Rights During the California Gold Rush: Conflicts over Economic Points of View," *Western Historical Quarterly* 14 (October 1983), 420-421.

[123] Browne and Taylor, *Mineral Resources*, 16-17; Littlefield, "Water Rights," 421; Philip Ross May, *Origins of Hydraulic Mining in California* (Oakland: The Holmes Book Company, 1970), 34-36.

[124] Donald Pisani, *To Reclaim A Divided West: Water, Law, and Public Policy, 1848-1902* (Albuquerque: University of New Mexico Press), 15; Dana Supernowicz, "A Contextual History, Programmatic Agreement and Evaluation Plan for Historic Water Conveyance Systems on the Eldorado National Forest, California," Eldorado National Forest (February 1990).

[125] W. Turrentine Jackson, Stephen D. Mikesell, and Harvey Schwartz, "Historical Survey of the New Melones Reservoir Project Area," prepared for the Department of the Army, Sacramento District Corps of Engineers (January 1976), 82; Paul, *California Gold*, 64-65.

[126] Franklin Street, *California in 1850* (Cincinnati: R. E. Edwards and Company, 1850; reprinted New York: Promontory Press, 1974), 39.

[127] Littlefield, "Water Rights," 421; Pisani, *To Reclaim*, 15.

[128] Thomas Harsha Pagenhart, "Water Use in the Yuba and Bear River Basins, California," Ph.D. Diss. (University of California, Berkeley, 1969), 89.

[129] State Engineering Department Field Notes, Book 34, Box 7, Sacramento, California State Archives. The Natoma Land and Water Company claimed 3,000 miner's inches based upon actual appropriations from the public domain prior to 1866. By the late 1870s the system was capable of carrying only about half this amount because its flumes were in need of repair. The ditch was later rehabilitated and used primarily for irrigation purposes below Folsom.

[130] Paul, *California Gold*, 161-62; Supernowicz, "A Contextual History," 2.

[131] Littlefield, "Water Rights," 423-25.

[132] Spring Valley Mining & Irrigating Company, Records, MSS 15, Meriam Library Special Collections, California State University, Chico.

[133] Carmel Barry Meisenbach, *Historic Mining Ditches of the Tahoe National Forest,* Tahoe National Forest Cultural Resources Report No. 28 (1989), 10-21.

[134] Meisenbach, *Historic Mining Ditches*, 15-18; Pagenhart, "Water Use," 123-27.

[135] J. Ross Browne, *Resources of the Pacific Slope: A Statistical and Descriptive Study* (New York: D. Appleton and Company, 1869), 186-87; Meisenbach, *Historic Mining Ditches*, 18.

[136] Meisenbach, *Historic Mining Ditches*, 23; Pagenhart, "Water Use," 119-20.

[137] Browne, *Resources of the Pacific Slope*, 180-181, 195; Littlefield, "Water Rights," 422.

[138] Donald J. Pisani, "Enterprise and Equity: A Critique of Western Water Law in the Nineteenth Century," *Western Historical Quarterly,* 18 (1987), 15-27; Littlefield, "Water Rights," 415, 421.

[139] Paul, *California Gold*, 179-81; John W. Caughey, *Gold Is the Cornerstone* (Berkeley: University of California Press, 1948), 296-97.

[140] Browne, *Resources of the Pacific Slope*, 200-206.

[141] Browne and Taylor, *Mineral Resources*, 65.

[142] John S. Hittell, *The Resources of California, Comprising Agriculture, Mining, Geography, Climate, Commerce* (San Francisco: A. Roman and Company, 1866), 253; Paul, *California Gold*, 62-63; May, *Origins of Hydraulic Mining*, 16-19, 29.

[143] Augustus J. Bowie, *A Practical Treatise on Hydraulic Mining in California with Description of the Use and Construction of Ditches, Flumes, Wrought-Iron Pipes, and Dams; Flow of Water on Heavy Grades, and Its Applicability, Under High Pressure to Mining,* 10th ed. (New York: D. Van Nostrand Company, 1905), 84.

[144] Browne and Taylor, *Mineral Resources*, 22-23.

[145] The career of Anthony Chabot is detailed in Sherwood D. Burgess' biography, *The Water King Anthony Chabot: His Life and Times* (Davis: Panorama West Publishing, 1992).

[146] May, *Origins of Hydraulic Mining*, 45-50.

[147] Bowie, *Practical Treatise*, 49.

[148] Hundley, *The Great Thirst*, 73-74; Harding, *Water in California,* 62-63.

[149] *Mining and Scientific Press*, June 6, 1867.

[150] Gray, *Quest for Deep Gold*, 12-13.

[151] Rossiter W. Raymond, *Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains*, House Executive Document No. 211, 42:2 (Washington: GPO, 1872), 93.

[152] Browne, *Resources of the Pacific Slope*, 180.

[153] Browne and Taylor, *Mineral Resources*, 17.

[154] W. S. Saunders, "Preliminary Report of the American River Development, El Dorado County, California, for Western Gas and Electric Company (1911)," Water Resources Center Archives, University of California, Berkeley.

[155] Robert Kelley, *Gold vs. Grain: The Mining Debris Controversy* (Glendale: The Arthur H. Clark Company, 1959), 45-46; Henry DeGroot, "Hydraulic and Drift Mining," in Henry Hanks, *Second Report of the State Mineralogist of California, from December 1, 1880, to October 1, 1882* (Sacramento: State [Printing] Office, 1882), 149-50.

[156] W. Turrentine Jackson, "Report on the Malakoff Mine, the North Bloomfield Mining District, and the Town of North Bloomfield," Prepared for the California Department of Parks and Recreation (Sacramento: 1967), 6-7; Meisenbach, *Historic Mining Ditches*, 12.

[157] Meisenbach, *Historic Mining Ditches*, 12; Jackson, "Malakoff Mine," 11-12.

[158] Jackson, "Malakoff Mine," 11-12, 58; Harding, *Water in California*, 67.

[159] *Mining and Scientific Press* (June 20, 1874), 378.

[160] George S. Davison and James D. Schuyler, "The Cherokee Hydraulic Gold Mines of Butte County, Cal.," 1, Schuyler Collection, Water Resources Center Archives, University of California, Berkeley; *Weekly Butte Record* (November 11, 1873).

[161] Davison and Schuyler, "Cherokee Hydraulic," 9-11; *Mining and Scientific Press* (July 23, 1870); Bowie, *Practical Treatise*, 172-74.

[162] Charles Waldeyer, "Hydraulic Mining in California," in Rossiter W. Raymond, *Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains*, House Executive Document No. 210, 42:3 (Washington: GPO, 1873), 406.

[163] Waldeyer, "Hydraulic Mining," 410.

[164] Meisenbach, *Historic Mining Ditches*, 3; Bowie, *Practical Treatise*, 122-24. Thus, in most places in California, 1 cfs equals 40 miner's inches.

[165] Meisenbach, *Historic Mining Ditches*, 3.

[166] Waldeyer, "Hydraulic Mining," 406-407.

[167] Waldeyer, "Hydraulic Mining," 407.

[168] Waldeyer, "Hydraulic Mining," 409; Bowie, *Practical Treatise*, 136-37.

[169] Waldeyer, "Hydraulic Mining," 409.

[170] Bowie, *Practical Treatise*, 130-31; James S. Tate, C. E., *Surcharged and Different Forms of Retaining Walls* (New York: Van Nostrand, 1873), 5-48; B. A. Etcheverry, *Irrigation Practice and Engineering,* Volume II: *Conveyance of Water* (New York: McGraw-Hill Book Company, 1916), 112-26.

[171] Waldeyer, "Hydraulic Mining," 409-10.

[172] Eric Ritter, "Historical Notes on Butte County's Miocene Ditch," *Butte County Historical Society Diggings,* 27:2 (Summer Edition 1983), 31-32; DeGroot, "Hydraulic and Drift Mining," 156-57; Bowie, *Practical Treatise*, 150-52.

[173] Etcheverry, *Irrigation Practice*, 173-238; Bowie, *Practical Treatise*, 142-44; Stephen R. Wee and Leslie Glover, "Archeological Survey and Historical Research Report on the El Dorado Canal, El Dorado County, California" (June 1991).

[174] Bowie, *Practical Treatise*, 158-60, 168-72; Waldeyer, "Hydraulic Mining," 407-08.

[175] Waldeyer, "Hydraulic Mining," 410-11; DeGroot, "Hydraulic and Drift Mining," 159; Bowie, *Practical Treatise*, 158-68.

[176] Donald C. Jackson, "A History of Water in the American West: John S. Eastwood and the `The Ultimate Dam' (1908-1924)" (Ph.D. Diss., University of Pennsylvania, 1986), 128-30.

[177] Hanks, *State Mineralogist, 1880-1882*, 36-37.

[178] Waldeyer, "Hydraulic Mining," 408.

[179] Hanks, *State Mineralogist, 1880-1882*, 39.

[180] DeGroot, "Hydraulic and Drift Mining," 162-63.

[181] Gray, *Quest for Deep Gold*, 12-13; Bowie, *Practical Treatise*, 142; Wee and Glover, "Archeological Survey," II-26.

[182] Bowie, *Practical Treatise*, 142; *Alta California* (October, 27, 1871).

[183] Wee and Glover, "Archeological Survey," II:11-19; Francis A. Bishop, Diary, 1873, BP 203 (1), and Letterbooks, 1864-1877, BP 204, Bishop MSS Collection, Huntington Library, San Marino, California.

[184] Rudolph Warner Van Norden, "The Water and Electric Systems of the South Yuba," *Journal of Electricity, Power and Gas* 13:1 (January 1903), 59-63. Like the El Dorado Canal, the Main South Yuba Canal includes extensive dry-laid, roughly coursed rock walls that utilize the native rock of the area through which it passes.

[185] DeGroot, "Hydraulic and Drift Mining," 159-60.

[186] *Alta California* (May 26, 1857); Samuel F. Emmons and George F. Becker, "Statistics and Technology of the Precious Metals," *Tenth Census, 1880* (Washington: GPO, 1885), 179, 210; Raymond, *Statistics of Mines* (1872); DeGroot, "Hydraulic and Drift Mining," 159-161.

[187] Kelley, *Gold vs. Grain*, 34-35; Joseph J. Hagwood, Jr., *The California Debris Commission: A History,* prepared for the United States Army Corps of Engineers, Sacramento District (Sacramento: 1981), 19.

[188] Kelley, *Gold vs. Grain*, 58.

[189] DeGroot, "Hydraulic and Drift Mining," 161.

[190] Hundley, *Great Thirst*, 77. See Kelley, *Gold vs. Grain*, for a full discussion of the protests against hydraulic mining.

[191] Jackson Research Projects, *Tahoe National Forest*, 87; Clark, *Gold Districts*, 6-7; Kelley, *Gold v. Grain*, 244-45; Hagwood, *California Debris Commission*, 27-30.

[192] Hagwood, *California Debris Commission*, 30-32.

[193] Mildred Brooke Hoover, Hero Eugene Rensch, Ethel Grace Rensch, William N. Abeloe, *Historic Spots in California*, 4th edition, revised by Douglas E. Kyle (Stanford: Stanford University Press, 1990), 504.

[194] California Department of Public Works, Division of Engineering and Irrigation, *First Biennial Report of the Division of Engineering and Irrigation, November 1, 1922* (Sacramento: State Printing Office, 1923), 40.

[195] W. S. Kingsbury and Lloyd L. Root, *Report of the Hydraulic Mining Commission upon the Feasibility of the Resumption of Hydraulic Mining in California* (Sacramento: State Printing Office, 1927), 5-6.

[196] Clark, *Gold Districts*, 4.

[197] Paul, *California Gold*, 130-31, 286-90; Clark, *Gold Districts*, 89.

[198] Paul, *California Gold*, 285-94.

[199] Paul, *California Gold*, 289-90; William Irelan, *Eighth Annual Report of the State Mineralogist for the Year Ending October 1, 1888* (Sacramento: State Printing Office, 1888), 692-95.

[200] Richard E. Lingenfelter, *Hardrock Miners: A History of the Mining Labor Movement in the American West, 1863-1893* (Berkeley: University of California Press, 1974), 4-5; Paul, *California Gold*, 288-89.

[201] Clark, *Gold Districts*, 13, 69-76; Stanley, "Brief History of Hydraulic Mining," 9.

[202] F. F. Thomas, "Water Wheels," in Irelan, *State Mineralogist, 1888*, 785-91.

[203] Lewis E. Aubrey, *Gold Dredging in California,* California State Mining Bureau Bulletin No. 57 (Sacramento: State Printing Office, 1910), 164-67.

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[208] "Mineral Resources of El Dorado County," *California Journal of Mines and Geology,* 34 (July 1938), 215, 255.

[209] Terry S. Reynolds and Charles Scott, "The Battle Creek Hydroelectric System: An Historical Study," Historic American Engineering Record (1982), 7-8.

[210] Thomas, "Water Wheels," 785, 791; Duncan Hay, *Hydroelectric Development in the United States, 1880-1940* (Washington, DC: Edison Electric Institute, 1991), 4-5.

[211] Durrenberger and Johnson, *Patterns on the Land*, 73.

[212] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: The Johns Hopkins University Press, 1983), 32-34; Hay, *Hydroelectric Development*, 6; James C. Williams, "Appendix B: DeSabla-Centerville Project Historical Report and Project Significance and Recommendations," in PAR, "Cultural Resources Inventory and Management Plan for the Proposed Improvements to the DeSabla-Centerville Hydroelectric System, Butte County, California (FERC No. 803)," prepared for Pacific Gas & Electric Company (1985).

[213] US Department of Commerce, Bureau of the Census, *Fifteenth Census of the United States, Manufactures, Vol. III* (Washington: GPO, 1933), 61, 65.

[214] Hay, *Hydroelectric Development*, 16-17; Jackson, "A History of Water in the American West," 174.

[215] Walter R. McLean, "The History of Hydro-Electric Development in Northern California and Southern Oregon," MS, Water Resources Center Archives, University of California, Berkeley.

[216] Jackson, "History of Water," 174-76; Hay, *Hydroelectric Development*, 16-17

[217] James Williams, "FERC Relicensing and Hydroelectric History in California," typescript (1992), 3; Frederick Hall Fowler, "Hydroelectric Power Systems of California and Their Extensions into Oregon and Nevada," *Water Supply Paper No. 493,* US Geological Survey (Washington, DC: GPO, 1923), 1.

[218] Hay, *Hydroelectric Development*, 17-18; Jackson, "History of Water," 176, 179; Fowler, *Hydroelectric Power Systems*, 544.

[219] Fowler, *Hydroelectric Power Systems*, 545.

[220] Jackson, "History of Water," 173-84.

[221] George P. Low, "The Generating, Transmission and Distribution Systems of The Edison Electric Company of Los Angeles, Cal.," *Journal of Electricity, Power and Gas,* 13:1 (January 1903), 10-12.

[222] Low, "Generating, Transmission and Distribution Systems," 21-23.

[223] Fowler, *Hydroelectric Power Systems*, 529-539; Low, "Generating, Transmission and Distribution Systems," 10.

[224] Fowler, *Hydroelectric Power Systems*, 149-51; W. F. C. Hasson, "Electric-Power Transmission Plants in California," in J. J. Crawford, *Thirteenth Report of the State Mineralogist for the Two Years Ending September 15, 1896* (Sacramento: State Printing Office, 1896), 673-76.

[225] *Engineering and Mining Journal* (September 7, 1901). In the 1890s and 1900s, smaller hydroelectric facilities were constructed near mines and mining operations to fill the needs of these operations. Hydroelectric powerhouses in Butte, Calaveras, Nevada, Placer, Sierra, and Tuolumne counties were all utilized exclusively for this purpose in 1901.

[226] Fowler, *Hydroelectric Power Systems*, 113-114.

[227] The Colgate water conduit was plagued with many additional problems. The dam at Lake Francis failed in 1899 and was rebuilt in 1902. The diversion dam on the North Fork was washed out in 1904 and replaced by a 41-foot-high masonry dam that same year. The flume through the steep, rugged North Fork Canyon contained a number of high trestles which were vulnerable to wind and slides. As early as the 1920s, the company pondered replacing the worst segments with tunnels. Hughes, *Networks of Power*, 270-74; Fowler, *Hydroelectric Power Systems*, 153-157.

[228] Hughes, *Networks of Power*, 274-75; Fowler, *Hydroelectric Power Systems*, 113-15, 269-70.

[229] Charles M. Coleman, *P. G. & E. of California: The Centennial Story of Pacific Gas and Electric Company* (New York: McGraw-Hill Company, 1952), 94.

[230] Fowler, *Hydroelectric Power Systems*, 173-89; Coleman, *P. G. & E. of California*, 99.

[231] The entire Bishop Creek hydroelectric power system made use of wood-stave pipe for its conduit and penstock. The pipe was protected by a rough, dry-laid rock wall laid on either side of the pipe and covered with earth fill to a depth of one foot. In 1915 the original wood-stave pipe (the conduit to Plant No. 4) was replaced with a 60-foot wood-stave pipe and the penstock was replaced with riveted pipe. Between 1956 and 1968, the remaining wood-stave pipe was replaced with steel pipe. Bishop Creek Hydroelectric Power System, Historic Resources Inventory, DPR 523; Fowler, *Hydroelectric Power Systems*, 762-63, 789.

[232] Reynolds and Scott, "Battle Creek, "16.

[233] F. G. Mudgett, comp., "History and Commercial Development of the Hydro-Electric Properties on the Pacific Coast, April 1915 (Proof Copy)," PG&E Archives.

[234] Bonner, *Water Powers of California*, 191-206; Hay, *Hydroelectric Development*, Appendix.

[235] Fowler, *Hydroelectric Power Systems*, 102; Coleman, *P. G. & E. of California*, 157.

[236] Fowler, *Hydroelectric Power Systems*, 203-225.

[237] Reynolds and Scott, "Battle Creek." Reynolds' fine report is significant in many respects, but perhaps most importantly he demonstrates, unlike most other studies reviewed, that the archival documentation on early hydroelectric water systems exists, if the researcher is clever enough to know where to look for it. See also, Stephen Wee and Leslie Glover, "Archeological Survey and Historical Evaluation Report on the El Dorado Canal, El Dorado County, California," Pacific Gas & Electric Company (1991).

[238] Reynolds and Scott, "Battle Creek," 43-47, 70-71.

[239] Rudolph Van Norden, "The Coleman Plant," *Journal of Electricity, Power and Gas,* 27 (1911), 414; *Red Bluff News* (August 14, 1909).

[240] Reynolds and Scott, "Battle Creek," 83-84.

[241] Reynolds and Scott, *Battle Creek*, 74, 84-85, 106-07; "The Coleman Hydroelectric Development on Battle Creek, California," *Engineering Record,* 64 (1911), 700-702.

[242] JRP, *Great Western Power Company: Hydroelectric Power Development on the North Fork of the Feather River, 1902-1930* (1986*);* James D. Schuyler, "Report on Water Storage and Power Development on North Fork of Feather River, California as Proposed by Western Power Company," Schuyler Collection, 44, Water Resources Center Archives, University of California, Berkeley (June 30, 1902); J. M. Howells, "Report on Water Supply from Big Meadows, Butte Creek and Yellow Creek, Plumas County, California," Schuyler Collection, 44, Water Resources Center Archives, University of California, Berkeley (August 4, 1905); John Freeman, "General Plan of the Big Meadows District," Freeman Papers, Massachusetts Institute of Technology (November 15, 1905).

[243] Hughes, *Networks of Power*, 279-80; Coleman, *P. G. & E. of California*, 257.

[244] Coleman, *P. G. & E. of California*, 257; Fowler, *Hydroelectric Power Systems*, 167-71; Bonner, *Water Powers of California*, 87.

[245] Coleman, *P. G. & E. of California*, 257-58; Fowler, *Hydroelectric Power Systems*, 176-78.

[246] Fowler, *Hydroelectric Power Systems*, 173-88; Bonner, *Water Powers of California*, 87; Coleman, *P. G. & E. of California*, 258.

[247] Laurence Shoup, "`The Hardest Working Water in the World:' A History and Significance Evaluation of the Big Creek Hydroelectric System," Archaeological and Historical Consultants (1988); Redinger, *The Story of Big Creek* (Los Angeles: Eureka Press, 1949).

[248] Fowler, *Hydroelectric Power Systems*, 777; Theodoratus Cultural Research, Bishop Creek Hydroelectric System, Historic Resources Inventory Form (1988).

[249] Fowler, *Hydroelectric Power Systems*, 622-34.

[250] I. C. Steele, "Large Units Characterize Hydro Plant Practice," *Civil Engineering* 20:10 (October 1950), 34; Hay, *Hydroelectric Development*, Appendix D, 1-2.

[251] Hay, *Hydroelectric Development*, 126; Harding, *Water in California*, 131.

[252] Harding, *Water in California*, 132.

[253] Harding, *Water in California*, 134; Fowler, *Hydroelectric Power Systems*, 745-57.

[254] Fowler, *Hydroelectric Power Systems*, 745-57.

[255] Fowler, *Hydroelectric Power Systems*, 735-41; Bonner, *Water Powers of California*, 201.

[256] Warren D. Hanson, *San Francisco Water and Power: A History of the Municipal Water Department and Hetch Hetchy System,* City and County of San Francisco (San Francisco: 1994), 36-39.

[257] Adams, *Irrigation Districts in California*, 180-89.

[258] Harding, *Water in California*, 134; Hay, *Hydroelectric Development*, 123-24.

[259] Hundley, *The Great Thirst*, 268-69; William L. Kahrl, ed., *The California Water Atlas,* Governor's Office of Planning and Research (Sacramento: 1979), 47-49.

[260] US Department of Interior, Bureau of Reclamation, Central Valley Project, Shasta/Trinity River Divisions, *California: Shasta, Trinity, and Tehama Counties* (Washington, DC: GPO, 1983), 1-4.

[261] Hundley, *The Great Thirst*, 269; Michael C. Robinson, *Water for the West: The Bureau of Reclamation, 1902-1977* (Chicago: Public Works Historical Society, 1979), 69.

[262] Robert Gauvreau, *Modesto: Images of Yesterday; Images of Today* (Modesto: McHenry Museum Society Press, 1984), 233; Harding, *Water in California*, 117-118.

[263] Harding, *Water in California*, 118-119.

[264] W. W. Robinson, *The Story of Riverside County*, Title Insurance and Trust Company (Los Angeles: 1957), 33.

[265] William Blomquist, *Dividing the Waters; Governing Groundwater in Southern California* (Los Angeles: ICS Press, 1992); Pat McAdam and Sandy Snider, *Arcadia: Where Ranch and City Meet,* Friends of the Arcadia Public Library (1981), 173.

[266] Preston, *Vanishing Landscapes*, 219.

[267] W. Turrentine Jackson, Rand Herbert, and Stephen Wee, *Engineers and Irrigation*, Engineer Historical Studies No. 5, USACE Office of History (Fort Belvoir, VA: 1990), 3-37; Pisani, *Family Farm to Agribusiness,* 166-167.

[268] Pisani, *Family Farm to Agribusiness*, 440-452; Cletus E. Daniel, *Bitter Harvest: A History of California Farmworkers, 1870-1941* (Berkeley: University of California Press, 1981), passim.

[269] Hundley, *The Great Thirst*, 169-200.

[270] Robert Bradford Marshall, *Irrigation of Twelve Million Acres in the Valley of California* (Sacramento: California State Irrigation Association, 1919).

[271] Pisani, *Family Farm to Agribusiness*.

[272] Hundley, *Great Thirst*, 243.

[273] Hundley, *Great Thirst*; Erwin Cooper, *Aqueduct Empire: A Guide to Water in California, Its Turbulent History and Management Today* (Glendale: Arthur H. Clark Company, 1968).

[274] Pisani, *Family Farm to Agribusiness*, 434-439; Hundley, *Great Thirst*, 232-257.

[275] US Bureau of Reclamation (USBR), "Central Valley Project: Its Historical Background and Economic Impacts," USBR, Mid-Pacific Region (Sacramento: 1981).

[276] USBR, "Central Valley Project."

[277] Cooper, *Aqueduct Empire*; USBR, "Central Valley Project."

[278] Hundley, *Great Thirst*.

[279] The literature on the CVP from an engineering standpoint tends to emphasize the importance of dam designs, although the size and durability are emphasized as well. See, for example, Hunter Rouse's *Hydraulics in the United States, 1776-1976* (1976), and Norman Smith's *Man and Water: A History of Hydro-Technology* (1975), both of which discuss the CVP in terms of hydraulic engineering.

[280] Pisani, *Farm to Agribusiness*, 434-439; Hundley, *Great Thirst*, 232-257.

[281] US Bureau of Reclamation (USBR*), Delta-Mendota Canal: Technical Record of Design and Construction* (Denver: June 1959).

[282] USBR, "Central Valley Project," 4.

[283] USBR, "Central Valley Project," 3-4, 7. Folsom Dam, along with Nimbus Dam, Sly Park Dam, and the American River Fish Hatchery, are part of the American River Division authorized in October 1949 and completed in 1955. The Folsom South Canal is not part of this unit. The USBR's Solano and Orland projects are not part of the CVP, even though built by the USBR.

[284] W. Turrentine Jackson and Alan M. Paterson, *The Sacramento-San Joaquin Delta: The Evolution and Implementation of Water Policy, an Historical Perspective*, California Water Resources Center, University of California, Davis, Contribution No. 163 (June 1977), 30.

[285] The Contra Costa County Board of Supervisors approved the organization of an agency to manages the distribution of water from this canal, the Contra Costa County Water District [CCCWD], in 1936.

[286] Jackson and Paterson, *Sacramento-San Joaquin Delta,* 37-40.

[287] Jackson and Paterson, *Sacramento-San Joaquin Delta,* 37-40; House Committee on Interior and Insular Affairs, *Central Valley Project Documents, Part II: Operating Documents,* 85th Cong., 1st Sess., H. Doc. 246, 1957, 56, 62; Teknekron, Inc., "An Overview of the Contra Costa Water District" (November 1977), 8.

[288] Jackson and Paterson, *Sacramento-San Joaquin Delta,* 37-40; USBR, *Delta-Mendota Canal: Technical Record of Design and Construction*, 2; Teknekron, "Contra Costa County Water District," 8.

[289] Michael C. Robinson, *Water for the West: The Bureau of Reclamation, 1902-1977* (Chicago: Public Works Historical Society, 1979), 67-69; US Geological Survey, topographical maps, Antioch North, Honker Bay, Vine Hill, 7.5 m. quadrangles; JRP field observations (1993-94).

[290] USBR, *Delta-Mendota Canal*, 13

[291] USBR, *Delta-Mendota Canal*, summary page.

[292] USBR, *Delta-Mendota Canal*, 122-134.

[293] USBR, Friant-Kern Canal: Technical Record of Design and Construction, Central Valley Project, Friant Division, California (Denver: May 1958).

[294] Kern County Museum Photo Collection, Box 25, Canals, Friant-Kern; USBR, *Friant-Kern Canal*, 1, 2, 6-7, 61-62, 82-85.

[295] USBR, “Friant-Kern Canal,” summary page, 117-118.

[296] California Department of Public Works, “Report on Irrigation, 1956-1958,” 5, 9, 26; California Department Of Public Works, Division of Water Resources, “Report on Irrigation and Water Storage Districts in California for 1959.” *Bulletin No. 21-59* (December 1960), 6.

[297] Porterville Irrigation District, "Water Conservation Plan Review Draft," (February 16, 1994), 1-4.

[298] Gary C. Taylor, "Economic Planning of Water Supply Systems," Giannini Foundation Research Report No. 291 (Berkeley: May, 1967), 51, 59.

[299] Taylor, "Economic Planning," 63-5.

[300] Interview with Don Robert, engineer, Madera Irrigation District (August 17, 1992).

[301] US Bureau of Reclamation, "Friant Division, Central Valley Project" (Washington, DC: 1958).

[302] Christiansen and Gaines, July 1981, 7; USBR, "Final Environmental Statement," June 7, 1972, 4-6, 12.

[303] Christiansen and Gaines, July 1981, 7.

[304] In raw numbers—acre-feet stored and delivered, combined total miles of canals, numbers of reservoirs, acres served, and so forth—the CVP is a much larger system. The SWP serves a somewhat different purpose, supplying municipal-industrial users as well as agricultural users.

[305] G.H. Davis, et al., “Groundwater Conditions & Storage Capacity in the San Joaquin Valley,” *Water Supply Paper No. 1469,* US Geological Survey (1959).

[306] Hundley, *Great Thirst*, 1992.

[307] Hundley, *Great Thirst*, 273-276.

[308] Hundley, *Great Thirst*, 276, 278, 284-286.

[309] California Department of Public Works, Division of Water Resources, "The California State Water Project in 1969" (Sacramento: State Printing Office), 2.

[310] Alfred R. Golze, "Concrete Features in the California Water Project," presented before the Southern California Chapter of the American Concrete Institute, (Los Angeles: May 20, 1965), 1.

[311] Golze, "Concrete Features," 11.

[312] Hundley, *Great Thirst*, 287.

[313] Cooper, *Aqueduct Empire*, 246; California Department of Water Resources, *California State Water Project* (1988), 2, 6.

[314] California Department Of Water Resources, *California State Water Project* (1988), 6, 11.

[315] Interview with Steven Lafond (August 17, 1993); Boyle Engineering Corporation, Plate 1.

[316] Kern County Water Agency, *1990-1991 Biennial Report*, 1991, 16-17.

[317] California Department Of Water Resources, *California State Water Project* (1988), 4-5.

[318] *Transactions of the American Society of Civil Engineers* (1915), 1013; *Engineering News-Record* (May 25, 1922), 854-861; (July 5, 1923), 20-21; (February 1, 1923), 194-199.

[319] Charles Prelini, *Tunneling* (New York: D. Van Nostrand Co., n.d.); "Economic Construction of Tunnels for Hydroelectric Plants," *Transactions of the American Society of Civil Engineers*, 79 (1915): 1012.

[320] Wood-stave pipes were often assembled at hydroelectric power sites because unassembled parts were more easily transported, a special advantage in rough, mountainous country.

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APPENDIX A:
List of Identified Water Conveyance Systems

The following list reflects the results of a comprehensive search of the electronic Historic Properties and Archaeological databases maintained by the California Office of Historic Preservation, current as of July 21, 1997. The search used both attribute codes and the words “canal,” “dam,” “ditch,” and “reservoir” to identify resources with water conveyance system features. In many cases, such features are simply one of several resource elements recorded at a given property. Associated resources have not been systematically incorporated on this list, although the presence of such elements is noted for some of the listed properties.

Some duplicate listings are present because the list was derived from two databases and some properties are registered in both. Hence, a few properties have both a historic property number and an archaeological trinomial designation. The list contains 1716 entries representing over 1500 properties with water conveyance system features. Many additional water conveyance systems features have been formally recorded, but have not yet been incorporated in the California OHP’s electronic databases. The following list nevertheless provides a useful starting point for any search involving water conveyance system features.

APPENDIX A: WCS Features Listed in OHP Databases*

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
11584	ALAMEDA	HIGH PRESSURE PUMPING STATION #1, CIT	1909	4623-0160-0000	3S			14, 22
12421	ALAMEDA	EUCLID, HAVILAND HALL	1923	4701-0353-0000	3S			15, 22
12486	ALAMEDA	LYDIA ATTERBURY HOUSE	1898	4701-0418-0000	3S			2, 22, 30
12517	ALAMEDA	W H SELLANDER HOUSE	1914	4701-0449-0000	3S			2, 4, 22
108527	ALAMEDA	WHITFIELD RESERVOIR OUTFALL STRUCTURE		FEMA960720D	2S2	AD	8/1/96	
ALA-000439H	ALAMEDA	AC-53	1856					02,03,04,06,10,15,16
ALA-000441H	ALAMEDA	RANCH COMPLEX						02,06,10
ALA-000536 H	ALAMEDA	COUNTY LINE BARN		BUR910227A	2D1	D	7/22/92	2,8,15
ALP-000075	ALPINE	ADAMS CAMPSITE						
ALP-000157H	ALPINE	FS# 05-03-51-0197						08,10
ALP-000163H	ALPINE	FS# 05-03-51-0210	1890					6
ALP-000250H	ALPINE							6
ALP-000294H	ALPINE	FS# 05-16-52-0758, UTICA 28, LAKE ALPINE AND DAMS	1892					8,9,16
ALP-000296H	ALPINE	FS# 05-16-52-0759, UTICA 31, UNION DAMS	1857					8,16
ALP-000298	ALPINE	FS# 05-16-52-0760, UTICA 32, UTICA DAMS	1908					7,8,16
ALP-000330H	ALPINE							6
58670	AMADOR	PRESTON SCHOOL HENDERSON RESEVOIR	1923	5640-0005-0003	3B			22
58711	AMADOR	PRESTON FARM RESERVOIR	1948	5640-0009-0028	4B			22, 33
58743	AMADOR	MOORE MINE- CAPTAIN LITTLES RANCH	1921	5642-0031-0000	3S			4, 8, 20, 21, 32, 39
97189	AMADOR	PARDEE DAM, PARDEE RESERVOIR	1929	COE950615B	2S2	AC	7/10/95	
97190	AMADOR	SOUTH SPILLWAY, PARDEE RESERVOIR	1929	COE950615B	2S2	AC	7/10/95	
103805	AMADOR	SILVER LAKE DAM	1906	FHWA960718A	6Y2		9/11/96	
AMA-000116H	AMADOR	FS# 05-03-51-89, -89B, -89C, and -90; UPPER BRUCES CAMP (4-AMA-69B)		USFS920317N	2D2	D	4/23/92	02,03,04,05,06,16
AMA-000149H	AMADOR							05,06,11
AMA-000150H	AMADOR							02,06,09,16
AMA-000163H	AMADOR	FS# 05-03-51-0067, MRCAD		USFS920317N	7J		4/23/92	6
AMA-000208H	AMADOR	ARGONAUT MINE						02,03,06,09,10,15,16
AMA-000227H	AMADOR	MK-36	1926					02,04,06,08,09,11
AMA-000323H	AMADOR	DNAS 34H						02,06,08
67872	BUTTE	HENDRICKS HEAD DAM		FERC900502A	6Y		5/29/90	
74226	BUTTE	MUD CREEK CANYON / RICHARDSON SPRINGS		NPS-73000396-0000	1S		8/14/73	22, 36
BUT-000340/H	BUTTE	S340						6
BUT-000573/H	BUTTE	SHUTE MT. 1, FS-05-11-54-14						04,06,10,16
BUT-000612/H	BUTTE	FS# 05-06-51-0333, KIM 2		USFS860319A	2S1	D	3/25/86	06,09,16
BUT-000614/H	BUTTE	KIM 4, FS-05-06-51-335						06,12,16
BUT-000649/H	BUTTE	R-1						6
BUT-000650/H	BUTTE	R-31						04,06,09,16
BUT-000667/H	BUTTE							6
BUT-000683/H	BUTTE							6
BUT-000715/H	BUTTE							6
BUT-000722/H	BUTTE	INCREDIBLE HULK SITE, FS 05-06-51-496						02,04,05,08,10
BUT-000810H	BUTTE	FS# 05-11-54-0147						04,06,08,09,10,15
BUT-000840H	BUTTE	MIOCENE CANAL		BLM821230A	6Y2		3/2/83	
BUT-000861H	BUTTE							04,06,07,09
BUT-000863H	BUTTE							02,04,06,10
BUT-000868H	BUTTE		1903					02,03,04,05,06,07,11
BUT-000869H	BUTTE		1870					02,04,05,06,07,08,15
BUT-000870H	BUTTE		1899					02,03,06,07,08,09,10
BUT-000872H	BUTTE							02,06,09,15

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
BUT-000873H	BUTTE							02,03,04,06
BUT-000874H	BUTTE		1850					02,06,07,08,10,15,16
BUT-000875	BUTTE		1873					04,06,07
BUT-000876H	BUTTE		1850					02,06,08,10,15,16
BUT-000877	BUTTE		1910					6
BUT-000881H	BUTTE							02,03,04,07,08,10
BUT-000882H	BUTTE			USFS860319A	2S2	D	3/25/86	06,16
BUT-000888H	BUTTE							02,04,07,08,11
BUT-000891H	BUTTE							6
BUT-000900H	BUTTE							06,09
BUT-000902H	BUTTE							6
BUT-000904H	BUTTE							6
BUT-000914H	BUTTE							06,09
BUT-000915H	BUTTE							6
BUT-000918H	BUTTE							6
BUT-000919H	BUTTE							6
BUT-000921	BUTTE							6
BUT-000924H	BUTTE	3	1930					02,04,06,11,15
BUT-000933H	BUTTE							6
CAL-000198	CALAVERAS	CANAL CAVE, SSC-CAL 14						
CAL-000201	CALAVERAS	SID TRICE CAMP, 4-CAL-36-B						4,6,16
CAL-000367H	CALAVERAS	MELONES ROARING CAMP / SLUMGLLION, 4-CAL-S-315 ' NMP-394		078 0050075	2D1	ACD	11/28/78	02,06,07,09,11,15,16
CAL-000371H	CALAVERAS	4-CAL-S-353 / NMP-704		078 0050075	2D1	ACD	11/28/78	06,15,16
CAL-000375H	CALAVERAS	4-CAL-S-357 / NMP-700		078 0050075	2D1	ACD	11/28/78	06,08,11,16
CAL-000409H	CALAVERAS	NMP-5, 4-CAL-S-409		078 0050075	2D1	ACD	11/28/78	06,07,11
CAL-000419H	CALAVERAS	4-CAL-S-419 / NMP-20		078 0050075	2D1	ACD	11/28/78	8
CAL-000436H	CALAVERAS	4-CAL-S-436 / NMP-713		078 0050075	2D1	ACD	11/28/78	6
CAL-000439H	CALAVERAS	4-CAL-S-439 / NMP-717		078 0050075	2D1	ACD	11/28/78	06,11
CAL-000441H	CALAVERAS	CARPENTER & STRATTEN DITCH, 4-CAL-S-441 / NMP-719		078 0050075	2D1	ACD	11/28/78	06,11
CAL-000449H	CALAVERAS	4-CAL-S-449 / NMP-721		078 0050075	2D1	ACD	11/28/78	06,11
CAL-000452H	CALAVERAS	4-CAL-S-452 / NMP-433		078 0050075	2D1	ACD	11/28/78	6
CAL-000457H	CALAVERAS	4-CAL-S-457 / NMP-126		078 0050075	2D1	ACD	11/28/78	06,11,16
CAL-000460H	CALAVERAS	4-CAL-S-460 / NMP-85		078 0050075	2D1	ACD	11/28/78	08,11,16
CAL-000468/H	CALAVERAS	4-CAL-S-468 / NMP-727		078 0050075	2D1	ACD	11/28/78	06,15
CAL-000469H	CALAVERAS	NMP-804 / 4-CAL-S-469		078 0050075	2D1	ACD	11/28/78	06,11
CAL-000471H	CALAVERAS	4-CAL-S-471 / NMP-434		078 0050075	2D1	ACD	11/28/78	08,11,16
CAL-000474H	CALAVERAS	4-CAL-S-474 / NMP-729		078 0050075	2D1	ACD	11/28/78	6
CAL-000491H	CALAVERAS	4-CAL-S-491 / NMP-825		078 0050075	2D1	ACD	11/28/78	06,11
CAL-000492H	CALAVERAS	4-CAL-S-492 / NMP-436		078 0050075	2D1	ACD	11/28/78	06,09,11,16
CAL-000495H	CALAVERAS	4-CAL-S-495 / NMP-824		078 0050075	2D1	ACD	11/28/78	06,11
CAL-000504H	CALAVERAS	4-CAL-S-504 / NMP-147		078 0050075	2D1	ACD	11/28/78	02,06,15,16
CAL-000512H	CALAVERAS	4-CAL-S-512 / NMP-254		078 0050075	2D1	ACD	11/28/78	6
CAL-000516H	CALAVERAS	4-CAL-S-516 / NMP-733		078 0050075	2D1	ACD	11/28/78	8
CAL-000518H	CALAVERAS	NMP-358 / 4-CAL-S-518		078 0050075	2D1	ACD	11/28/78	6
CAL-000522H	CALAVERAS	4-CAL-S-522 / NMP-344		078 0050075	2D1	ACD	11/28/78	02,06,07,09,11,16
CAL-000523H	CALAVERAS	4-CAL-S-523 / NMP-1105		078 0050075	2D1	ACD	11/28/78	6
CAL-000525H	CALAVERAS	NMP-354 / 4-CAL-S-525		078 0050075	2D1	ACD	11/28/78	08,11,16
CAL-000534H	CALAVERAS	4-CAL-S-534 / NMP-351		078 0050075	2D1	ACD	11/28/78	06,09,11,16
CAL-000543H	CALAVERAS	4-CAL-S-543 / NMP-470		078 0050075	2D1	ACD	11/28/78	08,09,16

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CAL-000552H	CALAVERAS	4-CAL-S-552 / NMP-164		078 0050075	2D1	ACD	11/28/78	02,06,11,16
CAL-000556H	CALAVERAS	4-CAL-S-556 / NMP-468		078 0050075	2D1	ACD	11/28/78	6
CAL-000557H	CALAVERAS	4-CAL-S-557 / NMP-473		078 0050075	2D1	ACD	11/28/78	02,08,15
CAL-000559H	CALAVERAS	4-CAL-S-559 / NMP-273		078 0050075	2D1	ACD	11/28/78	06,16
CAL-000561H	CALAVERAS	4-CAL-S-561 / NMP-268		078 0050075	2D1	ACD	11/28/78	02,08,09,11,16
CAL-000564H	CALAVERAS	4-CAL-S-564 / NMP-853		078 0050075	2D1	ACD	11/28/78	6
CAL-000568H	CALAVERAS	4-CAL-S-568 / NMP-284		078 0050075	2D1	ACD	11/28/78	02,06,16
CAL-000569H	CALAVERAS	4-CAL-S-569 / NMP-279		078 0050075	2D1	ACD	11/28/78	06,11
CAL-000570H	CALAVERAS	4-CAL-S-570 / NMP-278		078 0050075	2D1	ACD	11/28/78	06,11
CAL-000571H	CALAVERAS	4-CAL-S-571 / NMP-851		078 0050075	2D1	ACD	11/28/78	6
CAL-000574H	CALAVERAS	4-CAL-S-574 / NMP-283		078 0050075	2D1	ACD	11/28/78	8
CAL-000575H	CALAVERAS	4-CAL-S-575 / NMP-903		078 0050075	2D1	ACD	11/28/78	06,11
CAL-000576H	CALAVERAS	4-CAL-S-576 / NMP-905		078 0050075	2D1	ACD	11/28/78	06,11
CAL-000580H	CALAVERAS	4-CAL-S-580 / NMP-513		078 0050075	2D1	ACD	11/28/78	06,08,11
CAL-000581H	CALAVERAS	4-CAL-S-581 / NMP-131		078 0050075	2D1	ACD	11/28/78	6
CAL-000632H	CALAVERAS	WILSEYVILLE TIMBER SALE						06,09,10,11,16
CAL-000634/H	CALAVERAS							6
CAL-000682H	CALAVERAS	MR-BA-80-6						8
CAL-000683H	CALAVERAS	MR-BA-80-7						8
CAL-000686H	CALAVERAS	MR-BA-80-10						06,11
CAL-000688H	CALAVERAS	CAL-STI-2						6
CAL-000689H	CALAVERAS	CAL-SAI-4 / CAL-G-10						02,05,06,07,08,09,11
CAL-000749H	CALAVERAS							8
CAL-000752H	CALAVERAS							6
CAL-000774H	CALAVERAS							6
CAL-000794/H	CALAVERAS	ASC-T-68-CAL	1850					02,06,11
CAL-000803H	CALAVERAS							06,09
CAL-000817H	CALAVERAS							08,11
CAL-000818H	CALAVERAS							06,09,16
CAL-000834H	CALAVERAS							8
CAL-000853H	CALAVERAS							06,09,11
CAL-000919H	CALAVERAS		1849					06,09,10
CAL-000921H	CALAVERAS							06,09,10
CAL-000925H	CALAVERAS							06,09
CAL-000931H	CALAVERAS	4923						06,09
CAL-000933H	CALAVERAS		1930					06,16
CAL-000934H	CALAVERAS		1930					06,09
CAL-000935H	CALAVERAS							06,09
CAL-000948H	CALAVERAS							02,06,09,16
CAL-000953H	CALAVERAS							02,06,07,09,11,16
CAL-000957H	CALAVERAS							02,06,07,09,11,15,16
CAL-000958H	CALAVERAS							02,06,07,09,10,16
CAL-000965H	CALAVERAS							02,06,09,10,16
CAL-000968H	CALAVERAS							02,06,07,09,10,11
CAL-000986H	CALAVERAS	FS# 05-16-52-0349						6
CAL-000988H	CALAVERAS	FMR 1						6
CAL-001009H	CALAVERAS							6
CAL-001012/H	CALAVERAS							6
CAL-001013H	CALAVERAS							6
CAL-001015H	CALAVERAS							03,06,09,10,15,16
CAL-001047H	CALAVERAS							6

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
CAL-001064H	CALAVERAS							05,06
CAL-001111H	CALAVERAS	FS# 05-16-52-0335						6
CAL-001113H	CALAVERAS	FS# 05-16-52-0338						4,6,11
CAL-001116H	CALAVERAS	FS# 05-16-52-0341						6
CAL-001120H	CALAVERAS	FS# 05-16-52-0346						6
CAL-001129/H	CALAVERAS	RMK 9						04,08,09,15,16
CAL-001133H	CALAVERAS	RMK 15						6
CAL-001150H	CALAVERAS	FS# 05-16-52-0511						15,6
CAL-001189H	CALAVERAS	FS# 05-16-52-0541						6
CAL-001213H	CALAVERAS	SCIARONI 2						6
CAL-001244H	CALAVERAS	CC-S-1						9,6
CAL-001265H	CALAVERAS	FS# 05-16-52-0519, "A", "B", & "C"						6,11,16
CAL-001266H	CALAVERAS	FS# 05-16-52-0520, SEGMENTS "A" & "B"						6
CAL-001267H	CALAVERAS	FS# 05-16-52-0547						6
CAL-001277H	CALAVERAS	L-1	1890					6
CAL-001281H	CALAVERAS	ASMRK-7	1870					2,3,4,5,7,8,16
CAL-001285H	CALAVERAS	K-1	1869					2,3,4,5,6,8,9,15,16
CAL-001293H	CALAVERAS	COUNTY CENTER DITCH						6
CAL-001318/H	CALAVERAS	BUCK RANCH SITE, BR-TS1						2,4,11,6
CAL-001328H	CALAVERAS	MC-S-1						2,6,7,9,16
CAL-001331H	CALAVERAS	MC-S-4						6,16
CAL-001332H	CALAVERAS	MC-S-5						6
CAL-001336H	CALAVERAS	HOLMES MINING COMPLEX						2,8,9,16
CAL-001352/H	CALAVERAS	DAVIES CFIP #2						8,16
CAL-001359H	CALAVERAS	FIELD SITE 5 PIPELINE & TRUETT'S DITCH						6,16
CAL-001366H	CALAVERAS	JENSEN #2						8416
CAL-001367H	CALAVERAS	ANGELS 2, POWERHOUSE & PENSTOCK	1895					2,15,9,6,16
CAL-001368H	CALAVERAS	FS# 05-16-52-0719, UTICA 9		USFS950721B	2S2	AC	8/21/95	6
CAL-001369H	CALAVERAS	ANGELS 4 UNION DITCH, McCLROY/UNION DITCH	1875					6,16
CAL-001370H	CALAVERAS	UTICA 17						6
CAL-001372H	CALAVERAS	ANGELS 7-JUPITER DITCH, JUPITER DITCH	1884					6
CAL-001374H	CALAVERAS	ANGELS 9-UNION/TORREY/MONTEZUMA DITCH						6,16
CAL-001375H	CALAVERAS	TORREY DITCH						6
CAL-001376H	CALAVERAS	CRYSTAL MINE						4,6,9,16
CAL-001377H	CALAVERAS							6,16
CAL-001378H	CALAVERAS	ANGELS 13-TORREY/UNION DITCH						6
CAL-001379H	CALAVERAS							6
CAL-001381H	CALAVERAS	ROSS RESERVOIR COMPLEX						8,6,15,16
CAL-001383H	CALAVERAS	ANGELS BRANCH DITCH						6,16
CAL-001385H	CALAVERAS	RICHARDS RANCH DITCH						6,11,16
CAL-001389/H	CALAVERAS							8,9,16
CAL-001400H	CALAVERAS	UTICA 12-MURPHYS FOREBAY, AFTERBAY,, PENSTOCK, & POWERHOUSE						15,8,16
CAL-001401H	CALAVERAS	UTICA 13						6,16
CAL-001403H	CALAVERAS	UTICA 18						6
CAL-001404H	CALAVERAS	UTICA 19						6
CAL-001406/H	CALAVERAS	(COMBINED 1408 & 1406H)						8,9,11,16
CAL-001407H	CALAVERAS	UTICA 23						6,16
CAL-001423H	CALAVERAS							8
CAL-001430H	CALAVERAS							6
CAL-001440H	CALAVERAS	FS# 05-16-52-0727, REPORT #05-16-505						7,4,6

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
CAL-001442H	CALAVERAS	FS# 05-16-52-0725, REPORT #05-16-505						15,6,4
CAL-001453/H	CALAVERAS							6,9
CAL-001455H	CALAVERAS							6,8,16
CAL-001467H	CALAVERAS		1850					6
CAL-001468H	CALAVERAS		1848					6,16
CAL-001474H	CALAVERAS							2,4,8,9,11,16
CAL-001492H	CALAVERAS		1880					4,6
CAL-001498H	CALAVERAS							6
CAL-001502H	CALAVERAS							6
CAL-001503H	CALAVERAS							8,16
CAL-001506H	CALAVERAS							6
CAL-001520H	CALAVERAS		1936					2,4,6,16
CAL-Z00014H	CALAVERAS	LOPEZ-CAL-5-LOCALIZED DITCH		BLM970306B	6Y2		4/2/97	
49765	COLUSA	SACRAMENTO RIVER, LEVEE, BRIDGE	1870	5932-0078-0000	2D1		1/1/78	11, 19, 22
COL-000070H	COLUSA	SULPHUR SPRINGS SITE						02,06,08,15,16
COL-000071H	COLUSA	WIDE AWAKE MINE						04,06,10,11,15,16
COL-000073H	COLUSA	MANZANITA MINE I and II	1860					04,05,06,07,09,10,11
COL-000111H	COLUSA	EAST PARK DAM & SPILLWAY, HISTORIC SITE NO.	1910					02,05,08,15
COL-000194H	COLUSA	FOUTS SPRINGS HOTEL & RESORT	1874					2,3,6,7,11,15,
10047	CONTRA COSTA	THE LAGUNA		4520-0012-0000	5S			22
73329	CONTRA COSTA	ALVARADO, GRAND CANYON PARK; CA-CCO-5	1934	NPS-92000313-9999	1S	AC	4/9/92	21, 25, 35
CCO-000408/H	CONTRA COSTA	LOCUS 006 NE SCHOOLHOUSE						03,04,06,07
CCO-000449/H	CONTRA COSTA	T.F. #2, LOWER ARROYO PICNIC AREA		BUR910227A	6Y1		7/22/92	8
CCO-000479H	CONTRA COSTA	CL-3						02,06,10,11,15,16
CCO-000496H	CONTRA COSTA	AC-72						02,03,05,06,16
CCO-000504H	CONTRA COSTA	ANDERSON RANCH						03,06,15,16
CCO-000534H	CONTRA COSTA	KR-2/H		BUR910227A	2D1	D	7/22/92	02,04,05,08,16
CCO-000545H	CONTRA COSTA	HISTORIC HOMESTEAD SITE						02,04,05,06,16
CCO-000596H	CONTRA COSTA	KELLOGG UNIT #3 (K-3)						04,06,07,11,15,16
CCO-000597	CONTRA COSTA	KELLOGG UNIT #4 (K-4), HIGHLINE CANAL						
CCO-000606	CONTRA COSTA	AC-96						02,03,06,07
CCO-000638H	CONTRA COSTA	NICHOLS SCHOOL						6
CCO-000667H	CONTRA COSTA							2,5,6,10,15
CCO-000672H	CONTRA COSTA	AK						5,6
CCO-000674H	CONTRA COSTA	BJ						8
CCO-000675H	CONTRA COSTA	CC						6
CCO-Z00004	CONTRA COSTA	CONTRA COSTA CANAL		BUR910227A	6Y1		6/25/92	
69314	DEL NORTE	MYRTLE CREEK DITCH/HIOUCHI			2S1		10/28/77	
DNO-000068/H	DEL NORTE	FS# 05-10-51-0052, GO-92						04,06,09,15,16
DNO-000072/H	DEL NORTE	LOWER SITE #1						04,06
DNO-000073/H	DEL NORTE	LOWER SITE #2						6
DNO-000075H	DEL NORTE	MYRTLE CREEK TRAIL:SAVOY SITE #2	1880					6
DNO-000079/H	DEL NORTE	FS# 05-10-51-0027, BAKER FLAT SITE #3						02,04,07,08,10,15,16
DNO-000080/H	DEL NORTE	FS# 05-10-51-0011, BAKER FLAT / MONUMENTAL CAMP	1900					02,03,04,06,07,11,15
DNO-000081/H	DEL NORTE	FS# 05-10-51-0017, CAMP 7 / SITE 2	1880					02,03,04,06,08
DNO-000094/H	DEL NORTE	FS# 05-10-51-0030, PANTHER FLAT CAMPGROUND		USFS921005N	6Y1		11/5/92	02,03,04,06
DNO-000095/H	DEL NORTE	FS# 05-10-51-0031	1860					02,06,10,11
DNO-000133H	DEL NORTE	FS# 05-10-51-0113, SPLIT ROCK SPRING SITE, GO-						06,10
DNO-000167H	DEL NORTE	FS# 05-10-51-0092, CEDAR CAMP / SPRING SITE						6
DNO-000220H	DEL NORTE	FS# 05-10-51-0041, JONES CREEK FLUME						6

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
DNO-000222H	DEL NORTE	FS# 05-10-51-0016, ORA GRANDE FLUME						6
DNO-000261H	DEL NORTE	FS# 05-10-51-0179, MYRTLE CREEK						6
DNO-000271H	DEL NORTE	FS# 05-10-51-0174, MONKEY CREEK DITCH AND TRAIL						06,09,16
DNO-000273H	DEL NORTE	FS# 05-10-51-0172, RAINBOW MINE						06,11,16
DNO-000274H	DEL NORTE	FS# 05-10-51-0173, UPPER RAINBOW MINE						06,16
DNO-000279H	DEL NORTE	FS# 05-10-51-0182, FRENCH PLACER CANAL						6
DNO-000280H	DEL NORTE	FS# 05-10-51-0183, FAWCETT CABIN						02,05,06,11,16
68066	EL DORADO	DOGTIE DITCHES 05-03-56-115		USFS890112C	6Y		4/18/89	
68078	EL DORADO	EAGLE DITCH FS 05-30-56-397		USFS890310A	2	AC	7/13/89	
68285	EL DORADO	DOGTIE DITCH FS 05-03-56-372		USFS890112C	6Y		4/18/89	
69923	EL DORADO	EL DORADO CANAL	1874	USFS910125Z	7J		1/25/91	
72761	EL DORADO	ECHO LAKE DAM	1876	USFS910708A	6Y2		7/30/91	
73450	EL DORADO	CRAWFORD DITCH (CLEAR CREEK SEGMENT)	1852	NPS-91001522	1S	AC	10/21/91	20
73450	EL DORADO	CRAWFORD DITCH (CLEAR CREEK SEGMENT)	1852	09-0004	3S	AC	9/4/91	
73450	EL DORADO	CRAWFORD DITCH (CLEAR CREEK SEGMENT)	1852	USFS891006C	2S2	ABC	2/14/90	
77020	EL DORADO	HARRICKS RAVINE DITCH #05-03-53-244	1852	USFS920406A	6Y2		5/29/92	
77022	EL DORADO	HARRICKS RAVINE DITCH #05-03-53-256	1852	USFS920406B	6Y2		5/29/92	
77025	EL DORADO	HARRICKS RAVINE DITCH #05-03-53-258	1852	USFS920406C	6Y2		5/27/92	
77028	EL DORADO	HARRICKS RAVINE DITCH #05-03-53-259	1852	USFS920406D	6Y2		5/27/92	
77624	EL DORADO	CRAWFORD DITCH, CAMP CREEK SEGMENT		USFS891006C	6Y2		2/14/90	
77627	EL DORADO	CRAWFORD DITCH, NORTH FORK EXTENSION		USFS891006C	6Y2		2/14/90	
83147	EL DORADO	PRAY DITCH (F 5-05-03-56-188)	1886	USFS930416A	6Y1		7/23/93	
89296	EL DORADO	FSS #05-03-56-417,BARTLETT DITCH		USFS940318A	6Y1		4/10/94	
90427	EL DORADO	MORMON ISLAND		SHL-0569	7L		4/1/57	22
ELD-000224H	EL DORADO	F-30-H						06,09,16
ELD-000237H	EL DORADO							02,04,08,11
ELD-000238H	EL DORADO							06,09
ELD-000241H	EL DORADO							04,06,09
ELD-000259H	EL DORADO	SAC-364, F-8-H (SF)						6
ELD-000325/H	EL DORADO	FS# 05-03-56-0074, E.I.D. PLUM #4,#9,#5,#6, PLUM CREEK MILL SITE						02,04,05,06,15,16
ELD-000341H	EL DORADO	FS# 05-03-56-0099, MCKINNEY T.S. #2						02,04,05,06,15
ELD-000350H	EL DORADO	FS# 05-03-53-0014, GREY EAGLE CABIN 1-4, GROVE AND THIEL CABINS	1920					02,04,05,06,07,09
ELD-000351H	EL DORADO	FS# 05-03-53-0015, COVE HILL MINE, DIGIORGIO LAND EXCHANGE						02,04,06,07,09,10
ELD-000431H	EL DORADO	FS# 05-03-56-0078, PLUM CREEK TEMP. #8						06,11
ELD-000474H	EL DORADO	SO-7,						6
ELD-000477H	EL DORADO	SO-11						6
ELD-000483H	EL DORADO	SO-17						06,09
ELD-000492H	EL DORADO	SO-26						02,05,06,08,09,11
ELD-000493H	EL DORADO	SO-27						02,04,06,09
ELD-000494H	EL DORADO	SO-28						06,09
ELD-000501H	EL DORADO	SO-41						6
ELD-000502H	EL DORADO	S0-42, THE EPLEY MINE						09,06
ELD-000504H	EL DORADO	SO-50						6
ELD-000508H	EL DORADO	TH-02						02,04,06,09
ELD-000556H	EL DORADO	LCE 22						06,07
ELD-000603/H	EL DORADO							8
ELD-000639H	EL DORADO	CRAWFORD DITCH, CLEAR CREEK SEGMENT		91001522	1S	AC	10/21/91	

APPENDIX A: WCS Features Listed in OHP Databases*

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
ELD-Z00043	EL DORADO	FS# 05-03-56-0406, PORTION OF MINING DITCH		USFS970423A	6Y2		6/18/97	
ELD-Z00049	EL DORADO	FS# 05-03-56-0647, WATER CONVEYANCE DITCH		USFS970423A	6Y2		6/18/97	
68506	FRESNO	PERRIN CANAL		FHWA871218A	6Y		1/7/88	
81274	FRESNO	WEST BRANCH OF THE EAST BRANCH CANAL	1890	FHWA910729A	6Y1		8/1/91	
81275	FRESNO	EISEN DITCH	1870	FHWA910729A	6Y1		8/1/91	
81277	FRESNO	BRIGGS DITCH	1880	FHWA910729A	6Y1		8/1/91	
81278	FRESNO	HANSEN CANAL	1890	FHWA910729A	6Y1		8/1/91	
85125	FRESNO	HUNTINGTON LAKE DAMS #1,2,&3-BIG CREEK	1912	USFS931105A	2S2	ABC	12/24/93	
85127	FRESNO	HUNTINGTON LAKE DAMS #4,5 & 6-BIG CREEK	1926	USFS931105A	2S2	ABC	12/24/93	
85129	FRESNO	SHAVER LAKE DAM, BIG CREEK HYDROELECTIC	1927	USFS931105A	2S2	ABC	12/24/93	
89884	FRESNO	FRIANT-MADEN CANAL	1947	DOE-10-94-0001-	6Y1		7/1/94	
89884	FRESNO	FRIANT-MADEN CANAL	1947	FHWA940509A	6Y1		7/1/94	
90711	FRESNO	SYCAMORE POINT		SPHI-FRE-006	7L		10/5/71	22
101368	FRESNO	CAMP 62 CREEK DOMESTIC WATER SUPPLY		USFS960222A	6Y2		3/18/96	
FRE-000207/H	FRESNO	FS# 05-15-53-0009, EMMA MAJORS SITE,PRESCOTTS MILL, MATHEWS MILL						02,04,05,07,08,11,15
FRE-000210	FRESNO	SHAVER DAM SITE						
FRE-000619H	FRESNO	7-14-75-3						06,11,15
FRE-000825H	FRESNO	A-61-H						02,07,08,16
FRE-000831H	FRESNO	B-27-H						6
FRE-000847H	FRESNO	C-66-H						04,08,16
FRE-000853H	FRESNO	D-140-H						02,06,10,16
FRE-000881H	FRESNO	EA-1592-1						6
FRE-001089H	FRESNO	FS# 05-15-54-0319						06,08
FRE-001175H	FRESNO							6
FRE-001176H	FRESNO	FS# 05-15-53-0447						03,06,07,11,15,16
FRE-001316H	FRESNO							02,04,08
FRE-001506H	FRESNO	FS# 05-13-51-0144						02,04,06,07,10,11
FRE-001578H	FRESNO	FS# 05-15-54-0569						02,06,09,11,16
FRE-001607H	FRESNO	FS# 05-15-53-0766						04,06,07,16
FRE-001687H	FRESNO	PINE LOGGING CO./CAMP, LOCUS B						02,03,04,05,06,07,10
FRE-001805/H	FRESNO	FS# 05-13-51-0008, CONVERSE SAWMILL						02,03,04,06,07,10
FRE-001806H	FRESNO	FS# 05-13-51-0009, ROB ROY HOIST						02,04,06,16
FRE-001811H	FRESNO	FS# 05-13-51-0127, STUMP MEADOW LOGGING		USFS870408A	6Y		6/9/87	06,16
FRE-001854H	FRESNO	FS# 05-15-53-0911						02,06,15,16
FRE-001938H	FRESNO	FS# 05-15-53-0849, FLUME TENDER SITE						4,6,11,15,16
FRE-001954H	FRESNO	FS# 05-15-54-0674, BLACK ROCK DAM	1923					06,08
FRE-001957H	FRESNO	FS# 05-15-54-0675, BALCH POWERHOUSE #1	1926					06,15
FRE-002015H	FRESNO	FS# 05-15-53-0422	1917					02,06,07,10,15,16
FRE-002077H	FRESNO	FS# 05-13-51-0184, BARTON #4	1909					6
FRE-002503H	FRESNO	514-3-3						2,4,6,8,15
61925	GLENN	ORLAND PROJECT CANALS 43-45,60/70,71	1940	FHWA910411A	6Y1		6/14/91	
HUM-000362/H	HUMBOLDT		1875					6
HUM-000377/H	HUMBOLDT	FS# 05-10-53-0077, AMMON HOMESTEAD	1896					02,03,04,06,10,11,15
HUM-000395/H	HUMBOLDT	FS# 05-10-53-0091, WATER DITCH	1880					6
HUM-000424/H	HUMBOLDT	FS# 05-10-52-0025, NELSON MINE/CABIN						04,06,15,16
HUM-000428/H	HUMBOLDT	FS# 05-10-52-0092, CREEK T.S. SITE 3 / GARNIT RANCH/PLACE						02,03,04,06,07,09,11
HUM-000491/H	HUMBOLDT	FS# 05-10-53-0069						02,04,06,07,10
HUM-000492/H	HUMBOLDT	FS# 05-10-53-0124, DAM/DITCH/FLUME						06,07

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HUM-000513/H	HUMBOLDT	05-10-M-1; STRAWBERRY PRAIRIE; GAMBLE, PRAIRIE						03,04,06,07,10,11,15
HUM-000602H	HUMBOLDT		1883					6
HUM-000603H	HUMBOLDT	WILDER DITCH / BONDO DITCH	1860					06,11
HUM-000636H	HUMBOLDT	BUSSELL HOMESTEAD						02,06,16
HUM-000654H	HUMBOLDT	MILL CREEK MINE						03,04,06,07,15
HUM-000692H	HUMBOLDT	FS# 05-10-53-0231, BOARD CAMP MTN. LOOKOUT / B-1	1930					02,06,15
HUM-000775/H	HUMBOLDT	FS# 05-10-53-0262, PETE HOMESTEAD						03,06,11,16
HUM-000777H	HUMBOLDT	FS# 05-10-53-0264, KIMSEY MINE						06,09
HUM-000801H	HUMBOLDT	FS# 05-10-53-0249						06,16
HUM-000805H	HUMBOLDT	FS# 05-10-53-0272, FOUR MILE FLUME AND PASTURE						02,06,16
HUM-000814H	HUMBOLDT	FS# 05-10-52-0129, S.M. & D.S. FLUME						06,07
HUM-000862H	HUMBOLDT	MINING DITCH						6
HUM-000875H	HUMBOLDT	WATERWHEEL SITE						06,15
HUM-000900H	HUMBOLDT							4,6
HUM-000958H	HUMBOLDT							6,16
IMP-002551/H	IMPERIAL	4-IMP-3213						8
IMP-003307H	IMPERIAL	IMP-1763 / IMP-129-H / NSSG-15						05,06
IMP-003343H	IMPERIAL	42-IMP-(1865)-189, IMP-2074 / IMP-165-H						6
IMP-003344H	IMPERIAL	42-IMP-(1856)-190, IMP-2075 / IMP-166-H						6
IMP-003382H	IMPERIAL	45-IMP-(1856)-248, IMP-2132 / IMP-204-H						6
IMP-003384H	IMPERIAL	45-IMP-(1856)-251, IMP-2135 / IMP-206-H						6
IMP-003386H	IMPERIAL	45-IMP-(1856)-257, IMP-2141 / IMP-208-H						6
IMP-003419H	IMPERIAL	GOLD CROSS MINING CO PIPELINE, 47-IMP-(1856)-312 / IMP-2191						6
IMP-003420H	IMPERIAL	GOLD CROSS MINING CO PIPELINE, 47-IMP-(1856)-313 / IMP-2192						6
IMP-003421H	IMPERIAL	PAYMASTER MINING CO PIPELINE, 47-IMP-(1856)-314 / IMP-2193						6
IMP-003427H	IMPERIAL	GOLD CROSS MINING CO PIPELINE, 47-IMP-(1856)-320 / IMP-2199						6
IMP-003428H	IMPERIAL	PAYMASTER MINING CO PIPELINE, 47-IMP-(1856)-321 / IMP-2200						6
IMP-003429H	IMPERIAL	GOLD CROSS AND PAYMASTER PIPELINE, 47-IMP-(1856)-322 / IMP-2, 201						6
IMP-003434H	IMPERIAL	PAYMASTER MINING CO PIPELINE, 47-IMP-(1856)-328 / IMP-2207						6
IMP-003436H	IMPERIAL	GOLD CROSS MINING CO PIPELINE, 47-IMP-(1856)-330 / IMP-2209						6
IMP-003439H	IMPERIAL	GOLD CROSS MINING CO PIPELINE, 47-IMP-(1856)-333 / IMP-2712						6
IMP-004182H	IMPERIAL	HALON HEADING, 124A-2	1900					06,10,15
IMP-004420H	IMPERIAL	F E NICHOLS I						02,04,05,06,10
IMP-005102H	IMPERIAL			FHWA860228A	6Y		3/24/86	02,04,06,07
64280	INYO	INTAKE NO. 6	1913	3514-0016-0007	2B2		1/1/88	11, 21
64290	INYO	INTAKE NO. 5	1907	3514-0016-0017	2B2		1/1/88	11, 21
64314	INYO	INTAKE NO. 4	1912	3514-0016-0041	2B2		1/1/88	11, 21
64315	INYO	OLD DAM NO. 4, STEAM GAUGING STATION	1905	3514-0016-0042	2B2		1/1/88	11, 21
64320	INYO	INTAKE NO. 3	1913	3514-0016-0047	2B2		1/1/88	11, 21

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SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
64326	INYO	INTAKE NO. 2	1908	3514-0016-0053	2B2		1/1/88	11, 21
64327	INYO	SAME, ALSO INTAKE & FLOWLINE	1908	3514-0016-0054	2B2		1/1/88	11, 21
64328	INYO	WEIR LAKE FLOW MONITORING DAM	1911	3514-0016-0055	2B2		1/1/88	11, 21, 22
64329	INYO	HILLSIDE DAM, SOUTH LAKE DAM	1890	3514-0016-0056	2B2		1/1/88	11, 21, 22
64331	INYO	GREEN CREEK INTAKE, DIVERSION	1925	3514-0016-0058	2B2		1/1/88	11, 21
64332	INYO	RESERVOIR NO. 1/MIDDLE FORK DAM, LAKE	1910	3514-0016-0059	2B2		1/1/88	11, 21, 22
64340	INYO	MCGEE CREEK INTAKE, DIVERSION	1919	3514-0016-0067	2B2		1/1/88	11, 21
64341	INYO	LONGLEY LAKE DAM	1909	3514-0016-0068	2B2		1/1/88	11, 21
64342	INYO	BISHOP CREEK HYDROELECTRIC SYSTEM	1905	3514-0016-9999	2D2		1/1/88	8, 9, 11, 21
64377	INYO	BR 48 0010	1928	3545-0001-0000	6			19, 20, 77, 95
75674	INYO	WATERCOURSE		3549-0001-0020	1D	AB	7/20/78	20
75688	INYO	RESERVOIR		3549-0001-0027	1D	AB	7/20/78	21
103251	INYO	WALKER DITCH	1886	USFS960719A	6Y2		8/23/96	
INY-001330H	INYO	OV-19						6
INY-001517H	INYO	05-04-54 / STEVENS SAWMILL / COTTONWOOD, SAWMILL						06,07,11,15
INY-001833H	INYO	SV-31, MINERS SHACK						04,06,10,15
INY-002085H	INYO	PV-19,	1940					02,06,07,09,10,15
INY-002089H	INYO	WORLD BEATER MINE, PV-23	1890					04,06,07,09,10,15,16
INY-002193H	INYO	DA-82 / M27-3	1900					07,08,09,15
INY-002529H	INYO	FS# 05-04-53-0010, WILSHIRE-BISHOP CREEK-CARDINAL MINE	1900					02,04,06,09,10,15
INY-002662H	INYO	WR-2, DV-125 INY-24						6
INY-002768/H	INYO	FS# 05-04-53-0128, SALQUE MEADOW						06,08,11,16
INY-002770/H	INYO							04,08,15,16
73343	KERN	KERN RIVER NO.3 SYSTEM, KR3	1919	15-0005	7J		2/4/91	8, 11, 21
102400	KERN	STINE CANAL	1873	FHWA960509A	6Y2		5/24/96	
102401	KERN	CALLOWAY CANAL	1875	FHWA960509A	6Y2		5/24/96	
KER-000001	KERN	ISABELLA RESERVOIR #1, UCAS #8						
KER-000695H	KERN	EAFB-2	1910					02,04,05,06,07,16
KER-000707	KERN	EFB-86						05,06,16
KER-001351H	KERN		1870					02,03,04,06,11,15
KER-001519H	KERN	HF-4						02,05,08,16
KER-001700H	KERN	FS# 05-13-54-0080						05,06,09,10,11
KER-001709H	KERN	HR-23	1850					02,04,05,06,11,15,16
KER-001807/H	KERN	FS# 05-13-54-3738, 77, 78						02,06,09
KER-001809H	KERN	EAFB-98H	1930					8,16
KER-001823H	KERN	EAFB-265H	1930					04,06
KER-001845H	KERN	HR-47	1925					02,04,06,15
KER-001877H	KERN	EAFB-379H						04,06
KER-001925H	KERN	EAFB-HR-91	1935					02,04,05,06
KER-002031H	KERN	EAFB-HR-167 LOCUS B	1933					06,07,15,16
KER-002125/H	KERN	EAFB-632						02,04,05,06,11
KER-002304H	KERN	EAFB-980	1925					04,06
KER-002308H	KERN	EAFB-147	1900					02,03,04,05,06,11
KER-002310H	KERN	EAFB-847						02,03,04,06,08,11
KER-002343H	KERN	EAFB-820						02,03,06,16
KER-002344H	KERN	EAFB-896						02,05,06,16
KER-002361H	KERN	HWS-2						02,06,16
KER-002363H	KERN	HWS-4						06,07,16
KER-002365H	KERN	HWS-6						04,06,16

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KER-002367H	KERN	HWS-10						06,16
KER-002394H	KERN	EAFB-45	1910					04,06,11,15
KER-002447H	KERN	EAFB-38						04,05,06,11,15
KER-002483H	KERN	EAFB-31	1910					02,05,06,11
KER-002494H	KERN	RSP-27H						02,04,05,06
KER-002495H	KERN	RSP-28H						02,05,06,11
KER-002499H	KERN	EAFB-270H						04,05,06,16
KER-002511H	KERN	090-A	1910					04,05,06,16
KER-002809/H	KERN	122-3H						06,08,09
KER-002812/H	KERN	122-4H						6
KER-002911H	KERN	W-16						02,06
3513	LAKE	LAKE PILLSBURY		5453-0006-0000	6			2, 6, 21, 22
LAK-000938/H	LAKE	ALLEN SPRINGS RESORT						04,06,07,11,15
LAK-000939/H	LAKE							02,04,05,06,07,15
LAK-000964/H	LAKE	BIG INJUN MINE	1873					06,09,10,15
LAK-001020/H	LAKE	ALTER BROTHERS HOMESTEAD / (TEMP. 3), ISAAC ALTER HOMESTEAD						02,03,04,05,06,07,11
LAK-001096/H	LAKE	FS# 05-08-54-0171, MASON MILL #2	1915					02,03,04,06,07,08,10
LAK-001102/H	LAKE	ARNOLD SPRING SITE	1918					04,08,10,11
LAK-001237/H	LAKE	FS# 05-08-54-0251						02,04,05,08,16
LAK-001565H	LAKE	ROCKY CREEK WALL AND PITS /CACHE CREEK ARCH.DISTRICT		17-0005	7J	D	11/19/94	06,11,15
LAS-000033/H	LASSEN	MCQUEENS RANCH SITE	1923					6
LAS-001177H	LASSEN	FS# 05-06-58-0308						04,05,06
LAS-001295/H	LASSEN							03,04,06,07,08,11
LAS-001345H	LASSEN	FS# 05-09-54-0412						06,09
LAS-001366H	LASSEN		1890					02,04,05,06,07,09,10
21180	LOS ANGELES	SAN FERNANDO MISSION DAM	1808	0053-0284-0000	4S			21
21267	LOS ANGELES	CARROLL CANAL	1905	0053-0347-0001	1D	AC	8/30/82	11
21268	LOS ANGELES	LINNIE CANAL	1905	0053-0347-0002	1D	AC	8/30/82	11
21269	LOS ANGELES	HOWLAND CANAL	1905	0053-0347-0003	1D	AC	8/30/82	11
21270	LOS ANGELES	SHERMAN CANAL	1905	0053-0347-0004	1D	AC	8/30/82	11
21271	LOS ANGELES	GRAND CANAL	1905	0053-0347-0005	1D	AC	8/30/82	11
21272	LOS ANGELES	EASTERN CANAL	1905	0053-0347-0006	1D	AC	8/30/82	11
21273	LOS ANGELES	VENICE CANAL HISTORIC DISTRICT	1905	0053-0347-9999	1S	AC	8/30/82	11
27706	LOS ANGELES	LA CIENEGA WATER TREATMENT	1927	0213-0009-0000	3S			9, 22
32925	LOS ANGELES	WILSON RESERVOIR, MCDONALD PARK	1977	1109-0774-0146	7			9, 22, 30, 31
35411	LOS ANGELES	LITTLE ROCK CREEK DAM		3543-0001-0000	6W		1/1/77	21
68384	LOS ANGELES	KEWEN RESERVOIR		HUD881223X	6Y		2/1/89	
89532	LOS ANGELES	ST. FRANCIS DAM DISASTER SITE		SHL-0919	7L		4/26/78	21
100258	LOS ANGELES	PACOIMA DAM	1929	DOE-19-95-0056-	6Y4		2/22/95	
100258	LOS ANGELES	PACOIMA DAM	1929	HRG940202Z	6Y4		2/22/95	
101673	LOS ANGELES	WATER PUMP/RESERVOIR	1928	DOE-19-94-0553-	2D2	BC	9/30/94	11
101673	LOS ANGELES	WATER PUMP/RESERVOIR	1928	HRG940202Z	2D2	BC	9/30/94	
LAN-000887H	LOS ANGELES	LAS PLACITOS						02,04,06
LAN-001016H	LOS ANGELES	PRATRICIA ONTIVEROS ADOBE OLD FORT, SES-1 (ADOBE)	1800					02,04,06
LAN-001042H	LOS ANGELES	JAYNES RANCH	1900					8
LAN-001534	LOS ANGELES	PALMDALE DITCH		USFS910627D	2D2	AC	1/28/92	
102421	MADERA	BUILDING 7A, EARTH DAM #1	1938	USFS960423A	2D2		5/20/96	
MAD-000387/H	MADERA	FS# 05-15-57-0089, CV-18						04,06,07,16

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MAD-000421H	MADERA							6
MAD-000523H	MADERA	FS# 05-15-57-0133						02,06,07,10,16,04
MAD-000595H	MADERA	FS# 05-15-57-0222, CALIFORNIA MILL #2						02,06,07,10,16
MAD-000653H	MADERA	FS# 05-15-57-0231, GOAT BAKER'S SAWMILL						02,06,07,16
MAD-000710H	MADERA	118/80-1						6
MAD-000968/H	MADERA	FS# 05-15-57-0207, LOWER CROSS MIAMI CREEK						06,07
MAD-000990H	MADERA	FS# 05-15-57-0309	1880					06,16
MAD-001218H	MADERA	CV-10						6
MAD-001219H	MADERA	CV-15						08,15
MAD-001221H	MADERA	CV-14						06,07,10,11,15
MAD-001224H	MADERA	CV-13						02,03,04,06,07,10,15
MAD-001279/H	MADERA	"R"						08,16
MAD-001292H	MADERA	355						06,11
MAD-001318H	MADERA	FS# 05-15-55-0332						04,06,16
MAD-001376H	MADERA	FS# 05-15-57-0254, MADERA SUGAR PINE FLUME	1898					6,16
MAD-001377H	MADERA	FS# 05-15-57-0269, CALIF. MILL #4						02,06,07,16
MAD-001648H	MADERA	FS# 05-15-51-0506						04,06,16
2004	MARIN	SHANGHAI TUNNER & SPRINGS	1885	4965-0014-0000	4S			20
68553	MARIN	RESERVOIR	1920	NPS890717X	2D2	AC	9/25/90	
82072	MARIN	BLDG #719 WATER STORAGE RESERVOIR	1933	4947-0029-0067	7J		8/23/93	
82072	MARIN	BLDG #719 WATER STORAGE RESERVOIR	1933	COE910919B	2D2	AC	1/21/93	
MRN-000545H	MARIN	SPTSP-87-9H						04,06,11,16
MRN-000556/H	MARIN	HAMLET TOWNSITE	1870					02,03,04,05,06,07,09
MRN-000567H	MARIN	H-77,DIAS RANCH SITE						03,04,06,11,15
MRN-000571H	MARIN	H-75, THREE SEQUOIAS SITE						02,03,04,05,06
MRN-000572/H	MARIN	H,A-88, BIG SLIDE RANCH						02,03,04,05,06,15,16
56169	MARIPOSA	BIG GAP FLUME	1859	5311-0030-0000	1S		5/12/75	20
MRP-000399H	MARIPOSA	BCR 4						02,08,11
MRP-000432/H	MARIPOSA	ROCKY GULCH						04,06,08,09,10,11
MRP-000435H	MARIPOSA	MID EXCHNGE4		BLM970115X	6Y2		2/4/97	02,06,16
MRP-000437/H	MARIPOSA							08,16
MRP-000438/H	MARIPOSA							08,16
MRP-000564H	MARIPOSA	FS# 05-16-54-0053, MINERS GULCH MINE						6
MRP-000597/H	MARIPOSA							6
MRP-000599/H	MARIPOSA							06,07,09
MRP-000615H	MARIPOSA							02,03,04,06,09
MRP-000632H	MARIPOSA	FS# 05-15-51-0066	1908					06,15,16
MRP-000633H	MARIPOSA	FS# 05-15-51-0067						02,04,05,06,07,15
MRP-000640H	MARIPOSA							08,11
MRP-000643H	MARIPOSA							06,12
MRP-000659/H	MARIPOSA							02,04,08,09,11
MRP-000660/H	MARIPOSA							02,04,08
MRP-000692H	MARIPOSA	HELL HOLLOW 1						6
MRP-000716H	MARIPOSA							06,16
MRP-000734H	MARIPOSA	BRUCE LUMBER MILL; PART OF WAWONA ARCHAEOLOGICAL DISTRICT			2D1	D	12/7/78	02,05,06
MRP-000776H	MARIPOSA	5-16-54-515						6
MRP-000780H	MARIPOSA	FS# 05-16-54-0524						6
MRP-000784/H	MARIPOSA	FS# 05-16-54-0528						06,09
MRP-000789/H	MARIPOSA	FS# 05-16-54-0533						02,06,09
MRP-000792H	MARIPOSA	FS# 05-16-54-0536						8

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MRP-000793/H	MARIPOSA	FS# 05-16-54-0537						8
MRP-000805H	MARIPOSA	FS# 05-16-54-0557						6
MRP-000807H	MARIPOSA	FS# 05-16-54-0559						6
MRP-000808H	MARIPOSA	FS# 05-16-54-0565						6
MRP-000846H	MARIPOSA	FS# 05-16-54-0803						2,9,6,4
MRP-000848H	MARIPOSA	FS# 05-16-54-0805		USFS880526A	6Y		6/7/88	6
MRP-000860/H	MARIPOSA	FS# 05-16-54-0477, CA-TUO-1995/H						2,5,6,7,8,9,4
MRP-000867H	MARIPOSA	FS# 05-16-54-0787						8
MRP-000868H	MARIPOSA	FS# 05-16-54-0789						6
MRP-000879H	MARIPOSA	FS# 05-16-54-0867						6
MRP-000893H	MARIPOSA	FS# 05-16-54-0788						2,4,7,8,9,16
MRP-000940H	MARIPOSA	FS# 05-15-57-0448, RAINIER CREEK DIVERSION						6
MRP-000943H	MARIPOSA	FS# 05-16-54-1105						6
MRP-000958H	MARIPOSA	DOGGONE A						6,9
MRP-000959H	MARIPOSA	DOGGONE B						6,9
MRP-000961H	MARIPOSA	FS# 05-16-54-0890						6
MRP-000962H	MARIPOSA	FS# 05-16-54-0892						6
MRP-000964H	MARIPOSA	FS# 05-16-54-0900						2,4,6,9,10,11
MRP-001008/H	MARIPOSA	FS# 05-16-54-0262						9,8
MRP-001098H	MARIPOSA	SAXON 15/CANYON MINE						6,9
MRP-001104H	MARIPOSA	FS# 05-15-51-0553, MECCHI'S DITCH	1878					6
MRP-001114H	MARIPOSA	FS# 05-16-54-0776						4,6,9
MRP-001122H	MARIPOSA	FS# 05-15-51-0564, APPERSON MINE	1900					8,9,16
MRP-001135H	MARIPOSA	YOSE 90J-3-11 H						6
MRP-001137H	MARIPOSA	YOSE 90J-12-13 H						6,8,16
MRP-001167H	MARIPOSA	FS# 05-16-54-0784						6
MRP-001168H	MARIPOSA	FS# 05-16-54-0785						9,6,4
MRP-001173/H	MARIPOSA	FS# 05-16-54-0461, 05-16-273/461-1						6,16
MRP-001177H	MARIPOSA	FS# 05-16-54-0942						6
MRP-001178H	MARIPOSA	FS# 05-16-54-0944						6
MRP-001179H	MARIPOSA	FS# 05-16-54-0945						6,4
MRP-001184H	MARIPOSA	FS# 05-16-54-0950						4,9,6,16
MRP-001185H	MARIPOSA	FS# 05-16-54-0951						6,
MRP-001186H	MARIPOSA	FS# 05-16-54-0952						6
MRP-001187H	MARIPOSA	FS# 05-16-54-0953						6,9,16
MRP-001188H	MARIPOSA	FS# 05-16-54-0954						6,16
MRP-001198H	MARIPOSA	FS# 05-16-54-0940						6
MRP-001200H	MARIPOSA	FS# 05-16-54-0943						6
MRP-001206H	MARIPOSA	FS# 05-16-54-1237						6,16
MRP-001217H	MARIPOSA							7,15,4,6,16
MRP-001218/H	MARIPOSA							6,7,4,12
MRP-001225/H	MARIPOSA							9,2,11,6,
MRP-001230H	MARIPOSA							6,16
MRP-001238H	MARIPOSA							6,11,16
MRP-001243H	MARIPOSA							6,16
MRP-001960H	MARIPOSA	FS# 05-15-51-0584						2,4,6,11,16
MEN-001127/H	MENDOCINO		1855					03,05,06,11,15
MEN-001642/H	MENDOCINO	FS# 05-08-56-0388, DOUGS SITE						02,03,04,06,15
MEN-001702/H	MENDOCINO	ORR HOT SPRINGS PESTLE SITE, CA-MEN-1702 H						06,07,11,15,16
MEN-002107/H	MENDOCINO	FS# 05-08-56-0526, ERAP 10 / MANZANITA TRAIL SITE						6

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MEN-002274H	MENDOCINO	AC-94						08,15,16
MEN-002282H	MENDOCINO	GREENWOOD MILL COMPLEX						02,07,08,11,15,16
MEN-002413H	MENDOCINO	CAMP-20						04,06,16
MEN-002532/H	MENDOCINO	BBR 83/H						2,3,6
MEN-002615H	MENDOCINO	MUIR CABIN, E-8-29-2						6,16
MEN-002618H	MENDOCINO	BRANSCOMB RANCH, H1A1	1924					5,6,10
MEN-002670H	MENDOCINO	MOLINA THP						8
MEN-002693H	MENDOCINO	JOHNSTON DAM						8
MEN-002695H	MENDOCINO	VALENTINE CREEK DAM						8
MEN-002813H	MENDOCINO							6
99130	MERCED	ALLISON DITCH	1942	FHWA951009A	6Y2		12/26/95	
99158	MERCED	TURLOCK IRRIGATION DITCH LATERAL #6	1903	FHWA951009A	6Y2		12/26/95	
102767	MERCED	MAIN CANAL CENTR CA IRRIGATION DISTRICT	1874	FHWA960802A	6Y1		8/12/96	
102768	MERCED	MAIN CANAL CENTRA CA IRRIGATION DISTRICT	1874	FHWA960802A	6Y1		8/12/96	
102769	MERCED	MAIN CANAL CENTRAL CA IRRIGATION DIST.	1874	FHWA960802A	6Y1		8/12/96	
102770	MERCED	OUTSIDE CANAL CENTRAL CA IRRIG DIST.	1896	FHWA960802A	6Y1		8/12/96	
102771	MERCED	OUTSIDE CANAL CENTRAL CA IRRIGATION DIST.	1896	FHWA960802A	6Y1		8/12/96	
102772	MERCED	OUTSIDE CANAL CENTRAL CA IRRIGATION DIST.	1896	FHWA960802A	6Y1		8/12/96	
107077	MERCED	MAIN CANAL,CENTRAL CA IRRIGATION DIST.	1896	FHWA970110B	6Y2		3/5/97	
MER-000014/H	MERCED	MER 14						07,08
MER-000018/H	MERCED	MERS 5/27/64 / MERS 5-98						06,07
MER-000040/H	MERCED	MER 83						6
MER-000045/H	MERCED	GWH 45 / J 3						6
MER-000047/H	MERCED	GWH 143 / J 101						6
MER-000064/H	MERCED	GWH-64 / J-22						06,15
MER-000075/H	MERCED	GWH-75 / J-33						6
MER-000085/H	MERCED							6
MER-000086/H	MERCED							6
MER-000090/H	MERCED	COPICHA						06,07
MER-Z00003	MERCED	MERCED MAIN CANAL			2S2	ABC	8/3/92	
MOD-000381H	MODOC	T-15						04,06
MOD-000654	MODOC	FS# 05-09-55-0113, HACKAMORE RESERVOIR,						
MOD-001824H	MODOC	CALIFORNIA PINES #8	1880					02,04,06,07
70006	MONO	ALKALAI DITCH	0	FHWA910131A	6Y1		2/27/91	
70007	MONO	SWAGER DITCH	0	FHWA910131A	6Y1		2/27/91	
90838	MONO	MONO CANALS		SPHI-MNO-013	7L		3/29/67	20
MNO-000620/H	MONO	FS# 05-04-52-0020, SHERWIN CREEK CAMPGROUND						6
MNO-000622H	MONO	FS# 05-04-52-0022, MAMMOTH SAWMILL / HESS SAWMILL, 5/9-H	1908					02,06,10,16
MNO-000884H	MONO	FS# 05-04-53-0089, BE-176	1890					6
MNO-000893H	MONO	FS# 05-04-52-0087, BODLE DITCH	1878	ADOE-26-91-0-002-0	6Y1		4/3/91	6
MNO-001052/H	MONO	ADOBE VALLEY STOCK CORRALS / BE-77	1881					04,06,11
MNO-001656H	MONO	FS# 05-04-53-0120						6
MNO-001679H	MONO	FS# 05-04-51-0400						04,06,09,15,16
MNO-002762H	MONO	PORTION OF RUSH CREEK DITCH		FHWA950802A	6Y2		2/1/96	
MNO-002764H	MONO	PORTION OF LEE VINING DITCH SYSTEM		FHWA950802A	6Y2		2/1/96	
19290	MONTEREY	MOLERA IRRIGATION SYSTEM	1920	3920-0010-0007	3D			20
MNT-000480/H	MONTEREY	GAMBOA HOMESTEAD	1890					02,05,06,10,11,15
MNT-000781H	MONTEREY	FS# 05-07-51-0033, TWITCHELL PLACE, LCFN 17						03,04,06,11
MNT-000892H	MONTEREY	SAN ANTONIO DE PAUDA MISSON IRRIG. SYSTEM						6

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MNT-001200H	MONTEREY	DD-8	1820					06,08
MNT-001248H	MONTEREY	SAN CLEMENTE DAM CA-, H-3		COE860819A	2	D	7/16/87	02,03,06,07,08,15,16
MNT-001249H	MONTEREY	CARMEL DAM CA-MNT-12, H-4		COE860819A	2	D	7/16/87	07,08
MNT-001277/H	MONTEREY	GPFN 14, JOSE BORONDA HOMESTEAD						04,08,10,11,15,16
MNT-001347H	MONTEREY	AC-803-1						05,06,10,15,16
MNT-001364H	MONTEREY	FS# 05-07-51-0371, LCFN-6 / THE DIGGS HOMESTEAD						02,03,05,06,11,15,16
MNT-001519H	MONTEREY	PINEY CREEK RESERVOIR, FS: 05-O7-51-409	1933					5
MNT-001520 H	MONTEREY	HANGING VALLEY RESERVOIR, FS: 05-07-51-410						6
MNT-001530H	MONTEREY	ROBERTSON SITE, BIO-6H						3,6,10
MNT-001540/H	MONTEREY	BIO-16/H						2,5,6,16
MNT-001542/H	MONTEREY	SAN MIGUELITO RANCH/ADOBE SITE, BIO-18/H	1823					2,6,15,16
MNT-001547H	MONTEREY	DIVERSION DAM, BIO-23H						8,16
MNT-001566H	MONTEREY	WATER SYSTEM: SOUTH OF MISSION, BIO 42H						5,6
MNT-001569H	MONTEREY	DITCH TENDER'S ABODE						
MNT-001786 H	MONTEREY	P-27-000073; FHL-108H-03A						2,6,16
122	NAPA	S.F.-CLEARLAKE RAILROAD GRADE	1870	4558-0021-0000	7			18, 20
328	NAPA	LAKE CAMILLE DAM, NAPA STATE HOSPITAL	1883	4558-0197-0031	3D			21
329	NAPA	LAKE LOUISE DAM, NAPA STATE HOSPITAL	1888	4558-0197-0032	3D			21
330	NAPA	LAKE COMO DAM, NAPA STATE HOSPITAL	1890	4558-0197-0033	3D			21
332	NAPA	LAKE MARIE DAM, NAPA STATE HOSPITAL	1908	4558-0197-0035	3D			21
333	NAPA	COOMBS RANCH DAM, NAPA STATE HOSPITAL	1872	4558-0197-0036	3D			21
334	NAPA	NAPA STATE HOSPITAL	1874	4558-0197-9999	3S			3, 4, 14, 21, 39
403	NAPA	PRIEST SODA SPRINGS	1900	4574-0030-0000	4S			6, 20
84372	NAPA	YORK CREEK DAM	1900	FEMA930819A	6Y1		10/5/93	
NAP-000598/H	NAPA	AC-45						06,11
NAP-000624/H	NAPA	LAWLEY PATTEN TOLL HOUSE & RESORT	1866					02,06,07,11,15
NAP-000713H	NAPA	SNELL VALLEY 1985 #2						08,11,15,16
NAP-000746H	NAPA	DYER RANCH						03,05,06,08,11,15,16
47524	NEVADA	BOCA DAM	1937	5734-0003-0000	1S		3/25/81	21
105583	NEVADA	OMEGA DITCH	1870	USFS961008A	6Y2		11/15/96	
NEV-000122H	NEVADA	LITTLE HONG KONG, PBAS SITE 10						07,08
NEV-000169H	NEVADA	PBAS II 403						02,06,09
NEV-000170H	NEVADA	PBAS II 404						04,06,15,16
NEV-000171H	NEVADA	PBAS II 408						08,09
NEV-000172H	NEVADA	OCONNER HILL, PBAS II 409						02,06,11,16
NEV-000173H	NEVADA	PBAS II 411						02,04,06,07,11,15,
NEV-000191H	NEVADA	FRENCH CORRAL	1849					06,07,09,15,16
NEV-000200/H	NEVADA							02,06,09
NEV-000207H	NEVADA	EXCELSIOR WATER DITCH,			2S1	D	2/2/82	6
NEV-000213H	NEVADA	ROUGH&READY DITCH, E-4						06,11
NEV-000215H	NEVADA	E-6						6
NEV-000217H	NEVADA	E-8						6
NEV-000222H	NEVADA	E-13						6
NEV-000225H	NEVADA	E-16						06,09
NEV-000227H	NEVADA	E-18						6
NEV-000230H	NEVADA	E-21						06,09
NEV-000231H	NEVADA	E-22						6
NEV-000234H	NEVADA	E-25						06,08
NEV-000236H	NEVADA	E-27						6
NEV-000237H	NEVADA	E-28						6

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
NEV-000240H	NEVADA	E-31						6
NEV-000241H	NEVADA	BODIE CREEK, E-32						07,08,09
NEV-000242H	NEVADA	E-33						8
NEV-000243H	NEVADA	E-34						6
NEV-000263H	NEVADA	E-78						6
NEV-000264H	NEVADA	E-79						06,07,16
NEV-000268H	NEVADA	KNICKERBOCKER MINE, E-86						06,09
NEV-000274H	NEVADA	E-93						02,05,06,09,11
NEV-000277H	NEVADA	E-96 / E-100						6
NEV-000284H	NEVADA	E-105						6
NEV-000286H	NEVADA	DRY CREEK, E-108						6
NEV-000293H	NEVADA	E-43						6
NEV-000295H	NEVADA	E-45						06,09,16
NEV-000297H	NEVADA	E-48,41,47,49,53,55,56						02,06,09,16
NEV-000300H	NEVADA	E-52						6
NEV-000301H	NEVADA	75						6
NEV-000303H	NEVADA	E-59						6
NEV-000304H	NEVADA	E-61						6
NEV-000305H	NEVADA	E-62						6
NEV-000308H	NEVADA	E-65						06,09
NEV-000309H	NEVADA	E-67 / E-85						06,09
NEV-000310H	NEVADA	E-68						6
NEV-000311H	NEVADA	E-69						6
NEV-000313H	NEVADA	E-73						6
NEV-000317H	NEVADA	E-77						6
NEV-000322H	NEVADA	FS# 05-17-55-0081	1900					02,06,08,10,11,15,16
NEV-000323/H	NEVADA	FS# 05-17-55-0083, CHALK BLUFF #5						02,04,06,07,16
NEV-000348H	NEVADA	FS# 05-17-55-0091, MOUNTAIN VIEW MINE						02,04,06,09,10,15,16
NEV-000349H	NEVADA	FS# 05-17-55-0085						8
NEV-000350H	NEVADA	FS# 05-17-55-0080						6
NEV-000352H	NEVADA	FS# 05-17-55-0071						6
NEV-000354H	NEVADA	FS# 05-17-55-0074, KING WOOLFORD MILL	1880					02,04,08,10,15,16
NEV-000397H	NEVADA	W.H. #9						6
NEV-000399H	NEVADA	W.H. #11						04,05,06,08
NEV-000408H	NEVADA	SV 4/H						06,08,09,16
NEV-000428H	NEVADA	MINERS TUNNEL #1						6
NEV-000429	NEVADA	FS# 05-17-55-0106, GRIZZLEY RIDGE GRAVES SITE						04,06,12
NEV-000431H	NEVADA	FS# 05-17-55-0112, SHADY MINE CAMP						04,06,07,09,11,16
NEV-000432H	NEVADA	FS# 05-17-55-0115, STEEPHOLLOW SUSPENSION BRIDGE						04,06,07,09,16
NEV-000434H	NEVADA	FS# 05-17-55-0117, LEVEY DITCH CAMP						02,04,07,11,15,16
NEV-000438H	NEVADA	TARR DITCH, NID #1	1858					04,06,08
NEV-000439/H	NEVADA	FS# 05-17-55-0122, TOP STATION - BEAR VALLEY TRAMWAY	1880					02,04,07,08
NEV-000441H	NEVADA	FS# 05-17-55-0126, SPIRITVILLE	1866					04,06,09,11
NEV-000444H	NEVADA	FS# 05-17-55-0130, PHASED -OUT SITE	1880					02,04,06,09,11
NEV-000445H	NEVADA	FS# 05-17-55-0125, 05-17-55-129, LOST ROAD/ZEILBRIGHT MINE	1880					02,04,08,09,15,16
NEV-000448H	NEVADA	FS# 05-17-55-0135, DOUBLE POND SITE	1880					06,08
NEV-000449H	NEVADA	FS# 05-17-55-0136, "DRURY" VIRGINIAN SITE	1890					02,04,06,09
NEV-000512H	NEVADA	FS# 05-17-55-0157, UPPER PAN RAVINE						06,07

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
NEV-000514H	NEVADA	FS# 05-17-55-0178, 5-17-55-179						02,06,09
NEV-000515H	NEVADA	FS# 05-17-55-0180, MEADOW SITE						02,06
NEV-000517H	NEVADA	FS# 05-17-55-0182, BERM SITE	1881					04,06,09
NEV-000519H	NEVADA	FS# 05-17-55-0184, HEADRIG SITE						04,07,08,09,10,11,15
NEV-Z00054H	NEVADA	MINERS DITCH SEGMENT 435		USFS960213A	6Y2		2/27/96	
NEV-Z00055H	NEVADA	CHALK BLUFF DITCH SEGMENT 462		USFS960213A	6Y2		2/27/96	
NEV-Z00056H	NEVADA	IRISH DITCH SEGMENT 463		USFS960213A	6Y2		2/27/96	
NEV-Z00057	NEVADA	REMINGTON HILL DITCH SEGMENT 464		USFS960213A	6Y2		2/27/96	
36086	ORANGE		1922	2634-0006-0001	5D			2, 20, 28
40297	ORANGE	FRENCH PARK DISTRICT	1880	2701-0107-9999	5S			3, 4, 20, 30, 31
70070	ORANGE	BEE CANYON WASH CANAL/DITCH	1945	DOE-30-91-0001-	6Y2		3/13/91	
70070	ORANGE	BEE CANYON WASH CANAL/DITCH	1945	FHWA910214A	6Y2		3/13/91	
45299	PLACER	P G & E COMPANY'S DRUM DIVISION	1928	5603-0323-0000	7J		3/22/94	9, 11, 19, 20
45299	PLACER	P G & E COMPANY'S DRUM DIVISION	1928	5603-0010-0008	3S			
45577	PLACER	BOARDMAN CANAL	1860	5603-0078-0000	4S			20
47517	PLACER	LAKE TAHOE DAM	1909	5730-0005-0000	1S		3/25/81	21
47520	PLACER	LAKE TAHOE OUTLET GATES	1870	5730-0008-0000	1S		12/13/72	21
47520	PLACER	LAKE TAHOE OUTLET GATES	1870	SHL-O797	7L		9/16/64	
88490	PLACER	P.G. & E. AQUEDUCT	1931	5603-0262-0000	7J		3/22/94	20
88496	PLACER	BEAR RIVER DITCH/SOUTH YUBA CANAL	1850	5603-0268-0000	7J		3/22/94	20
88498	PLACER	ROCK CREEK DAM	1916	5603-0269-0000	7J		3/22/94	21, 22
88512	PLACER	HALSEY FOREBAY & BANCROFT RANCH SITE	1913	5603-0281-0000	7J		3/22/94	21, 22
88534	PLACER	GOLD HILL CANAL	1850	5603-0300-0000	7J		3/22/94	20
88638	PLACER	LAKE ARTHUR	1909	5603-0327-0000	7J		3/22/94	21, 22
108822	PLACER	WISE CANAL	1940	5603-0362-0000	7J		6/16/97	20
108832	PLACER	MINING DITCH	1880	5714-0081-0000	7J		6/16/97	43
108835	PLACER	STRUCTURE	1940	5701-0001-0000	7J		6/16/97	20
108866	PLACER	HYDRAULIC MINING DITCH	1880	5714-0088-0000	7J		6/16/97	43
108898	PLACER	LONE STAR CANAL		5603-0374-0000	7J		6/16/97	20
108902	PLACER	ROCK CREEK CANAL	1940	5603-0375-0000	7J		6/16/97	20
108913	PLACER	DITCH-WESLEY LANE	1940	5603-0378-0000	7J		6/16/97	20
109272	PLACER	DRUM POWERHOUSE	1912	5714-0095-9999	7J		6/16/97	6, 9, 11, 21
109495	PLACER		1935	5603-0447-9999	7J		6/16/97	2, 20, 29, 30
109523	PLACER		1900	5701-0010-0000	7J		6/16/97	2, 20, 29
PLA-000112H	PLACER							02,08,16
PLA-000184H	PLACER							06,08,09,16
PLA-000222H	PLACER			RTC931230A	6Y2		1/10/94	08,09,16
PLA-000229H	PLACER							05,06,09,16
PLA-000241H	PLACER							02,04,06
PLA-000250H	PLACER	F-6-H						06,15
PLA-000253H	PLACER	F-2-H						02,06,07,16
PLA-000267H	PLACER	F-27-H						02,08,16
PLA-000293/H	PLACER							06,09,11
PLA-000304H	PLACER	FS# 05-17-57-0187, DEER CREEK TIMBER SALE, ADDENOUM SITE #3						6
PLA-000346H	PLACER	FS# 05-17-54-0040						06,11,15
PLA-000353H	PLACER	FS# 05-17-54-0047						06,15
PLA-000358H	PLACER	FS# 05-17-54-0184						6
PLA-000360H	PLACER	FS# 05-17-54-0189						02,08,09,16
PLA-000362H	PLACER	FS# 05-17-54-0191						6
PLA-000363H	PLACER	FS# 05-17-54-0192						6

APPENDIX A: WCS Features Listed in OHP Databases*

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
PLA-000364H	PLACER	FS# 05-17-54-0059						02,06
PLA-000366H	PLACER	FS# 05-17-54-0063						8
PLA-000369/H	PLACER	FS# 05-17-54-0121, 5-17-54-122, SECTION CORNER CABIN SITE	1940					04,06,09,15
PLA-000372H	PLACER	FS# 05-17-54-0127, SOLITARY WOMAN SITE	1930					02,04,08,09
PLA-000373/H	PLACER	FS# 05-17-54-0128, 5-17-54-129, ORCHARD	1900					03,06
PLA-000408H	PLACER	FS# 05-17-54-0180						06,08
PLA-000655H	PLACER	CA-PLA-655/H WIDEN D / AA1		FHWA880623A	6Y		7/20/88	6
PLA-000657/H	PLACER	FS# 05-17-54-0227, 05-17-471						02,04,06,07,09
PLA-000670H	PLACER	SEGMENT BOARDNAN CANAL		COE961004A	6Y2		10/25/96	
PLA-Z00016	PLACER	BROCKWAY RESERVOIR		USFS920929A	6Y1		8/6/92	
91800	PLUMAS	BUCKS LAKE		SHL-0197	7L		6/20/35	5, 21, 22, 37
104053	PLUMAS	LAKE ALMANOR DAM	1913	FERC960729A	2S2	ABC	9/25/96	
PLU-000155H	PLUMAS	FS# 05-11-52-0001, ROUND VALLEY DAM SITE	1864					8
PLU-000170H	PLUMAS	FS# 05-11-52-0016, LONG VALLEY GUARD STATION, V-21	1910					02,04,06,09,11,15
PLU-000270H	PLUMAS	FS# 05-06-51-0331, MC-1	1920					02,04,06,15
PLU-000306/H	PLUMAS	GLW-5						04,06
PLU-000309/H	PLUMAS	GLW-8						6
PLU-000318/H	PLUMAS	JPBB-1						04,06
PLU-000341H	PLUMAS	ELIZABETH TOWN HISTORICAL MARKER	1851					02,04,06
PLU-000380H	PLUMAS	FS# 05-11-53-0043, HARRISON DIGGINS		078 0002015	2S2	D	11/14/79	02,03,04,06,07
PLU-000418H	PLUMAS		1850					06,09
PLU-000433H	PLUMAS	FS# 05-11-52-0101, LONG VALLEY DAM, V-2						04,06,08,09
PLU-000434H	PLUMAS	FS# 05-11-52-0103, PLACER COMPLEX & LOG CABIN, V-16	1900					02,04,06,09
PLU-000435H	PLUMAS	FS# 05-11-52-0104, COMEBACK MINE, V-7						04,06,07,09
PLU-000439H	PLUMAS	FS# 05-11-52-0102, MEADOW VIEW PLACER, V-4	1930					02,04,06,09,15
PLU-000480H	PLUMAS	FS# 05-11-56-0103, BEAR CREEK SALV SAL-1						02,04,06
PLU-000481H	PLUMAS	FS# 05-11-56-0106, GREENHORN INSECT SALV SAL-11						04,06,15
PLU-000483H	PLUMAS	FS# 05-11-56-0111, SPANISH SITE #1 (RATTLESNAKE)						04,06,09
PLU-000488H	PLUMAS	FS# 05-11-56-0118	1930					04,06,09
PLU-000490H	PLUMAS	FS# 05-11-56-0122						06,08
PLU-000491H	PLUMAS	FS# 05-11-56-0123						02,04,06,09
PLU-000508H	PLUMAS	FS# 05-11-53-0221, CTS-5						04,06,09,11
PLU-000509H	PLUMAS	FS# 05-11-53-0222, CTS-6						06,09
PLU-000510H	PLUMAS	FS# 05-11-53-0223, CTS-7						04,06,09
PLU-000515H	PLUMAS	FS# 05-11-53-0228, PINCHARD MINING DITCH, CTS-12						6
PLU-000548H	PLUMAS	FS# 05-11-54-0266						04,06,09
PLU-000549H	PLUMAS	FS# 05-11-54-0265						04,06,09
PLU-000551H	PLUMAS	FS# 05-11-53-0288, LJR#2	1850					04,06,09,10
PLU-000552H	PLUMAS	FS# 05-11-53-0018, SAWPIT FLAT	1850					02,04,06,09,10
PLU-000555H	PLUMAS	FS# 05-11-53-0168, ONION VALLEY SITE #3						8
PLU-000557H	PLUMAS	FS# 05-11-53-0170, ONION VALLEY SITE #5						06,08
PLU-000559H	PLUMAS	FS# 05-11-53-0173						02,04,06,08,09,11
PLU-000560H	PLUMAS	FS# 05-11-53-0174, ONION VALLEY SITE #9	1920					02,04,06
PLU-000561H	PLUMAS	FS# 05-11-53-0295						02,06

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
PLU-000562H	PLUMAS	FS# 05-11-53-0296, SPANISH FLAT PLACER DIGGINGS						04,06,09
PLU-000565H	PLUMAS	FS# 05-11-53-0015, BARNARDS DIGGINGS						06,07,09
PLU-000566H	PLUMAS	FS# 05-11-53-0023, PORTWINE (TOWNSITE)	1862					02,04,06,09,12
PLU-000582H	PLUMAS	FS# 05-11-51-0338						02,04,06,09
PLU-000684H	PLUMAS	FS# 05-11-53-0552	1916					02,04,06,08,09,10 ,
PLU-000713H	PLUMAS	FS# 05-11-56-0300						06,08,10,15
PLU-000745H	PLUMAS	FS# 05-11-56-0170						02,04,06,07,09
59300	RIVERSIDE	LAKE MATHEWS DAM	1938	1720-0002-0397	4S			11
60184	RIVERSIDE	RESERVOIR, MWD	1933	2201-0005-0000	5S			11, 22
60530	RIVERSIDE	HAYFIELD PUMPING STATION, JULIAN HIND	1939	2239-0016-0000	3S			9, 11, 20
60536	RIVERSIDE	BARKER DAM	1900	2240-0001-0000	1S		10/24/75	21
60583	RIVERSIDE	EAGLE MOUNTAIN PUMPING PLANT	1936	2241-0002-0000	4S			9, 11, 20
60608	RIVERSIDE	COACHELLA CANAL	1948	2254-0010-0000	6			20
61400	RIVERSIDE	RICHIE HOUSE	1915	2343-0071-0000	3S			2, 4, 20
61436	RIVERSIDE		1925	2343-0109-0000	5S			2, 20, 29
61574	RIVERSIDE	NUEVO RESERVOIR	1930	2367-0029-0000	5S			9, 22
62600	RIVERSIDE	--, WEST PORTAL - EMWD AQUEDUCT	1939	2383-0101-0000	4S			8, 11, 20
62647	RIVERSIDE	RESERVOIR	1920	2388-0021-0011	3D			22
81111	RIVERSIDE	#406 RESERVOIR	1934	NPS-94001420-0133	2D2	AC	12/6/94	22
81111	RIVERSIDE	#406 RESERVOIR	1934	DOE-33-93-0001-	2D2	AC	3/11/93	
81111	RIVERSIDE	#406 RESERVOIR	1934	USAF920428A	2D2	AC	3/11/93	
81112	RIVERSIDE	#407 RESERVOIR	1932	NPS-94001420-0099	2D2	AC	12/6/94	22
81112	RIVERSIDE	#407 RESERVOIR	1932	DOE-33-93-0001-	2D2	AC	3/11/93	
81112	RIVERSIDE	#407 RESERVOIR	1932	USAF920428A	2D2	AC	3/11/93	
81113	RIVERSIDE	#408 RESERVOIR	1932	NPS-94001420-0132	2D2	AC	12/6/94	22
81113	RIVERSIDE	#408 RESERVOIR	1932	DOE-33-93-0001-	2D2	AC	3/11/93	
81113	RIVERSIDE	#408 RESERVOIR	1932	USAF920428A	2D2	AC	3/11/93	
81114	RIVERSIDE	STONE DRAINAGE CANAL	1942	NPS-94001420-0100	2D2	AC	12/6/94	20
81114	RIVERSIDE	STONE DRAINAGE CANAL	1942	DOE-33-93-0001-	2D2	AC	3/11/93	
81114	RIVERSIDE	STONE DRAINAGE CANAL	1942	USAF920428A	2D2	AC	3/11/93	
81116	RIVERSIDE	#409 RESERVOIR	1940	NPS-94001420-0101	2D2	AC	12/6/94	22
81116	RIVERSIDE	#409 RESERVOIR	1940	DOE-33-93-0001-	2D2	AC	3/11/93	
81116	RIVERSIDE	#409 RESERVOIR	1940	USAF920428A	2D2	AC	3/11/93	
89185	RIVERSIDE	EAST FORK DAM,INTAKE/FLOWLINE,SAN GORGONIO		USFS940310A	2D2	AC	4/22/94	
89186	RIVERSIDE	SOUTH FORK DAM/INTAKE-SAN GORGONIO HWY		USFS940310A	2D2	AC	4/22/94	
89554	RIVERSIDE	SITE OF BLYTHE INTAKE	1877	SHL-0948	7L		3/1/82	21, 39
90945	RIVERSIDE	HEMET DAM AND LAKE HEMET	1887	SPHI-RIV-020	7L		6/7/68	21, 22
90976	RIVERSIDE	PEDLEY-TYPE DAM	1913	SPHI-RIV-048	7L		7/12/74	21
RIV-001435	RIVERSIDE							6
RIV-002320	RIVERSIDE							6
RIV-002321	RIVERSIDE							6
RIV-002621/H	RIVERSIDE	A-124 / 132		73000422	1D	ACD	1/8/73	04,06,07
RIV-002622/H	RIVERSIDE	A-135 / 178		73000422	1D	ACD	1/8/73	04,06,07
RIV-002623/H	RIVERSIDE	A-33 / 41		73000422	1D	ACD	1/8/73	04,06,07
RIV-002624	RIVERSIDE	A-216 (SC-2)						04,06,07
RIV-002625/H	RIVERSIDE	A-214		73000422	1D	ACD	1/8/73	04,06,07
RIV-002626/H	RIVERSIDE	A-194 / 195		73000422	1D	ACD	1/8/73	04,06,07
RIV-002627/H	RIVERSIDE	A-189		73000422	1D	ACD	1/8/73	04,06,07
RIV-002628/H	RIVERSIDE	A-115 / 117		73000422	1D	ACD	1/8/73	04,06,07

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
RIV-002629/H	RIVERSIDE	A-75 / 76		73000422	1D	ACD	1/8/73	04,06,07
RIV-002630/H	RIVERSIDE	A-23		73000422	1D	ACD	1/8/73	04,06,07
RIV-002631/H	RIVERSIDE	A-7		73000422	1D	ACD	1/8/73	04,06,07
RIV-002760	RIVERSIDE							6
RIV-002761	RIVERSIDE							6
RIV-002762	RIVERSIDE							6
46316	SACRAMENTO	FOLSOM POWERHOUSE	1895	5630-0001-0000	1S		1/1/73	9, 11, 22
46316	SACRAMENTO	FOLSOM POWERHOUSE	1895	SHL-0633	7L		3/3/58	
48370	SACRAMENTO	SACRAMENTO WEIR		5813-0738-0000	2S1		1/1/76	21
48870	SACRAMENTO	WATER FILTRATION PLANT	1921	5813-1000-0000	3S			9, 11, 22
91683	SACRAMENTO	PLEASANT GROVE CANAL-RECLAMATION DISTRICT 1000	1912	COE900711G	2D2	A	9/21/94	
91684	SACRAMENTO	CROSS CANAL-RECLAMATION DISTRICT 1000	1912	COE900711G	2D2	A	9/21/94	
91685	SACRAMENTO	CROSS CANAL LEVEE-RECKANATUIB DUSTRUC	1912	COE900711G	2D2	A	9/21/94	
91688	SACRAMENTO	NATOMAS MAIN DRAINAGE CANAL-RECLAMATION DISTRICT 1000	1912	COE900711G	2D2	A	9/21/94	
107094	SACRAMENTO	FOLSOM SOUTH CANAL,CENTRAL VALLEY PROJECT	1970	FTA970129A	6Y2		3/3/97	
SAC-000340H	SACRAMENTO							8
SAC-000358H	SACRAMENTO	F-2-H (SF)						02,06,07,08,11,16
SAC-000359/H	SACRAMENTO	F-3-P (SF)						08,11,16
SAC-000434H	SACRAMENTO	NATOMA DITCH		COE920813A	2S2	AC	5/2/95	
SBN-000034/H	SAN BENITO	ISAACSON SITE						05,06,07,15,16
SBN-000035/H	SAN BENITO	PENN SITE	1770	35-0007				02,03,06,07,11,15,16
SBN-000099H	SAN BENITO	H-17	1890					8
SBN-000191H	SAN BENITO	MILLERS CANAL						6
59346	SAN BERNARDINO	WEIR BOX	1880	1730-0037-0000	4S			20
59624	SAN BERNARDINO		1926	1761-0090-0013	4D			20
60793	SAN BERNARDINO	COW CAMP	1880	2277-0001-0000	1S		10/29/75	21, 22
60858	SAN BERNARDINO	BIG BEAR DAM BRIDGE 54-310	1924	2315-0002-0000	4S			21, 95
60933	SAN BERNARDINO	SOUTHWEST SHORE COLONY, BIG BEAR	1912	2315-0004-9999	4S			2, 21, 22, 32
60934	SAN BERNARDINO	OLD BEAR VALLEY DAM	1883	2315-0005-0000	3S			1121
60934	SAN BERNARDINO	OLD BEAR VALLEY DAM	1883	SHL-0725	7L		2/5/60	
62122	SAN BERNARDINO	MILL CREEK ZANJA	1819	2373-0447-0000	1S		5/12/77	20, 36
62122	SAN BERNARDINO	MILL CREEK ZANJA	1819	SHL-0043	7L		8/1/32	
67796	SAN BERNARDINO	NORTH FORK CANAL DISTRICT	1884	DOE-36-90-0002-	6Y	C	5/14/90	20
67796	SAN BERNARDINO	NORTH FORK CANAL DISTRICT	1884	FHWA900419B	6Y	C	5/14/90	
67797	SAN BERNARDINO	HIGHLAND CANAL DISTRICT	1888	DOE-36-90-0003-	6Y		5/14/90	20
67797	SAN BERNARDINO	HIGHLAND CANAL DISTRICT	1888	FHWA900419B	6Y		5/14/90	
67799	SAN BERNARDINO	NORTH FORK MAIN CANAL	1884	DOE-36-90-0002-	6Y	C	5/14/90	20
67799	SAN BERNARDINO	NORTH FORK MAIN CANAL	1884	FHWA900419B	6Y	C	5/14/90	
67800	SAN BERNARDINO	HIGHLAND MAIN CANAL	1888	DOE-36-90-0003-	6Y		5/14/90	20
67800	SAN BERNARDINO	HIGHLAND MAIN CANAL	1888	FHWA900419B	6Y		5/14/90	
67802	SAN BERNARDINO	CITY CREEK DITCH DISTRICT	1884	DOE-36-90-0005-	2S2	C	5/14/90	20
67802	SAN BERNARDINO	CITY CREEK DITCH DISTRICT	1884	FHWA900419B	2S2	C	5/14/90	
70270	SAN BERNARDINO	1911 BEAR VALLEY DAM	1911	FHWA910404A	6Y2		5/2/91	19, 21
91081	SAN BERNARDINO	WEST TWIN CREEK WATER CO. SYSTEM FLUME	1854	SPHI-SBR-104	7L		11/16/84	20
91090	SAN BERNARDINO	GRAPELAND HOMESTEADS AND WATER WORKS		SPHI-SBR-116	7L		8/8/91	2, 20
107103	SAN BERNARDINO	CITY CREEK MAIN CANAL	1884	DOE-36-90-0005-	2D2	C	5/14/90	20
107103	SAN BERNARDINO	CITY CREEK MAIN CANAL	1884	FHWA900419B	2D2	C	5/14/90	
SBR-001634-H	SAN BERNARDINO	Stagecoach Spring Site /, SBCM-1392 / EM-217						04,05,06,07

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SBR-003040-H	SAN BERNARDINO	Hart Oil Derrick / Hart Well & Tank Site, SBCM-4482 / EM-329						05,06
SBR-003421-H	SAN BERNARDINO	Sherman Springs Site, JM-17 / SBCM-3510						6
SBR-003686/H	SAN BERNARDINO	Juniper Flats Site, LV-BLM-3 / SBCM-3915						02,04,08,15,16
SBR-004194-H	SAN BERNARDINO	Brookings Sawmill Site, SBCM-4592						02,04,05,07,08,10,15
SBR-004294-H	SAN BERNARDINO	FS# 05-12-51-0091, Saddle Flats Water Tunnel, SBCM-4682						02,04,06,07
SBR-004336/H	SAN BERNARDINO	Union Flats #6, 25/13 / SBCM-2507						6
SBR-004408H	SAN BERNARDINO	Caughlin Road Foundation, SBCM-4783						02,04,05,08
SBR-005499-H	SAN BERNARDINO	SAC-2	1896	FERC930622B	2S2		10/19/93	02,04,06,11,15,16
SBR-005508H	SAN BERNARDINO	SEVEN OAKS DAM SAW-5, SAW-5		COE870819A	2	D	4/12/88	04,05,06
SBR-005516-H	SAN BERNARDINO	Santa Ana River No. 3	1904					02,06,15
SBR-005517-H	SAN BERNARDINO	Mill Creek Powerhouses Nos. 2 and 3,	1900					02,06,15
SBR-005519-H	SAN BERNARDINO	FS# 05-12-51-0113, Snow Valley D						8
SBR-005521-H	SAN BERNARDINO	FS# 05-12-51-0112, Snow Valley C						02,04,06,08,16
SBR-005526H	SAN BERNARDINO	SEVEN OAKS DAM (SBR-5, SAW-3)	1920	COE870819A	2	D	4/12/88	02,04,05,06,10
SBR-005527-H	SAN BERNARDINO	Clark's Ranch, FB2-1	1887					02,04,06,11
SBR-005577-H	SAN BERNARDINO	FS# 05-12-51-0101, Hooks Creek Site						07,08
SBR-005588-H	SAN BERNARDINO	Water-Hitchcock Ranch #1, 15/12						6
SBR-005589-H	SAN BERNARDINO	Water-Belleville #2, 11/12						8
SBR-005591-H	SAN BERNARDINO	Historic Bertha Peak #3, HV-15 / 4/5						6
SBR-005592-H	SAN BERNARDINO	Historic John Bull #1 / HV-4 / 27/7 /, HV-5 / 27/6 / HV-		FHWA960311A	6Y2		3/18/96	6
SBR-005593-H	SAN BERNARDINO	HV-8 / 10/12						04,07,08,09
SBR-005595-H	SAN BERNARDINO	Historic Hitchcock Ranch #5, HV-7 / 11/23 / 12/4						6
SBR-005782-H	SAN BERNARDINO	FS# 05-01-52-0031, South Miner's Bowl Placer Diggins, MBSA-1						06,09
SBR-005783-H	SAN BERNARDINO	FS# 05-01-52-0032, Miner's Bowl Hydraulic Pit, MBSA-11						06,09
SBR-005785-H	SAN BERNARDINO	FS# 05-01-52-0034, Hocumac Reservoir, MBSA-13	1894					6
SBR-005787-H	SAN BERNARDINO	FS# 05-01-53-0046, Coldwater Crossing Site, MBSA-5						06,16
SBR-005962	SAN BERNARDINO	5 Tanks						04,06,03,15
SBR-005972-H	SAN BERNARDINO	3						6
SBR-005977-H	SAN BERNARDINO	12						02,04,06,11,15
SBR-005978-H	SAN BERNARDINO	14						02,04,06
SBR-005980-H	SAN BERNARDINO	16						06,15
SBR-005983-H	SAN BERNARDINO	21 / 22						06,11,15
SBR-005985-H	SAN BERNARDINO	25						02,04,06,15
SBR-005986-H	SAN BERNARDINO	32						6
SBR-005995-H	SAN BERNARDINO	31						06,08,15
SBR-006000-H	SAN BERNARDINO	Featherstone Ranch Grove, P1064-22-H / MCW-2						06,11,16
SBR-006001-H	SAN BERNARDINO	Brown Ranch / Sunrise Ranch, P1064-24-H / MCW-5A	1880					03,06,10,11,15
SBR-006002H	SAN BERNARDINO	Brown Ranch / Sunrise Ranch / SEVEN OAKS DAM (SBR-6, P1064-25-H/MCW-5B)	1880	COE870819A	2	D	4/12/88	02,06,07
SBR-006003-H	SAN BERNARDINO	P1064-26-H / MCW-5C						05,06,15
SBR-006004-H	SAN BERNARDINO	MCW-6						02,03,05,06,11
SBR-006005-H	SAN BERNARDINO	Bear Valley Highline, PSBR-10-H / MCW-8 / SC-3	1889					6
SBR-006006-H	SAN BERNARDINO	P1063-3-H / SAW-12	1930					02,04,05,06,11,16
SBR-006026/H	SAN BERNARDINO	Wells Ranch / Fenton Slaughter Reservoir, PB-62		COE911223A	6Y2		8/9/93	02,04,05,06
SBR-006109-H	SAN BERNARDINO	H-12	1850					6
SBR-006110-H	SAN BERNARDINO	H-13	1897					6
SBR-006111-H	SAN BERNARDINO	H-14						6

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SBR-006181H	SAN BERNARDINO	BS-51		BLM881011A	6Y		1/4/89	02,05,06,11
SBR-006196H	SAN BERNARDINO	CDL-152		BLM881011A	6Y		1/4/89	02,04,05,06,11
SBR-006901	SAN BERNARDINO	SUMMIT AVE DITCH		FHWA910719A	6Y1		8/30/91	
SBR-007168H	SAN BERNARDINO	GAGE CANAL		FHWA950905A	6Y2		10/17/95	
43089	SAN DIEGO	OLD MISSION DAM	1800	2138-0011-0000	1S		10/15/66	11, 21, 36
43089	SAN DIEGO	OLD MISSION DAM	1800	SHL-0052	7L		12/6/32	
74588	SAN DIEGO	RESIDENTAL DAM	1888	2002-0032-0000	4S2	A	3/3/92	21
74663	SAN DIEGO	SWEETWATER DAM	1886	2077-0002-0000	4S2	C	3/6/92	21, 30
74665	SAN DIEGO	SWEETWATER DAM CARETAKERS COTTAGE	1914	2077-0003-0000	4S2	C	3/6/92	39
85767	SAN DIEGO	MISSION SAN LUIS REY BUILDINGS	1798	2054-0136-0000	7J		1/14/94	4, 20, 30
89612	SAN DIEGO	DERBY DIKE		SHL-0244	7L		6/10/36	21
90248	SAN DIEGO	PORTESEUELO ARCHAEOLOGICAL DISTRICT	1790	37-0076				20, 32, 40
109346	SAN DIEGO	STRUCTURE 264/ WATER DAM PT LOMA NAVAL STATION	1939	USN960819B	4D2		10/31/96	
109351	SAN DIEGO	STRUCTURE 316/PUBLIC WORKS RESERVOIR	1941	USN960819B	4D2		10/31/96	
SDI-000010/H	SAN DIEGO	HAENSZEL'S SITE #5, SDi-10A						02,08,08
SDI-000203/H	SAN DIEGO	CAL-E4-34						01,08,03,
SDI-000204/H	SAN DIEGO	W200/MISSION DAM						08,04,07,
SDI-001357/H	SAN DIEGO	FP49						16,04,08,
SDI-001463/H	SAN DIEGO	FP155						16,04,08,
SDI-001493/H	SAN DIEGO							16,03,08
SDI-002241/H	SAN DIEGO	LSP7						11,07,08,
SDI-002330/H	SAN DIEGO							04,06,16
SDI-002533/H	SAN DIEGO							04,06,08,
SDI-002628/H	SAN DIEGO							07,03,08
SDI-002653/H	SAN DIEGO							16,08,11
SDI-002706/H	SAN DIEGO							16,04,06,
SDI-004306H	SAN DIEGO	JL08						6
SDI-004610/H	SAN DIEGO							15,04,08,
SDI-004672/H	SAN DIEGO							8
SDI-004816H	SAN DIEGO							02,06,11,15,16
SDI-004827/H	SAN DIEGO							11,08
SDI-005021/H	SAN DIEGO							11,04,08
SDI-005108/H	SAN DIEGO							16,03,08
SFR-000046H	SAN FRANCISCO	LOTTAS FOUNTAIN / LOTTA CRABTREE FOUNTAIN	1875					06,16
SFR-000102H	SAN FRANCISCO	AC-38	1897					06,16
SJO-000229H	SAN JOAQUIN	TOWNSITE OF WICKLUND, AC-104						2,4,6,7,16
SJO-000234H	SAN JOAQUIN	11/6/91-1						5,6,11,15
SJO-000235H	SAN JOAQUIN	11/3/91-1						6
SJO-000242H	SAN JOAQUIN							7,11,6,16
SLO-000941/H	SAN LUIS OBISPO	CA:-SLO-1						02,03,06,16
SLO-000942H	SAN LUIS OBISPO	4-SLO-AS-H005						06,07,11
SLO-000943H	SAN LUIS OBISPO							06,07,08,11,16
SLO-000944H	SAN LUIS OBISPO							6
SLO-000947H	SAN LUIS OBISPO							02,07,08,16
SLO-001074H	SAN LUIS OBISPO	ACE-SML-6						6
5358	SAN MATEO	EARTH DAM, WATER STORAGE LAKE, PUMP HOUSE	1913	4062-0004-0010	1D		1/1/86	4, 21, 22
5425	SAN MATEO	WOODHUE COURT STONE DAM	1900	4063-0060-0000	4S			21
68328	SAN MATEO	LOWER CRYSTAL SPRINGS DAM		FHWA890822B	2	AC	9/19/89	30
91147	SAN MATEO	CRYSTAL SPRINGS DAM	1887	SPHI-SMA-003	7L		5/19/71	21

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102001	SAN MATEO	OLD PUMP HOUSE AND RESERVOIR	1910	DOE-41-96-0122-	2D2		4/18/96	1
102001	SAN MATEO	OLD PUMP HOUSE AND RESERVOIR	1910	UMTA900828A	2D2		4/18/96	
102069	SAN MATEO	CARETAKER'S HOUSE AND RESERVOIRS	1910	DOE-41-96-0124-	2S2		4/18/96	2
18129	SANTA BARBARA	JOHN S. EDWARDS HOUSE, DOLE HOUSE	1911	3102-0471-0000	5S			2, 20, 30
68174	SANTA BARBARA	GIBRALTER DAM		USFS870608A	6Y		8/8/88	
SBA-000518H	SANTA BARBARA	SANTA YNEZ MISSIONS	1804					02,03,04,06,11,12,15
SBA-000625	SANTA BARBARA	LADRONES RESERVOIR						
SBA-001092H	SANTA BARBARA							02,04,06,15
SBA-001178H	SANTA BARBARA		1804					6
SBA-001573H	SANTA BARBARA	CR-20						6
SBA-001712H	SANTA BARBARA							06,08
SBA-001713H	SANTA BARBARA							02,04,06
SBA-001714H	SANTA BARBARA		1800					04,06,10,15
SBA-001774/H	SANTA BARBARA							05,06
69161	SANTA CLARA	LEXINGTON DAM	1952	FHWA900925A	6Y1		10/16/90	
SCL-000268/H	SANTA CLARA							03,06
SCL-000411H	SANTA CLARA	DAIRY						06,15
SCL-000525H	SANTA CLARA	ROS DJP-1H	1920					8
SCL-000536H	SANTA CLARA	THOMAS CABIN SITE, HS-5						04,06,15,16
SCL-000569H	SANTA CLARA	ORCHARD 515						02,04,05,06,16
14667	SANTA CRUZ	HUSHBECK HOUSE	1860	5076-0030-0000	3S			20, 29
SCR-000186H	SANTA CRUZ	SCH-10/AUG/78-5						06,08,11,15
SCR-000241H	SANTA CRUZ		1930					6
SCR-000242H	SANTA CRUZ		1930					6
SCR-000243H	SANTA CRUZ		1930					6
68157	SHASTA	DEDRICK DITCH FS 05-14-54-175		USFS880802A	2	A	9/1/88	
68180	SHASTA	STONEY CREEK DITCH INTAKE FS 05-14-56		USFS880303B	6Y		4/4/88	
68385	SHASTA	SOUTH COW CREEK DIVERSION DAM		FERC890310A	6Y		5/5/89	
68483	SHASTA	SHASTA DAM	1938	BUR900822A	2S2	AC	9/12/90	
91404	SHASTA	AQUEDUCT OF ANDERSON-COTTONWOOD IRRIGATION DISTRICT		SPHI-SHA-013	7L		11/16/84	20
93017	SHASTA	KESWICK DAM/CENTRAL VALLEY PROJECT	1951	BUR940908A	2S2	A	12/6/94	
96818	SHASTA	ANDERSON-COTTONWOOD IRRIGATION DISTRICT	1917	BUR950419A	6Y2		7/17/95	
SHA-000076/H	SHASTA	CA-SHA-76/74						06,16
SHA-000173/H	SHASTA							02,03,04,06
SHA-000176/H	SHASTA							06,09
SHA-000193/H	SHASTA	CA-SHA-194		85003483	1D	D	11/4/85	03,06,07,11,12
SHA-000195/H	SHASTA			NPS910617A	6Y1		7/8/91	04,06,07,09,10
SHA-000506H	SHASTA							02,06,07,11
SHA-000518/H	SHASTA							02,06
SHA-000626/H	SHASTA			85003483	1D	D	11/4/85	06,09
SHA-000632/H	SHASTA	FIELD H	1906					03,06,08,
SHA-000633/H	SHASTA	FIELD I	1906					03,06,08,
SHA-000635/H	SHASTA	FIELD K						03,08
SHA-000652/H	SHASTA	STACY 3, FS 05-14-56-43|						02,04,06,16
SHA-000669H	SHASTA	FS# 05-14-58-0058	1923					6
SHA-000719/H	SHASTA	DG29,D38H,D39H,D37H,S46H,S47H	1870					02,04,05,06,08,09,11
SHA-000801/H	SHASTA	ORESTANO 9						04,08
SHA-000804/H	SHASTA	FS# 05-14-51-0008, PHILPOT LAKE						02,04,06,08
SHA-000826/H	SHASTA	SECTION 32 CABIN AND MINING ACTIVITY, FS 05-14-56-213						04,06,15

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SHA-000827/H	SHASTA	DAMN-CLEAR SITE, FS 05-14-56-212						02,04,15
SHA-000829/H	SHASTA	TRESTLE 29 WATER TOWER, FS 05-14-56-210						06,07,16
SHA-000847/H	SHASTA	TEPEE GULCH CAMP, FS 05-14-56-236						04,06
SHA-000882/H	SHASTA	KENNETT TOWN SITE, FS 05-14-58-155						04,06,07,08,12,16
SHA-000942H	SHASTA	FS# 05-14-61-0143, CAMP NINE FLAT						02,04,06
SHA-000999/H	SHASTA	HAZEL CREEK HISTORIC SITE A, X5, FS 05-14-59-						02,03,04,06,08,09,16
SHA-001002/H	SHASTA	HAZEL CREEK PLACER MINING CLAIMS, FS 05-14-59-174						04,06,07,09,16
SHA-001020/H	SHASTA	THE INCLINE, FS-05-14-59-190	1906					02,04,05,06,07
SHA-001021/H	SHASTA	LA MOINE LUMBER AND TRADING CO MILL 2, FS 05-59-191	1900					02,03,04,06,07,08,16
SHA-001023/H	SHASTA	LA MOINE LUMBER AND TRADING CO MILL 1, FS 05-14-59-126	1900					02,03,04,06,07,09,15
SHA-001024/H	SHASTA	LA MOINE LUMBER AND TRADING CO MILL 2, FS 05-14-59-14	1910					02,04,06,07,16
SHA-001035H	SHASTA	FS# 05-14-59-0131, LAMOINE FLUME	1900					04,06,07
SHA-001071/H	SHASTA	FS# 05-14-56-0317, WEATHER STATION MINING	1930					04,06,09
SHA-001116/H	SHASTA		1860					04,06,09
SHA-001125/H	SHASTA							04,06,09
SHA-001195H	SHASTA							02,04,06,09
SHA-001197H	SHASTA		1860					06,09
SHA-001198H	SHASTA		1900					06,09
SHA-001209H	SHASTA							6
SHA-001228H	SHASTA		1887					02,04,05,06,09
SHA-001233H	SHASTA							02,06,08,09,11
SHA-001234H	SHASTA							06,09,16
SHA-001238H	SHASTA							06,08,09
SHA-001240H	SHASTA							06,08,09,11,16
SHA-001241H	SHASTA		1870					06,09,16
SHA-001242H	SHASTA							03,06,09,16
SHA-001244H	SHASTA							06,09,16
SHA-001249H	SHASTA		1900					04,06
SHA-001250H	SHASTA							06,08,09
SHA-001251H	SHASTA		1930					04,06
SHA-001261H	SHASTA							06,08
SHA-001267H	SHASTA							06,09
SHA-001271H	SHASTA							02,06
SHA-001274H	SHASTA		1870					02,04,06,09,11,16
SHA-001281H	SHASTA							6
SHA-001283H	SHASTA							8
SHA-001295H	SHASTA		1860					02,04,06
SHA-001296H	SHASTA		1920					02,04,06,09,10,16
SHA-001297H	SHASTA							06,08,09
SHA-001298H	SHASTA		1870					02,04,06,08
SHA-001299H	SHASTA		1870					04,06,09,16
SHA-001300/H	SHASTA		1870					04,06,16
SHA-001341H	SHASTA		1900					02,04,06,07,11,16
SHA-001343H	SHASTA		1910					6
SHA-001344H	SHASTA							02,06,09,16
SHA-001352H	SHASTA	CA-030-149	1900					06,07,09
SHA-001369H	SHASTA							02,04,05,06,11

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
SHA-001394/H	SHASTA							06,07,11
SHA-001413/H	SHASTA							02,03,04,06,08
SHA-001416/H	SHASTA							06,07
SHA-001434/H	SHASTA	CA-030-177						6
SHA-001448/H	SHASTA	CA-030-188						02,04,06,09
SHA-001450/H	SHASTA	CA-030-190	1880					02,04,06,09,11
SHA-001462/H	SHASTA	CA-SHA-129/360						02,04,06
SHA-001465	SHASTA							03,06,11
SHA-001467/H	SHASTA							03,04,06
SHA-001468/H	SHASTA							02,04,06,10
SHA-001471	SHASTA							6
SHA-001472/H	SHASTA							06,11
SHA-001512H	SHASTA	IGO CHINESE RESERVOIR, CA-030-238						06,08
SHA-001530H	SHASTA							02,04,08,11
SHA-001531H	SHASTA							02,03,04,05,06
SHA-001536H	SHASTA		1880					02,04,06
SHA-001550/H	SHASTA							6
SHA-001560H	SHASTA		1940					6
SHA-001570H	SHASTA		1880					02,06
SHA-001606H	SHASTA	FS# 05-14-58-0007						02,04,06,07,11
SHA-001696/H	SHASTA	CA-030-320	1850					02,03,04,06,07,09,12
SHA-001798H	SHASTA	FS# 05-14-59-0345						02,04,06,09
SHA-001806H	SHASTA	HORSTMAN MINE	1880					02,04,06,07,09
SHA-001807H	SHASTA							02,06
SHA-001809H	SHASTA		1880					06,08
SHA-001810H	SHASTA		1880					02,04,06,09
67660	SIERRA	MILTON DITCH FS 05-17-55-52		USFS880907B	2	A	4/25/90	
SIE-000083H	SIERRA	FS# 05-17-53-0045, DEPOT HILL MINE / JOUBERT DIGGINGS	1852					04,06,09
SIE-000085H	SIERRA	FS# 05-17-53-0047, INDIAN HILL MINE, SCANLAN: FIELD NO.2	1850					04,06,09,16
SIE-000088H	SIERRA	FS# 05-17-53-0051, SCANLAN: FIELD NO.6						02,04,06
SIE-000092/H	SIERRA	FS# 05-17-53-0058, SCANLAN: FIELD NO.13						06,09,16
SIE-000095H	SIERRA	FS# 05-17-53-0062, INDIAN HILL SETTLEMENT, SCANLAN: FLD #17&18/USFS-63						02,03,04,05,08,09,15
SIE-000097H	SIERRA	FS# 05-17-53-0066, KANAKA CREEK SUMP, BOPE FIELD #1						04,06
SIE-000106H	SIERRA	FS# 05-17-53-0183, PRIDE MINE NUCLEUS	1880					02,03,06,09
SIE-000109H	SIERRA	FS# 05-17-53-0049, JOUBERTS DITCH, SCANLAN: FIELD NO.4	1850					6
SIE-000137/H	SIERRA	FS# 05-17-56-0062, WATER WHEEL SITE						04,06,07,15
SIE-000147H	SIERRA	FS# 05-17-53-0119, COMET STAMP MILL / COMET I MINE	1883					02,04,06,09,10,15
SIE-000149H	SIERRA	FS# 05-17-53-0121	1860					02,04,06,09
SIE-000151H	SIERRA	FS# 05-17-53-0123, GREAT REPUBLIC						02,04,06,09,11
SIE-000186H	SIERRA	FS# 05-17-53-0225, MAGNOLIA MINE						06,09,10,15,16
SIE-000189H	SIERRA	FS# 05-17-53-0227, HIGH RISE						04,06,09,16
SIE-000212H	SIERRA	FS# 05-17-53-0182						04,06
SIE-000218H	SIERRA	FS# 05-17-53-0002, BRANDY CITY, USFS 05-17-53-214 & -217	1850					02,03,04,06,09,10,12

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
SIE-000219H	SIERRA	FS# 05-17-53-0215, ORCHARD SITE, USFS 05-17-53-366	1870					03,04,06,09
SIE-000220H	SIERRA	FS# 05-17-53-0216, DITMARS CABIN						04,06,09,15
SIE-000238H	SIERRA	FS# 05-17-53-0208, CAP FIRE SITE 14 &15 / REM #1 & #2, USFS 05-17-53-209						04,06,09,16
SIE-000242H	SIERRA	FS# 05-17-53-0194, CAP FIRE SITE 2						04,06,08,09,11,16
SIE-000273H	SIERRA	FS# 05-17-53-0320, LONE MINER	1880					04,06,09
SIE-000276H	SIERRA	FS# 05-17-53-0337, BRANDY CITY MILL						02,04,06,16
SIE-000279H	SIERRA	FS# 05-17-53-0344, LOWER DIGGINS RAVINE						02,04,06,09
SIE-000281H	SIERRA	FS# 05-17-53-0351, DEEP WELL	1870					04,05,06,09
SIE-000282H	SIERRA	FS# 05-17-53-0352, CHINESE RAVINE	1860					04,06,09
SIE-000285H	SIERRA	FS# 05-17-53-0367, ONE THE BRINK , FEATURE 5	1880					02,04,06,11
SIE-000288H	SIERRA	FS# 05-17-53-0338, LOWER DIGGINS SADDLE						02,04,06
SIE-000289H	SIERRA	FS# 05-17-53-0341, 1001 PLACER MINE NUCLEUS						04,06,09,15,16
SIE-000295H	SIERRA	FS# 05-17-53-0329, CUT EYE FOSTERS BAR	1850					02,04,06,09,11,16
SIE-000298H	SIERRA	FS# 05-17-53-0369	1880					02,03,04,05,06,09,11
SIE-000300H	SIERRA	FS# 05-17-53-0373, MAMAS MILL						02,04,06,07,09,16
SIE-000302H	SIERRA	FS# 05-17-53-0375, HALF MOON CABIN	1906					02,04,06,07,09
SIE-000305H	SIERRA	FS# 05-17-53-0378, BANNER MINE						02,04,06,07,09,11,15
SIE-000307H	SIERRA	FS# 05-17-53-0380, ALPO ESTATES	1930					04,06,09,16
SIE-000310/H	SIERRA	FS# 05-17-53-0306, QUERCUS LITHICS						04,06,09
SIE-000314H	SIERRA	FS# 05-11-53-0289, UNION HILL TOWNSITE	1890					02,04,06,09
SIE-000316H	SIERRA	FS# 05-11-53-0292, UPPER CHINA RESERVOIR						02,04,06,08,11,16
SIE-000319/H	SIERRA	FS# 05-17-53-0346, HUFF SITE	1880					02,03,04,06,16
SIE-000321H	SIERRA	FS# 05-17-53-0231, EUREKA CEMETERY	1850	USFS880907B	6Y		11/14/88	04,06,12
SIE-000323H	SIERRA	FS# 05-17-53-0234, SLUG		USFS880907B	6Y		11/14/88	04,06,07,09
SIE-000325H	SIERRA	FS# 05-17-53-0004, EUREKA DIGGINGS	1850					04,06,09,16
SIE-000328/H	SIERRA	FS# 05-17-53-0237, BEN THOMPSONS PLACE	1935					04,06,09,15
SIE-000331/H	SIERRA	FS# 05-17-53-0268, BIG SUGAR						04,06,09
SIE-000333H	SIERRA	FS# 05-17-53-0271, TIMMYS TUNNELS		USFS880907B	6Y		11/14/88	04,06,07,09
SIE-000336/H	SIERRA	FS# 05-17-53-0274, NO NAME CITY		USFS880907B	2S	ACD	3/6/90	02,04,06,08
SIE-000338/H	SIERRA	FS# 05-17-53-0277, BLAMA BOYS SITE						02,04,06,07,09
SIE-000340H	SIERRA	FS# 05-17-53-0281, DONT BUG ME						02,04,06,09
SIE-000343H	SIERRA	FS# 05-17-53-0301, DITCH TENDERS CABIN / WATKINS PROJECT	1900					04,06,07,11
SIE-000364H	SIERRA	FS# 05-17-56-0155, BIG DEPRESSION SITE						02,04,05,06
SIE-000365/H	SIERRA	FS# 05-17-56-0156, BUTLERS CAMP	1915					02,04,05,06,
SIE-000367H	SIERRA	FS# 05-17-56-0160, BUTLERS DEAD END CAMP	1915					02,04,05,06,07,11,16
SIE-000369/H	SIERRA	FS# 05-17-56-0162, SHANTY TOWN MEADOW (B-V)	1915					02,04,06,07,11,16
SIE-000370H	SIERRA	FS# 05-17-56-0163, HOLLOW LOG (B-VI)	1915					04,06,07,16
SIE-000373/H	SIERRA	FS# 05-17-56-0247, S.O.HOLIDAY	1923					04,06,07
SIE-000377H	SIERRA	FS# 05-11-53-0290, GOLD POLE MINE						02,04,06,09,15
SIE-000401H	SIERRA	FS# 05-17-53-0461						02,04,05,06,07,09
SIE-000415H	SIERRA	FS# 05-11-53-0519						02,04,06
SIE-000416H	SIERRA	FS# 05-11-53-0490						02,04,06,07
SIE-000417H	SIERRA	FS# 05-11-53-0491						02,04,06,07,11
SIE-000419H	SIERRA	FS# 05-11-53-0503						02,04,06,07,09,10
SIE-000420H	SIERRA	FS# 05-11-53-0474						02,03,04,06,08,09
SIE-000423H	SIERRA	FS# 05-11-53-0477						02,04,07,08,12
SIE-000431H	SIERRA	FS# 05-11-53-0203						02,03,04,05,06,07,09
SIE-000432H	SIERRA	FS# 05-11-53-0323	1889					02,04,06,07,08,09,11

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
SIE-000434H	SIERRA	FS# 05-17-53-0428						6
SIE-000435H	SIERRA	FS# 05-17-53-0429						02,04,05,06,07,08,09
SIE-000437H	SIERRA	FS# 05-17-53-0286						02,04,06
SIE-000439H	SIERRA	FS# 05-17-53-0288						02,04,06,07,09,11
SIE-000443H	SIERRA	FS# 05-17-53-0292	1850					02,04,05,06,09,11,15
SIE-000448H	SIERRA	FS# 05-17-53-0297						03,04,06,07,09,10
SIE-000454H	SIERRA	FS# 05-17-53-0442	1852					02,04,06,07,09,10,11
SIE-000455H	SIERRA	FS# 05-17-53-0456						02,04,06,07,09
SIE-000458H	SIERRA	FS# 05-17-53-0436						02,04,06,09
SIE-000461H	SIERRA	FS# 05-17-53-0384						6
SIE-000464H	SIERRA	FS# 05-17-53-0241	1858					02,04,06,12
SIE-000466H	SIERRA	FS# 05-17-53-0001						02,03,04,06,07,09,10
SIE-000468H	SIERRA	FS# 05-17-56-0181						02,04,06,07,08
SIE-000477H	SIERRA	FS# 05-17-56-0168						02,04,05,06
SIE-000507H	SIERRA	FS# 05-17-56-0200	1886					02,04,05,06,11
SIE-000513H	SIERRA	FS# 05-17-53-0308						04,06,09,10
SIE-000519H	SIERRA	FS# 05-17-53-0371	1930					02,04,07,08,09,10
SIE-000520H	SIERRA	FS# 05-17-53-0432	1860					02,04,05,06,07,09,10
SIE-000523H	SIERRA	FS# 05-17-53-0451						02,04,06,07,08,09
SIE-000526H	SIERRA	FS# 05-17-53-0391						8
69887	SISKIYOU	MCCLOUD DAM	1965	FERC901220A	6Y1		1/16/91	
SIS-000393H	SISKIYOU		1930					02,04,06
SIS-000515H	SISKIYOU	FS# 05-05-58-0008, MERRILL CREEK DITCH	1898					6
SIS-000549H	SISKIYOU	FS# 05-05-52-0015, MUC A MUC MINE	1870					04,06,09
SIS-000601/H	SISKIYOU	FS# 05-14-61-0047,		USFS880411F	6Y		10/26/88	04,06,16
SIS-000638H	SISKIYOU	GH-2						6
SIS-000738H	SISKIYOU	FS# 05-14-61-0111						04,06,15
SIS-000816H	SISKIYOU	FS# 05-14-61-0141, ALGOMAH MILL	1903					02,04,06,07,10,16
SIS-000881H	SISKIYOU	CA-030-023						04,06,07,09
SIS-000895H	SISKIYOU	GOLDEN SEAL MINE, CA-030-158						02,04,06,09,15
SIS-000896H	SISKIYOU	FINO MINE, CA-030-159						02,06,09
SIS-000897H	SISKIYOU	LOST LEDGE QUARTZ LODE MINE, CA-030-160	1890					06,07,09
SIS-000898H	SISKIYOU	QUARTZ HILL COMPLEX, CA-030-161	1860					04,06,09
SIS-001066/H	SISKIYOU	CA-030-210						02,04,06,07,08,09
SIS-001090/H	SISKIYOU		1852					03,04,06,07,09,10,11
SIS-001091H	SISKIYOU		1852					06,16
SIS-001138H	SISKIYOU	FS# 05-05-51-0069						02,03,04,06,11,15
SIS-001142H	SISKIYOU	FS# 05-05-51-0055	1890					02,04,06,07,09,15
SIS-001163H	SISKIYOU							02,06,07,09,15
107526	SOLANO	PINE LAKE,RESERVOIR (BENICIA ARSENAL)	1939	DOE-48-89-0061-	6Y2		8/31/89	22, 34
107526	SOLANO	PINE LAKE,RESERVOIR (BENICIA ARSENAL)	1939	FHWA890809A	6Y2		8/31/89	
107532	SOLANO	RESERVOIR, BENCIA ARSENAL BUILDING #R	1881	DOE-48-89-0065-	6Y2		8/31/89	22, 34
107532	SOLANO	RESERVOIR, BENCIA ARSENAL BUILDING #R	1881	FHWA890809A	6Y2		8/31/89	
SOL-000065H	SOLANO							06,11
SOL-000275/H	SOLANO							06,09,10
3925	SONOMA	CITY RESERVOIR, OLD RESERVOIR	1925	5472-0132-0000	4S			9, 22
4299	SONOMA	NATHANSON CREEK, BANCROFT	1915	5476-0185-0000	3S			20, 22
68371	SONOMA	DITCH SEGMENT SIPHON		FHWA880909B	6Y		3/7/89	
SON-000086H	SONOMA							7,8,11,16
SON-000104/H	SONOMA	PETERS 104 / CA-SON-104						02,03,08,11,16
SON-000112/H	SONOMA	PETERS 112 / CA-SON-112						08,16

APPENDIX A: WCS Features Listed in OHP Databases*

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
SON-000365/H	SONOMA	BAUERS DM-4 / PETERS 351, CA-SON-365 / CA-SON-351						05,07,08,16
SON-000671/H	SONOMA	CA-SON-671 / SDA-8						05,06,16
SON-000679/H	SONOMA	REDWOOD SPRING SITE, CA-SON-679 / SDA-20						05,06,16
SON-001033/H	SONOMA							02,06,07,15
SON-001126/H	SONOMA	H-26 / H-26:DAVID IRELAND HOMESTEAD	1880					03,04,05,06,11,15
SON-001127/H	SONOMA	H-27 / H-30:JOHN J. VAN ALLEN HOMESTEAD	1870					02,03,04,05,06,07,10
SON-001129/H	SONOMA	H-33:J.H. PRITCHETT HOMESTEAD	1870					02,03,04,05,06,07,10
SON-001131/H	SONOMA	H-38:MOSES HENDRICKS FARMSTEAD	1870					02,03,04,06,07,11
SON-001135/H	SONOMA	H-42 A+B+C+D+E+F:SKAGGS SPRINGS RESORT, SON-594:H42/43A	1850					02,03,04,05,06,07,08
SON-001150/H	SONOMA	WEGENERVILLE RESORT:DR. PATRICK FLYNN, RESIDENCE	1863					02,03,04,05,07,08,10
SON-001162/H	SONOMA							02,06
SON-001166/H	SONOMA	H-21C	1879					02,03,06,07,10,11,15
SON-001188H	SONOMA							04,06
SON-001405H	SONOMA	GRACE HOPKILN COMPLEX	1865					02,03,04,05,06,07,10
SON-001482H	SONOMA	ARS 82-53-1, TODD RANCH						02,03,04,07,08,11,16
SON-001536H	SONOMA	REDWOOD COTTAGE						04,08,16,15
SON-001541H	SONOMA	TUNZI-1H	1880					02,03,04,05,06,07,08
SON-001556H	SONOMA	JLS BARN REMAINS						02,08,11,16
SON-001557H	SONOMA	GRAHAM CREEK DAM						8
SON-001559H	SONOMA	HOME ORCHARD						06,11,16
SON-001577H	SONOMA	COBBLESTONE QUARRY COMPLEX, ASP-87-2H						07,08,11,16
SON-001930	SONOMA	JOHNSON'S CASTLE HOUSE, RANCHO BUENA VIS						02,06,08
68200	STANISLAUS	WHITESIDE MEADOW DAM FS 05-16-53-118		USFS880926A	6Y		10/7/88	
68201	STANISLAUS	MEADOW LAKE DAM FS 05-16-53-119		USFS880926A	6Y		10/7/88	
68202	STANISLAUS	BEAR LAKE DAM FS 05-16-53-120		USFS880926A	6Y		10/7/88	
68203	STANISLAUS	HORSE MEADOW DAM FS 05-16-53-129		USFS880926A	6Y		10/7/88	
68204	STANISLAUS	COW MEADOW LAKE DAM FS 05-16-53-130		USFS880926A	6Y		10/7/88	
68205	STANISLAUS	HUCKLEBERRY LAKE DAM FS 05-16-33-131		USFS880926A	6Y		10/7/88	
68206	STANISLAUS	SNOW LAKE DAM FS 05-16-53-132		USFS880926A	6Y		10/7/88	
68207	STANISLAUS	COOPER MEADOW DAM FS 05-16-53-331		USFS880926A	6Y		10/7/88	
68208	STANISLAUS	MIDDLE EMIGRANT LAKE DAM		USFS880926A	6Y		10/7/88	
68209	STANISLAUS	HIGH EMIGRANT DAM FS 05-16-53-497		USFS880926A	6Y		10/7/88	
68214	STANISLAUS	BIGELOW LAKE DAM FS 05-16-53-134		USFS880926A	2	A	11/14/88	
68215	STANISLAUS	LONG LAKE DAM FS 05-16-53-133		USFS880926A	2	A	11/14/88	
68216	STANISLAUS	EMIGRANT MEADOW LAKE DAM FS 05-16-53-		USFS880926A	2	A	11/14/88	
68218	STANISLAUS	EMIGRANT LAKE DAM FS 05-16-53-137		USFS880926A	2	A	11/14/88	
68219	STANISLAUS	LEIGHTON LAKE DAM FS 05-16-53-495		USFS880926A	2	A	11/14/88	
68220	STANISLAUS	LOWER BUCK LAKE DAM FS 05-16-53-136		USFS880926A	2	A	11/14/88	
91465	STANISLAUS	LA GRANGE DAM	1891	SPHI-STA-003	7L		7/31/79	21
97228	STANISLAUS	OAKDALE IRRIGATION DISTRICT CANALS	1913	FHWA950530A	6Y2		8/16/95	
STA-000147/H	STANISLAUS	TAKIN & LAKIV VILLAGE, FIELD NO. STA-3						02,03,04,06,07,11
STA-000168H	STANISLAUS	TULLOCH MILL&WAREHOUSE, H-8						02,08,11,16
STA-000169H	STANISLAUS	H-9	1860					02,03,05,07,08,11,16
STA-000283H	STANISLAUS							6
STA-000311H	STANISLAUS		1911					3,8,2,6
STA-000344H	STANISLAUS		1900					4,6,16
88683	TEHAMA	CULVERTS AND DRAINAGE DITCHES (HEADQUARTERS)	1927	NPS931216B	2D2	AC	3/21/94	

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
TEH-000967H	TEHAMA	FS# 05-08-53-0211						06,16
TEH-000983/H	TEHAMA	FS# 05-08-51-0141						6
TEH-001098/H	TEHAMA	FS# 05-08-51-0186, MASON CAMP						04,06,16
TEH-001164H	TEHAMA	HHF-46-H						02,04,05,08,10,16
TEH-001171H	TEHAMA	HHF-34-H						6
TEH-001174H	TEHAMA	J-19-H						06,16
TEH-001175H	TEHAMA	D-26-H						06,16
TEH-001176H	TEHAMA	D-25-H						04,06,09
TEH-001279H	TEHAMA							02,04,06
TEH-001281H	TEHAMA							04,05,06,09
TEH-001287H	TEHAMA							04,08
TEH-001312H	TEHAMA							02,08
TEH-001349H	TEHAMA							05,06,11
TEH-001443/H	TEHAMA	CA-030-275						6
TEH-001459/H	TEHAMA	CA-030-311						6
TEH-001460/H	TEHAMA	CA-030-312						02,04,06
TEH-001484H	TEHAMA	CA-030-323	1880					02,03,04,05,08,10,11
45185	TRINITY	HOBOKEN OR HOBOKEN FLAT, HOBOKEN SITE	1858	5527-0012-0000	6			5, 6, 11, 20, 32
45194	TRINITY	SAME/BURNT RANCH SITE, MCDONALD	1855	5527-0016-0000	6			4, 20, 33
50217	TRINITY	UNION HILL MINE	1862	6024-0003-0000	4S			19, 20, 39
50220	TRINITY	CLEMENT RANCH, RK RANCH	1855	6024-0006-0000	3S			4, 20, 33
50339	TRINITY	ARKANSAS DAM SITE	1850	6048-0001-0000	6			2, 4, 6, 21
50341	TRINITY	STURDEVANT RANCH, SKY RANCH	1853	6048-0003-0000	6			11, 19, 20, 30, 32, 33
50366	TRINITY	JACKASS BAR, CANYON CITY	1851	6048-0007-9999	4D			2, 5, 6, 14, 15, 20
50370	TRINITY	SAME-COOPERS BAR, MCGILLIVRAYS RANCH	1851	6048-0011-0000	6			20, 29, 30, 33, 39
50399	TRINITY	GRASS VALLEY SCHOOL		6052-0008-0000	5S			15, 20, 30, 37
50436	TRINITY	SAME/COMBS SPRINGS/COMBSVILLE, DEER L	1885	6076-0001-0000	3S			2, 4, 20, 30
50501	TRINITY	THE HOLLAND MINE		6091-0024-0000	4S			4, 11, 20, 21
50507	TRINITY	OLD TRINITY CENTER/CARRVILLE	1852	6091-0030-9999	4D			11, 20, 33, 39
50516	TRINITY	LA GRANGE MINE, LA GRANGE MINE SITE	1862	6093-0003-0000	3S			2, 5, 15, 20, 37
50516	TRINITY	LA GRANGE MINE, LA GRANGE MINE SITE	1862	SHL-0778	7L		9/25/62	5
50518	TRINITY	LA GRANGE MINE WATER SYSTEM		6093-0005-0000	3S			20
50522	TRINITY	DIENER HOUSE,MINE,TRESTLE	1853	6093-0009-0000	4S			2, 11, 20
50612	TRINITY	BUCKEYE DITCH	1875	6093-0019-0000	3S			11, 20
50644	TRINITY	BOLTS HILL, BUCKEYE DITCH	1875	6093-0051-0000	3S			39
68828	TRINITY	GRAY'S DITCH		FHWA900913A	6Y1		10/10/90	
TRI-000140/H	TRINITY	FS# 05-14-52-0002, NATURAL BRIDGE MASSACRE SITE	1852					04,06,08,09,16
TRI-000291H	TRINITY	FS# 05-14-56-0027, C C C SPIKE CAMP						02,06,09,16
TRI-000293H	TRINITY	FS# 05-14-56-0029, GOLD MINE						06,09
TRI-000297H	TRINITY	FS# 05-14-56-0033						06,09
TRI-000298H	TRINITY	FS# 05-14-56-0034	1900					04,06,16
TRI-000299H	TRINITY	FS# 05-14-56-0035, HWY 299 @ P.M. 27.8		USFS940307Z	6Y2		4/5/94	06,16
TRI-000300H	TRINITY	FS# 05-14-56-0036, POND #2						06,08
TRI-000301H	TRINITY	FS# 05-14-56-0037						06,16
TRI-000303H	TRINITY	FS# 05-14-56-0039, HAYWARD FLAT 1						06,16
TRI-000315H	TRINITY	FS# 05-14-56-0062	1930					04,06,15
TRI-000426H	TRINITY	FS# 05-10-53-0072, WILLIAMSON GRAY HOMESTEAD	1914					02,03,04,06
TRI-000441/H	TRINITY	FS# 05-14-51-0072, WATSON CABIN						02,04,06,09,11
TRI-000486H	TRINITY	FS# 05-14-52-0075						02,03,04,06,07,16

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
TRI-000526H	TRINITY	FS# 05-14-54-0054						6
TRI-000529H	TRINITY	FS# 05-14-56-0186						02,06,10
TRI-000546H	TRINITY	FS# 05-14-56-0283, GOLD HILL MINE						6
TRI-000551H	TRINITY	FS# 05-14-56-0249						04,06,09
TRI-000554H	TRINITY	FS# 05-14-51-0086						08,09,15,16
TRI-000565H	TRINITY	FS# 05-14-56-0189						04,06
TRI-000605H	TRINITY	FS# 05-14-54-0163						02,04,06,09,10,15
TRI-000618H	TRINITY	FS# 05-14-54-0057, RIPSTEIN CAMPGROUND		USFS960130G	6Y2		2/6/96	06,09
TRI-000632H	TRINITY	FS# 05-14-56-0303, PAPOOSE CREEK TRAIL AND MINE						02,04,06,07,09,10,15
TRI-000652H	TRINITY	FS# 05-14-54-0074, RED ROCK MINING CLAIM	1900					02,04,05,06,09,16
TRI-000678H	TRINITY							04,06,07,09,10
TRI-000679H	TRINITY	FS# 05-14-56-0273						04,06,15,16
TRI-000684H	TRINITY	FS# 05-14-56-0323, BUCKEYE DITCH TUNNEL						06,07,16
TRI-000686H	TRINITY	FS# 05-14-56-0289, RICH HYDRAULIC MINING RESERVOIR						06,08
TRI-000697/H	TRINITY	FS# 05-14-54-0077, DUTCH CREEK RANCH	1900					02,03,03,06,09,11
TRI-000698H	TRINITY	FS# 05-14-54-0078, MAPLE CREEK MINE	1890					04,06,09,15
TRI-000699H	TRINITY	FS# 05-14-54-0079, KUNZ MINE	1890					04,06,07,09
TRI-000700H	TRINITY	FS# 05-14-54-0080, DUTCH CREEK MINE	1900					02,04,06,09
TRI-000712/H	TRINITY	FS# 05-14-54-0043, EAGLE RANCH	1870		2S1	D	2/2/82	03,04,06,11,15,16
TRI-000721H	TRINITY	FS# 05-14-56-0325, BOTTS MINE	1875					04,06,09
TRI-000773H	TRINITY	FS# 05-14-52-0253, CONRAD GULCH MINE SITE						04,06,09,16
TRI-000775H	TRINITY	FS# 05-14-52-0252, S HAYFORK VALLEY WATER TRANS LINE						06,09
TRI-000834H	TRINITY	FS# 05-14-52-0213	1880					02,04,06,09,11
TRI-000840H	TRINITY	CLEAR GULCH MINE, CA-030-027	1883					02,06,07,09
TRI-000841H	TRINITY	CA-030-006	1890					02,04,06,09
TRI-000904H	TRINITY	FS# 05-14-51-0031						02,03,04,08,11
TRI-000913H	TRINITY	FS# 05-14-52-0206						6
TRI-000928H	TRINITY	FS# 05-14-56-0406						04,06,11
TRI-000929H	TRINITY	FS# 05-14-56-0408						02,04,06,09
TRI-000931H	TRINITY	FS# 05-14-56-0410	1890					02,04,06,09
TRI-000937H	TRINITY	FS# 05-14-59-0201						08,09
TRI-000941H	TRINITY	FS# 05-14-54-0128						6
TRI-000943H	TRINITY							02,04,06,07,09,11
TRI-000944H	TRINITY	FS# 05-14-56-0385, LA GRANGE DITCH SYSTEM	1893					02,04,06,08,11,16
TRI-000950H	TRINITY	FS# 05-14-52-0351	1940					02,04,06,07,09,10,15
TRI-001017H	TRINITY	FS# 05-14-56-0444, MIDDLE MOONEY MINING MADNESS						02,04,06,09,10
TRI-001043H	TRINITY	FS# 05-14-56-0438						6
TRI-001044H	TRINITY	FS# 05-14-56-0398	1893					6
TRI-001045H	TRINITY	FS# 05-14-56-0399						6
TRI-001047H	TRINITY	FS# 05-14-56-0404						06,16
TRI-001138H	TRINITY	UPPER/LOWER DITCH		USFS880211C	6Y2		2/22/88	
TRI-Z00006H	TRINITY	BOWERMAN DITCH (MEANDERING DITCH)		USFS930927D	6Y2		4/6/94	
TRI-Z00017	TRINITY	FS# 05-14-54-0229, LADD RANCH DITCH		USFS950925A	6Y2		10/11/95	
TRI-Z00021	TRINITY	MILL DITCH 05-14-52-146		USFS960418A	6Y2		4/25/96	
TRI-Z00024H	TRINITY	TAYLOR FLAT DITCH		USFS960521C	6Y2		5/29/96	
51064	TULARE	BR 46-10	1911	3208-0001-0000	3S			9, 19, 21, 72, 96
67707	TULARE	PERSIAN DITCH		FHWA900423A	2	AC	5/21/90	

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68247	TULARE	KAWEAH HYDROELECTIC SYSTEM NO. 3	1912	FERC890210A	2D2	AC	8/27/90	9, 20, 21, 22
68847	TULARE	MARBLE FORK DAM	1913	FERC890210A	6Y1		10/9/90	
68848	TULARE	MIDDLE FORK DAM	1913	FERC890210A	6Y1		10/9/90	
73155	TULARE	DINUBA TOWN DITCH	1884	FHWA910903C	6Y1		10/10/91	
73156	TULARE	SMITH MOUNTAIN CANAL	1884	FHWA910903C	6Y1		10/10/91	
93557	TULARE	BAHWELL-BEQUETTE HISTORIC DISTRICT	1870	54-0005				2, 20, 37
TUL-000561H	TULARE							04,06,16
TUL-000801H	TULARE	CSUF-426 / DRS-2						02,03,05,06,07,16
TUL-000823H	TULARE	JOHNSONDALE	1937					03,04,07,08,10,15
TUL-001085H	TULARE	FS# 05-13-53-0020						6
TUL-001095/H	TULARE	TUL-RIV-IND-RES #1						02,06
TUL-001096/H	TULARE	TUL-RIV-IND-RES #2						02,06,01
TUL-001131H	TULARE	FS# 05-13-52-0147						02,06,07
TUL-001494/H	TULARE	05-13-56-471						08,16
67813	TUOLUMNE	RELIEF RESERVOIR HISTORIC DISTRICT		USFS900124D	2	ACD	2/20/90	
67814	TUOLUMNE	RELIEF DAM AND RESERVOIR		USFS900124D	2D	ACD	2/20/90	
73519	TUOLUMNE	PHOENIX DITCH	1852	FHWA910920A	6Y1		10/10/91	
73520	TUOLUMNE	SONORA DITCH	1920	FHWA910920A	6Y1		10/10/91	
TUO-000373/H	TUOLUMNE	GARDELLA 15, 4-TUO-S373						4,5,6
TUO-000381/H	TUOLUMNE	CLAVEY P2-1, 4-TUO-S381						8,9,11,16
TUO-000438H	TUOLUMNE	NMP-101/TUO-S-438		078 0050075	2D1	ACD	11/28/78	08,15,16
TUO-000442	TUOLUMNE	NMP-405/TUO-S-442		078 0050075	2D1	ACD	11/28/78	06,08,11
TUO-000443H	TUOLUMNE	NMP-407/TUO-S-443		078 0050075	2D1	ACD	11/28/78	06,11
TUO-000452H	TUOLUMNE	NMP-410/TUO-S-452		078 0050075	2D1	ACD	11/28/78	06,11,15,16
TUO-000468H	TUOLUMNE	NMP-212 / TUO-S-468		078 0050075	2D1	ACD	11/28/78	04,08,11
TUO-000471H	TUOLUMNE	NMP-307 / TUO-S-471		078 0050075	2D1	ACD	11/28/78	08,16
TUO-000476/H	TUOLUMNE	NMP-414 4-TUO-S476		078 0050075	2D1	ACD	11/28/78	08,16
TUO-000478/H	TUOLUMNE	NMP-55,56; TUO-S479,478		078 0050075	2D1	ACD	11/28/78	06,07
TUO-000486/H	TUOLUMNE	NMP-208,214; 4-TUO-S486A		078 0050075	2D1	ACD	11/28/78	06,16
TUO-000547H	TUOLUMNE	NMP-317 / TUO-S-547		078 0050075	2D1	ACD		06,07,16
TUO-000549H	TUOLUMNE	NMP-61 / TUO-S-549		078 0050075	2D1	ACD	11/28/78	6
TUO-000552H	TUOLUMNE	NMP-68 / TUO-S-552		078 0050075	2D1	ACD	11/28/78	02,08,11,16
TUO-000553H	TUOLUMNE	NMP-74 / TUO-S-553		078 0050075	2D1	ACD	11/28/78	6
TUO-000556H	TUOLUMNE	NMP-75 / TUO-S-556		078 0050075	2D1	ACD	11/28/78	8
TUO-000564H	TUOLUMNE	NMP-431 / TUO-S-564		078 0050075	2D1	ACD	11/28/78	8
TUO-000571H	TUOLUMNE	NMP-332 / TUO-S-571		078 0050075	2D1	ACD	11/28/78	8
TUO-000572H	TUOLUMNE	NMP-334 / TUO-S-572		078 0050075	2D1	ACD	11/28/78	08,11
TUO-000573H	TUOLUMNE	NMP-338 / TUO-S-573		078 0050075	2D1	ACD	11/28/78	08,16
TUO-000584H	TUOLUMNE	NMP-243 / TUO-S-584		078 0050075	2D1	ACD	11/28/78	06,08
TUO-000587H	TUOLUMNE	NMP-232 / TUO-S-587		078 0050075	2D1	ACD	11/28/78	06,16
TUO-000589H	TUOLUMNE	NMP-339 / TUO-S-589		078 0050075	2D1	ACD	11/28/78	06,16
TUO-000590H	TUOLUMNE	TUO-S-590 / NMP-249		078 0050075	2D1	ACD	11/28/78	08,16
TUO-000593H	TUOLUMNE	NMP-247 / TUO-S-593		078 0050075	2D1	ACD	11/28/78	06,11,16
TUO-000594H	TUOLUMNE	NMP-329 / TUO-S-594		078 0050075	2D1	ACD	11/28/78	06,16
TUO-000596H	TUOLUMNE	NMP-239 / TUO-S-596		078 0050075	2D1	ACD	11/28/78	6
TUO-000598H	TUOLUMNE	TUO-S-598 / NMP-457		078 0050075	2D1	ACD	11/28/78	02,08,09,16
TUO-000602/H	TUOLUMNE	4-TUO-S-602/NMP-445		078 0050075	2D1	ACD	11/28/78	08,09,11,16
TUO-000606/H	TUOLUMNE	4-TUO-S606/NMP-535		078 0050075	2D1	ACD	11/28/78	07,08,15,16
TUO-000611/H	TUOLUMNE	4-TUO-S611/ NMP-515		078 0050075	2D1	ACD	11/28/78	08,16
TUO-000623/H	TUOLUMNE	4-TUO-S623/NMP-458		078 0050075	2D1	ACD	11/28/78	06,11,16
TUO-000630/H	TUOLUMNE	4-TUO-S-630 / NMP-514		078 0050075	2D1	ACD	11/28/78	6

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TUO-000642/H	TUOLUMNE	4-TUO-S-642/NMP-287		078 0050075	2D1	ACD	11/28/78	06,11,16
TUO-000649H	TUOLUMNE	TUO-S-649 / NMP-177		078 0050075	2D1	ACD	11/28/78	06,16
TUO-000659H	TUOLUMNE	TUO-S-659 / NMP-446		078 0050075	2D1	ACD	11/28/78	08,11,16
TUO-000669H	TUOLUMNE	TUO-S-669 / NMP-169		078 0050075	2D1	ACD	11/28/78	06,11
TUO-000670H	TUOLUMNE	TUO-S-670 / NMP-166		078 0050075	2D1	ACD	11/28/78	6
TUO-000671H	TUOLUMNE	TUO-S-671 / NMP-170		078 0050075	2D1	ACD	11/28/78	6
TUO-000683H	TUOLUMNE	TEMP #6						08,09
TUO-000726/H	TUOLUMNE	AC-19						06,11
TUO-000727/H	TUOLUMNE	AC-20						6
TUO-000730/H	TUOLUMNE	AC-23						6
TUO-000731/H	TUOLUMNE	AC-24						6
TUO-000732/H	TUOLUMNE	AC-25						6
TUO-000779H	TUOLUMNE	MR-2						08,11
TUO-000803H	TUOLUMNE	NMP-309/TUO-S-501		078 0050075	2D1	ACD	11/28/78	06,16
TUO-000806H	TUOLUMNE	NMP-309(b) / 4-TUO-S-504		078 0050075	2D1	ACD	11/28/78	6
TUO-000825/H	TUOLUMNE	NMP-225/TUO-S-523		078 0050075	2D1	ACD	11/28/78	06,07,11,16
TUO-000900/H	TUOLUMNE	4-TUO-S-303;TUO-309						06,11
TUO-000918/H	TUOLUMNE	SCOFIELD HOMESTEAD,BRUNETTE RANCH, 4-TUO-S-347;TUO-483	1928					2,3,4,5,6,7,10,11
TUO-001237H	TUOLUMNE	FS# 05-00--0000, SOUTH FORK FLAT						4,6,8,16
TUO-001245/H	TUOLUMNE	FS# 05-16-51-0148, DINGALING FLAT						6
TUO-001293/H	TUOLUMNE	GOODWIN-1	1848					06,11
TUO-001297/H	TUOLUMNE	TUO-G-28,G-31,G-32						06,08
TUO-001299/H	TUOLUMNE	TUO-G-22						06,08,09
TUO-001300H	TUOLUMNE	TUO-G-33						6
TUO-001306H	TUOLUMNE							06,09,11
TUO-001311H	TUOLUMNE	TUO-G-13						06,09,15
TUO-001313H	TUOLUMNE							04,06,09
TUO-001315H	TUOLUMNE							06,09
TUO-001362H	TUOLUMNE							8
TUO-001364H	TUOLUMNE							07,08,16
TUO-001365H	TUOLUMNE							06,09,16
TUO-001369H	TUOLUMNE							05,06
TUO-001370H	TUOLUMNE							06,09
TUO-001371H	TUOLUMNE							02,08,16
TUO-001372H	TUOLUMNE							06,16
TUO-001376H	TUOLUMNE							6
TUO-001411/H	TUOLUMNE	FS# 05-16-54-0416,						04,06,16
TUO-001412H	TUOLUMNE	5-16, 54-417						06,08
TUO-001481H	TUOLUMNE	FS# 05-16-53-0022						02,08,16
TUO-001512H	TUOLUMNE	FS# 05-16-53-0338, FIELD SITE #S-5 / MINER'S DITCH, 05-16-49-5F						6
TUO-001523H	TUOLUMNE							6
TUO-001592H	TUOLUMNE	FS# 05-16-54-0443						06,11
TUO-001751H	TUOLUMNE	FS# 05-16-54-0322, GOLDEN ROCK DITCH	1859					6
TUO-001803H	TUOLUMNE	FS# 05-16-51-0325						6
TUO-001807H	TUOLUMNE	FS# 05-16-51-0337						6
TUO-001809H	TUOLUMNE	FS# 05-16-51-0339						6
TUO-001823H	TUOLUMNE	FS# 05-16-51-0364						6
TUO-001839H	TUOLUMNE	FS# 05-16-54-0390						6
TUO-001844/H	TUOLUMNE	FS# 05-16-54-0909, P-55-357, REPORT NO: 570						4,16,7,8,15

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TUO-001862H	TUOLUMNE	FS# 05-16-54-0417						6, 16
TUO-001874H	TUOLUMNE	FS# 05-16-51-0251						6
TUO-001876H	TUOLUMNE	FS# 05-16-51-0253						6
TUO-001896H	TUOLUMNE	FS# 05-16-51-0290						6
TUO-001964H	TUOLUMNE	FS# 05-16-54-0556						04,08
TUO-001966H	TUOLUMNE	FS# 05-16-54-0561						8
TUO-001968H	TUOLUMNE	FS# 05-16-54-0563						6
TUO-001970H	TUOLUMNE	FS# 05-16-54-0567						6
TUO-001980H	TUOLUMNE	FS# 05-16-54-0023						04,06
TUO-001987H	TUOLUMNE	FS# 05-16-54-0424						9,2,6
TUO-001988H	TUOLUMNE	FS# 05-16-54-0425						6
TUO-001989/H	TUOLUMNE	FS# 05-16-54-0426,						9,4,2,6
TUO-001991H	TUOLUMNE	FS# 05-16-54-0429						06,08
TUO-001993H	TUOLUMNE	FS# 05-16-54-0431						6
TUO-001996H	TUOLUMNE	FS# 05-16-54-0478						06,09,15
TUO-001998H	TUOLUMNE	FS# 05-16-54-0480						6
TUO-002006H	TUOLUMNE	FS# 05-16-54-0488						6
TUO-002009H	TUOLUMNE	FS# 05-16-54-0492						6
TUO-002012H	TUOLUMNE	FS# 05-16-54-0495						6
TUO-002016H	TUOLUMNE	FS# 05-16-54-0500						6
TUO-002019H	TUOLUMNE	FS# 05-16-54-0503						06,08
TUO-002023H	TUOLUMNE	FS# 05-16-54-0510						04,06,09
TUO-002025H	TUOLUMNE	FS# 05-16-54-0512,						6
TUO-002030H	TUOLUMNE	FS# 05-16-54-0555						6
TUO-002064/H	TUOLUMNE	FS# 05-16-51-0071						2,4,6,11,16
TUO-002066H	TUOLUMNE	FS# 05-16-52-0479						6
TUO-002109H	TUOLUMNE	FS# 05-16-53-0469	1920					4,6,7
TUO-002144H	TUOLUMNE	CVE 1						5,6,9,10
TUO-002145H	TUOLUMNE	CVE 2						5,6,9,8
TUO-002182H	TUOLUMNE	GOLF 4						6
TUO-002183H	TUOLUMNE	GOLF 5						6
TUO-002184H	TUOLUMNE	GOLF 6						6
TUO-002187H	TUOLUMNE	BOS 1						6
TUO-002188H	TUOLUMNE	BOS 3,						6
TUO-002189H	TUOLUMNE	BOS 4						6
TUO-002190H	TUOLUMNE	BOS 5						6
TUO-002201H	TUOLUMNE	BR 2						6,8
TUO-002220H	TUOLUMNE	FS# 05-16-51-0433						2,6,8,9,
TUO-002222/H	TUOLUMNE	FS# 05-16-51-0435						4,6,7,8,9,10,11,15
TUO-002230/H	TUOLUMNE	KISTLER RANCH 1						8,9
TUO-002237/H	TUOLUMNE	FS# 05-16-51-0422						2,4,6,8,9,11,15
TUO-002241H	TUOLUMNE	FS# 05-16-51-0676						2,6
TUO-002243H	TUOLUMNE	FS# 05-16-54-0725, MARY ELLEN O						2,4,6,7,8,9,10,15
TUO-002255H	TUOLUMNE	MARLOW DIGGINGS/DITCH						6,9
TUO-002260H	TUOLUMNE	ROAD MINE						9,7,6,16
TUO-002290H	TUOLUMNE	FS# 05-16-51-0533						6,7,16
TUO-002304H	TUOLUMNE	FS# 05-16-51-0572						6
TUO-002317H	TUOLUMNE	FS# 05-16-51-0557						9,11,6
TUO-002319H	TUOLUMNE	FS# 05-16-51-0560						9,6,16
TUO-002348H	TUOLUMNE	CRYSTAL SPRING PLACER, K-1	1888					6,9,11
TUO-002354H	TUOLUMNE	FS# 05-16-54-0058, JAWBONE STATION, GARAGE	1935					15,6

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
TUO-002362H	TUOLUMNE	FS# 05-16-53-0507, RELIEF DAM AND RESERVOIR	1906					2,8,10,16
TUO-002363H	TUOLUMNE	FS# 05-16-53-0138, RELIEF DAM AND CONSTRUCTION SITE	1906					2,4,5,7,8,10,16
TUO-002394H	TUOLUMNE	GW33						6
TUO-002398H	TUOLUMNE	GW-37						8,9,16
TUO-002411H	TUOLUMNE	MINING DITCH AND RESERVOIR, EG-2						2,11
TUO-002412H	TUOLUMNE	COLUMBIA GOLD MINING DISTRICT,						5,2,11,8,6
TUO-002440H	TUOLUMNE	FS# 05-16-51-0582, FAIR OAKS MINE						6,9,16
TUO-002445/H	TUOLUMNE	FS# 05-16-54-0346						8,6,16
TUO-002460H	TUOLUMNE	VCE #2						6,9,16
TUO-002463H	TUOLUMNE	VCE-5						6
TUO-002467/H	TUOLUMNE	HATCHERY WEST						8,11,3,16
TUO-002488H	TUOLUMNE	FS# 05-16-51-0609		USFS900816A	6Y1		7/25/91	6
TUO-002514H	TUOLUMNE	FS# 05-16-51-0650						6
TUO-002539H	TUOLUMNE	GIBBS 2 (MORALES)						3,4,8
TUO-002570H	TUOLUMNE	THOMPSON 1						6
TUO-002624H	TUOLUMNE	FS# 05-16-51-0563						3,6,16
TUO-002629H	TUOLUMNE	FS# 05-16-53-0523, SUMMIT CREEK MEASURING WEIR	1906					6,16
TUO-002636H	TUOLUMNE	FS# 05-16-51-0022						15,6
TUO-002644H	TUOLUMNE	JL-1	1852					6,8
TUO-002645H	TUOLUMNE	JL-2						8,9
TUO-002679H	TUOLUMNE	FS# 05-16-54-0858						6
TUO-002698H	TUOLUMNE	FS# 05-16-54-1044						6
TUO-002700H	TUOLUMNE	FS# 05-16-54-1046						6
TUO-002706H	TUOLUMNE	FS# 05-16-54-1043						6,8
TUO-002714H	TUOLUMNE	FS# 05-16-54-1090						7,2,4,6,16
TUO-002722H	TUOLUMNE	CHEROKEE DITCH, F-1	1854					6
TUO-002723H	TUOLUMNE	YUKON MINE	1902					2,6,9,11
TUO-002724H	TUOLUMNE	LANDER DITCH SPUR, DENIS 4	1876					6
TUO-002726H	TUOLUMNE	DENIS 5						6
TUO-002734H	TUOLUMNE	FS# 05-16-54-0965						2,11,6
TUO-002758H	TUOLUMNE	FS# 05-16-54-0779						9,6
TUO-002759H	TUOLUMNE	WARD'S FERRY CROSSING, NS-1	1912					6,16
TUO-002762H	TUOLUMNE	NS-5						6,16
TUO-002764H	TUOLUMNE	NS-7						8,15,16
TUO-002765H	TUOLUMNE	PHOENIX DITCH, NS-9						6,8,16
TUO-002777H	TUOLUMNE	NS-31						6
TUO-002785H	TUOLUMNE	NELSON 3						6
TUO-002842/H	TUOLUMNE	SC-S-1						2,4,6,15,16
TUO-002857H	TUOLUMNE	FIELD SITE #S-6						6
TUO-002858H	TUOLUMNE	FIELD SITE #S-7						6
TUO-002859H	TUOLUMNE	FIELD SITE #S-8						6
TUO-002861H	TUOLUMNE	FIELD SITE #S-10 / COLUMBIA DITCH						6
TUO-002879H	TUOLUMNE	ROACH'S CAMP DITCH, M-3						6,11
TUO-002894H	TUOLUMNE	CLAVEY P2-5						8,9,16
TUO-002900H	TUOLUMNE	SMITH DITCH, SMC-3						9 0
TUO-002908H	TUOLUMNE	GARDELLA 7	1871					6
TUO-002911H	TUOLUMNE	GARDELLA 10						6,9
TUO-002931H	TUOLUMNE	JAMESTOWN DITCH						6
TUO-002933H	TUOLUMNE	FS# 05-16-54-1295, KANAKA DITCH						6,15,16

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
TUO-002946H	TUOLUMNE							6
TUO-002963H	TUOLUMNE							6
TUO-002965H	TUOLUMNE							9,6
TUO-002966H	TUOLUMNE							6
TUO-002967H	TUOLUMNE							6
TUO-002971H	TUOLUMNE							6
TUO-002975H	TUOLUMNE							6
TUO-003028H	TUOLUMNE							6
TUO-003109/H	TUOLUMNE	FS# 05-16-51-0437, FS 05-16-0476						2,4,6,16
TUO-003120H	TUOLUMNE							6,16
TUO-003122H	TUOLUMNE	AMERICAN CAMP DITCH						6
TUO-003134H	TUOLUMNE		1859					6
TUO-003135H	TUOLUMNE							3,9,11,8,16
TUO-003136H	TUOLUMNE							6,16
TUO-003163H	TUOLUMNE							4,6,9,11,16
TUO-003166/H	TUOLUMNE							6,8,4,16
TUO-003174H	TUOLUMNE							6,2,16
TUO-003175H	TUOLUMNE							6,16
TUO-003176H	TUOLUMNE							6,16
TUO-003178H	TUOLUMNE							6,16
TUO-003180H	TUOLUMNE							4,6
TUO-003182H	TUOLUMNE							2,4,6,9,16
TUO-003183H	TUOLUMNE							4,6,16
TUO-003197H	TUOLUMNE							6,11
TUO-003208H	TUOLUMNE							6
TUO-003225H	TUOLUMNE							6
TUO-003242H	TUOLUMNE	FS# 05-16-51-1063, REPORT NO: 679						8
TUO-003257H	TUOLUMNE	FS# 05-16-53-0481, DAM ON COW CREEK						8,6
TUO-003286H	TUOLUMNE	FS# 05-16-51-0849, REPORT NO.: 05-16-0657						6
TUO-003289H	TUOLUMNE	FS# 05-16-51-0869, REPORT NO.: 05-16-0657						6
TUO-003290H	TUOLUMNE	FS# 05-16-51-0870, REPORT NO.: 05-16-0657						6
TUO-003291H	TUOLUMNE	FS# 05-16-51-0901, REPORT NO.: 05-16-0657						6
TUO-003292H	TUOLUMNE	FS# 05-16-51-0902, REPORT NO.: 05-16-0657						6
TUO-003301H	TUOLUMNE							6,7,10,16
TUO-003305H	TUOLUMNE	SHAWS FLAT DITCH						6
TUO-003310H	TUOLUMNE	FS# 05-16-54-1238, REPORT NO: 809						5,6,16
TUO-003340H	TUOLUMNE							6,7,16
TUO-003356H	TUOLUMNE							6,16
TUO-003357H	TUOLUMNE							6,4,16
TUO-003361H	TUOLUMNE							6,4,16
TUO-003385/H	TUOLUMNE							6,4
TUO-003387H	TUOLUMNE							6
TUO-003388H	TUOLUMNE							6
TUO-003389/H	TUOLUMNE							2,16,4,6,11
TUO-003412/H	TUOLUMNE	FS# 05-16-51-0004, INDIAN SPRING, SCHOETTGEN						4,6
TUO-003428H	TUOLUMNE	FS# 05-16-51-1016, REPORT NO: 592						2,11,5,4,8
TUO-003429/H	TUOLUMNE							6,16
TUO-003430/H	TUOLUMNE							8,4
TUO-003436H	TUOLUMNE							16,4,6,2
TUO-003440H	TUOLUMNE	FS# 05-16-51-0620, REPORT NO: 476						6,16
TUO-003442H	TUOLUMNE	FS# 05-16-51-0624, REPORT NO: 476						8,6,16

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
TUO-003444H	TUOLUMNE	FS# 05-16-51-0652, REPORT NO: 476						8,16
TUO-003448H	TUOLUMNE							6
TUO-003449H	TUOLUMNE							6
TUO-003451H	TUOLUMNE	FS# 05-16-51-1146, REPORT NO: 1038						8,16
TUO-003452H	TUOLUMNE	FS# 05-16-51-1147, REPORT NO: 1038						6
TUO-003454H	TUOLUMNE	FS# 05-16-51-1149, REPORT NO: 1038						6
TUO-003455H	TUOLUMNE	FS# 05-16-51-1150, REPORT NO: 1038						6
TUO-003456H	TUOLUMNE	FS# 05-16-51-1151, REPORT NO: 1038						6
TUO-003457H	TUOLUMNE	FS# 05-16-51-1152, REPORT NO: 1038						6
TUO-003458H	TUOLUMNE	FS# 05-16-51-1153, REPORT NO: 1038						6
TUO-003459H	TUOLUMNE	FS# 05-16-51-1154, REPORT NO: 1038						6
TUO-003460H	TUOLUMNE	FS# 05-16-51-1155, REPORT NO: 1038						6
TUO-003461H	TUOLUMNE	FS# 05-16-51-1156, REPORT NO: 1038						6
TUO-003466H	TUOLUMNE	FS# 05-16-53-0622, REPORT NO: CRMR#3001						6,16,4
TUO-003487H	TUOLUMNE	FS# 05-16-51-1052, CHARLES BAKER						6,11,16
TUO-003543H	TUOLUMNE	DRI						6
TUO-003558H	TUOLUMNE	FS# 05-16-54-0719, P-55-313						6
TUO-003560H	TUOLUMNE							6
TUO-003565H	TUOLUMNE	FS# 05-16-51-0058, P-55-329						6
TUO-003581H	TUOLUMNE	FS# 05-16-51-0926, P-55-385, REPORT NO: 679						6,16,4
TUO-003583H	TUOLUMNE	FS# 05-16-51-0927, P-55-387, REPORT NO: 679						16,6
TUO-003588H	TUOLUMNE	FS# 05-16-51-0879, P-55-392, REPORT NO: 605						6,7
TUO-003592H	TUOLUMNE	FS# 05-16-51-0934, P-55-396, REPORT NO: 605						6,16
TUO-003595H	TUOLUMNE	FS# 05-16-51-0938, P-55-400, REPORT NO: 679						4,6
TUO-003616H	TUOLUMNE	FS# 05-16-51-0948, P-55-423, REPORT NO: 679						6,16
TUO-003642H	TUOLUMNE	FS# 05-16-51-0957, P-55-467, REPORT NO: 679						4,6,16
TUO-003692H	TUOLUMNE	APP DITCH						6
ZZZ-000023	UNKNOWN	VANDER PLAS DITCH			6Y2		6/12/90	
ZZZ-000157	UNKNOWN	NID DITCH		FHWA921028A	6Y1		2/26/93	
ZZZ-000175H	UNKNOWN	HAYFORD CREEK DITCH		USFS920130Z	6Y1		2/6/92	
15478	VENTURA	SAN BUENAVENTURA MISSION AQUEDUCT	1782	SHL-0114-01	7L		6/12/89	11, 20, 28, 30, 36
15478	VENTURA	SAN BUENAVENTURA MISSION AQUEDUCT	1782	NPS-75000497-0000	1S		3/7/75	
15603	VENTURA	SAN BUENAVENTURA MISSION DISTRICT	1782	3001-0075-9999	7K		7/1/83	4, 6, 11, 16, 20, 36
15603	VENTURA	SAN BUENAVENTURA MISSION DISTRICT	1782	NPS-75000496-9999	1S	AD	4/10/75	
16238	VENTURA	RESERVOIR	1911	3015-0119-0005	3D			22
16370	VENTURA	ANNE LINN GIBSON RESERVOIR	1900	3023-0030-0002	6			22
17050	VENTURA	SOUTHSIDE RESERVOIR	1887	3034-0003-0002	4B			22
17075	VENTURA	STONE & CONCRETE DITCH, ROBERTSON RANCH		3034-0022-0004	4B			11
17225	VENTURA	PIRU WATER SYSTEM DITCH	1888	3040-0058-0000	6			32
17633	VENTURA	PRESA DE SAN FRANCESQUITO		3060-0098-9999	7			2, 21, 36
99037	VENTURA	RESERVIOR #1	1919	DOE-56-94-0041-	2S2	A	4/13/94	22
99037	VENTURA	RESERVIOR #1	1919	HRG940202Z	2S2	A	4/13/94	
VEN-000059/H	VENTURA	VE-22						06,16
VEN-000082H	VENTURA							06,16
VEN-000368H	VENTURA	FS# 05-07-55-0052	1877	USFS770826A	2S1	CD	12/16/77	6
VEN-000725H	VENTURA							02,08,11
45778	YOLO	CAPAY DAM	1915	5607-0015-0000	3S			21
46355	YOLO	COLUSA DRAINAGE CANAL	1914	5645-0002-0000	4S			20
46756	YOLO	SACRAMENTO WEIR & YOLO BYPASS	1918	5691-0023-0000	3S			9, 19, 21
47422	YOLO	MOORE DITCH	1856	5695-0343-0000	3S			20
93387	YOLO	MORTOR-BLACKER CANAL	1911	FHWA940711A	6Y2		8/2/94	

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
93392	YOLO	MAIN CANAL, RECLAMATION DISTRICT 900	1911	FHWA940711A	6Y2		8/2/94	
YUB-000194H	YUBA	TIMBUCTOO / MDAS SITE D						02,03,04,05,06,07
YUB-000198H	YUBA	MDAS SITE CC						06,16
YUB-000199H	YUBA	MDAS SITE FD						06,08,09
YUB-000201H	YUBA	MDAS SITE FF						02,04,06,09,
YUB-000206H	YUBA	MARK ANTONY MINE / MDAS SITE EJ						06,09
YUB-000254H	YUBA	PBAS II 126						8
YUB-000260H	YUBA	PBAS II 150						6
YUB-000279H	YUBA	PBAS II 55						6
YUB-000284H	YUBA	PBAS II 75						8
YUB-000289H	YUBA	PBAS II 71						06,09,15
YUB-000293H	YUBA	PBAS II 79						8
YUB-000300H	YUBA	PBAS II 90						6
YUB-000306H	YUBA	PBAS II 118						8
YUB-000335/H	YUBA	PBAS II 165						6
YUB-000559H	YUBA	PBAS II 304						08,11
YUB-000566H	YUBA	PBAS II 248						8
YUB-000568H	YUBA	PBAS II 220						8
YUB-000569H	YUBA	PBAS II 237						06,09
YUB-000572H	YUBA	PBAS II 265						06,08
YUB-000574H	YUBA	PBAS II 405						04,06,08
YUB-000575H	YUBA	PBAS II 407						06,08
YUB-000578H	YUBA	PBAS II 416						08,16
YUB-000581H	YUBA	PBAS II 651						06,16
YUB-000584H	YUBA	PBAS II 75						8
YUB-000591H	YUBA	PBAS II 205						06,15
YUB-000592H	YUBA	PBAS II						02,06,09,11
YUB-000593H	YUBA	PBAS II 188						6
YUB-000606H	YUBA	PBAS II 395						06,08
YUB-000621H	YUBA							03,06
YUB-000622H	YUBA							03,06
YUB-000626H	YUBA							6
YUB-000636H	YUBA							6
YUB-000654H	YUBA							6
YUB-000682/H	YUBA	SUCKER FLAT	1850					02,04,05,06,07,08
YUB-000683H	YUBA	HALES FLAT						06,08,09
YUB-000685H	YUBA	KELLYS HILL						06,09
YUB-000686H	YUBA	SQUAW CREEK						06,16
YUB-000693H	YUBA	ENGLEBRIGHT DAM&RESER. / NARROW DAM						05,08
YUB-000748H	YUBA	BROWNS VALLEY DITCH						6
YUB-000770H	YUBA	LAGUE 19 / MINE AREA 3						06,09,
YUB-000922H	YUBA	LM-16						8
YUB-000924H	YUBA	LM-18						6
YUB-000937H	YUBA	R-3						6
YUB-000938H	YUBA	R-2						6
YUB-000940H	YUBA	R-24						02,04,06
YUB-000942H	YUBA	R-26						8
YUB-000966H	YUBA	OD-16						02,03,04,06,16
YUB-000967H	YUBA	OD-10						06,09
YUB-000968H	YUBA	OD-15						06,09
YUB-000969H	YUBA	OD-7						8

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
YUB-000970H	YUBA	OD-6						6
YUB-000971H	YUBA	OD-12						6
YUB-000972H	YUBA	OD-13						6
YUB-000973H	YUBA	OD-14						6
YUB-000976H	YUBA	BL-2						6
YUB-000977H	YUBA	BL-4						6
YUB-000978H	YUBA	BL-5						02,06,08,09
YUB-000979H	YUBA	BL-6						06,08,09
YUB-000998H	YUBA	SITE 5						6
YUB-001000H	YUBA	SITE 8						8
YUB-001001H	YUBA	SITE 25						6
YUB-001002H	YUBA	SITE 40 / SITE 54						06,08
YUB-001003H	YUBA	SITE 42						6
YUB-001004H	YUBA	SITE 53						6
YUB-001005H	YUBA	SITE 56						6
YUB-001006H	YUBA	SITE 1						02,04,06
YUB-001007H	YUBA	SITE 3						02,04,06,11
YUB-001015H	YUBA	SITE 19						06,08,09
YUB-001017H	YUBA	SITE 29						06,09,16
YUB-001018H	YUBA	SITE 31						06,08,09,16
YUB-001021H	YUBA	SITE 34						06,09,16
YUB-001023H	YUBA	SITE 44						02,06,08,16
YUB-001033/H	YUBA	H-12 / H-13 / H-14						02,08,09,11
YUB-001043H	YUBA	H-3						6
YUB-001044H	YUBA	H-5						6
YUB-001045H	YUBA	H-7						6
YUB-001050H	YUBA	H-19						6
YUB-001052H	YUBA	FS# 05-17-53-0092, YOUNGS HILL						02,03,04,05,06,07,09
YUB-001085H	YUBA	SITE 24						6
YUB-001086H	YUBA	SITE 12						6
YUB-001090H	YUBA	FS# 05-17-53-0043, BERESFORD RANCH, SITE #4 - MOSQUITO T.S.	1939					04,06,10,11,16
YUB-001112H	YUBA	FS# 05-17-53-0312, CASSIDY RAVINE DITCH TENDER	1860					02,04,06,09
YUB-001114H	YUBA	FS# 05-17-53-0314, PITTSBURG ORCHARD	1900					04,06,11
YUB-001115H	YUBA	FS# 05-17-53-0322, COLLAPSED CABIN	1900					02,04,06,07
YUB-001119H	YUBA	FS# 05-17-53-0326, BARTCH'S CABINS	1900					02,04,06,09
YUB-001120H	YUBA	FS# 05-17-53-0327, SLATE RANGE BAR	1850					02,03,04,06,09,11
YUB-001126H	YUBA	FS# 05-17-53-0162, HONEYCOMB STAMPMILL	1922					04,06,07,09,15,16
YUB-001133H	YUBA	FS# 05-17-53-0246, ELBOW GREASE						04,06,07
YUB-001134/H	YUBA	FS# 05-17-53-0247, T. WARP						03,04,06,09
YUB-001142H	YUBA	FS# 05-17-53-0255, MH-3, LOWER DIXIE QUEEN						02,04,06,09,11
YUB-001144/H	YUBA	FS# 05-17-53-0267, ORE WHAT SITE						03,04,06,09
YUB-001147H	YUBA							06,09,15
YUB-001148H	YUBA	FS# 05-17-53-0096, PIKE: 35-1						6
YUB-001152H	YUBA	FS# 05-17-53-0101, PIKE: 2-5						04,06,09
YUB-Z00020	YUBA	AH-37,BERM,CONCRETE FOOTING,PUMP HOUSE,DITCH AND PIER BLOCKS		USAF940315A	6Y2		9/16/94	
68106		GREAT DITCH OF TRINITY FS 05-14-56-27		USFS880129A	6Y		2/22/88	
68109		BLOSS-MCCLEARY DITCHES NO 1 & NO 2 FS		USFS880129A	6Y		2/22/88	
68110		DITCH TENDERS CABIN FS 05-14-56-351		USFS880129A	6Y		2/22/88	

APPENDIX A: WCS Features Listed in OHP Databases*

SITE# or PROPERTY#	COUNTY	OTHER DESIGNATIONS	DATE BUILT	OHP REFERENCE	NRHP STATUS**	CRITERIA	EVAL. DATE	ATTRIBUTE CODES***
68112		CEDAR CREEK DITCH FS 05-14-56-408		USFS880129A	6Y		2/22/88	
68120		COFFEE DITCH FS 05-14-56-475		USFS880129A	6Y		2/22/88	
68121		SQUIRRELLY CEDAR DITCH FS 05-14-56-47		USFS880129A	6Y		2/22/88	
68130		DEDRICK DITCH FS 05-14-54-175		USFS880211C	6Y		2/22/88	
68131		UPPER DITCH SYSTEM FS 05-14-54-178		USFS880211C	6Y		2/22/88	
68132		LOWER DITCH SYSTEM FS 05-14-54-179		USFS880211C	6Y		2/22/88	

*This list reflects the results of a comprehensive search of the electronic Historic Properties and Archaeological databases maintained by the California Office of Historic Preservation, current as of July 21, 1997. The search used both attribute codes and the words "canal," "dam," "ditch," and "reservoir" to identify resources with water conveyance system features. In many cases, WCS features are simply one of several resource elements present at a given property (see Note 3 below). Some duplicative listings are present, because the list was derived from 2 databases and some resources have both site and historic property numbers. This list contains 1716 entries.

**The initial number in this code has the following meaning: 1=Listed; 2=Determined eligible; 3=Appears eligible; 4=May become eligible; 5=Ineligble, but of local interest; 6=Ineligible; 7=Unevaluated. If there is no entry in this column, the resource has not been evaluated.

***The Archaeological and Historic Property databases use different coding systems. Historic Properties have numeric designations in column 1, while those with a three letter county code prefix are from the Archaeological Database. The following codes identify WCS features present at each listed property. Many other types of attributes may also be present at these listed properties (for a complete list of Attribute Codes refer to the OHP's (1995) *Instructions for Recording Historical Resources* .

Archaeological Database: 6=Canal or ditch; 8=Dam

Historic Properties Database: 11=Engineering structure; 20=Canal or aqueduct; 21=Dam; 22=Lake, river, or reservoir

APPENDIX B:
Detailed Typology of
Water System Components

This typology offers examples and illustrations of the various water system components discussed previously under "Typical Components." Examples are drawn largely from documentary sources, supplemented by reasonable conjectures as necessary. Because these examples have not been field checked, their current condition and integrity are mostly unknown. Consequently, unless they are the subject of recent documentation, they should be examined before being cited in any comparative analyses.

The following presentation is organized by major component types: diversion structures, conduits, flow control and cleansing devices, and associated resources. Those categories are further broken down into subtypes and design variants. Each type, subtype, and design variation is also linked to the kinds of systems that commonly possess such elements. However, themes and typologies are not intended to be restrictive. Comparisons across historical themes may be appropriate and necessary in some circumstances, and transitional systems may also be significant for their ability to illustrate the evolution of particular designs and innovations. The following abbreviations are used to indicate the themes and periods of time in which various water system components are likely to occur:

Irrigation
IR1=Native American Irrigation
IR2=Spanish/Mexican Irrigation (1769-1848)
IR3=American Irrigation (1848-)

Mining
M1=Early Placer (pre-1865)
M2=Large Scale Hydraulic (1865-1884)
M3=Post-1884 Mining (all types)

Hydroelectric
HE1=Early Private (pre-1910)
HE2=Late Private (post-1910)
HE3=Public

Community Water Systems (CWS)
Reclamation Systems (RS)
Multi-purpose Systems (MPS)

DIVERSION STRUCTURES

The examples below describe weirs, dams, tunnels that tap natural lakes, and pumping stations, all typical diversion structures, sometimes including associated reservoirs or lakes. Other associated features are covered separately.

Weirs

- Temporary brush (IR1, IR3, M1)
- Temporary cobblestone or gravel (IR1, IR3, M1)

  Example: Vandalia Ditch, circa 1900 (see Figure B1)

Figure B1. Temporary cobble diverting weir, Vandalia Ditch, circa 1900
(Mead 1902, Bulletin No. 119:Plate 26)

- Log crib (IR3, M1)
- Framed lumber (IR3, M1)

    Example: Beardsley Canal, Kern County (IR3)
    Example: Moore Weir, Cache Creek, Yolo County, removable (IR3)
    Example: Kern River (see Figure B2)

- Mortared stone (IR2, IR3)
- Concrete (IR3, M3, CWS)
- Collapsible steel (IR3)

    Example: Crocker-Huffman Weir System, Merced County, built circa 1915 (see Figure B3)

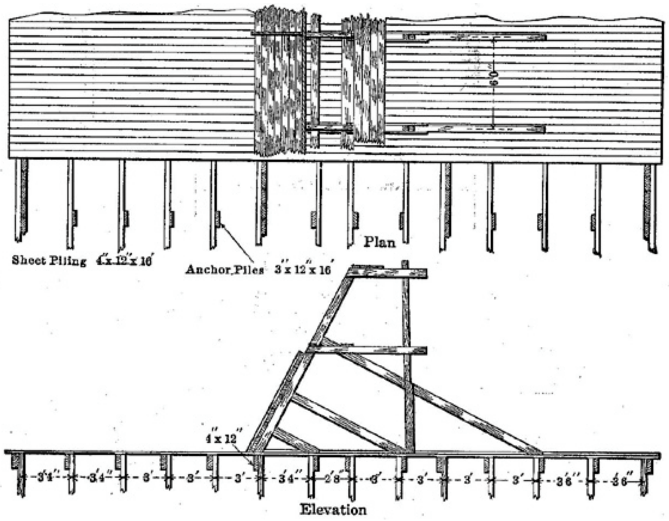

Figure B2. Wooden weir, Kern River, circa 1915
(Etcheverry 1916:53)

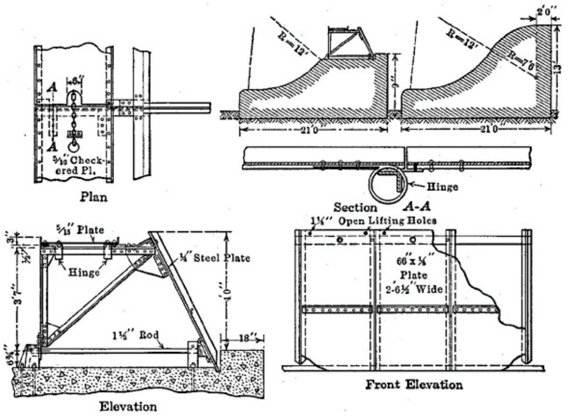

Figure B3. Steel weir, Crocker-Huffman System, circa 1915 (Etcheverry 1916:78)

Dams

- Earth (IR1, IR2, IR3, M1, M2, M3, CWS, RS)
- Earth with rubble core (IR3, M1, M2, RS, MPS)
- Framed lumber with rubble core and plank face (IR3, M1)

Example: Milton Canal, S. Fork Middle Yuba River (M1)

- Cribbed Log (IR1, IR2, M1, M2)

Example: Slate Creek Dam

- Mortared stone (IR2, IR3)

    Example: Mission San Antonio de Padua (IR2:1776 and 1805)
    Example: Mission San Diego de Alcala (IR2)
    Example: San Diego River Canal, built 1880s (IR3)

- Concrete (HE1, HE2, HE3, CWS, RS, MPS)

    Example: Shasta Dam (HE3, MPS)
    Example: O'Shaughnessy Dam, Tuolumne County, completed 1923 (CWS)

Natural Lakes and Aquifers Tapped by Tunnels

- Lake tapped by bedrock tunnel

  Example: Eagle Lake, Lassen County (IR3)

- Aquifer tapped by tunnel

  Example: Grapeland Tunnel, Lytle Creek, San Bernardino County (IR3)

Pumping Plant Intakes

- Pumping plant (MPS)
  Example: Tracy Pumping Plant (MPS) (see Figure B4)

Associated Reservoirs

Reservoirs of varying sizes were used to store water and mediate seasonal shortages. Small reservoirs were sometimes lined with clay, mortared stone, or concrete, but most consisted of unmodified natural terrain. Rarely associated with prehistoric irrigation systems, historic irrigation systems built between 1848 and 1880, or mining ditch systems constructed before 1865, reservoirs are commonly associated with all other historic themes and periods. Extensive pondage is often associated with systems used for hydraulic mining, hydroelectric power generation, community water supplies, reclamation systems, and major multi-purpose systems.

- Mortared Stone (IR2)

  Example: Mission San Antonio de Padua at San Antonio River, built 1778 (IR2), and Mission Creek, built 1826 (IR2)
  Example: Mission San Diego de Alcala at Mission Creek (IR2)

- Unlined earth/bedrock (All contexts except IR1)

  Examples: Shasta, Oroville, and Millerton (MPS)

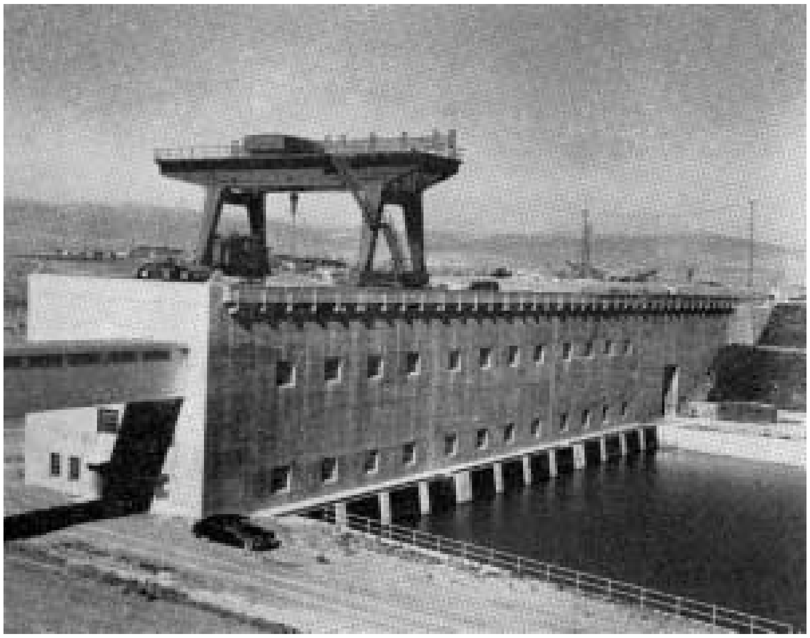

Figure B4. Tracy Pumping Plant
(Water Project Authority 1953:22)

CONDUITS

The four basic types of conduits, often used in combination to convey water over variable terrain, consist of open canals, flumes, tunnels, and pipelines. The materials that were used influenced their design.

Open Canals

- Unlined earth (all historic contexts) (see Figure B5)

Figure B5. Fresno Scraper
(California Room, California State Library)

Example: Mission San Antonio de Padua, cut in bedrock (IR2)
Example: Centerville & Kingsburg Canal, built 1878, used a natural channel (IR3)
Example: Lone Tree Canal, built in 1870s, used a natural channel (IR3)
Example: Mokelumne Hill and Campo Seco Ditch, Calaveras County–2,000 miner's inches; 35 miles long; canal size varied with the grade (M2)
Example: Calloway Canal, built circa 1880 (IR3)
Example: Forbestown Ditch, Butte County–2,000 miner's inches; 30 miles long; 5-6.5' wide on bottom; grade of 9.6' per mile (M2) (see Figure B6)

Figure B6. Forbestown Ditch, 1910
(PG&E Archives)

Example: South Yuba Water & Mining Company, Nevada County—5 ,000 miner's inches; 60 miles long; 8' on top, 5' on bottom, 4' deep; grade 14' per mile (M2)
Example: Miocene Ditch, Butte County—2,000 miner's inches; 36 miles long; 9' wide on top, 6' on bottom, 4' deep; grade 8' per mile (M2)
Example: Cedar Creek Ditch, Placer County—4,000 miner's inches; 45 miles long; 6' wide on top, 4' on bottom, 3' deep; grade 16' per mile (M2)
Example: Gold Run Ditch, Placer County—4,000 miner's inches; 40 miles long; 6' wide on top, 4' bottom, 3' deep; grade 16' per mile (M2)
Example: Dry Creek Tunnel & Fluming Company Canal (also known as the Hayward, or Hardscrabble, Ditch), Shasta County—2,000 miner's inches; 24 miles long; 9' wide on top, 6' on bottom, 3' deep; grade 9' and 3' per mile (M2)
Example: Excelsior Water & Mining Company Canal, Yuba County—3,000 miner's inches; 36 miles long; 9' wide on top, 6' on bottom, 2.5' deep; grade 10' per mile (M2)
Example: La Grange Ditch (M2) (see Figure B7)
Example: Inskip Canal, built 1910 (HE2)
Example: Coleman Canal, built 1912 (HE2)
Example: Drum Canal, built 1913 (HE2)

- Concrete lined (IR3, HE2, HE3, CWS, RS, MPS)

  Example: Friant-Kern Canal, built 1948 (MPS) (see Figure B8)
  Example: Fruitdale Canal, lined 1880 (IR3)
  Example: Gage Canal, lined 1890 (IR3)
  Example: North Fork San Joaquin power system, built 1906-1913 (HE2)
  Example: Kaweah No. 3 conduit, built 1913 (HE2)
  Example: California Aqueduct, built 1970s (MPS)

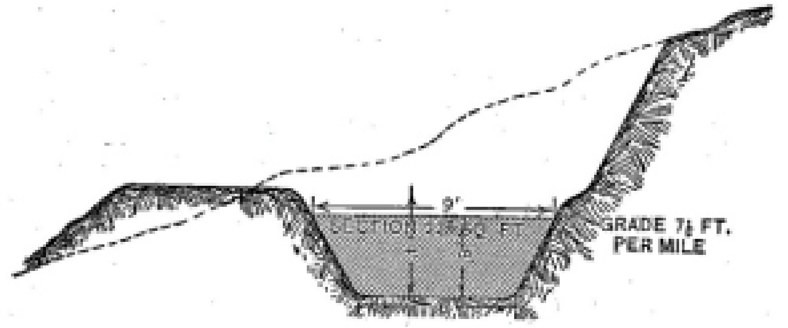

Figure B7. La Grange Ditch
(Bowie 1905: 141)

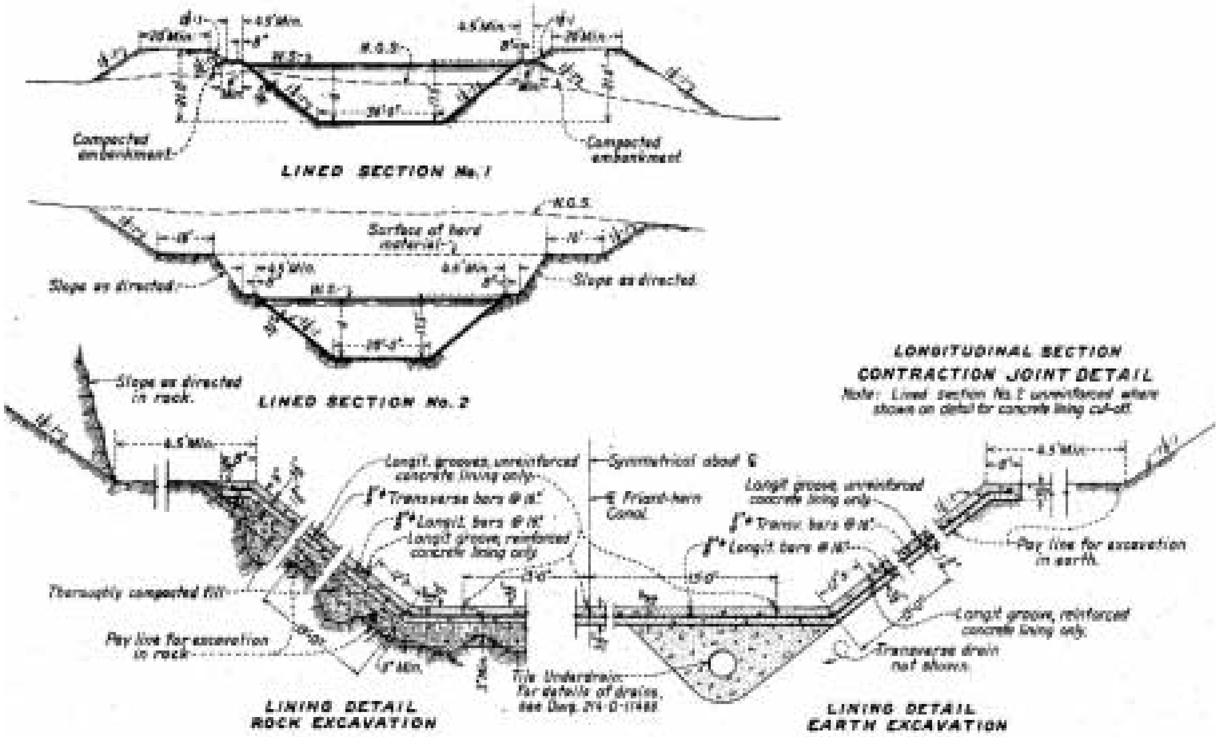

Figure B8. Plans for concrete lined Friant-Kern Canal
(USBR 1958:10)

- Earth with dry-laid stone lining on one or both banks (IR2, M2, HE1)

  Example: Mission San Antonio de Padua, clay core with stacked cobbles (IR2)
  Example: Santa Ana Plant No. 3 Conduit, built 1904 (HE2)

- Earth with wood plank lining (M1)

- Earth with clay lining

Example: All-American Canal, built 1939 (MPS)
Example: Friant-Kern Canal, built 1946 (MPS)
Example: Delta-Mendota Canal, built 1950 (MPS)

- Mortared stone (IR3, HE2)

  Example: Mission San Buenaventura Aqueduct (IR2)
  Example: Mission San Antonio de Padua Aqueduct, arched stone (IR2)
  Example: Drum Canal, Nevada and Placer Counties, built 1913 (HE2)

Flumes

Flumes were made from a variety of materials and most commonly had rectangular or semi-circular cross sections. They were supported on trestles, on mudsills set on sidehill cuts, atop bench walls, or suspended from cliff faces. They were typically used where ditching was impractical, such as where inclined drops were needed or to cross valleys or ravines.

- Wooden box on wood trestle (IR3, M1, M2, M3, HE1, HE2, RS) (see Figure B9)

  Example: Magenta Flume, Eureka Lake Canal (1859), 126' tall by 1400' long (M1)
  Example: National Flume, Eureka Lake Canal (1859), 65' tall by 1800' long (M1)
  Example: Kern Valley Power Development Company Flume (HE1)

- Wooden box on sidehill cut (M2)

  Example: Milton Flume (M2)

- Wooden box on dry-laid bench wall (IR3, M2, HE1)

  Example: El Dorado Water & Mining Company Flume (M2)
  Example: Santa Ana Plant No. 3 Flume, built 1904 (HE1)

- Suspended wooden box

  Example: Miocene Canal (M1)

- Semi-circular wood stave (IR3, HE2)

- Semi-circular riveted steel (IR3, HE2)

  Example: Nevada Irrigation District, built circa 1930 (IR3)
  Example: North Fork San Joaquin power system, built 1906-1913 (HE2)

- Mortared stone (aqueduct) (M1, M2, HE1)
  Example: Natomas Company Canal east of Folsom (M1)
  Example: Azusa Flume, built 1898 (HE1)

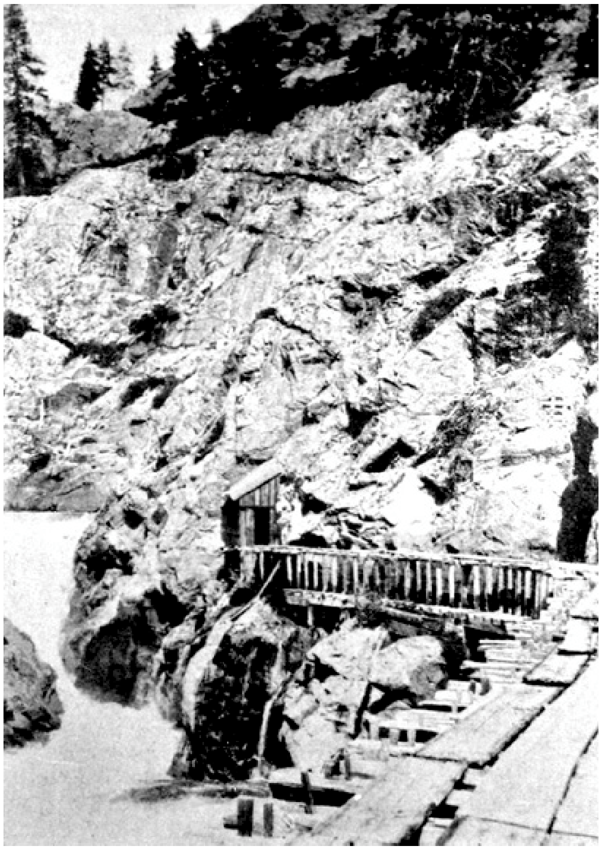

Figure B9. Trestled wood box flume, head of South Yuba Ditch (PG&E Archives)

- Concrete box on concrete arches (IR3, HE1, HE2)

  Example: Modesto Irrigation District Flume, built circa 1915 (IR3)
  Example: Centerville Flume, built 1898 (HE1)
  Example: Kaweah No. 3 Flume (HE2)

Tunnels

- Unlined rock or earth (M1, M2, HE1, HE2, CWS)

  Example: Diamond Creek Ditch, 1000' long, built 1876 (M2)

- Timber cribbed (M2, HE1, HE2)

- Timber cribbed with wood box flume inserted within tunnel (M2)

  Example: Eureka Lake Canal
  Example: Milton Canal

- Concrete lined (HE1, HE2, CWS, MPS)

  Example: Santa Ana River Power System (HE1)
  Example: North Fork San Joaquin power system (HE2)
  Example: Tunnels through Tehachapi Mountains, California Aqueduct (MPS)
  Example: Elizabeth Tunnel, Los Angeles Aqueduct, built 1907-1913 (CWS)

- Mortared stone lining (IR3)

  Example: San Diego Flume tunnel, built 1880s

Pipelines (siphons, penstocks, and other pressurized conduit)

- Clay (IR2)

  Example: La Purisima Mission branch distribution lines (IR2)
  Example: Mission San Antonio de Padua, 3.5" diameter pipe, built 1824 (IR2)

- Hollow log (M1)
- Wood stave (use as penstocks rare) (HE1, HE2) (see Figure B10)

  Example: Colgate system, 1.65 miles long, 36" diameter (HE1)
  Example: Drum System, 8' diameter, 4" thick staves, built 1913 (HE2)
  Example: Bishop Creek System (HE1, HE2)

Figure B10.Wood stave pipe construction
(California Room, California State Library)

Example: Tule River System (HE2)

- Riveted iron with stove-pipe joints (common prior to 1920s) (M1, M2, HE1, HE2, CWS) (see Figure B11)

  Example: Nine Mile Canyon, No Name Canyon, Sand Canyon, Grapevine Canyon, Jawbone Canyon, and Antelope siphons, Los Angeles Aqueduct, built 1907-1913 (CWS)
  Example: Cherokee Mining Company inverted siphon, built 1871 (M2)
  Example: Texas Creek inverted siphon, below Bowman Dam, Nevada County (M2)
  Example: Malakoff penstock, 27" head diameter narrowing to 22," with air escape valves
- Welded steel penstocks—commonly used beginning in the 1920s (HE2)
  Example: Tule River System (HE2)

- Concrete Pipe (MPS)
  Example: Mountain House Road siphon, Delta-Mendota Canal (MPS)
  Example: King River siphon, Friant-Kern Canal (MPS)

- Concrete box (CWS, MPS)

  Example: Siphon under AT&SF railroad, Friant-Kern Canal (MPS)
  Example: Antelope Valley covered conduit, Los Angeles Aqueduct, built 1907-1913 (CWS)

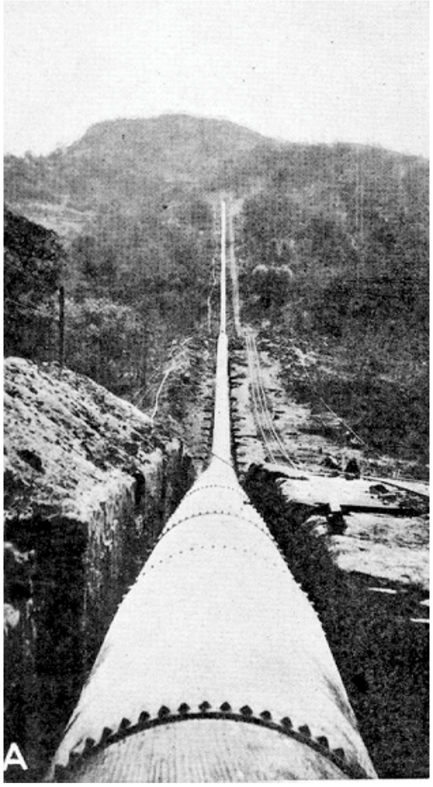

Figure B11. Riveted steel pipe
(Scobey 1930:73)

FLOW CONTROL STRUCTURES

A wide variety of structures are used to regulate flows, distribute water to users, and dispose of excess water. Gates, gauges, and valves allow direct control of the volume of water passing a given point in the system, while turnouts direct a portion of the flow into a branch conduit. Regulating chambers such as forebays, head boxes, and surge chambers are often used to maintain steady supplies of water at intake structures. Drops, chutes, tailraces, and afterbays are used to reduce the velocity of flowing water when it is necessary to make rapid changes in elevation, while wasting structures like spillways dispose of excess water.

Gates, Gauges, and Valves

- Wood slide and drop gates—common before 1880 and still used (IR3, M1, M2, M3, CWS)

- Steel drop gates (IR3, M2, M3)

- Steel gauge wheels—rare (M2)

- Concrete control structures with wood or metal drop gates and gauges—common beginning in the 1880s (IR3, HE1, HE2, HE3, CWS, RS, MPS)

- Concrete waste gates—used during repairs or emergencies (M2, HE1, HE2, HE3, CWS, RS, MPS)

Example: North Bloomfield Tunnel (M2)

Turnouts and Distribution Boxes

- Temporary earth or cobble (IR1, IR3)

- Wood box (IR3, M1, M2, M3, CWS)

- Mortared stone (IR2)

  Example: La Purisima Mission

- Concrete (IR3, M3, CWS, RS, MPS)

  Example: Panoche Water Distribution Association turnout, Delta-Mendota Canal (MPS)

Forebays, Head Boxes, and Surge Chambers

- Earth forebays/regulating reservoirs (M1, M2, M3, HE1, HE2, CWS)

  Example: Marlow Reservoir (1.72 million cf) and Waldron Reservoir (5.35 million cf), North Bloomfield System (M2)

- Concrete-lined forebays and surge chambers (HE1, HE2)
- Wood head (pressure) boxes (M1, M2, M3, HE1, HE2, CWS)

  Example: La Grange System, Stanislaus County (M2)
  Example: North Bloomfield System (M2)

- Terminal reservoirs (MPS)

  Example: Lake Perris and Castaic Lake (MPS)

Drops, Chutes, Wasting Structures, and Afterbays

- Concrete chutes (IR3, CWS, MPS)

  Example: San Fernando Cascade, Los Angeles Aqueduct, built 1907-1913 (CWS)

- Wood box drops (M1)

- Wood riffle box waste channels (M2)

  Example: Gold Run Mining Company, railroad tie riffles

- Mortared rock spillways (M2, HE1, HE2)

- Waste tunnels (M1, M2)

  Example: North Bloomfield Tunnel waste channel, mortared rock pavement
  Example: Polar Star Mine, 1600’ long, 8’ x 8’ dimensions, grade 10” per 12’
  Example: Gold Run Tunnel, 650’ long, 10’ x 12’ dimensions, grade 6” per 12’

- Concrete spillways (IR3, M3, HE1, HE2, HE3, CWS, RS, MPS)

- Mortared rock afterbays and recovery reservoirs (M2, HE1, HE2, HE3)

  Example: Bloody Run Recovery Dam, Milton System
  Example: Poorman Creek Recovery Dam, Graniteville

- Concrete tailraces and afterbays (HE1, HE2)

CLEANSING STRUCTURES

Cleansing structures are used to keep foreign materials from entering a system at the intake structure or to remove sediments from water moving through the system. Floating booms, grates, and screens are typically used to prevent vegetation and other floating debris from entering the system, while sand traps and sluices are designed to remove sediments at regular intervals along conduits. These structures are very common on hydroelectric systems (HE1, HE2, HE3); hydraulic mining systems (M2); and hard-rock mining systems with power applications (M3), where debris and sediments can cause wear or damage to turbines, penstocks, and other equipment subject to high pressure and velocity. They are less common on other types of systems, but can be found on some American Period irrigation systems (IR3), Community Water Supply systems (CWS), Reclamation Systems (RS), and Multi-purpose Systems (MPS). These structures are primarily constructed of reinforced concrete, and they often feature riffles.

- Floating booms

- Iron trash grates and screens

  Example: Portal of Kern River tunnel (see Figure B12)

- Wood sand trap (HE1)

  Example: Santa Ana Plant No. 1 (see Figure B13)

- Concrete sand trap (HE1, HE2, HE3, MPS)

Figure B12. Trash grate at Kern River Tunnel intake, 1909 (PG&E Archives)

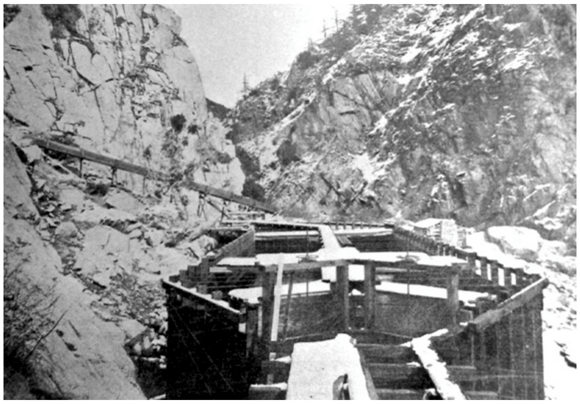

Figure B13. Two-way sand box, Santa Ana Plant No. 1, 1901 (PG&E Archives)

ASSOCIATED RESOURCES

Associated resources are defined in this report as properties that may be either directly or incidentally associated with water conveyance systems but are not integral components of the structure itself. The most common associations are listed below; others may be identified in the future.

Habitation sites

- Directly associated construction camps—likely to be associated with all large systems (IR3, M1, M2, M3, HE1, HE2, HE3, CWS, RS, MPS)

  Example: 58 camps associated with construction of the Los Angeles Aqueduct, including Alabama Gates (CA-INY-3760/H) (see Figure B14)
  Example: Relief Dam and construction camp in Tuolumne County, determined eligible under Criterion D
  Example: Santa Ana system camps recorded as CA-SBR-5500/H and -5503/H, evaluated as eligible under D
  Example: Butt Lake construction camp in Plumas County, determined eligible under D

- Directly associated maintenance camps/operators' housing compounds—most likely in association with large systems located in remote or mountainous terrain (M1, M2, M3, HE1, HE2, HE3, CWS)

  Example: Tule River operator housing complex in Tulare County, determined eligible under criteria A and C

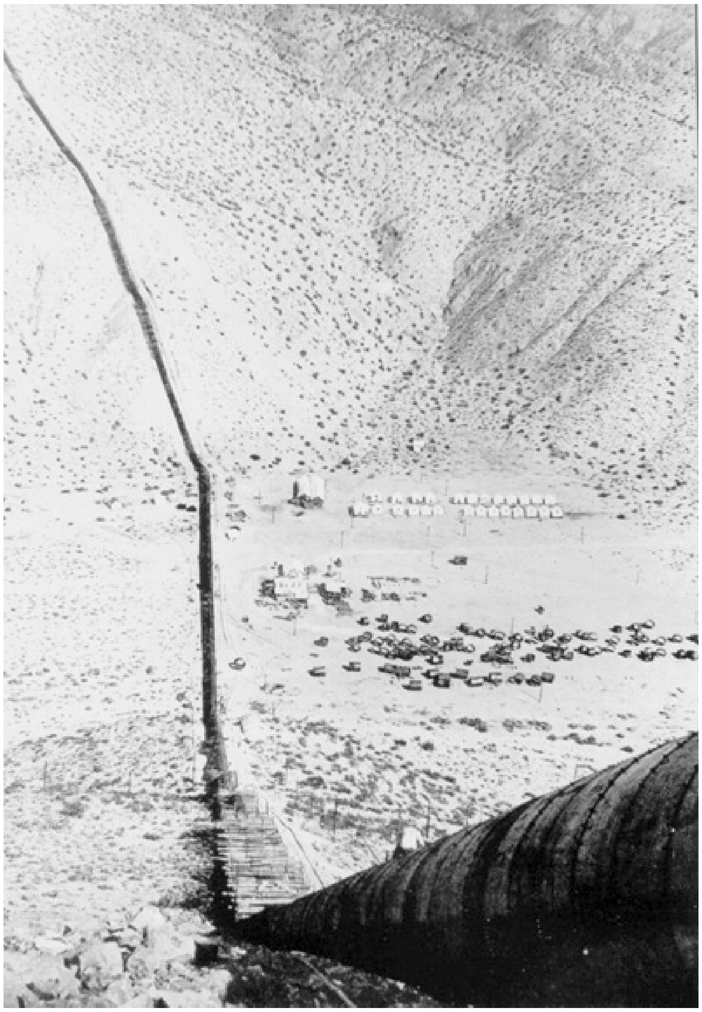

Figure B14. Construction camp at Jawbone inverted siphon, Los Angeles Aqueduct, 1913
Los Angeles Department of Water & Power)

- Incidental habitation sites—possible occupation by Native Americans, miners, homesteaders, and others who settled near water conveyance systems and relied on them for water; most likely association with systems in remote and mountainous terrain, particularly on the west slope of the Sierra Nevada

  Example: Historic period Native American occupation at CA-TUO-1749/H, CA-TUO-395/H, and CA-CAL-1063/H

Landscapes

- Mined landscapes (M1, M2, M3)
- Agricultural landscapes (IR1, IR2, IR3)

Power, Transmission, and Communication

- Hydroelectric power plants and electrical power transmission lines (HE1, HE2, HE3)

  Example: Big Bend powerhouse (see Figure B15)

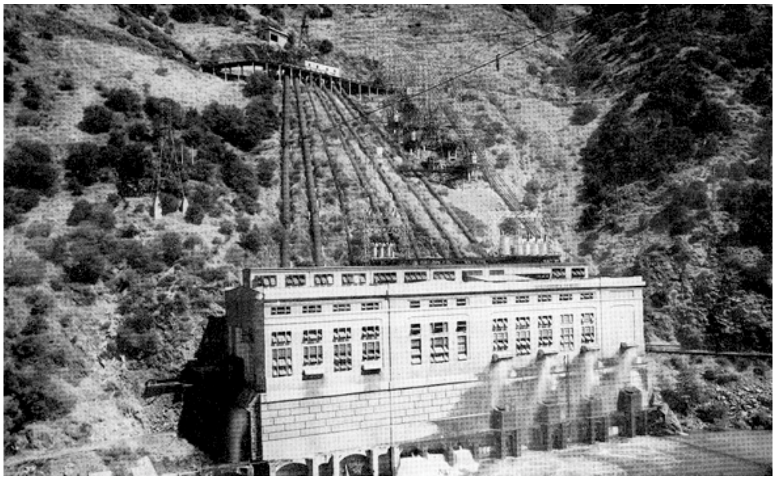

Figure B15. Big Bend Powerhouse
(Coleman 1952: 199)

- Telecommunication lines—common on most large systems built or operated in the twentieth century
- Radio-controlled monitoring/ control equipment—common on most large systems in use during the twentieth century

Transportation Facilities

- Access roads and bridges—often associated with larger systems, particularly those in use after 1900

Back Cover Photograph: Large wood stave pipe under construction
(courtesy of the California Room, California State Library)