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CALIFORNIA PIONEERS NEW WATER DEVELOPMENT CONCEPTS

WILLIAM E. WARNE*

Historic events sometimes all but escape notice at the time of their occurrence and are left for historians to identify.

Such an event may have occurred in the field of water development in California in recent years. The shaping in California of a bold new concept of guided, comprehensive, inter-basin water conservation, transfer and use may have an impact of historic importance far beyond the borders of the State.

A new, self-reliant leadership role of the State has been taken in water development in California. The State has taken the responsibility of coordinating all water projects and of providing comprehensive water development. California thus becomes the first state of the 50 United States to master her own water destiny.

The events in California which have brought this about are:

First, under the urging of Governor Edmund G. Brown, the adoption by the State Legislature in 1959 of the California Water Plan. The California Water Plan is a comprehensive but flexible blueprint for the ultimate development of all the water in all areas of the State. The plan encompasses projects of the State, Federal and local governments, irrigation districts, and private utility companies. It comprehends local developments and major inter-regional transfers.

Second, the adoption (again leadership being provided by Governor Brown) by the voters of the State in the election of November 8, 1960, of the State Water Project, sometimes called the Feather River Project. The project is sometimes confused with the State Water Plan. Whereas the plan is a master guide for future water developments in California designed to prevent duplication and waste, the State Water Project is a specific construction program to provide certain facilities as the first stage of state-financed water development, designed to satisfy statewide urgent water requirements until 1990.

The State Water Project includes works for the transfer of surplus waters from the northern part of the State to areas of water deficiency as far as 750 miles south. Authorization of this specific water transfer project came after a hard-fought campaign that ended 20 years of bickering. The Governor's campaign slogan, "California—One State," dramatized the nature of the problem and of the contest. Various localities and subdivisions either jealously guarded waters, sometimes greatly in excess of any possible need, or aggressively sought supplemental supplies, sometimes with little regard of other's needs and aspirations. In California, only the need for water is truly pervasive, i.e., statewide.

For years in California, the north and the south had been in sharp disagree-

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ment over future water programs. The northern part of the State had 70 percent of the rainfall and only about one third of the population. The south ranged from arid to semi-arid, but there lived 70 percent of the people. This imbalance was the source of many controversies involving water programs. The adoption of the State Water Plan by the Legislature, and the adoption by the voters of the $1\frac{3}{4}$ billion dollar bond issue to finance and build the initial State Water Project marked the beginning of a new era of unity and cooperation which could well launch the State on a new wave of prosperity and growth. California is now going ahead with the construction of the most complex and ambitious single water project so far undertaken in the United States.

Until the voters made their decision, many Californians had often revealed a "let George do it" attitude as regards solutions to water problems. They (1) had relied on local water districts or municipalities to build water projects as needs were felt, or they (2) had looked to federal agencies for easy solutions. The Bureau of Reclamation and the U.S. Army Corps of Engineers, of course, had extended their national programs to California to meet some irrigation and flood control needs just as they had extended these programs to other states. Water problems were being felt in California of a magnitude beyond the scope of local districts, or municipalities and these agencies could no longer cope with them. These problems did not fit the formulae that brought them under the jurisdiction of the federal agencies. They were not largely irrigation or largely flood control; instead they were mainly identified with the need for interbasin transfers of water for domestic, municipal and industrial use, although they involved all of the conventional requirements as well.

The people of the State endorsed a broad concept of beneficial water development related to needs and in support of growth. If California had lain in a single river basin, perhaps a basin plan such as that of the TVA would have been employed. Earlier, the most far-reaching concept was comprehensive river basin development to serve a maximum number of beneficial uses in an entire drainage area—water supply, irrigation, hydroelectric power, flood control, recreation, and fish and wildlife enhancement. This type of development is exemplified by the Tennessee Valley Authority, which because of the geography of the river basin, finds it necessary to cross state lines in its planning and development.

There is no single river basin that encompasses California. Instead, a part of the State is in the basin of the Colorado, a part in the basins of the Smith and Klamath on the north, a part in the basin of the Tia Juana on the south, and parts in basins shared with Nevada on the east of such rivers as the Truckee, Carson and Walker. Of course, the basin of the great Central Valley lies wholly in the State and many streams rise in the State and flow westward directly into the sea. Among these are such important rivers as the Eel, the Salinas, the Santa Maria, the Los Angeles, and the San Diego.

There developed of necessity a concept of comprehensive statewide planning to

carry the multiple-purpose principle to its logical conclusion. In California, this makes possible the inter-basin transfer of surplus waters to and among semi-arid regions. Thus excess runoff in the northern streams, which could be wasted to the sea sometimes as damaging floods, can be turned to useful pursuits in the water-deficient areas farther south.

In launching the State Water Project, California did not preclude future developments by local irrigation districts and municipalities, or by the federal agencies. Both reclamation and flood control projects consistent with the State Water Plan are under study at this time by the Bureau of Reclamation or the Corps of Engineers. These agencies have played a vital part in water development in the State in the past and will be encouraged to continue to do so in the future.

The Davis-Grunsky Act, an integral part of the state water development programs, provides a means for the State to assist the local agencies in developing local projects consistent with the plan. The State Water Project includes financing of \$130,000,000 for small projects to be selected with an eye toward meeting the developing needs of the areas where the water originates. These projects are expected for the most part to be unrelated, upstream works, but they are integrally part of the State Water Projects.

The State Water Project, itself, contemplates federal cooperation on two of its major elements. The Corps of Engineers has already been authorized to share the cost of the big Oroville Dam on the Feather River to the extent of flood control benefits, which is expected to be about 22 percent of the cost of construction of the facility, exclusive of the power plant. The Bureau of Reclamation will build the San Luis Project, about 50 miles south of the Sacramento-San Joaquin River Delta in Merced County, as a joint project in cooperation with California. The State will pay its share of the cost, estimated at 55 percent, and the reservoir will serve the Bureau's needs in the western San Joaquin Valley as well as provide "enroute" storage and a part of the transmission for the State Water Project main aqueduct to Central and Southern California.

These cooperative projects, however, are only tokens of the continuing cooperative relationship between the State of California and the federal agencies. As plans mature, other projects are expected to be undertaken by both the Bureau of Reclamation and the Corps of Engineers.

Operation of the State Project will be coordinated with the extensive Central Valley Project of the Bureau and the many flood control projects of the Corps that are already completed, as well as with future elements to be constructed in the State.

WATER PROBLEM REVIEWED

It would perhaps be helpful at this point briefly to review the fundamental water problems of California and the history of water developments.

The basic problem, of course, is distribution.

William Mulholland, debarking from a ship in Los Angeles in 1877 and admiring California's pleasant climate and dry hills, predicted:

"Whoever brings the water will bring the people."

This young Irish immigrant, who had \$10 in his pocket and a resolve to "grow with the country," worked his way to the head of the Los Angeles Department of Water and Power and built the 23-mile aqueduct from the Owens River, which sparked that city's spectacular growth.

The runoff from California streams averages 71,000,000 acre-feet annually. The streams of the North Coastal Region, including the Eel, Trinity, Klamath, Mad and Van Duzen, furnish about 41 percent of this runoff, and the Sacramento River and its tributaries, including the Feather, Yuba and American, provide 42 percent. Most of the remaining runoff—about 16 percent—occurs in the streams contributing to the San Joaquin River.

Also significant in California is the vagaries of the timing of precipitation. The bulk of the rain and snow occurs in a few winter months, while summers are long, hot and dry.

In addition, California is subject to extended wet and dry periods. In the late 1920's and early 1930's, for example, the State went through a severe drought during which runoff in the streams averaged only a little more than 50 percent of normal during the 10-year period. During the spring of 1962, California emerged from a three year period of drought into a normal water year. This normal year, however, will not eliminate entirely all of the water shortages caused by the long period of drought. Full impact of this shortage has been felt in areas dependent on surface water supplies, where no storage or inadequate storage facilities exist. Three consecutive water-short years have taxed to the limit even the areas with normally adequate storage, and rapidly falling ground water tables complicate the situation.

Although runoff from the higher mountain ranges is regulated to a considerable extent by the effect of mountain snowfall, most of the stream flow in California closely follows the rainfall pattern, coming during the winter and early spring months—frequently in the form of damaging floods of high intensity and short duration.

Ground water basins have provided an important source of supply for much of the State. In fact, half of the State's entire annual water consumption of more than 15 million acre-feet comes from underground. This has supported the economic development of much of Southern California and of the San Joaquin Valley. But the warning flags have been going up for years. The draft on many of these underground storage reservoirs greatly exceeds replenishment. The State is estimated to be overdrawing its ground water by more than five million acre-feet per year. In some instances the overdraft is so great as to threaten permanent damage through admitting intrusive salt water to the natural storage basins.

GROWTH MAGNIFIES DIFFICULTIES

California's water problems are being magnified more and more each day by the spectacular increase in population, the growth of new industries, and by a constantly expanding agricultural economy.

More than four-fifths of the agriculture of the State is dependent on irrigation. Approximately eight million acres are irrigated. These watered lands represent an advanced stage of development when compared with any similar region in the world. Proof of this lies in the remarkable fact that California farmers have been able to continue to produce record high harvests, worth in combination more than \$3 billion each year, even during the present three-year drought. This attests to the efficient irrigation systems that have been developed as well as to the fortunate position of the State in having great underground water supplies.

Many of the State's new industrial enterprises are also heavy water users, and additional strain is applied by increases in the number of water consumers, an average of a half-million persons each year. The State's population has more than doubled since 1940, when it had seven million people. Forecasts indicate that the 1960 population of 16 million will expand to more than 28 million by 1975.

For each resident there must be provided 200 gallons of water per day for domestic and industrial needs, and 1,300 gallons a day to grow the food and fiber required to sustain the type of economy California is building. By 1975 California must have increased its water supply by more than 6,500,000 acre-feet to meet the demands, according to present estimates.

WATER PROBLEMS ARE NOT NEW TO STATE

Water problems in California are not new. From the time of the earliest Spanish settlements, when the Mission Padres in the late 18th Century picked locations for their settlements near streams so that irrigation water would be readily available for orchards and gardens, until now, Californians have had to meet and to resolve the difficulties of obtaining adequate water supplies.

Later white settlers also settled along rivers, where water diversion for domestic and agricultural needs was relatively easy. As the State grew and greater quantities of water were needed, it became necessary to transport it over increasingly greater distances.

During early California history, irrigation water was diverted without the aid of storage facilities. Hence, the water had to be used when it was available. Soon the need was recognized for storing water during wet seasons of the year for use in subsequent dry periods.

The large metropolitan areas of the State were first to feel the pressure of growing water demands coupled with diminishing sources close at hand. Los Angeles, in 1905, recognized that it had outgrown its local water supplies from the Los Angeles River in which it had pueblo rights and started looking far afield

for new sources. In 1913 it completed the Los Angeles Aqueduct to carry water from the Owens Valley on the eastern slope of the Sierras to storage reservoirs in the San Fernando Valley. This gravity flow system, one of the greatest water conveyance systems of its time, was later extended further north to Mono County on the eastern slope of the Sierras.

The Los Angeles Aqueduct was followed in a few years by still another and greater project—the Colorado River Aqueduct, construction of which started in the 1930's when it became evident that even larger water supplies would be needed in Southern California. Colorado River water is lifted 1,600 feet over mountain barriers and conveyed 242 miles across mountains and desert by a system of tunnels, aqueducts, canals and five pumping plants. The Aqueduct built by the Metropolitan Water District of Southern California, which is now comprised of 93 cities and six counties spread over 4,000 square miles, first went into operation in 1941. It is designed to deliver 1,212,000 acre-feet yearly. It is now operating at capacity.

Other examples of initiative in water development are the systems built by the City of San Francisco and the East (San Francisco) Bay Municipal Utility District to meet growing demands for water. The Hetch-Hetchy Aqueduct brings water from the Tuolumne River watershed in the Sierras by pipeline, tunnels and canals to storage reservoirs in the San Francisco area.

The East Bay developed a water supply on the Mokelumne River at Pardee Reservoir in the Sierra foothills. An aqueduct delivers this water to reservoirs in Contra Costa and Alameda Counties.

FEDERAL PROJECTS IN CALIFORNIA

Federal agencies have played a big part in water resources development in California. The Corps of Engineers, with responsibility for flood control and stream navigation, and the Bureau of Reclamation, in the interest of conservation and reclamation, both have constructed major multi-purpose projects, and, in cooperation with each other, the State, and local districts, have coordinated efforts in comprehensive river basin development plans in the Central Valley.

Federal agencies for over a half century had been interested in California water developments, but their important activity in the State came as a result of state planning. In the early 1930's, an earlier California Water Plan was developed to solve some of California's water maldistribution problems. The initial unit of this plan was authorized by the State Legislature and was known as the Central Valley Project.

This was to be a state enterprise, and a \$170,000,000 revenue bond issue was authorized in 1932 to finance its construction and operation. However, due to economic conditions at the time, the bonds were never marketed, and in 1935 the State turned to the Federal Government for aid.

Today the Central Valley Project is being built and operated by the Bureau of Reclamation. It is designed to supply water for irrigation and to municipalities, to improve navigation on the Sacramento River, provide adequate stream flows to halt sea water intrusion in the Sacramento-San Joaquin River Delta, control floods in the valleys, generate hydroelectric power, and serve other purposes such as providing expanded recreation facilities. This project is still being expanded. It incorporates a fundamental concept of conserving surplus runoff in the Sacramento watershed for transfer to water deficient areas in the San Joaquin Valley.

Individual features of the CVP include Shasta Dam on the Sacramento River; Folsom Dam on the American River; Friant Dam on the San Joaquin River; and others. Major aqueducts, such as the Delta-Mendota Canal, Madera Canal, Friant-Kern Canal, and Contra Costa Canal convey conserved water to serve agricultural lands in the valleys.

Another key unit of the Central Valley Project is the Trinity River Project, now under construction. This facility will convey Trinity River water across the drainage divide into the Sacramento River, developing hydroelectric power enroute. The San Luis cooperative project, in its federal phase, is an addition to the Central Valley Project.

LOCAL WATER DEVELOPMENT

While the accomplishments of the metropolitan districts and the Federal Government have been dramatic, the projects of the hundreds of local water and irrigation districts have been responsible for the development of most of the State's water supply. California pioneered the district concept of water development, beginning with the passage of the Wright Act of 1887. This sparked an unprecedented era of water development that has seen more than 950 dams and reservoirs constructed in the State. Under local and regional leadership, monumental achievements in water development have come into being. These include the Modesto-Turlock irrigation project and the Imperial-Coachella complex.

THE STATE WATER PLAN

The controversies that grew out of some of the water quests in California provided arguments for state action when the time finally arrived, on the basis of the need for a major north-south transfer of water. These controversies also gave rise to such laws as those protecting the counties of origin of water and the Watershed Protection Act. In effect, these laws provide that projects designed to export water from a watershed or from the county where it originates must accommodate later local developments in these counties, and must not preclude them.

The State had long realized the need for coordinated development of Cali-

ifornia's water resources. In 1947, long-range studies to cover the entire scope of water resources were begun. The studies include an inventory of all water supplies available within California borders and an estimate of all water requirements, both present and future.

The California Water Plan was evolved from this 10-year investigation. It is a master blueprint for ultimate development of all water resources of the state, and is purposely designed to be flexible and adaptable to changes dictated by the future growth of California. It offers possible solutions to many of the State's water problems—proposing specific physical projects that could be built, if found feasible from engineering, economic, and financial standpoints.

To implement this master plan, the California Water Resources Department filed on all unappropriated waters in the State with the intent of protecting supplies for the State Water Plan. Before any project may go forward having as its objective the development of new water supplies, the proposal must be tested by the California Water Commission, a state agency, to determine whether a release of the State's filing in behalf of the proposed project would be consistent with the State Water Plan. In this way it is planned to protect all areas of the State, and ultimately to make possible their development to the full limit of supporting water supplies.

DEVELOPING THE STATE WATER PROJECT

With the State Water Plan, California assumed leadership in a statewide water resources development. It also had to assume the role of "water provider" in instances of major engineering works beyond the resources of local districts or the scope of federal agencies. To meet this requirement, the State developed the State Water Project, a physical engineering program to develop surplus waters in Northern California for distribution to South Central, South San Francisco Bay, North Bay, and Southern California areas.

In 1959 the Legislature passed the Burns-Porter Act, authorizing (subject to the 1960 referendum) the State Water Project, defining it, and establishing a means of financing it. As previously mentioned, the voters in 1960 approved the measure.

PHYSICAL WORKS OF THE STATE WATER PROJECT

Here is a brief sketch of the main construction works authorized as the State Water Project, listed from north to south:

Oroville Dam.—When constructed it will be the world's highest earthen dam, requiring 80 million cubic yards of material. The 735 foot high structure, with a crest more than one mile long, will create a 3,500,000 acre-foot reservoir to impound surplus Feather River water for power, flood control, and for conveyance to semi-arid sections of California. This \$457,000,000 facility also will

provide an additional 275,000 acre-feet of water annually for irrigation in the Feather River service area immediately downstream. Water from the reservoir, released to the delta in periods of low San Joaquin-Sacramento River runoff, will also help prevent saline water intrusion in the delta. Economic benefits will accrue from recreational use of the 15,500-acre surface area of the reservoir. The project also includes a 600,000 kilowatt capacity hydroelectric plant.

Five upstream dams in the Feather River drainage area—Antelope Valley Dam, construction of which will get underway this year, and the Dixie Refuge and Abbey Bridge Dams, are in the Indian Creek Recreation Project. These reservoirs are primarily for recreation purposes, but will also aid in stream flow maintenance. Frenchman Dam, completed in October 1961, and Grizzly Valley Dam will provide stream flow maintenance and recreation opportunities in Plumas County. The latter two also will irrigate the Sierra Valley.

Delta Project.—A key work of the statewide development program, it will repel sea water and will salvage from loss to the sea two million acre-feet of fresh water annually, which can be transported to semi-arid regions. Final plans from various alternatives being studied will be selected after meetings this year with municipal, irrigation, industrial, recreational and other interests, and after hearings before the California Water Commission. Water for export to the south will be guided across the many delta channels in San Joaquin and Contra Costa Counties by a series of control structures with gated openings for discharging flood flows, barge locks and fishways, earthfill channel closures, siphons, and pumping plants. Recreational, agricultural and industrial development benefits will accrue to the area.

California Aqueduct.—One of the most spectacular features of the State Water Project will be this conveyance system to move water through the Central Valley and over the Tehachapi Mountains to the southern coastal plains, providing new water supplies to areas of need enroute, including Kern County farm lands. Sizing of this aqueduct is scheduled for 1964, after water agencies along the aqueduct route have had an opportunity to determine their needs and to contract with the State for the use of the water required. Of particular interest to water project planners throughout the world are the big lift pumping plants which will be required to lift the water to elevations of 3,167 feet through the Tehachapis. The conveyance system will terminate at Perris Reservoir in Riverside County and Castaic Reservoir in Los Angeles County, from which Southern California water agencies will take delivery and convey water to points even farther south.

North Bay Aqueduct.—Another authorized state project, this 60-mile aqueduct will move surplus delta waters through Napa and Sonoma Valleys to Marin County, north of the San Francisco Bay, providing for irrigation, domestic, and industrial needs along the way.

South Bay Aqueduct.—This project already is under construction, and is designed to transport surplus delta water to Alameda, Contra Costa, and Northern Santa Clara Counties. Delivery of water to Livermore Valley in Alameda County began in May, 1962.

Coastal Aqueduct.—This 131-mile aqueduct will carry water from the California Aqueduct at Avenal Gap across the Salinas Valley in Monterey County and terminate in the Santa Maria Valley in San Luis Obispo and Santa Barbara Counties, providing for irrigation, domestic, and other needs in the Central Coastal Area. This aqueduct will require big pumping lifts to carry water through the Coastal Mountain Range.

San Joaquin Valley Master Drain.—This facility will remove brackish drainage waters from the valley to prevent pollution of valuable ground water basins.

San Luis Dam.—This previously mentioned joint federal-state earthfill dam will create a two million acre-foot reservoir near Los Banos at an estimated cost of \$400 million. The federal-state cooperation in this project provides a unique "first" in water development in the United States.

Davis-Grunsky Project.—This project embraces a number of disassociated small projects designed to meet developing local needs, particularly in areas of water origin.

WORK ON PROJECT ALREADY UNDERWAY

Construction is proceeding under full steam on the State Water Project. For the past four years relocation work has been underway at the Oroville site in Butte County, removing Highway 40A and the Western Pacific Railroad facilities from the area to be inundated. Twenty miles of highway and 27 miles of railroad line are included.

The Western Pacific relocation includes construction of five tunnels and three bridges. The tunnels, now nearing completion, total 21,730 feet, the largest being 8,830. The three bridges are (1) main Feather River Bridge, a 1,100-foot steel girder structure, just north of Oroville; (2) North Fork Feather River Bridge, a 1,011-foot long concrete arch bridge, at the northern extreme of the future reservoir; and (3) the West Branch Bridge, a double deck truss structure providing four lanes of relocated Highway 40A on the upper level, which is 2,732 feet long, and a single track rail line on the lower level, which is 1,800 feet long.

All of the major relocation work is due for completion in the summer of 1962, when the start on the Oroville Dam embankment will begin. The dam is scheduled for completion in 1968.

Construction of the first 12 miles of the South Bay Aqueduct is now complete. Frenchman Dam and Reservoir on the upper Feather also is completed.

San Luis Dam is in the design stage, and construction will begin in 1963. Right-of-way for the California Aqueduct is now being acquired. Construction

of this main aqueduct will be completed to its southern terminus by 1972. The timetable for other facilities:

(1) Construction of access roads in the Tehachapi Mountains preparatory to tunnel construction to begin in 1963. Tehachapi tunneling to begin in 1964 and be completed in 1969.

(2) Canals crossing the Antelope and Mojave Valleys in Southern California to be dug between 1965 and 1970.

(3) Tehachapi pumping plant construction to start in 1966 and be completed in 1970.

(4) Construction of Cedar Springs Reservoir in San Bernardino County and tunnel from Cedar Springs Reservoir to Devil Canyon scheduled to be built between 1967 and 1970.

(5) Work on Castaic Reservoir in Los Angeles County to begin in 1967 and be completed in 1970.

(6) Dam at Perris Reservoir in Los Angeles County to begin in 1967 and be completed in 1970.

The State estimates its annual average construction expenditures for the next 25 years on the State Water Facilities at \$75,000,000. In contrast, California's highway construction program calls for expenditures nine times that amount each year.

BENEFITS OF PROJECT

It would be impossible to assess all the benefits that will accrue from construction of the State Water Project in California, but without it, the present growth in population and industry and agriculture in many sections of the State would be seriously curtailed, and in some areas halted, during the next 25 years.

The project will transport nearly four million acre-feet of water to various parts of the State to care for the growth to about 1990. While general obligation bonds are authorized to finance the construction, the project is expected to pay its own way through vended services.

"In the past it was gold that came out of the fabulous Sierra streams and mines to bring men wealth," Robert de Roos wrote in *The Thirsty Land*, a history of the Central Valley Project. "Now from those same hills comes the inexhaustible resource, the one sure wealth of the state . . . How water is used will determine what California will be."

California has adopted the forward-looking concept of statewide, comprehensive water development incorporated in the State Water Plan and has begun the construction of the first stage of such a development in the State Water Project. In doing so, the State deliberately has taken the guiding hand in determining what California will be in 1990 and in the near future. This historic action may become more significant in this and other states as the years go by and the results of it become apparent.

State of California
CALIFORNIA WATER PROJECT

Facility Name		
	Acquisition	Construction
1) Frenchman Reservoir	Finished	1/2 Fin.
2) Antelope Valley Reservoir	Started	None
3) Dixie Refuge Reservoir	Started	--
4) Abbey Bridge Reservoir	Started	--
5) Grizzly Valley Reservoir	--	--
6) Oroville Reservoir	Started relocation only	
a) Thermalito Diversion Dam	Started	--
b) Thermalito Forebay	Started	--
d) Thermalito Afterbay	Started	--
7) Delta Project	--	--
8) North Bay Aqueduct	--	--
9) Novato Reservoir	Started	--
10) California Aqueduct	Started	Started
11) Bethony Forebay	Finished	Finished
12) South Bay Aqueduct	Started	Started
13) Doonan Canyon Reservoir	--	--
14) Del Valle Reservoir	Started	--
15) Airport Reservoir	Comp.	--
16) San Luis Forebay *	Started	--
17) San Luis Reservoir *	Started	--
18) Las Perillas	--	--
19) Coastal Aqueduct	--	--
20) West Branch California Aqueduct	Started	--
21) Coastal Reservoir	Started	--
22) East Branch Aqueduct	Started	--
23) Cedar Springs Reservoir	Started	--
24) Perris Reservoir	Started	--

* Federal-State Project

