California State Water Project

ATLAS

June · 1999

This book is dedicated to the staff of the California Department of Water Resources – past and present – for their commitment and diligent labor on behalf of the State of California and its people. These dedicated men and women have greatly contributed to the success of many of DWR's programs, including the **State Water Project***.*

FOREWARD

Despite the numerous reports and bulletins prepared by the Department since the late 1950s, there does not exist a publication that gives the public a visual, comprehensive, and concise look at the State Water Project and its facilities. The Department's Bulletin 200 series, published in the early 1980s, discusses the design and construction of many of its facilities. Numerous construction bulletins do the same on individual facilities. The very portable "Data Handbook" provides essential statistical information on the SWP but was created for the engineer in the field.

Designed as an easy-to-use reference book, the Atlas presents the State Water Project through general information, basic facility data, technical drawings, and photos.

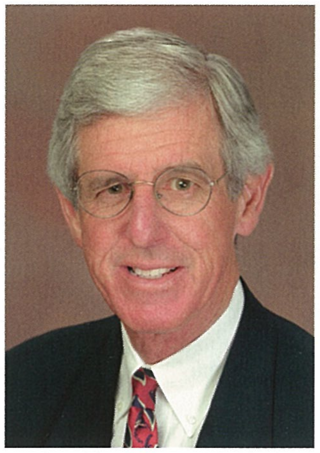
The book opens with a brief historical narrative on the events that led to what is now the State Water Project and the benefits it provides. The introductory sections also describe the agencies that pay for SWP facilities through long-term contracts, as well as provide a look into the people and technology of the Project Operations Center from which Project facilities can be remotely controlled.

The Atlas's main section contains descriptions of all of the SWP's major facilities. They are listed from north to south within the five field divisions responsible for their operation and maintenance. Statistics on each facility are accompanied by at least two technical drawings – an overview (plan) and a cross-section (profile) – as a glimpse of the magnitude and complexity of effort that helped plan, design, and construct the system.

In the Appendix, additional statistical data, technical drawings, a metric conversion table, and references are available.

We at the California Department of Water Resources take pride in the State Water Project and its operations, which have strived to keep pace with changing public needs and concerns. Over the years, the Project has focused not only on the business of delivering water but also on the roles of providing flood control and recreation, generating electricity, and protecting and restoring the natural environment.

David N. Kennedy
DWR Director (1983-1998)



Prologue

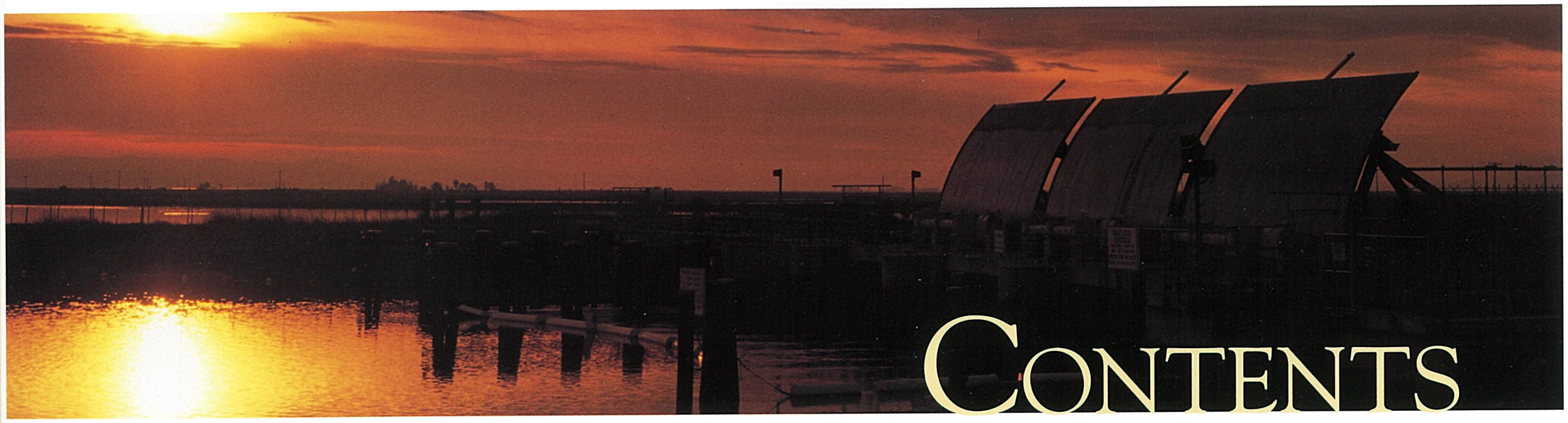
The State Water Project Atlas culminates 18 months of intensive research, writing, and editing to create an authoritative reference book that fully describes the SWP, one of the nation's multipurpose water conveyance and hydroelectric systems. The Atlas' content of general facts, technical data and drawings, and photos bear witness to the diligence and skill of the individuals who helped plan, design, and construct the system, and those who now operate and maintain its facilities.

Since its origins in the late 1950s, the Project has added a number of facilities to improve and expand water delivery, enhance its operational flexibility, and protect the environment. The Atlas reflects those facilities as well as the future East Branch Extension.

As the new Director of the California Department of Water Resources, I am proud to welcome you to learn about the State Water Project and how it has contributed to California's economy and the well-being of its people. As we enter the new century, the Department and its staff will continue to ensure the operational integrity of the SWP.

Thomas Hannigan
DWR Director, 1999

Governor Gray Davis appointed Hannigan as DWR's seventh director, effective March 1, 1999. The first former legislator to head the Department, Hannigan was an Assemblyman from Solano County for 18 years. From 1986 to 1996, he served as Majority Floor Leader in the Assembly.

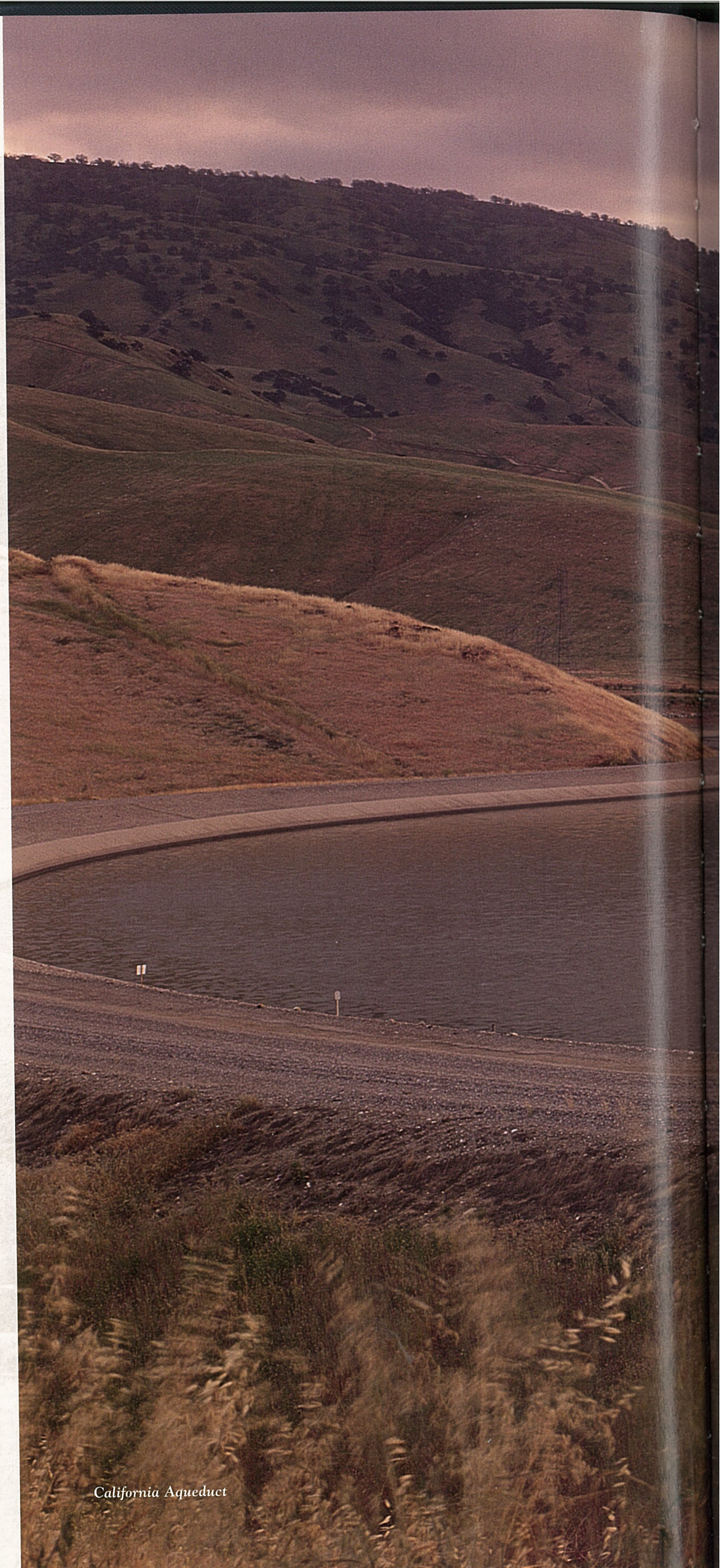


CONTENTS

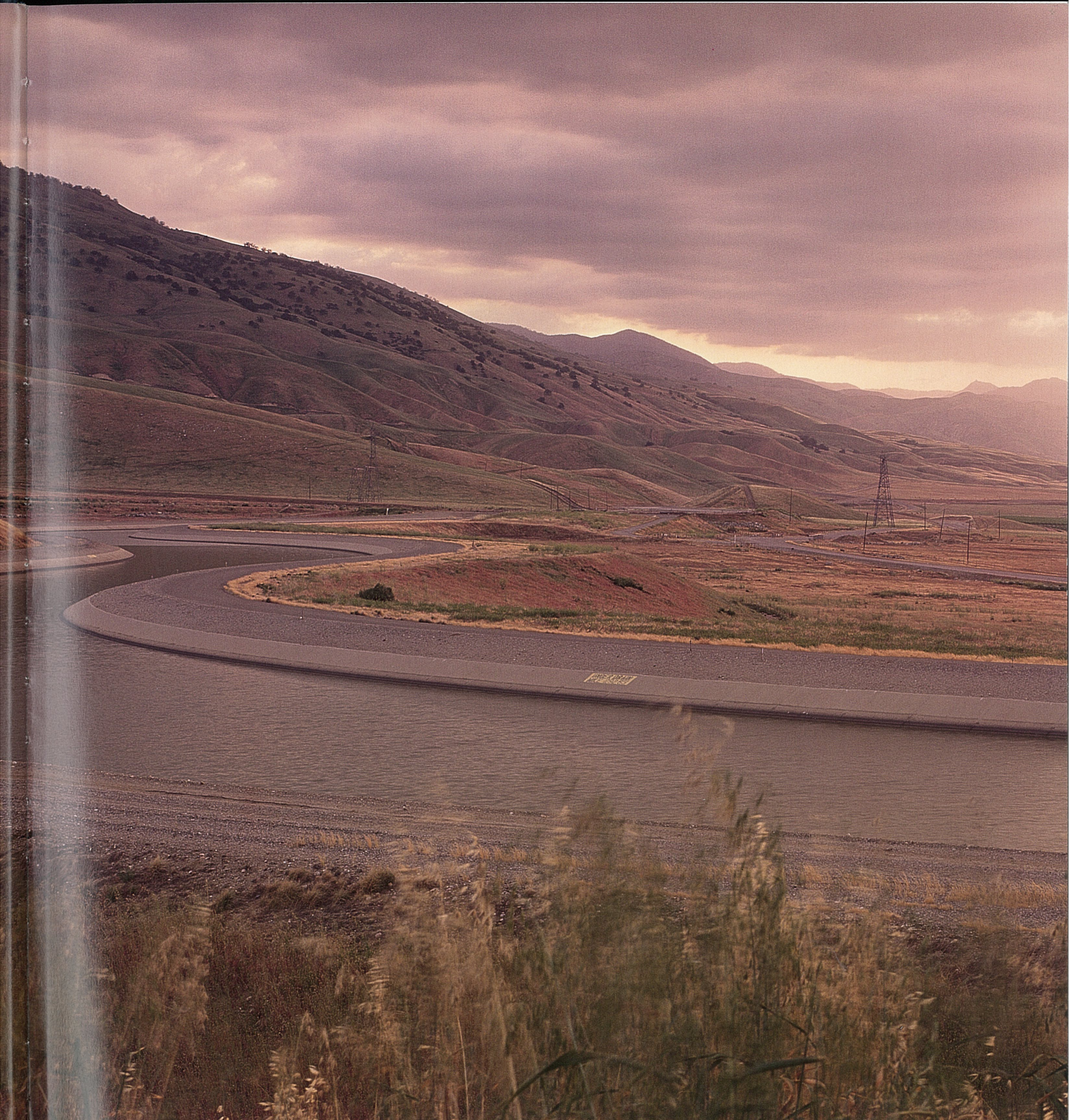
CALIFORNIA DEPARTMENT OF WATER RESOURCES

Our Mission:
To manage the water resources of California, in cooperation with other agencies, to benefit the state's people and protect, restore, and enhance the natural and human environments.

The California Department of Water Resources planned, designed, and oversaw the construction of the State Water Project. Today, DWR operates and maintains the SWP facilities, as well as plans, designs, and oversees any repairs, modifications, or new construction. All of the financing, contract administration, water allocation and accounting, and power generation transactions are handled by the Department. DWR also provides technical and financial assistance to local urban and agricultural water agencies for water supply management, reclamation or recycling, and conservation projects; works with other state and federal agencies on environmental compliance, mitigation, and protection programs; and studies, plans, and develops water management strategies, reports, and programs to address California's growing water demands, as well as projects and programs to protect and enhance the estuary of the Sacramento-San Joaquin Delta. Other DWR responsibilities include providing for public safety through dam safety and flood control programs, and educating the public about the Department's role and the significance of water in their lives.



California Aqueduct



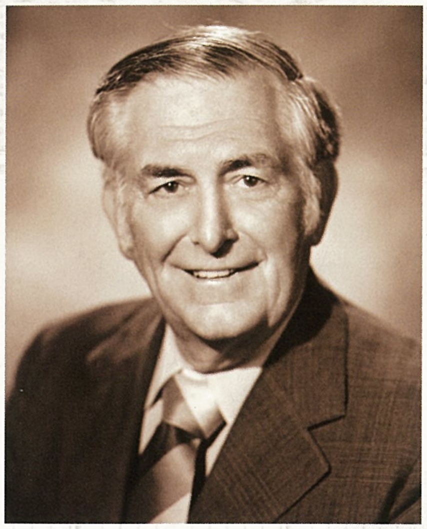
William Hammond Hall

DWR Directors 1956-1998

More than a century ago, William Hammond Hall was appointed State Engineer to investigate California's water resources. The wealth of data collected under his direction served as a legacy to those who would follow. His proposal that these resources be developed on a statewide basis would be realized with the establishment of the Department of Water Resources in 1956. DWR's first Director would oversee the beginning of a State Water Project that his successors will complete and continue to benefit the people of California.

Harvey O. Banks (1956-61)

DWR's first director, a civil engineer, presided over the completion of the first comprehensive California Water Plan (now the Bulletin 160 series). Under his charge, planning continued and construction was begun on railroad relocations at the Oroville Reservoir site and the South Bay and California Aqueduct portions of the State Water Project. His efforts helped to build public support for the project leading to its successful financing.



William E. Warne (1961-67)

William Warne, a long-time federal administrator, continued the planning of the SWP and is credited with successfully getting its major construction program underway. His promotion of service contracts and computer-oriented program management procedures helped keep early construction activities on schedule. By the time Mr. Warne left office, Oroville Dam was nearly completed, construction of the Tehachapi Crossing was ready to start, and South Bay Aqueduct water deliveries begun to Santa Clara and Alameda counties.

William R. Gianelli (1967-73)

A civil engineer, William Gianelli continued construction of the SWP. He met the challenge of maintaining the Project's financial integrity and oversaw the completion and start of operations of many SWP facilities. Under his charge, the Department accepted new responsibilities, such as in water quality and water desalination. After his state service, he continued his work as a consulting civil engineer and later served as Assistant Secretary of the Army for Civil Works.

John R. Teerink (1973-75)

John Teerink, a long-time DWR engineer-manager, presided as the SWP began full operations. Under his guidance, Bulletin No. 200, which recorded the planning, financing, design, construction, and operation of the SWP, was prepared and published. In addition, Pyramid Lake and various aqueduct pumping facilities were completed, the state's hydroelectric potential was inventoried, and studies on alternative water supplies were continued.

Ronald B. Robie (1975-83)

Director Ronald Robie, an attorney, was an effective contributor to the management of California's water resources through the second driest year of record, during the drought of 1976-77. He was also instrumental in recognizing environmental forces and in implementing conservation measures which would eventually lead to innovative water management and storage programs.

David N . Kennedy (1983-98)

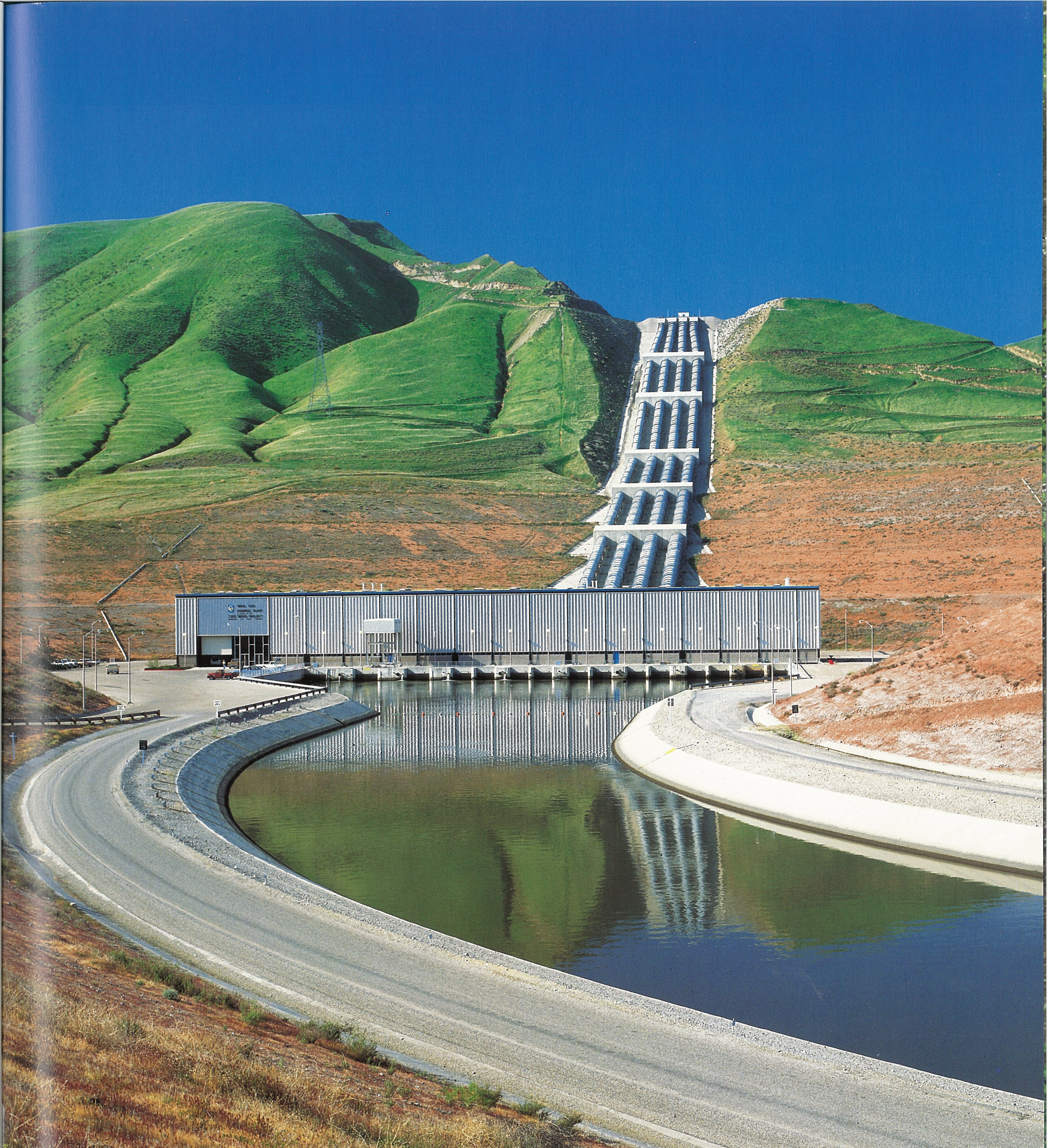
A civil engineer, Director David Kennedy directed construction of the SWP Coastal Branch, East Branch Extension, East Branch Enlargement, and North Bay Aqueduct. He also created DWR's Environmental Services Office and negotiated the Monterey Agreement, which gives SWP contractors more operational flexibility.

CALIFORNIA STATE WATER PROJECT

Stretching from the mountains in Plumas County to the flatlands of Riverside County, the State Water Project is one of the largest water and power systems in the world. The SWP currently conveys an annual average of about 2.5 million acre-feet through its 17 pumping plants, 8 hydroelectric power plants, 32 storage facilities, and 660-plus miles of aqueducts and pipelines. Water delivered serves more than two-thirds of the population and approximately 600,000 acres of irrigated farmlands in the Feather River and San Francisco Bay area, San Joaquin Valley, Central Coast, and Southern California.

To understand why and how this ambitious undertaking was conceived and completed requires a look at California itself and its early history of water development and settlement.

Opposite Page:
Ira J. Chrisman Wind Gap Pumping Plant



SETTING

With more than 32 million people, California has the largest population among the 50 states. If it were an independent country, its economy would rank as the seventh largest in the world. It leads the nation in agriculture, producing about 11 percent of the U.S. market.

Precipitation is heaviest in the north and along the Sierra Nevada mountain range, which traverses much of the state. The north is also blessed with most of the state's total streamflow. Southward the land becomes arid and includes large desert areas. The state's Central Valley, a vital agricultural region spanning 400 miles along its length, averages 25 inches a year at the northern end to 5 inches in the south.

Most of California's population and irrigated agricultural land lie to the south of San Francisco. This imbalance between the location of water supply and water needs comprises the fundamental factor that has driven statewide water development and will continue to do so.

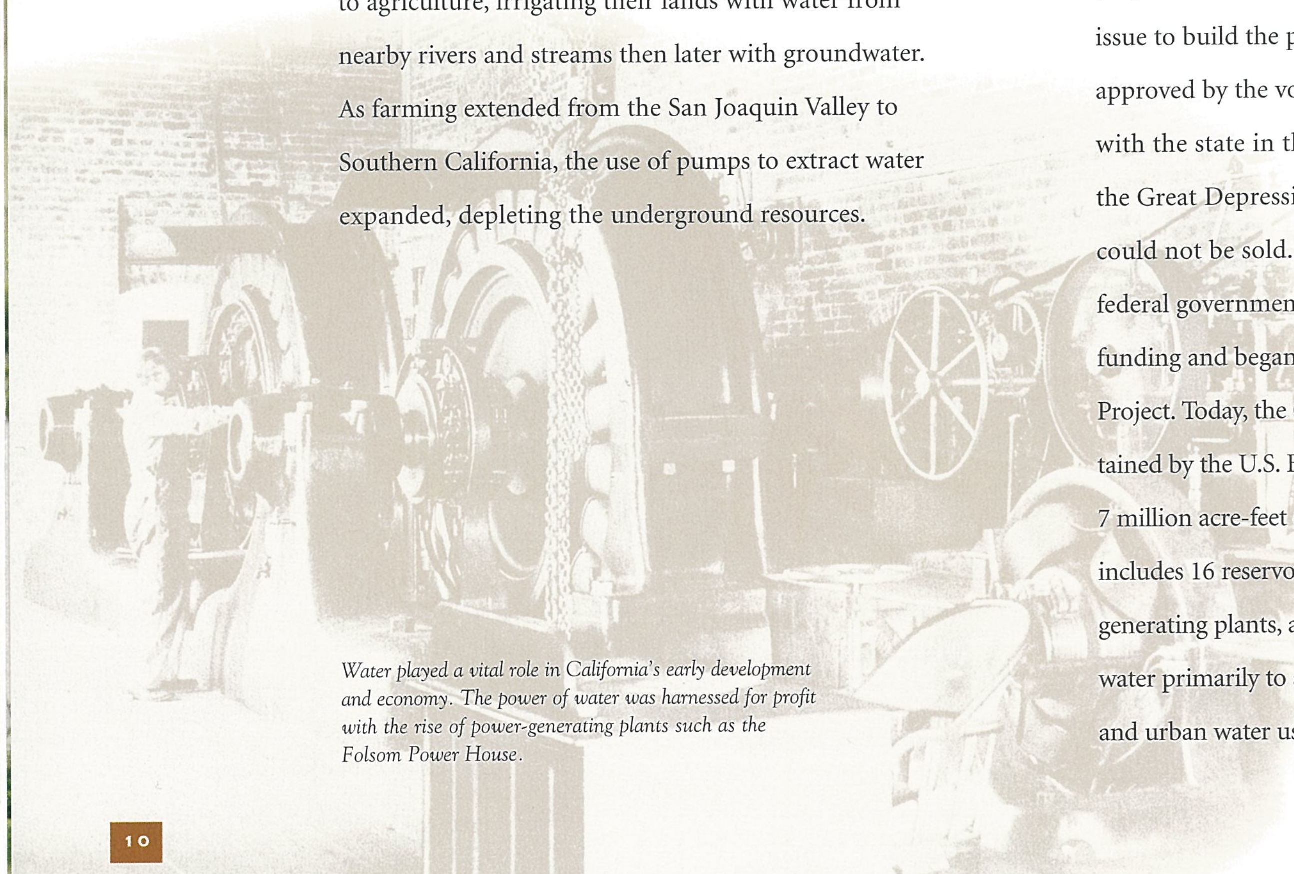
From Northern California's watersheds, the SWP provides about 20 million Californians with at least part of their drinking water supply. The Project also provides water to about 600,000 acres of California farmlands.

Early Water Development

The earliest irrigation systems can be traced back to around A.D. 800, when native California Indian tribes, such as the Paiutes in Owens Valley and the Quechans along the lower Colorado River, began cultivating the land. More elaborate waterworks were built in the late 1760s by Spain's mission settlements. These systems irrigated crops, operated mills, and recycled water. Spanish sovereignty over the region also introduced new concepts of water rights.

In 1849, the Gold Rush triggered the development of extensive water systems. Networks of ditches and flumes, some still in use today, were constructed to flush the precious metal from streambeds and mountainsides. But this enterprise soon produced destructive consequences, clogging rivers with sediment and debris – a situation which was halted by regulation.

With the gold fever ebbing as the precious metal became harder to find, California's new settlers turned to agriculture, irrigating their lands with water from nearby rivers and streams then later with groundwater. As farming extended from the San Joaquin Valley to Southern California, the use of pumps to extract water expanded, depleting the underground resources.



Water played a vital role in California's early development and economy. The power of water was harnessed for profit with the rise of power-generating plants such as the Folsom Power House.

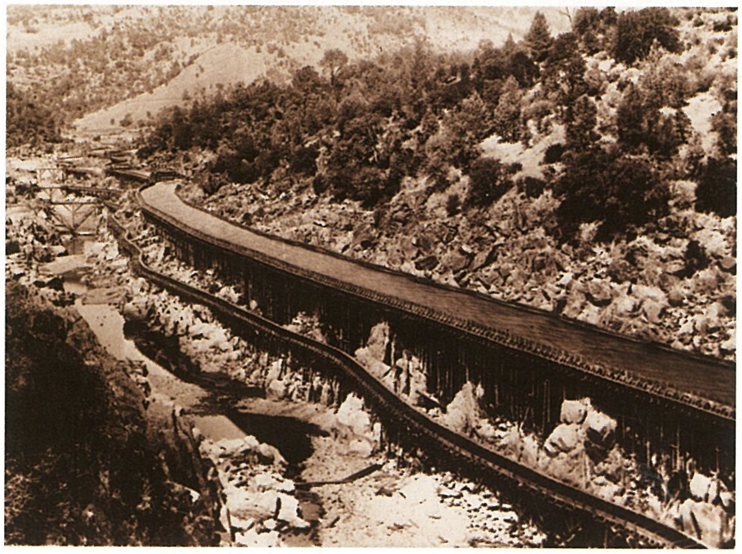
At the turn of the century, dams and hydroelectric generation of power turned into profitable ventures. Cities began to develop, attracting increasing numbers of people and businesses. Los Angeles and San Francisco constructed expansive water delivery systems to meet their growing water needs.

A Statewide Plan

The concept of a statewide water development project was raised in 1919 by Lt. Colonel Robert B. Marshall. He published a plan for transferring water from the ample Sacramento River system to the San Joaquin Valley and from there moving it through the Tehachapi Mountains to Southern California.

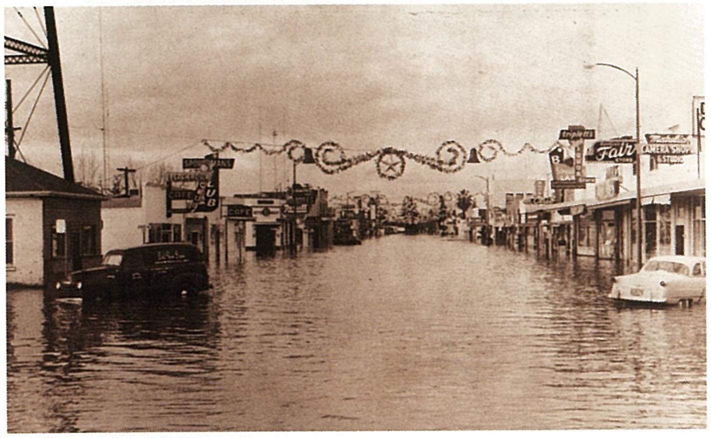
His proposal led to the first State Water Plan, published in 1931, which identified facilities and means of accomplishing the north-to-south water transfer. To implement the plan, the Legislature passed the Central Valley Project Act in 1933. The proposal and a $170 million bond issue to build the project were approved by the voters. However, with the state in the midst of the Great Depression, the bonds could not be sold. In 1937, the federal government took over the funding and began constructing the Central Valley Project. Today, the CVP, which is operated and maintained by the U.S. Bureau of Reclamation, delivers about 7 million acre-feet of water through its system which includes 16 reservoirs, 39 pumping plants, 2 pumping-generating plants, and 7 power plants. The CVP delivers water primarily to agricultural users in the Central Valley and urban water users in the San Francisco Bay area.

Lt. Colonel Robert Marshall



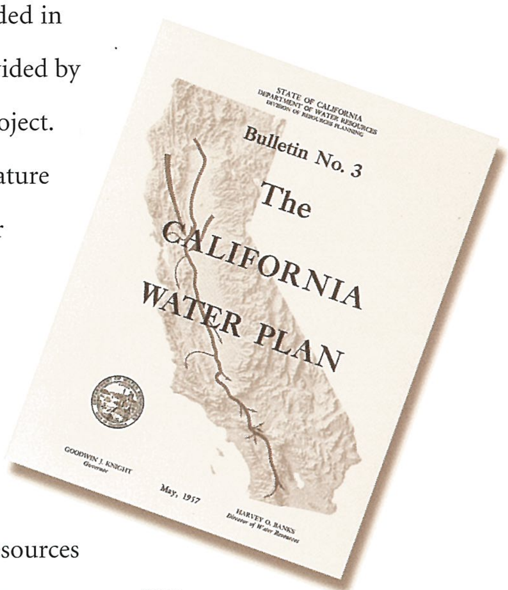
The population boom began with the Gold Rush (1849), which lured thousands of people of all colors and creeds. Miles of canals and flumes were built to harvest the precious metal. Later hydraulic mining (far left) used high-pressure water streams to break down hillsides in search of gold. The debris was washed into rivers and streams, filling the channels and limiting their navigability and carrying capacities.

Floods were commonplace in the Central Valley. The Flood of 1955 breached levees at Yuba City (above) and caused widespread destruction and more than 60 deaths. Because the Oroville project would help control such floodwaters, the State Legislature quickly approved money in 1956 for its final design.



State Water Project Plans

During and following World War II, California's population nearly doubled, and agriculture became big business. More water was needed in addition to that provided by the Central Valley Project. Therefore, the Legislature asked the State Water Resources Board to update and expand the prewar water studies. This task was given to the Division of Water Resources (predecessor to the Department of Water Resources) of the Department of Public Works.



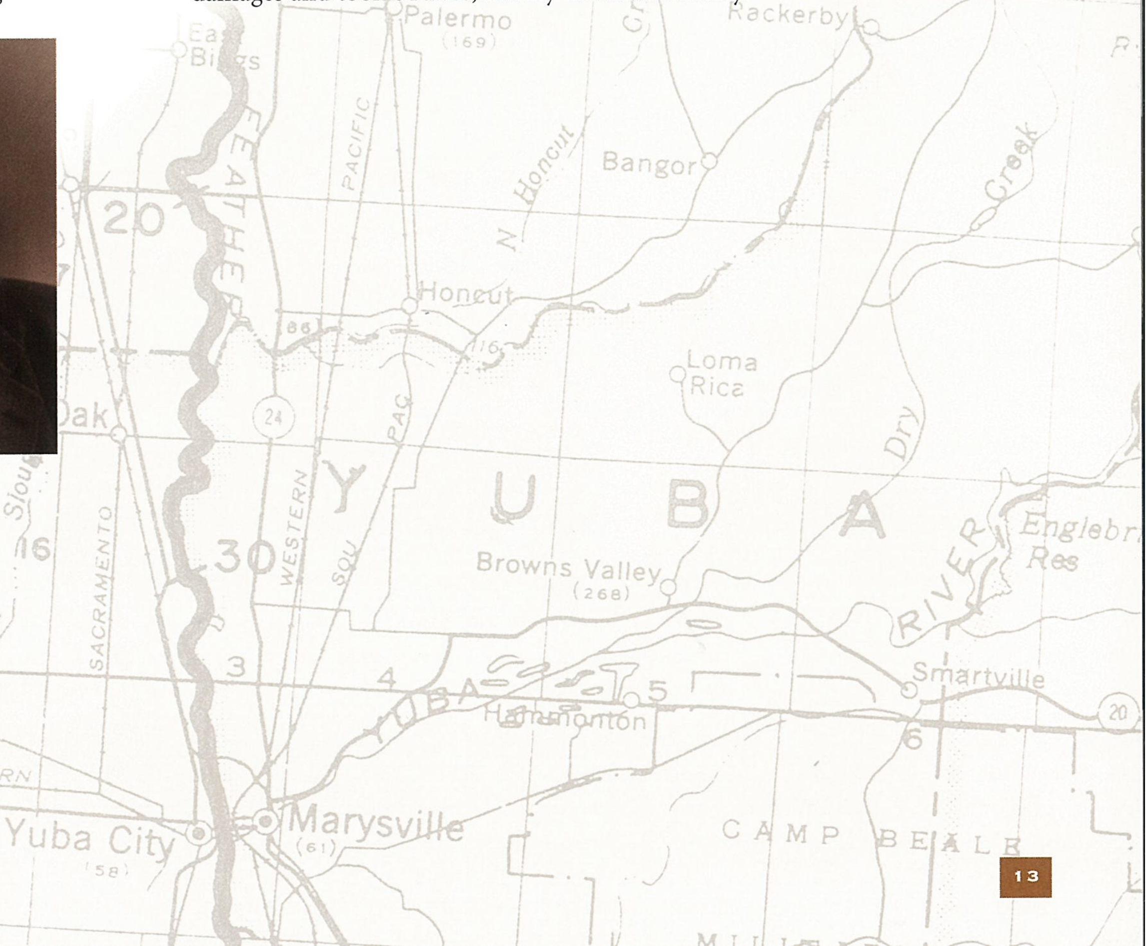
Their work produced Bulletin 1 (1951), a collection of data on precipitation, runoff, floods and droughts, water storage and quality statewide; Bulletin 2 (1955), a survey of current water uses with forecasts of future needs; and Bulletin 3 (1957), "The California Water Plan," the preliminary plans for full development of the state's water resources to meet its "ultimate" water needs. These plans included local development together with works needed for the transfer of water from areas of surplus in the north to the water-deficient areas to the south.

A. D. Edmonston

Concurrently, under the direction of State Engineer A.D. Edmonston, other specialists completed the first proposal for a "Feather River Project" in 1951 to meet the state's immediate water needs. It called for a multipurpose dam and reservoir on the Feather River near Oroville, a Delta Cross Channel, an electric power transmission system, an aqueduct to convey water from the Sacramento-San Joaquin Delta to the San Francisco Bay Area, and another aqueduct to transport water from the Delta to the San Joaquin Valley and Southern California.

The proposed project was authorized by the State Legislature in 1951. In 1955, a second report on the Feather River Project was completed and included the addition of a San Luis Reservoir.

That same year, Northern and Central California experienced one of the greatest floods of record. The floods caused more than $200 million in property damages and took 64 lives, mainly in Sutter County.



President John F. Kennedy and Governor Edmund G. Brown, Sr., headed the 1962 groundbreaking ceremony to begin constructing the San Luis Reservoir (photo, p.16) and other joint-use facilities. Today the reservoir is the nation's largest off-stream storage reservoir, serving both the federal Central Valley Project and the State Water Project.

Responding to this disaster, the Legislature made the first emergency appropriation of $25.2 million to the Department of Water Resources (officially created in July 1956) to construct the State Water Project. Work began in May 1957 on facilities in the Oroville area, beginning with the relocation of the Western Pacific Railroad to make way for the dam and reservoir.

Although the Legislature continued to appropriate funds to build units of the SWP, it wasn't until 1959 that the California Water Resources Development Bond Act, known as the Burns-Porter Act, was passed. The act authorized the issuance of $1.75 billion in general obligation bonds to finance the SWP and additional facilities that might be required in the future to augment water supplies and meet local needs. Federal funding was provided for flood control and federal-state joint-use facilities. In November 1960, voters approved the bond act.

Construction of the Oroville complex on the Feather River started in 1957 and ended in 1971. The dam itself took nearly six years to complete (1962-68). Part of it was building the 283,000-cubic-yard concrete core block (bottom right photo) and preparing the foundation for the main dam (bottom left photo). Final cost of the dam was $135.3 million when DWR signed the completion documents on April 26, 1968. Today, Lake Oroville (top photo) is the SWP's largest reservoir and the second largest reservoir in California.

The SWP facilities – including San Luis Reservoir (left photo) and Buena Vista Pumping Plant (right) – represent a capital investment of about $5 billion, most of which is being repaid by the agencies that have long-term contracts for water supply. The SWP's water supplements the local supplies of many urban and agricultural areas.

The SWP Today

California's State Water Project is among the largest water and power systems in the world. The SWP conveys water from Northern California watersheds to agricultural areas in the San Joaquin Valley and urban regions in the San Francisco Bay area, Central Coast, and Southern California. Water is delivered to local water agencies which in turn supply water to farms, homes, and industries.

While the SWP was built primarily for water supply, the Project and its facilities also provide the people of California with many other benefits.

Benefits

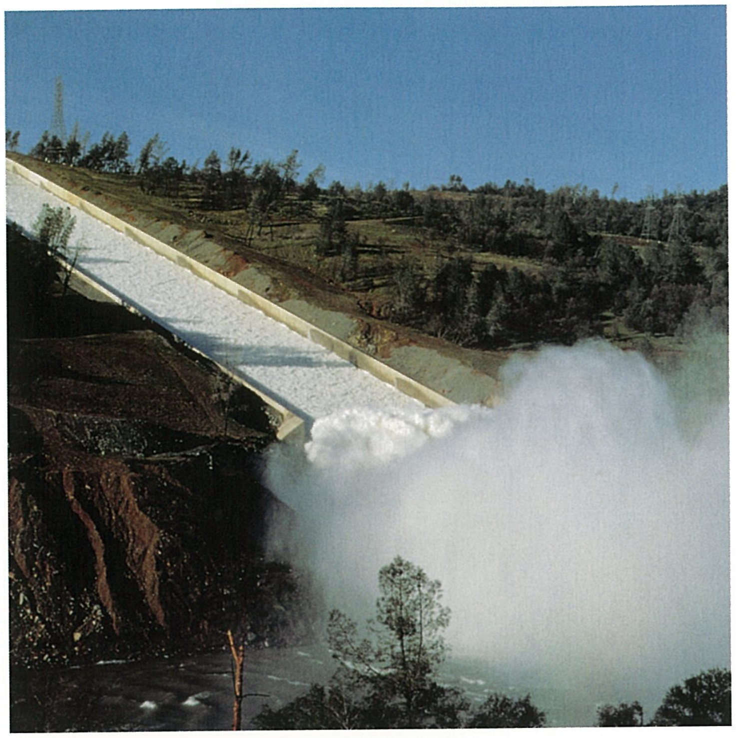
The multipurpose State Water Project provides water supply to its contracting agencies. Other SWP benefits include flood control, recreation, fish and wildlife enhancement, power, and salinity control in the Sacramento-San Joaquin Delta.

Water Supply

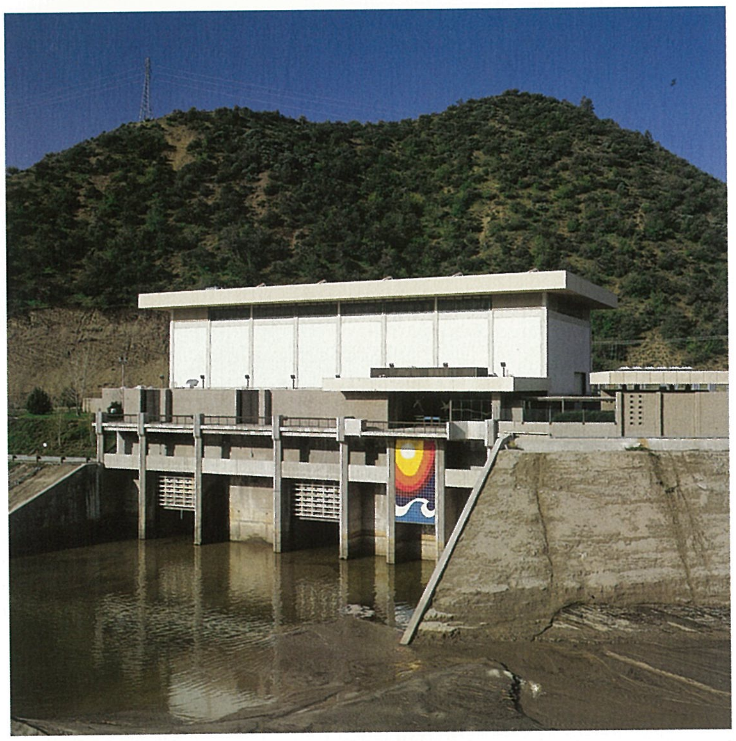
The State Water Project's main purpose is water supply – to divert and store surplus water during wet periods and distribute it to 29 contracting agencies. Water supply contracts were signed between the state and public agencies stretching from Sutter, Butte, and Plumas counties in the north; to Alameda, Santa Clara, Napa, and Solano counties in the San Francisco Bay area; through the San Joaquin Valley; and into Southern California.

SWP facilities were designed to deliver 4.2 million acre-feet of water a year. To date, the SWP has supplied a maximum of 3.2 MAF. Its capacity to deliver full water supply requests in a given year depends on probabilities of rainfall, snowpack, runoff, water in storage, and pumping capacity from the Delta, as well as operational constraints for fish and wildlife protection, water quality, and legal restrictions.

About 20 million Californians and 600,000 acres of farmland receive water from the SWP. Of the contracted water supply, about 70 percent goes to urban users and 30 percent to agricultural users.



At Oroville Dam, storage space is reserved for flood flows. Releases made through the spillway and river outlet are coordinated with other reservoirs to prevent flooding downstream.



DWR's eight hydroelectric power plants (Warne Powerplant, above; Hyatt Powerplant, opposite page) generate enough electricity to meet 75 percent of the SWP's energy needs. The rest is provided through a coal-fired plant and power exchanges and purchases.

Flood Control

One of the Project's primary functions is to provide flood control in Northern California. Storage space is provided in Oroville and Del Valle Lakes to capture flood flows and protect areas downstream. In Kern County a gated structure can divert Kern River flood flows into the California Aqueduct.

Power

The SWP is the state's fourth largest energy supplier and the single largest user of power. Its nine hydroelectric plants and a coal-fired plant in Nevada generate an annual average of 6 billion kilowatthours. How much energy is consumed by Project facilities depends on annual water demands and the amount of water available for delivery and storage. Since 1984 annual power requirements have ranged from under 4 billion to over 8 billion kWh.

To provide for its needs, the Department entered into agreements with other electrical utilities, energy brokers, and power pools in California, the Northwest, and Southwest for short-term sale, purchase, or exchange of power and transmission capacity. When power resources are greater than SWP needs, the Department sells surplus power to help reduce the cost of water deliveries.

The SWP's flexibility in managing its pumping operations helps keep its costs down. Pumping is minimized when electricity rates are higher and maximized when costs are lower. Such flexibility allows the Department to purchase inexpensive surplus generation from other power suppliers and sell generated power at higher rates.

The Suisun Marsh Salinity Control Gates assist in maintaining suitable water quality for thousands of acres of waterfowl and wildlife habitat located in the Bay-Delta estuary.

Fish & Wildlife Protection

Major facilities built for fish and wildlife protection are the Feather River Fish Hatchery, the Suisun Marsh Salinity Control Gates, and the Skinner Fish Protective Facility. Compensating for lost spawning grounds on the Feather River near Oroville, the hatchery raises about 20 million fall-run and spring-run chinook salmon and steelhead annually. These fish are released into Northern California lakes, rivers, and the Delta.

The salinity control gates protect water quality in the Suisun Marsh, one of the largest contiguous brackish water marshes in the U.S. Its radial gates trap fresher water in the marsh, diluting saline waters from San Francisco Bay.

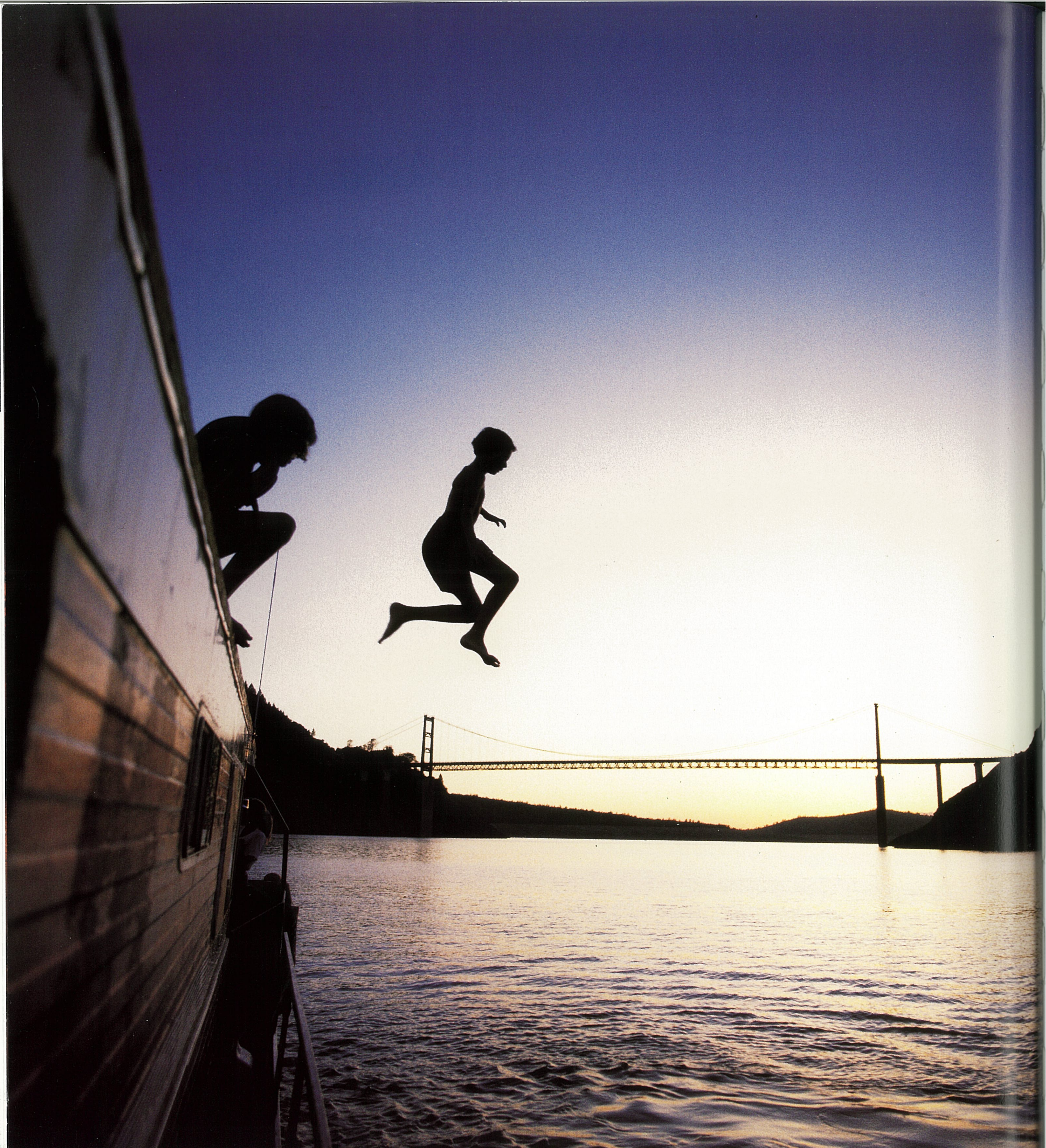
Located along the intake channel to Banks Pumping Plant, the Skinner Fish Facility uses louver screens and fish bypass systems to divert fish from entering the plant's pumps. These fish are counted, identified, recorded, and transported back to the Delta for release.

Other environmental protection measures include streamflow maintenance and temperature control, flow augmentation, restricted pumping schedules, fish screens, and mitigation agreements.

Salinity Control

The State Water Project, in coordination with the federal Central Valley Project, is operated to limit salinity intrusion into the Delta and Suisun Marsh. This is accomplished by supplementing freshwater outflows to San Francisco Bay and limiting water exports from the Delta during specific times of the year.

Funds from the SWP contractors are spent on a variety of fish and wildlife programs such as the Feather River Fish Hatchery. The fish ladder to the hatchery begins near the Fish Barrier Dam (top photo). Other programs include the Skinner Fish Protective Facility, and wildlife studies (bottom photo).

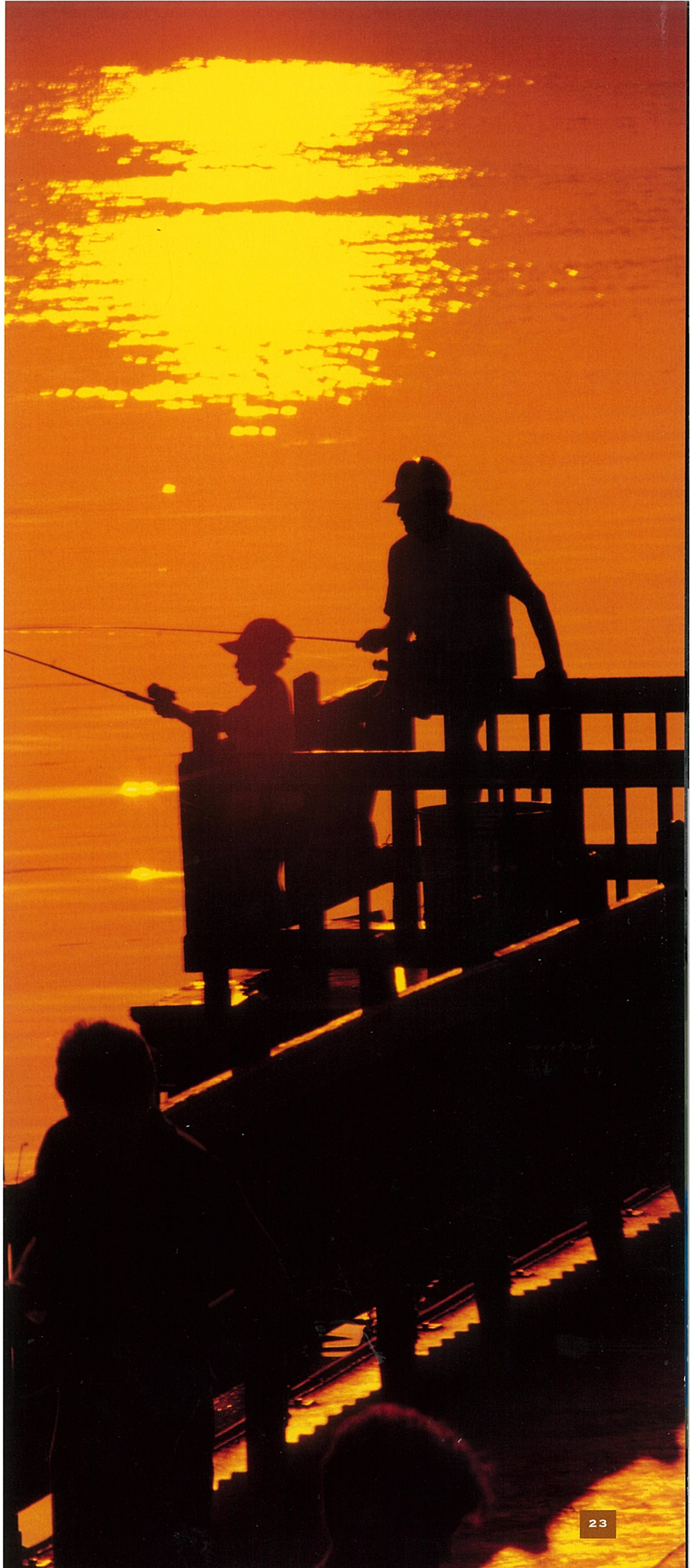


Recreation

Project reservoirs were designed to provide a variety of recreational opportunities. Most facilities offer boating, fishing, swimming, picnicking, camping, cycling, and hiking. At Lake Oroville, visitors will also find, among the usual water recreation, floating campsites, an equestrian camping facility, and a 41-mile bike trail. Thermalito Afterbay and Thermalito Forebay, part of the Oroville complex, offer additional opportunities for recreation.

Fishing from designated access sites is allowed along the California Aqueduct, where bicyclists can also ride along specified trails.

Passage of the Davis-Dolwig Act (1961) provided initial funding for the SWP's recreational sites, which include 12 reservoirs and lakes, and 16 fishing access sites along the California Aqueduct.



SWP CONTRACTORS

In the early 1960s, long-term contracts were negotiated with 31 water-purveying agencies. Through these contracts, the contractors are presently repaying the revenue and general obligation bonds (plus interest) that initially funded the State Water Project's construction, as well as current costs necessary to operate and maintain all project facilities.

Today, there are 29 contractors who receive a specified annual amount of water until the year 2035. Each contract contains a schedule of the annual amount of water the agency is entitled to receive each year. Generally, contractors receive the amount they request or a portion of that, depending on supply. For most contracts, the amounts increase yearly up to the maximum annual entitlements.

The service areas of the 29 contracting agencies extend from Plumas County in the north to the Mexican border. These agencies comprise almost one-quarter of California's land area and more than two-thirds of its population. While most of the contractors are agencies that were in existence for many years, a number of new districts were formed for the express purpose of contracting for SWP water.

SWP water supplements the agencies' local and other imported supplies. SWP water is used mostly for irrigated agriculture in the southern San Joaquin Valley, while in the other service areas, it satisfies mainly urban needs.

The SWP made its first deliveries in 1962 to the Alameda County Flood Control and Water Conservation District Zone 7, and the Alameda County Water District. In 1965, deliveries were made to the Santa Clara Valley Water District, where imported supplies were used to solve a land subsidence problem caused by long-term overdrafting of local groundwater basins. In 1968, service was extended into the central and southern San Joaquin Valley, and by 1972, Southern California areas began receiving their first deliveries.

Thirty percent of contracted SWP water supplies go to agricultural water contractors such as Kern County Water Agency, which provides water mainly for irrigation in Kern County (above). The county is the third most productive agricultural county in the nation. (Photo courtesy of Greg Iger and Kern County Water Agency) Drip irrigation (left) is one of the many irrigation methods used by growers.

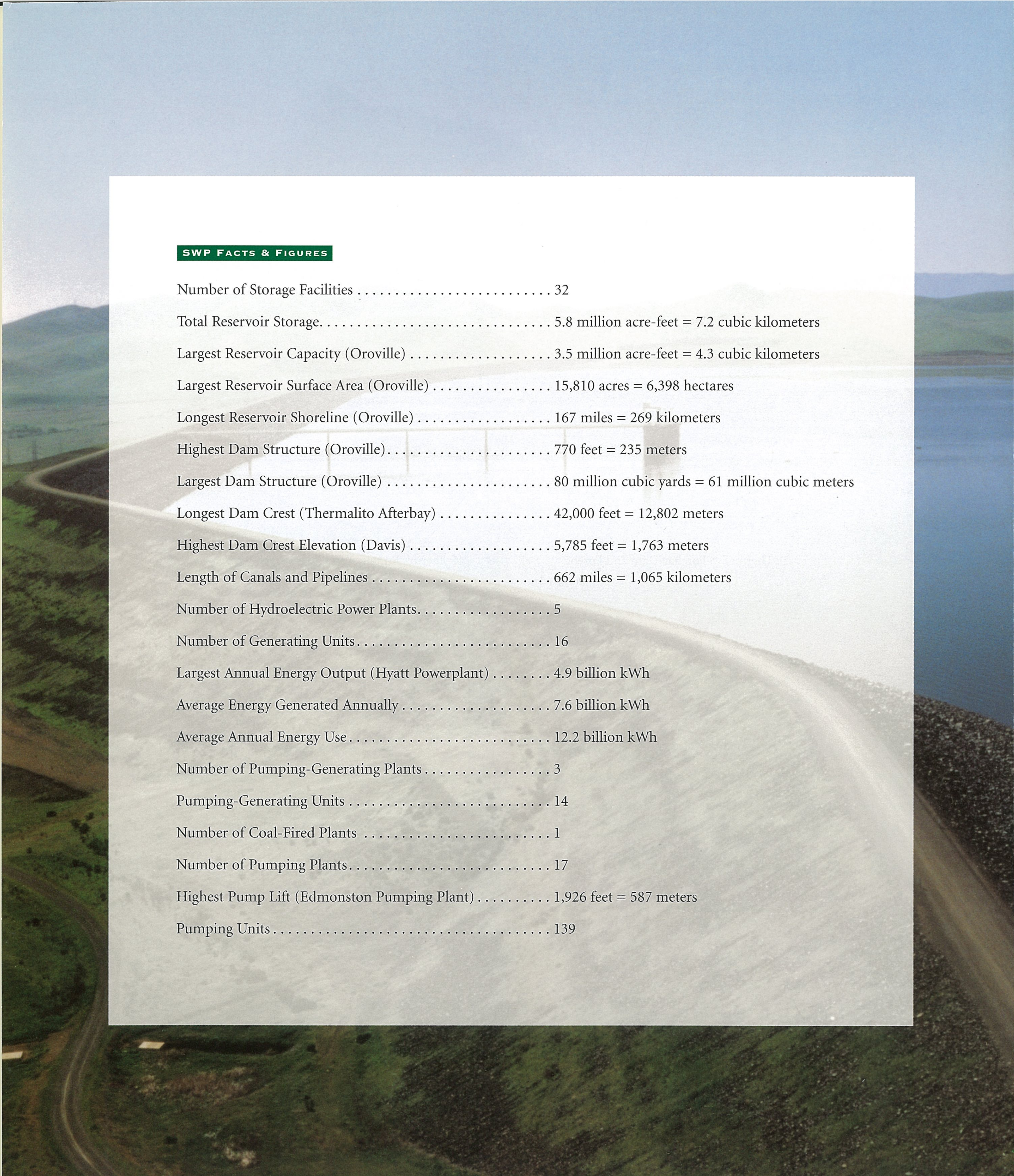
THE 1994 MONTEREY AGREEMENT

In December 1994, representatives of the Department of Water Resources and the State Water Project Contractors signed the Monterey Agreement, amendments that redefine the way DWR administers its long-term water contracts.

Major issues covered by the agreement include:

- Adjustments in water allocations among contractors in years of short supply. (In years of shortages, agricultural and urban contractors will receive the same percent reductions in deliveries.)
- Future transfers of entitlements from agricultural contractors to urban users: 45,000 acre-feet of agricultural entitlement is permanently transferred to DWR and retired, and 130,000 acre-feet is available for permanent sale (willing buyer-willing seller basis) to urban contractors.
- Transfer of the SWP portion of the Kern Water Bank (a groundwater storage project) to Kern County Water Agency for use in regional banking programs.
- Financial restructuring to establish a SWP operating reserve and water rate management to reduce contractor charges when SWP cash flow permits.
- Added operational flexibility. Such provisions include storage of SWP water in non-SWP surface storage facilities outside a contractor's service area for later use, expanded rules for carryover in SWP conservation reservoirs; and no limits for groundwater storage of SWP water outside a contractor's service area for later use within the service area.

Paper mills are among the industries that use water for manufacturing. Urban water use, which includes homes and government, is closely related to population growth. (Photo courtesy of Metropolitan Water District of Southern California)



SWP Facts & Figures

Number of Storage Facilities	32
Total Reservoir Storage	5.8 million acre-feet = 7.2 cubic kilometers
Largest Reservoir Capacity (Oroville)	3.5 million acre-feet = 4.3 cubic kilometers
Largest Reservoir Surface Area (Oroville)	15,810 acres = 6,398 hectares
Longest Reservoir Shoreline (Oroville)	167 miles = 269 kilometers
Highest Dam Structure (Oroville)	770 feet = 235 meters
Largest Dam Structure (Oroville)	80 million cubic yards = 61 million cubic meters
Longest Dam Crest (Thermalito Afterbay)	42,000 feet = 12,802 meters
Highest Dam Crest Elevation (Davis)	5,785 feet = 1,763 meters
Length of Canals and Pipelines	662 miles = 1,065 kilometers
Number of Hydroelectric Power Plants	5
Number of Generating Units	16
Largest Annual Energy Output (Hyatt Powerplant)	4.9 billion kWh
Average Energy Generated Annually	7.6 billion kWh
Average Annual Energy Use	12.2 billion kWh
Number of Pumping-Generating Plants	3
Pumping-Generating Units	14
Number of Coal-Fired Plants	1
Number of Pumping Plants	17
Highest Pump Lift (Edmonston Pumping Plant)	1,926 feet = 587 meters
Pumping Units	139

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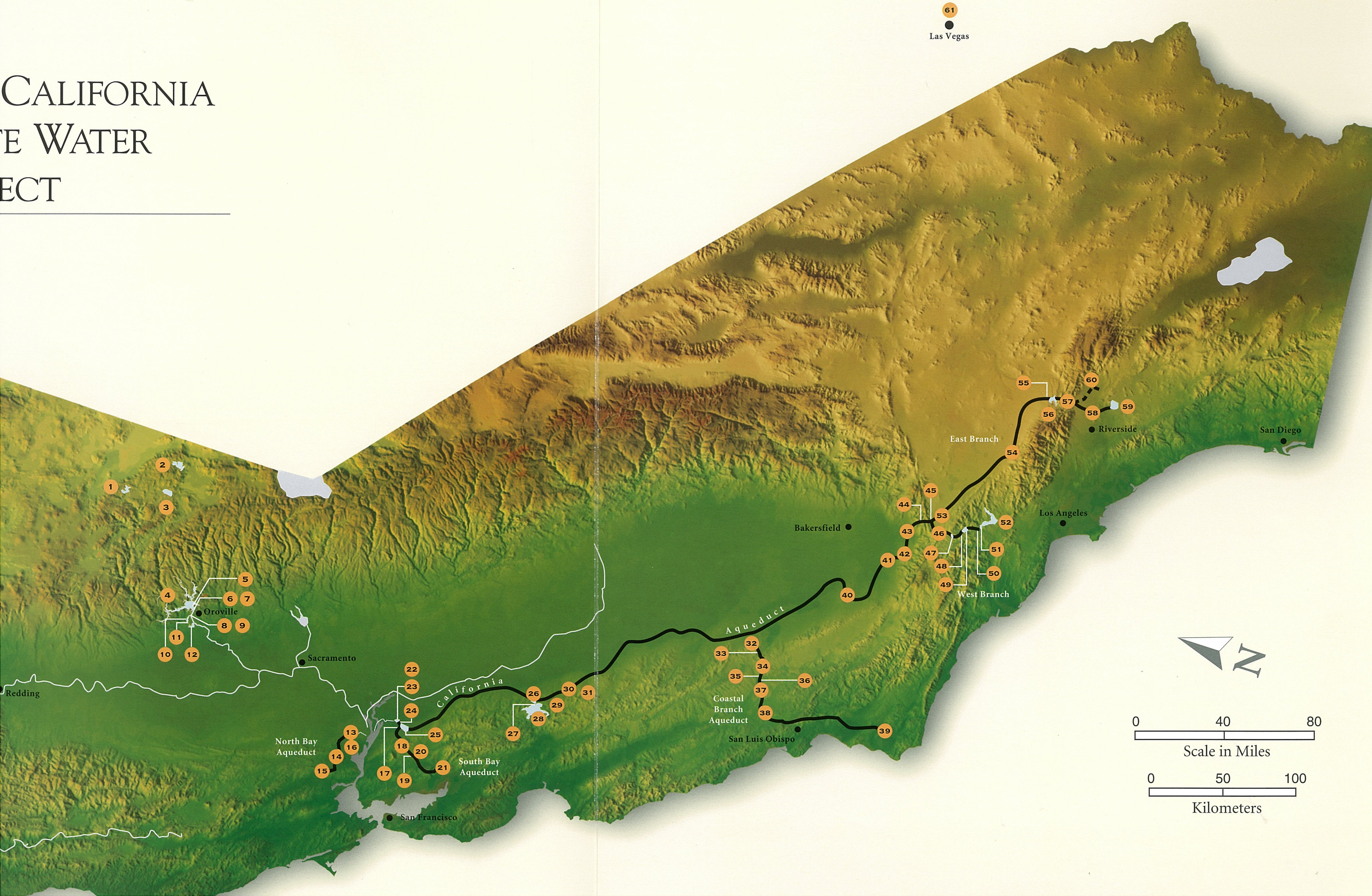
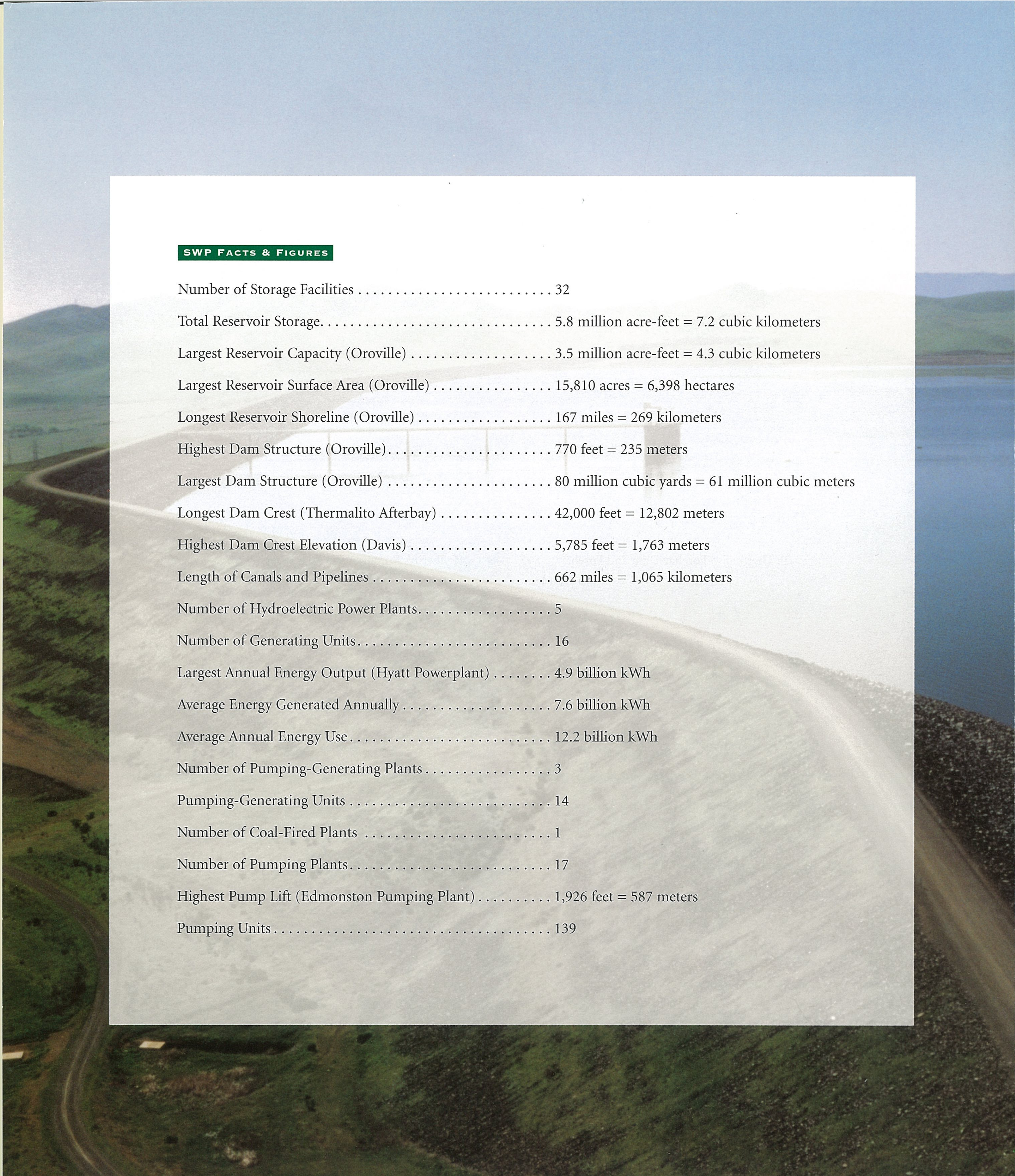




SWP Facts & Figures

Number of Storage Facilities	32
Total Reservoir Storage	5.8 million acre-feet = 7.2 cubic kilometers
Largest Reservoir Capacity (Oroville)	3.5 million acre-feet = 4.3 cubic kilometers
Largest Reservoir Surface Area (Oroville)	15,810 acres = 6,398 hectares
Longest Reservoir Shoreline (Oroville)	167 miles = 269 kilometers
Highest Dam Structure (Oroville)	770 feet = 235 meters
Largest Dam Structure (Oroville)	80 million cubic yards = 61 million cubic meters
Longest Dam Crest (Thermalito Afterbay)	42,000 feet = 12,802 meters
Highest Dam Crest Elevation (Davis)	5,785 feet = 1,763 meters
Length of Canals and Pipelines	662 miles = 1,065 kilometers
Number of Hydroelectric Power Plants	5
Number of Generating Units	16
Largest Annual Energy Output (Hyatt Powerplant)	4.9 billion kWh
Average Energy Generated Annually	7.6 billion kWh
Average Annual Energy Use	12.2 billion kWh
Number of Pumping-Generating Plants	3
Pumping-Generating Units	14
Number of Coal-Fired Plants	1
Number of Pumping Plants	17
Highest Pump Lift (Edmonston Pumping Plant)	1,926 feet = 587 meters
Pumping Units	139

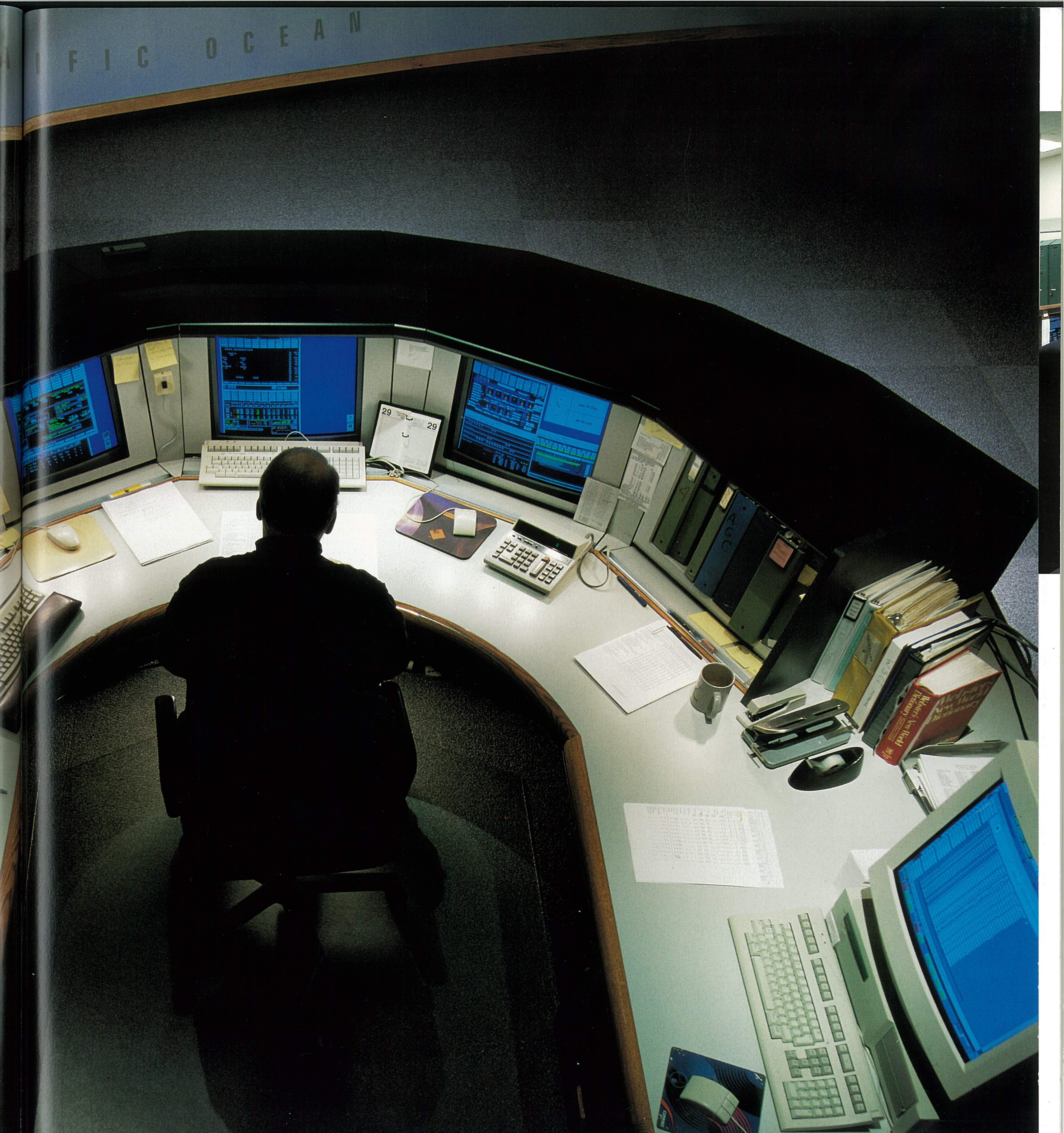
State Water Project Control Systems

The State Water Project's network of pumping and power plants, reservoirs, canals, and pipelines is served by a communications network of fiber optics cable, radio, and microwave. This communications network allows water and power dispatchers and hydroelectric plant operators to remotely control and monitor the operation of the SWP's major facilities and water flows along the California Aqueduct.

From the Project Operations Center located in Sacramento, dispatchers can remotely coordinate operations of the entire project and implement computerized project-wide schedules for water delivery and power sales and purchases. Three dispatchers staff the POC around the clock to monitor water and power operations via a huge map board depicting the entire system and computer displays that indicate the status of all of the Project's major facilities and check structures that control water flow in the aqueducts.

The POC has the authority and ability to take command of the SWP from Area Control Centers in five field divisions. These field divisions handle the daily operations of the facilities within their respective geographic jurisdictions. The ACCs use similar control

Each dispatcher at the POC knows the SWP system through experience and can now visualize what's happening in the field from data and diagrams on a number of computer screens and the map board. *(photo next page)*


IFIC OCEAN


BAKERSFIELD
PACIFIC OCEAN

Standing 12 feet high and spanning 54 feet across the front of the POC, the map board displays data from specific locations and flashes alarm lights that alert dispatchers to changes in operational status.

The field divisions' Area Control Centers are in constant contact with the Project Operations Center. The ACCs handle the day-to-day operations within their jurisdictions, but the POC can take over controls in emergencies. Photo above show the ACC at Oroville Field Division.

systems that are linked to the POC by a computer system. This system is fed real-time data by remote terminal units located in SWP plants and reservoirs, as well as along the aqueducts. The data is displayed on computer monitors and can be accessed by the POC or the ACCs. Such data includes water levels, flow measurements at hydraulic structures, check gates or valve positions, and critical electrical and mechanical parameters at pumping and power plants. The information enables operators to make minute-by-minute operational decisions.

Such decisions are crucial, especially in making rapid changes in flow in the 444-mile-long California Aqueduct. This allows aqueduct operation to be coordinated in real-time with power generation and transmission needs of the electric utilities with whom DWR buys and sells power, and with Central Valley Project water operations, especially in the Delta.

State Water Project Field Division Jurisdictions

STATE WATER PROJECT FIELD DIVISIONS

Daily operations and maintenance of SWP facilities are divided among five field divisions–Oroville, Delta, San Luis, San Joaquin, and Southern. Each field division is responsible for the facilities within its assigned geographic area. Among their responsibilities, staff operates and maintains pumping and power plants, monitors water levels and water quality, oversees daily water delivery amounts and schedules, and maintains all structures and equipment.

Oroville/Thermalito Complex
Oroville Field Division
Susanville
Chester
Lake Almanor
Antelope Lake
Indian Creek
River
Feather
Quincy
Big Grizzly Creek
Beckwourth Subcenter
Lake Davis
Frenchman Lake
Feather River
Portola
Little Last Chance Creek
North Fork
Middle Fork
South Fork
Paradise
West Fork
Oroville Dam and Lake
Thermalito Pumping-Generating Plant
Oroville O&M Center
Lake Oroville Visitors Center
Area Control Center and Edward Hyatt Powerplant
Thermalito Fish Rearing Ponds
Oroville
River
Thermalito Diversion Dam and Powerplant
Feather River Fish Hatchery and Barrier Dam
Thermalito Forebay Dam & Forebay
Thermalito Afterbay Dam & Afterbay
Feather
Truckee
Nevada City
Grass Valley
N
SCALE IN MILES
0 3 6

Oroville Field Division

The Oroville Field Division's responsibilities extend from the three Upper Feather River lakes in Plumas County to the Oroville-Thermalito Complex, a storage and pumping operation, on the Feather River. The facilities include three power plants (Hyatt Powerplant, Thermalito Diversion Dam Powerplant, and Thermalito Pumping-Generating Plant, two of which can either pump water or generate power), the SWP's largest reservoir (Lake Oroville), a forebay and afterbay, a fish hatchery, and a visitors center. As water leaves this region, it flows down Feather River and Sacramento River channels to the Sacramento-San Joaquin Delta.

ANTELOPE DAM & LAKE

Antelope Dam and Lake are located entirely in the Plumas National Forest on Upper Indian Creek, a tributary of the Feather River's North Fork. The facility was among five units initially authorized by the State Legislature in 1957 for water and recreation development in the Upper Feather River Basin. Construction began in 1962 and was completed in 1964. Today, the lake provides recreation and assures year-round stream flows to improve the fishery in Indian Creek and to fulfill prior water rights. Though Antelope Dam impounds the smallest of the Upper Feather River lakes, it has the longest crest of the three dams.

DAM

Type: two zoned earth embankments:
a 120-foot-high main dam and
a 60-foot-high auxiliary dam

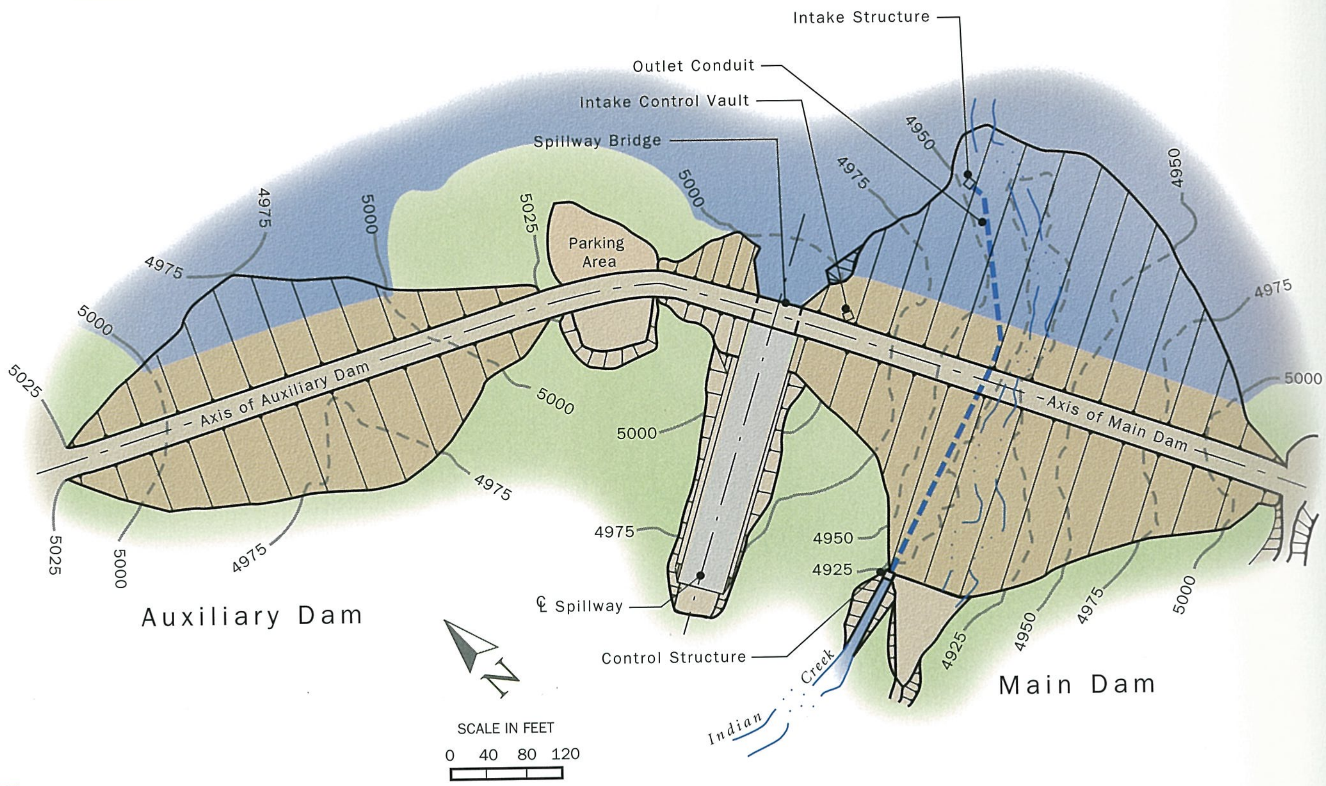
Embankment volume ..... 380,000 cubic yards
Height .... 120 feet
Crest length .... 1,320 feet
Crest elevation .... 5,025 feet

LAKE

Maximum operating storage .. 22,570 acre-feet
*Water surface elevation @ mos** ..... 5,002 feet
Water surface area @ mos .... 930 acres
Shoreline @ mos .... 15 miles

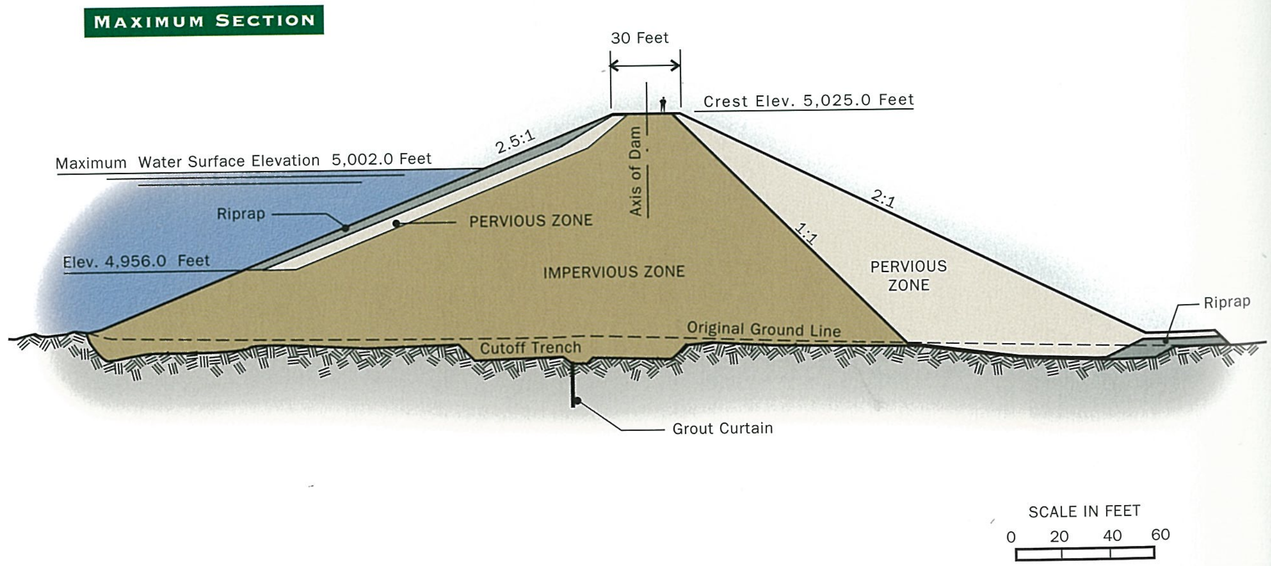
**maximum operating storage*

GENERAL PLAN



Antelope's dam consists of impervious zones of decomposed granite and pervious zones of streambed sands and gravels.

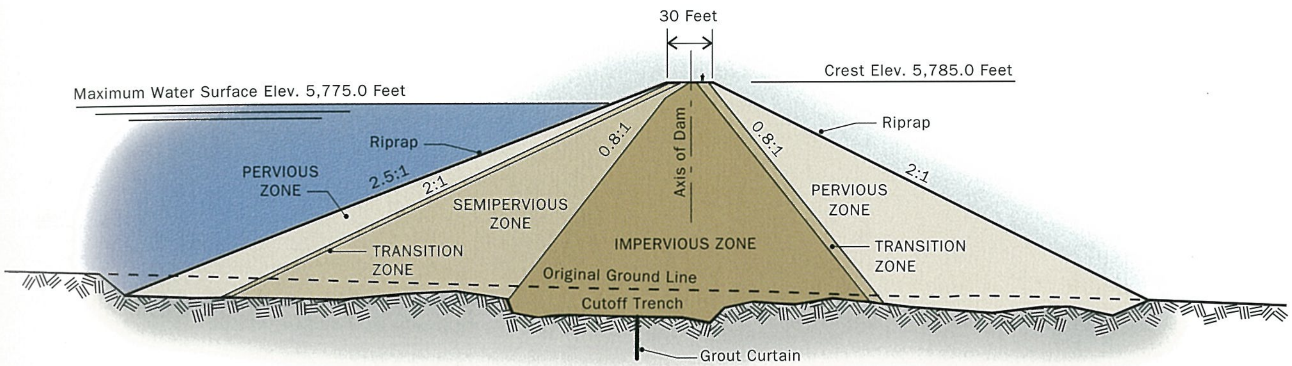
MAXIMUM SECTION



Grizzly Valley Dam & Lake Davis

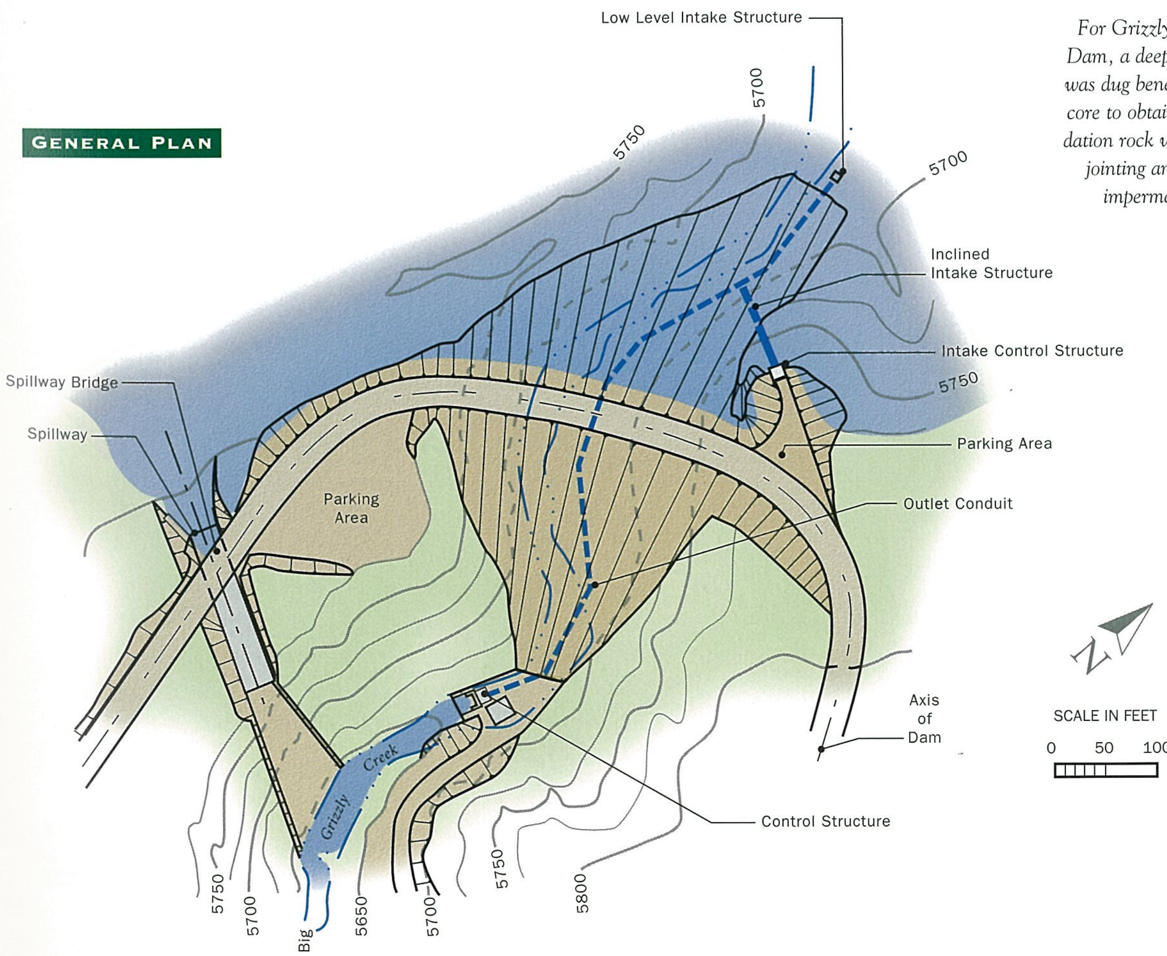
Also located within the Plumas National Forest, Lake Davis and Grizzly Valley Dam lie on Big Grizzly Creek, a tributary of the Middle Fork of the Feather River. Constructed between 1964 and 1967, the lake is the largest of the three Upper Feather River lakes. Water releases from Lake Davis fulfill prior water rights for agriculture, as well as provide fish and wildlife enhancement, recreation, and water supply for the city of Portola (eight miles south of Lake Davis) through the six-mile-long Grizzly Valley Pipeline.

MAXIMUM SECTION



For Grizzly Valley Dam, a deep trench was dug beneath the core to obtain foundation rock with less jointing and more impermeability.

GENERAL PLAN



Dam

Type: zoned earth and rockfill

Embankment volume	*253,000 cubic yards*
Height	*132 feet*
Crest length	*800 feet*
Crest elevation	*5,785 feet (highest in SWP system)*

Lake

Maximum operating storage	*84,370 acre-feet*
*Water surface elevation @ mos**	*5,775 feet*
Water surface area @ mos	*4,030 acres*
Shoreline @ mos	*32 miles*

**maximum operating storage*

FRENCHMAN DAM & LAKE

To the east of Lake Davis is Frenchman Dam and Lake. Like the other two Upper Feather River lakes, Frenchman Lake is situated entirely within the Plumas National Forest and lies on Little Last Chance Creek, a tributary of the Feather River's Middle Fork. Releases from the lake are used to irrigate farmland in the Sierra Valley, and improve fish habitat in Little Last Chance Creek. The lake also provides recreation. Frenchman Dam is the tallest of the three Upper Feather River dams. Construction of the facility began in 1959 and was completed in 1961.

Since Frenchman Dam was constructed on a volcanic series of rock, no foundation settlement was anticipated.

DAM

Type: homogeneous earthfill

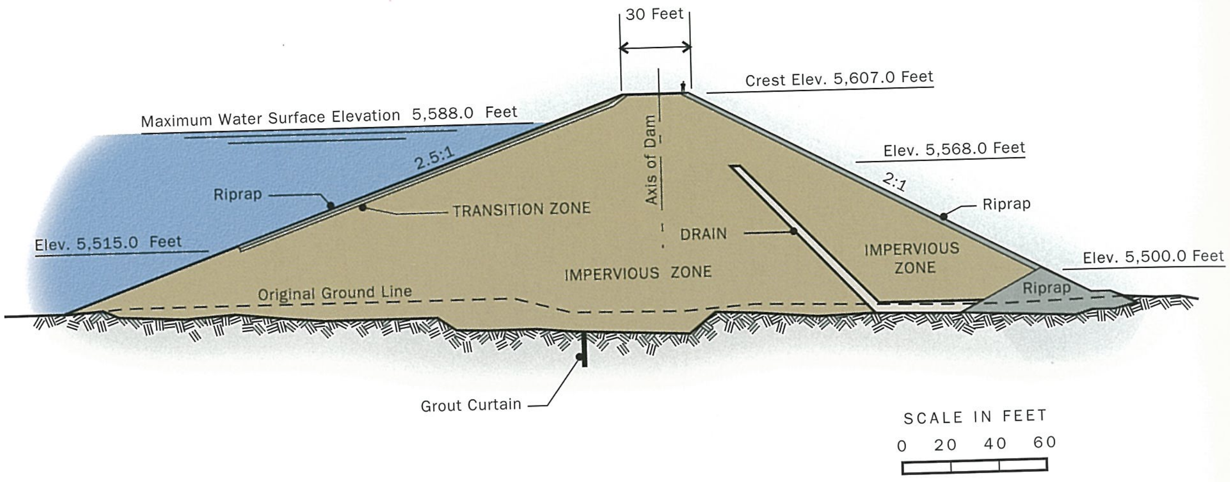
Embankment volume	*537,000 cubic yards*
Height	*139 feet*
Crest length	*720 feet*
Crest elevation	*5,607 feet*

LAKE

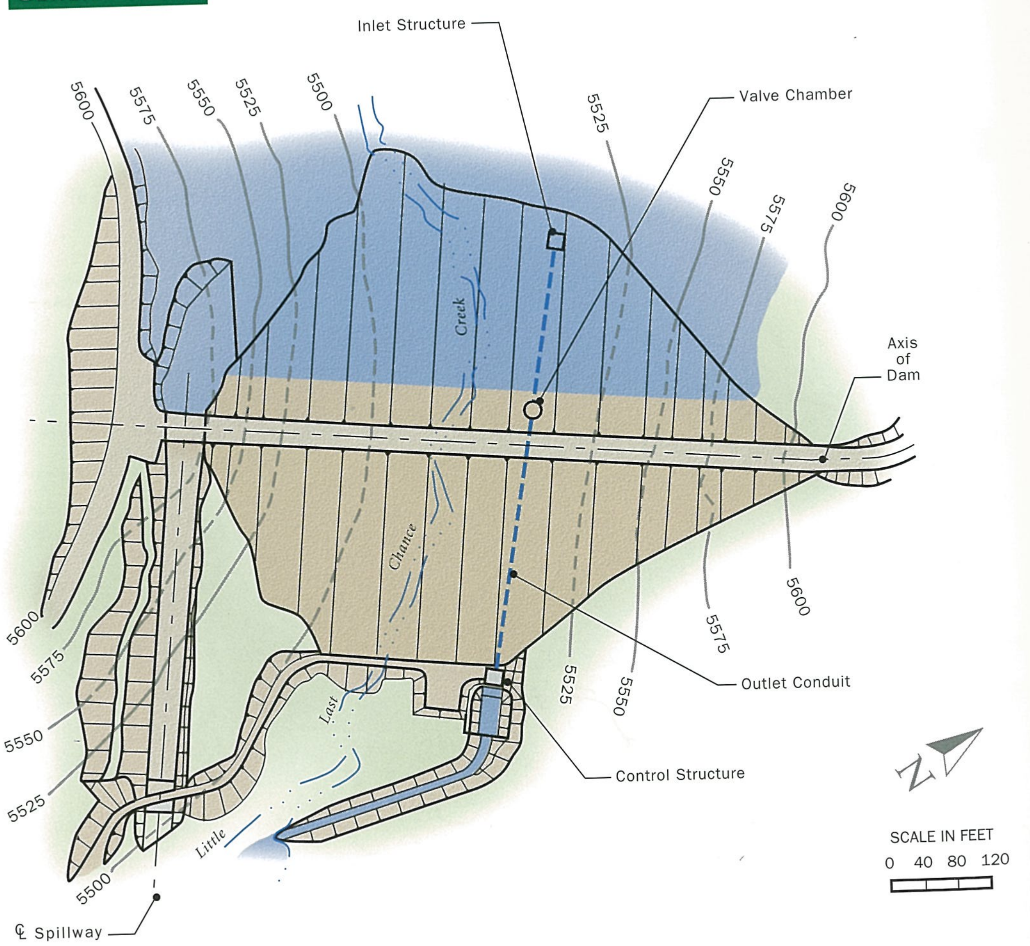
Maximum operating storage	*55,480 acre-feet*
*Water surface elevation @ mos**	*5,588 feet*
Water surface area @ mos	*1,580 acres*
Shoreline @ mos	*21 miles*

**maximum operating storage*

MAXIMUM SECTION



GENERAL PLAN



Streambed diversion from the dam site at **Antelope** *was done through a temporary diversion pipeline laid through the foundation area. Work on the outlet works conduit is also shown (right center of photo). The entire length of the outlet works was founded in rock.*

This is a close view of **Grizzly Valley Dam's** *outlet works trench showing hand-cleaning operations. By late September more than 465 lineal feet of 36-inch diameter steel liner had been placed and hydrostatically tested.*

A total of 34,016 cubic yards was excavated for the spillway chute at **Frenchman Dam**.

OROVILLE DAM & LAKE OROVILLE

Oroville Dam and Lake Oroville lie in the foothills on the western slope of the Sierra Nevada and are one mile downstream of the junction of the Feather River's major tributaries. The lake stores winter and spring runoff which is released into the Feather River to meet the Project's needs. It also provides pumped-storage capacity, 750,000 acre-feet of flood control storage, recreation, and freshwater releases to control salinity intrusion in the Sacramento-San Joaquin Delta and for fish and wildlife enhancement.

Construction first began in 1957 on relocating what is now Highway 70 and the Western Pacific Railroad. Work on the dam site began in 1961. The embankment was topped out in 1967.

To protect the dam embankment, the Oroville Dam spillway was designed to pass the probable maximum flow.

DAM

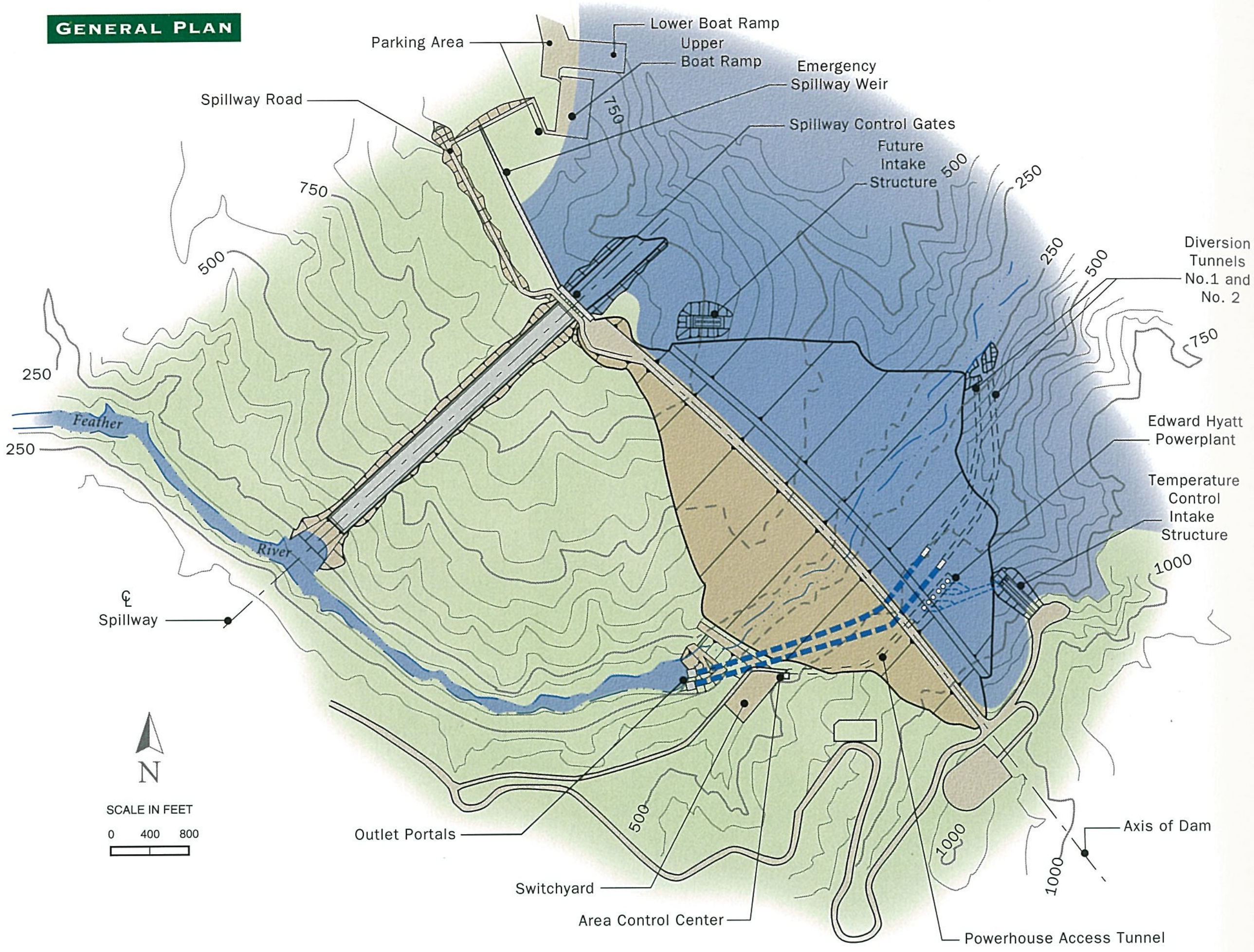
Type: zoned earthfill (highest in U.S.)	
Embankment volume	*80,000,000 cubic yards*
Height	*770 feet*
Crest length	*6,920 feet*
Crest elevation	*922 feet*

LAKE

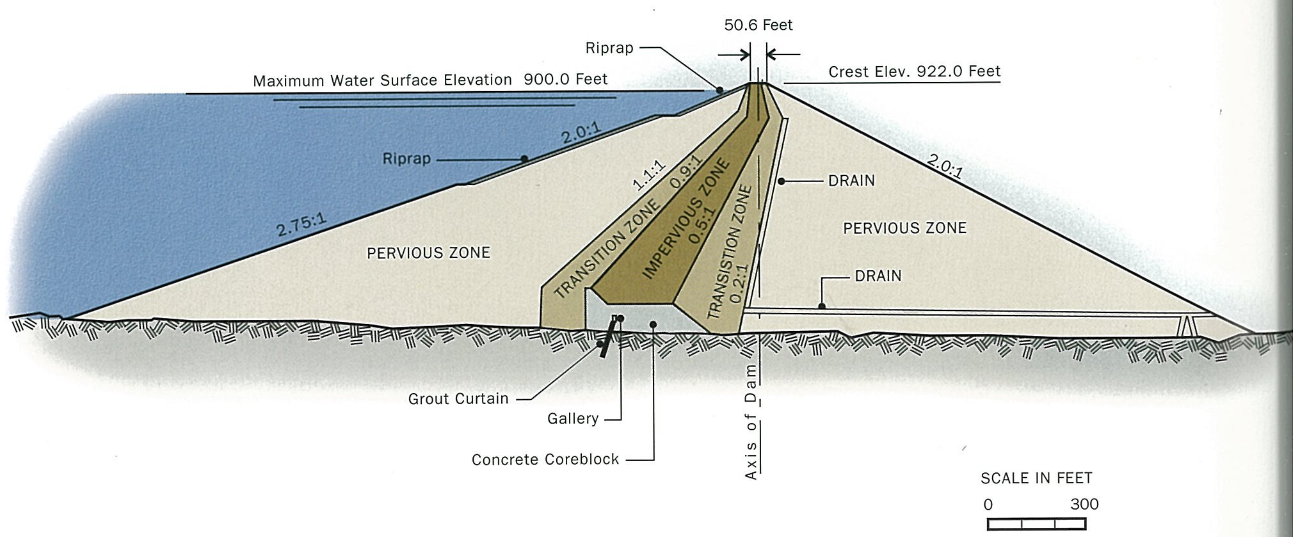
Maximum operating storage	*3,537,580 acre-feet*
*Water surface elevation @ mos**	*900 feet*
Water surface area @ mos	*15,810 acres*
Shoreline @ mos	*167 miles*

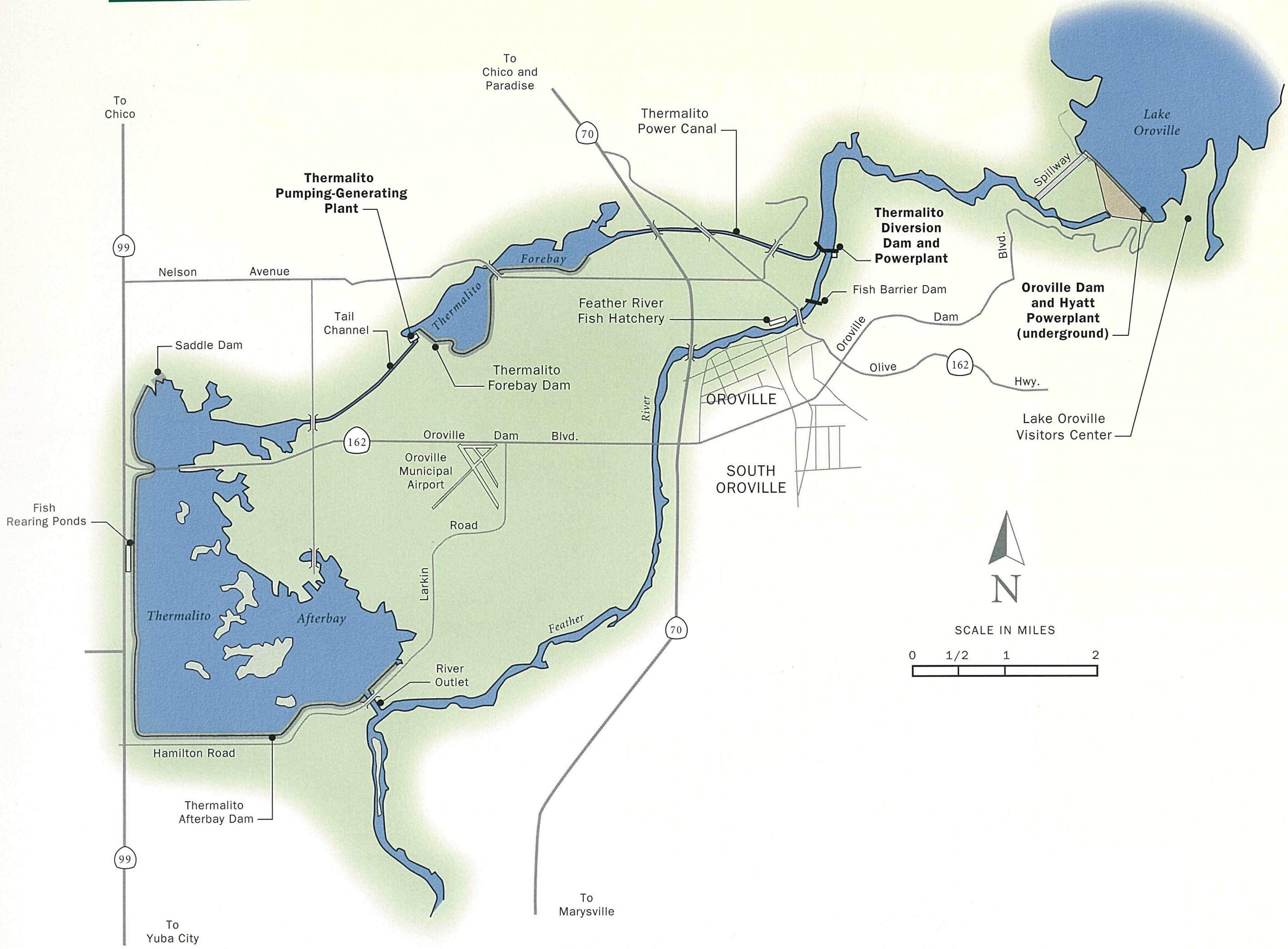
maximum operating storage

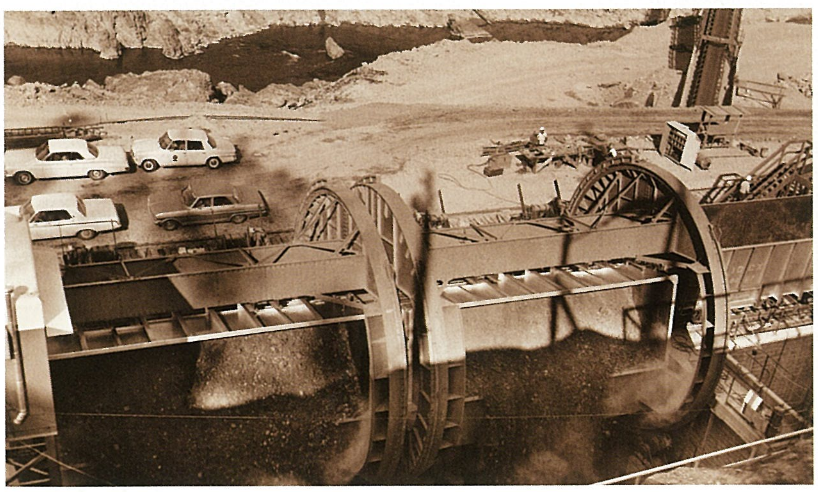
GENERAL PLAN



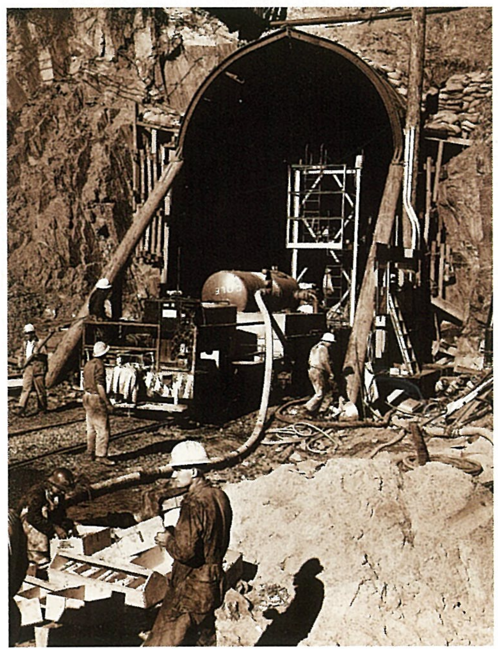
MAXIMUM SECTION







Each of the trains used to haul embankment materials pulled 42 gondola cars an average of 12 miles. Two cars at a time could be rotated to empty their loads into a hopper, from where the materials were transported on a conveyor across Feather River to the dam site.



The 4,400-foot-long, concrete-lined diversion tunnels were initially used to bypass the river from the construction site and later as tailrace tunnels for the underground power plant. During 1964 the tunnels helped divert a new flood of record (about 250,000 cfs) with negligible downstream damage.

Edward Hyatt Powerplant

Located in rock in the left abutment near the axis of Oroville Dam, Edward Hyatt Powerplant is an underground, hydroelectric, pumping-generating facility. Construction of the plant began in 1964 and was completed in 1967. Hyatt Powerplant maximizes power production through a pumped-storage operation where water, released for power in excess of local and downstream requirements, is returned to storage in Lake Oroville during off-peak periods and is used for generation during peak power demands.

Water from the lake is conveyed to the units through penstocks and branch lines. After passing through the units, water is discharged through the draft tubes to one free surface and one full-flow tailrace tunnel.

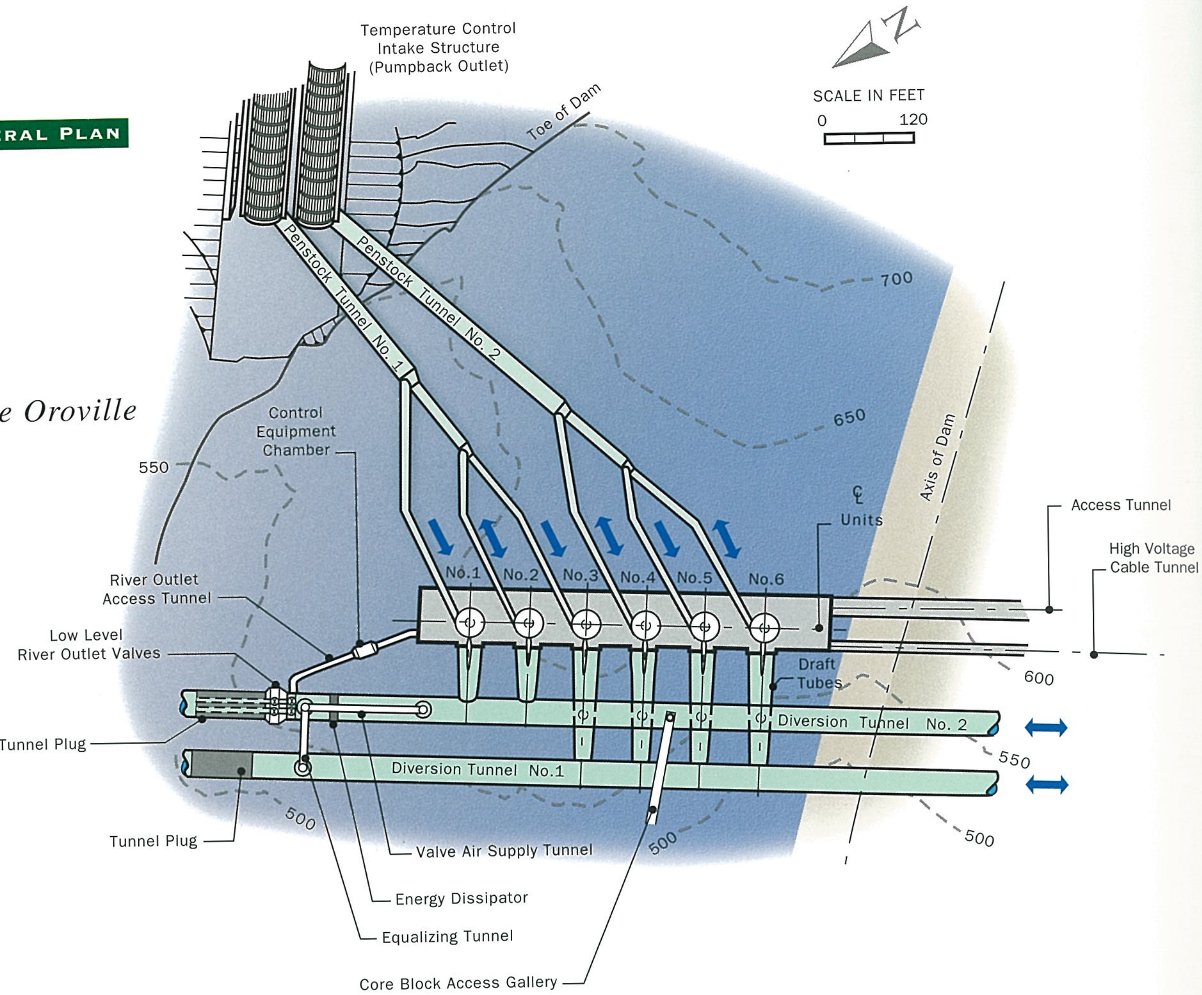
Pumping

Installed capacity	*5,610 cfs, 519,000 hp*
Normal static head	*500-660 feet*
Design dynamic head	*592 feet*
No. of units	*3 (p/g)*
Unit Size	*1,870 cfs,173,000 hp*

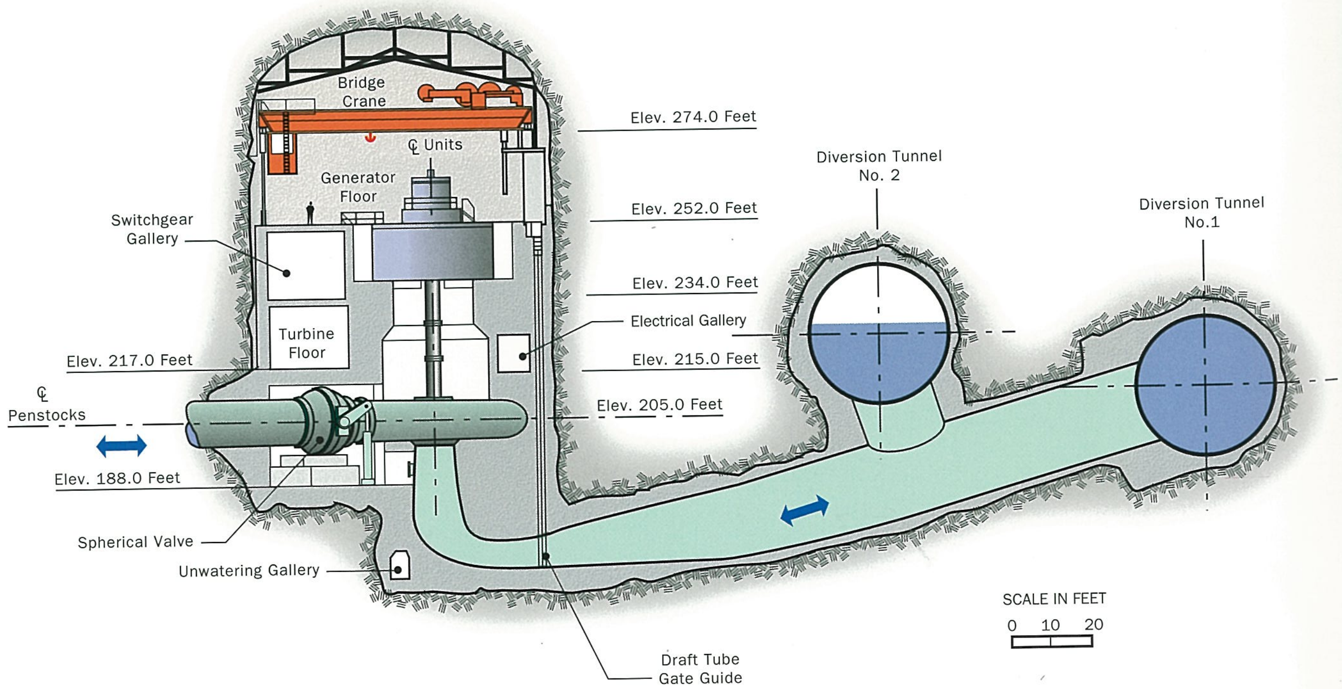
Generating

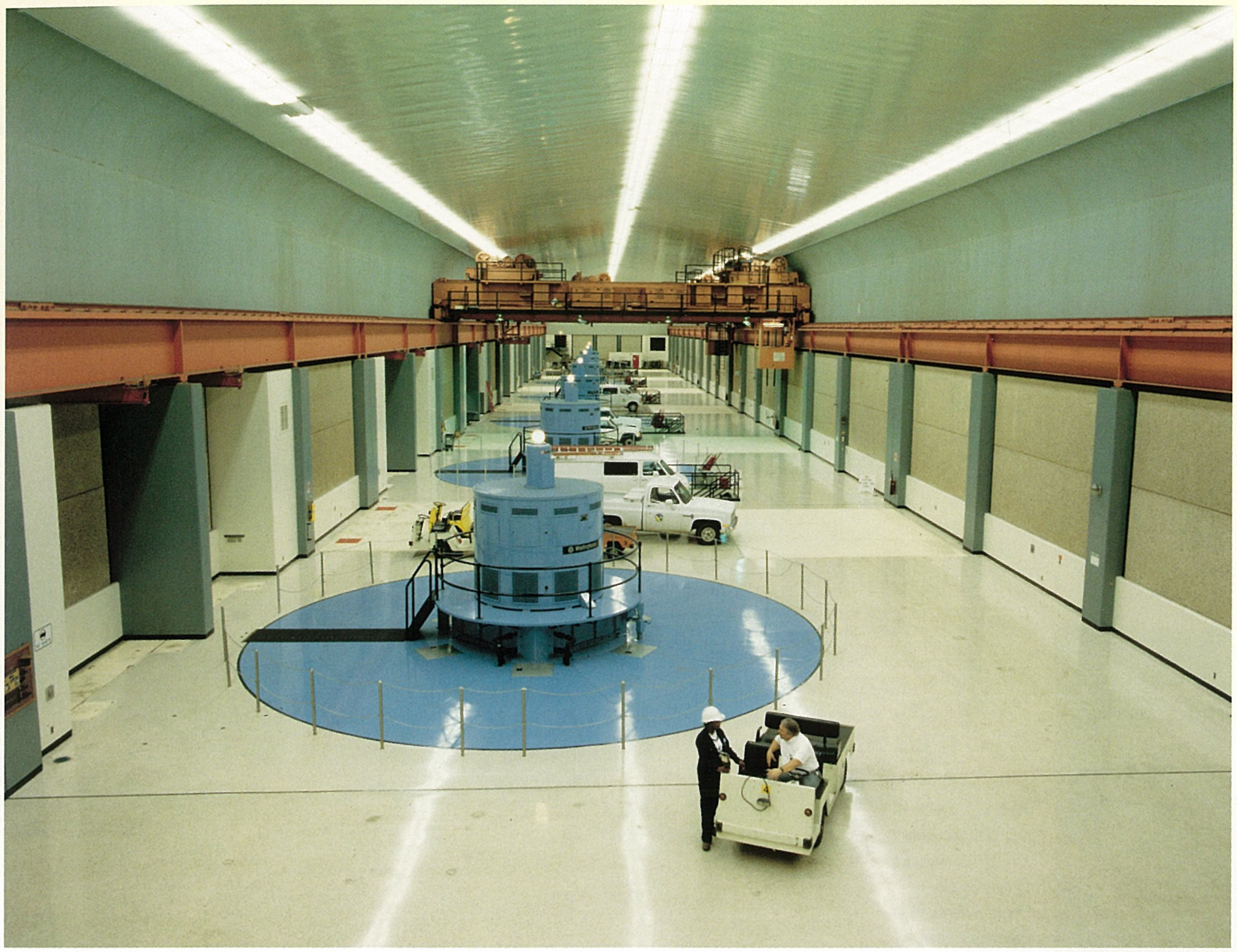
Installed capacity	*819 MVA, 16,950 cfs*
Normal static head	*410-676 feet*
Design dynamic head	*615 feet*
Number of units	*6 (3 g, 3 p/g)*
Unit size	*3 @ 132 MVA, 2,800 cfs* *3 @ 141 MVA, 2,850 cfs*
Penstock/diameter	*2 @ 22 feet*

GENERAL PLAN



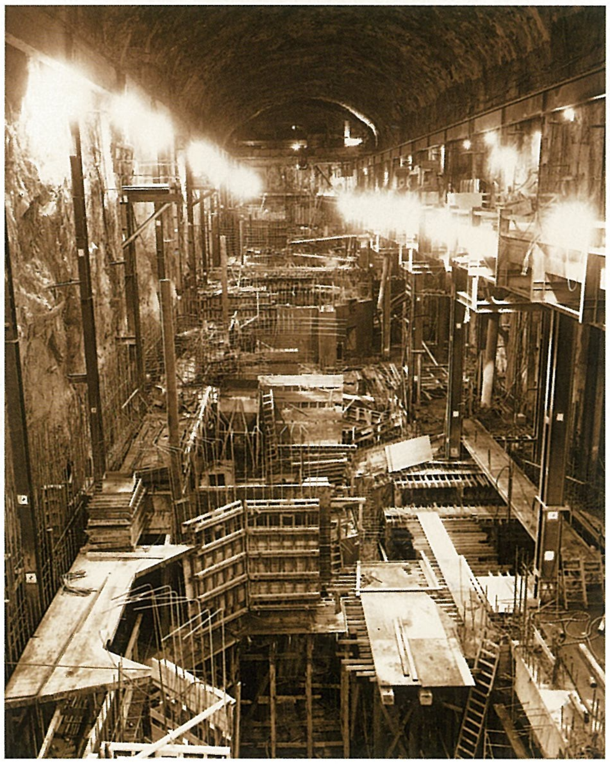
TRANSVERSE SECTION





The underground Hyatt Powerplant is remotely operated from the Oroville Area Control Center located above ground, adjacent to the switchyard.

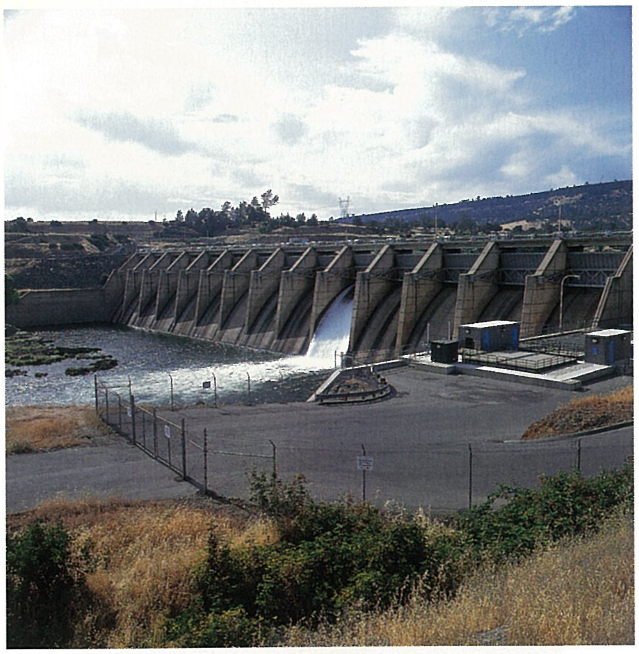
A cavern, large enough to hold two football fields, was excavated to house the Hyatt Powerplant.



The power plant was built in a metavolcanic rock formation.

Thermalito Diversion Dam Powerplant

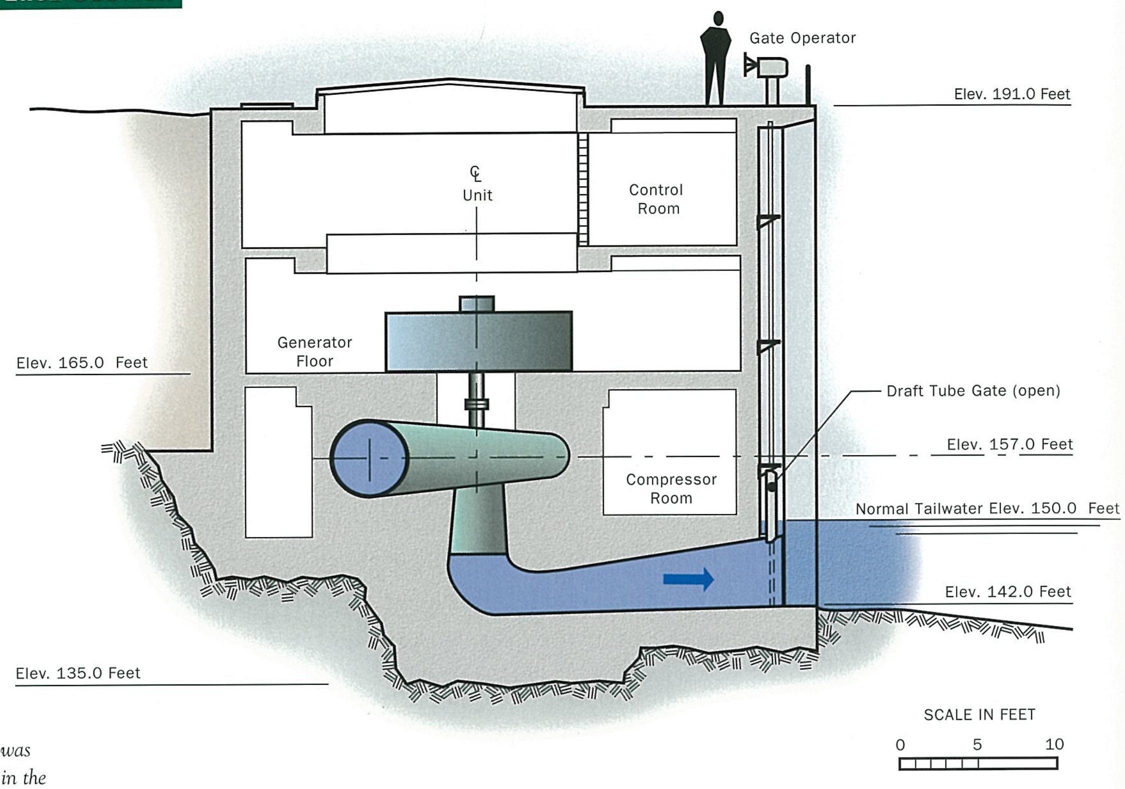
Thermalito Diversion Dam Powerplant is located at Thermalito Diversion Dam below the left abutment of the dam. The power plant generates electricity from water released to the Feather River to maintain fish habitat between the diversion dam and Thermalito Afterbay river outlet. It was constructed between 1985 and 1987.



Generating

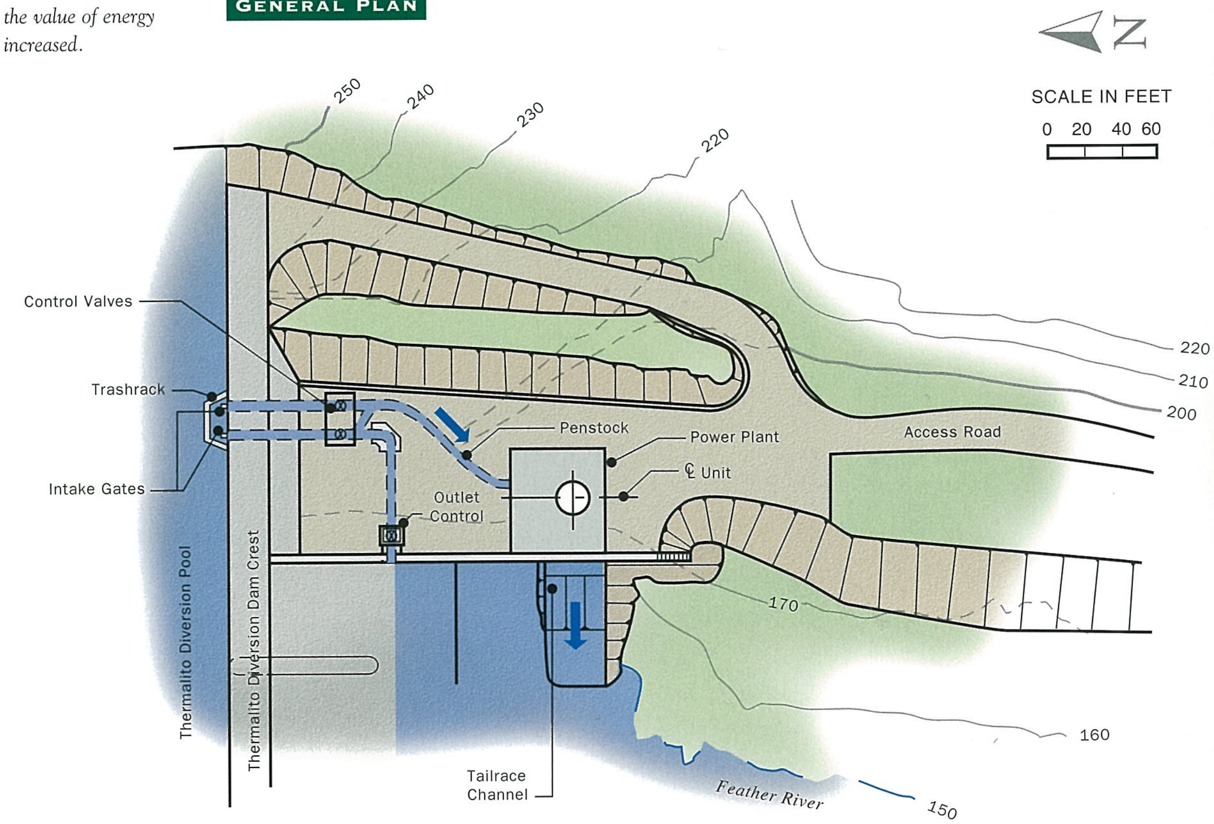
Installed capacity	*3.3 MVA, 615 cfs*
Normal static head	*63-77 feet*
Design dynamic head	*67 feet*
No. of units	*1*
Unit size	*3.3 MVA, 615 cfs*
Discharge lines/diameter	*2@5 to 1@7.5*

Transverse Section



Although it was planned for in the 1970s, Thermalito Diversion Dam Powerplant was built more than a decade later when the value of energy increased.

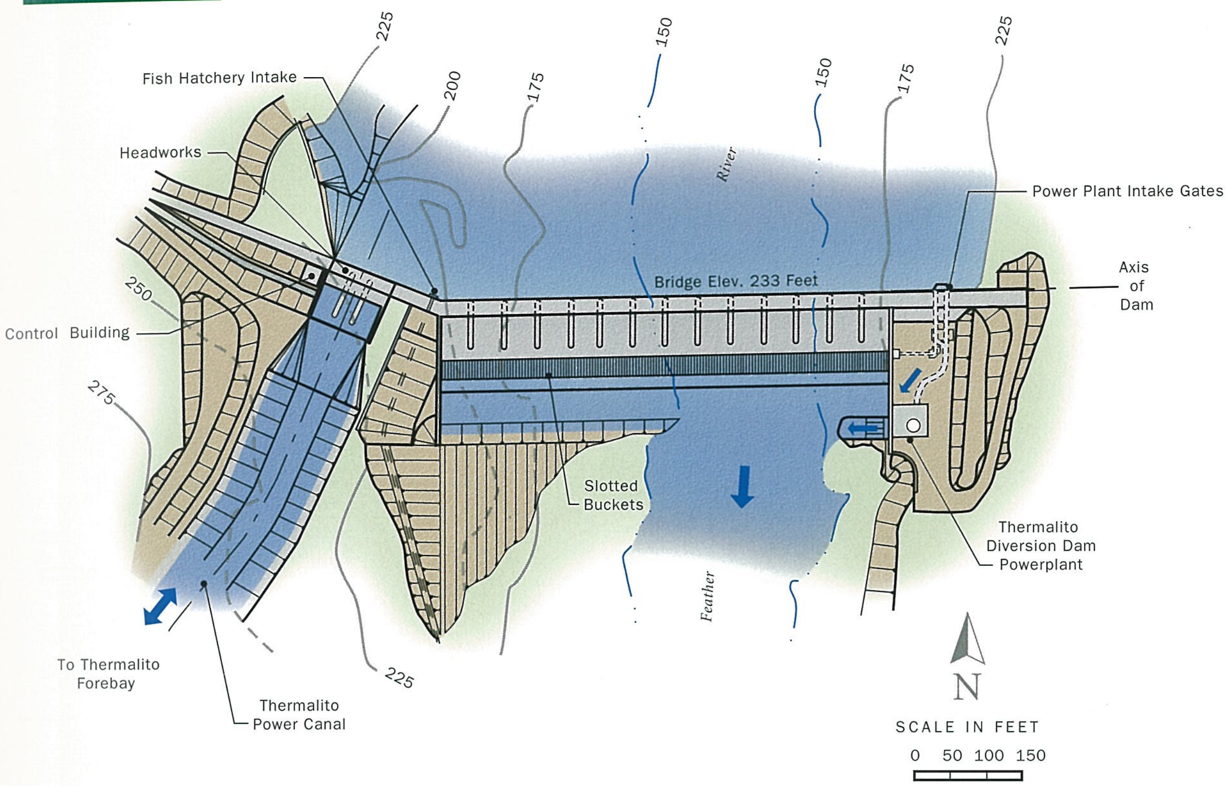
General Plan



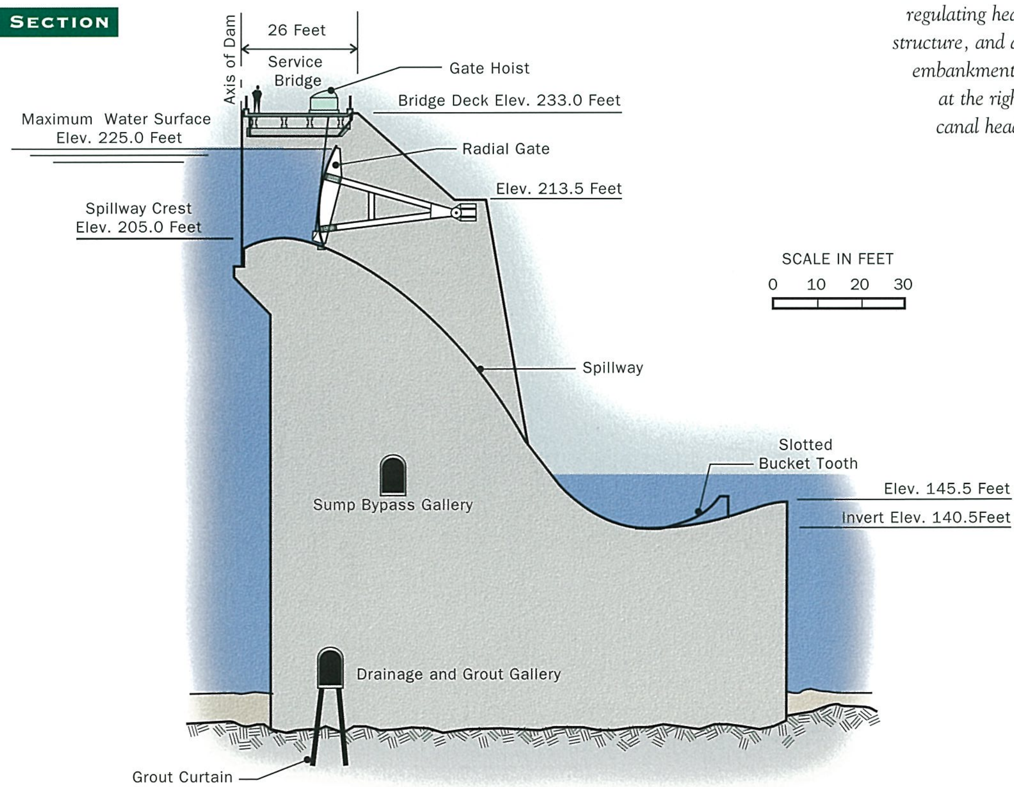
THERMALITO DIVERSION DAM & POOL

Constructed between 1963 and 1968, Thermalito Diversion Dam and Pool are located on the Feather River, about 4.5 miles downstream from Oroville Dam. The dam diverts water in Thermalito Power Canal for power generation at Thermalito Pumping-Generating Plant and creates a tailwater pool for Hyatt Powerplant. The reservoir acts as a forebay when Hyatt Powerplant is pumping water back into Lake Oroville. It also provides recreation opportunities.

General Plan



Transverse Section



Thermalito Diversion Dam also includes an ogee spillway, a canal-regulating headworks structure, and an earth embankment section at the right of the canal headworks.

DAM

Type: concrete gravity	
Concrete volume	*154,000 cubic yards*
Height	*143 feet*
Crest length	*1,300 feet*
Crest elevation	*233 feet*

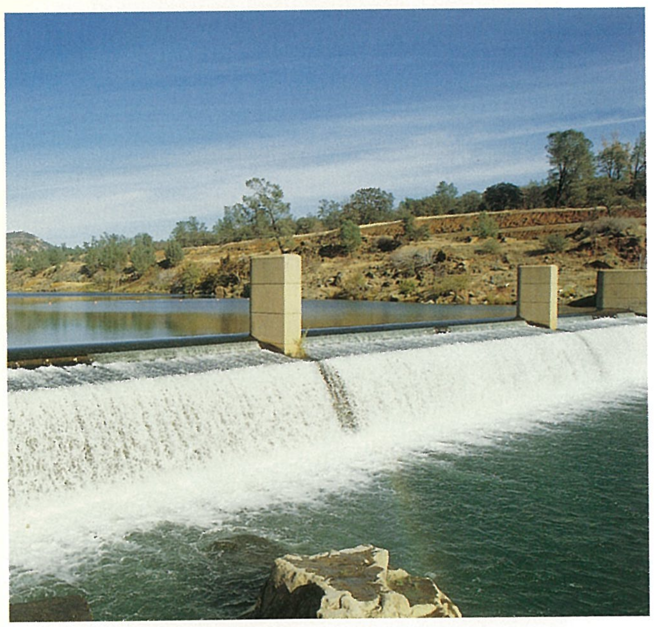
POOL

Maximum operating storage	*13,350 acre-feet*
*Water surface elevation @ mos**	*225 feet*
Water surface area @ mos.	*320 acres*
Shoreline @ mos.	*10 miles*

**maximum operating storage*

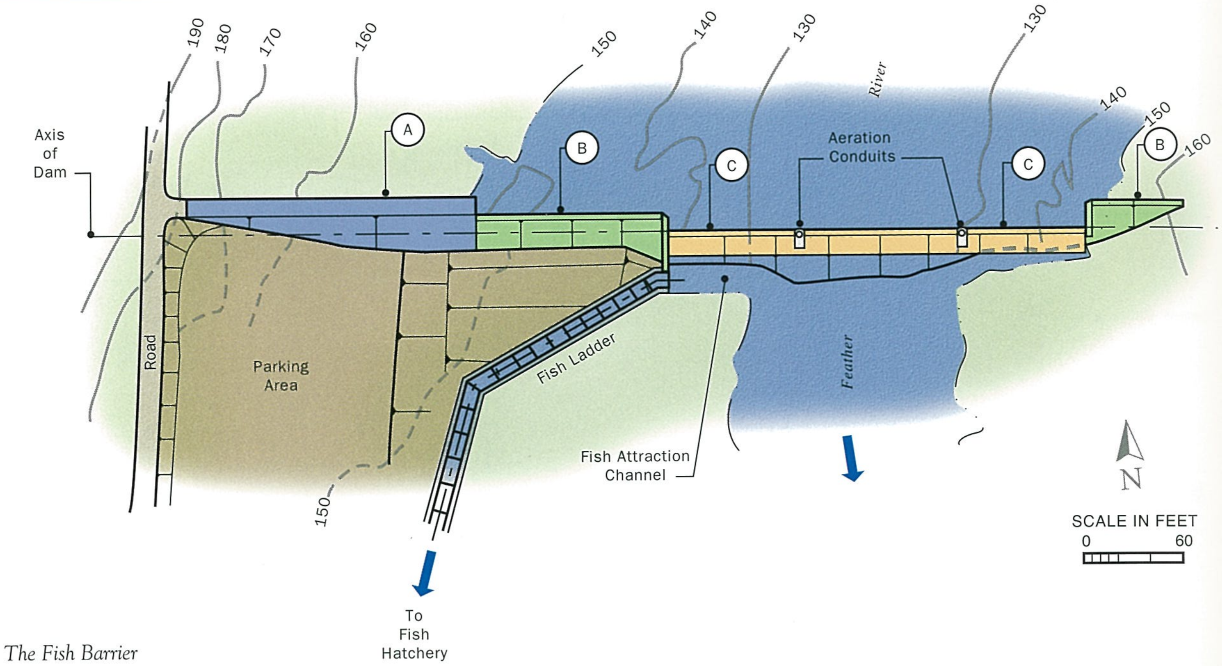
FISH BARRIER DAM & POOL

The facility, located upstream of the Feather River Fish Hatchery, diverts fish into a fish ladder that leads to the hatchery. Flows at the dam are controlled by releases at Oroville Dam and Thermalito Diversion Dam. It was constructed from 1962 to 1964.

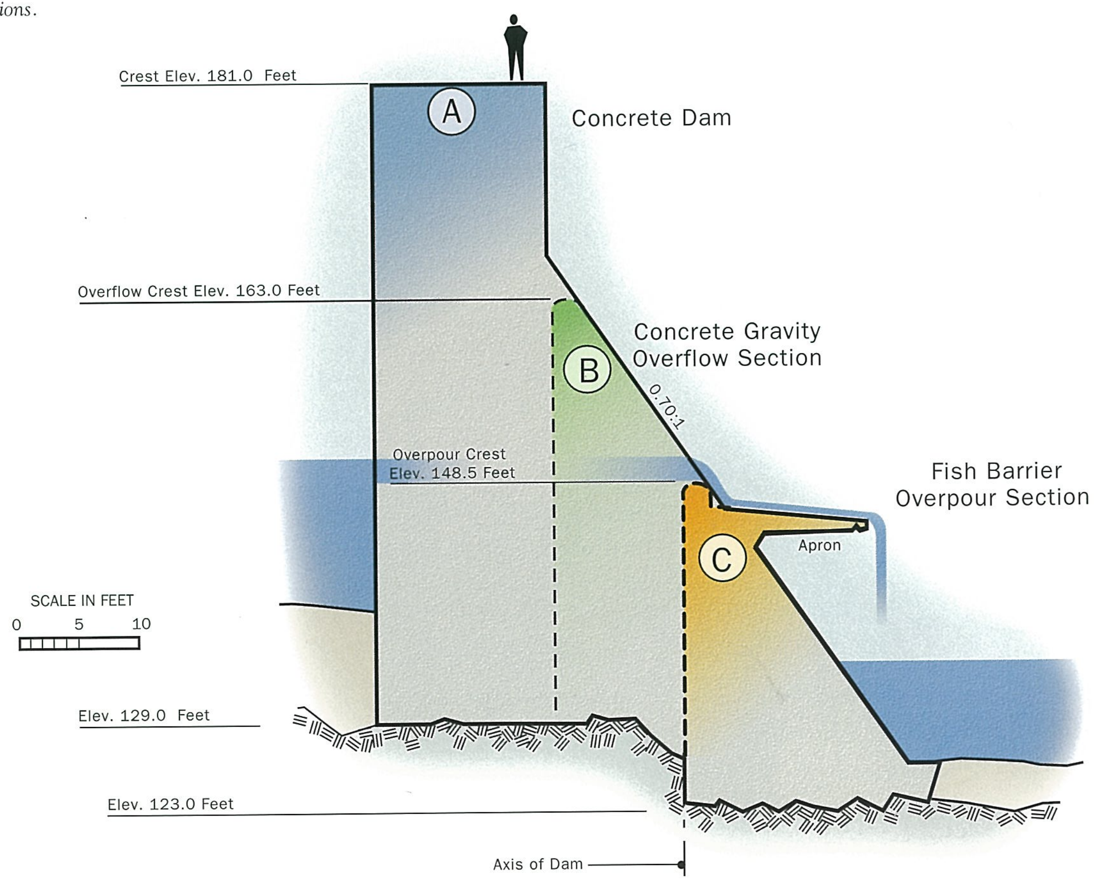


The Fish Barrier Dam has an overpour section designed to pass river flows up to 200,000 cfs before overtopping the other sections.

GENERAL PLAN



TRANSVERSE SECTION



DAM

Type: concrete gravity	
Concrete volume	*9,300 cubic yards*
Height	*91 feet*
Crest length	*600 feet*
Crest elevation	*181 feet*

POOL

Gross storage capacity	*580 acre-feet*
*Water surface elevation @ mos**	*overpour spill*
Water surface area @ mos.	*50 acres*
Shoreline @ mos	*1 mile*

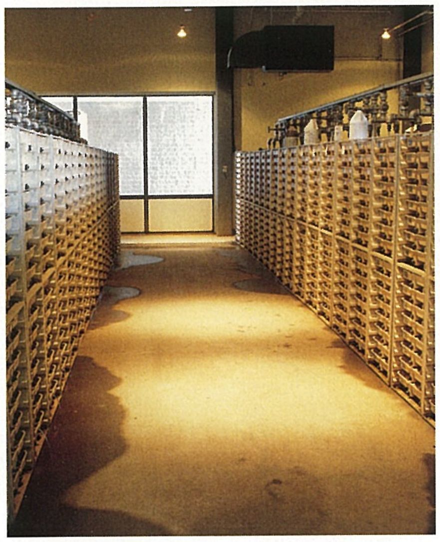
**maximum operating storage*

Overlooking the Feather River is an observation platform. Below is the start of the fish ladder leading into the hatchery. Glass panels allow for an underwater view of fish swimming up the ladder.

Fish are unable to pass over the dam's overpour section, but water flow from the ladder makes passage upriver possible. The hatchery is located at the top of the ladder.

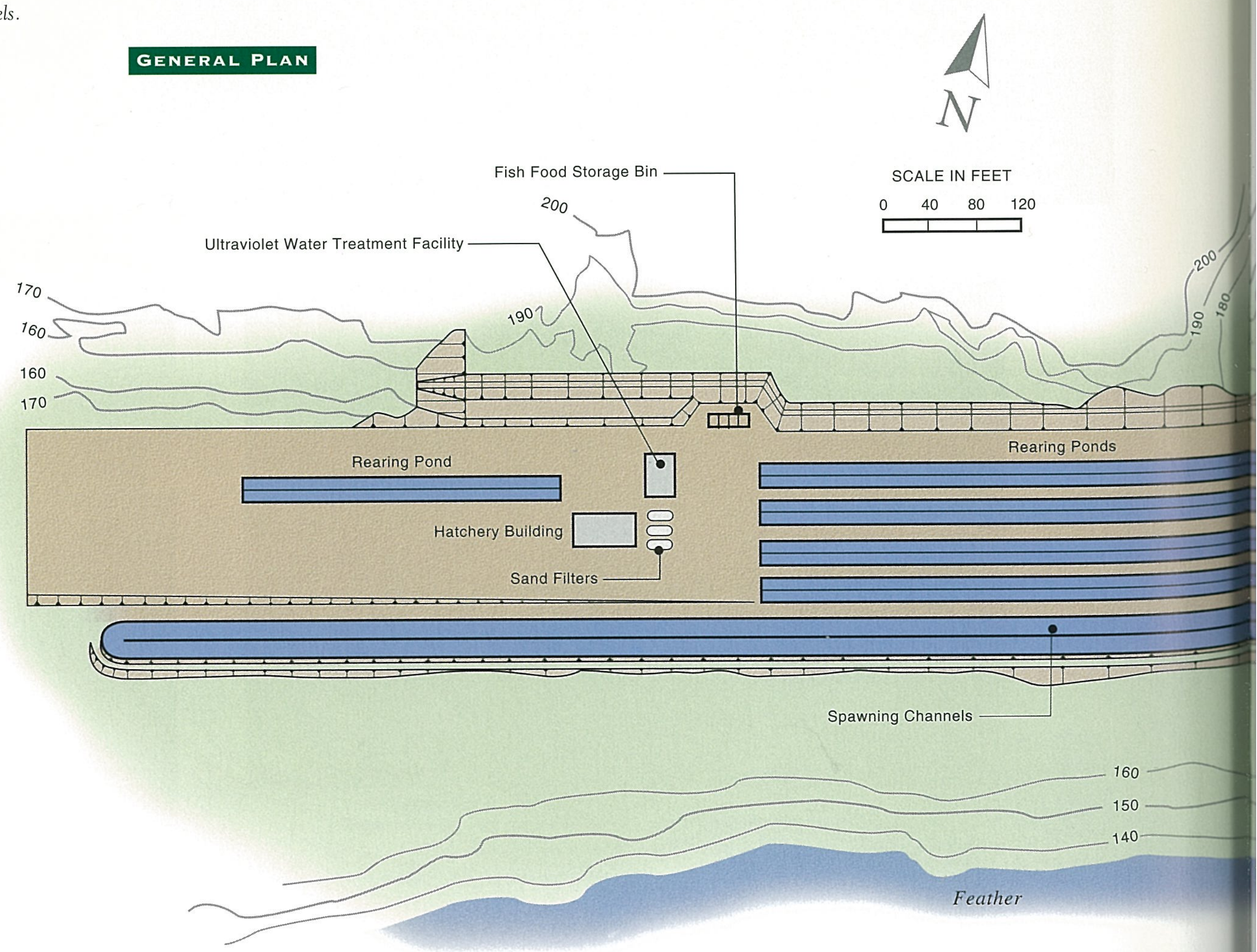
In the main hatchery building, the chinook salmon and steelhead are artificially spawned. Eggs, taken from the females, are mixed with milt from the males.

The facility was cooperatively planned by DWR and the California Department of Fish and Game, with assistance from the U.S. Fish and Wildlife Service and other agencies. Funding was provided by the SWP contractors, who also pay for daily operations and maintenance costs. DFG personnel staff the facility. The hatchery was expanded in 1998.

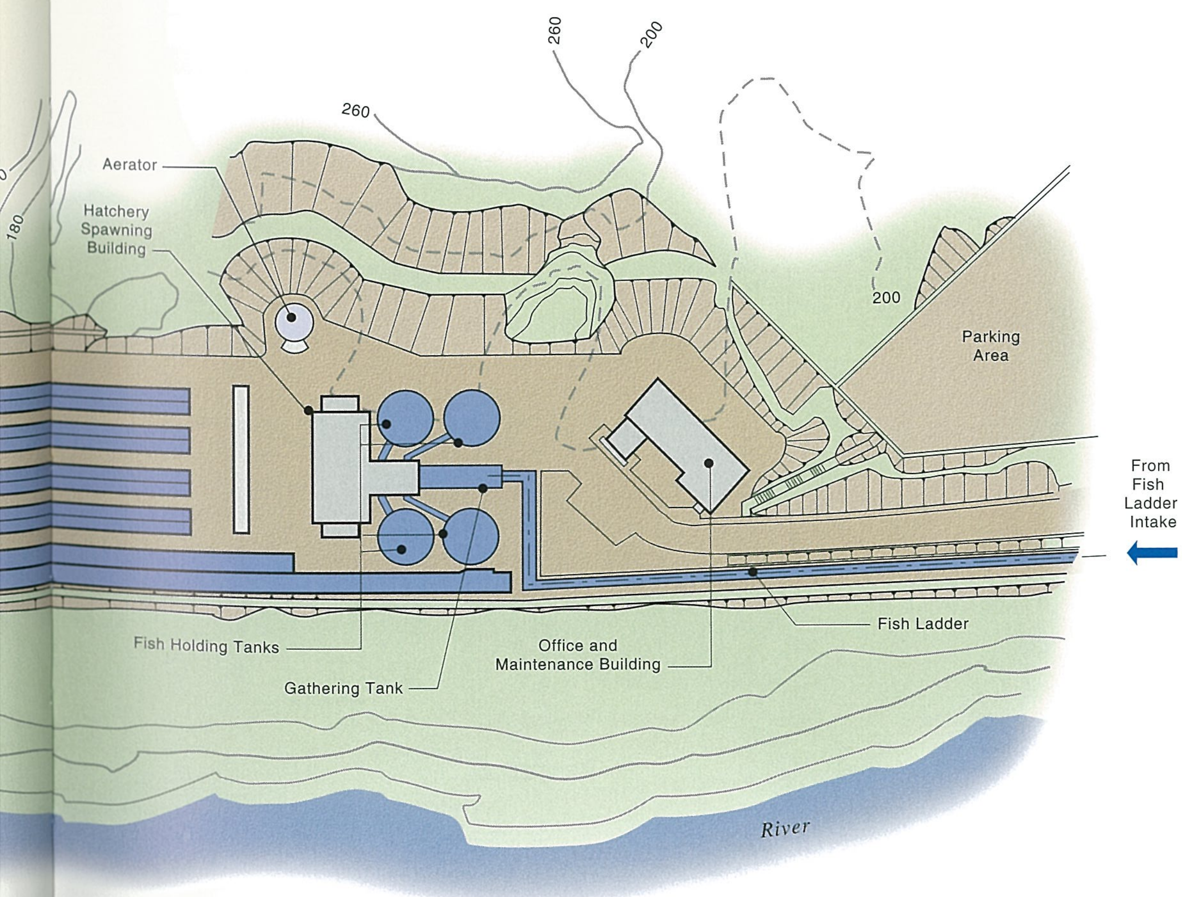


Incubators can hold up to 25 million eggs. In about two and a half months, the fry (baby fish) are ready to be transferred to the rearing channels.

GENERAL PLAN



The rearing ponds hold the fish for different lengths of time. Steelhead are held for one year, while salmon are released at various times up to one year.



Feather River Fish Hatchery

Constructed between 1966 and 1967, the Feather River Fish Hatchery was built to compensate for spawning grounds lost to returning salmon and steelhead trout with the construction of Oroville Dam. The first salmon and steelhead entered the hatchery in September 1967. Today, the facility accommodates an average 8,000 fish.

Salmon and steelhead raised at the hatchery are transported in oxygenated, temperature-controlled tanks and released in Oroville Lake, in the Feather and Sacramento rivers, or in the Delta near the San Francisco Bay area. These fish account for an estimated 20 percent of the ocean sport and commercial catch in the Pacific Ocean.

Fish Ladder

Type: pool and weir
Length . . . . 2,150 feet
Pool length . . . . 8 to 1,000 feet
Minimum width . . . . 6 feet
Minimum water depth . . . . 2 feet
Velocity of flow in ladder . . . . 2-5 fps
Maximum drop between pools . . . . 1 foot

Spawning-Hatchery Building

Type: T-shaped, concrete
Spawning room . . . . 45 x 30 feet
Purpose . . . . artificial spawning
Hatchery room . . . . 44 x 98 feet
Purpose . . . . holds incubators
Capacity . . . . 20-25 million eggs

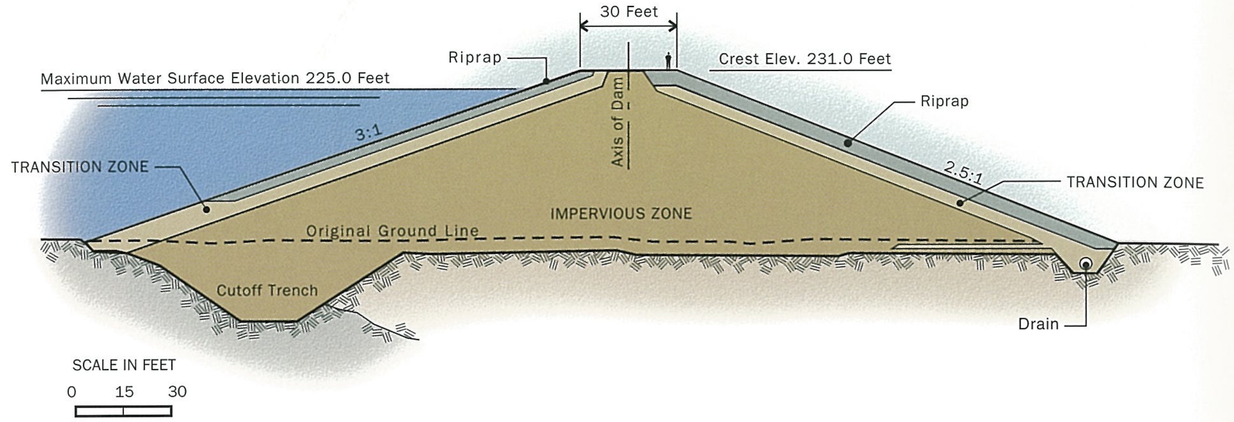
Rearing Ponds

Dimensions: 4 concrete-lined ponds blocked off in intervals to form 48 individual pools 100 feet long, 10 feet wide
Water flow and velocity . . 3 to 5 cfs, 0.1 foot/sec

Thermalito Forebay Dam & Forebay

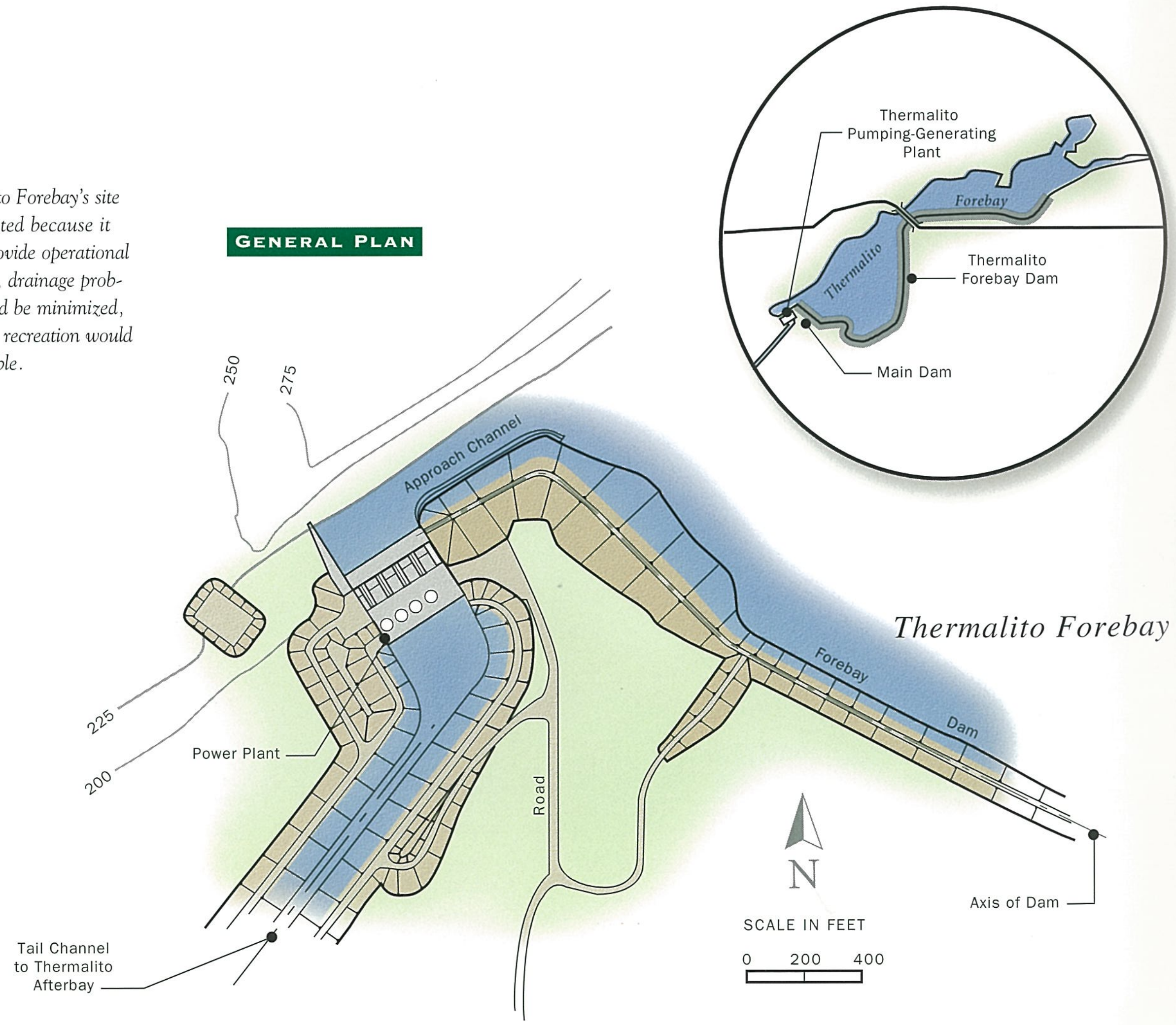
Constructed between 1965 and 1968, Thermalito Forebay is an offstream reservoir contained by Thermalito Forebay Dam on the south and east and by Campbell Hills on the north and west. It is located about four miles west of the city of Oroville. The forebay conveys generating and pumping flows between Thermalito Power Canal and Thermalito Pumping-Generating Plant, provides regulatory storage and surge damping for the Hyatt-Thermalito power complex, and serves as a recreational site.

Maximum Section



Thermalito Forebay's site was selected because it would provide operational flexibility, drainage problems could be minimized, and more recreation would be available.

General Plan



Dam

Type: homogeneous and zoned earthfill	
Embankment volume	*1,840,000 cubic yards*
Height	*91 feet*
Crest length	*15,900 feet*
Crest elevation	*231 feet*

Forebay

Maximum operating storage	*11,770 acre-feet*
*Water Surface elevation @ mos**	*225 feet*
Water surface area @ mos	*630 acres*
Shoreline @ mos	*10 miles*

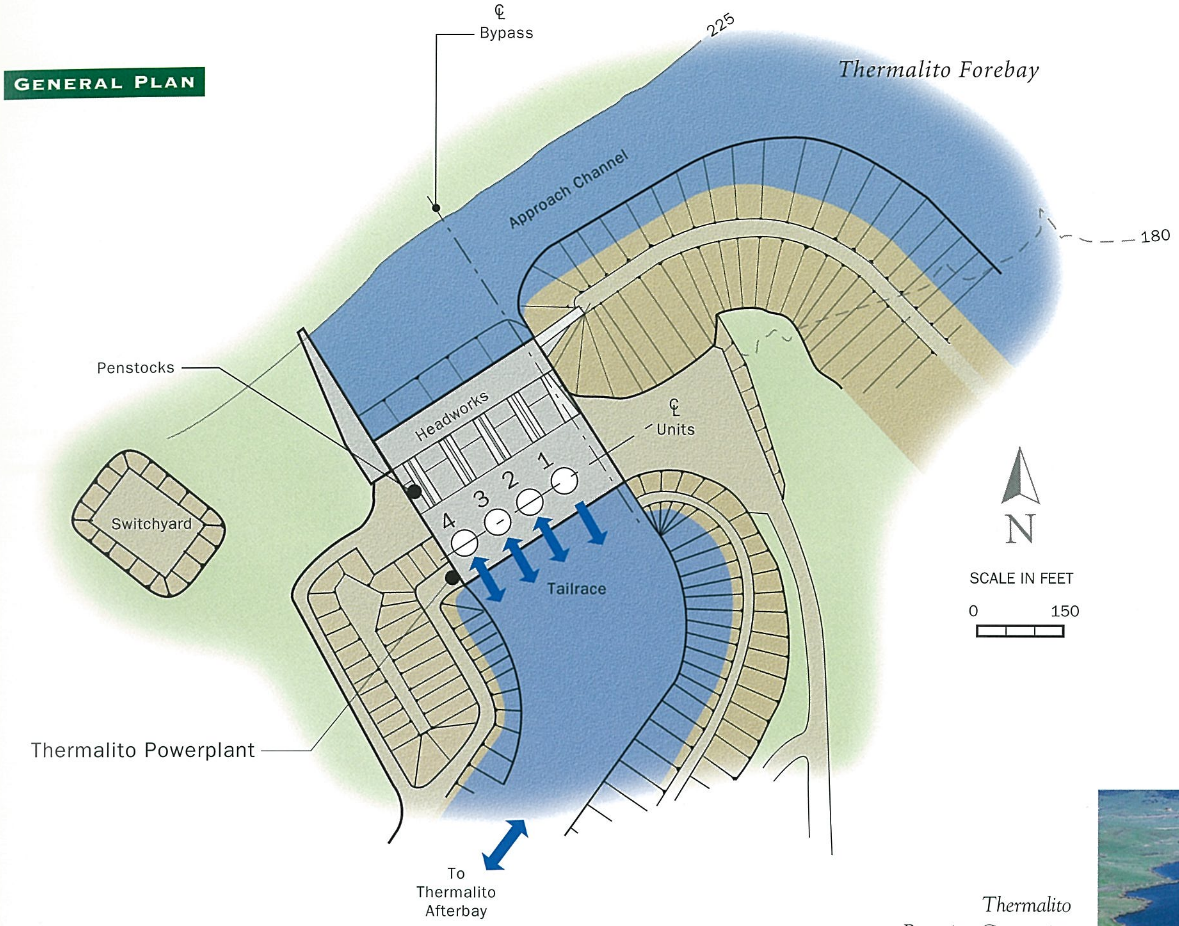
maximum operating storage

Thermalito Pumping-Generating Plant

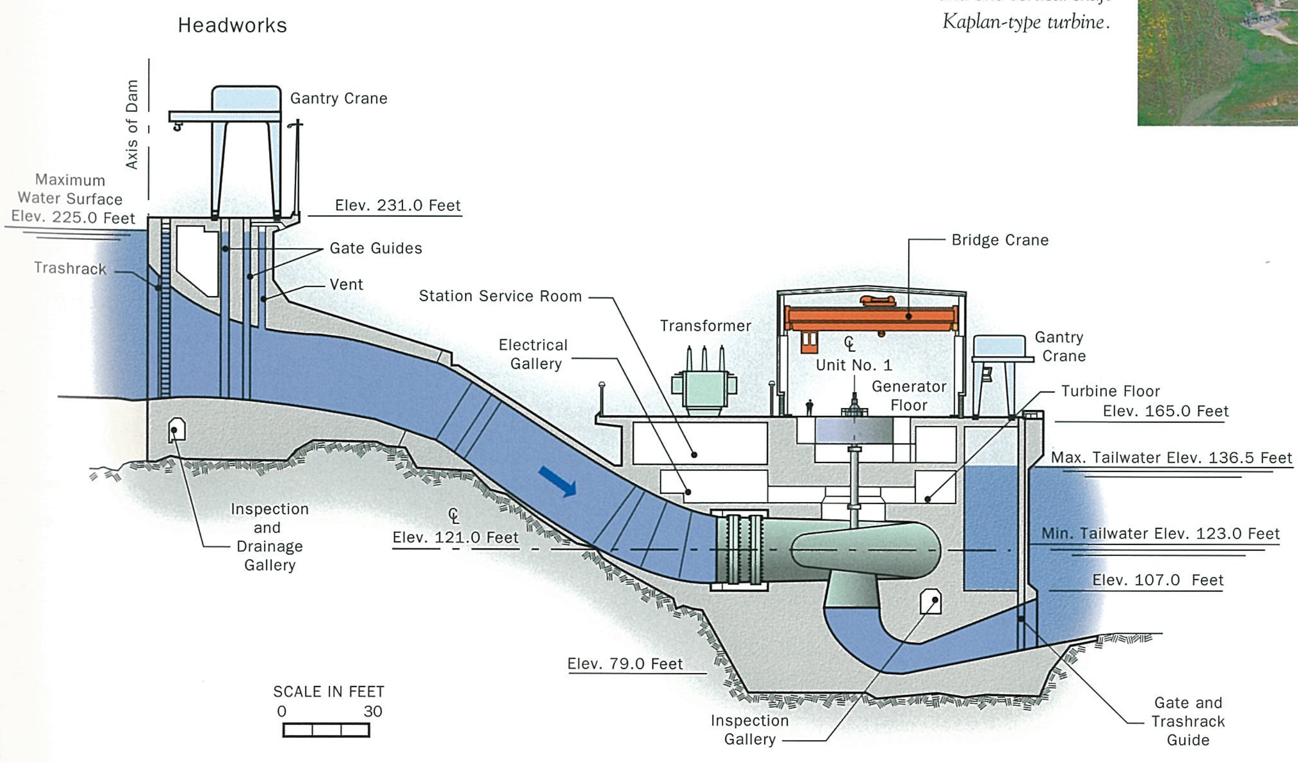
Located about four miles west of the city of Oroville in Butte County, Thermalito Pumping-Generating Plant is a principal feature of the Oroville-Thermalito pumped-storage power complex. A pumping-generating plant, the facility is operated in tandem with Hyatt Powerplant and Thermalito Diversion Dam Powerplant to produce power. Water released for power in excess of local and downstream requirements is conserved by pumpback operation during off-peak hours through both power plants into Lake Oroville. The water is subsequently released for power generation during periods of peak power demand. Construction on the plant began in 1964 and was completed in 1969, with operations starting in 1968.

Thermalito Pumping-Generating Plant contains three vertical-shaft Francis-type pump/turbines and one vertical shaft Kaplan-type turbine.

General Plan



Transverse Section



Pumping

Installed capacity . . . . 9,120 cfs, 120,000 hp
Normal static head. . . . . 85-102 feet
Design dynamic head . . . . 99 feet
Number of units. . . . . 3 (p/g)
Unit size. . . . . 3@ 3,040 cfs, 40,000 hp

Generating

Installed capacity . . . . 120 MVA, 17,400 cfs
Normal static head . . . . 85-102 feet
Design dynamic head . . . . 95 feet
Number of units. . . . . 4 (1g, 3 p/g)
Unit size . . . . 3 @ 28 MVA (p/g), 4,200 cfs
1 @ 36 MVA (g), 4,800 cfs
Penstock/diameter. . . . . 1 @ 24 to 21 feet
3 @ 21 to 18 feet

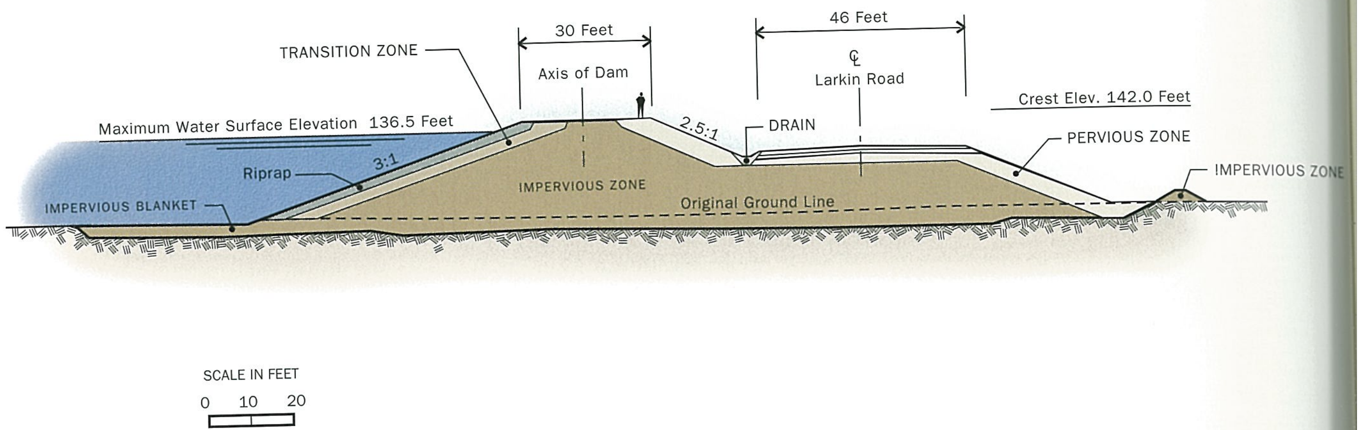
**maximum operating storage*

THERMALITO AFTERBAY DAM & AFTERBAY

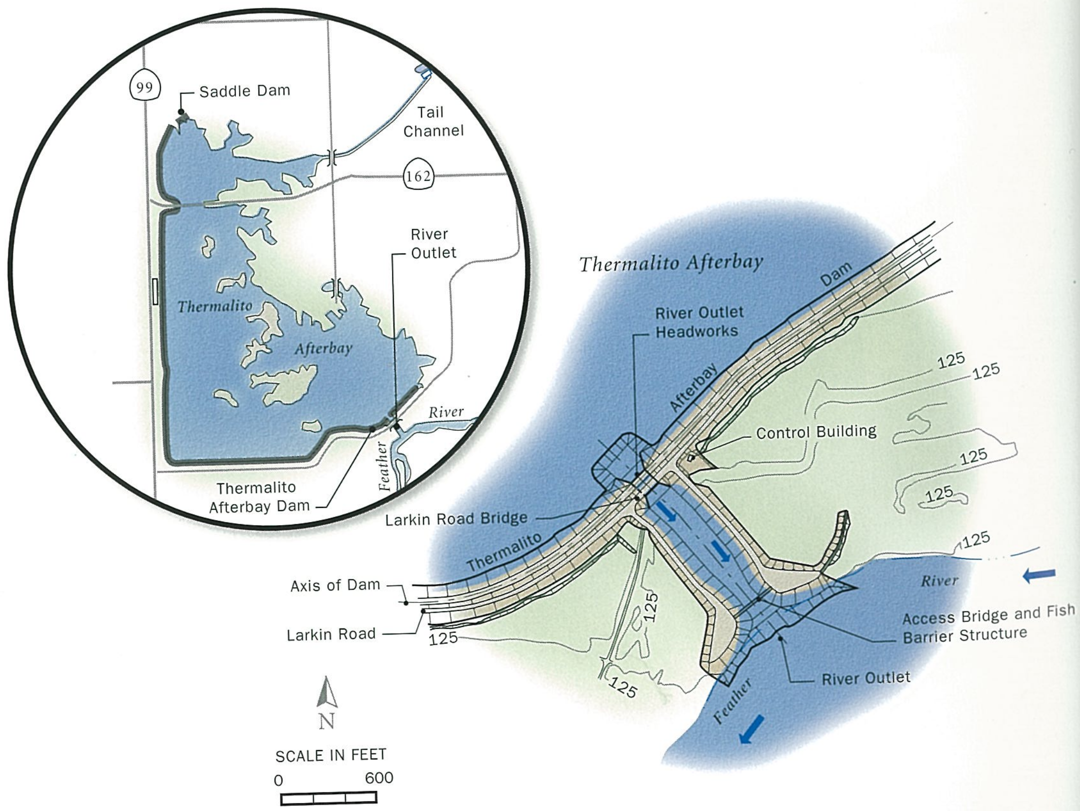
Located about six miles southwest of the city of Oroville, Thermalito Afterbay is an offstream reservoir. The afterbay provides storage for the water required by the pumpback operation to Lake Oroville, helps regulate the power system, produces controlled flow in the Feather River downstream from the Oroville-Thermalito facilities, and provides recreation. Thermalito Afterbay Dam has the longest crest in the SWP system. The facility was constructed from 1965 to 1968.

Water released from Thermalito Afterbay's river outlet (located in the southeast corner of the reservoir) is used for downstream project use, streamflow maintenance, and water-right commitments.

MAXIMUM SECTION



GENERAL PLAN



DAM

Type: homogeneous earthfill
Embankment volume . . . 5,020,000 cubic yards
Height . . . . 39 feet
Crest length . . . . 42,000 feet
Crest elevation. . . . . 142 feet

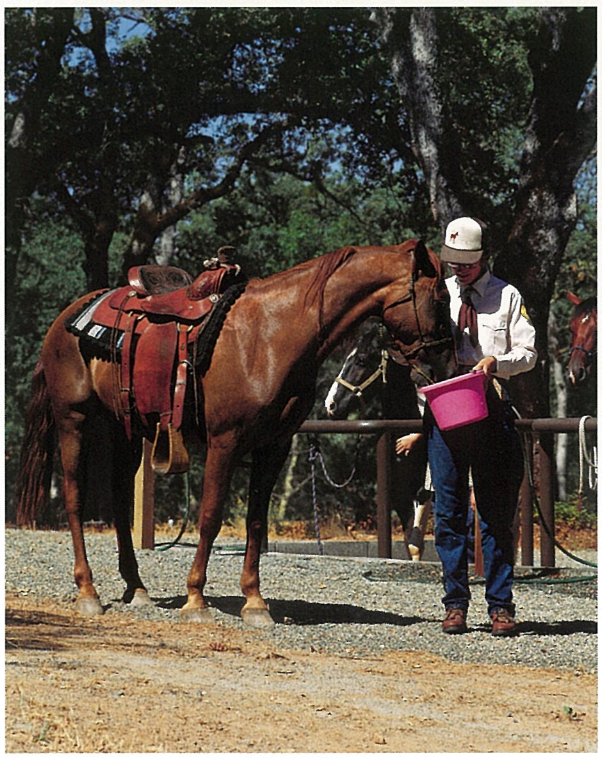
AFTERBAY

Maximum operating storage . . 57,040 acre-feet
Water surface elevation @ mos. . . . . 136.5 feet*
Water surface area @ mos . . . . 4,300 acres
Shoreline @ mos. . . . . 26 miles

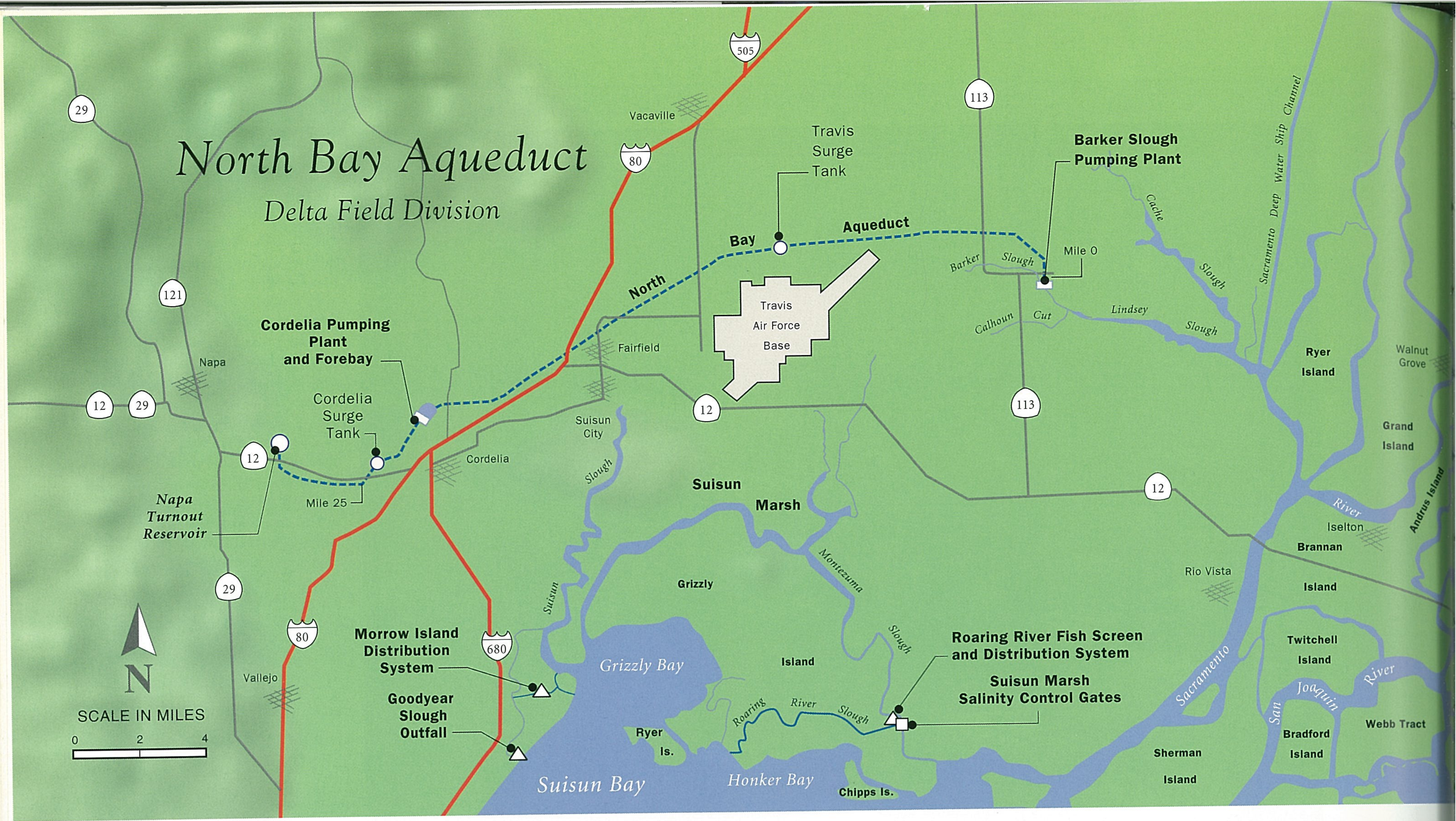
**maximum operating storage*

Lake Oroville, the largest SWP reservoir, is also a recreationist's paradise, offering an amazing array of activities: boating (two marinas), waterskiing, fishing, swimming, picnicking, hiking, camping (also on floating campsites on the lake), model plane runway, and an aquatic center. Visitors can see a fish hatchery in action (late fall) or learn about water at the Lake Oroville Visitors Center. They can also walk or jog the span of the highest earthfill dam in the nation. In addition Thermalito Diversion Pool and Thermalito Forebay and Afterbay offer more choices of recreation.

A unique feature at Lake Oroville is the equestrian camp facility at Loafer Creek. The site has pullouts for horse trailers, horse showers and feeder stalls, and bathing facilities for riders.



Bicyclists enjoy the 41-mile trail that circles Thermalito Forebay, Thermalito Afterbay, and the crest of Oroville Dam.


North Bay Aqueduct
Delta Field Division
North Bay Aqueduct
Travis Surge Tank
Barker Slough Pumping Plant
Mile 0
Cordelia Pumping Plant and Forebay
Cordelia Surge Tank
Napa Turnout Reservoir
Mile 25
Travis Air Force Base
Vacaville
Fairfield
Suisun City
Cordelia
Napa
Vallejo
Rio Vista
Isleton
Walnut Grove
Suisun Marsh
Grizzly Island
Ryer Island
Grand Island
Brannan Island
Twitchell Island
Bradford Island
Webb Tract
Sherman Island
Andrus Island
Ryer Is.
Chipps Is.
Grizzly Bay
Suisun Bay
Honker Bay
Morrow Island Distribution System
Goodyear Slough Outfall
Roaring River Fish Screen and Distribution System
Suisun Marsh Salinity Control Gates
Barker Slough
Calhoun Cut
Lindsey Slough
Cache Slough
Sacramento Deep Water Ship Channel
Suisun Slough
Montezuma Slough
Roaring River Slough
Sacramento River
San Joaquin River
SCALE IN MILES
0 2 4
N
505
80
113
29
121
12
680


California Aqueduct
& South Bay Aqueduct
Delta Field Division
Clifton Court Forebay
John E. Skinner Delta Fish Protective Facility
Delta O&M Center
Harvey O. Banks Delta Pumping Plant
South Bay Pumping Plant
Inlet Structure
Tracy Pumping Plant (Federal)
Bethany Reservoir
Tracy
Delta-Mendota Canal (Federal)
California Aqueduct
Mile 25
Ck 1
Ck 2
Ck 3
Ck 4
Ck 5
Ck 6
Ck 7
Ck 8
End Delta Field Division
South Bay Aqueduct
Patterson Reservoir
Hetch Hetchy Aqueduct (local)
Lake Del Valle
Del Valle Pumping Plant
La Costa Tunnel
Mission Tunnel
Santa Clara Terminal Reservoir
End Delta FD
SCALE IN MILES
0 1 2 3
N
205
BUS 205
5
132
33
580
680

DELTA FIELD DIVISION

Within Delta Field Division's jurisdiction lie the North Bay and South Bay Aqueducts. North Bay's underground pipeline and facilities take its water from Barker Slough at the north end of the Delta, while South Bay branches off from Bethany Reservoir to serve Santa Clara and Alameda counties. The field division also operates and maintains SWP facilities within the Delta. These include Clifton Court Forebay, the Harvey O. Banks Delta Pumping Plant, which lifts water into the California Aqueduct, and two major environmental protection projects: the Skinner Fish Protective Facility, a fish salvage operation, and the Suisun Marsh Salinity Control Gates, a water quality control structure, protecting one of the largest contiguous brackish water marshes in the nation.

NORTH BAY AQUEDUCT

The North Bay Aqueduct, an underground pipeline, extends for 27.6 miles from Barker Slough in the Delta to the end of the Napa Pipeline. The aqueduct provides supplemental water supplies to Napa and Solano counties.

The aqueduct was constructed in two phases. Phase I (1967 – 68) began serving Napa County in 1968, using an interim supply of water from the USBR's Solano Project. Phase II (1985 to 1988) extended the pipeline 23 miles from the Cordelia Surge Tank eastward to Barker Slough.

Water is pumped from the Delta at Barker Slough Pumping Plant through a pipeline to Travis Surge Tank then to the Cordelia Pumping Plant. Through two turnouts along the way, deliveries are made to Travis Air Force Base and the Solano County communities of Fairfield, Suisun City, and Vacaville. Two of Cordelia Pumping Plant's three discharge pipelines serve Benicia and Vallejo, with the third carrying water to the Napa Turnout Reservoir. The storage tank is the aqueduct's western terminus. Three turnouts deliver water to the American Canyon Water District and the City of Napa, which in turn uses its facilities to deliver water to Yountville and Calistoga in Napa County.

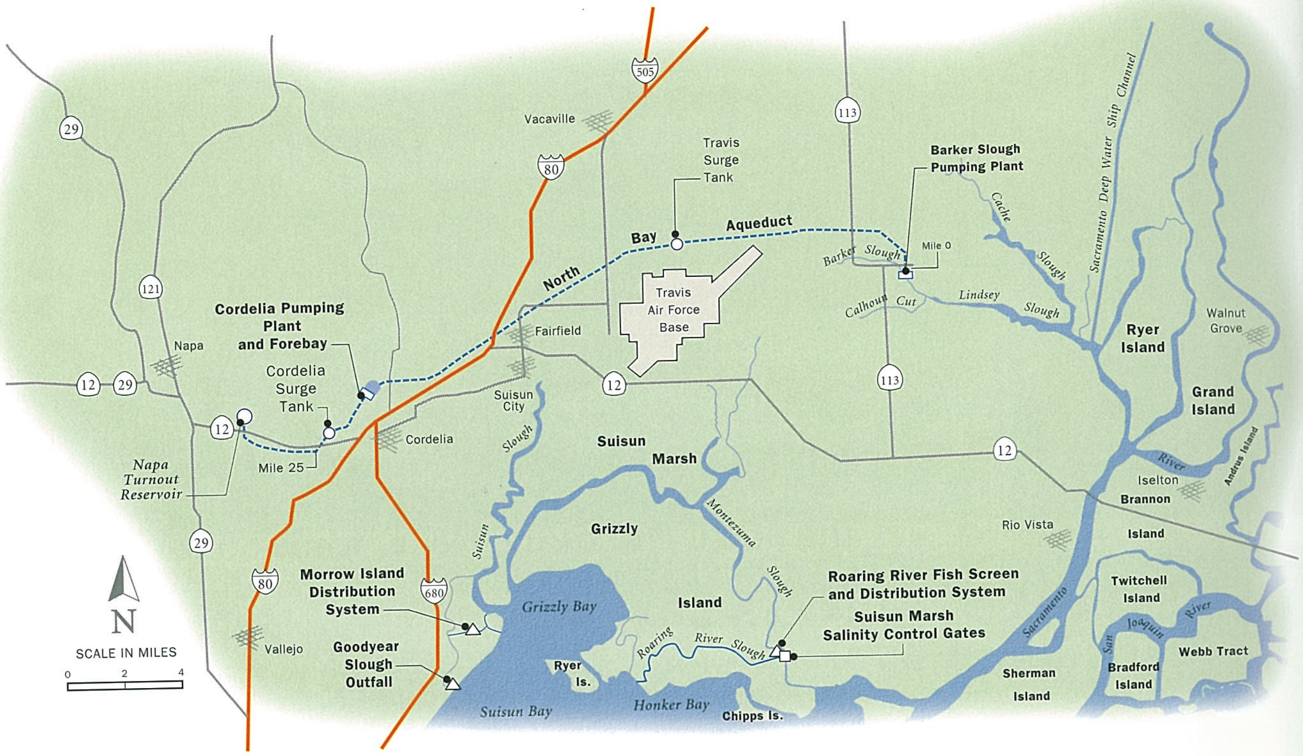
PIPELINE

Type: precast, prestressed concrete cylinder, pretensioned concrete cylinder, and reinforced concrete pipe.

Diameter. . . . . varies from 3 to 6 feet

Capacity. . . . . steps down from 175 cfs to 39 cfs

AQUEDUCT MAP



The pipeline was placed at sufficient depth for pipeline protection and to insure that future developments, such as subdivisions, roads, sewer lines, and water mains, could be installed with minimum disruption of the pipeline. In areas where subdivisions were anticipated, it was required to have at least five feet of cover, including about 2.5 feet of consolidated or compacted material.

Precast, pretensioned concrete cylinder pipe was used for most of the pipeline.

Manholes like the one shown above provide access for inspection and repair along the North Bay Aqueduct.

Barker Slough Pumping Plant

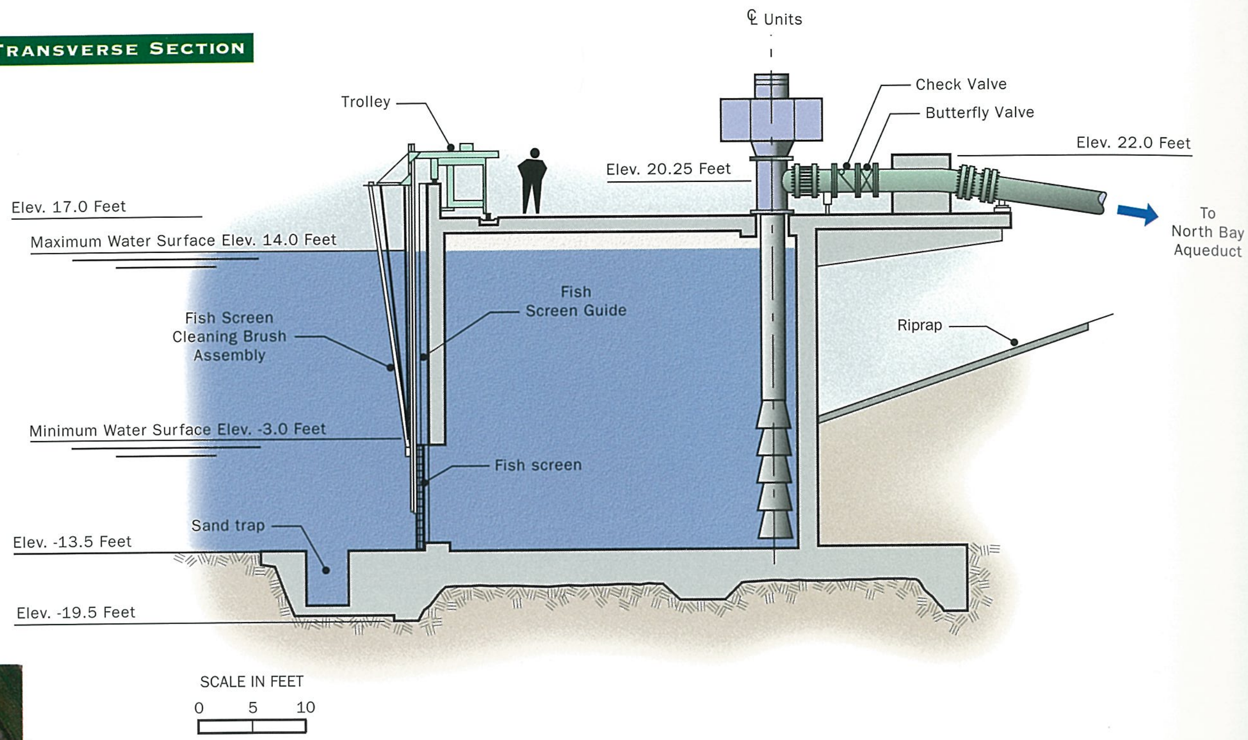
Located on the northwestern edge of the Sacramento-San Joaquin Delta, Barker Slough Pumping Plant marks the beginning of the North Bay Aqueduct. Its pumps lift water from Barker Slough into a pipeline that conveys the water to the Travis Surge Tank, nearly nine miles away. Water then flows by gravity to Cordelia Pumping Plant. Construction of the plant began in 1986 and was completed in 1987.

Barker Slough Pumping Plant diverts water from the periphery of the Delta.

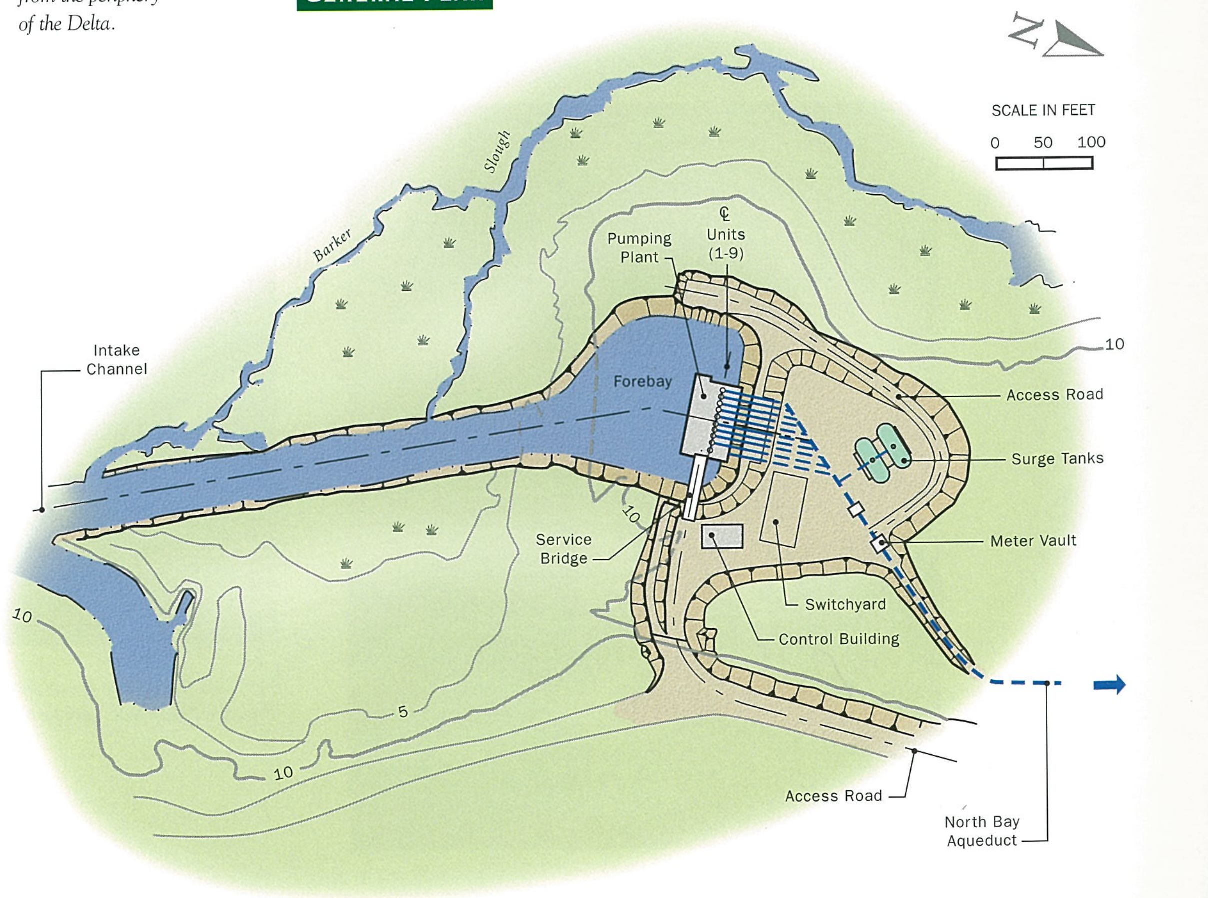
Pumping

Installed capacity	*228 cfs, 4,800 hp*
Normal static head	*95-120 feet*
Design dynamic head	*137 feet*
Number of units	*9*
Unit size	*2 @ 14.4 cfs, 300 hp* *7 @ 28.4 cfs, 600 hp*
Discharge line/diameter	*1 @ 6 feet*

Transverse Section



General Plan



CORDELIA PUMPING PLANT FOREBAY

Located in Solano County near Highway 80, Cordelia Pumping Plant Forebay is a shallow reservoir that permits regulation of flows into Cordelia Pumping Plant. It was constructed between 1986 and 1987.

DAM

Type: earthen, asphalt-lined

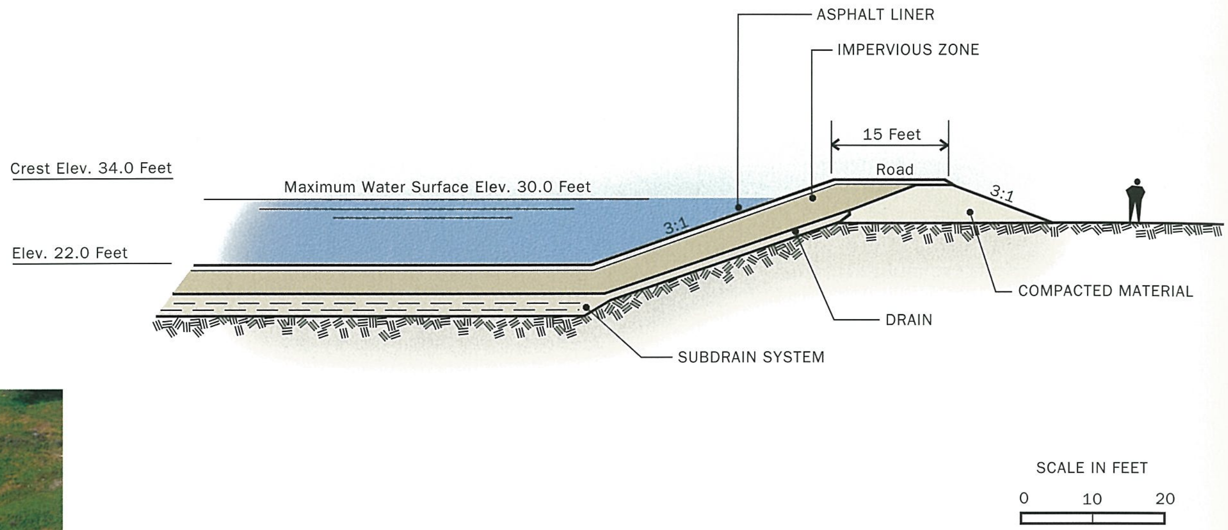
Height	*34 feet*
Crest length	*1,100 feet*
Crest elevation	*34 feet*

FOREBAY

Maximum operating storage	*11 acre-feet*
*Water surface elevation @ mos**	*30 feet*
Water surface area @ mos.	*2 acres*
Shoreline @ mos	*0.3 miles*

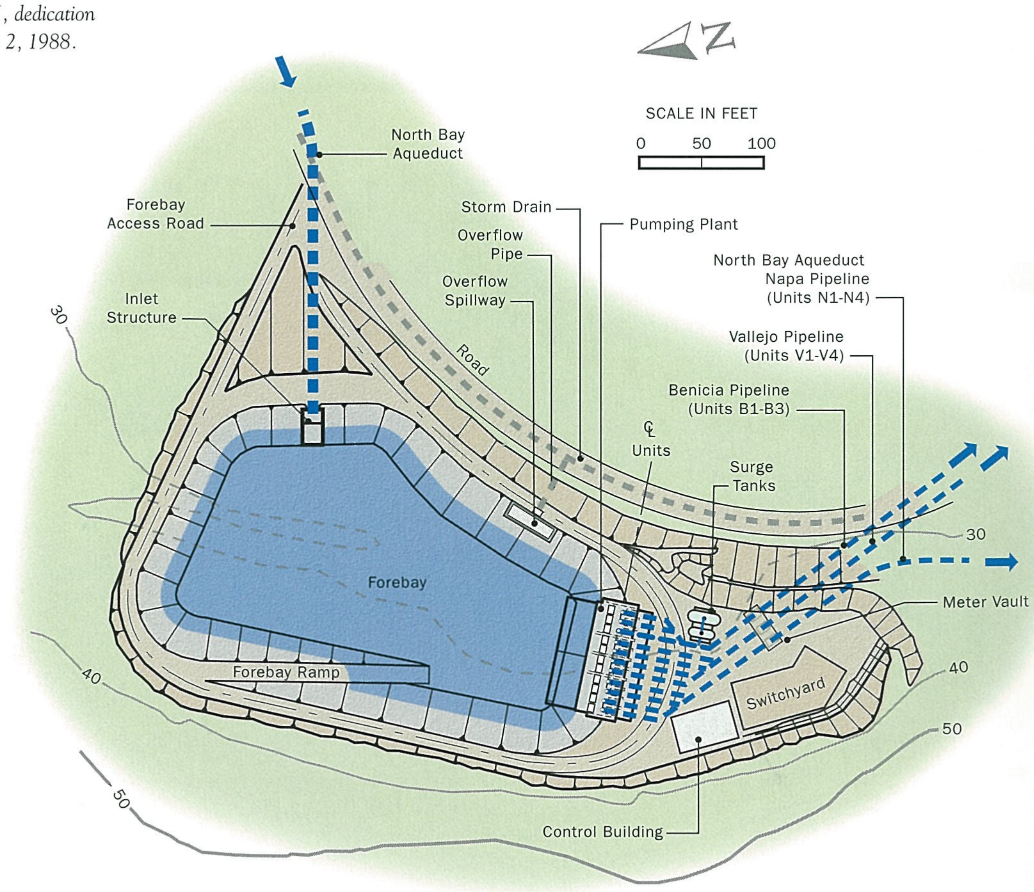
**maximum operating storage*

TYPICAL SECTION

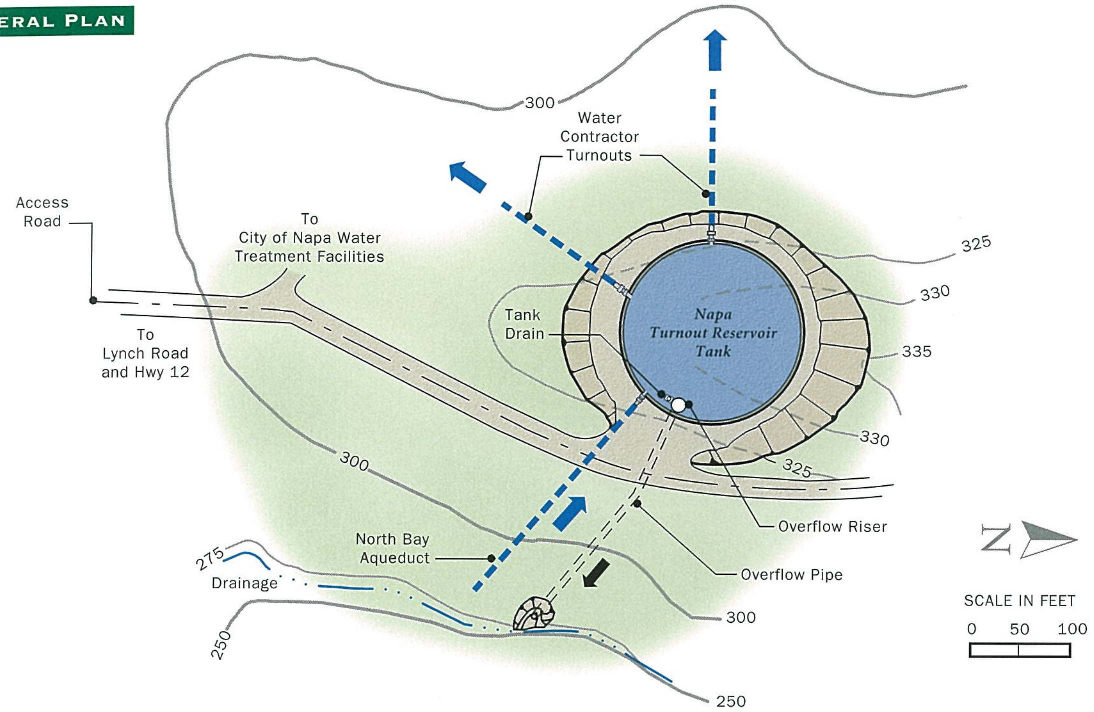


The Cordelia Pumping Plant Forebay was filled for the first time during the North Bay, Phase II, dedication on May 2, 1988.

GENERAL PLAN



GENERAL PLAN



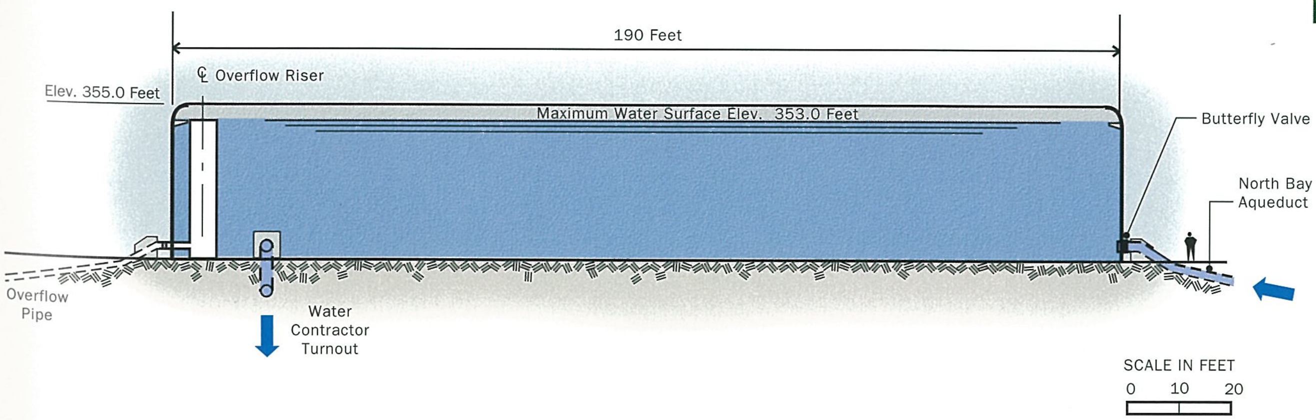
NAPA TURNOUT RESERVOIR

The western terminus of the North Bay Aqueduct, the Napa Turnout Reservoir is located in eastern Napa County near Highway 12. The steel tank receives water from a four-mile pipeline connecting it with the Cordelia Surge Tank.

Constructed between 1967 and 1968, the Napa Turnout Reservoir was originally filled by the SWP's North Bay Interim Pumping Plant. Today, the reservoir stores water for delivery to Napa County Flood Control and Water Conservation District.

The Napa Turnout Reservoir's dimensions were based on comparison of combinations of depths and diameters, plus pumping costs, and tank costs. First deliveries made from the reservoir were on April 5, 1968.

TRANSVERSE SECTION



TANK

Type: steel plate, cylindrical open-top

Height	*35 feet*
Diameter	*190 feet*
Elevation	*355 feet*

RESERVOIR

Maximum operating storage	*22 acre-feet*
*Water surface elevation @ mos**	*353 feet*
Water surface area @ mos	*0.7 acres*

**maximum operating storage*

Suisun Marsh Salinity Control Gates

Located at the eastern end of the Montezuma Slough in the Sacramento-San Joaquin Delta near Collinsville, the Suisun Marsh Salinity Control Gates maintain proper salinity levels in the Suisun Marsh during periods of low Delta outflow. These levels affect the growth of food plants for waterfowl using the marsh as a wintering area.

Operation of the gates is based on modifying the tidal flows through Montezuma Slough. The radial gates are opened to allow better quality water from the Sacramento and San Joaquin rivers to flow westerly into the marsh. As the direction of tidal flows reverses, the radial gates close to trap this better quality water, which will dilute the saltier water flowing easterly into the marsh from Grizzly Bay.

Construction on the gates began in 1986, and tests of tidal pumping began in 1988. They were declared operational in 1989.

Structure (Overall)

Length . . . . *465 feet*

Gates

Type: 3 steel, radial, motorized, computer-sensor controlled

Width . . . . *36 feet*

Height . . . . *28.5 feet*

Weight . . . . *40 tons*

Radial Gate Structure

Type: lightweight, reinforced, concrete

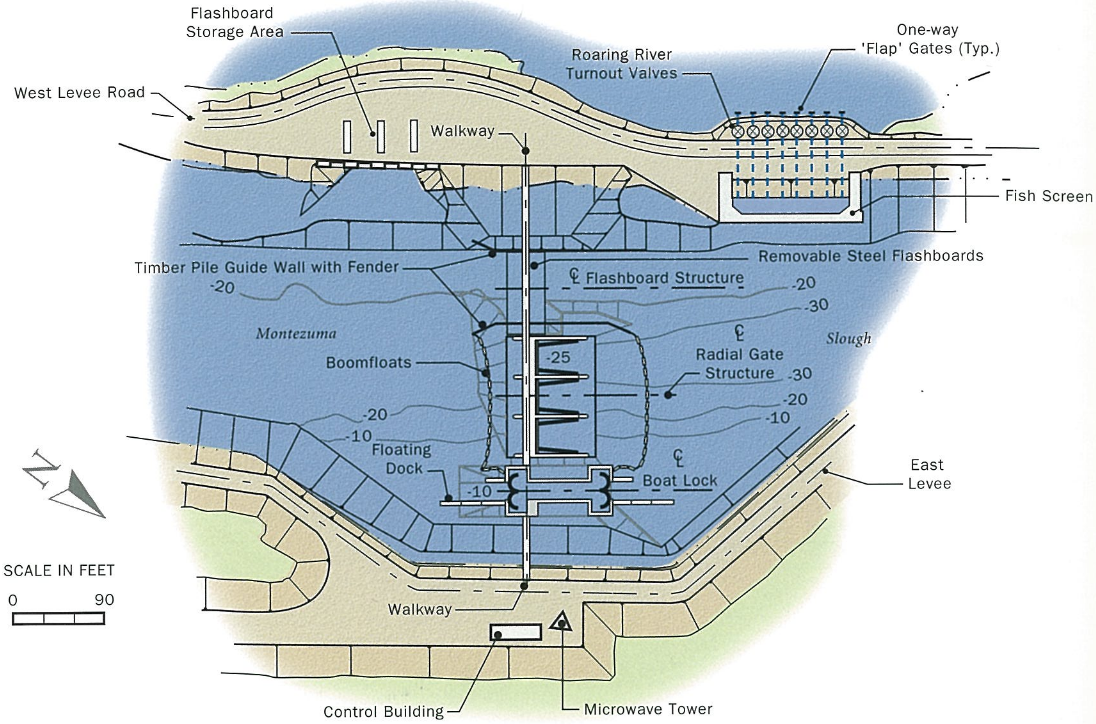
Height . . . . *53 feet*

Width . . . . *80 feet*

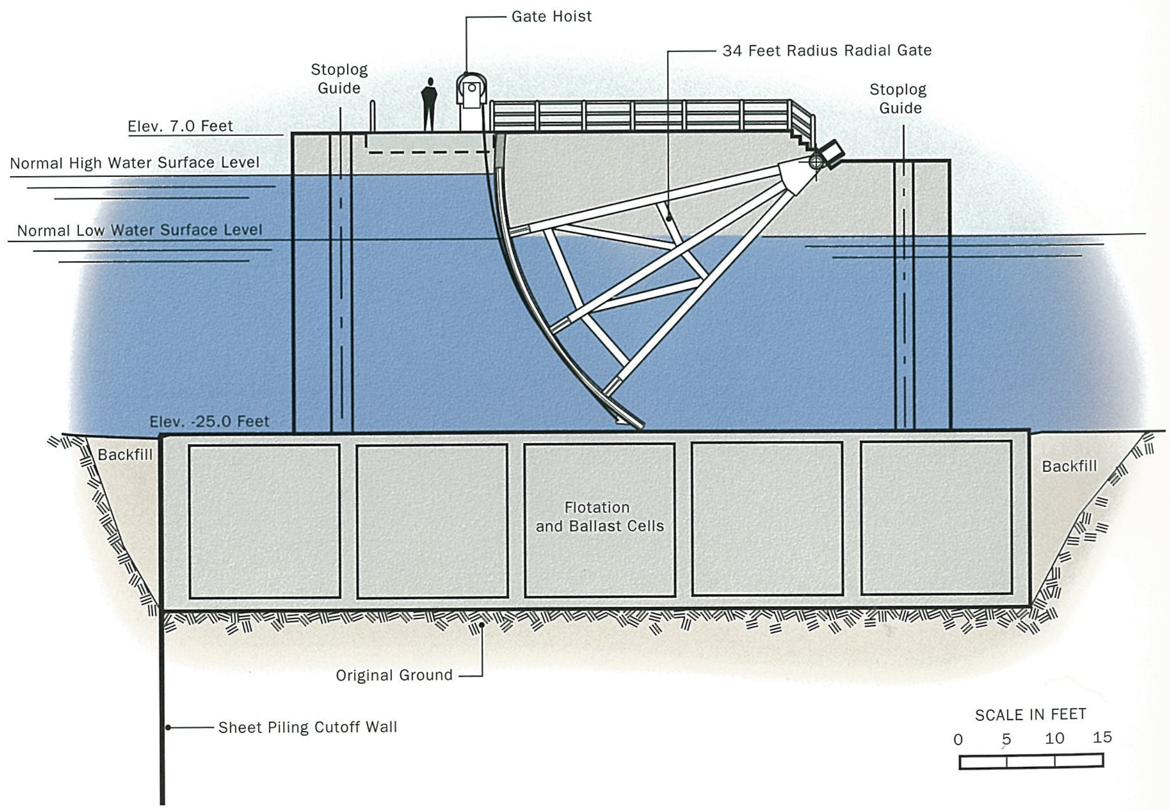
Length . . . . *120 feet*

Weight . . . . *6,500 tons*

General Plan



Transverse Section



The gates help maintain proper salinity levels in the Suisun Marsh. Proper salinity levels help preserve the habitats of fish and wildlife that reside in the marsh.

By building most of the structure offsite, DWR saved money and reduced construction impacts on the surrounding environment and to recreational users. The concrete modules were constructed in Stockton then towed to Rio Vista and later to the Montezuma Slough site near Collinsville.

Computer sensors control the radial gate operations. Gates open when water levels on the west side are lower to allow fresh water to enter Montezuma Slough. Gates close when the tides reverse to keep the better quality water in the marsh.

SOUTH BAY AQUEDUCT

South Bay Aqueduct was the first delivery system completed in the State Water Project and has been conveying water to Alameda and Santa Clara counties since 1962 and 1965, respectively. Constructed between 1958 and 1969, the 42.9-mile system consists of 8.4 miles of canals, 32.9 miles of pipeline, and 1.6 miles of tunnels.

Water agencies served by the aqueduct are the Alameda County Water District, the Alameda County Flood Control and Water Conservation District (Zone 7), and Santa Clara Valley Water District. They can receive up to 188,000 acre-feet annually.

PIPELINES

Type: 32.9 miles of buried reinforced concrete, cylinder, and steel pipes

Diameter. . . . . varies from 42 to 90 inches

Capacity. . . . . varies from 120 to 363 cfs

CANALS

Type: 8.4 miles of concrete-lined, trapezoidal, checked

Capacity. . . . . 300 cfs

Water depth . . . . 4.7 and 5.6 feet

Side slope 1 1/2:1

Width . . . . 8 feet (bottom)

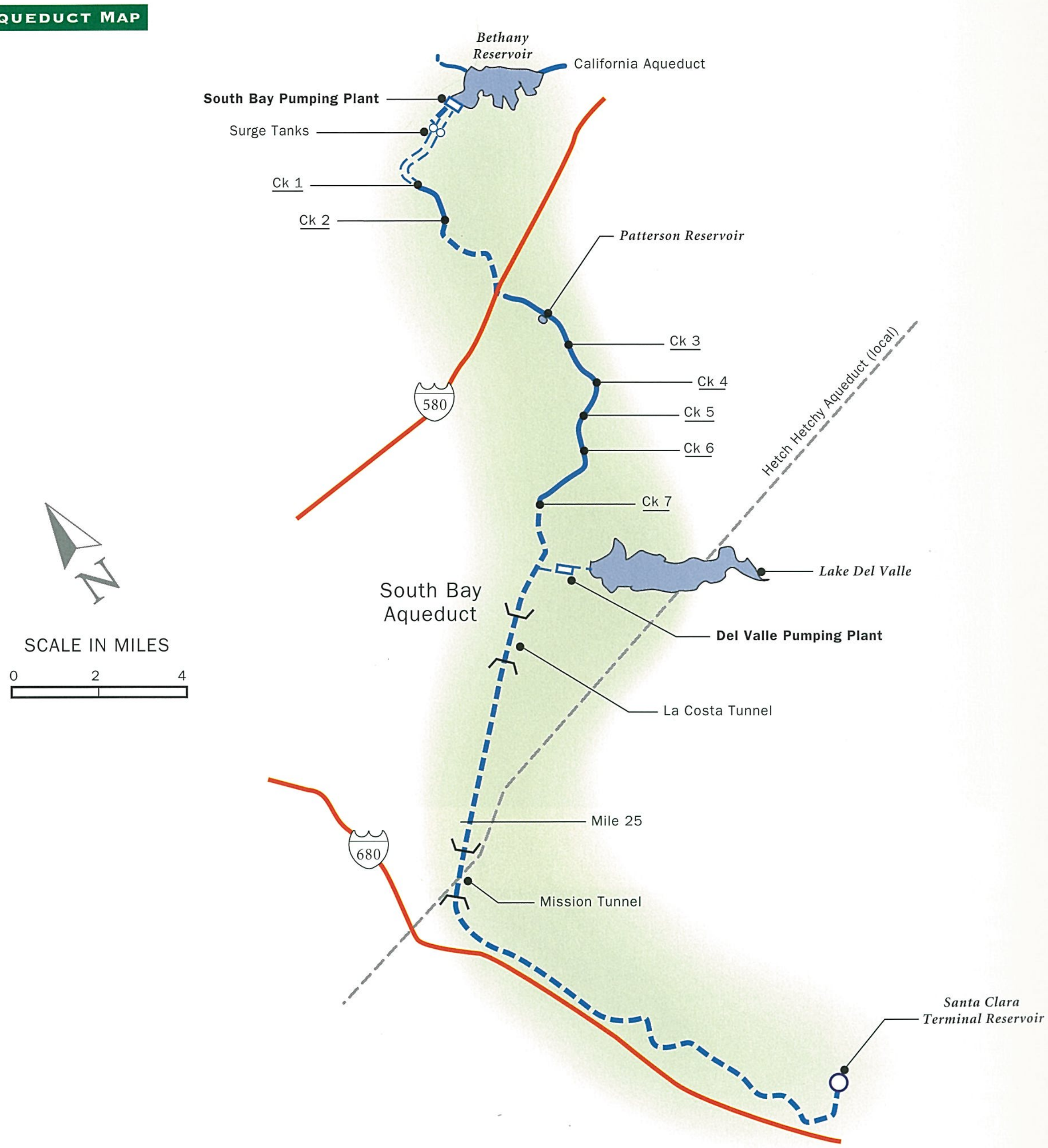
TUNNELS

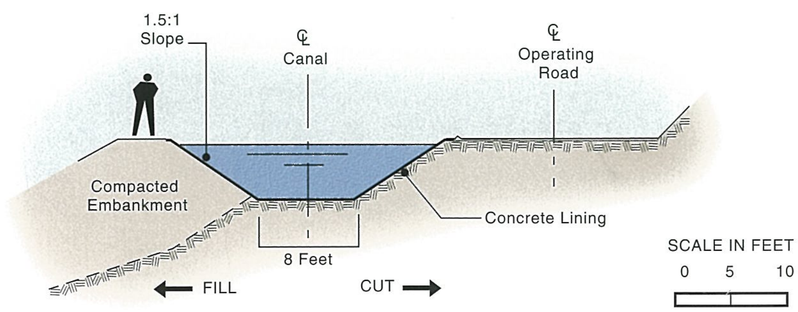
Type: 1.6 miles of concrete-lined horseshoe tunnel, finished to a circular shape

Diameter. . . . . 93 inches

Capacity . . . . 305 and 255 cfs

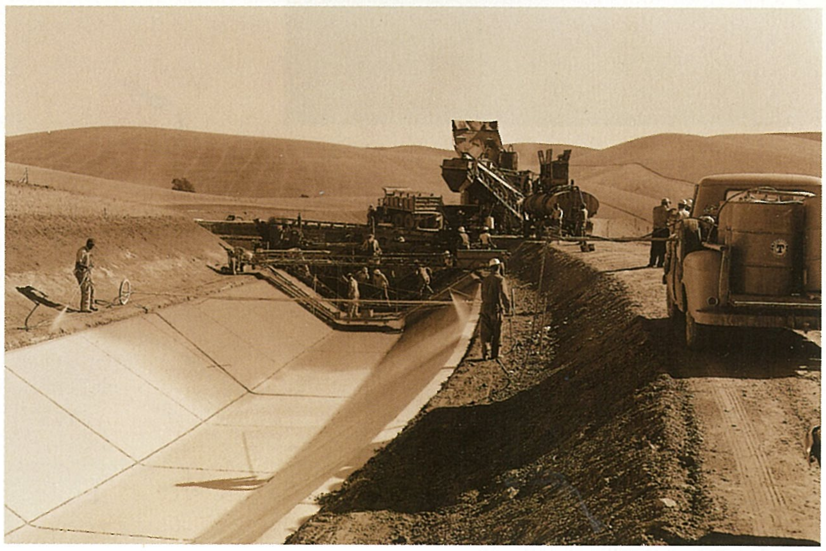
AQUEDUCT MAP





Water from the South Bay Aqueduct helps alleviate serious overdraft of local groundwater basins resulting from growing demands of an increasing economy. SBA water is also used for irrigation of agricultural land and domestic and industrial use.

The rolling hills and steep slopes caused difficult construction problems. The pipeline alignment was pioneered by benching out work areas with dozers. The trench was mucked out with a dragline then excavated with a backhoe equipped with a two-cubic-yard bucket wherever possible.

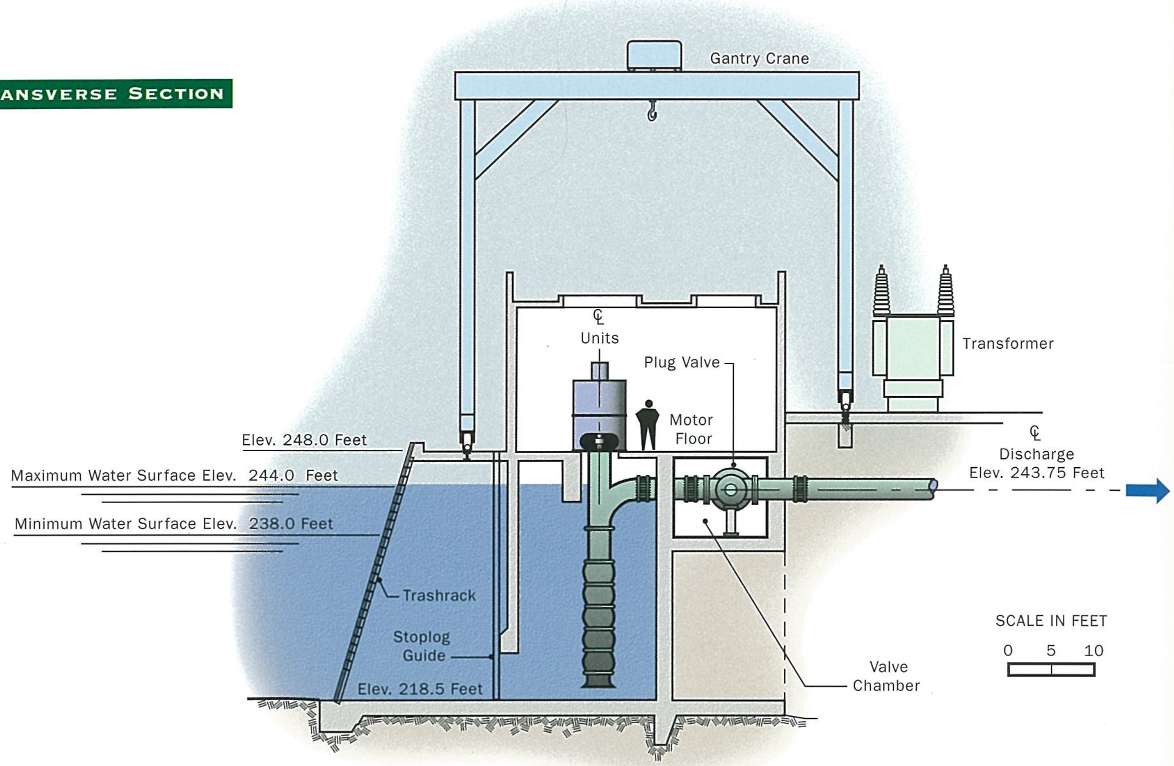


South Bay's canal sections were lined with unreinforced concrete from 2.5 to 3.5 inches thick.

South Bay Pumping Plant

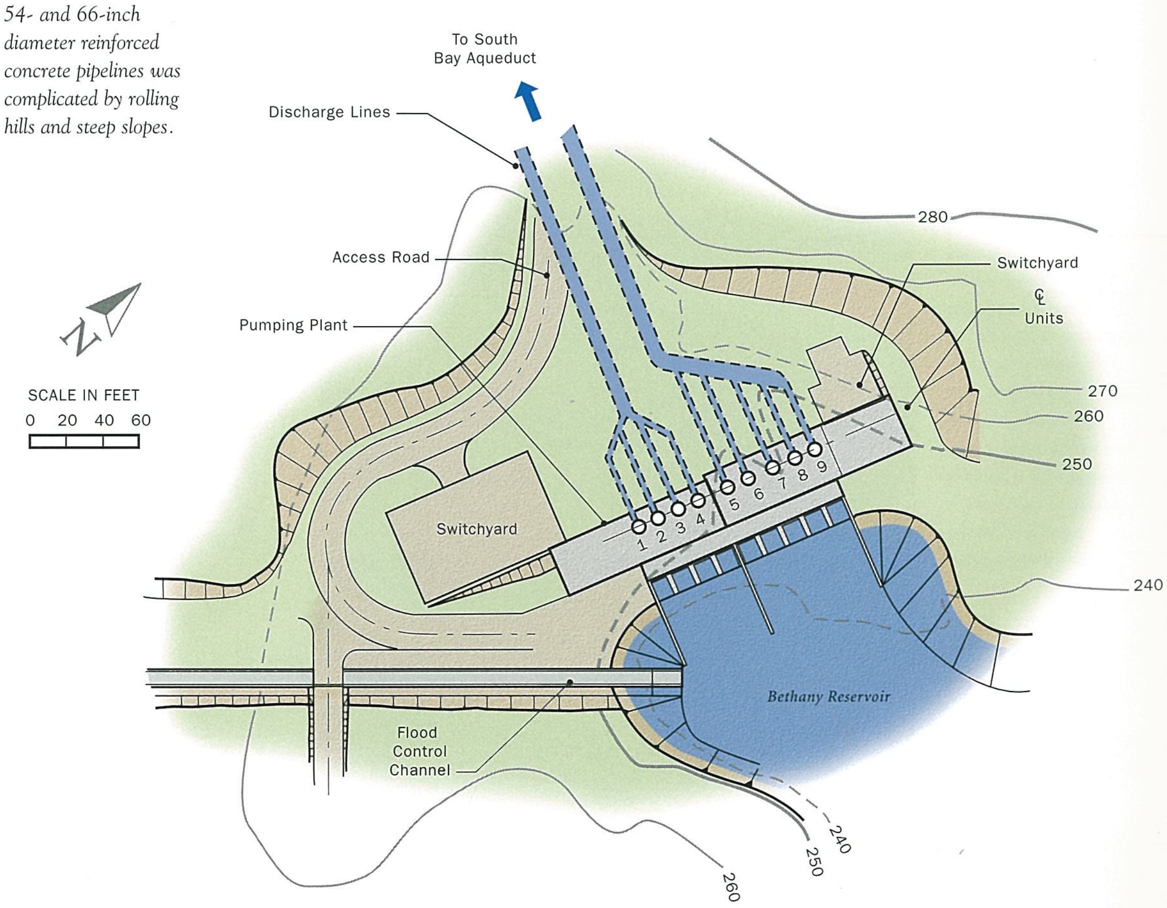
Located at the upper end of Bethany Reservoir, South Bay Pumping Plant lifts water into the first reach of the South Bay Aqueduct. It is situated in the north-eastern corner of Alameda County, about 12 miles west of Tracy. The plant's staged construction took place between 1960 and 1969.

Transverse Section



South Bay Pumping Plant lifts water through two discharge lines known as Brushy Creek Pipelines. Construction of these 54- and 66-inch diameter reinforced concrete pipelines was complicated by rolling hills and steep slopes.

General Plan



Pumping

Installed capacity	*330 cfs, 27,750 hp*
Normal static head	*566 feet*
Design dynamic head	*611 feet*
Number of units	*9*
Unit size	*1 @ 15 cfs, 1,250 hp* *3 @ 30 cfs, 2,500 hp* *3 @ 45 cfs, 4,000 hp* *2 @ 45 cfs, 3,500 hp*
Discharge lines/diameter	*1 @ 4.5 feet* *1 @ 5.5 feet*

Del Valle Pumping Plant

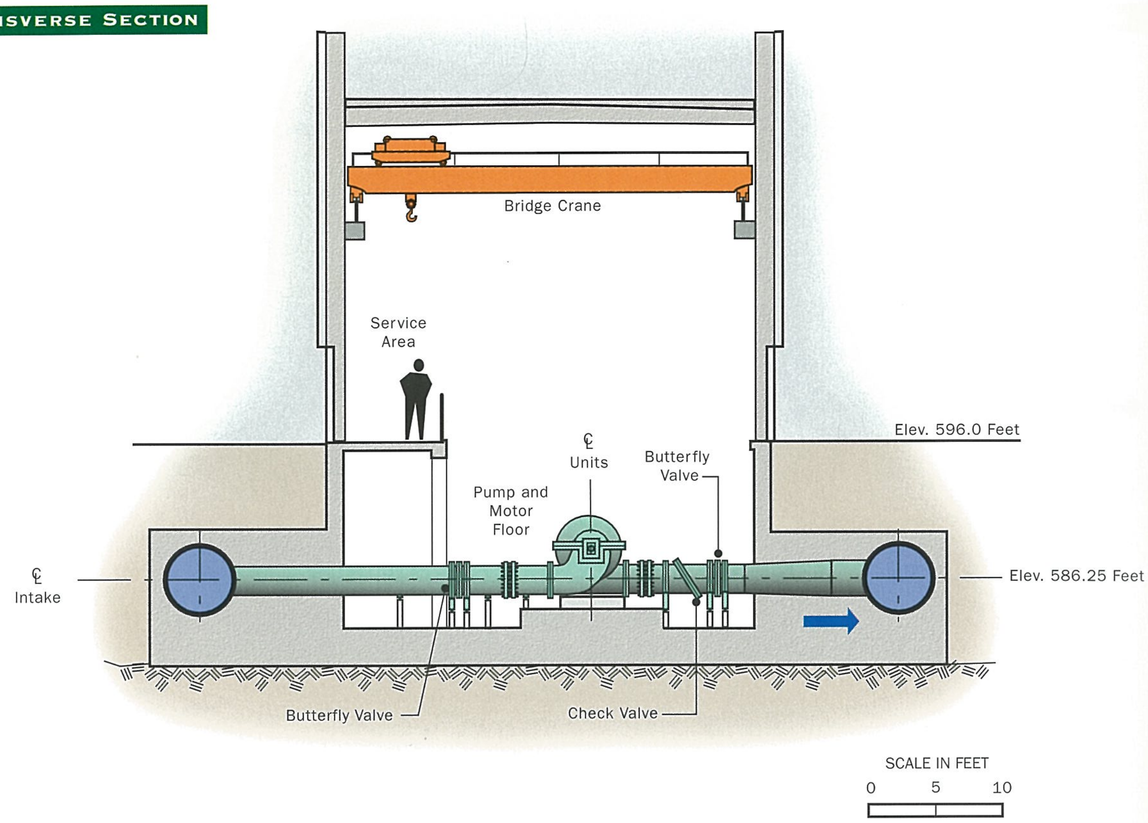
Constructed between 1967 and 1969, Del Valle Pumping Plant pumps water during low demand periods from the South Bay Aqueduct into Lake Del Valle for storage and conveys it back to the aqueduct when demand is high and the water level is too low to allow flow back into the aqueduct via gravity. It actually serves as a booster station in the branch line between South Bay Aqueduct and Lake Del Valle. The plant lies immediately downstream of Del Valle Dam, about 4.5 miles south of the city of Livermore, and is the smallest SWP pumping facility.

Del Valle Pumping Plant's location was governed by the topography of the narrow canyon and alignment of the Del Valle Branch Pipeline.

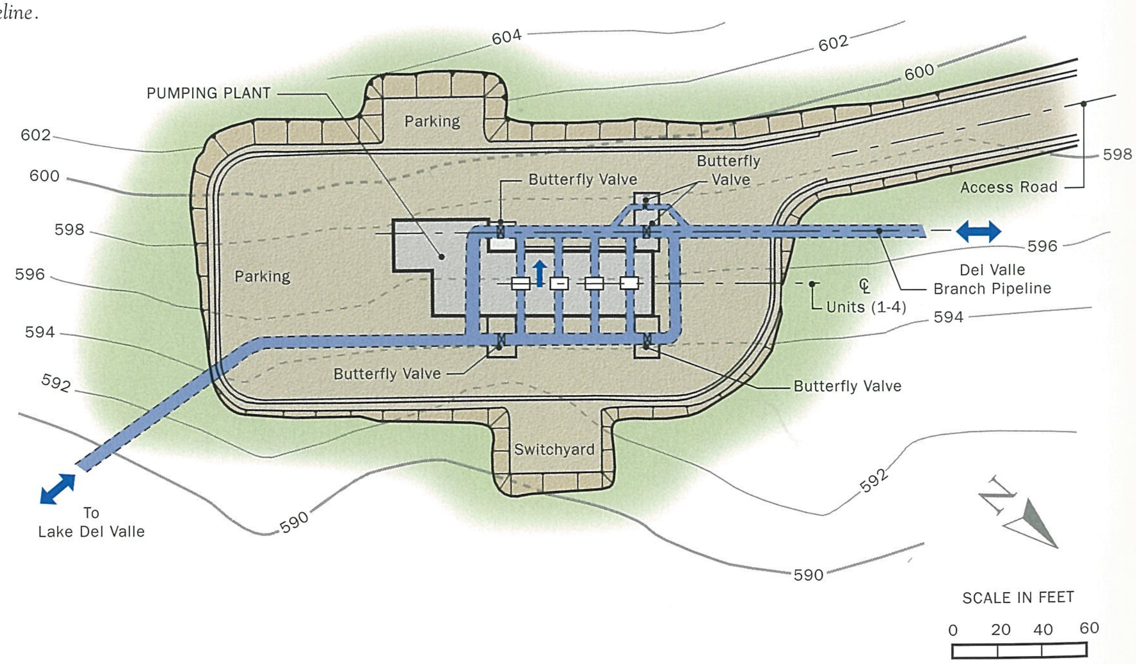
Pumping

Installed capacity	*120 cfs, 1,000 hp*
Normal static head	*0-38 feet*
Design dynamic head	*60 feet*
Number of units	*4*
Unit size	*30 cfs, 250 hp*
Discharge line/diameter	*1 @ 5 feet*

Transverse Section



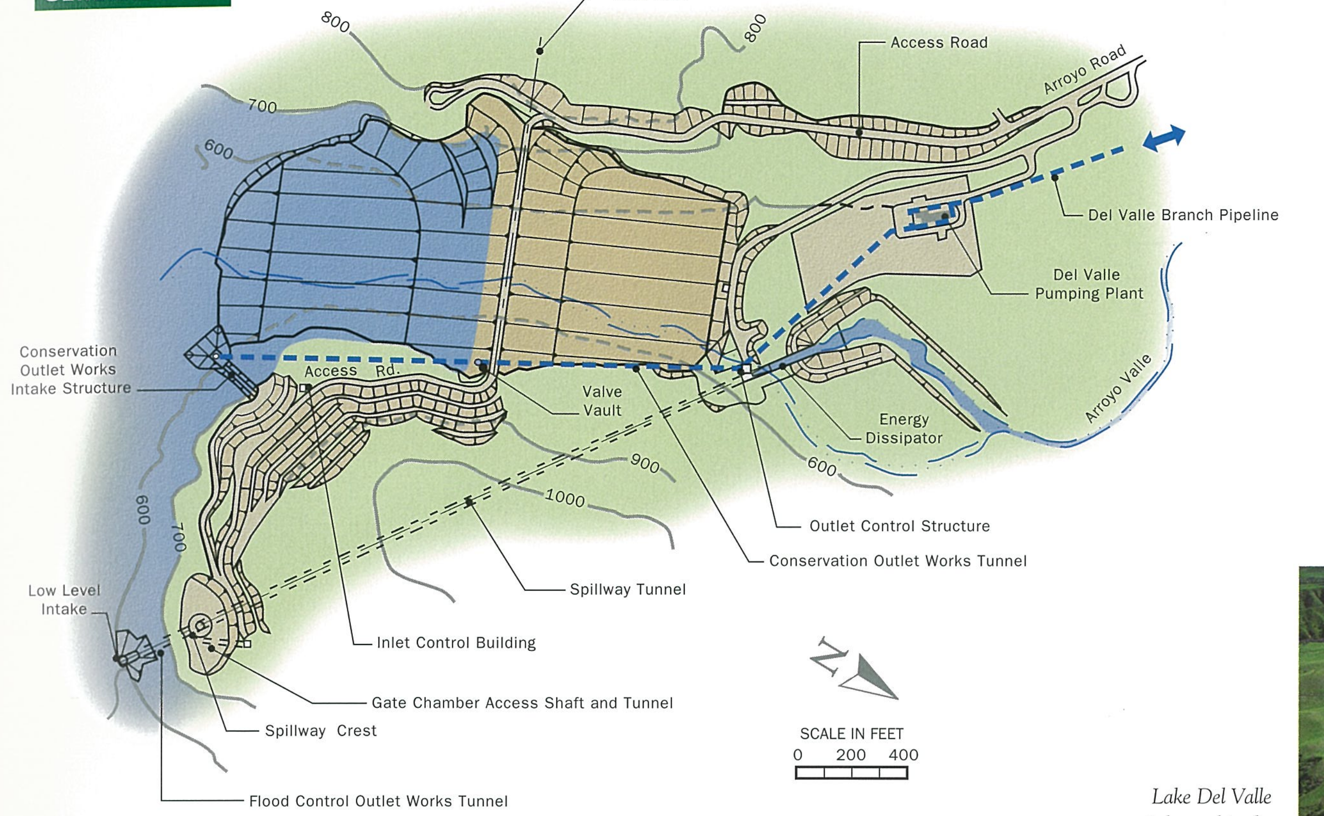
General Plan



DEL VALLE DAM & LAKE DEL VALLE

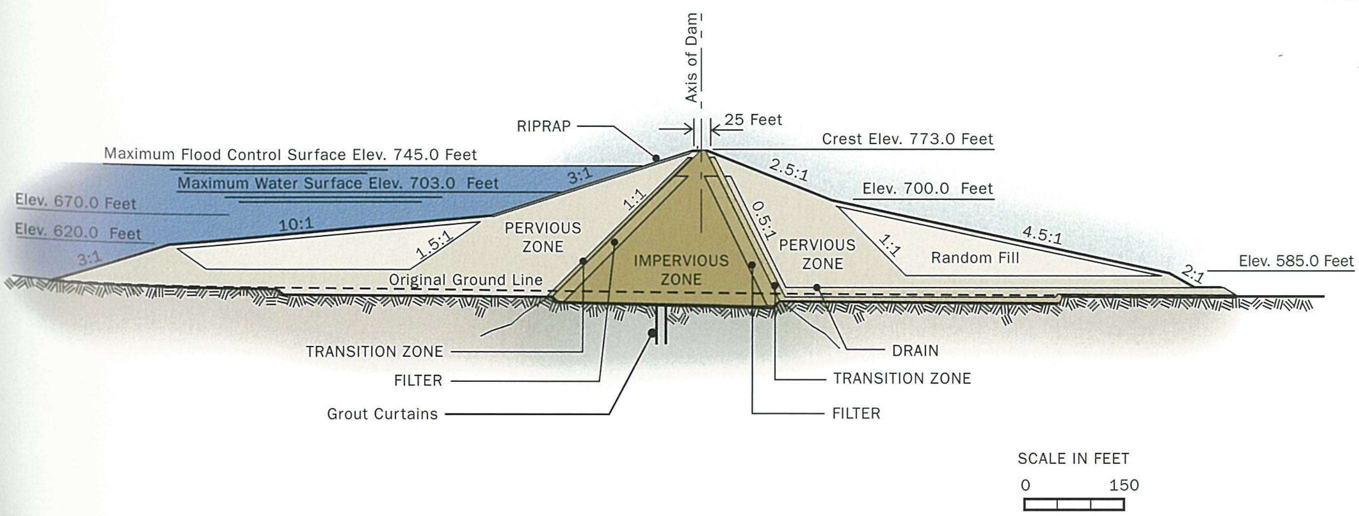
Located in Arroyo Del Valle, about four miles from the City of Livermore in Alameda County, Del Valle Dam and Lake Del Valle provide regulatory storage for the South Bay Aqueduct, flood control (38,000 acre-feet reservation) for Alameda Creek, conservation of storm runoff, recreation, and fish and wildlife enhancement. The facility was constructed from 1966 to 1968.

GENERAL PLAN



Lake Del Valle is located in the Diablo Mountain Range, a part of the Coastal Range.

MAXIMUM SECTION



DAM

Type: zoned earthfill
Embankment volume . . . 4,150,000 cubic yards
Height. . . . . 235 feet
Crest length. . . . . 880 feet
Crest elevation . . . . 773 feet

LAKE

Maximum operating storage. . . 77,110 acre-feet
Water surface elevation @ mos . . . . . . 745 feet*
Water surface area @ mos . . . . 1,060 acres
Shoreline @ mos. . . . . 16 miles

**maximum operating storage*

Santa Clara Terminal Reservoir

The Santa Clara Terminal Reservoir, a steel holding tank, is located five miles east of downtown San Jose on the site of the Santa Clara Valley Water District's Penitencia Treatment Facilities. It supplies domestic water to the Santa Clara area through a feed line to the treatment plant and an overflow pipe ending at the district's groundwater percolation basin. It was constructed from 1964 to 1965.

Santa Clara Terminal Reservoir was the site of South Bay Aqueduct's dedication on July 1, 1965.

Tank

Type: steel, cylindrical open-top

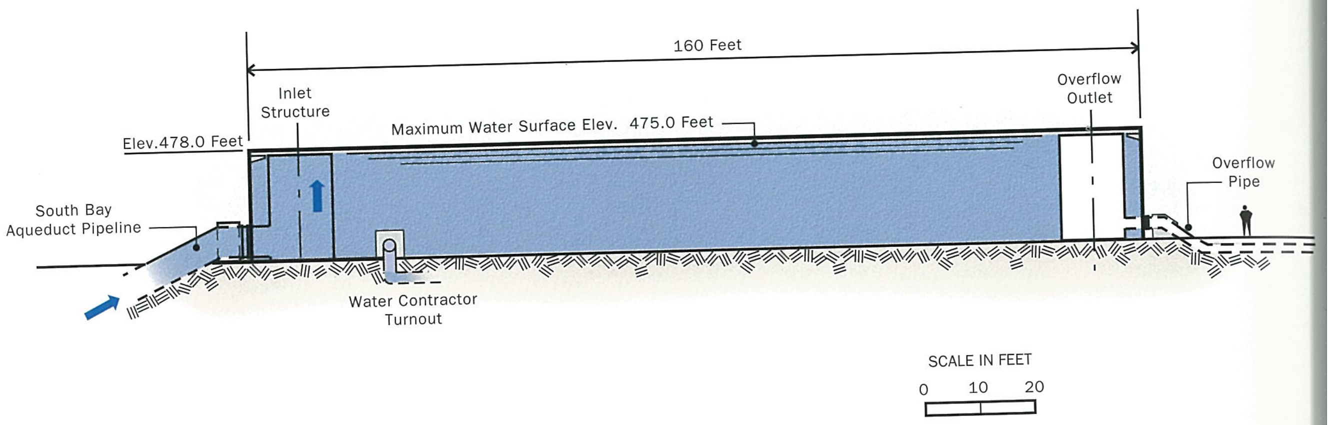
Diameter . . . . 160 feet
Height . . . . 20 feet
Elevation . . . . 478 feet

Reservoir

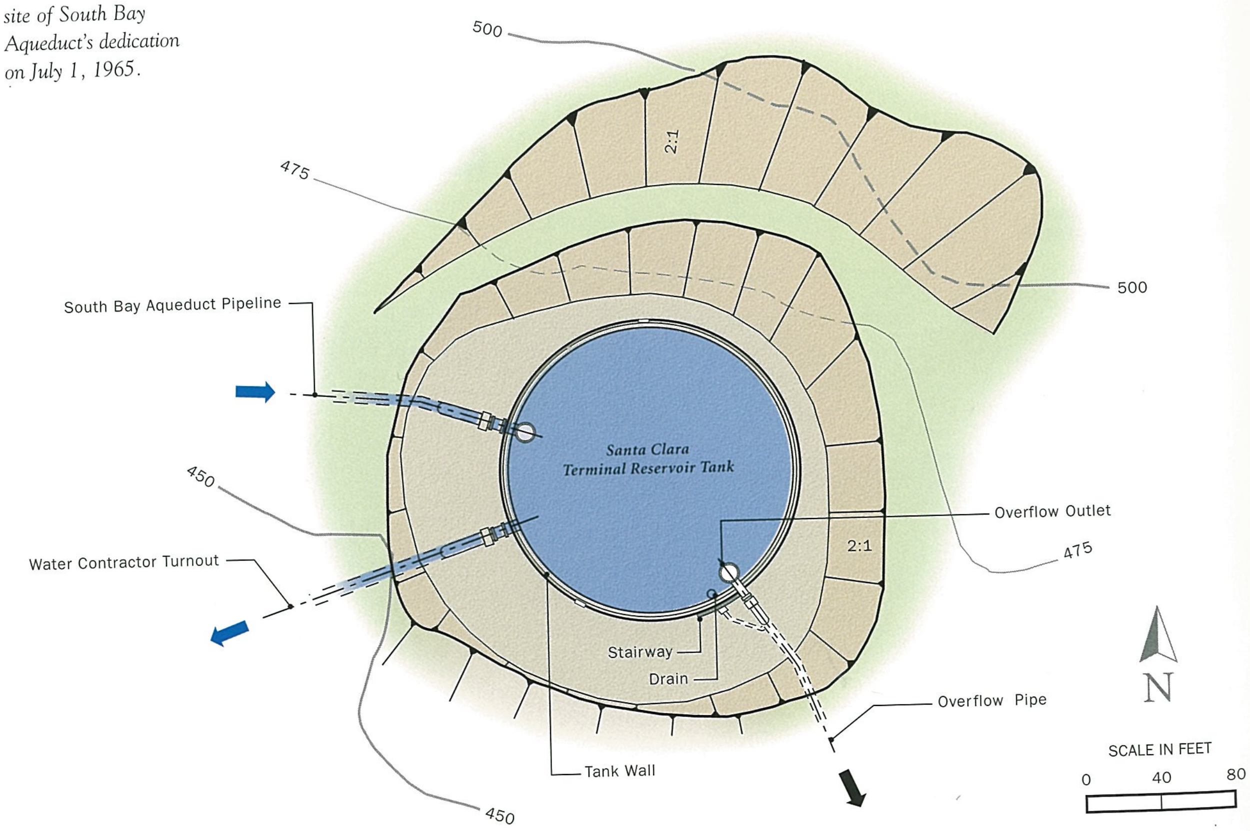
Maximum operating storage. . . . . . . 9 acre-feet
Water surface elevation @ mos . . . . . . 475 feet*
Surface area @ mos. . . . . 0.5 acres

*maximum operating storage

Transverse Section



General Plan



Recreation at Lake Del Valle is operated by the East Bay Regional Park District. During the summer months, boat tours of the lake are offered for a nominal cost.

California Aqueduct

The California Aqueduct in the Delta Field Division originates at Clifton Court Forebay in the Delta and ends at Check Structure 8, about 46 miles from Clifton Court Forebay. Most of the water delivered by the SWP enters this division which crosses Contra Costa, Alameda, San Joaquin, Stanislaus, and Merced counties. From the Delta, the aqueduct extends along or near the western foothills of the San Joaquin Valley for 66.7 miles, which includes Bethany to O'Neill Forebay, part of the San Luis Joint-Use Facilities. It was constructed from 1963 to 1968.

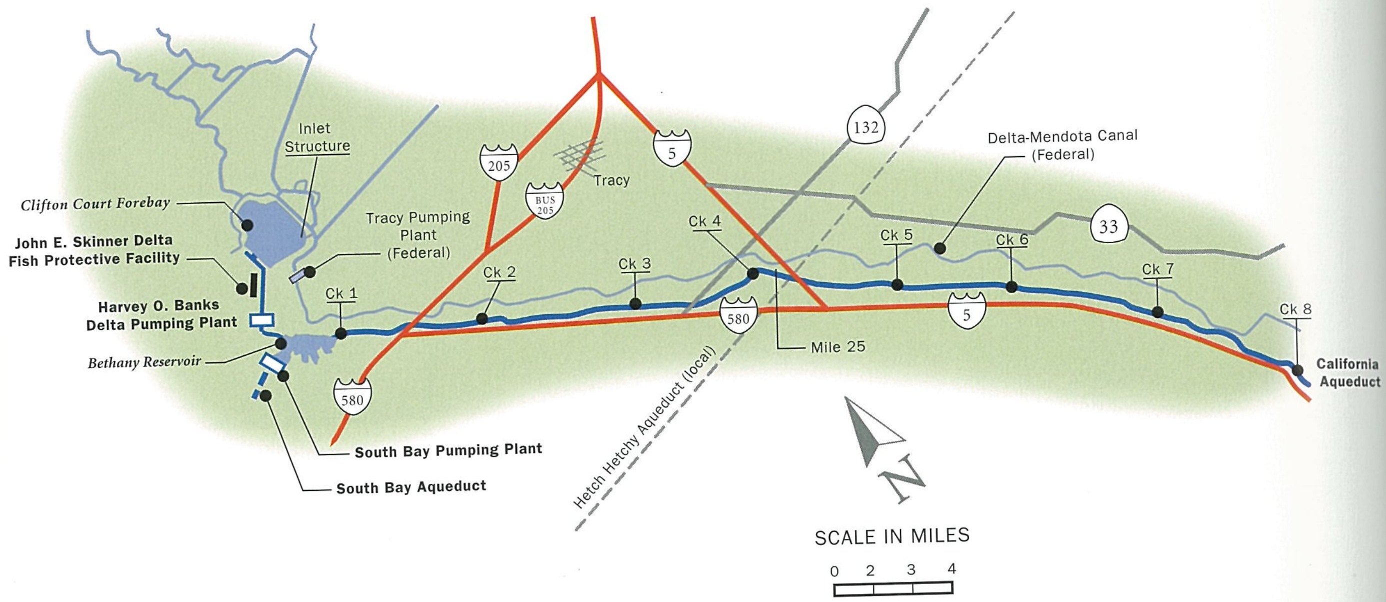
Intake Channel (Banks Pumping Plant)

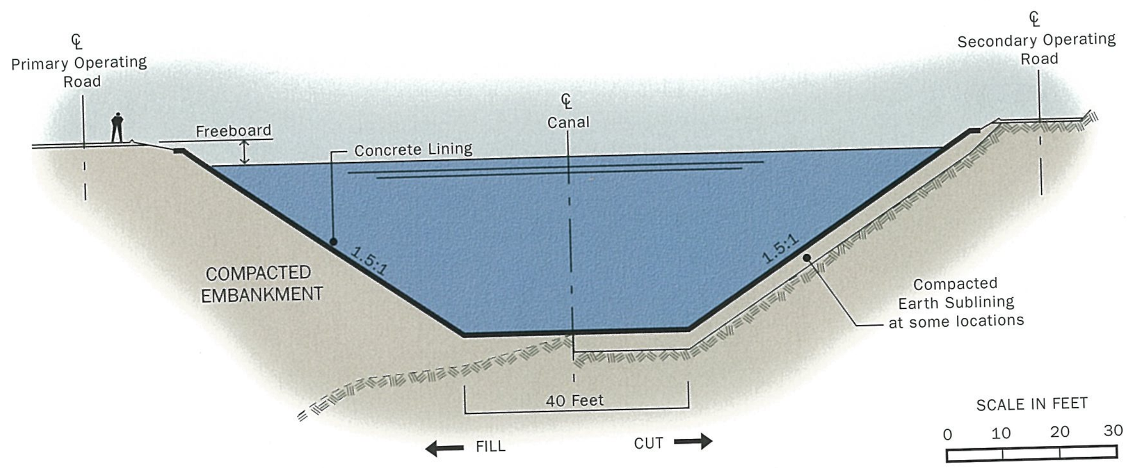
Type: 2.6 miles of unlined, trapezoidal intake channel
Water depth . . . . varies from 38 to 42 feet
Side slope . . . . varies from 3:1 to 1:75
Width . . . . . varies from 80 to 60 feet (bottom)

Canal (Banks Pumping Plant to O'Neill Forebay)

Type: 63.4 miles of concrete-lined, trapezoidal, checked
Capacity: 10,300 cfs from Delta to Bethany
10,000 cfs from Bethany Reservoir to O'Neill Forebay
Water depth . . . . 30 feet
Side slope 1.5:1
Width . . . . 40 feet (bottom)

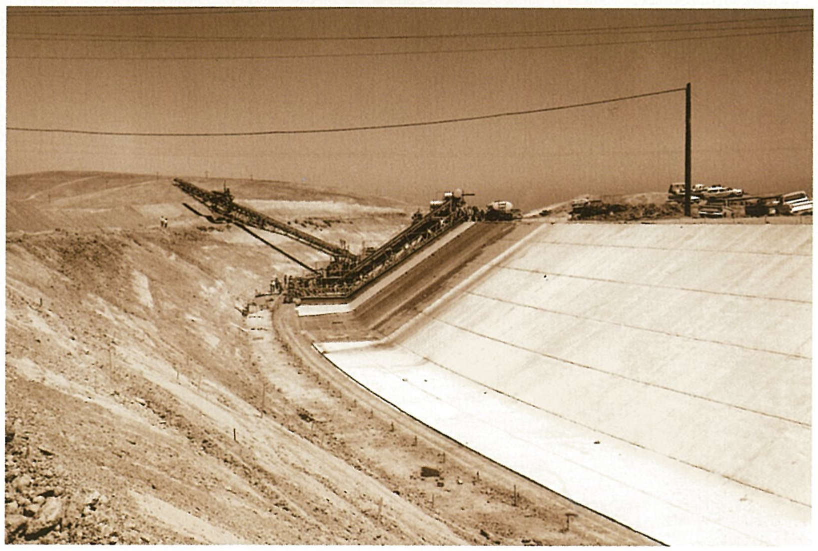
Aqueduct Map





The California Aqueduct is the SWP's largest conveyance system. In the central San Joaquin Valley, the aqueduct's route generally parallels Interstate Highway 5 and the federal Central Valley Project's Delta-Mendota Canal. This area is rural and agricultural with orchards, vineyards, and row crops adjacent to the canal.

Specialized excavators, graders, and pavers were custom-made to ease construction of the miles of lined canal.



To prevent seepage or piping through the foundation, the embankment foundation and canal prism were overexcavated to remove cohesionless material when it occurred adjacent to the canal prism. The material was replaced with an impervious layer under the concrete lining.

Clifton Court Forebay Dam & Forebay

Clifton Court Forebay, located in the southwestern edge of the Sacramento-San Joaquin Delta, about 10 miles northwest of the city of Tracy, is a shallow reservoir at the head of the California Aqueduct. The forebay provides storage and regulation of flows into Banks Pumping Plant. Before completion of the forebay, Italian Slough connected directly to the present-day intake channel. Work started on the forebay in 1967 and was completed in 1969.

Radial gates at the head of Clifton Court Forebay signify the beginning of the California Aqueduct.

Dam

Type: zoned earthfill
Embankment volume . . . 2,440,000 cubic yards
Height . . . . 30 feet
Crest length . . . . 36,500 feet
Crest elevation . . . . 14 feet

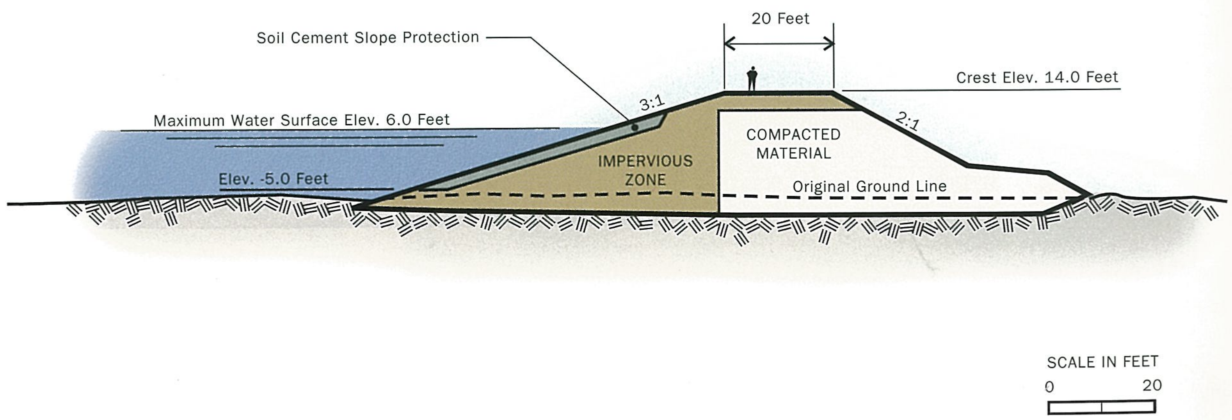
Forebay

Maximum operating storage. . . 31,260 acre-feet
Water surface elevation @ mos . . . . 6 feet*
Water surface area @ mos . . . . 2,180 acres
Shoreline @ mos. . . . . 8 miles

**maximum operating storage*

GENERAL PLAN

TYPICAL SECTION



On this infra-red aerial shot of the Sacramento-San Joaquin Delta, Clifton Court Forebay is visible as well as the California Aqueduct and Bethany Reservoir. (lower right)

JOHN E. SKINNER DELTA FISH PROTECTIVE FACILITY

Located two miles upstream of the Banks Pumping Plant, the Skinner Fish Facility contains a giant fish screen to keep most fish away from the pumps that lift water into the California Aqueduct. Large fish and floating debris are directed away by a 388-foot-long trash boom. Smaller fish are diverted from the intake channel (leading to the pumping plant) into bypasses by a series of metal louvers, while the main flow of water continues through the louvers and towards the pumps. These fish pass through a secondary system of screens and pipes into seven holding tanks, where they are later counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks.

The Skinner Fish Facility, which salvages an average of 15 million fish a year, was constructed from 1966 to 1970. A second building with three holding tanks was built during 1991 to 1992. Operations of the initial facility began in 1968.

PRIMARY CHANNEL

Dimensions . . . . 383 feet long, 158 feet wide, 29 feet deep

Capacity . . . . 10,300 cfs

Velocity . . . . 1.5 to 3.5 fps

LOUVER ASSEMBLIES

Type: aluminum alloy, closely spaced, parallel, vertical slats arranged in a sawtooth pattern to screen the primary channel

Height . . . . 26 feet

FISH HOLDING TANKS

Type: cylindrical, reinforced concrete

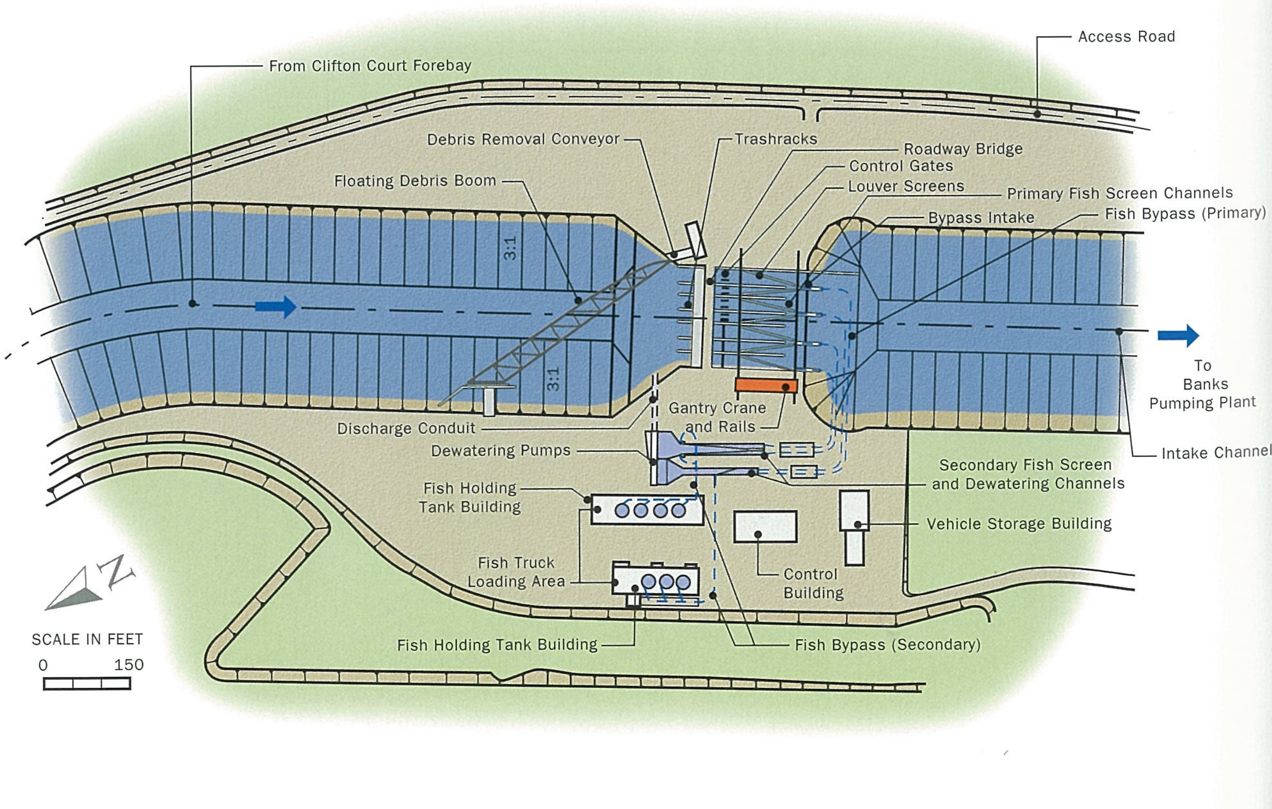
Number. . . 4 in first building, 3 in second building

Diameter . . . . 20 feet

Depth. . . . . 19.5 feet

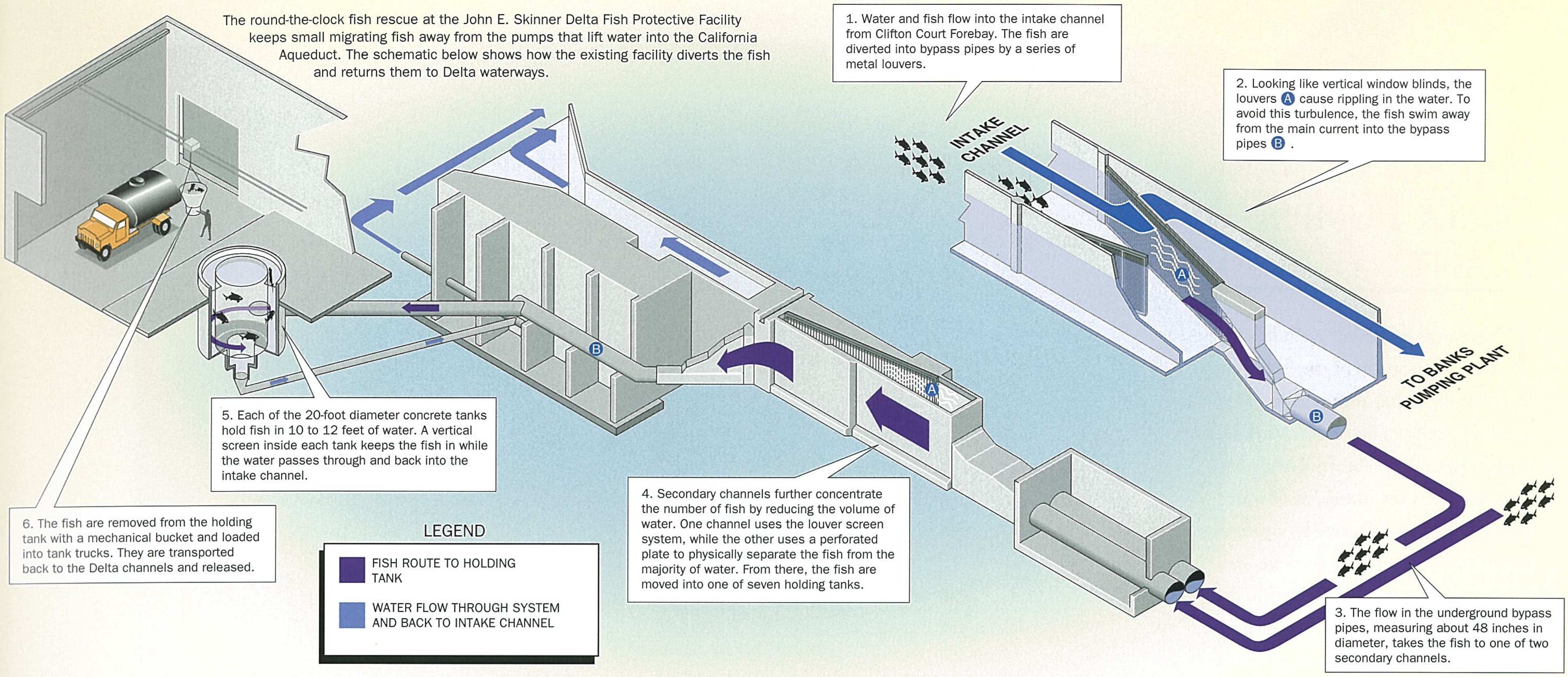
Skinner Fish Facility is operated and maintained by DWR, but the California Department of Fish and Game conducts fish collection and fish transport activities 24 hours a day.

GENERAL PLAN

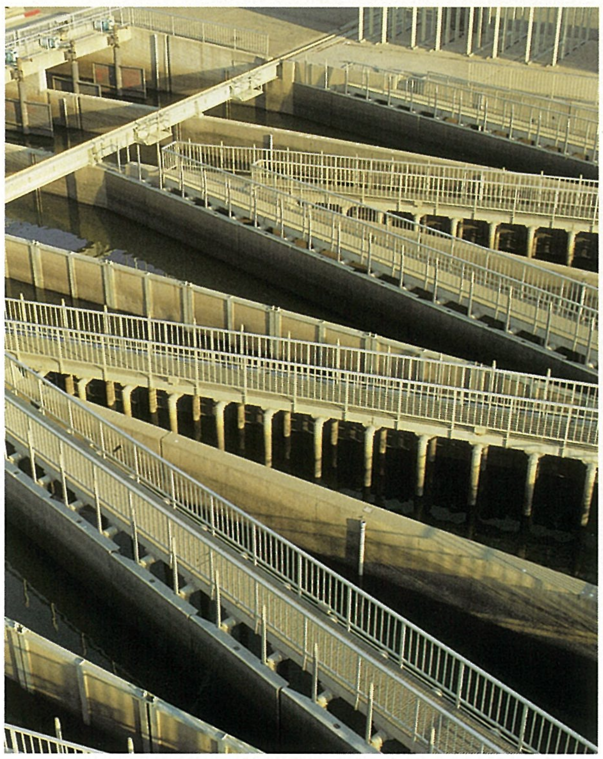


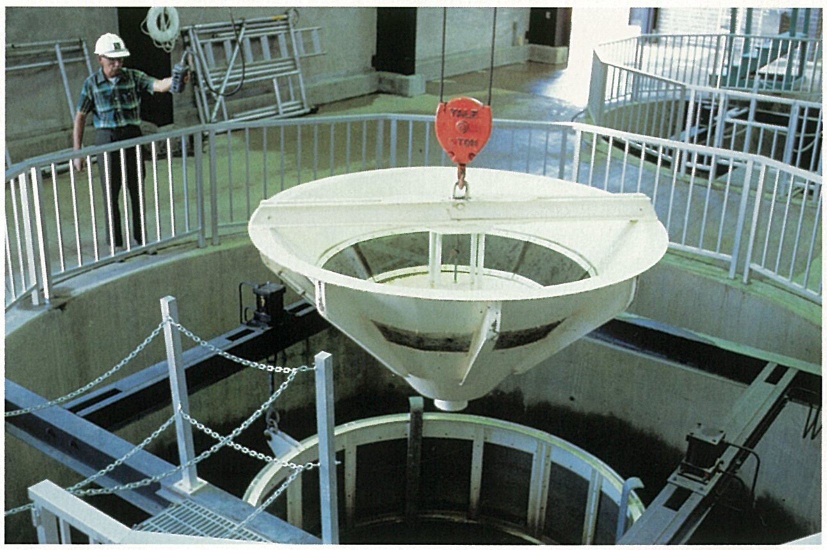
STEP-BY-STEP

The round-the-clock fish rescue at the John E. Skinner Delta Fish Protective Facility keeps small migrating fish away from the pumps that lift water into the California Aqueduct. The schematic below shows how the existing facility diverts the fish and returns them to Delta waterways.



Metal louvers create a rippling in the water. To avoid this turbulence fish are diverted from the main current into bypass slots where water draws them into underground pipes leading to one of seven 20-foot diameter concrete holding tanks.



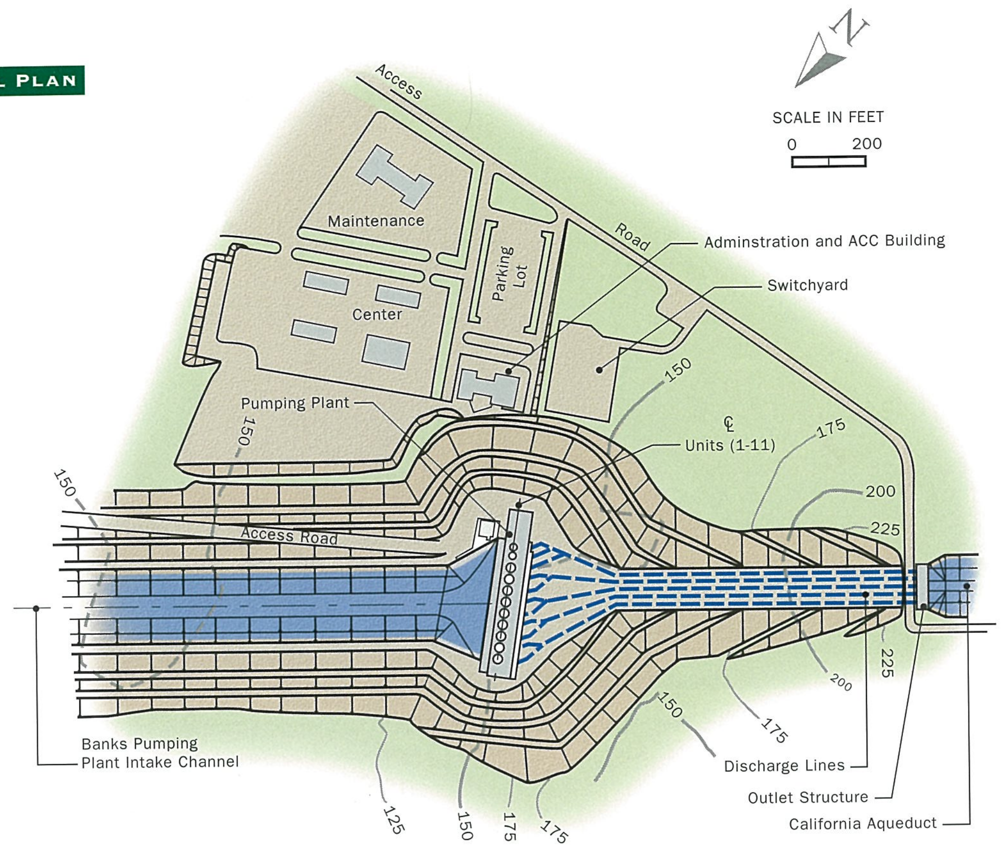


A conical bucket is lowered into the holding tank to retrieve the salvaged fish. After they are counted and recorded, the fish are then moved to an oxygenated truck for transport back to the Delta.

HARVEY O. BANKS DELTA PUMPING PLANT

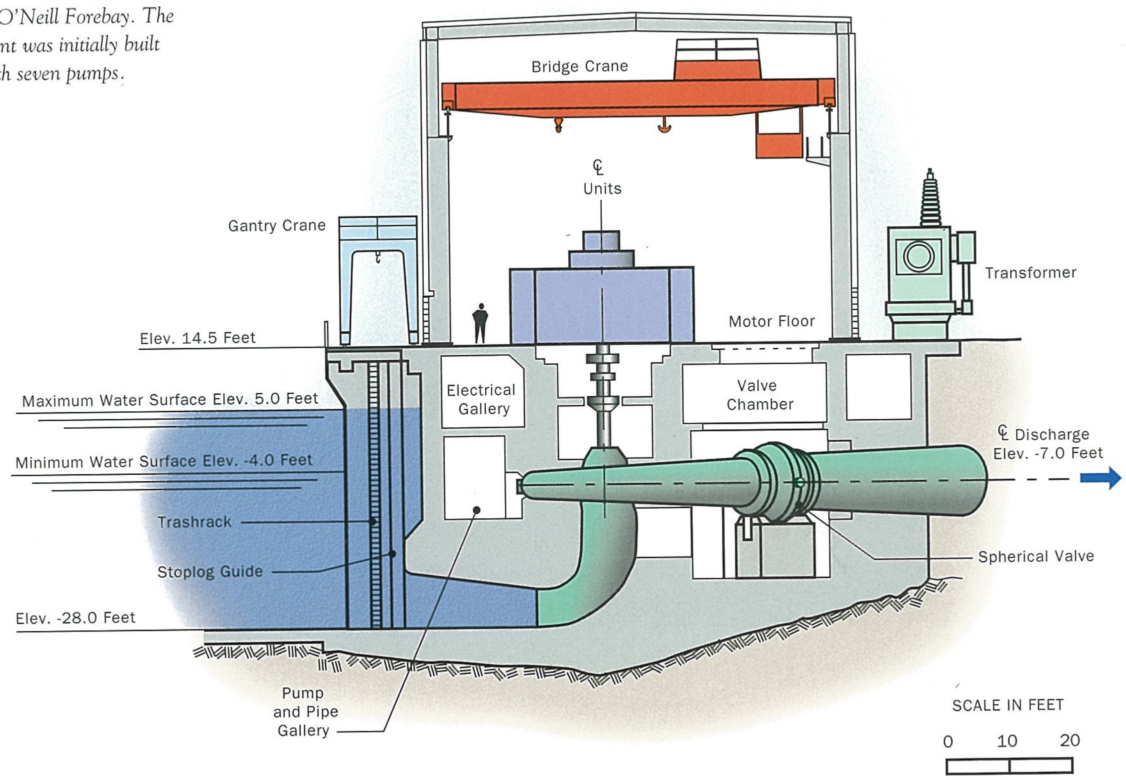
The Banks Pumping Plant lies in the southern portion of the Sacramento-San Joaquin Delta, almost 20 miles southwest of the city of Stockton. Marking the beginning of the California Aqueduct, the plant provides the initial lift of water 244 feet into the canal. During its construction (1963-1969), seven pumps were installed. In 1986, four more were added to divert and pump more water during the wet months to fill offstream storage reservoirs and groundwater basins south of the Delta to improve water supply reliability.

GENERAL PLAN



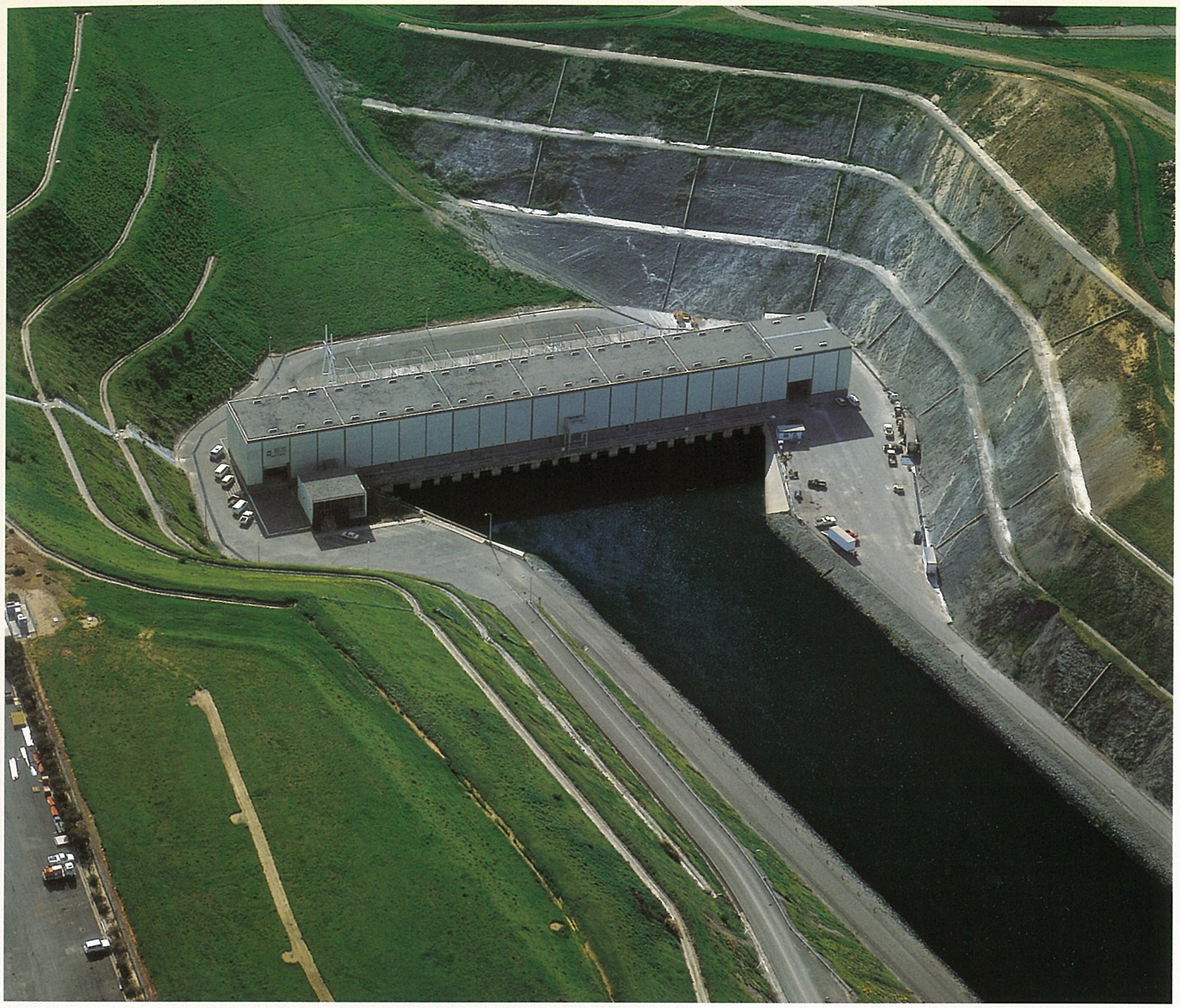
Water lifted by Banks Pumping Plant into the California Aqueduct travels south by gravity to O'Neill Forebay. The plant was initially built with seven pumps.

TRANSVERSE SECTION



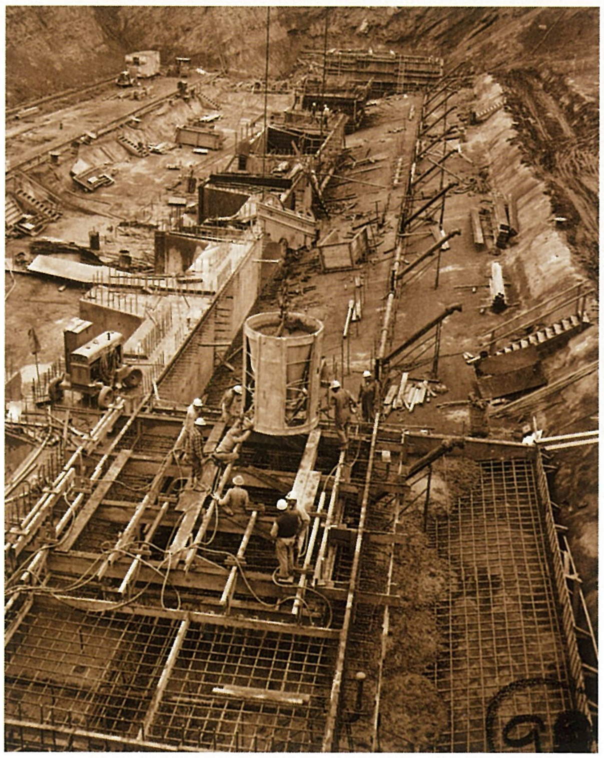
PUMPING

Installed capacity	*10,670 cfs, 333,000 hp*
Normal static head	*236-252 feet*
Design dynamic head	*249*
No. of units	*11*
Unit size	*2 @ 375 cfs, 11,250 hp* *5 @ 1,130 cfs, 34,500 hp* *4 @ 1,067 cfs, 34,500 hp*
Discharge lines/diameter	*1 @ 13.5 feet* *4 @ 15.0 feet*



Banks Pumping Plant was the first major plant to be designed and set the architectural motif that guided the remainder of the SWP construction.

Construction of the pumping plant required considerable coordination of activities and attention to embedded pipes and close tolerances necessary for the huge pumps and valves.



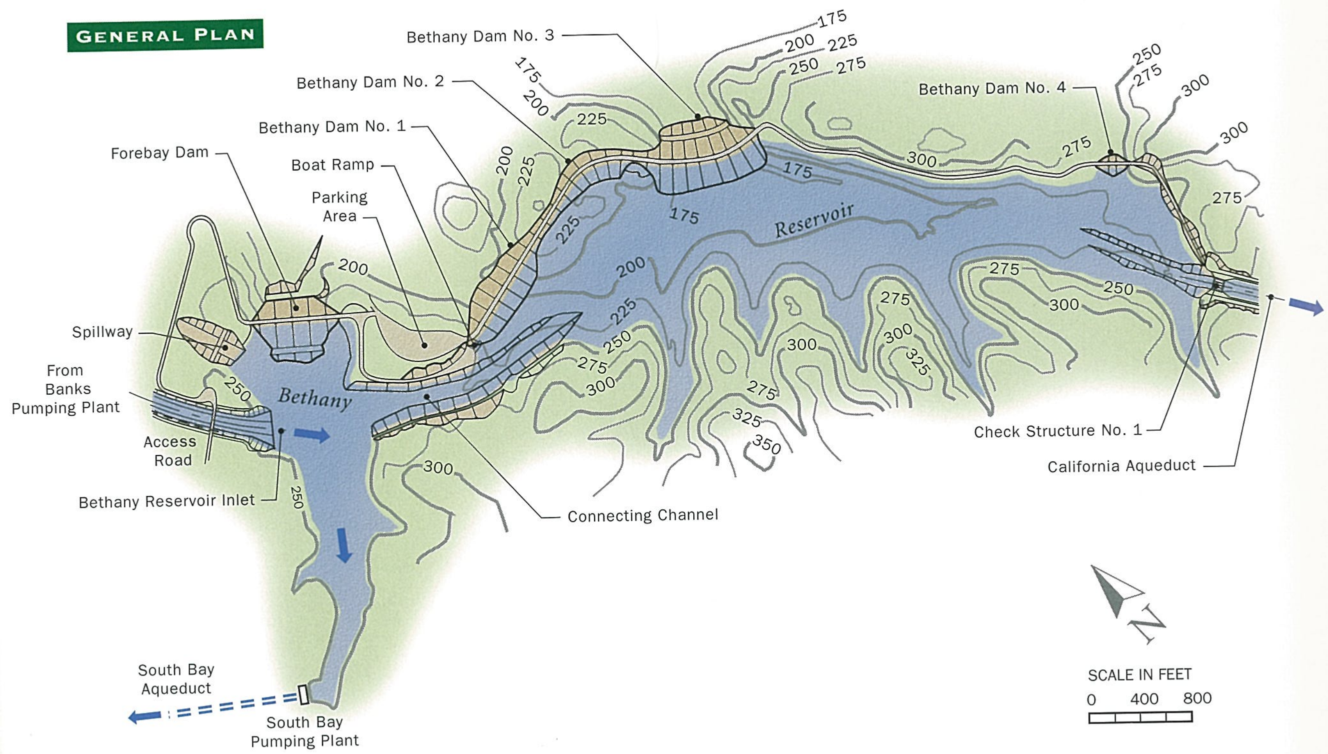
Plant location was determined by balancing the cost of excavation for the intake channel and pumping plant bowl with the cost of discharge lines.

Bethany Dams and Reservoir

The South Bay Aqueduct begins at Bethany Reservoir, located on the California Aqueduct, 1.5 miles downstream from Banks Pumping Plant. The reservoir, impounded by five earth dams, serves as the forebay for South Bay Pumping Plant and the afterbay of Banks Pumping Plant. In this reach of the California Aqueduct, Bethany serves as a conveyance facility and provides recreational opportunities.

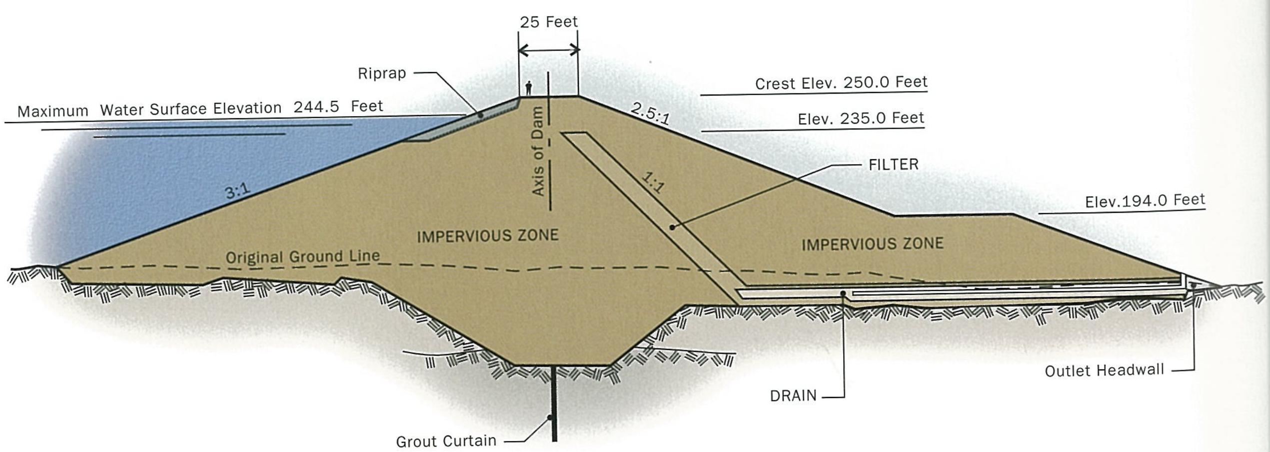
Construction of the forebay dam began in 1959 and was completed in 1961, with the adjacent dams and connecting channel constructed between 1965 and 1967.

General Plan



Initially known as Bethany Forebay, the reservoir was created by a single dam to supply South Bay Pumping Plant. Four dams were added a few years later to expand the reservoir, which provided the most economical conveyance facility for this portion of the California Aqueduct.

Maximum Section



Dams

Type: homogeneous earthfill
Embankment volume . . . . 1,400,000 cubic yards
Height . . . . 121 feet (maximum)
Crest length . . . . 3,940 feet (five dams)
Crest elevation . . . . 250 feet

Reservoir

Maximum operating storage. . . . 5,070 acre-feet
Water surface elevation @ mos. . . . . 244.5 feet*
Water surface area @ mos. . . . . 180 acres
Shoreline @ mos. 6 miles

**maximum operating storage*

Bethany Reservoir also provides recreation including boating, fishing, and picnicking.


California Aqueduct
& San Luis Canal
San Luis Field Division
Start San Luis Field Division
Ck 8
Mile 50
Ck 9
Ck 10
California Aqueduct
Ck 11
O'Neill Pump-Generation Plant (federal)
Ck 12
Romero Visitors Center
Santa Nella
Outlet Structure
Mile 75
Los Banos
B.F. Sisk San Luis Dam and San Luis Reservoir
O'Neill Forebay
San Felipe Division (Santa Clara Tunnel-federal)
Los Banos Detention Dam and Reservoir
Delta-Mendota Canal (federal)
William R. Gianelli Pumping-Generating Plant
Dos Amigos Pumping Plant
San Luis O&M Center
Ck 14
Little Panoche Inlet
Little Panoche Detention Dam and Reservoir
Mile 100
Mendota Pool
Ck 15
California Aqueduct San Luis Canal
Fresno Slough
Ck 16
Mile 125
Ck 17
Cantua Creek Inlet
Salt Creek Inlet
Coalinga O&M Subcenter
Mile 150
Ck 18
Ck 19
Arroyo Pasajero Ponding Basin
Gale Avenue Inlets
End San Luis Field Division
Ck 20
Ck 21
Kettleman City
Merced
Chowchilla
Madera
Fresno
Coalinga
N
SCALE IN MILES
0
4
8
5
33
140
99
152
180
145
269
198
41

San Luis Field Division

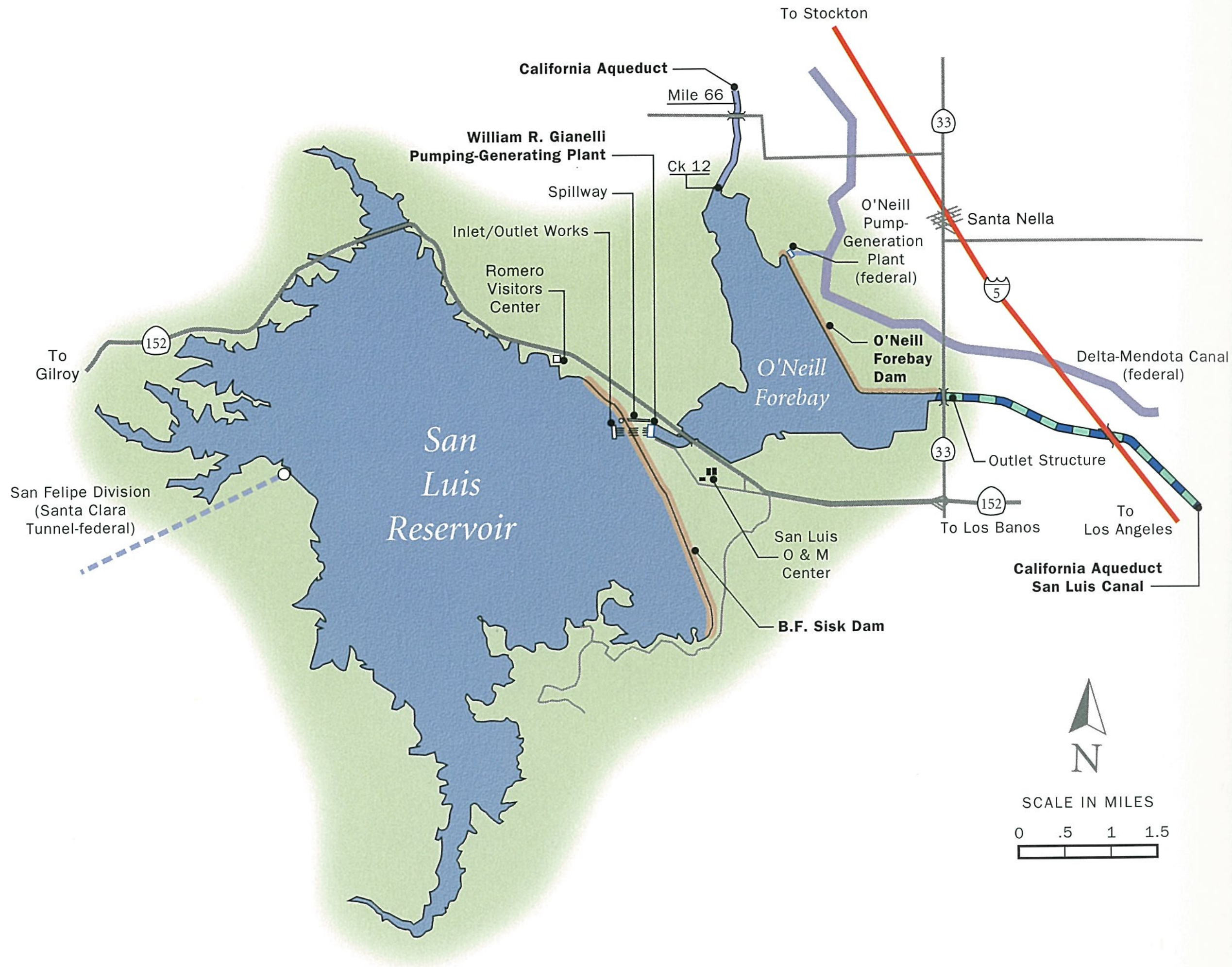
The northern boundary of the San Luis Field Division is at Check 8 on the California Aqueduct, about 20 miles upstream of the O'Neill Forebay in Merced County. The forebay marks the start of the San Luis Joint-Use Facilities. The state and federal complex includes O'Neill Forebay, San Luis Reservoir, Sisk Dam, Gianelli Pumping-Generating Plant, the Romero Overlook Visitors Center, the San Luis Canal, Dos Amigos Pumping Plant, and two smaller detention dams and reservoirs. The field division's jurisdiction ends at the terminus of the joint-use facilities near Kettleman City in Kings County.

San Luis Complex

The San Luis Complex includes all of the joint-use facilities designed and constructed by the federal Bureau of Reclamation and operated and maintained by the Department of Water Resources. Costs and facilities are shared (55 percent state and 45 percent federal). Operation of state and federal projects is coordinated to manage available water efficiently and to safeguard the health of the Delta.

The federal O'Neill Pump-Generation Plant has six reversible units, each with its own 10-foot-diameter discharge line to the forebay. Each line carries water at a 700-cubic-foot-per-second rate.

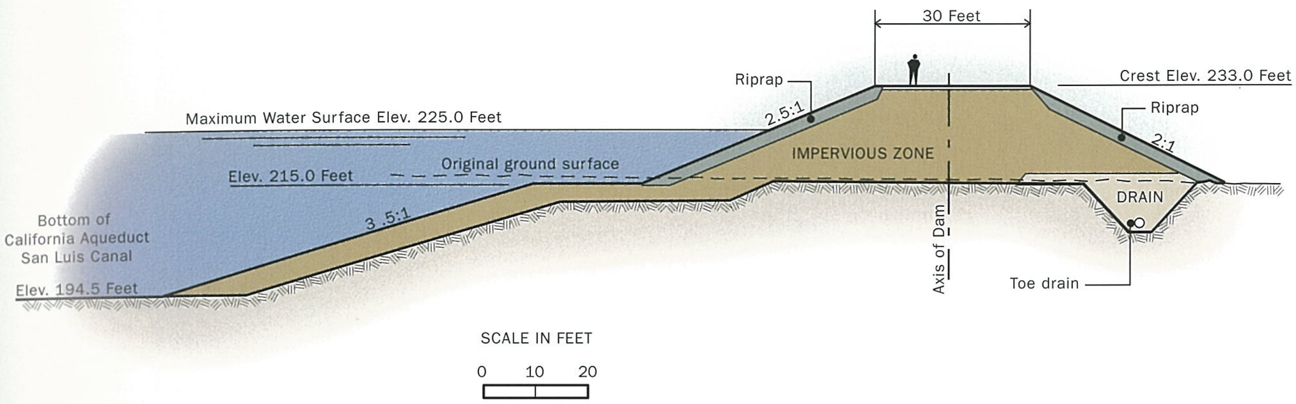
General Plan



O'NEILL DAM & FOREBAY

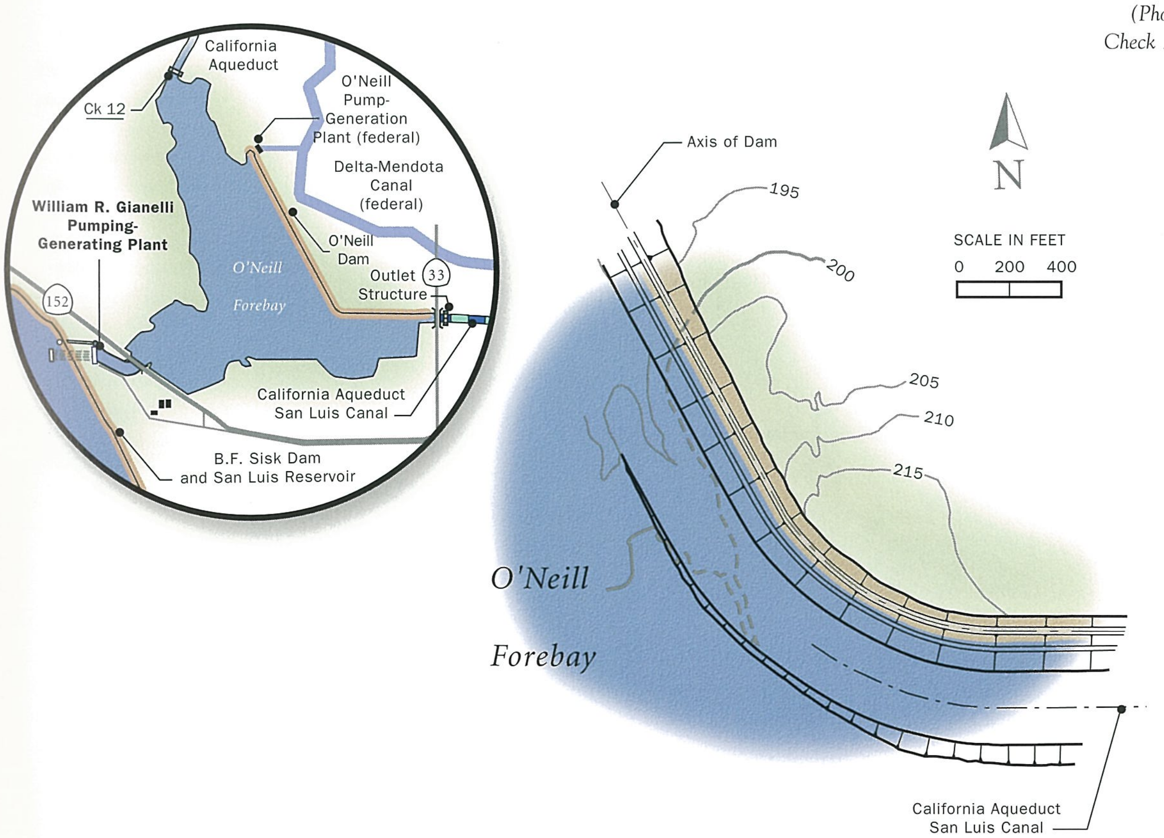
Along the western side of the San Joaquin Valley in Merced County, the California Aqueduct enters O'Neill Forebay from the north. Water from the Delta-Mendota Canal, part of the federal Central Valley Project, is pumped into the forebay by the O'Neill Pump-Generation Plant. Constructed between 1963 and 1967, O'Neill Forebay offers a variety of recreational activities including camping, boating, windsurfing, and fishing.

MAXIMUM SECTION



O'Neill Forebay has several inlets and outlets that serve both state and federal water projects. (Photo shows Check 12 inlet.)

GENERAL PLAN



DAM

Type: homogeneous earthfill
Embankment volume . . . 3,000,000 cubic yards
Height. . . . . 88 feet
Crest length . . . . 14,350 feet
Crest elevation . . . . 233 feet

FOREBAY

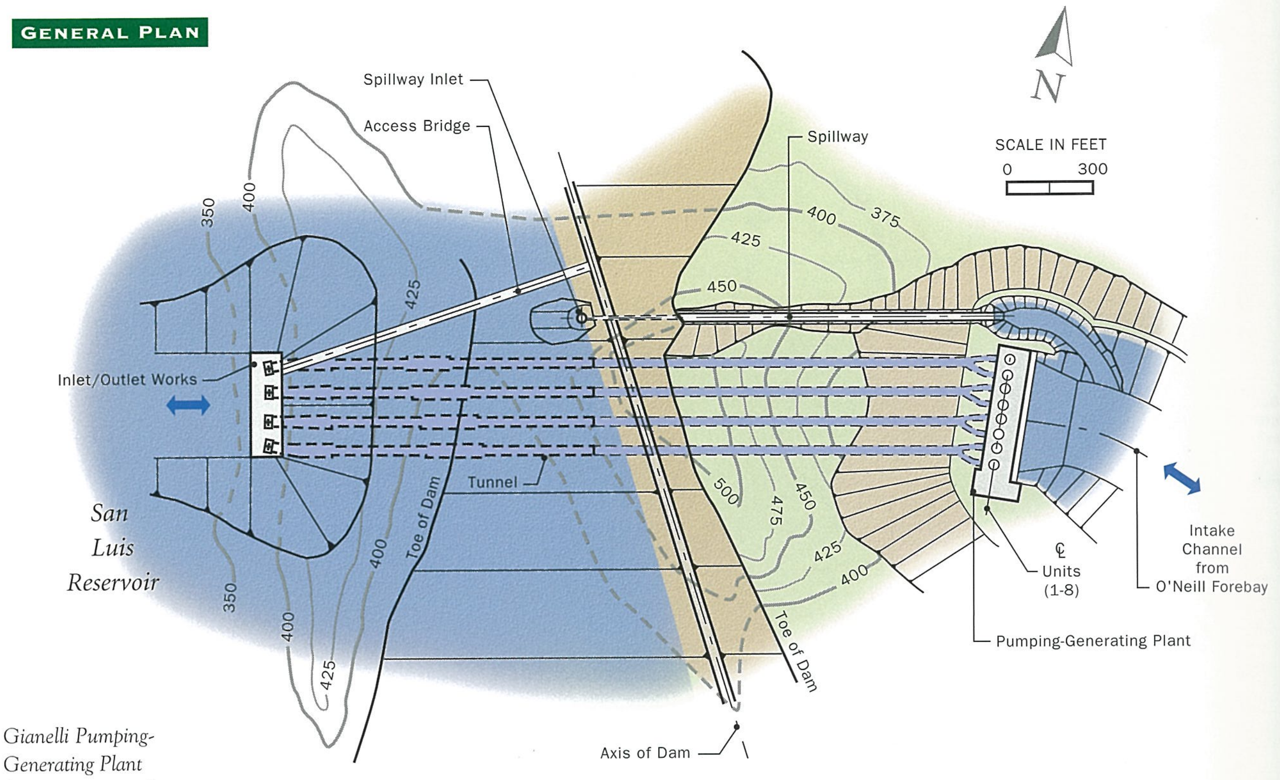
Maximum operating storage. . . 56,430 acre-feet
Water surface elevation @ mos . . . . . . 225 feet*
Water surface area @ mos. . . . . 2,700 acres
Shoreline @ mos. . . . . 12 miles

**maximum operating storage*

WILLIAM R. GIANELLI PUMPING-GENERATING PLANT

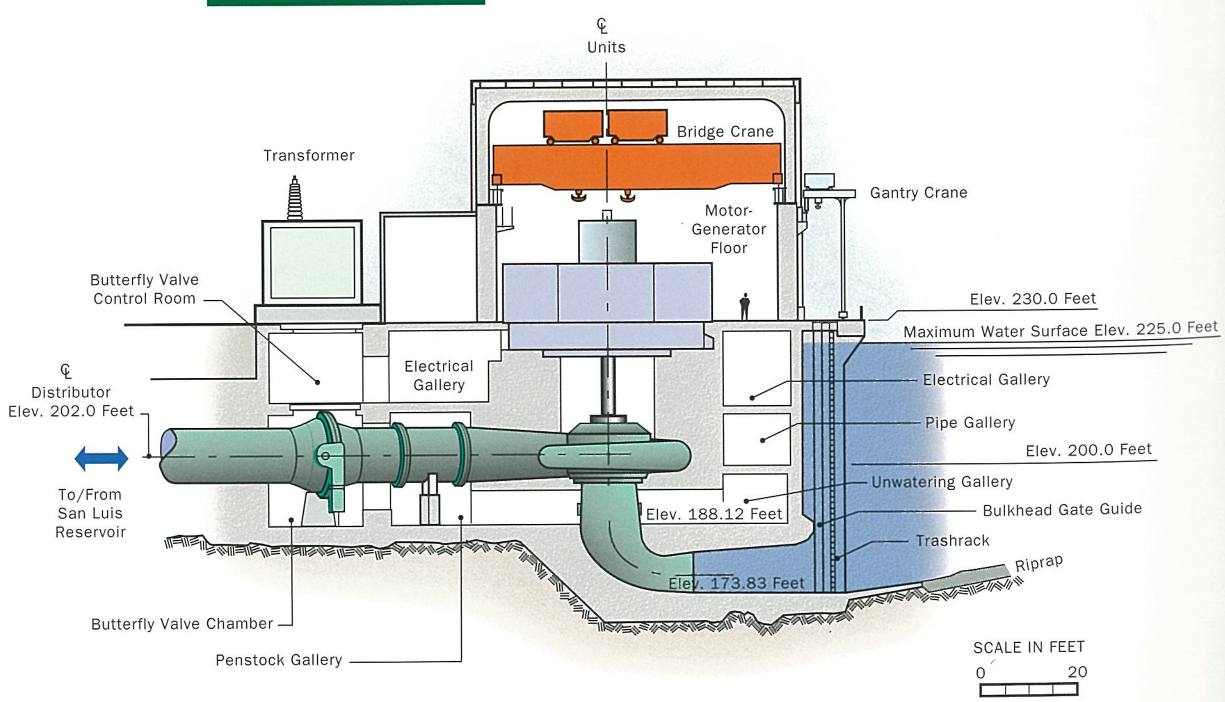
Located about 12 miles west of the city of Los Banos adjacent to State Highway 152, the Gianelli Pumping-Generating Plant pumps water from O'Neill Forebay into San Luis Reservoir. Water is released through the plant in generating mode when service area demands are in excess of direct Delta diversions. Construction of the plant began in 1963 and was completed in 1967.

GENERAL PLAN



Gianelli Pumping-Generating Plant functions as an inlet and outlet for San Luis Reservoir. Four tunnels near the left abutment connect the plant to an inlet-outlet structure. Each tunnel services two pump-turbines.

TRANSVERSE SECTION



PUMPING

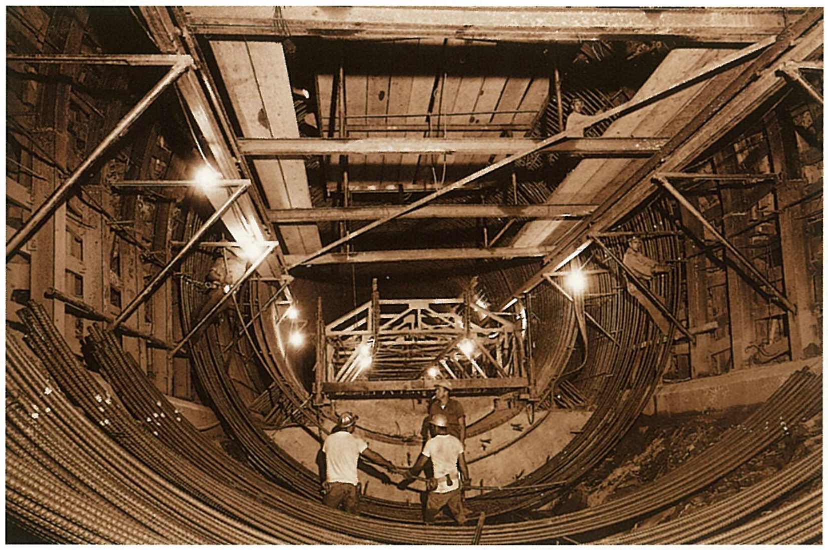
Installed capacity	*11,000 cfs, 272,000/504,000 hp*
Normal static head	*99-327 feet*
Design dynamic head	*290 feet*
Number of units	*8 p/g (two-speed units)*
Unit size	*1,375 cfs, 34,000/63,000 hp*

GENERATING

Installed capacity	*272/504 MVA, 16,960 cfs*
Normal static head	*99-327 feet*
Design dynamic head	*197 feet*
Number of units	*8 p/g (two-speed units)*
Unit size	*34/53 MVA, 2,120 cfs*
Penstock/diameter	*4 @ 17.5 feet*

The Gianelli Pumping-Generating Plant was built on the left abutment of the Sisk Dam. Highway 152 passes in front of the dam.

The pumping-generating plant was built to house eight Francis pump-turbines with single-impeller runners. When water flows are reversed, the plant generates electricity. Because of the extreme head variations, from 99 to 327 feet, the pump-turbines operate at two speeds, 120 and 150 rpm.



The northern inlet-outlet tunnel under construction. There are four 17.5-foot-diameter inlet-outlet tunnels, each serving two plant units. The tunnels are steel-lined for part of their 2,150-foot lengths. About 1,000 feet of each tunnel's upstream end is lined with concrete.

B.F. Sisk San Luis Dam & San Luis Reservoir

San Luis Reservoir, impounded by Sisk Dam, lies at base of foothills on the west side of the San Joaquin Valley in Merced County, about 2 miles west of O'Neill Forebay. A second key conservation facility of the SWP, the reservoir provides offstream storage for excess winter and spring flows diverted from the Sacramento-San Joaquin Delta. It is sized to provide seasonal carryover storage. San Luis Reservoir can hold 2,027,840 acre-feet, of which 1,062,180 acre-feet is the state's share and 965,660 acre-feet is the federal's share. Construction began in 1963 and was completed in 1967. Filled in 1969, the reservoir also provides a variety of recreational activities, as well as fish and wildlife benefits.

Dam

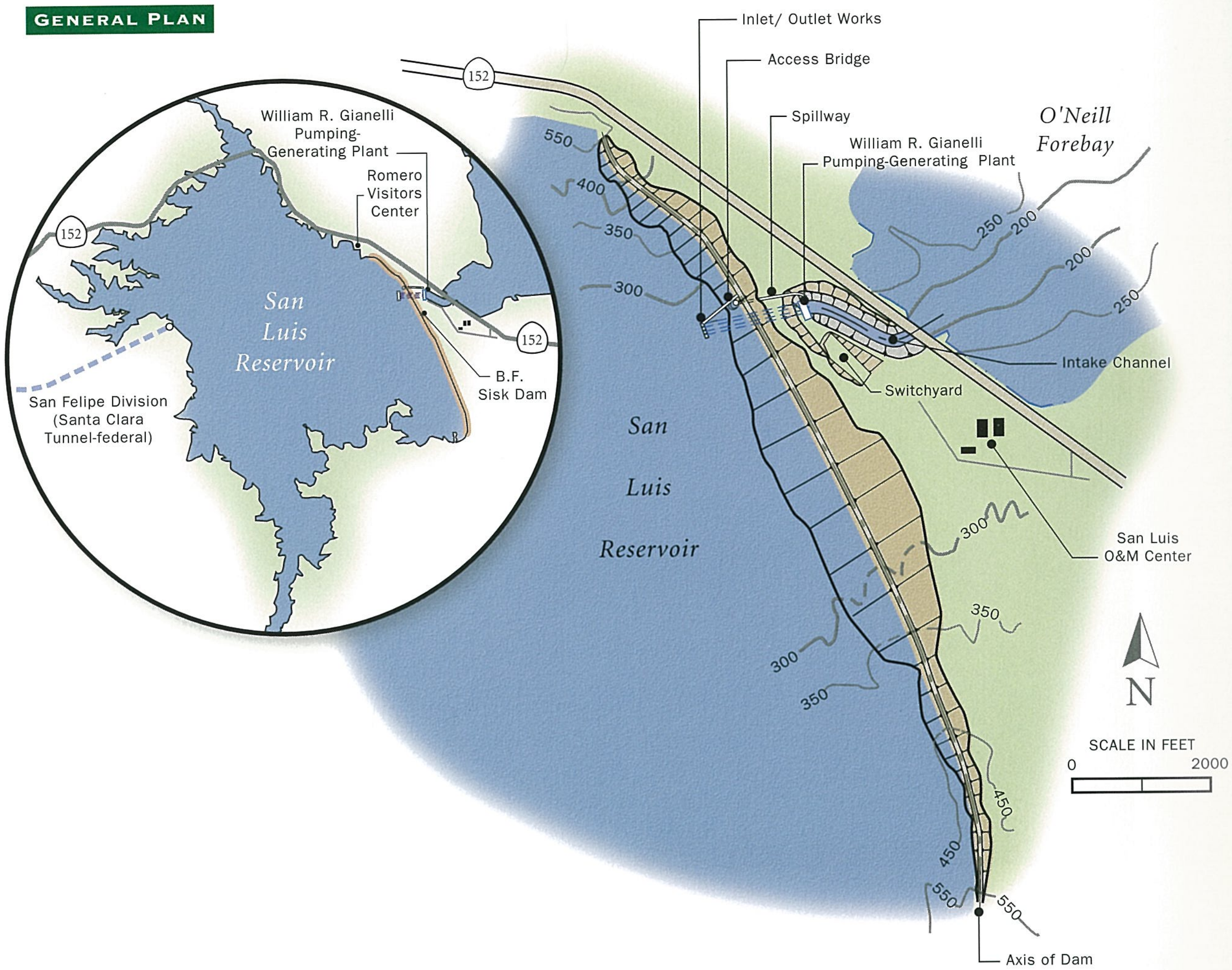
Type: zoned earth and rockfill
Embankment volume . . . 77,645,000 cubic yards
Height . . . . 385 feet
Crest length . . . . 18,600 feet
Crest elevation . . . . 554 feet

Reservoir

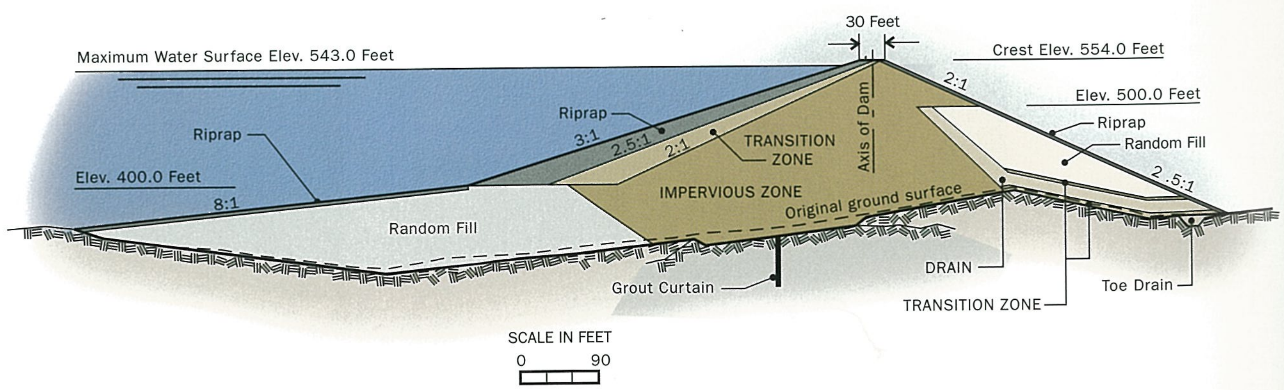
Maximum operating storage . . 2,027,840 acre-feet
Water surface elevation @ mos . . . . . . 543 feet*
Water surface area @ mos . . . . 12,520 acres
Shoreline @ mos . . . . 65 miles

**maximum operating storage*

General Plan

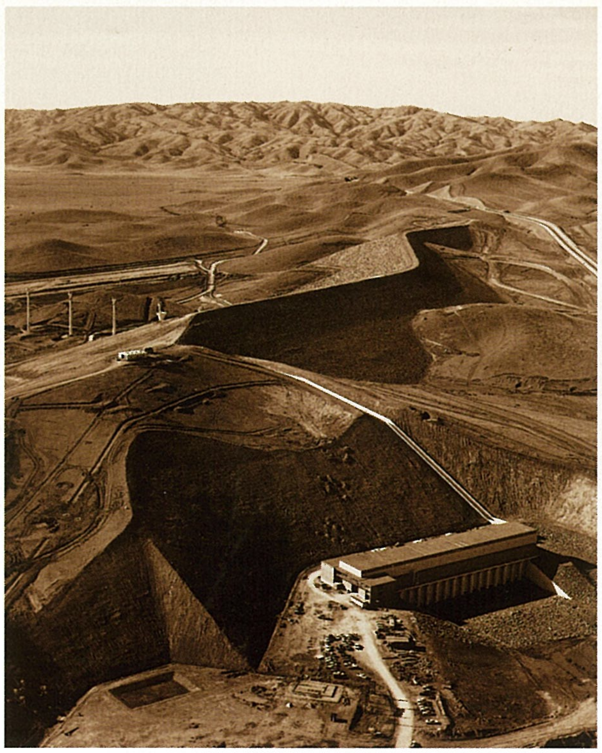


Maximum Section



San Luis Reservoir is sized to provide seasonal carryover storage. Hydroelectric power generation, on a nondependable schedule, is a project benefit. Water was first pumped into the reservoir on April 12, 1967. The reservoir was filled for the first time on May 31, 1969.

Excavation for the dam was in excess of 100 feet in depth into alluvial deposits terminating on a competent, firm, clayey, gravel formation extending to Panoche bedrock.



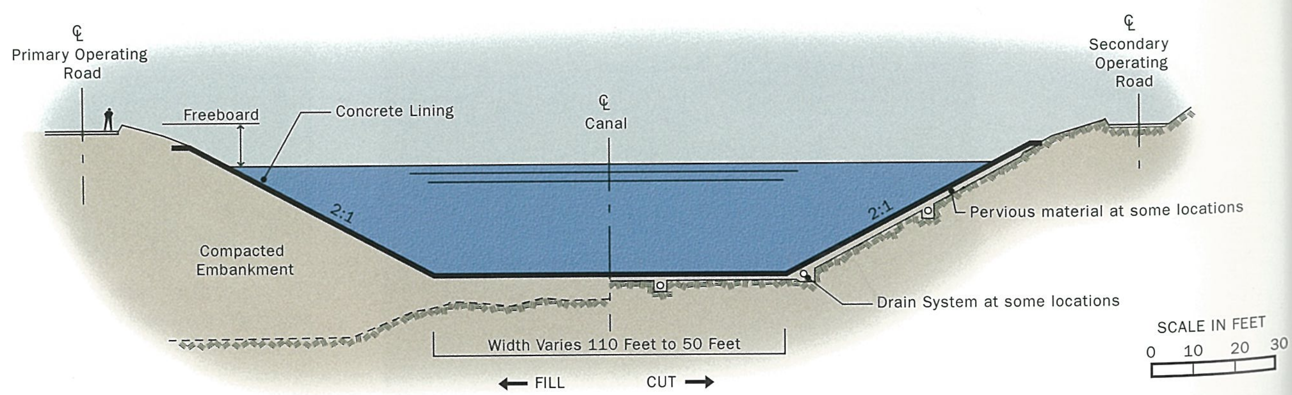
This wheel-type excavator was especially designed for the San Luis project. It dug earth and loaded it into the trucks simultaneously. Ten buckets on the wheel, with a combined capacity of 25 cubic yards, did the digging.

CALIFORNIA AQUEDUCT SAN LUIS CANAL

San Luis Canal, a segment of the California Aqueduct, begins on the southeast edge of O'Neill Forebay and extends about 101.5 miles southeasterly to a point near Kettleman City. It substantially parallels Interstate Highway 5 located on the western side of the San Joaquin Valley at the eastern flank of the Coast Ranges. Water from the canal serves the San Luis federal service area, mostly for agricultural purposes and for some municipal and industrial uses. SWP water is conveyed through the San Luis Canal to Check 21, where the joint-use facilities end and the California Aqueduct continues. The canal was constructed from 1963 to 1968.

AQUEDUCT MAP

The San Luis Canal traverses the western side of the San Joaquin Valley.



CANAL

Type: 101.5 miles of concrete-lined, trapezoidal, checked

Capacity . . . . varies in steps from 13,100 cfs at inlet to 8,100 cfs at Check 21

Water depth . . . . . varies from 32.8 to 23.9 feet

Side slope 2:1

Width . . . . . varies from 110 to 50 feet (bottom)

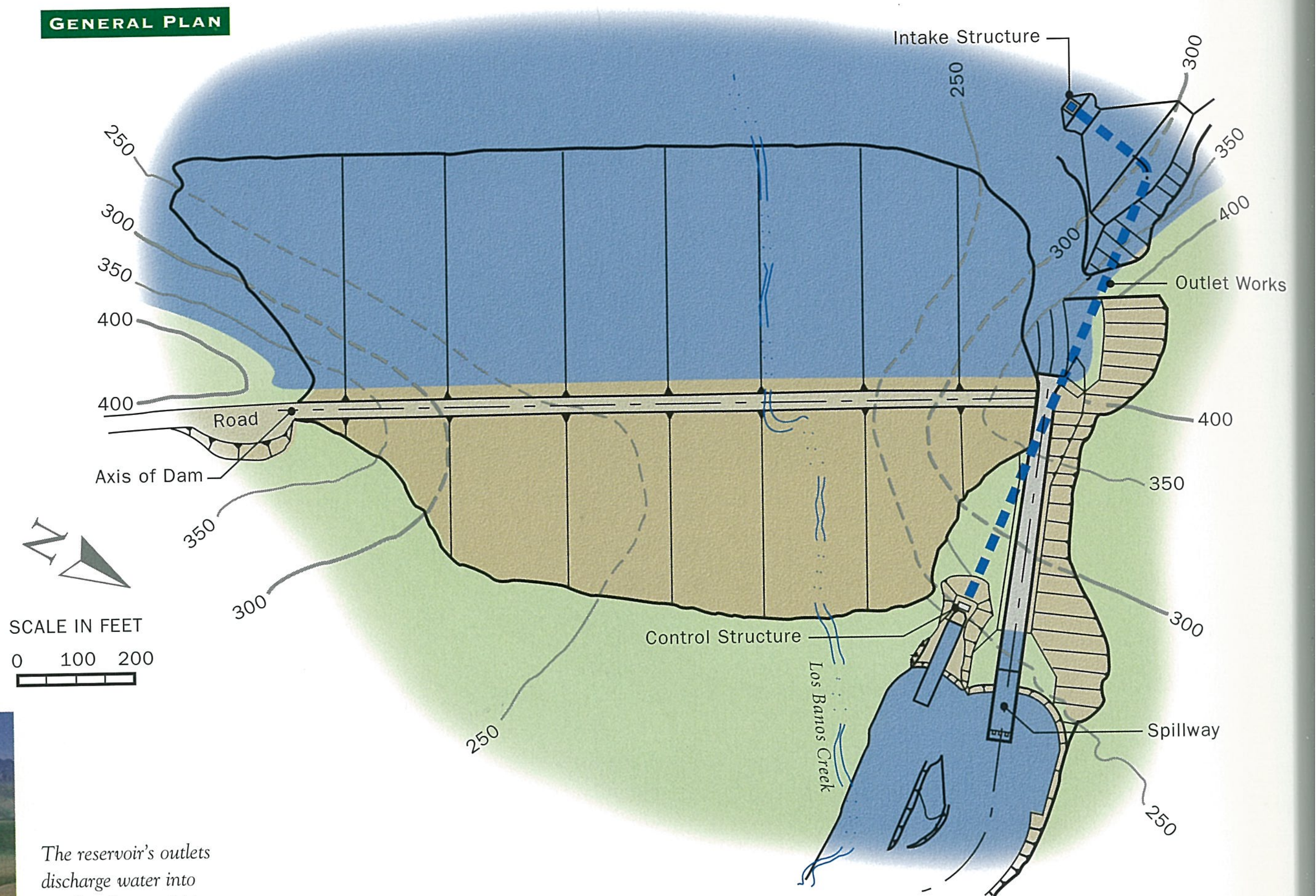
A specialized combination of machines was the giant paving train, which trimmed the earth and lined the canal with a 4.5-inch-thick unreinforced concrete layer.

This photo shows a segment of the San Luis Canal running parallel to Interstate Highway 5 under construction.

The canal's top width is about 240 feet wide with a water depth of up to 33 feet in its largest section. The canal's dimensions and capacity step down as it travels southward.

Los Banos Detention Dam & Reservoir

Los Banos Detention Dam and Reservoir provide flood protection for San Luis Canal, Delta-Mendota Canal, the city of Los Banos, and other downstream developments. Between September and March, 14,000 acre-feet of space is maintained for flood control under specified conditions. The facility is located on the west side of the San Joaquin Valley in Merced County, about seven miles southwest of the city of Los Banos. Construction began in 1964 and was completed in 1965.



The reservoir's outlets discharge water into a stilling basin which in turn empties into the existing channel of Los Banos Creek downstream of the facility.

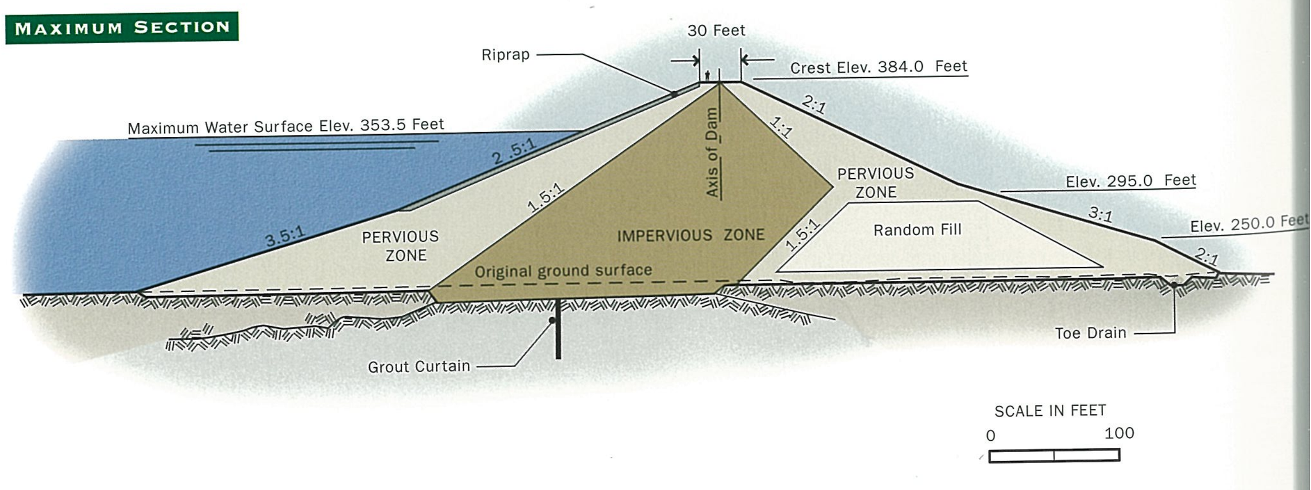
Dam

Type: zoned earthfill
Embankment volume . . . 2,100,000 cubic yards
Height . . . . 167 feet
Crest length . . . . 1,370 feet
Crest elevation . . . . 384 feet

Reservoir

Maximum operating storage . . . . 34,560 acre-feet
Water surface elevation @ mos . . . . . 353.5 feet*
Water surface area @ mos. . . . . 620 acres
Shoreline @ mos . . . . 12 miles

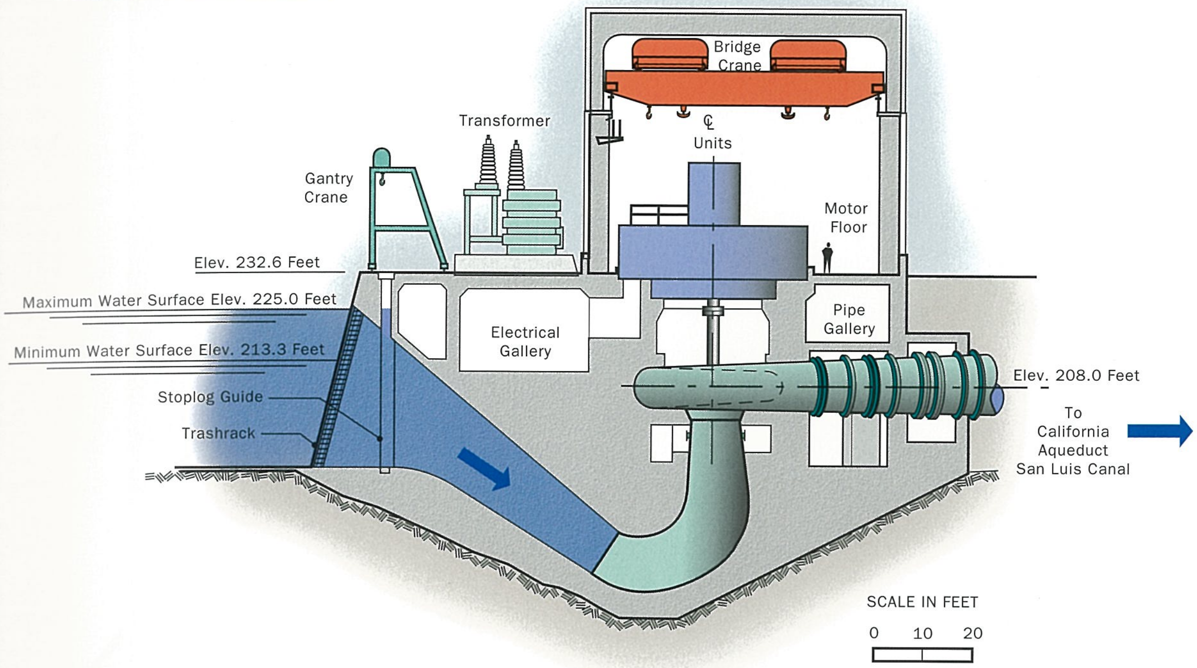
**maximum operating storage*



Dos Amigos Pumping Plant

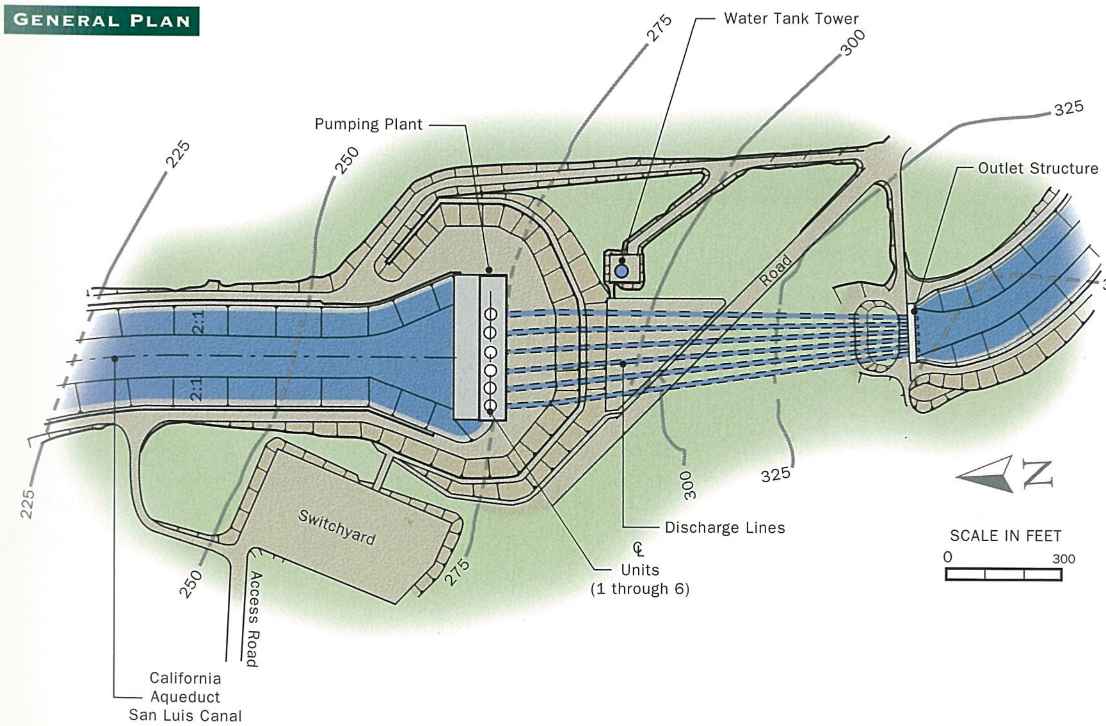
Dos Amigos Pumping Plant is located on the San Luis Canal, about 10 miles south of the city of Los Banos and 18 miles southeast of Sisk Dam in Merced County. It lifts water 113 feet from the aqueduct as it flows south from O'Neill Forebay. The plant's construction began in 1963 and was completed in 1966.

TRANSVERSE SECTION



Dos Amigos Pumping Plant was originally called Mile 18 Pumping Plant because it is located 18 miles southeast of Sisk Dam.

GENERAL PLAN



Pumping

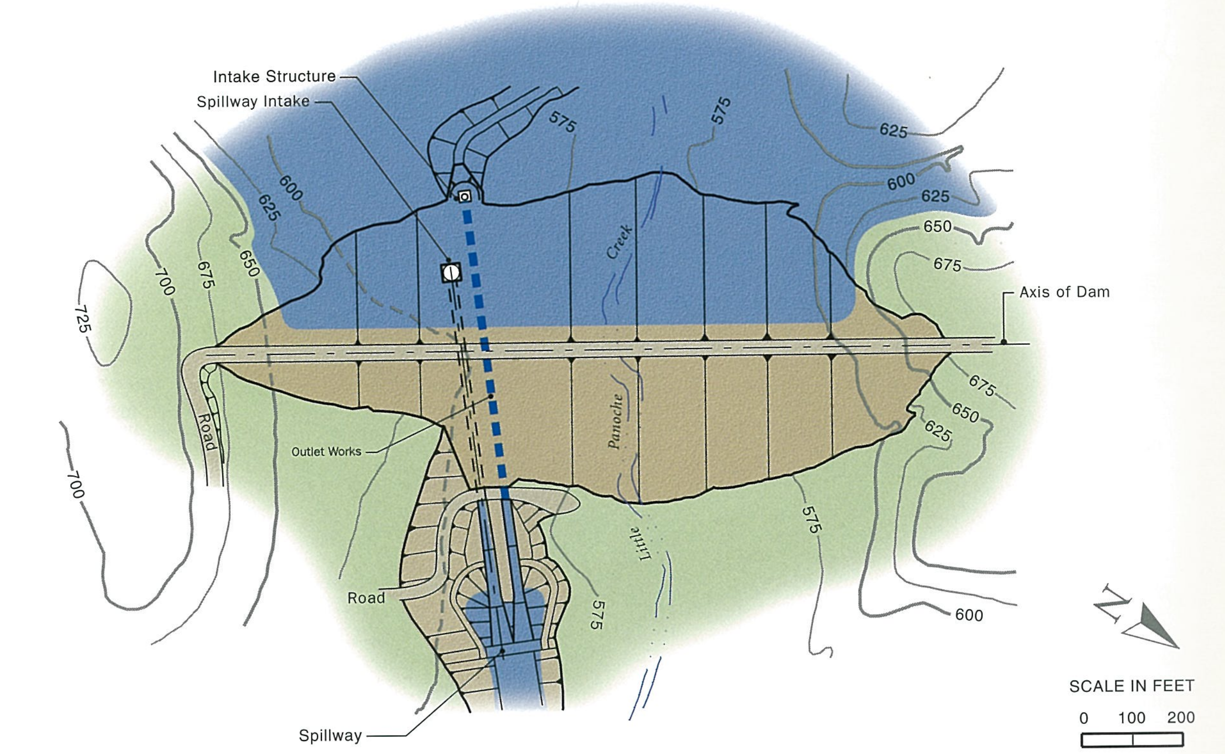
Installed capacity	*15,450 cfs, 240,000 hp*
Normal static head	*107-125 feet*
Design dynamic head	*125 feet*
Number of units	*6*
Unit Size	*3 @ 2,550 cfs*, 40,000 hp* *3 @ 2,600 cfs, 40,000 hp*
Discharge line/diameter	*6 @ 18 feet*

**variable capacity limits*

Little Panoche Detention Dam & Reservoir

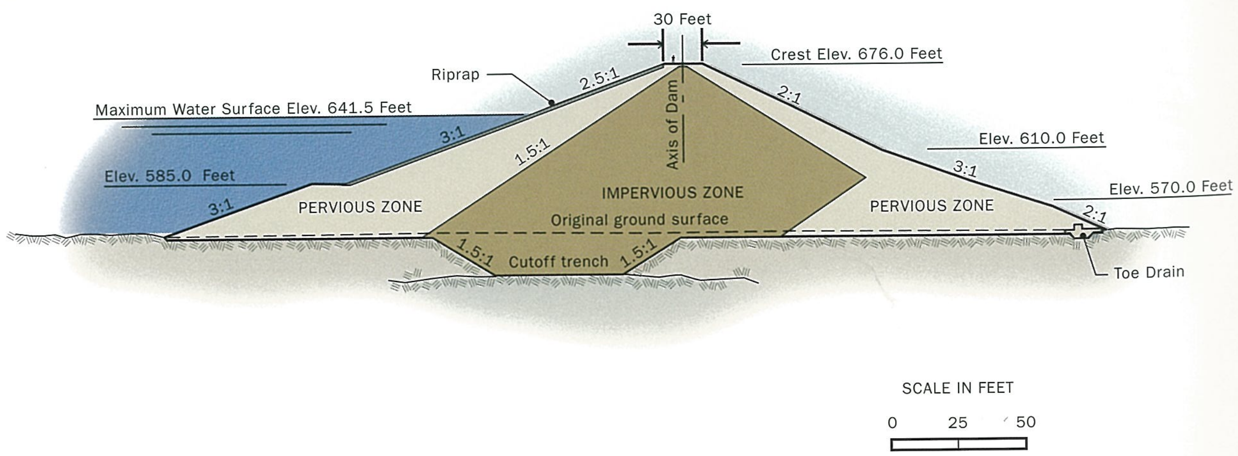
Situated in Fresno County 20 miles southwest of the city of Los Banos, Little Panoche Detention Dam and Reservoir provide flood protection for San Luis Canal, Delta-Mendota Canal, and other downstream developments. Water is stored behind the dam above dead storage of 315 acre-feet only during the period that inflow from Little Panoche Creek exceeds the capacity of the outlet works. Construction of the facility occurred between 1965 and 1966.

General Plan



Little Panoche Detention Dam's foundation was not grouted because the reservoir storage will not be held for longer than five days at a time.

Maximum Section



Dam

Type: zoned earthfill
Embankment volume . . . 1,210,000 cubic yards
Height . . . . 151 feet
Crest length . . . . 1,440 feet
Crest elevation . . . . 676 feet

Reservoir

Maximum operating storage . . . 5,580 acre-feet
Water surface elevation @ mos . . . . . 641.5 feet*
Water surface area @ mos. . . . . 190 acres
Shoreline @ mos. 6 miles

**maximum operating storage*

At the climax of the groundbreaking ceremony for the San Luis Joint-Use Complex, TNT and multi-colored smoke grenades were detonated along the 8,500 feet of the San Luis (Sisk) Dam's axis. The colored smoke trail from the helicopter indicates the height of the dam

President John F. Kennedy represented the federal government at the August 18, 1962 groundbreaking ceremony for the San Luis Joint-Use Complex.

Hundreds of people gathered near the dam site to witness the groundbreaking ceremony for the new state-federal facilities.


California Aqueduct & Coastal Branch Aqueduct
San Joaquin Field Division
Surge Tank
End
San Joaquin Field Division
A.D. Edmonston Pumping Plant
San Joaquin
O&M Center
Ck 39
Ck 38
Wheeler
Ridge
Bakersfield
99
5
Ira J.Chrisman Pumping Plant
John R. Teerink Pumping Plant
Ck 37
58
119
46
Ck 34
Kern River
Intertie
Ck 33
Cross Valley Canal
Ck 29
Buena Vista
Lake Bed
Ck 32
Mile 250
Ck 28
Ck 27
California
Aqueduct
Ck 31
166
119
Buena Vista Pumping Plant
Ck 26
Mile 225
33
Ck 25
Ck 24
Lost Hills
O&M Subcenter
Start
San Joaquin
Field Division
Ck 23
Ck 21
Mile 175
Mile 200
Ck 22
Kettleman City
Las Perillas Pumping Plant
Badger Hill
Pumping Plant
Ck 4
Ck 3
41
Ck 5
Devil's Den
Pumping Plant
Bluestone
Pumping Plant
46
58
SCALE IN MILES
0
6
12
N
Mile 25
Polonio Pass Pumping Plant
Tank Site No. 1
Coastal
Branch
Aqueduct
Mile 50
41
Tank Site No. 2
46
101
Mile 100
Energy
Dissipator
Mile 75
Santa Maria
Cuesta Tunnel
San Luis Obispo
1
1
Central Coast
Water Authority
Extension
Tank Site 5
End
San Joaquin Field Division

San Joaquin Field Division

Near Kettleman City, the San Joaquin Field Division begins its responsibilities for the 123-mile stretch of the California Aqueduct, which includes four pumping plants and the Coastal Branch and its facilities. The Coastal Branch includes nearly 100 miles of buried pipelines and five pumping plants: Las Perillas, Badger Hill, Devil's Den, Bluestone, and Polonio Pass. Along the main line of the California Aqueduct, the field division also maintains and operates Buena Vista, Teerink, Chrisman, and Edmonston Pumping Plants. The Edmonston plant lifts water nearly 2,000 feet up the Tehachapi Mountains to a surge tank (marking the end of the field division), before beginning its trip over the mountain range and into Antelope Valley.

Coastal Branch Aqueduct

The Coastal Branch, which extends about 115 miles from Kettleman City into Santa Barbara County, was constructed in two phases. Phase I, placed into operation in 1968, consists of some 15 miles of canal and two pumping plants – Las Perillas and Badger Hill.

Constructed from 1993 to 1998, Phase II facilities include three pumping plants – Devil's Den, Bluestone, and Polonio Pass – which lift water 1,500 feet through a buried pipeline to the Polonio Pass Water Treatment Plant. Treated water then enters a pipeline which drops it nearly 1,000 feet to the floor of the Cholame Valley. It passes through three tunnels, under Shedd and Calf Canyons in San Luis Obispo County, then travels near the cities of Arroyo Grande, Nipomo, and Santa Maria, terminating at a storage tank at Vandenberg Air Force Base in Santa Barbara County. From that point, the Coastal Branch pipeline links to another buried pipeline, a 42-mile-long locally owned extension which ends at Lake Cachuma in Santa Barbara County.

Pipelines

Type: 97.9 miles of mortar-lined steel cylinder
Diameter . . . . varies from 3.25 to 4.75 feet
Capacity . . . . varies from 32 to 100 cfs

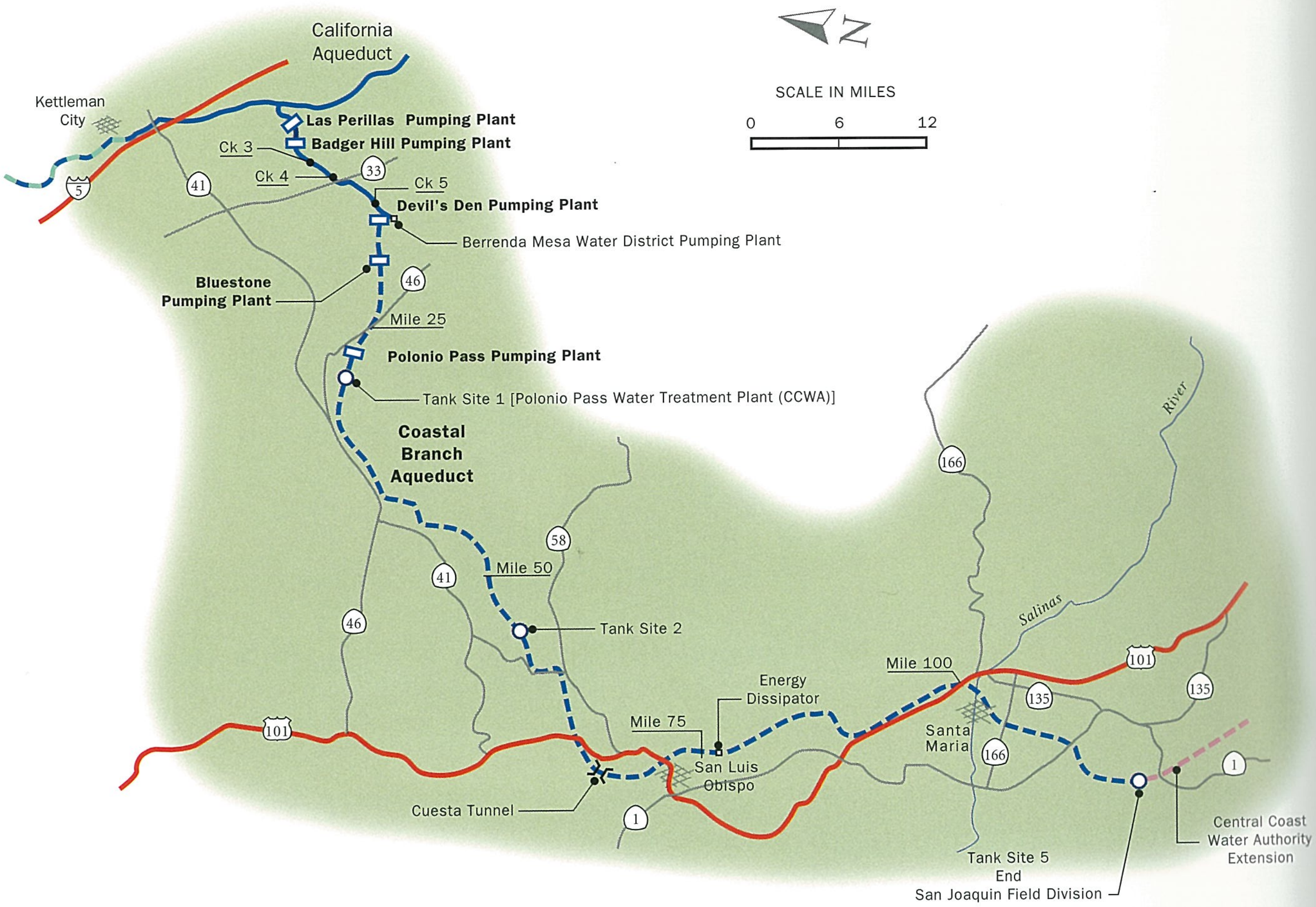
Canals

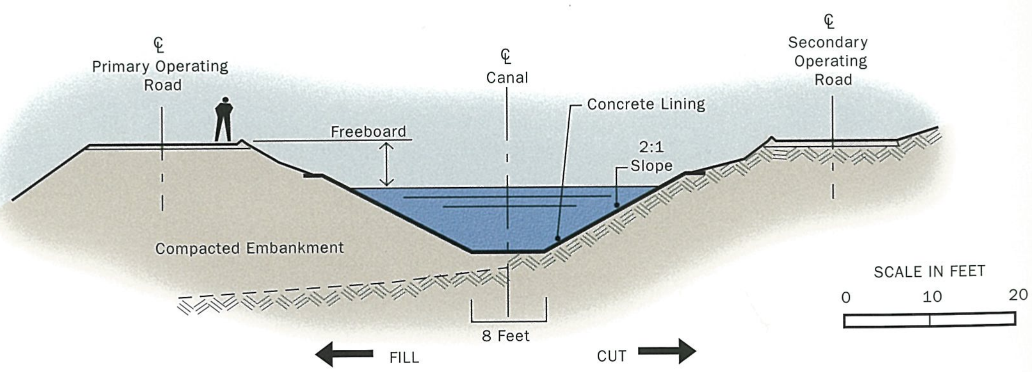
Type: 15.0 miles of concrete-lined, trapezoidal, checked
Capacity . . . . 450 cfs
Water depth . . . . 7 feet
Side slope 2:1
Width . . . . 8 feet (bottom)

Tunnels

Type: 2.7 miles of steel liner
Diameter . . . . varies 3.25, 3.5, and 5 feet
Capacity . . . . 68 and 71 cfs

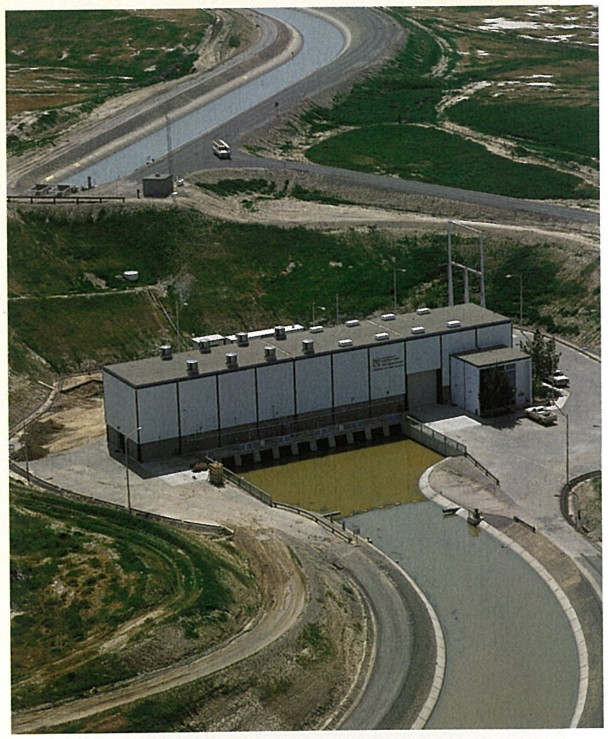
AQUEDUCT MAP



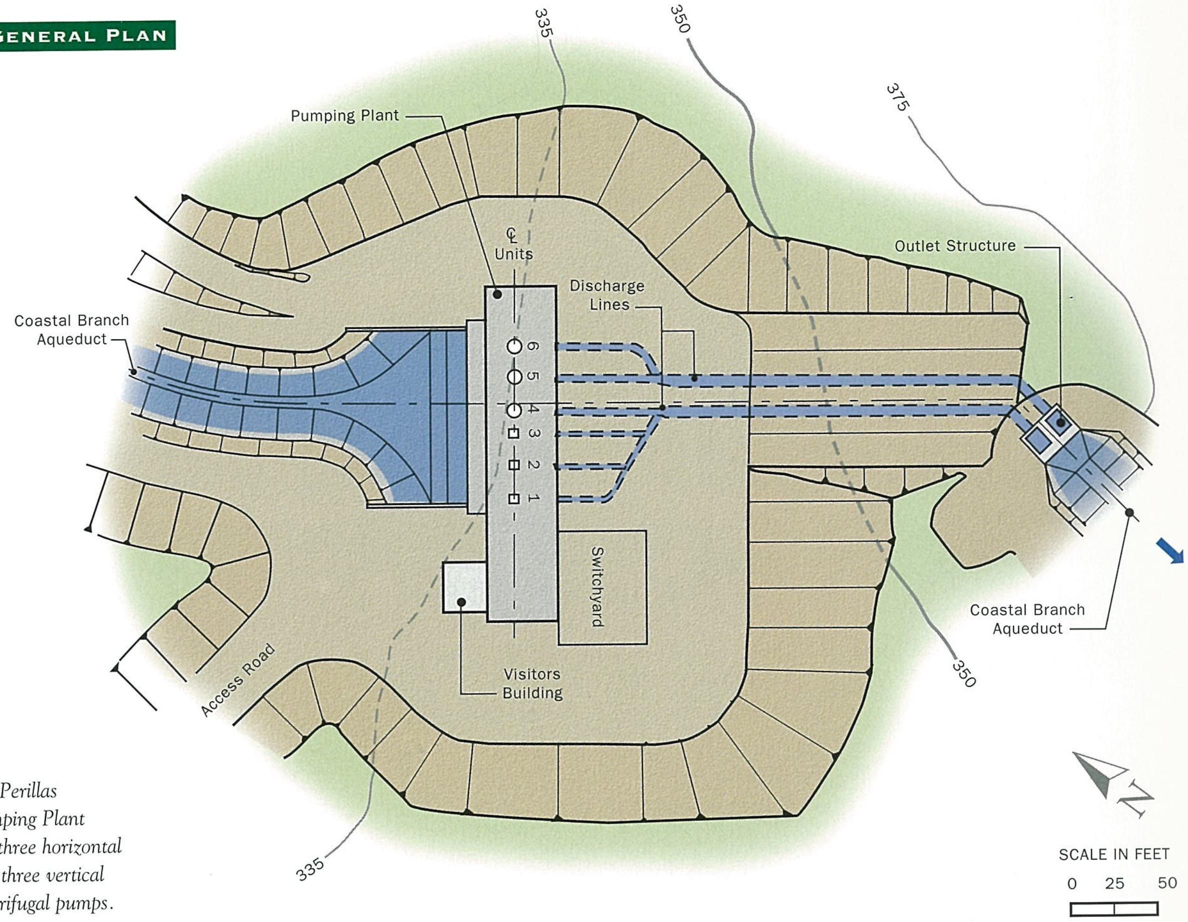


Las Perillas Pumping Plant

Las Perillas Pumping Plant was constructed between 1966 and 1968 as part of the Coastal Branch Aqueduct, Phase I. It is located about one mile from the California Aqueduct and lifts water from the aqueduct for delivery through the first 15 miles of the Coastal Branch.

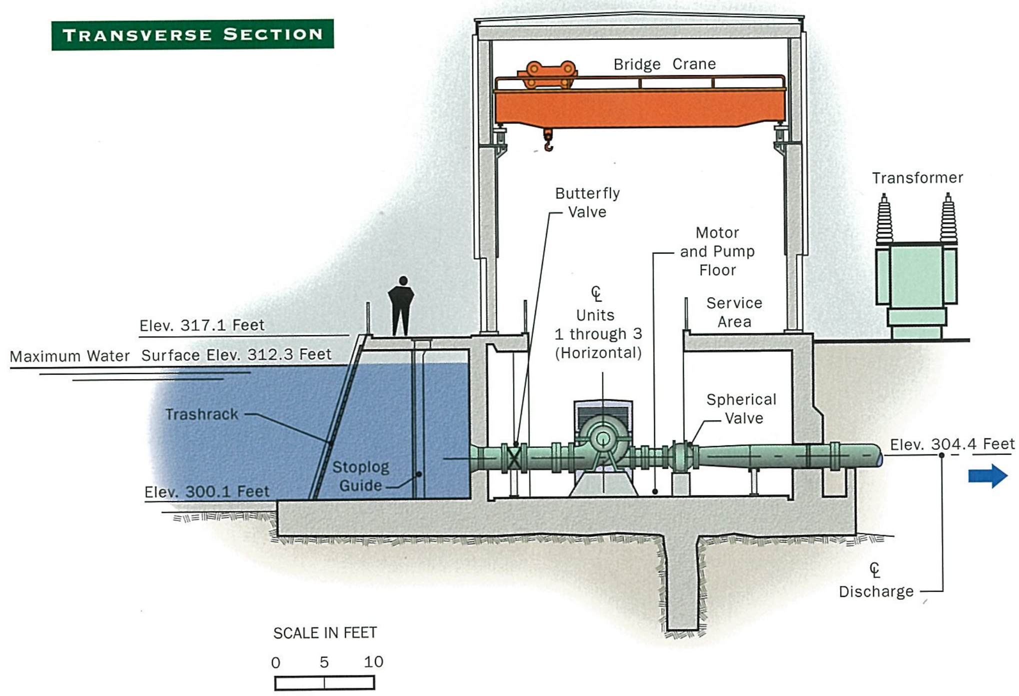


General Plan



Las Perillas Pumping Plant has three horizontal and three vertical centrifugal pumps.

Transverse Section



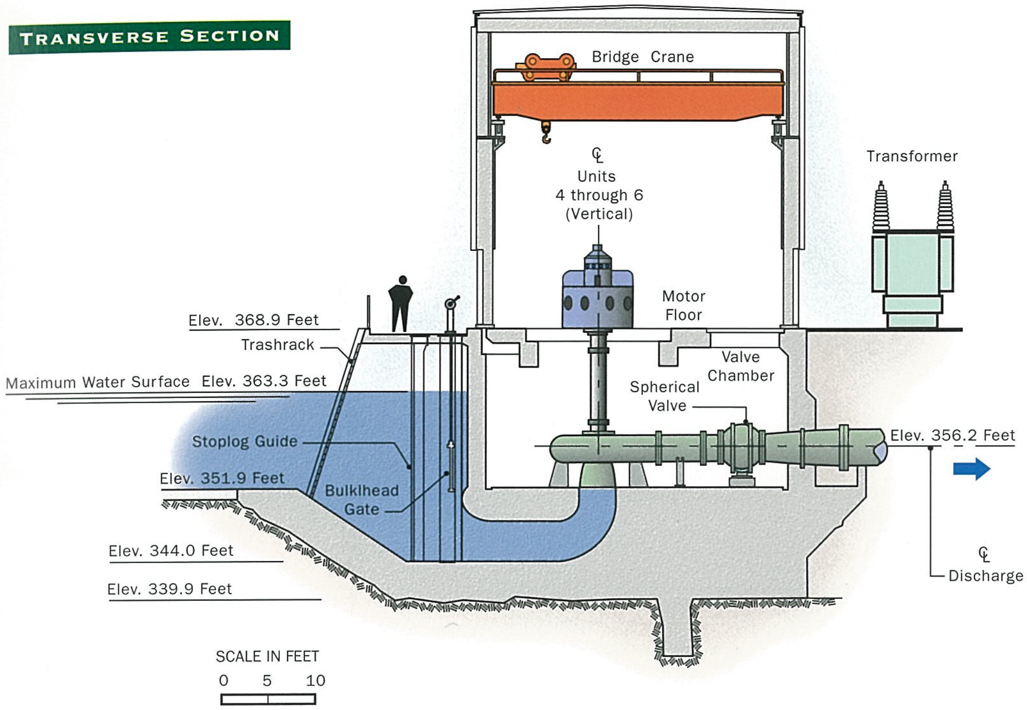
Pumping

Installed capacity	*461 cfs, 4,050 hp*
Normal static head	*55 feet*
Design dynamic head	*4 @ 61 feet* *2 @ 60 feet*
Number of units	*6*
Unit Size	*3 @ 38 cfs, 350 hp* *1 @ 122 cfs, 1,000 hp* *2 @ 112 cfs, 1,000 hp*
Discharge line/diameter	*2 @ 6.5 feet*

BADGER HILL PUMPING PLANT

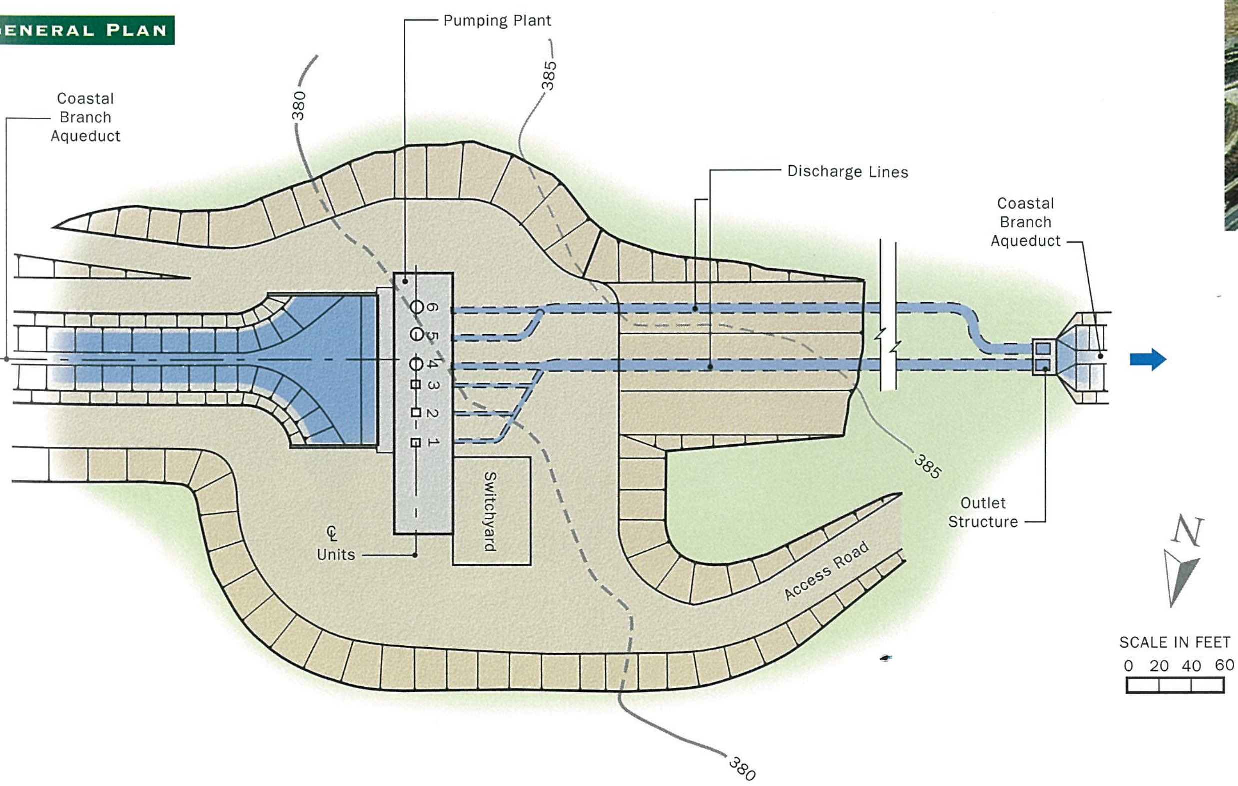
Built as part of the Coastal Branch Aqueduct, Phase I, Badger Hill Pumping Plant is located three miles downstream from Las Perillas Pumping Plant and provides the second lift for delivery through the first 15 miles of the Coastal Branch. The plant's construction took place between 1966 and 1968.

TRANSVERSE SECTION



Badger Hill Pumping Plant is similar in appearance and construction to the Las Perillas plant.

GENERAL PLAN



PUMPING

Installed capacity	*454 cfs, 11,750 hp*
Normal static head	*151 feet*
Design dynamic head	*3 @ 163 feet*
	2 @ 162 feet
	1 @ 187 feet
Number of units	*6*
Unit size	*3 @ 38 cfs, 1,000 hp*
	1 @ 116 cfs, 2,750 hp
	2 @ 112 cfs, 3,000 hp
Discharge line/diameter	*2 @ 6.5 feet*

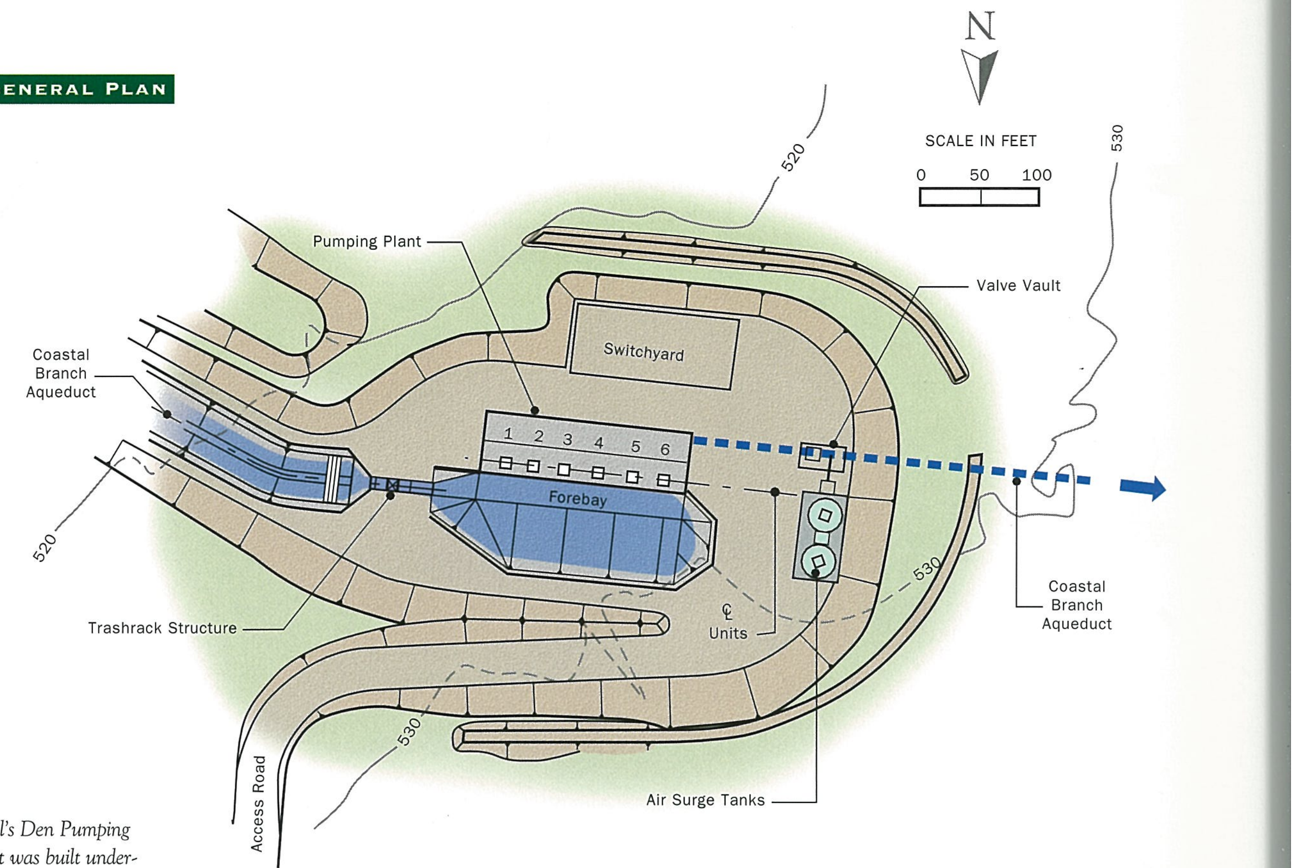
DEVIL'S DEN PUMPING PLANT

Devil's Den Pumping Plant is the first in a series of three pumping plants that lift water 1,500 feet in elevation through a buried 57-inch diameter pipeline to the summit of Polonio Pass of the Temblor Mountain Range. The plant was constructed between 1994 and 1996 as part of the Coastal Branch Aqueduct, Phase II.

PUMPING

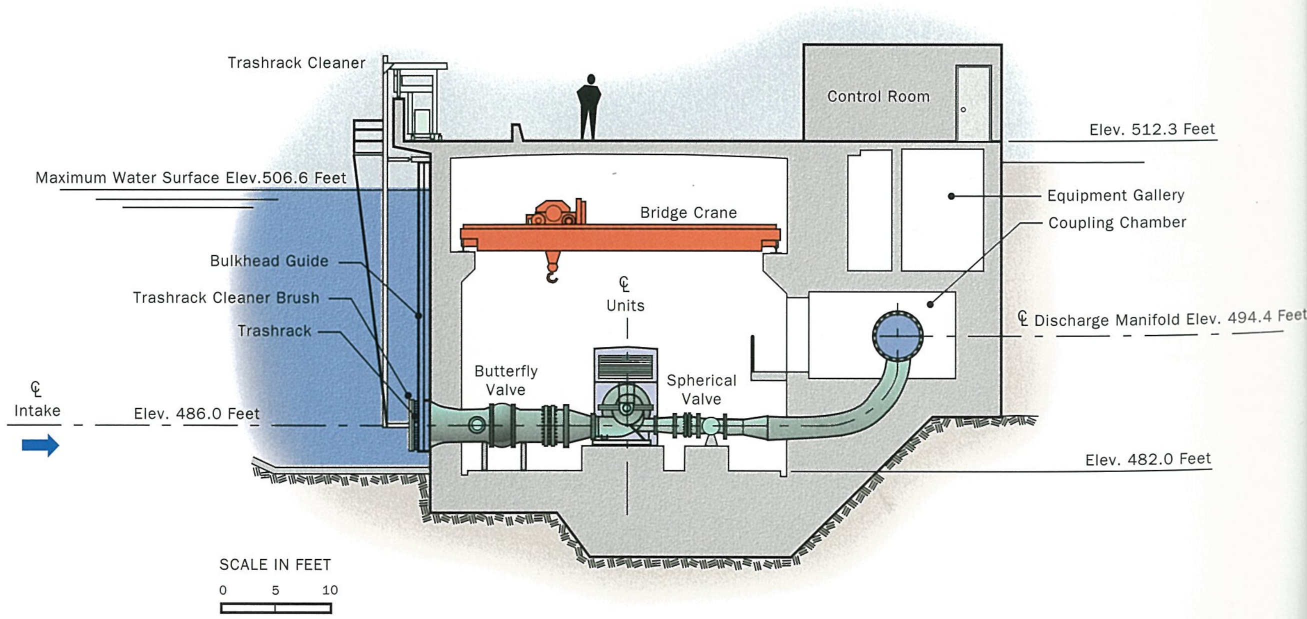
Installed capacity . . . . *134 cfs, 10,500 hp*
Normal static head . . . . *521 feet*
Design dynamic head . . . . *555 feet*
Number of units . . . . *6 (1 unit is reserve)*
Unit size . . . . *22.3 cfs, 1,750 hp*
Discharge line/diameter . . . . *1 @ 4 feet*

GENERAL PLAN



Devil's Den Pumping Plant was built underground and has a small forebay to regulate the amount of water conveyed.

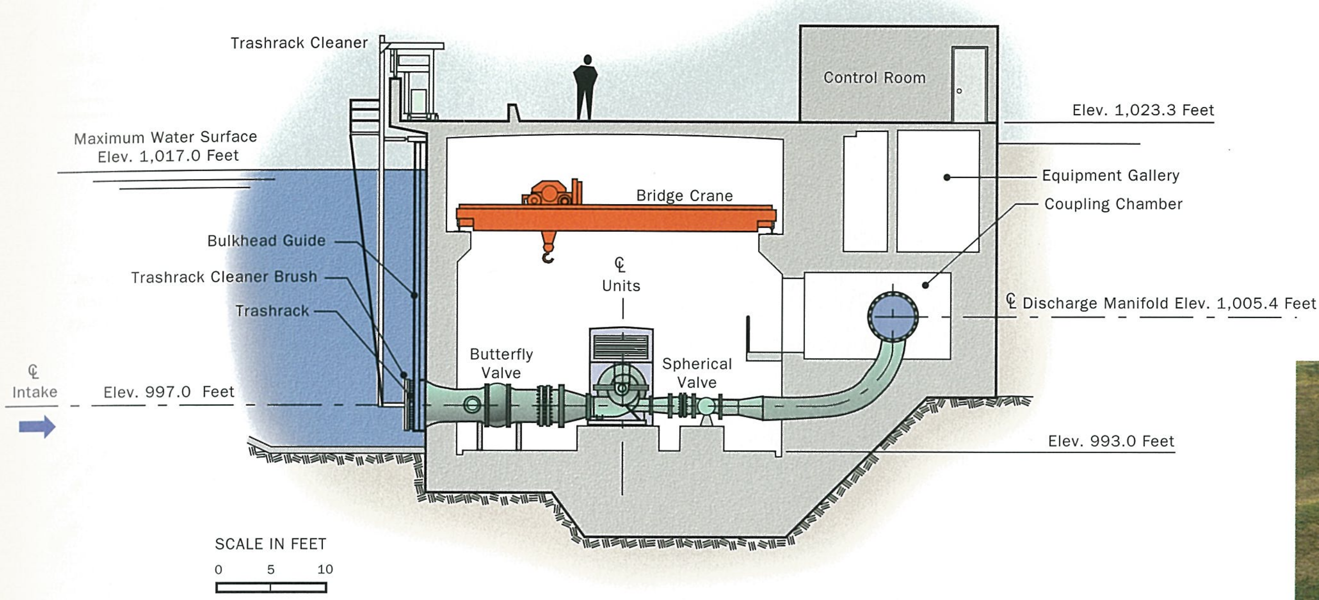
TRANSVERSE SECTION

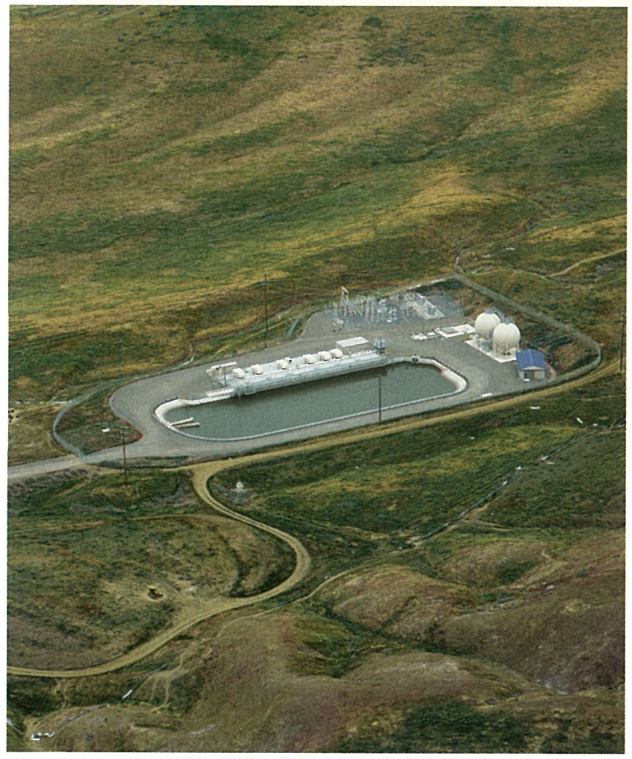


Bluestone Pumping Plant

Constructed between 1994 and 1996, Bluestone Pumping Plant is the second plant to sequentially lift water 1,500 feet in elevation through a buried 57-inch diameter pipeline to the summit of Polonio Pass of the Temblor Mountain Range. Its construction is similar to Devil's Den.

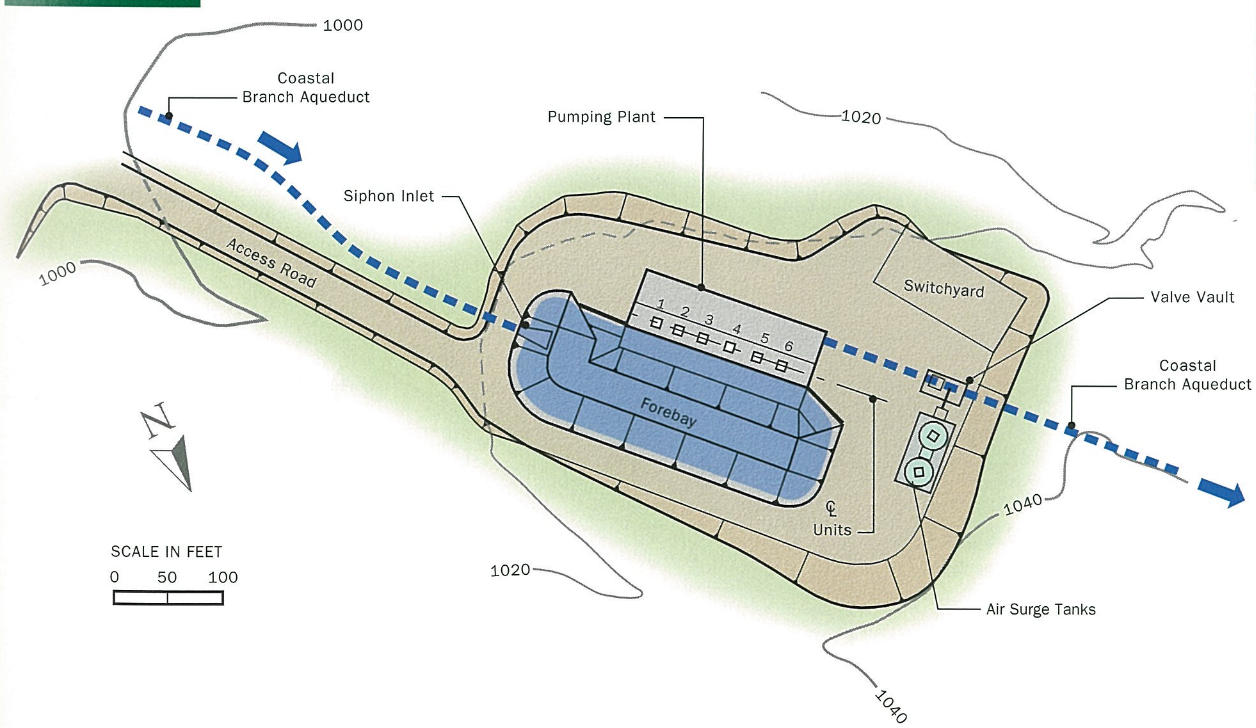
Transverse Section





Bluestone Pumping Plant was named for the serpentine rock found in the area.

General Plan



Pumping

Installed capacity	*134 cfs, 10,500 hp*
Normal static head	*484 feet*
Design dynamic head	*555 feet*
Number of units	*6 (1 unit in reserve)*
Unit Size	*22.3 cfs, 1,750 hp*
Discharge line/diameter	*1 @ 4 feet*

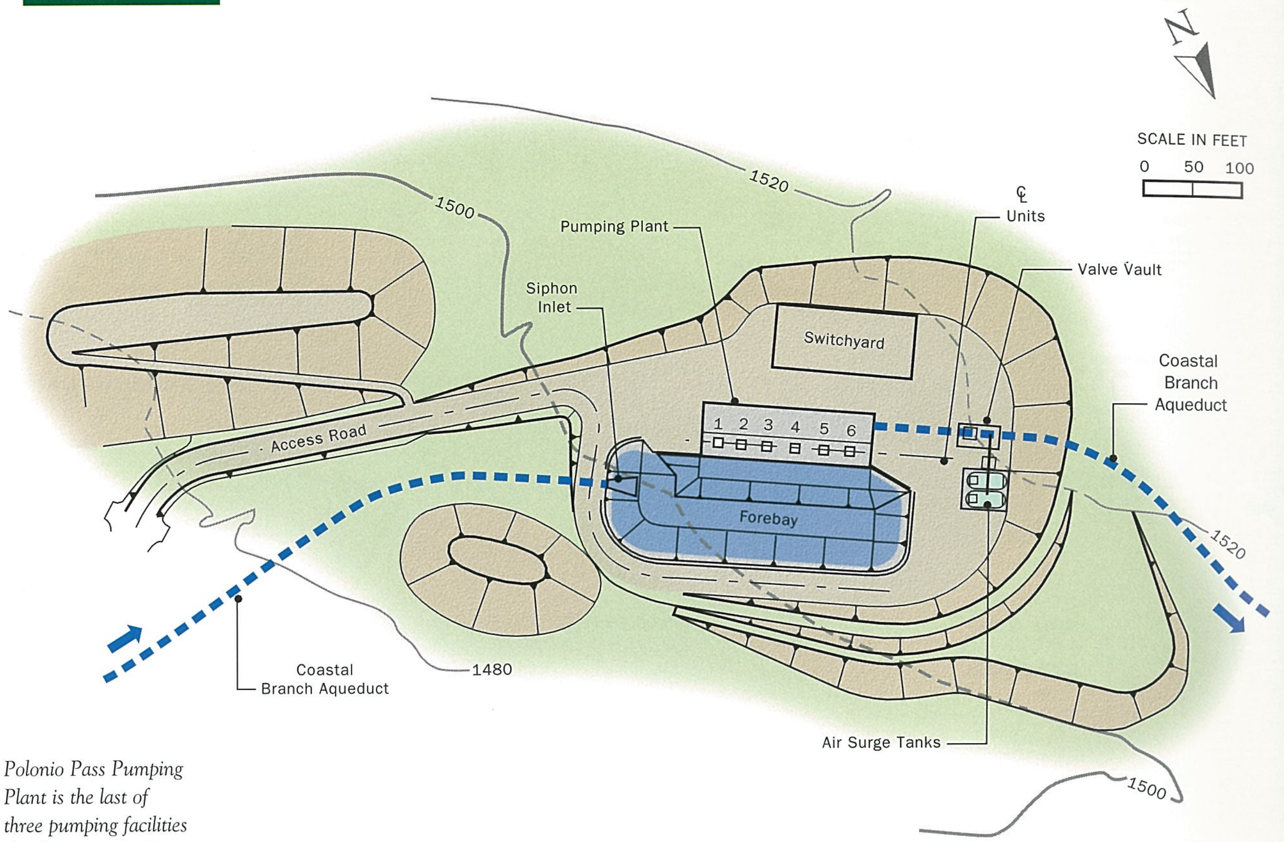
Polonio Pass Pumping Plant

Polonio Pass Pumping Plant is the third plant to sequentially lift water 1,500 feet in elevation through a buried 57-inch diameter pipeline to the summit of Polonio Pass of the Temblor Mountain Range. It was constructed between 1994 and 1996.

Pumping

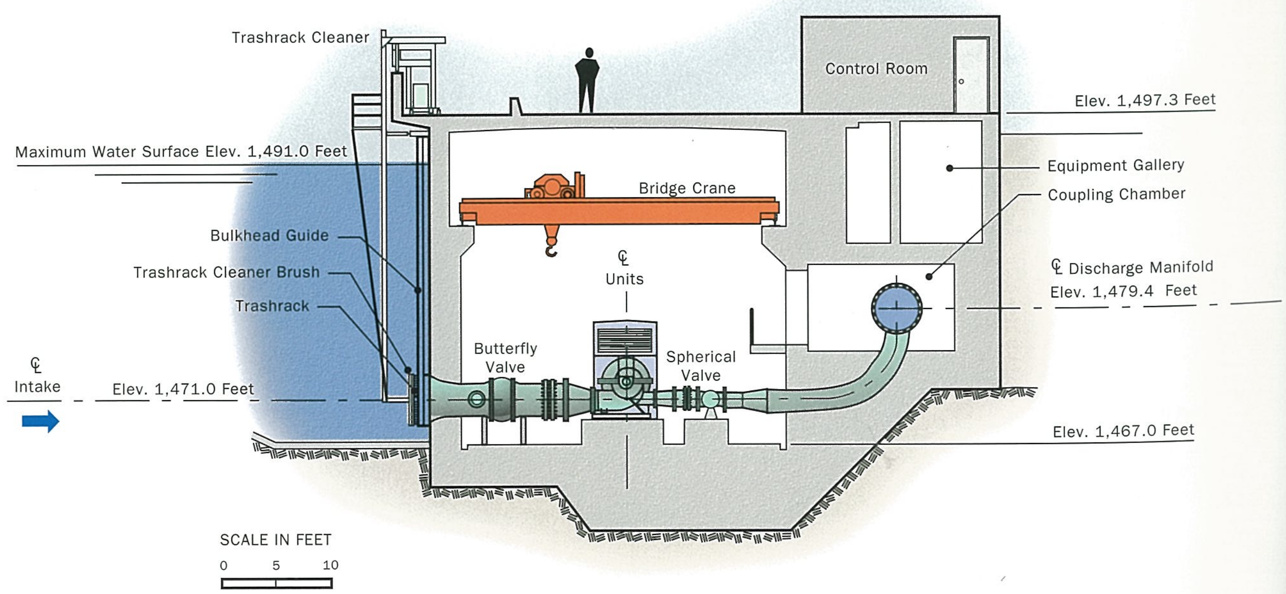
Installed capacity	*134 cfs, 10,500 hp*
Normal static head	*533 feet*
Design dynamic head	*555 feet*
Number of units	*6 (1 unit in reserve)*
Unit size	*22.3 cfs, 1,750 hp*
Discharge line/diameter	*1 @ 4 feet*

General Plan



Polonio Pass Pumping Plant is the last of three pumping facilities that have nearly identical specifications.

Transverse Section



Among the protected resources along the Coastal Branch were the region's oak trees. DWR aligned the pipeline around critical areas or tunneled the pipe underground to avoid disturbing the trees. For those trees impacted, DWR collected acorns and seeds along the pipeline's route to preserve the "species integrity" and genetic diversity of the revegetated areas.

To protect the endangered blunt-nosed leopard lizard, California Conservation Corps members helped the Department build miles of exclusion fencing to keep the lizards out of the construction site. The fence also made it easy to capture those within the fenced area.

The habitats of several state and federally endangered species were found within the project's boundaries. Among the listed species was the San Joaquin kit fox.

CALIFORNIA AQUEDUCT

The section of the California Aqueduct under the San Joaquin Field Division starts below Check 21 at the end of the San Luis Joint-Use Facilities near Kettleman City and terminates at Edmonston Pumping Plant's surge tank in the Tehachapi Mountains. It is the third and last division of the aqueduct to originate and end in the San Joaquin Valley. This division also serves the largest number of the SWP's agricultural water users. There are a total of 15 check structures, 12 siphon structures, 2 wasteways, and more than 40 water delivery turnouts within the division. These facilities were designed and constructed during the period from 1960 to 1971.

CANALS

Type: 120.9 miles of concrete-lined, trapezoidal, checked

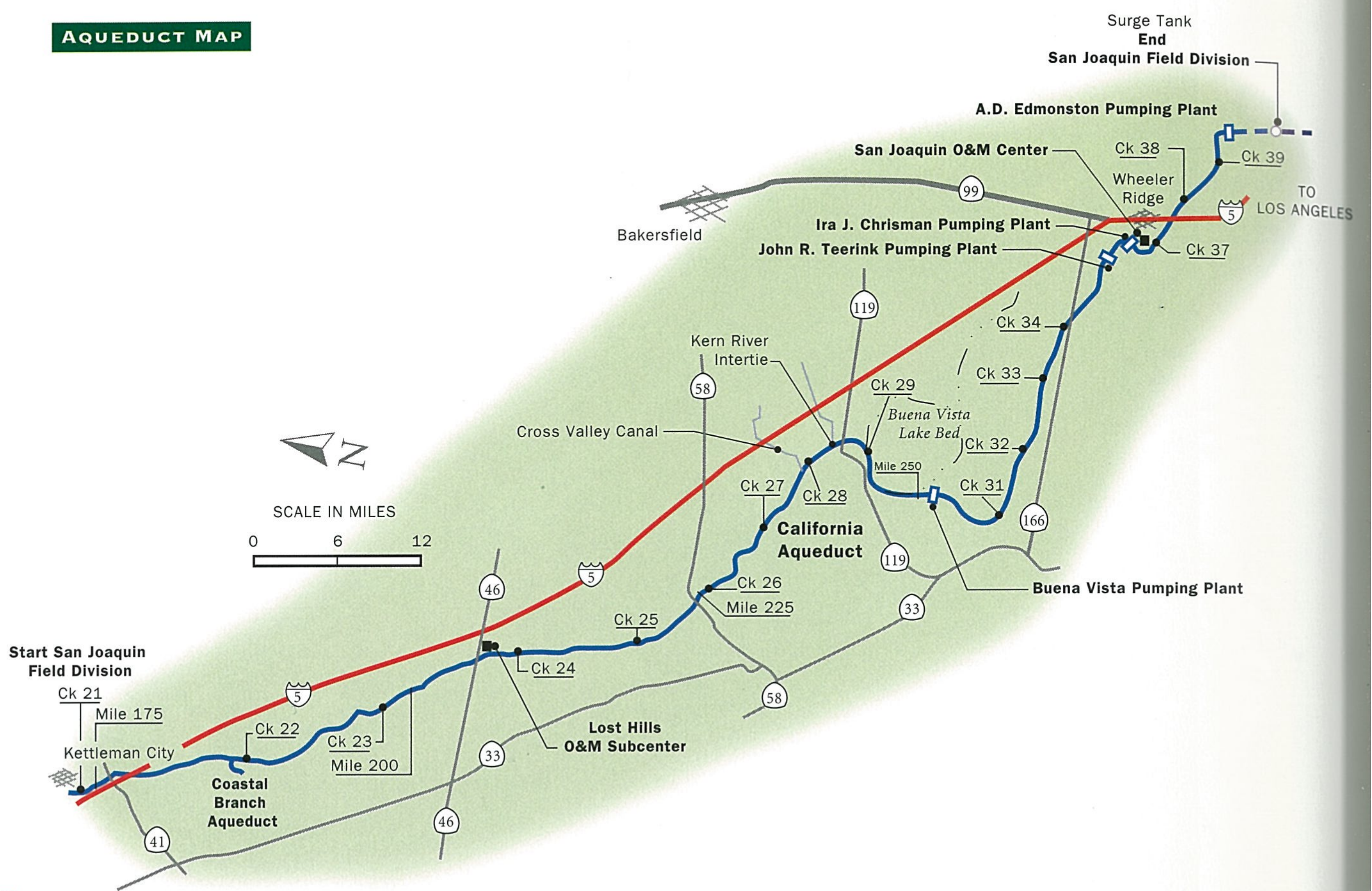
Capacity: variable in steps from 8,100 cfs at Check 21 to 4,400 cfs at intake to Edmonston Pumping Plant

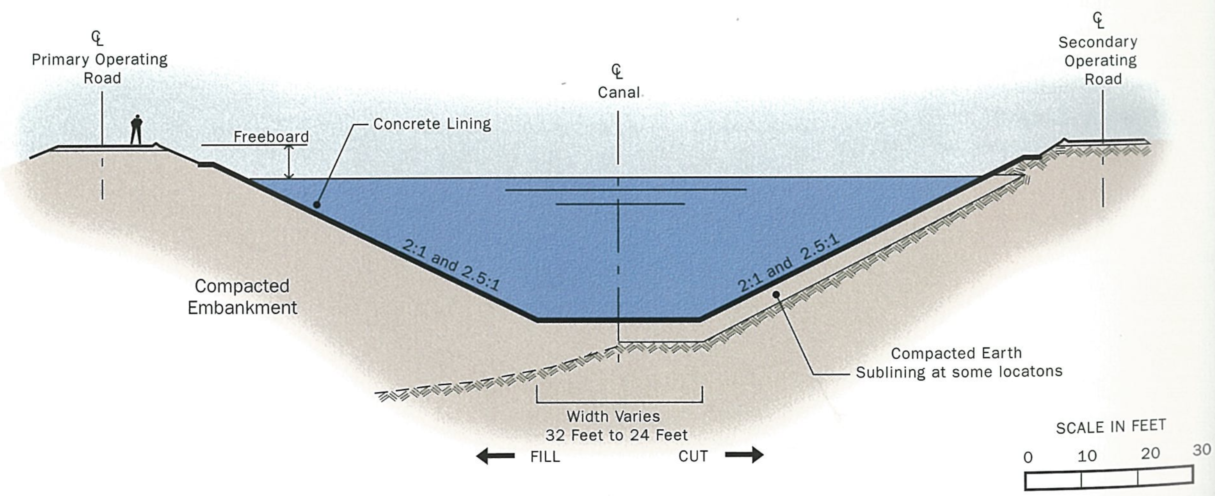
Water depth. . . . . . varies from 20.8 to 26.9 feet

Side slope . . . . 2:1 and 2.5:1

Width . . . . . varies from 32 to 24 feet (bottom)

AQUEDUCT MAP





The majority of design features and criteria are consistent with, and in many cases, identical to, those used in the Delta Field Division. Check structures were designed so that the canal smoothly transitioned from a trapezoidal section to a rectangular section. This design reduced water headloss during design flows.

Flatter side slopes were adopted because of the weaker soils encountered and to allow for the residual subsidence from hydrocompaction or foundation liquefaction. Road and utility crossings and drainage cross structures were placed as needed along the entire aqueduct.

Buena Vista Pumping Plant

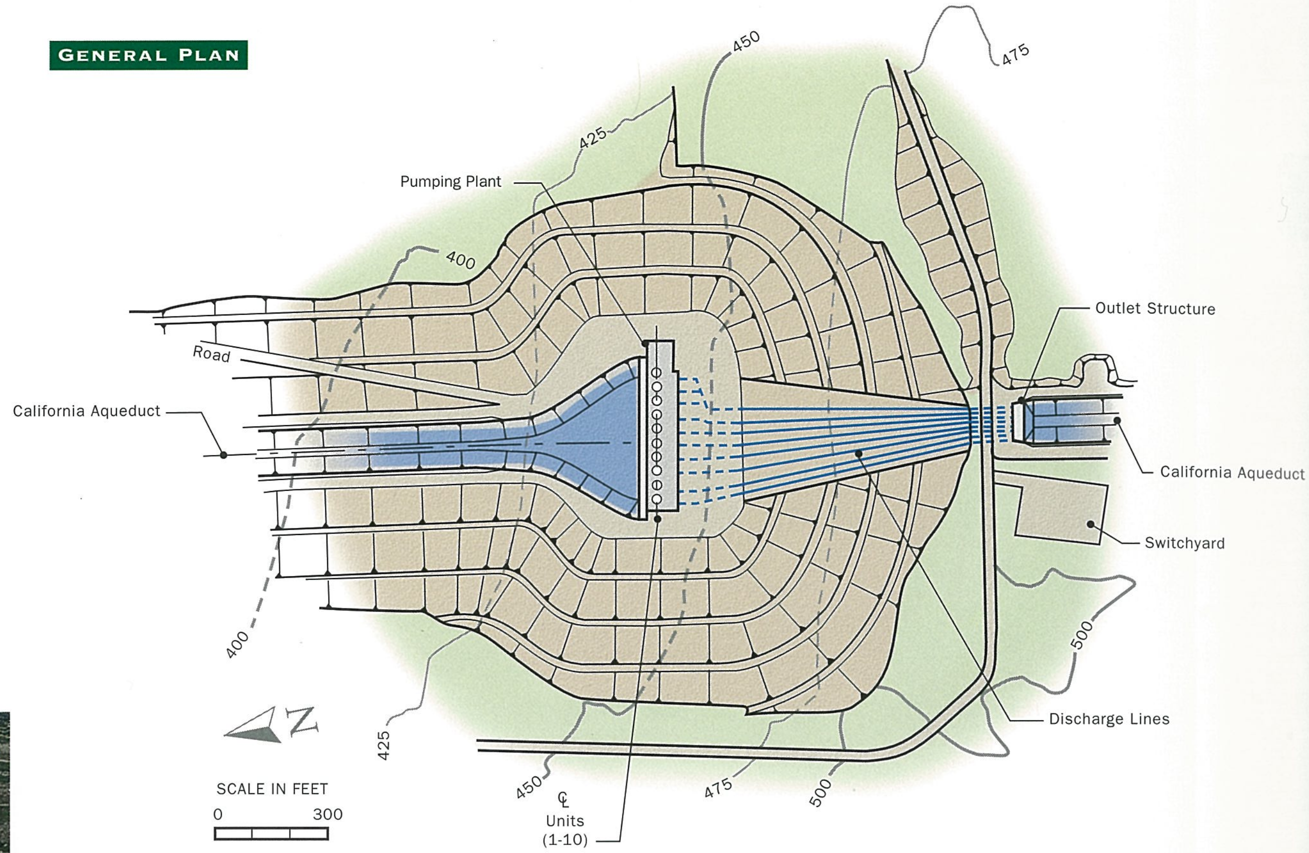
Buena Vista Pumping Plant, constructed during 1967 to 1972, is located on the California Aqueduct, about 24 miles southwest of Bakersfield in Kern County. The plant operates in a series of sequential lifts in southern San Joaquin Valley with Teerink, Chrisman, and Edmonston Pumping Plants to convey California Aqueduct water to and across the Tehachapi Mountains. The Buena Vista plant provides the first lift from elevation 295.4 to 500.6 feet.

Buena Vista Pumping Plant's intake transitions to form the forebay.

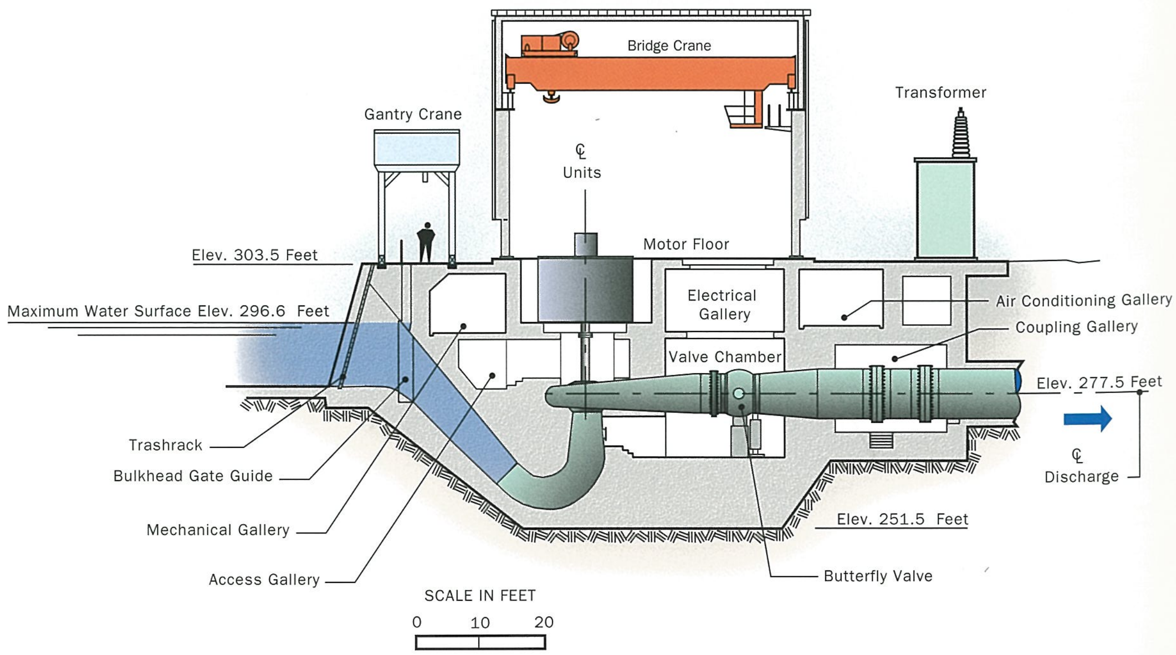
Pumping

Installed capacity .... *5,405 cfs, 144,500 hp*
Normal static head .... *205 feet*
Design dynamic head .... *209 feet*
Number of units .... *10 (1 unit in reserve)*
Unit size .... *3 @ 320 cfs, 8,500 hp*
7 @ 635 cfs, 17,000 hp
Discharge lines/diameter .... *8 @ 9 feet*

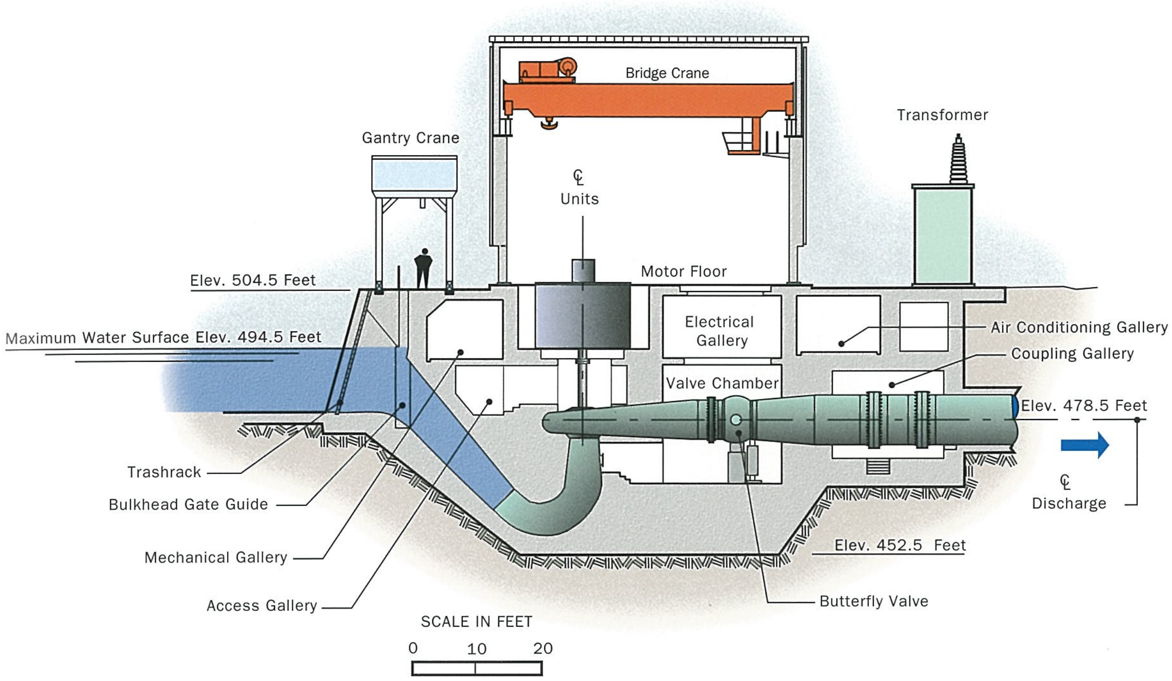
General Plan



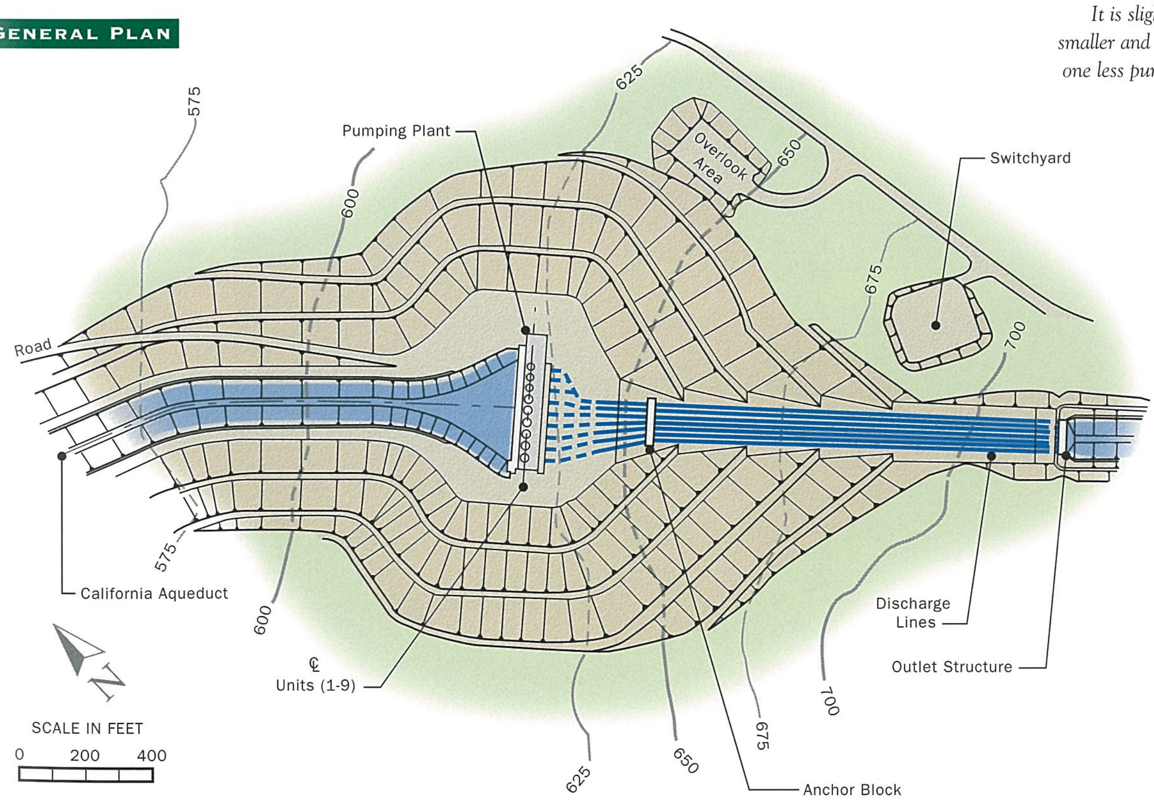
Transverse Section



TRANSVERSE SECTION



GENERAL PLAN



JOHN R. TEERINK WHEELER RIDGE PUMPING PLANT

Teerink Pumping Plant is located on the California Aqueduct, about 27 miles downstream from Buena Vista Pumping Plant and about 23 miles south of Bakersfield in Kern County. The plant provides the second lift from elevation 492 to 724.5 feet and furnishes water for a turnout in the reach of the aqueduct that leads to Chrisman Pumping Plant. It was constructed from 1967 to 1972.

Teerink Pumping Plant is similar in design and configuration to Buena Vista. It is slightly smaller and has one less pump.

PUMPING

Installed capacity	*5,445 cfs, 150,000 hp*
Normal static head	*233 feet*
Design dynamic head	*238 feet*
Number of units	*9 (1 unit in reserve)*
Unit size	*3 @ 335 cfs, 10,000 hp* *6 @ 740 cfs, 20,000 hp*
Discharge lines/diameter	*7 @ 9 feet*

Ira J. Chrisman Wind Gap Pumping Plant

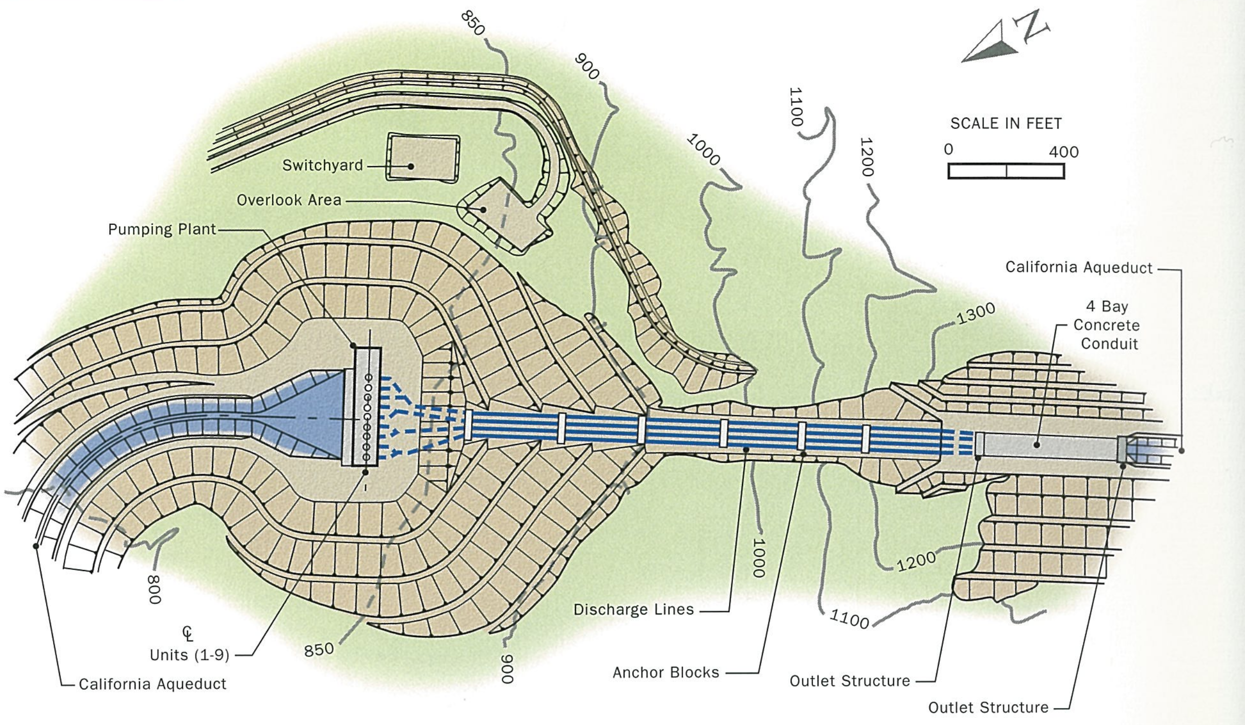
An in-line plant, Chrisman Pumping Plant is situated on the California Aqueduct, about 1.6 miles downstream from Teerink Pumping Plant. It operates in a series of sequential lifts in southern San Joaquin Valley with Buena Vista, Teerink, and Edmonston Pumping Plants to convey California Aqueduct water to and across the Tehachapi Mountains. Construction took place from 1966 to 1973.

Water discharged from the Chrisman plant flows by gravity to the Edmonston Pumping Plant.

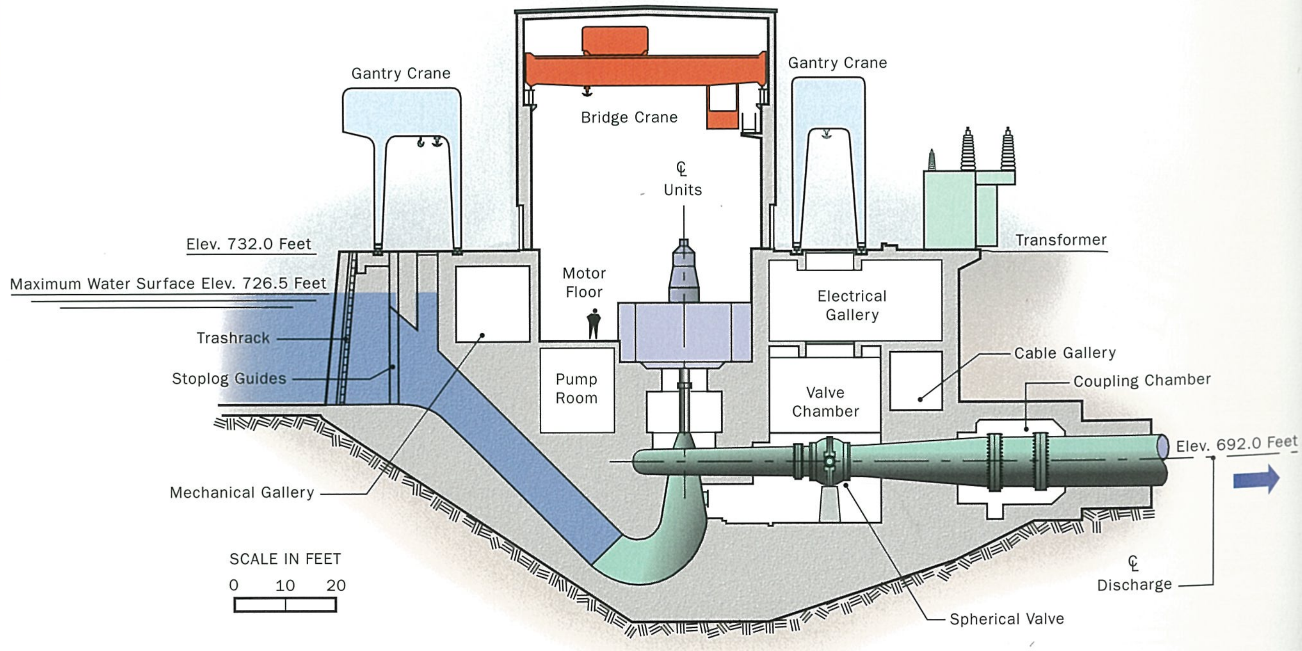
Pumping

Installed capacity	*4,995 cfs, 330,000 hp*
Normal static head	*518 feet*
Design dynamic head	*524 feet*
Number of units	*9 (1 unit in reserve)*
Unit size	*3 @ 310 cfs, 22,000 hp* *3 @ 685 cfs, 44,000 hp* *3 @ 670 cfs, 44,000 hp*
Discharge lines/diameter	*1 @ 9.5 feet* *3 @ 12.5 feet*

General Plan



Transverse Section



Chrisman Pumping Plant's four discharge lines are visible from Interstate Highway 5. The plant's location was controlled by the canal alignment upstream and a low saddle in the Wheeler Ridge Hills.

The plant sits in a deep bowl, the bottom of which was excavated approximately 110 feet below original ground level. The excavation is about 640 feet wide and 530 feet long at the bottom.

On-site fabrication was required for the 12.5-foot-diameter straight sections and for the manifold sections. All pieces were welded together as they slowly turned together on rollers. Then each section was sandblasted, externally coated with inorganic zinc silicate, and internally coated with coal-tar epoxy. Large concrete anchor blocks surround the pipe to prevent pipe movement during operational changes.

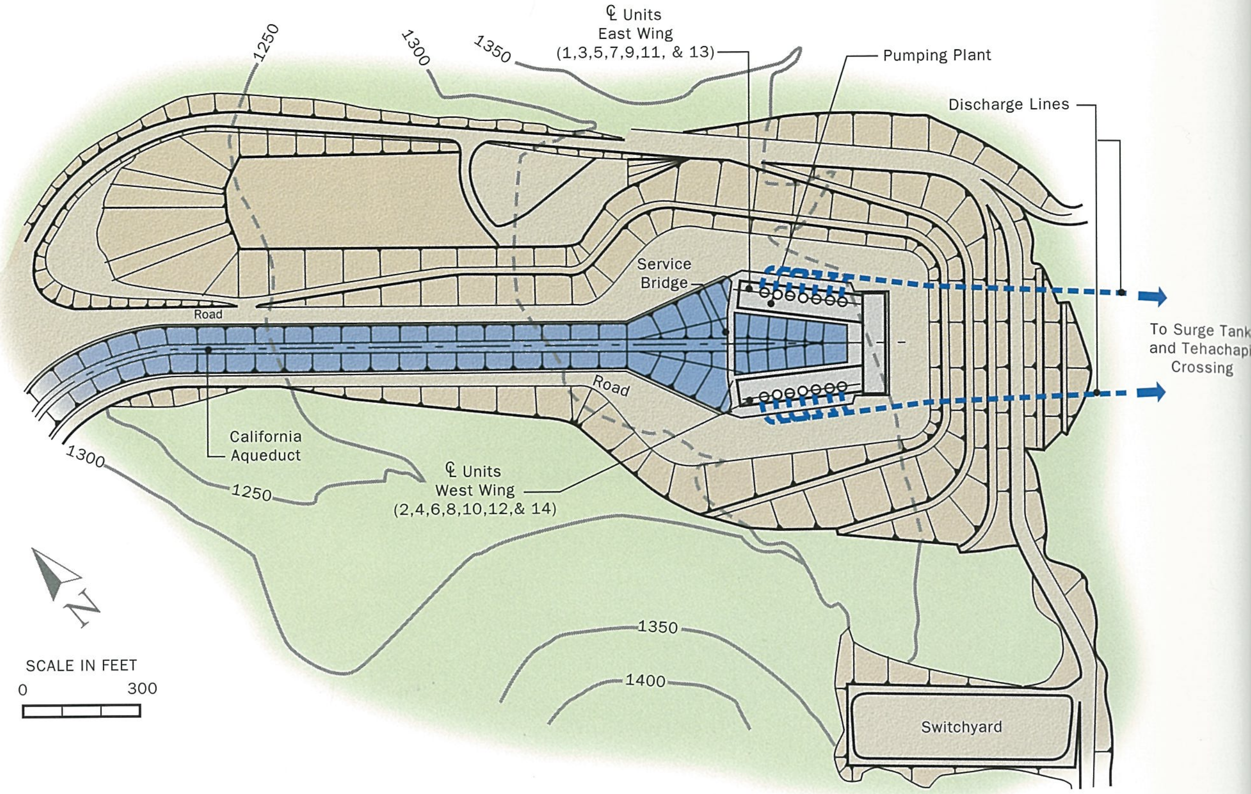
A.D. EDMONSTON PUMPING PLANT

Constructed from 1967 to 1973, Edmonston Pumping Plant provides the largest lift, nearly 2,000 vertical feet, in the SWP system. The plant's two main discharge lines stair-step 8,400 feet up the mountain side to a 62-foot-high, 50-foot-diameter surge tank. Near the top of the lift, 14-foot-diameter valves can close each discharge line in the event of a system rupture and minimize water flowing back into the plant below.

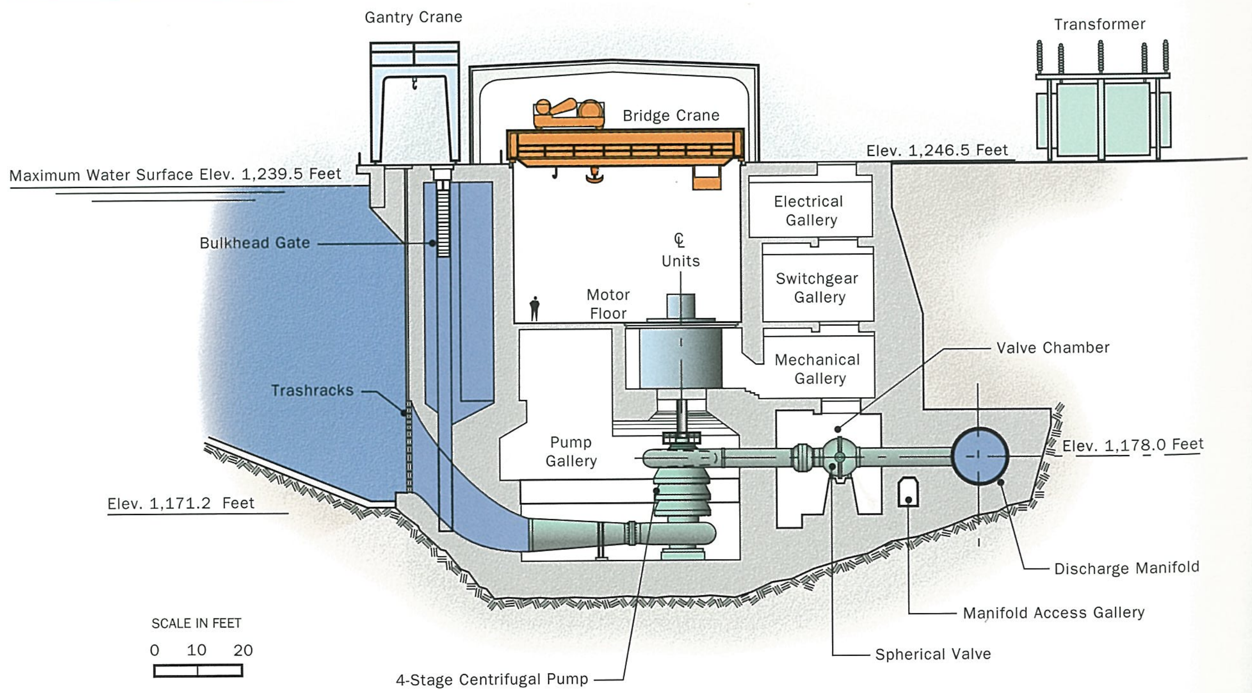
PUMPING

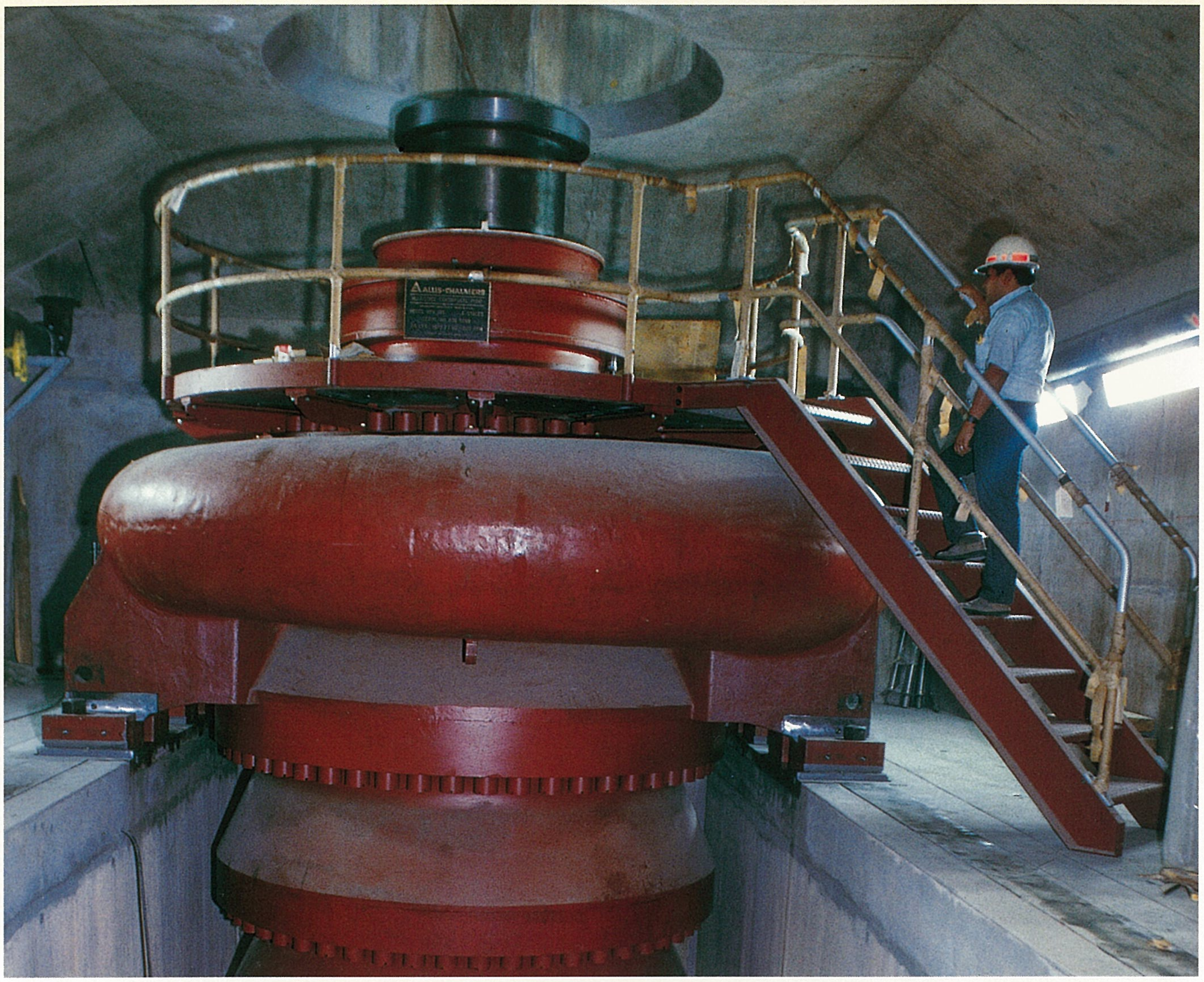
Installed capacity . . . . . *4,480 cfs, 1,120,000 hp*
Normal static head. . . . . *1,926 feet*
Design dynamic head. . . . . *1,970 feet*
Number of units . . . . *14 (1 unit in reserve)*
Unit size . . . . *320 cfs, 80,000 hp*
Discharge lines/diameter . . . *2 @ 14 to 12.5 feet*

GENERAL PLAN



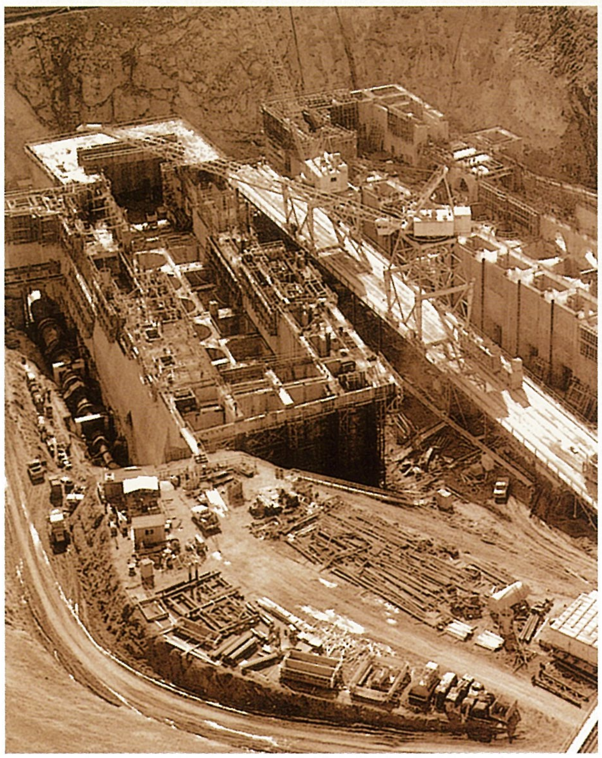
TRANSVERSE SECTION



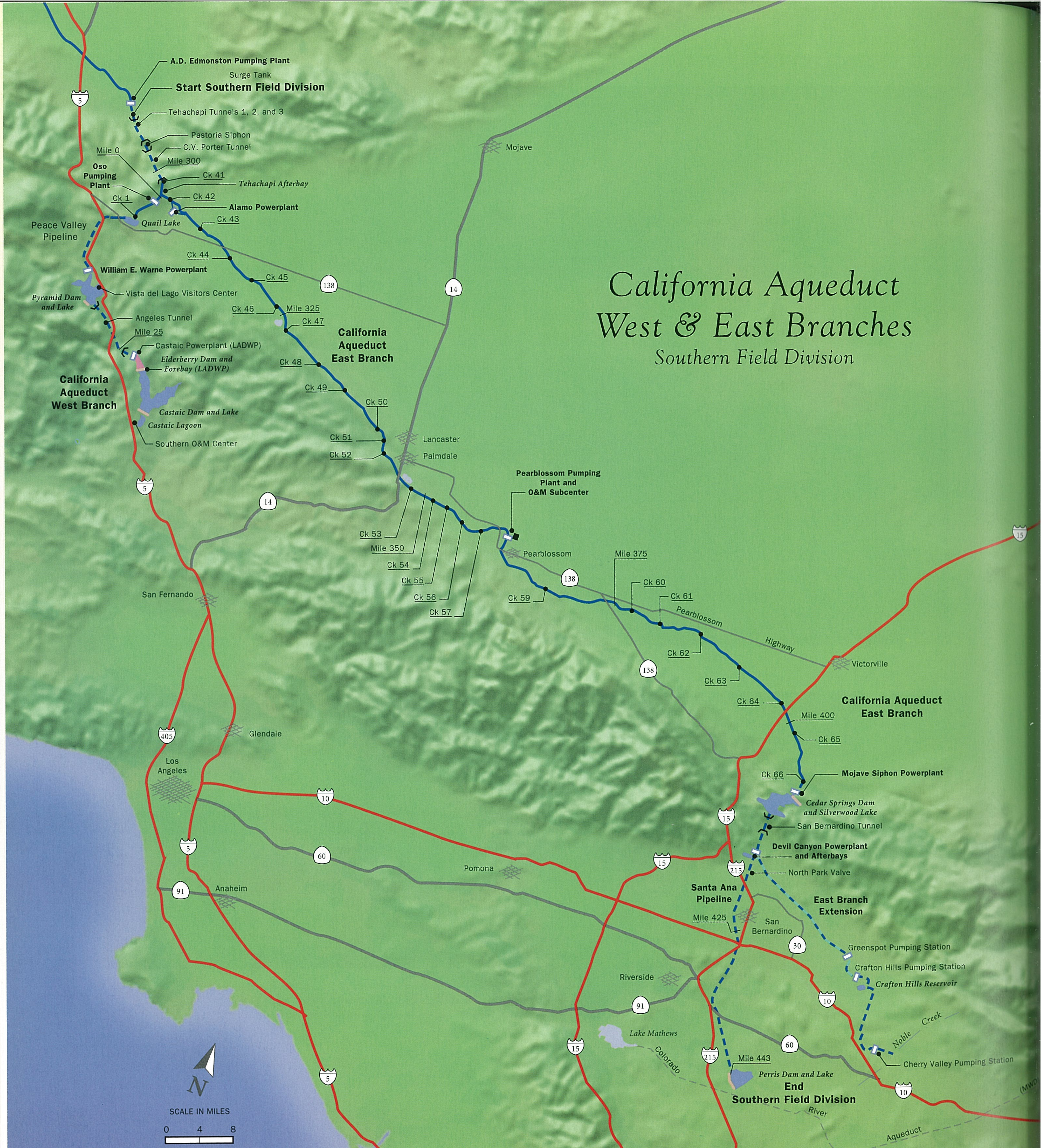


The Edmonston plant has 14 four-stage centrifugal pumps. The four-stage pump was designed as a single-lift pump, lifting water some 2,000 feet up the Tehachapi Mountain Range. The pumps are too massive to start by switching power directly to them. They must be started by two 35,000 hp motors that gradually transfer power to the pump units.

The plant's foundation rests on bedrock and is nearly 100 feet beneath the water surface when operational.



The steel-lined discharge line tunnels are 12.5 feet in diameter from the manifold to about midpoint (of its overall length), where it enlarges to 14 feet in diameter. Total length of each tunnel is about 8,400 feet.


California Aqueduct
West & East Branches
Southern Field Division
A.D. Edmonston Pumping Plant
Surge Tank
Start Southern Field Division
Tehachapi Tunnels 1, 2, and 3
Pastoria Siphon
C.V. Porter Tunnel
Mile 0
Mile 300
Oso Pumping Plant
Ck 41
Tehachapi Afterbay
Ck 1
Ck 42
Alamo Powerplant
Quail Lake
Ck 43
Peace Valley Pipeline
Ck 44
William E. Warne Powerplant
Ck 45
Pyramid Dam and Lake
Vista del Lago Visitors Center
Ck 46
Mile 325
Angeles Tunnel
Ck 47
Mile 25
Castaic Powerplant (LADWP)
Elderberry Dam and Forebay (LADWP)
California Aqueduct East Branch
Ck 48
California Aqueduct West Branch
Ck 49
Ck 50
Castaic Dam and Lake
Castaic Lagoon
Southern O&M Center
Ck 51
Ck 52
Lancaster
Palmdale
Mojave
Pearblossom Pumping Plant and O&M Subcenter
Ck 53
Mile 350
Ck 54
Ck 55
Ck 56
Ck 57
Pearblossom
Mile 375
Ck 59
Ck 60
Ck 61
Pearblossom Highway
Ck 62
Ck 63
Victorville
Ck 64
California Aqueduct East Branch
Mile 400
Ck 65
Ck 66
Mojave Siphon Powerplant
Cedar Springs Dam and Silverwood Lake
San Bernardino Tunnel
Devil Canyon Powerplant and Afterbays
North Park Valve
Santa Ana Pipeline
East Branch Extension
Mile 425
San Bernardino
Greenspot Pumping Station
Crafton Hills Pumping Station
Crafton Hills Reservoir
Noble Creek
Cherry Valley Pumping Station
Mile 443
Perris Dam and Lake
End Southern Field Division
Lake Mathews
Colorado River Aqueduct
(Mwd)
San Fernando
Glendale
Los Angeles
Pomona
Anaheim
Riverside
5
14
138
405
10
60
91
15
215
30
N
SCALE IN MILES
0 4 8

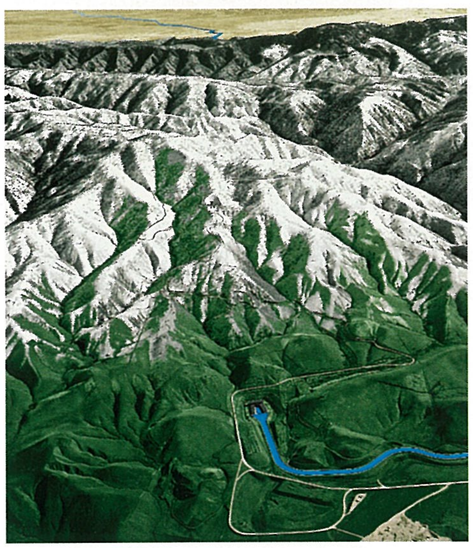
SOUTHERN FIELD DIVISION

Southern Field Division assumes responsibility as water enters the Tehachapi Tunnels to cross the mountain range then descends to Tehachapi Afterbay. The California Aqueduct then bifurcates into the West Branch and East Branch as it travels into the Southern California region. This section of the SWP serves the largest area of the state, including Los Angeles, Riverside, and San Bernardino counties.

The East Branch carries water through Antelope Valley, the San Bernardino Mountains, and terminates at Lake Perris near the city of Riverside. An East Branch extension will convey water to the east side of San Bernardino County. On the West Branch, water flows mainly within the area of the Angeles National Forest. Vista del Lago Visitors Center is located along the branch, which terminates at Castaic Lake.

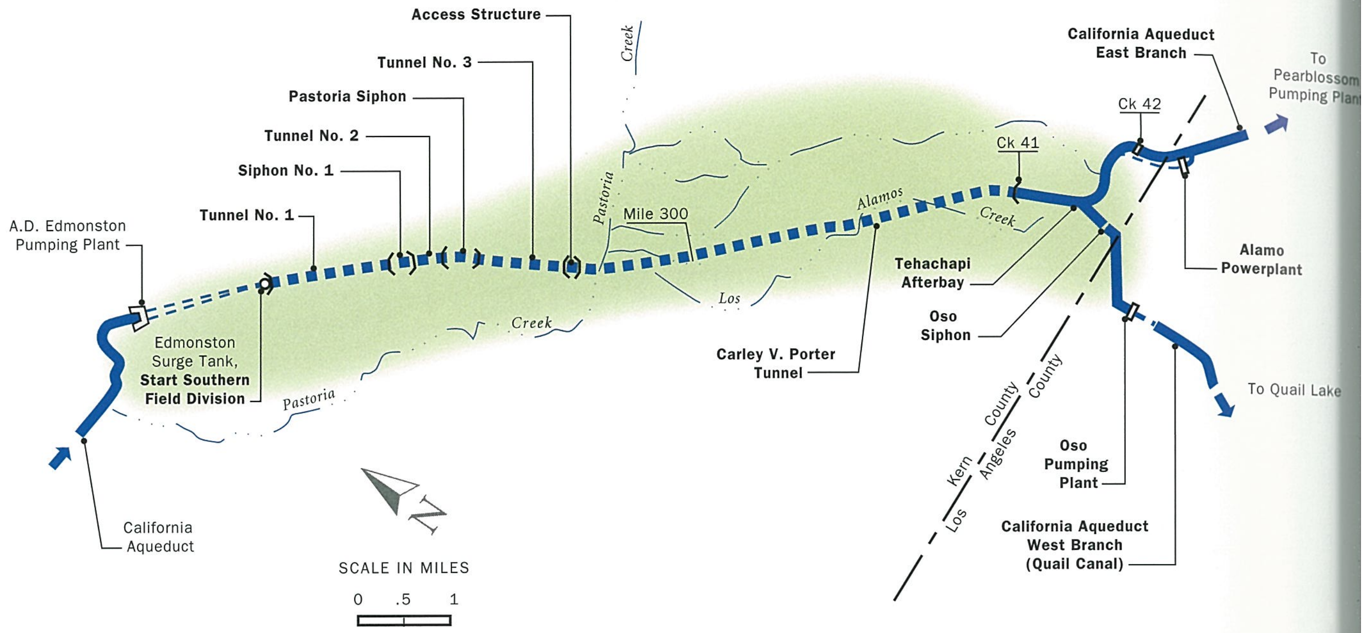
TEHACHAPI CROSSING

Four tunnels traverse the Tehachapi Mountains, a rugged, semiarid barrier between the San Joaquin Valley and Antelope Valley. Pipe conduits between portals connect the four tunnels which end at the Tehachapi Afterbay. Tunnel 1, just downstream of the surge chamber which receives water lifted by Edmonston Pumping Plant, is 7,933 feet long and connected to Tunnel 2 by 242 feet of cast-in-place concrete pipe. Tunnel 2 is 2,810 feet long and is connected across a canyon to the next tunnel by 2,580-foot-long Pastoria Creek Siphon, a steel-pipe siphon. Tunnel 3 is 5,709 feet long and connected to Tunnel 4 by 315 feet of cast-in-place concrete pipe designated the Beartrap Access Structure. The fourth and final tunnel, renamed the Carley V. Porter Tunnel, is 25,100 feet long and discharges water through a gated control structure into the Tehachapi Afterbay. The tunnels were constructed from 1964 to 1971.

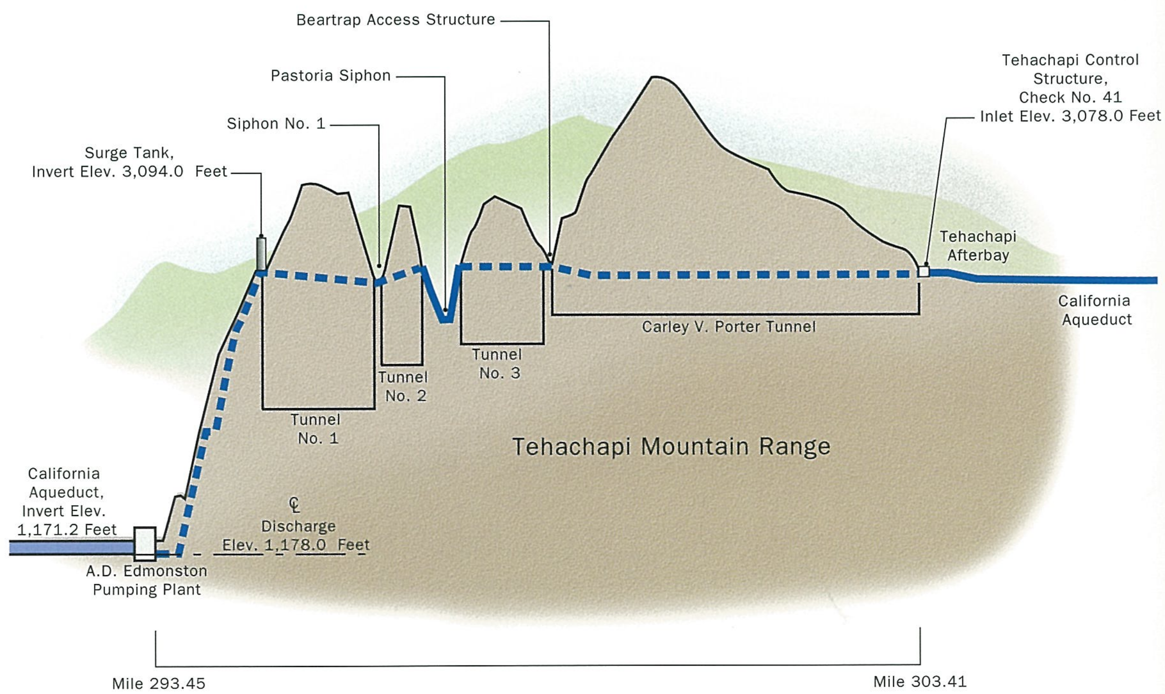


An aerial view of the Tehachapis with A.D. Edmonston Pumping Plant in the foreground.

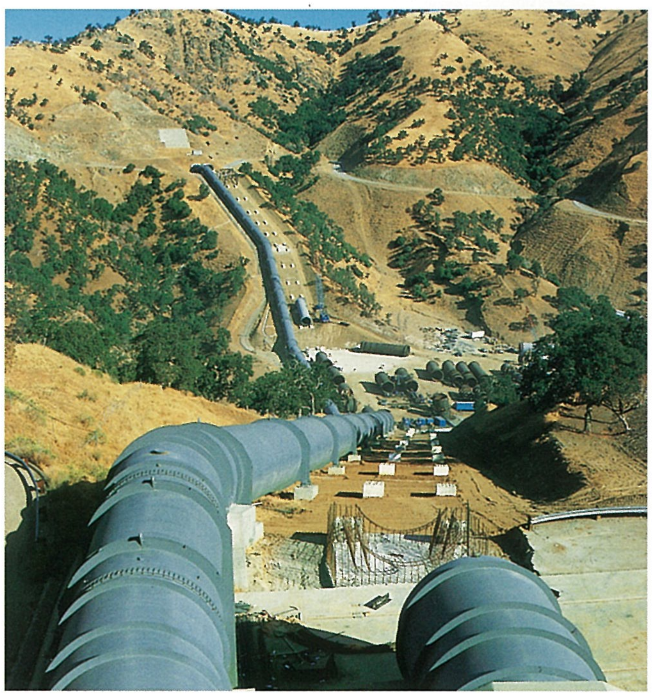
GENERAL PLAN



PROFILE



Above is an aerial view of the Pastoria Siphon.



The Pastoria Siphon was constructed across a canyon to connect Tunnel 2 to Tunnel 3. It was designed for two barrels, but the second one was not added until 1982.

Tunnel 1

Type: concrete-lined
Diameter. . . . . 23.5 feet
Capacity. . . . . 5,360 cfs

Siphon 1

Type: reinforced concrete pipe
Diameter. . . . . 23.5 feet
Capacity. . . . . 5,360 cfs

Tunnel 2

Type: concrete-lined
Diameter. . . . . 23.5 feet
Capacity. . . . . 5,360 cfs

Pastoria Siphon

First barrel
Type: steel pipe
Diameter . . . . 16 feet
Capacity. . . . . 2,580 cfs
Second barrel
Type: steel pipe
Diameter. . . . . 16 feet
Capacity. . . . . 2,580 cfs

Tunnel 3

Type: concrete-lined
Diameter. . . . . 23.5 feet
Capacity. . . . . 5,360 cfs

Beartrap Access Structure

Type: reinforced concrete pipe
Diameter. . . . . 20 feet
Capacity . . . . 5,360 cfs

Carley Porter Tunnel

Type: concrete-lined
Diameter . . . . 20 feet
Capacity. . . . . 5,360 cfs

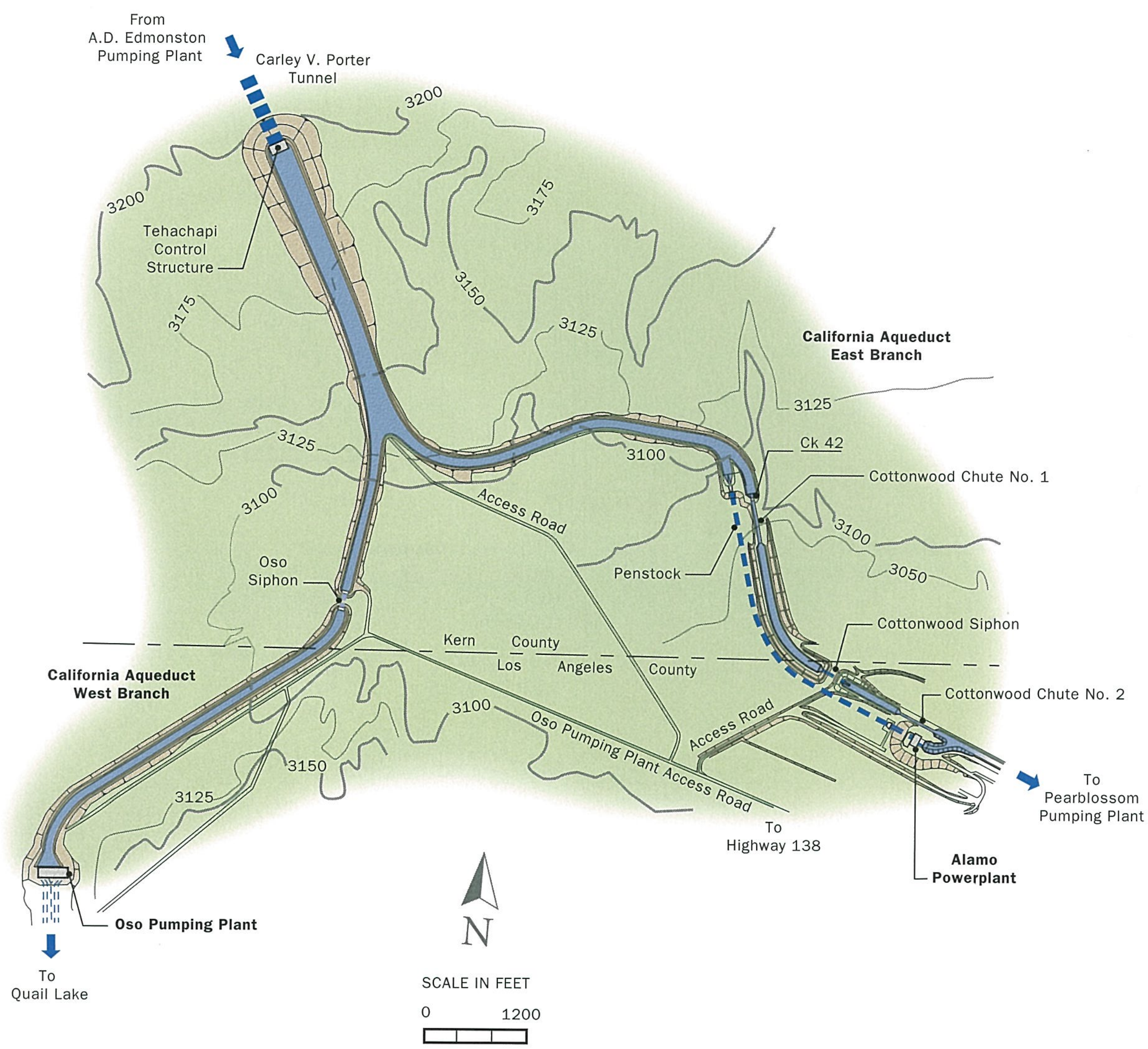
Following structural design concepts established by the Department, the tunnels were concrete-lined and pressure-grouted after the lining was in place. Flow regulation in the tunnels is minimal because the system is designed for gravity flow downstream of the surge tank and is governed only by the natural energy gradelines of the system. In this photo, a jumbo moves the tunnel lining into place.

Longest of the four tunnels, the Carley V. Porter Tunnel was excavated from both portals simultaneously with rock boring equipment. Three distinctive types of rock formations were bored, most of which were granite.

TEHACHAPI AFTERBAY

Located near the south portal of the Carley V. Porter Tunnel in Cottonwood Canyon, the afterbay includes the bifurcation of the California Aqueduct into the West and East Branches. It receives discharges from the tunnel through a gated control structure. The facility was constructed from 1970 to 1971.

GENERAL PLAN



Tehachapi Afterbay's impervious sublining on its bottom and sides protects the concrete lining from high groundwater back-pressures which can occur during the fluctuation of canal water levels.

AFTERBAY

Type: concrete-lined, trapezoidal canal
Length . . . . 2.9 miles
Maximum operating storage. . . . . . 550 acre-feet
Water surface elevation @ mos . . . . . 3,101 feet*
Water surface area @ mos . . . . 40 acres

**maximum operating storage*

West Branch Aqueduct

SWP water flows by gravity from Tehachapi Afterbay through Oso Siphon to Oso Pumping Plant. From there it is pumped into Quail Canal, which flows into Quail Lake. Water released from the lake travels through Lower Quail Canal and enters the Peace Valley Pipeline. The pipeline, serving as the penstock for Warne Powerplant, drops water about 725 feet through the plant's turbines to produce electricity. Water is discharged into Pyramid Lake then travels through the 7.2-mile Angeles Tunnel and into the turbines of Castaic Powerplant. Water leaving the plant enters Elderberry Forebay which, along with Pyramid Lake, is used for pumped-storage operations. From the forebay, water flows into Castaic Lake, which is the terminal reservoir of the West Branch. Located south of the lake, Castaic Lagoon provides recreation and serves as a recharge basin. The West Branch and its facilities were constructed between 1967 and 1982.

Canals

Type: 8.4 miles of concrete-lined, trapezoidal, checked

Capacity. . . . . 3,129 cfs

Water depth. . . . . 16.5, 16.7 and 38.3 feet

Side slope. . . 2:1 and varies (Lower Quail Canal)

Width. . . . . 24 feet (bottom)

Pipeline (Peace Valley)

Type: 5.5 miles of prestressed concrete cylinder pipe

Diameter. . . . . 12 feet

Capacity. . . . . 1,564 cfs

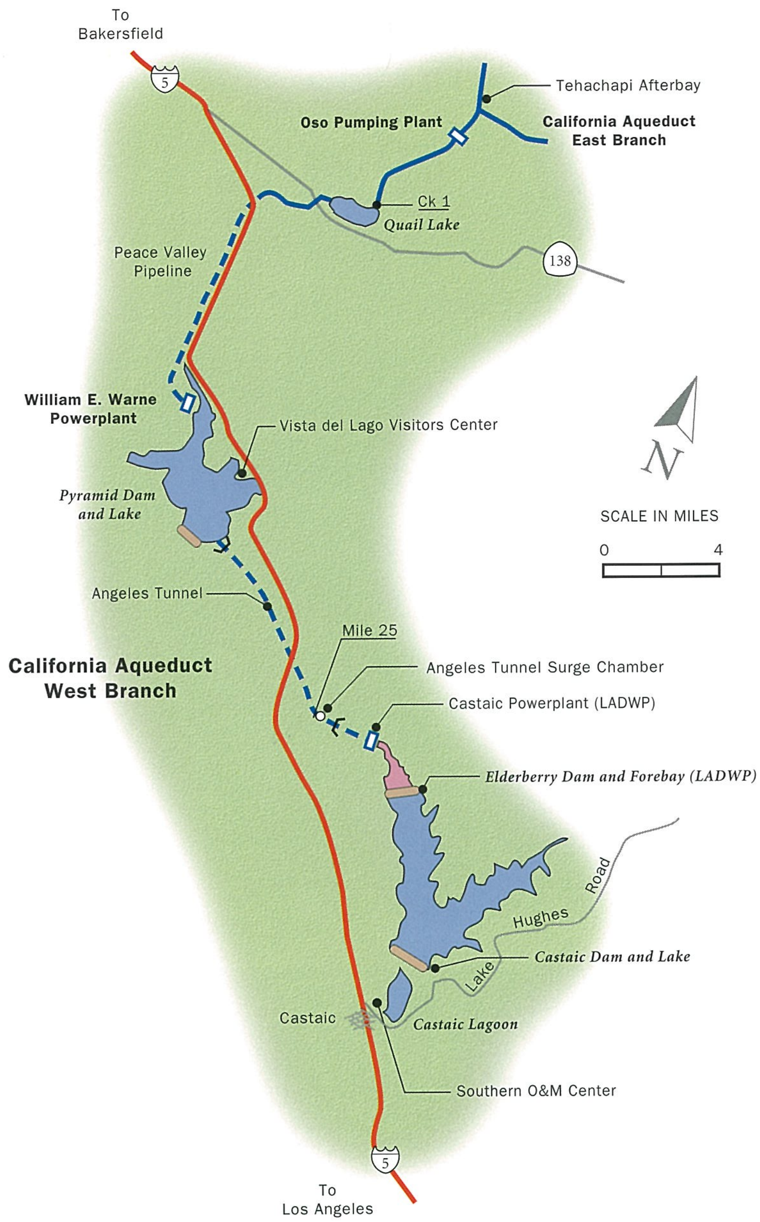
Tunnel (Angeles)

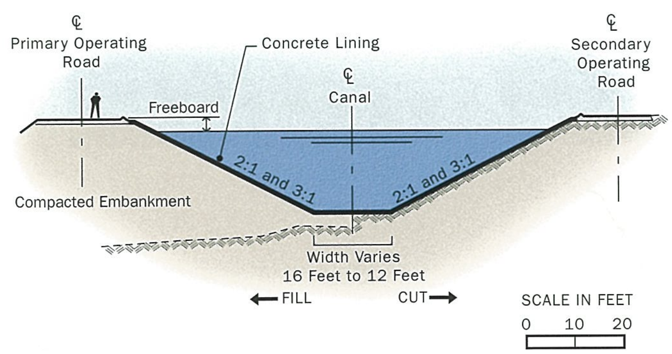
Type: 7.2 miles of concrete-lined

Diameter. . . . . 30 feet

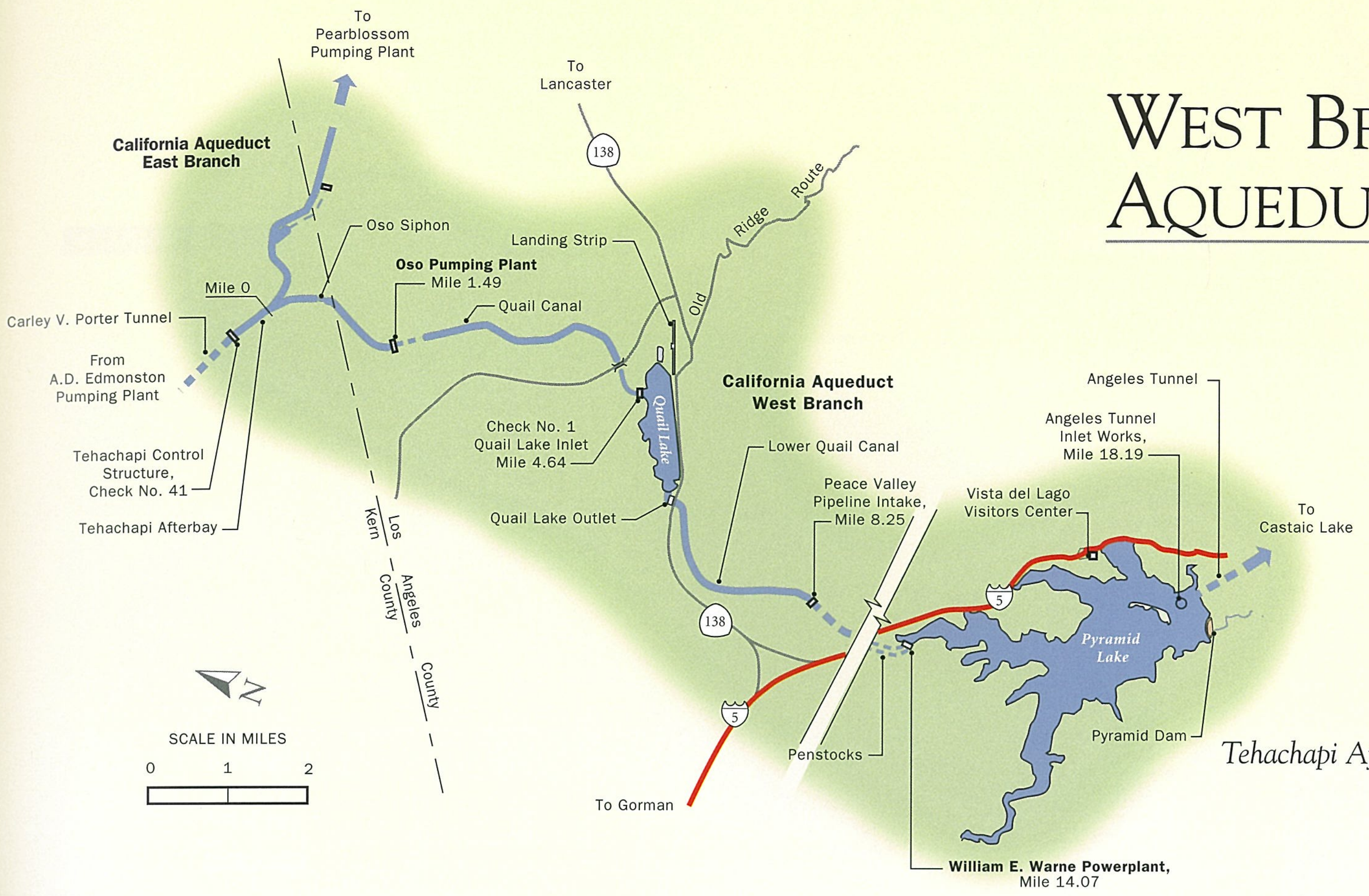
Capacity. . . . . 18,000 cfs

Aqueduct Map



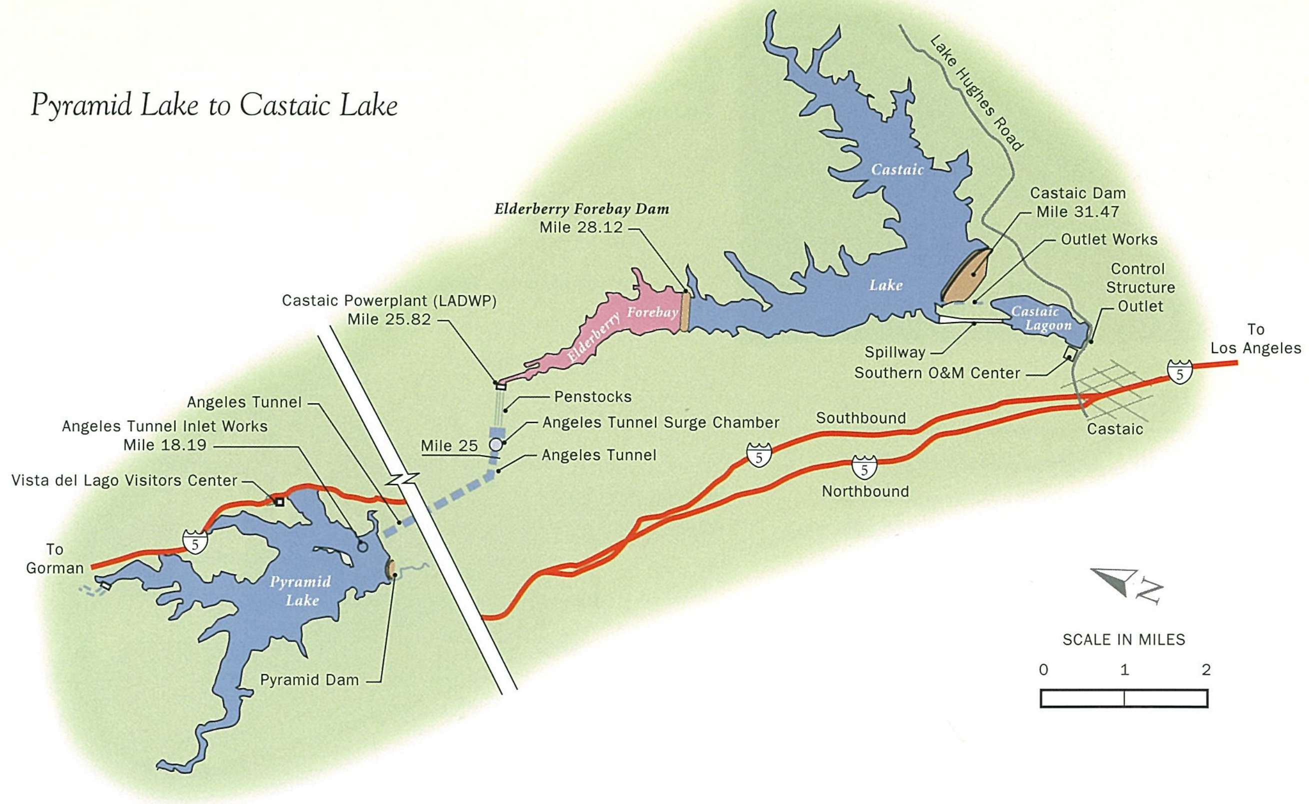


WEST BRANCH AQUEDUCT



Tehachapi Afterbay to Pyramid Lake

Pyramid Lake to Castaic Lake



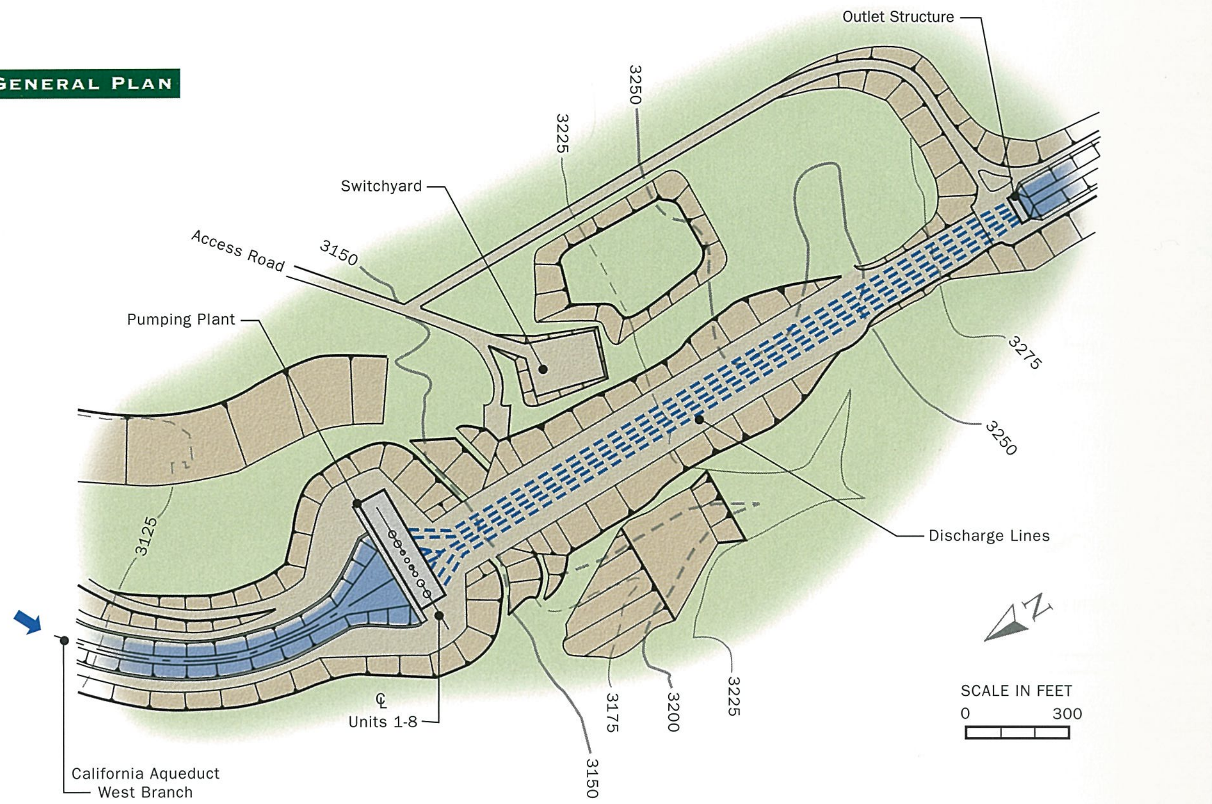
Oso Pumping Plant

Located on the California Aqueduct, about seven miles east of Gorman and 40 miles west-northwest of Lancaster, Oso Pumping Plant is the first major structure on the West Branch of the California Aqueduct. Constructed between 1967 and 1972, the plant lifts water 231 feet from Tehachapi Afterbay to Quail Canal which leads into Quail Lake.

Pumping

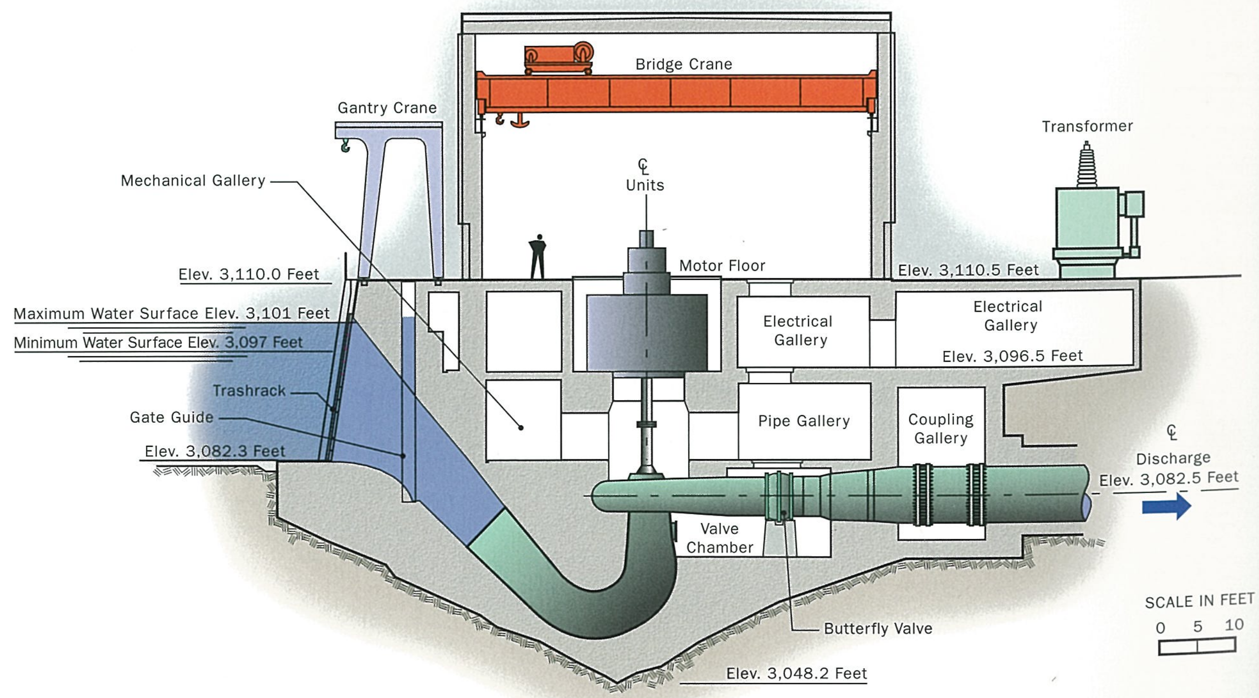
Installed capacity	*3,252 cfs, 93,800 hp*
Normal static head	*231 feet*
Design dynamic head	*4 @ 238 feet*
	4 @ 236 feet
Number of units	*8*
Unit size	*4 @ 645 cfs, 18,750 hp*
	4 @ 168 cfs, 4,700 hp
Discharge lines/diameter	*5 @ 9 feet*

General Plan



Oso Pumping Plant pumps are vertical-shaft, single-stage, double-volute, centrifugal type directly connected to synchronous motors.

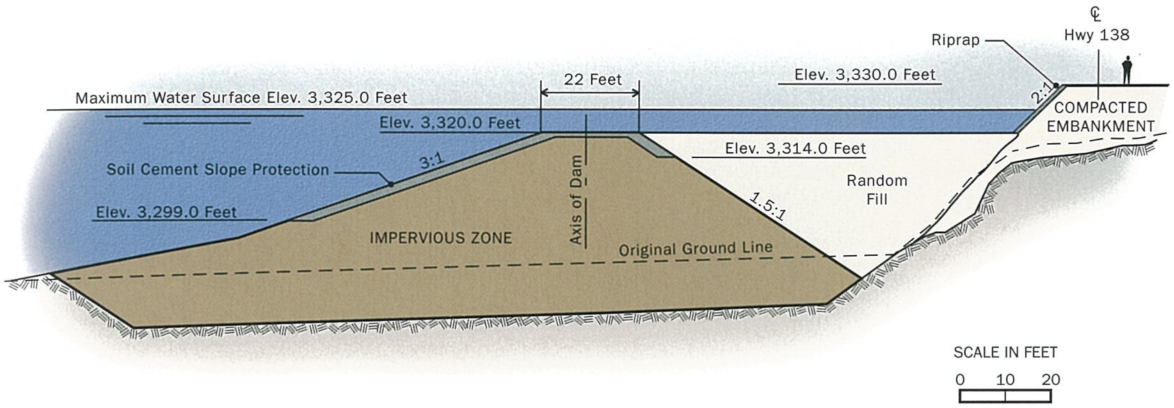
Transverse Section



QUAIL DAM & LAKE

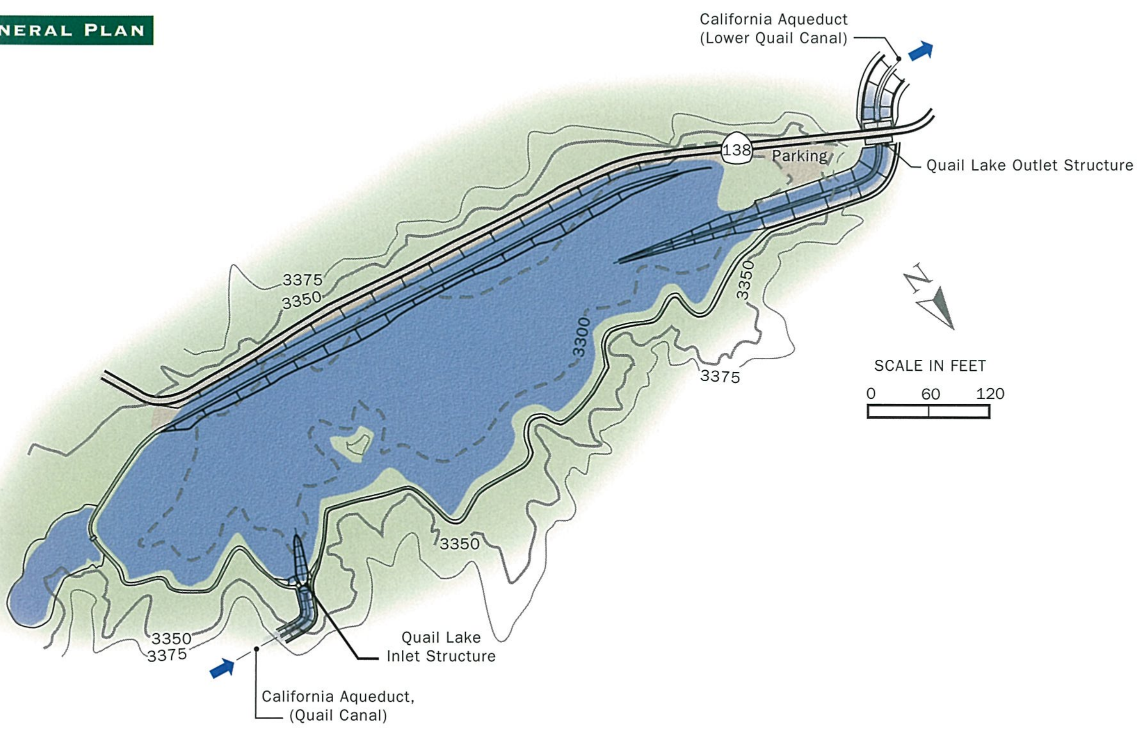
Quail Lake, originally a pond created by a cataclysmic movement of the San Andreas Fault ages ago, was enlarged to move water safely across the fault. It receives off-peak flows from Oso Pumping Plant and provides storage. The lake also provides limited recreation and fish and wildlife habitat in the Tejon Ranch area of the western Antelope Valley, about 45 miles northwest of Lancaster and 70 miles north of downtown Los Angeles. Construction of Quail Dam and Lake took place during 1967.

MAXIMUM SECTION



Quail Lake is used to balance the discharge of Oso Pumping Plant.

GENERAL PLAN



DAM

Type: homogeneous earthfill
Embankment volume.... 1,900,000 cubic yards
Height.......................... 45 feet
Crest length..................... 6,600 feet
Crest elevation.................. 3,330 feet

RESERVOIR

Maximum operating storage ... 7,580 acre-feet
Water Surface elevation @ mos..... 3,325 feet*
Water surface area @ mos.......... 290 acres
Shoreline @ mos.................... 3 miles

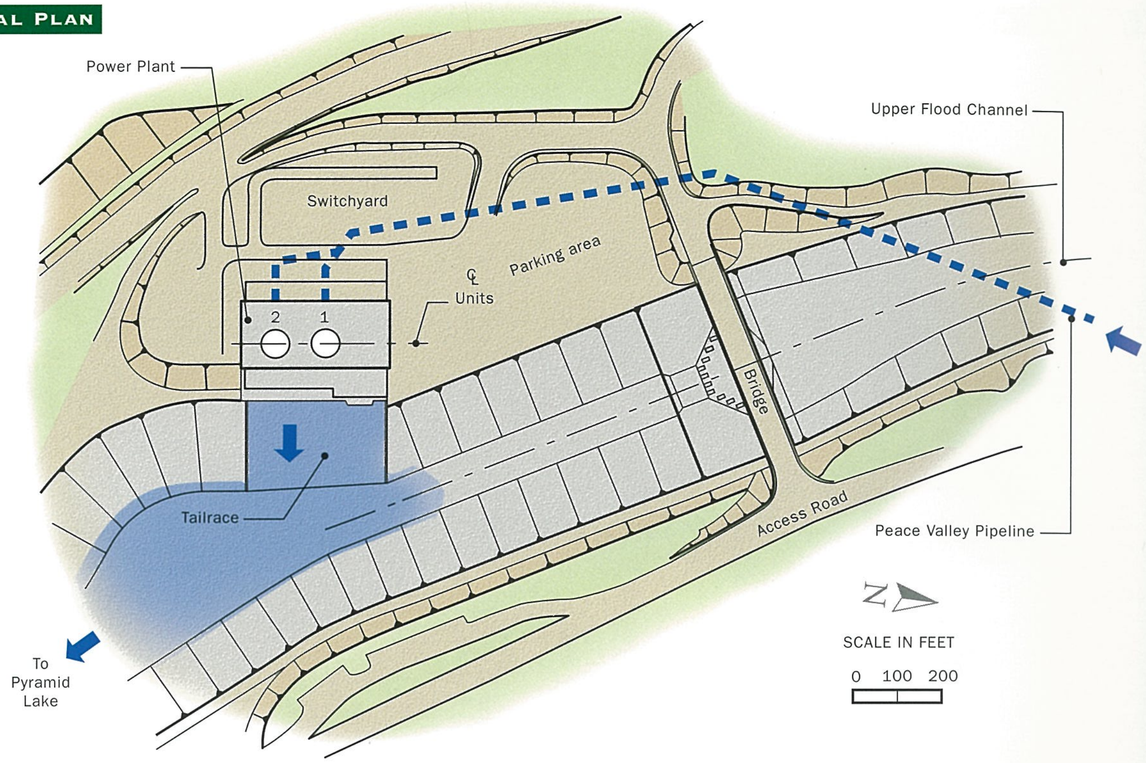
**maximum operating storage*

William E. Warne Powerplant

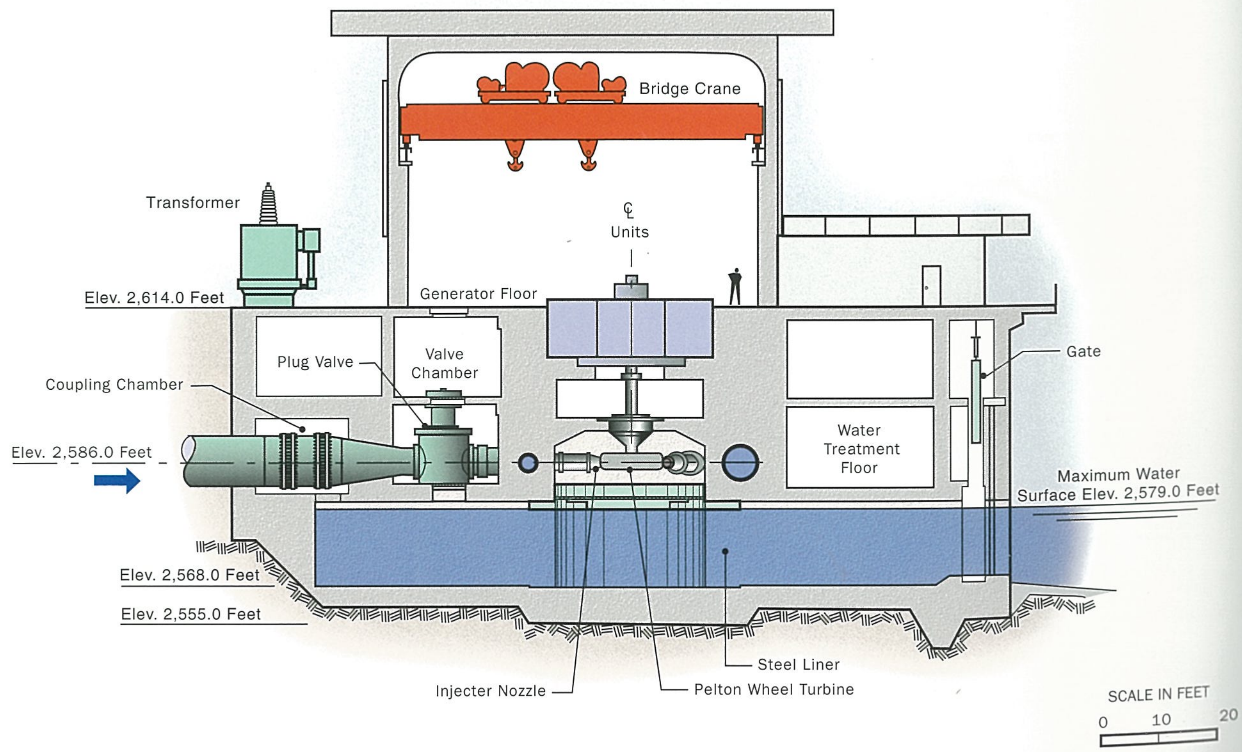
Warne Powerplant, in Los Angeles County near Pyramid Lake, recovers about 25 percent of the energy used by Edmonston Pumping Plant to lift water over the Tehachapis. The plant uses the 725-foot drop from the Peace Valley Pipeline to generate electricity with its Pelton wheel turbines. Construction on the plant began in 1978 and was completed in 1982.

Warne Powerplant was designed to eventually house two additional generators.

General Plan



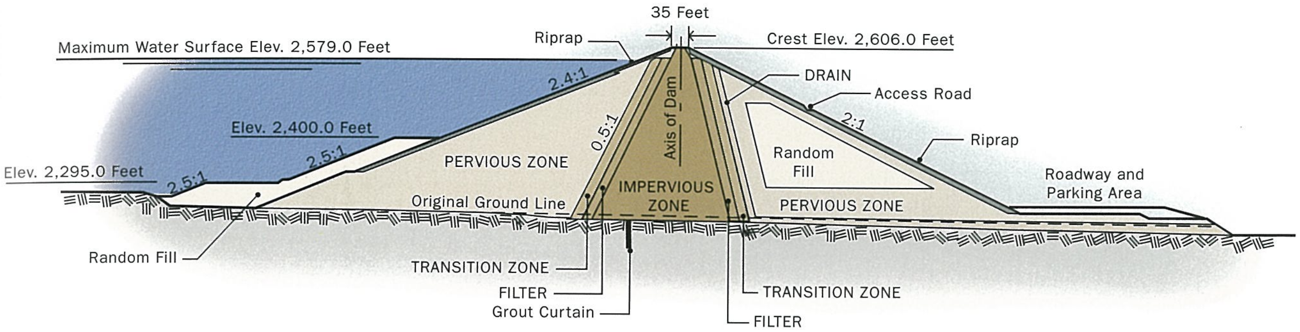
Transverse Section



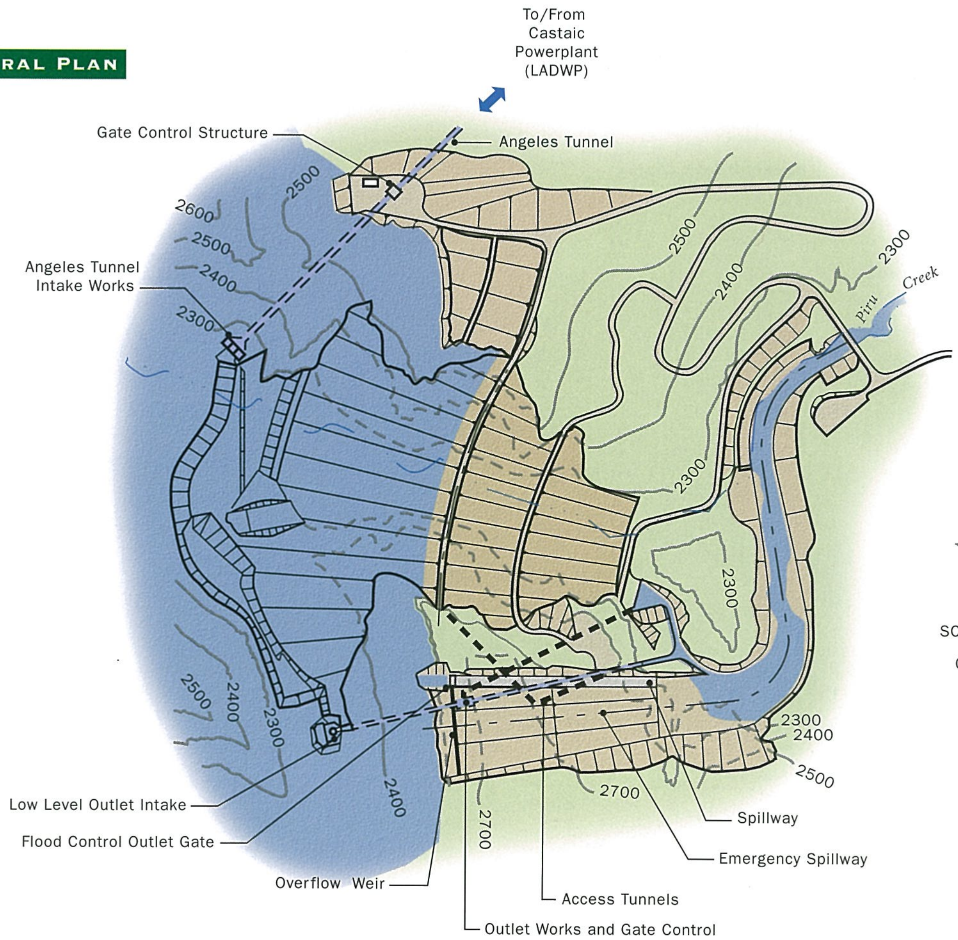
Generating

Installed capacity	*78.2 MVA, 1,564 cfs*
Normal static head	*719-739 feet*
Design dynamic head	*650 feet*
Number of units	*2*
Unit size	*2 @ 39.1 MVA, 782 cfs*
Penstock/diameter	*1 @ 12 feet*

Maximum Section



General Plan



Pyramid Dam & Lake

Pyramid Dam and Lake are located on Piru Creek near Pyramid Rock, about 14 miles north of the town of Castaic along Interstate Highway 5. The lake provides en route regulatory storage for Castaic Powerplant, serves as an afterbay for Warne Powerplant, affords emergency storage for deliveries from the West Branch, and is a recreational spot for Southern Californians. Construction on the dam and lake began in 1969 and was completed in 1973.

Pyramid Lake has two outlets: the Angeles Tunnel and a stream release facility.

Dam

Type: zoned earth and rockfill
Embankment volume . . . 6,860,000 cubic yards
Height. . . . . 400 feet
Crest length. . . . . 1,090 feet
Crest elevation . . . . 2,606 feet

Lake

Maximum operating storage . . . 171,200 acre-feet
Water surface elevation @ mos. . . . . 2,579 feet*
Water surface area @ mos . . . . 1,300 acres
Shoreline @ mos. . . . . 21 miles

**maximum operating storage*

Castaic Powerplant

Located about 40 miles northwest of Los Angeles between Pyramid Lake and Castaic Lake, Castaic Powerplant was built under a cooperative agreement between the Department of Water Resources and the Los Angeles Department of Water and Power. Unlike other facilities along the California Aqueduct, this pumping-generating plant is owned and operated by LADWP. The facility recovers power from the lift over the Tehachapis and has pumpback capability for peaking capacity. Construction began in 1969 and was completed in 1973.

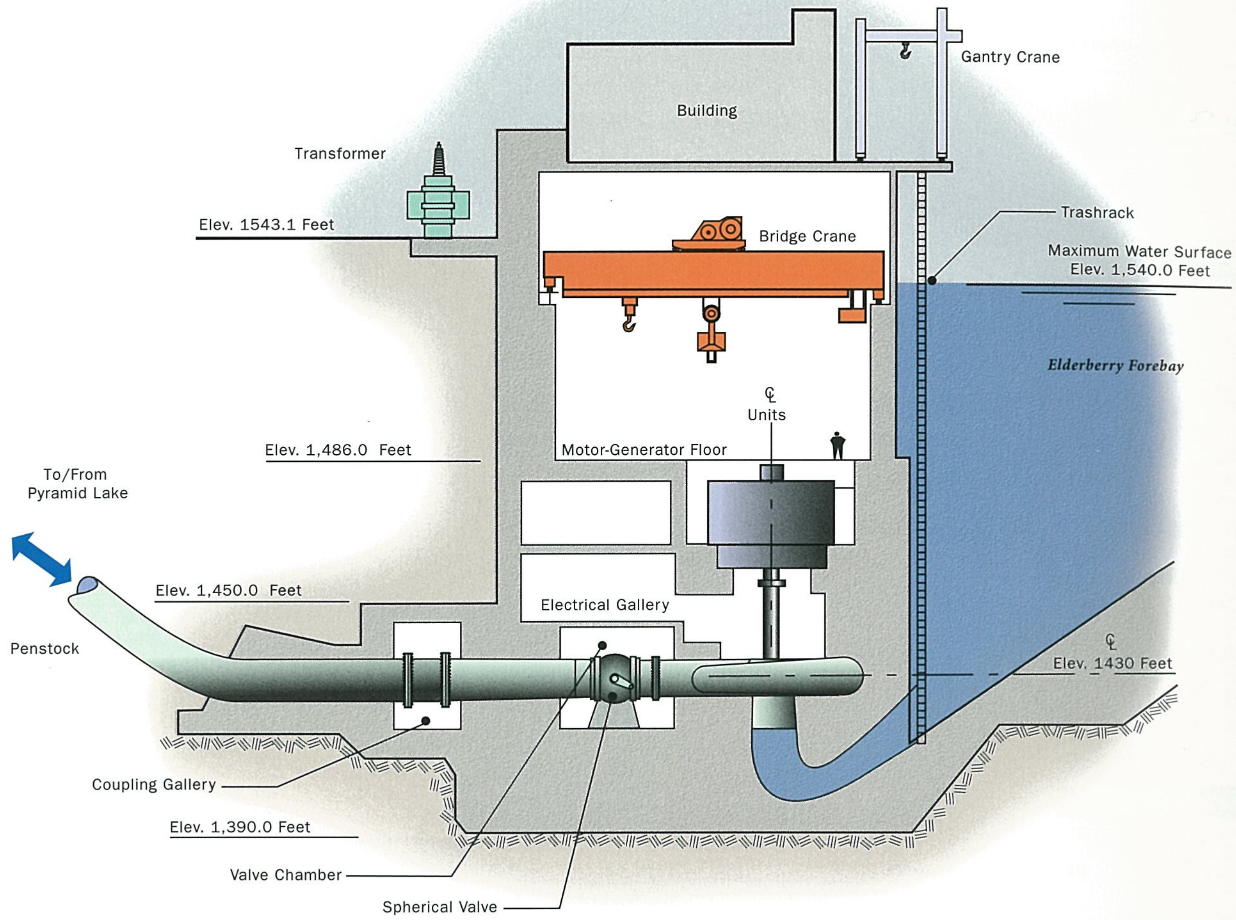
Pumping

Installed capacity. . . . . 12,000 cfs, 1,920,000 hp
Normal static head . . . . 1,078 feet
Design dynamic head . . . . 1,060-1,150 feet
Number of units . . . . 6 p/g
Unit size . . . . 6 @ 2,300 cfs, 320,000 hp

Generating

Installed capacity . . . . . 1,260 MVA, 17,840 cfs
Normal static head . . . . 1,048 feet
Design dynamic head . . . . 900-1,050 feet
Number of units. . . . . 7 (6 p/g, 1g)
Unit size . . . . 6 @ 210 MVA, 3,470 cfs
1 @ 59.7 MVA, 800 cfs
Penstock/diameter . . . . 6 @ 13.5 to 9 feet
1 @ 9 to 7 feet

Transverse Section

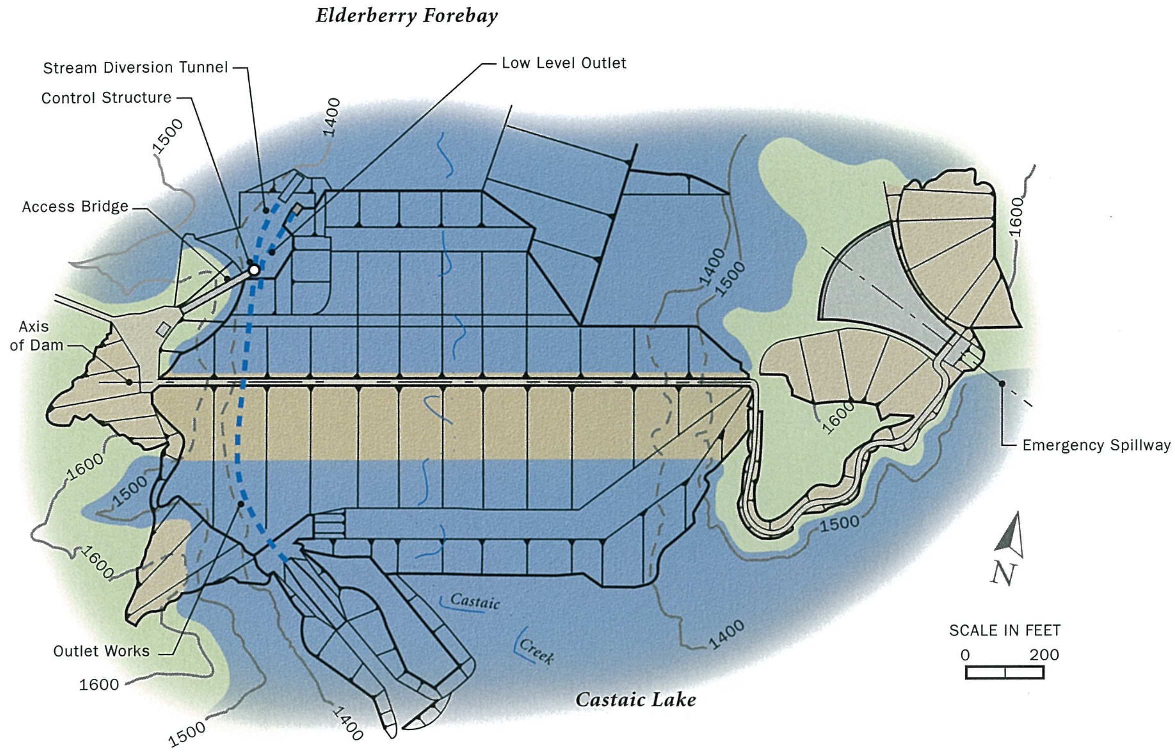


Castaic Powerplant generates electricity during peak hours and pumps water back into Pyramid Lake during off-peak hours.

ELDERBERRY FOREBAY & DAM

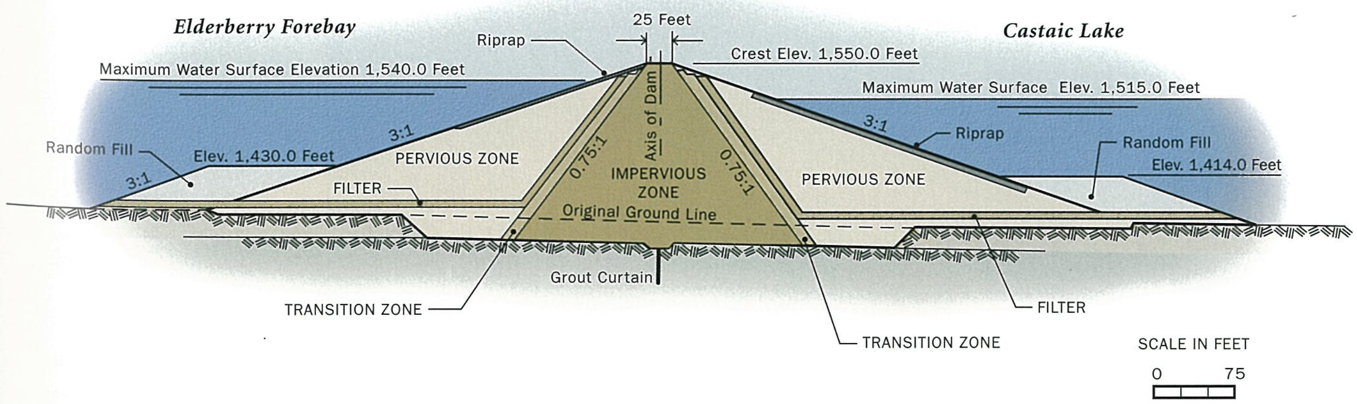
Elderberry Forebay, located on the upper end of Castaic Lake, provides regulatory storage which can be used by Castaic Powerplant for pumpback during off-peak hours, permits submergence for the pump-generator when the lake is at its lowest operating levels, and reduces daily and weekly fluctuations in Castaic Lake. The forebay was constructed between 1965 and 1974 by the Los Angeles Department of Water and Power, which also operates the facility.

GENERAL PLAN



Under normal operating conditions, the forebay is used to provide submergence for Castaic Powerplant's tailrace.

MAXIMUM SECTION



DAM

Type: zoned earthfill
Embankment volume . . . 6,000,000 cubic yards
Height . . . . 200 feet
Crest length . . . . 1,990 feet
Crest elevation . . . . 1,550 feet

FOREBAY

Maximum operating storage . . . 32,480 acre-feet
Water surface elevation @ mos . . . . 1,540 feet*
Water surface area @ mos . . . . 500 acres
Shoreline @ mos. . . . . 7 miles
**maximum operating storage*

Castaic Dam, Lake & Lagoon

Located about 45 miles northwest of Los Angeles and about two miles north of the community of Castaic, Castaic Dam and Lake were constructed (1965-74) to provide emergency storage during a shutdown of the California Aqueduct to the north, assuring deliveries from the West Branch. It also acts as regulatory storage for deliveries during normal operations and provides recreation for Southern California.

Castaic Lagoon, originally a borrow area for construction of the dam, also provides recreation and serves as a recharge basin for downstream groundwater aquifers.

Dam

Type: zoned earthfill
Embankment volume . . . . 46,000,000 cubic yards
Height . . . . 425 feet
Crest length . . . . 4,900 feet
Crest elevation . . . . 1,535 feet

Lake

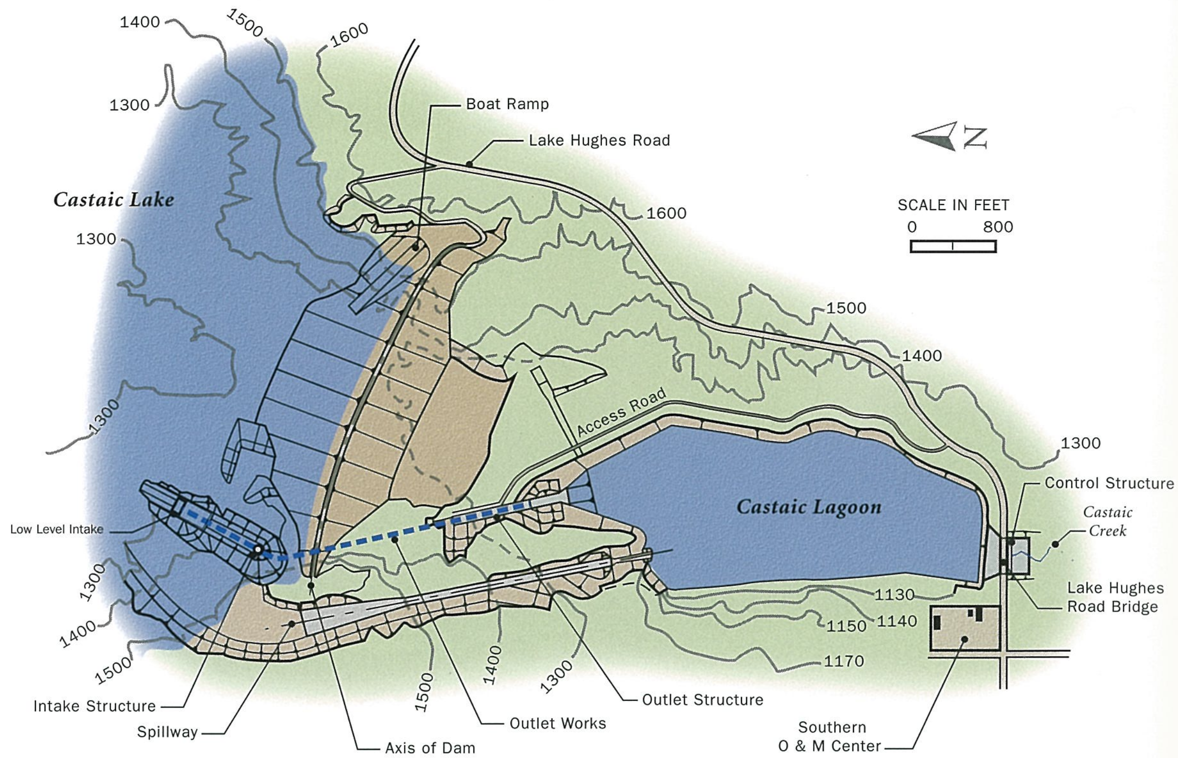
Maximum operating storage . . . 323,700 acre-feet
Water surface elevation @ mos . . . . . 1,515 feet*
Water surface area @ mos . . . . 2,240 acres
Shoreline @ mos . . . . 29 miles

Lagoon

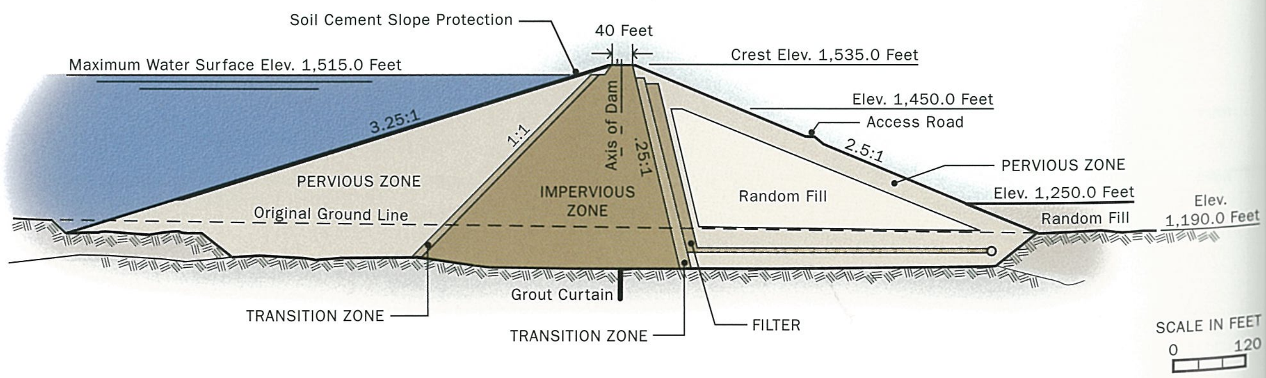
Maximum operating storage . . . 5,560 acre-feet
Water surface elevation @ mos . . . . 1,135.5 feet
Water surface area @ mos . . . . 200 acres
Shoreline @ mos . . . . 3 miles

**maximum operating storage*

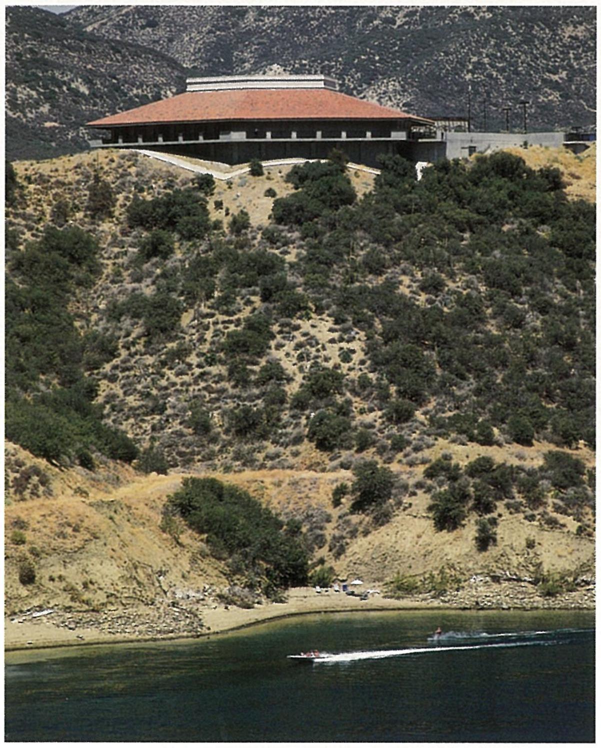
General Plan



Maximum Section



An aerial view of Castaic Lagoon (bottom), Castaic Lake (center), and Elderberry Forebay (top left).



The 18,500-square-foot Vista del Lago Visitors Center sits on a bluff overlooking Pyramid Lake. Located 60 miles north of downtown Los Angeles, the center houses exhibits featuring water's role in our daily lives and the importance of the State Water Project.

Castaic Lake/Lagoon is a popular recreation destination for Southern Californians.

East Branch Aqueduct

Starting at the bifurcation at Tehachapi Afterbay, water in the East Branch drops about 140 feet through Alamo Powerplant to generate electricity. Water then travels 55 miles to Pearblossom Pumping Plant, where it is lifted 540 feet. From there, water flows downhill through an open aqueduct, linked at its end to four underground pipelines which carry the water under the Mojave River bed and the Las Flores Valley floor into Mojave Siphon Powerplant to generate power before entering Silverwood Lake. Released from the lake, water passes through the San Bernardino Tunnel and plunges more than 1,400 feet through two penstocks into Devil Canyon Powerplant, where it generates power before being discharged into its afterbays. The afterbays supply water to contracting agencies and flow through the buried Santa Ana Pipeline to Lake Perris, the SWP's southernmost terminus reservoir. Water from Devil Canyon will eventually supply water to the East Branch Extension.

Canals:

Type: 93.4 miles of concrete-lined, trapezoidal, checked

Capacity .... varies from 2,630 to 2,880 cfs
Water depth ..... varies, from 15.5 to 17.4 feet
Side slope..................... 2:1 and 3:1
Width.............. 12 and 16 feet (bottom)

Tunnel (San Bernardino)

Type: 3.8 miles of concrete-lined
Diameter.............. 12.75 and 13.0 feet
Capacity....................... 2,811 cfs

Pipeline (Santa Ana)

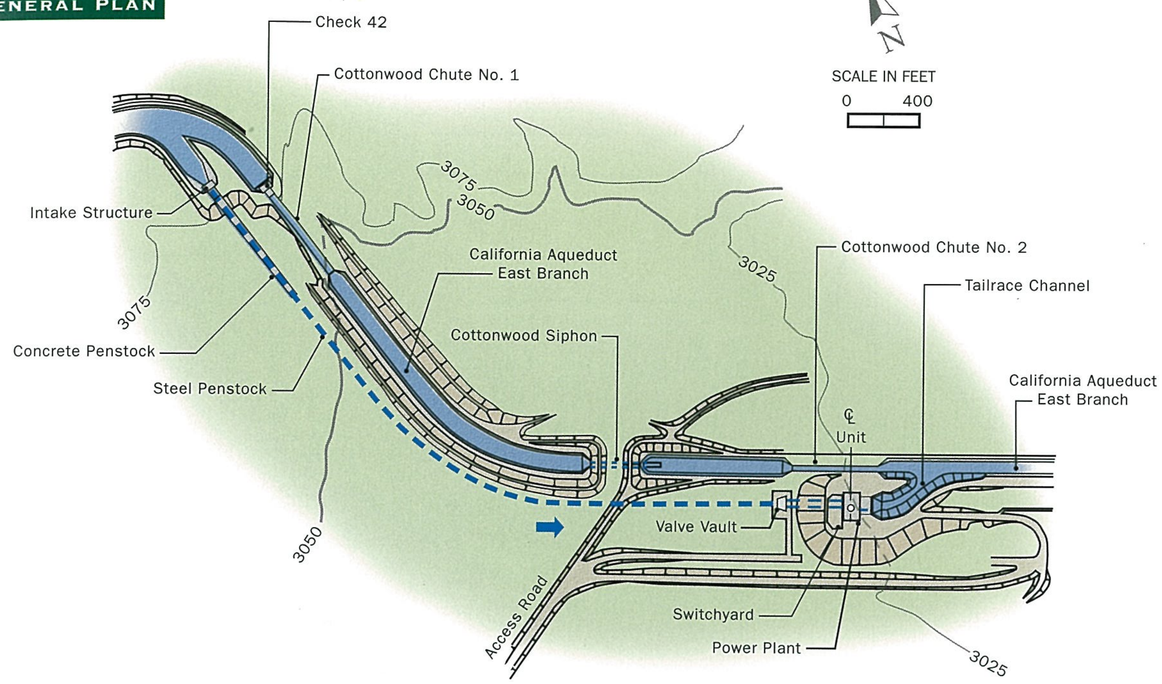
Type: 28.1 miles of prestressed concrete cylinder
Diameter........... varies from 9 to 10 feet
Capacity.................. 585 and 520 cfs

Aqueduct Map

Alamo Powerplant

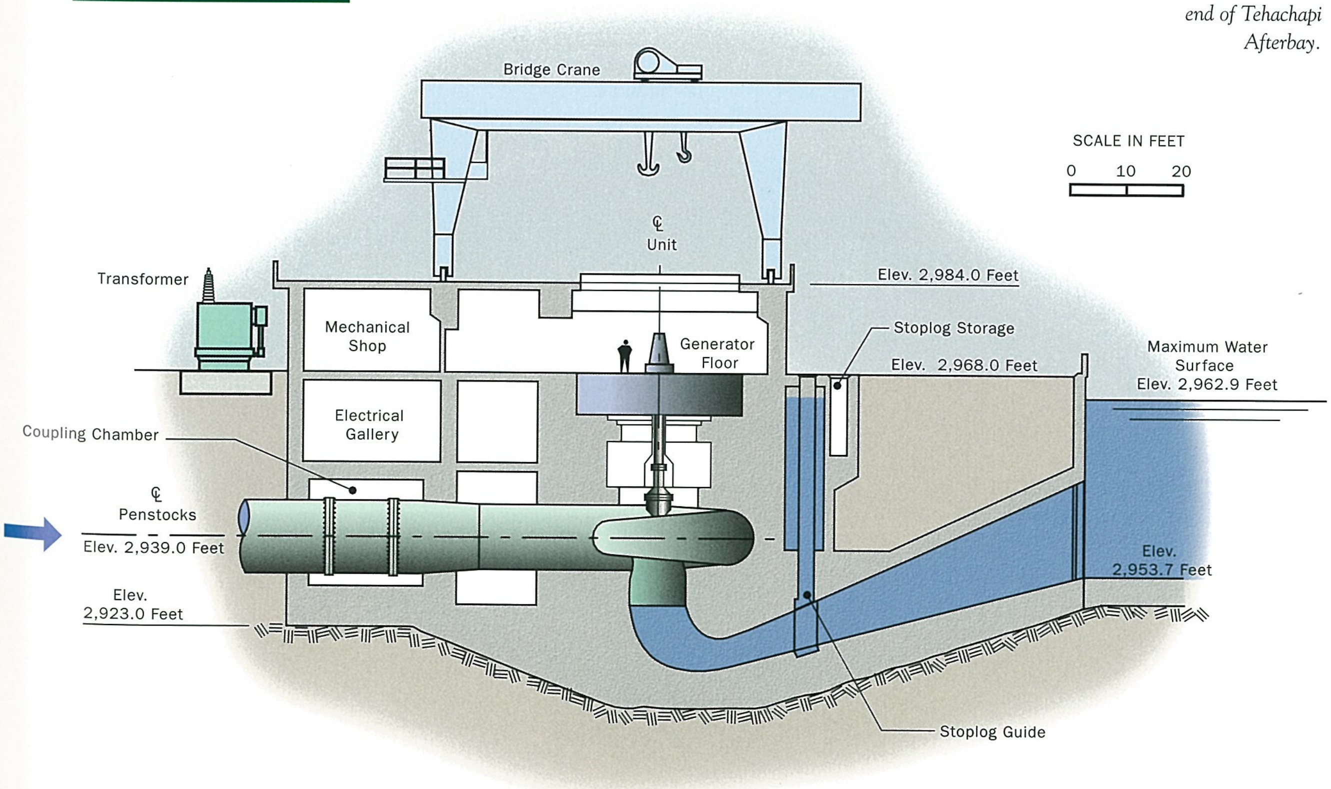
Located on the East Branch of the California Aqueduct, Alamo Powerplant lies approximately 10 miles east of the town of Gorman on the Kern-Los Angeles County line. It was constructed between 1982 and 1985, with the first of two planned units operational by 1986. The power plant uses the 133-foot head between Tehachapi Afterbay and Pool 43 of the California Aqueduct to generate electricity. This operation takes place in conjunction with scheduled water deliveries.

General Plan



Alamo Powerplant's intake structure is located at the lower end of Tehachapi Afterbay.

Transverse Section



Generating

Installed capacity	*18 MVA, 1,740 cfs*
Normal static head	*115-141 feet*
Design dynamic head	*118 feet*
Number of units	*1*
Unit size	*1 @ 18 MVA, 1,740 cfs*
Penstock/diameter	*1 @ 12 feet*

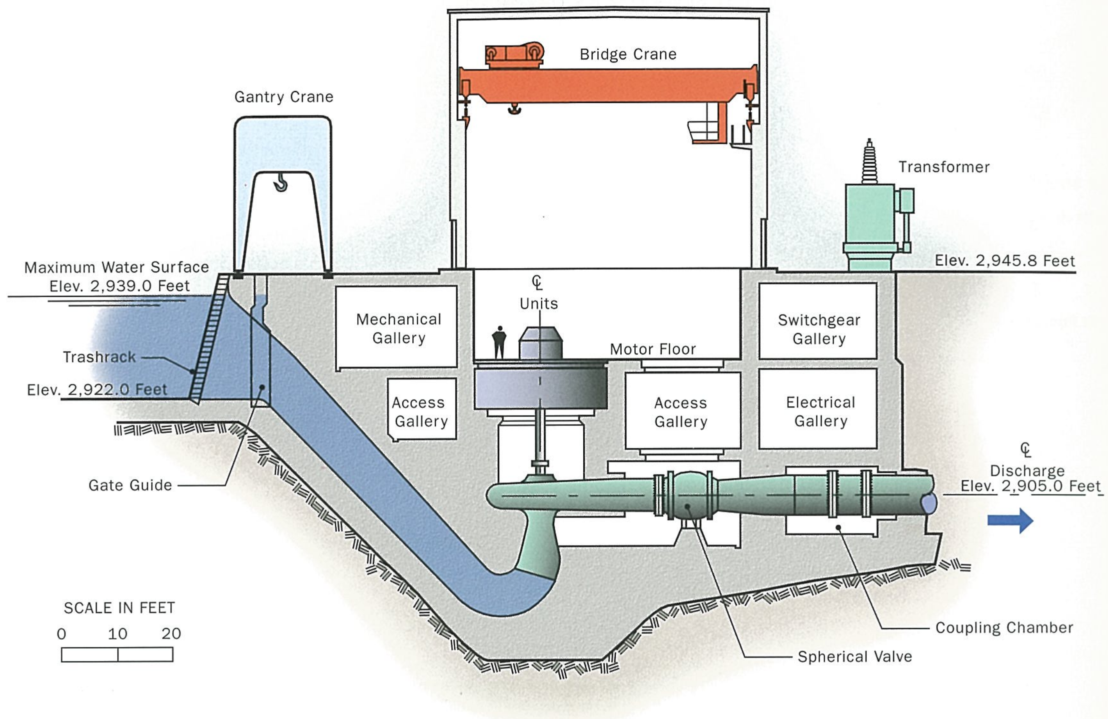
Pearblossom Pumping Plant

Pearblossom Pumping Plant is located on the California Aqueduct, about 25 miles from the city of Lancaster and 12 miles east of the town of Palmdale. Constructed from 1967 to 1973, the plant lifts water about 540 feet to continue by gravity to Silverwood Lake. Pearblossom discharges water 3,479 feet above sea level, the highest point along the entire California Aqueduct.

Pumping

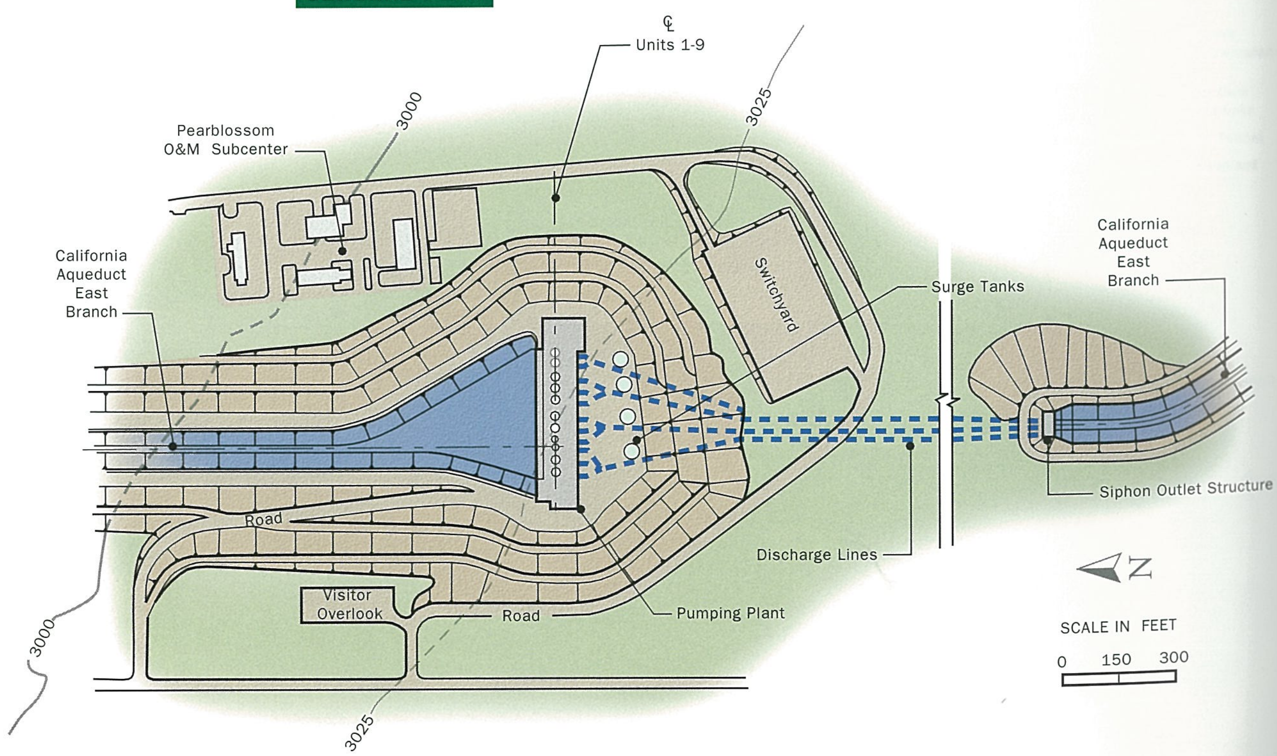
Installed capacity	*2,575 cfs, 203,200 hp*
Normal static head	*540 feet*
Design dynamic head	*569 feet*
Number of units	*9*
Unit size	*4 @ 290 cfs, 22,500 hp*
	2 @ 145 cfs, 11,600 hp
	3 @ 375 cfs, 30,000 hp
Discharge lines/diameter	*2 @ 9 feet*
	1 @ 13 feet

Transverse Section



Three pumps were added at the Pearblossom plant during the East Branch Enlargement Project.

General Plan

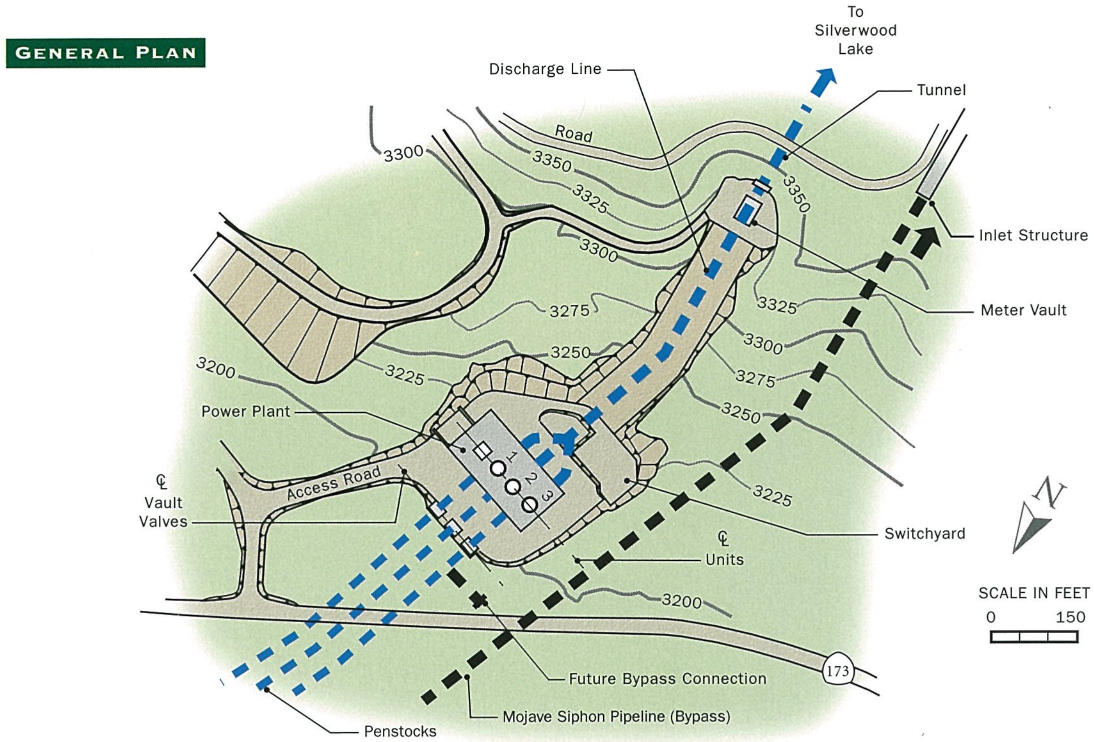


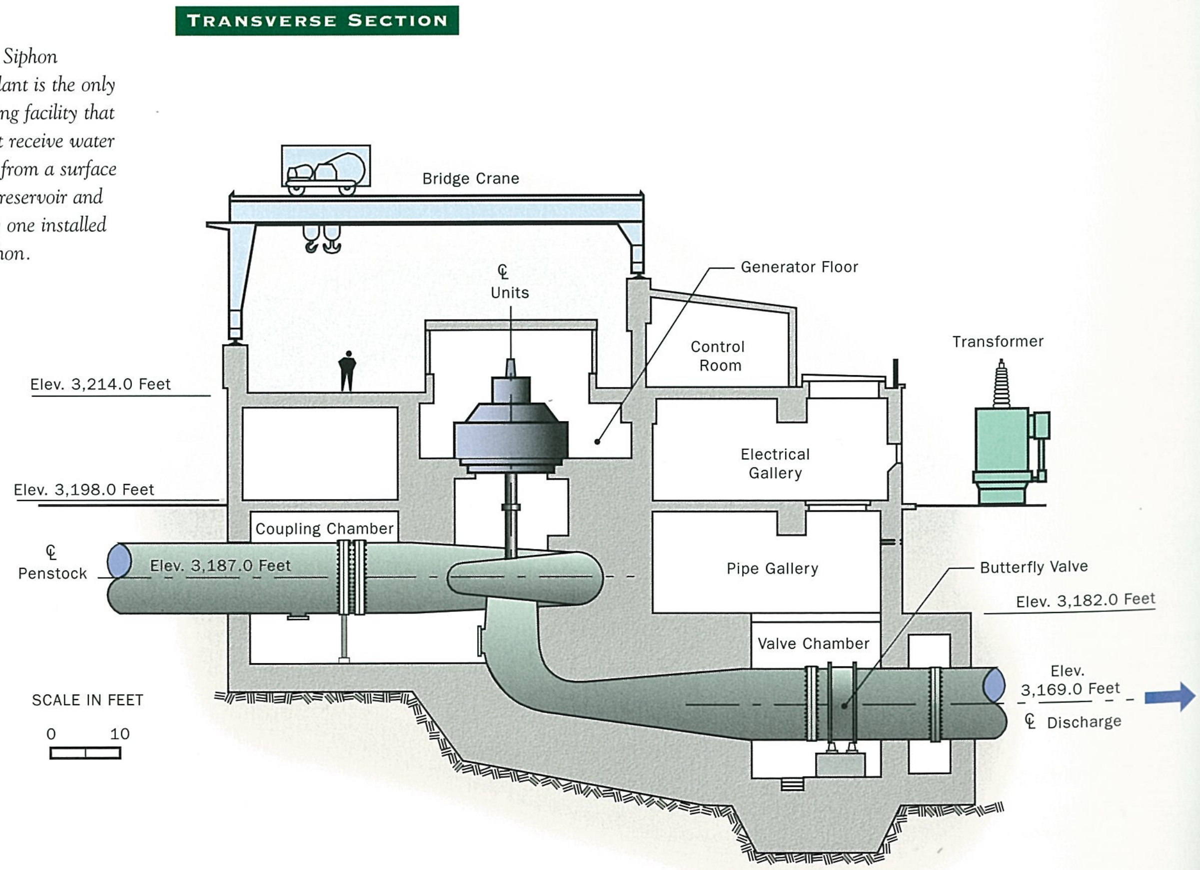
Mojave Siphon Powerplant

Mojave Siphon Powerplant, constructed between 1990 and 1996, is the newest SWP power plant. It generates electricity from water flowing downhill after its 540-foot lift by Pearblossom Pumping Plant. Water travels down the open aqueduct until it reaches Check 66, where it enters three underground pipelines. These carry the water under the Mojave River bed and the Las Flores Valley floor. The pipelines convey water through the power plant before entering Silverwood Lake. The plant is situated near Silverwood Lake's Cedar Springs Dam.

Generating

Installed capacity . . . . 34.5 MVA, 2,880 cfs
Normal static head. . . . . 81-136 feet
Design dynamic head. . . . . 106 feet
Number of units 3
Unit size. . . . . 3 @ 11.5 MVA, 960 cfs
Penstocks/diameter . . . . 3 @ 12 to 10 feet



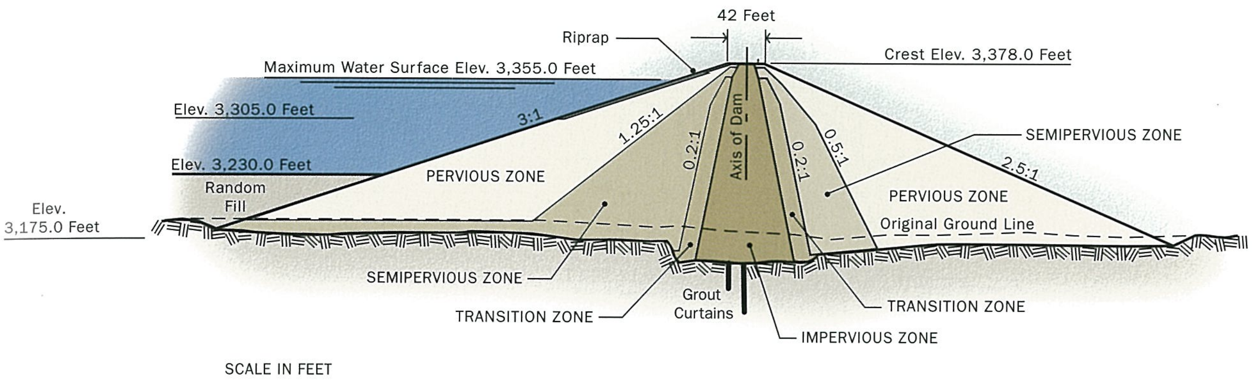


Mojave Siphon Powerplant is the only generating facility that does not receive water directly from a surface storage reservoir and the only one installed in a siphon.

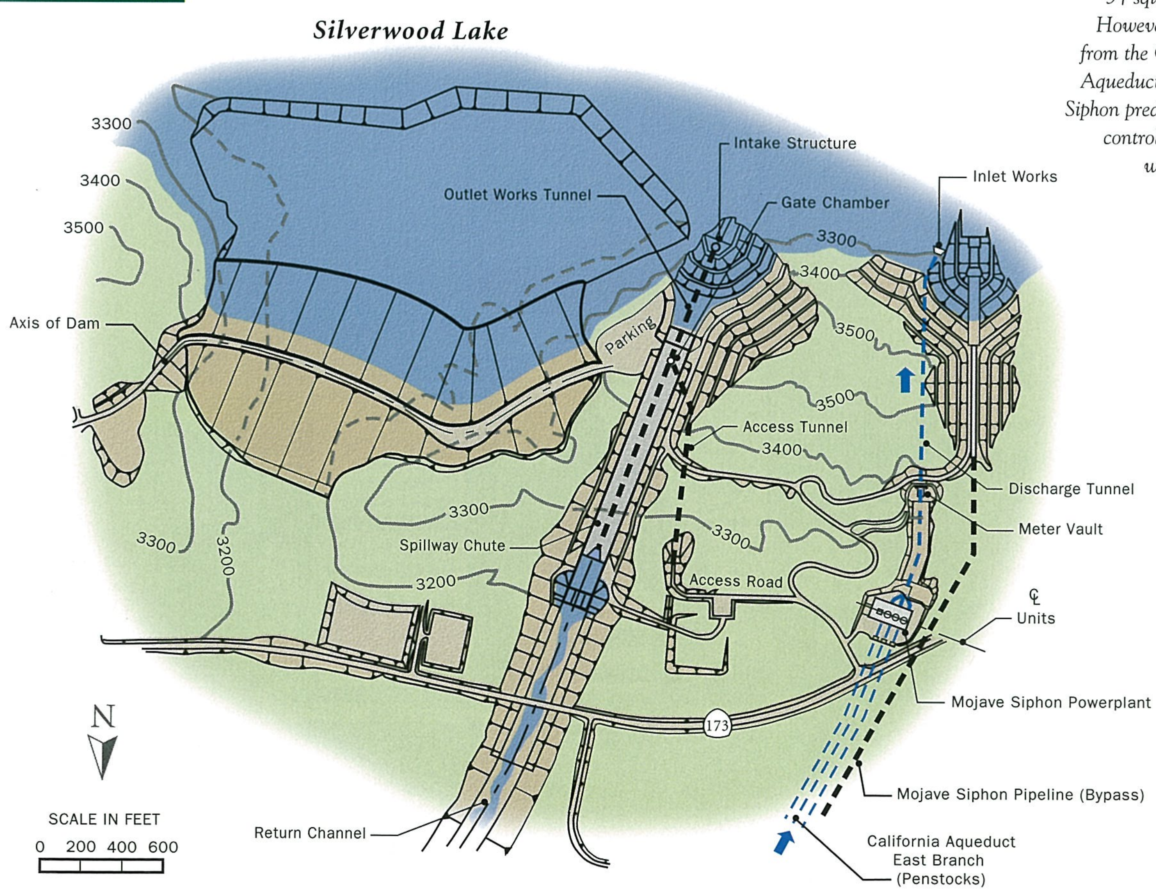
Cedar Springs Dam & Silverwood Lake

Out of the four SWP reservoirs in Southern California, Silverwood Lake is the highest at an elevation of 3,355 feet. Located about 30 miles north of the city of San Bernardino on the West Fork of Mojave River, the lake was constructed (1968 to 1971) to provide regulatory and emergency storage, help firm deliveries to users along the East Branch, provide recreation, and assure continuity of discharges through Devil Canyon Powerplant.

Maximum Section



General Plan



Silverwood Lake's drainage area covers 34 square miles. However, inflows from the California Aqueduct's Mojave Siphon predominately control the lake's water level.

Dam

Type: zoned earth and rockfill
Embankment volume . . . . 7,600,000 cubic yards
Height . . . . 249 feet
Crest length . . . . 2,230 feet
Crest elevation . . . . 3,378 feet

Lake

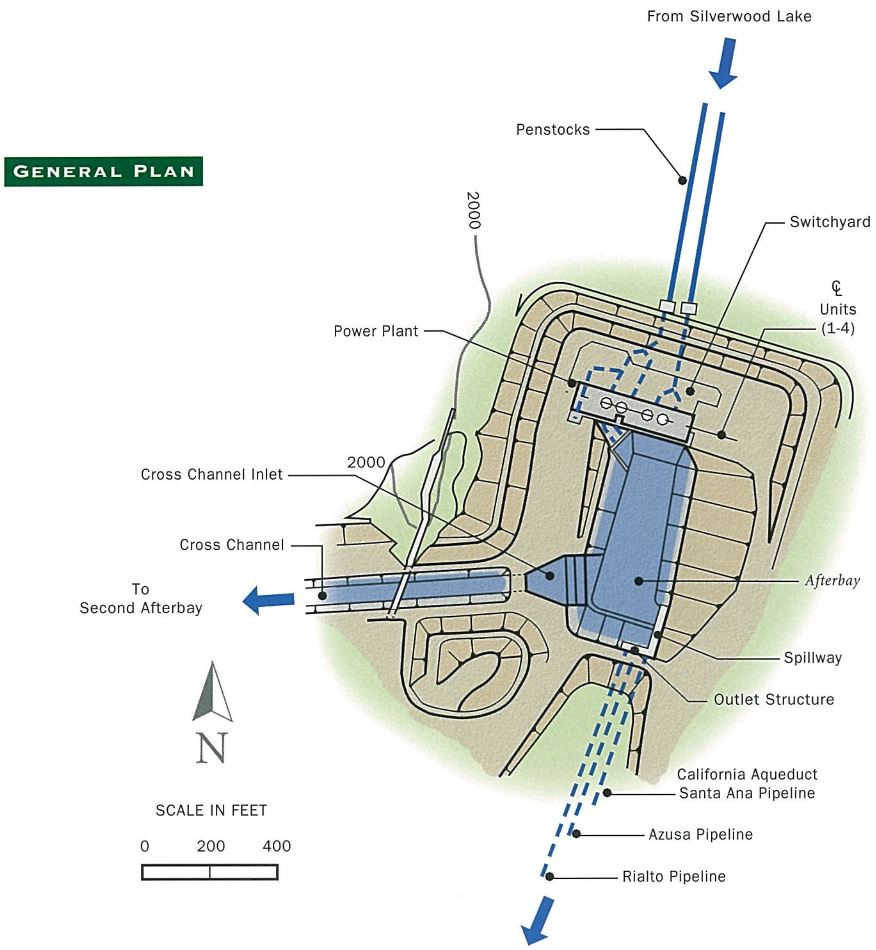
Maximum operating storage . . . . 74,970 acre-feet
Water surface elevation @ mos . . . . . 3,355 feet*
Water surface area @ mos . . . . 980 acres
Shoreline @ mos . . . . 13 miles
**maximum operating storage*

Devil Canyon Powerplant

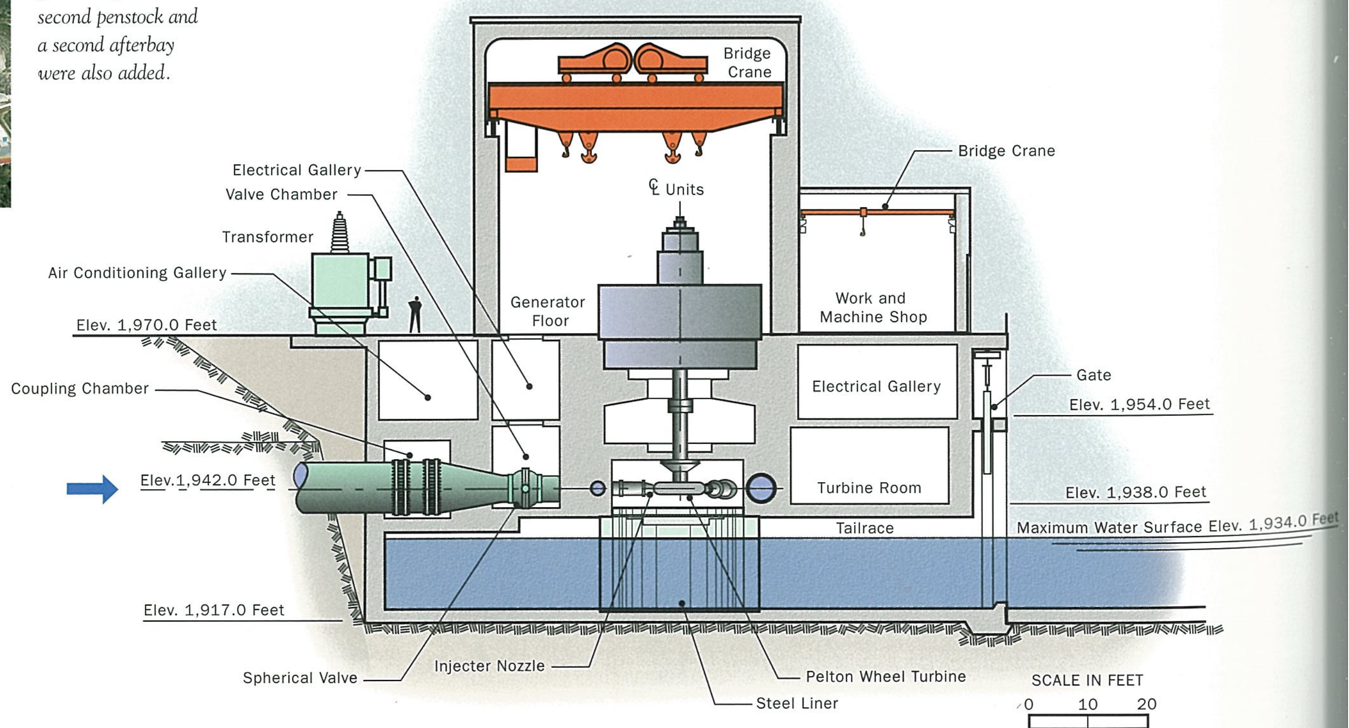
A power recovery facility, Devil Canyon Powerplant is situated near the mouth of Devil Canyon at the southern base of the San Bernardino Mountains, about 5 miles north of San Bernardino. It generates electricity from water traveling through the plant from Silverwood Lake. The water is then discharged into two afterbays from which water is distributed to contracting water users. Water not delivered continues to Lake Perris through the Santa Ana Pipeline. Devil Canyon Powerplant, constructed between 1969 and 1974, has the highest head in the SWP system.

Devil Canyon Powerplant was enlarged in 1991 to accommodate two new 80 megawatt generating units. A second penstock and a second afterbay were also added.

General Plan



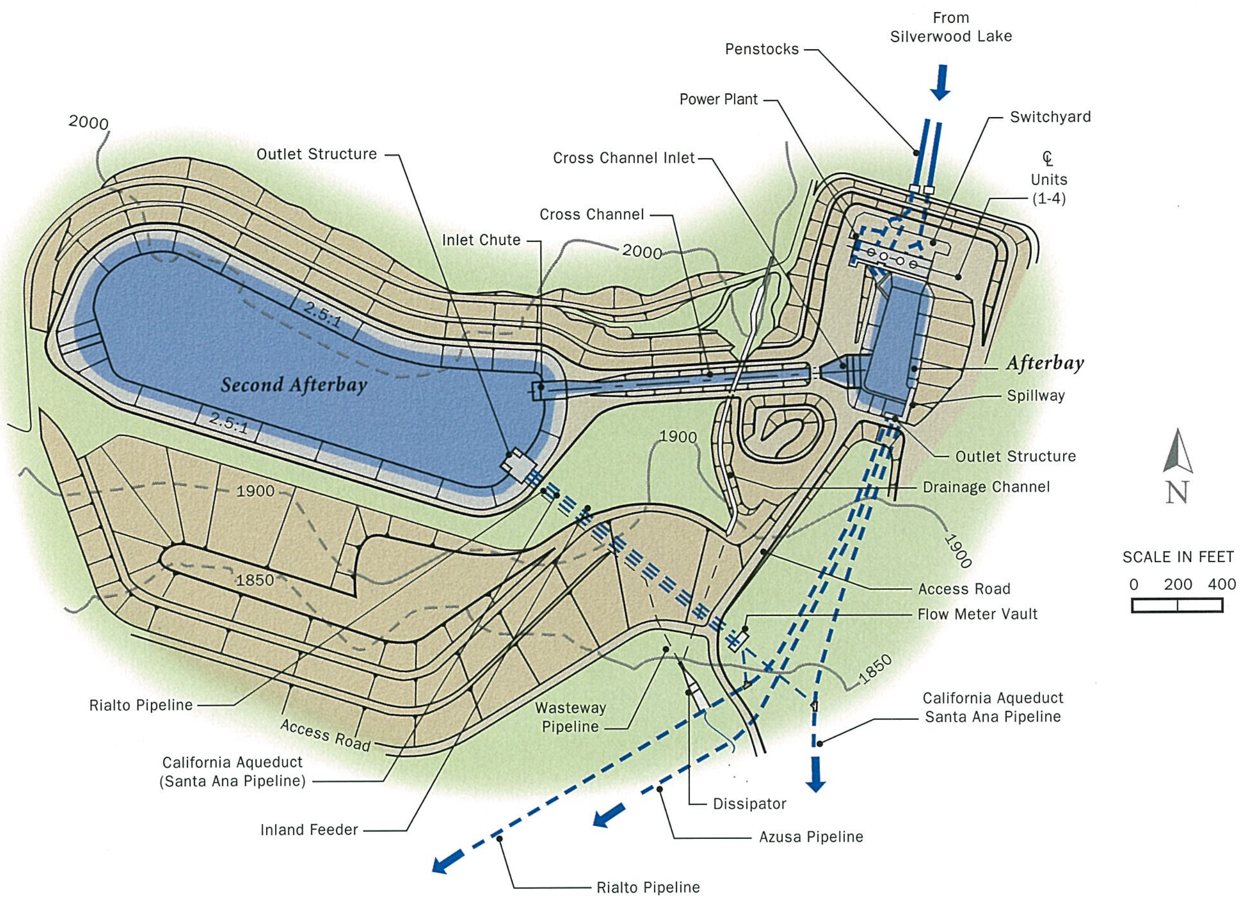
Transverse Section



Generating

Installed capacity	*291 MVA, 2,940 cfs*
Normal static head	*1,406 feet*
Design dynamic head	*2 @ 1,357 feet* *2 @ 1,300 feet*
Number of units	*4*
Unit size	*2 @ 63 MVA, 670 cfs* *2 @ 82.5 MVA, 800 cfs*
Penstocks/diameter	*1 @ 9.5 to 8 feet* *1 @ 12.5 to 8 feet*

GENERAL PLAN



Devil Canyon Afterbay & Second Afterbay

Flows through Devil Canyon Powerplant discharge into the afterbay, constructed from 1969 to 1974. The afterbay provides a minimal amount of storage for mismatching of the power plant's inflows and outflows, as well as an open water surface crossing of the San Andreas Fault. Seismic damage to the afterbay would be relatively easy and quick to repair. Construction of the second afterbay (1992 to 1995), which is connected to the existing afterbay through a cross channel, increased the power plant's operational flexibility and capacity. From the two outlet structures, pipelines deliver water to contracting users and the Santa Ana Pipeline to Lake Perris. The inland feeder outlet will connect the East Branch to the Colorado River Aqueduct system through a contractor's future 45-mile pipeline.

Afterbay

Type: earthen, excavated
Maximum operating storage . . . . . 50 acre-feet
*Water surface elevation @ mos*1,933 feet Water*
Surface area @ mos . . . . 4 acres

Connecting Structure

152-foot-wide spillway discharges into a cross channel, 1,100 feet long and 40 feet wide

Second Afterbay

Type: excavated, multi-element asphalt lined
Maximum operating storage . . . . . 980 acre-feet
Water surface elevation @ mos . . . . . 1,930.5 feet
Surface area @ mos . . . . 36 acres

*maximum operating storage

Santa Ana Pipeline

The 28-mile-long Santa Ana Pipeline is a buried pipeline that conveys water through urbanized San Bernardino County and into Riverside County, passing near a ridge line by Sugar Loaf Mountain and crossing Moreno Valley to Lake Perris, the terminal facility on the East Branch. Constructed between 1969 and 1973, the pipeline provides turnouts along its alignment for water deliveries to contracting users.

Santa Ana Pipeline's alignment lies in a highly seismic area, with two large active faults.

Pipeline

Type: 28.1 miles of prestressed concrete, cylinder
Diameter. . . . . varies from 9 to 10 feet
Capacity . . . begins at 585 and decreases to 520 cfs

Aqueduct Map

The Santa Ana Pipeline's alignment was based on the shortest overall pipeline possible considering geologic and right of way restraints and for ease of construction and operation. In urban areas, the location of high-pressure sections of the pipeline were restricted to streets and along flood channels.

Workers inspect Santa Ana Pipeline's 10-foot-diameter valve that control flows from Devil Canyon's Second Afterbay.

Perris Dam and Lake Perris

Located in northwestern Riverside County, about 13 miles southeast of the city of Riverside and about 65 miles east of Los Angeles, Lake Perris is the terminal storage facility on the East Branch and the southernmost SWP facility. Constructed between 1970 and 1974, the lake provides water supply for contracting users and fish and wildlife enhancement. It is also one of the most heavily used lakes for recreation in the State Park System.

Lake Perris is a very popular recreation spot for Southern Californians.

Dam

Type: zoned earthfill

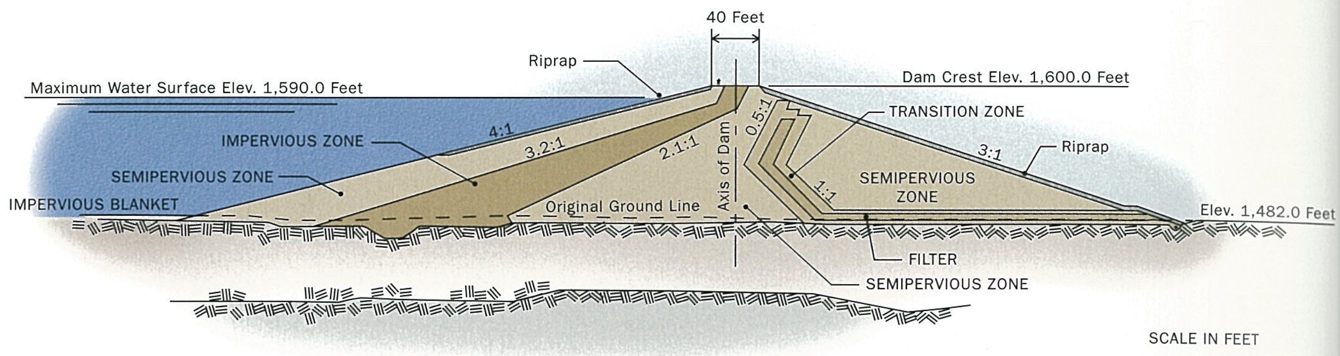
Embankment volume	*20,000,000 cubic yards*
Height	*128 feet*
Crest length	*11,600 feet*
Crest elevation	*1,600 feet*

Lake

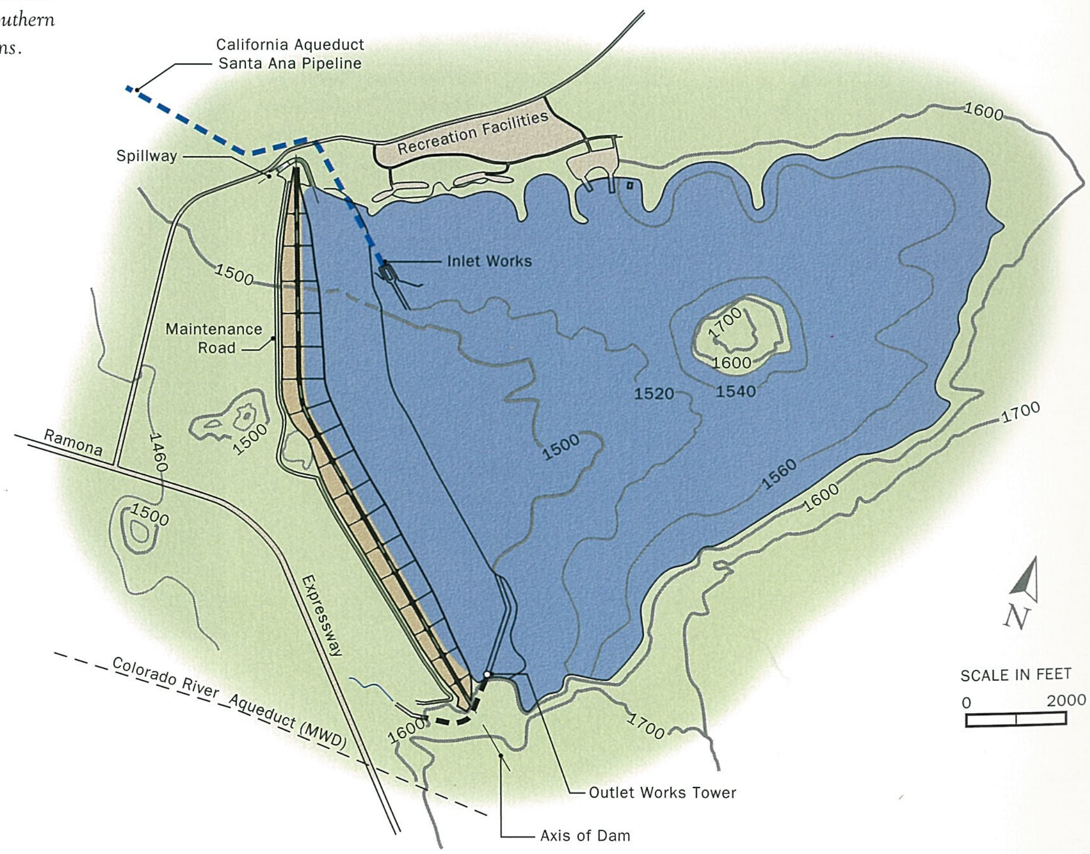
Maximum operating storage	*131,450 acre-feet*
*Water surface elevation @ mos**	*1,590 feet*
Water surface area @ mos	*2,320 acres*
Shoreline @ mos	*10 miles*

**maximum operating storage*

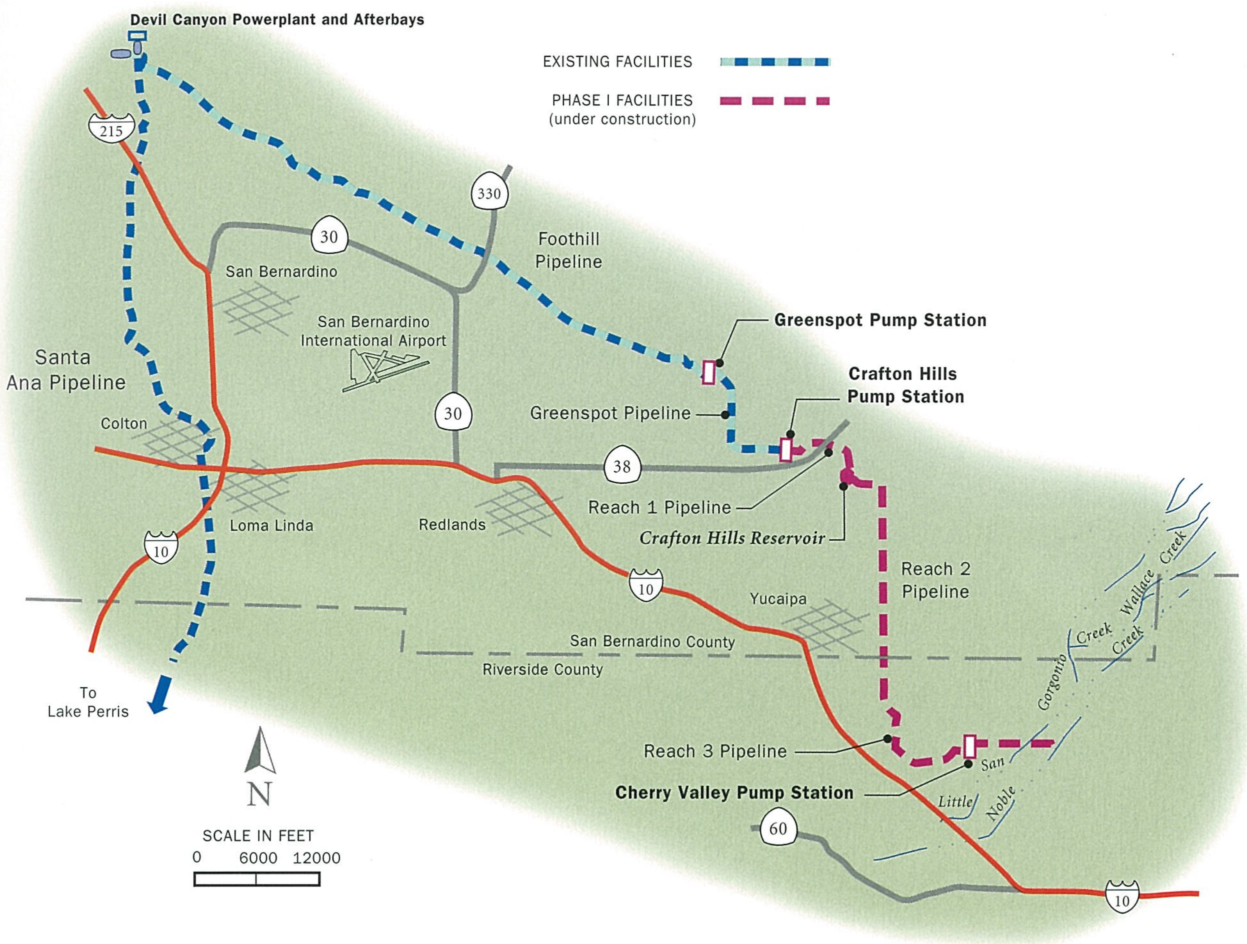
Maximum Section



General Plan



AQUEDUCT MAP



EAST BRANCH EXTENSION PHASE 1

Construction of an extension of the East Branch to deliver SWP water from Devil Canyon Powerplant Afterbay to the eastern San Bernardino and San Gorgonio Pass service areas began in April 1999. The extension is a cooperative effort between DWR, San Bernardino Valley Municipal Water District, and San Gorgonio Pass Water Agency. The extension is scheduled for completion in March 2001.

PIPELINE

Type: 13 miles of buried welded steel

GREENSPOT PUMP STATION

Number of units	*4*
Normal static head	*570 ft*
Total flow at design head	*50 cfs*
Motor ratings	*3 @ 800hp* *1 @ 1500hp*

CRAFTON HILLS PUMP STATION

Number of units	*3*
Normal static head	*650 ft*
Total flow at design head	*40 cfs*
Motor ratings	*2 @ 1000hp* *1@ 2000hp*

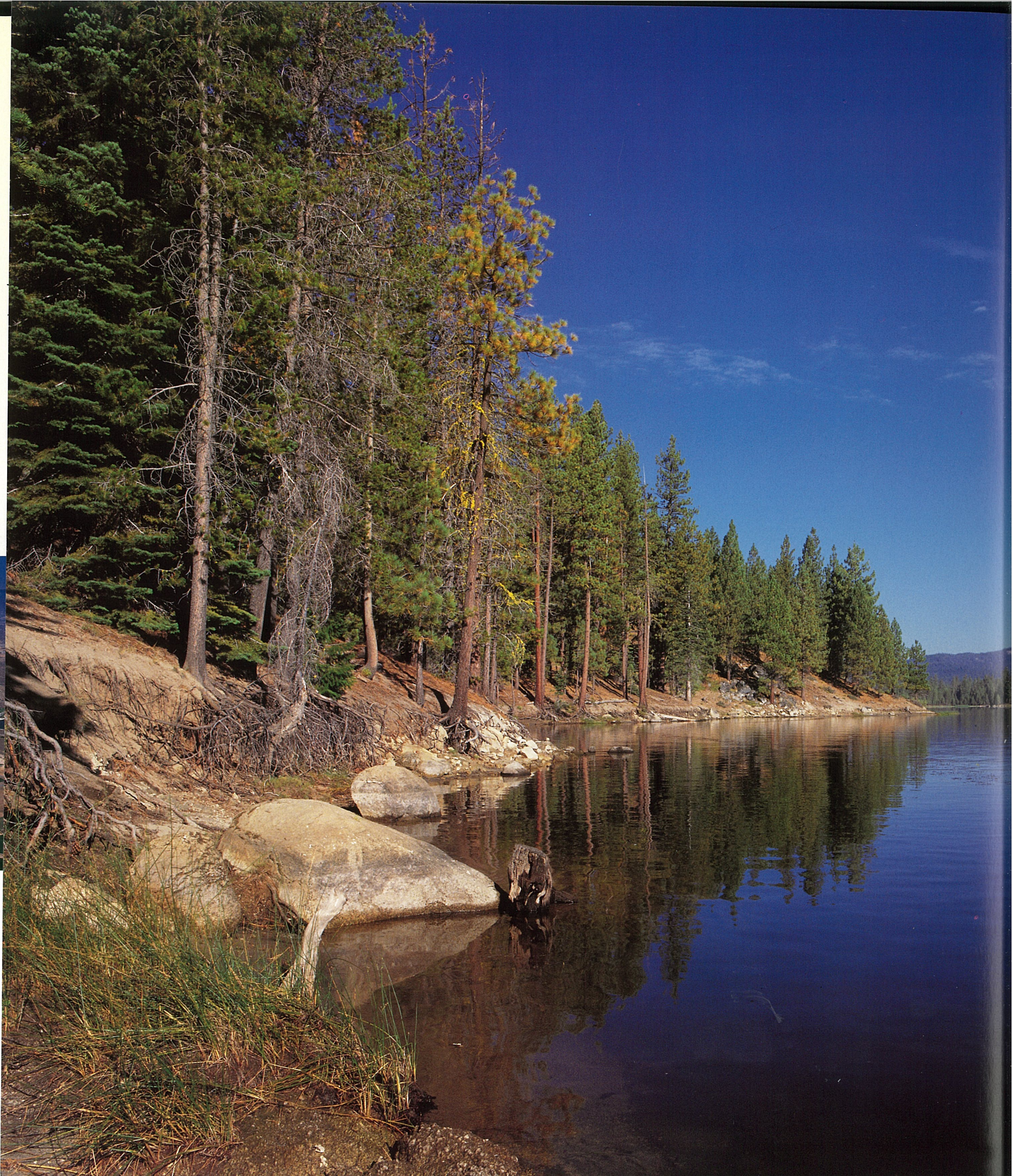
CHERRY VALLEY PUMP STATION

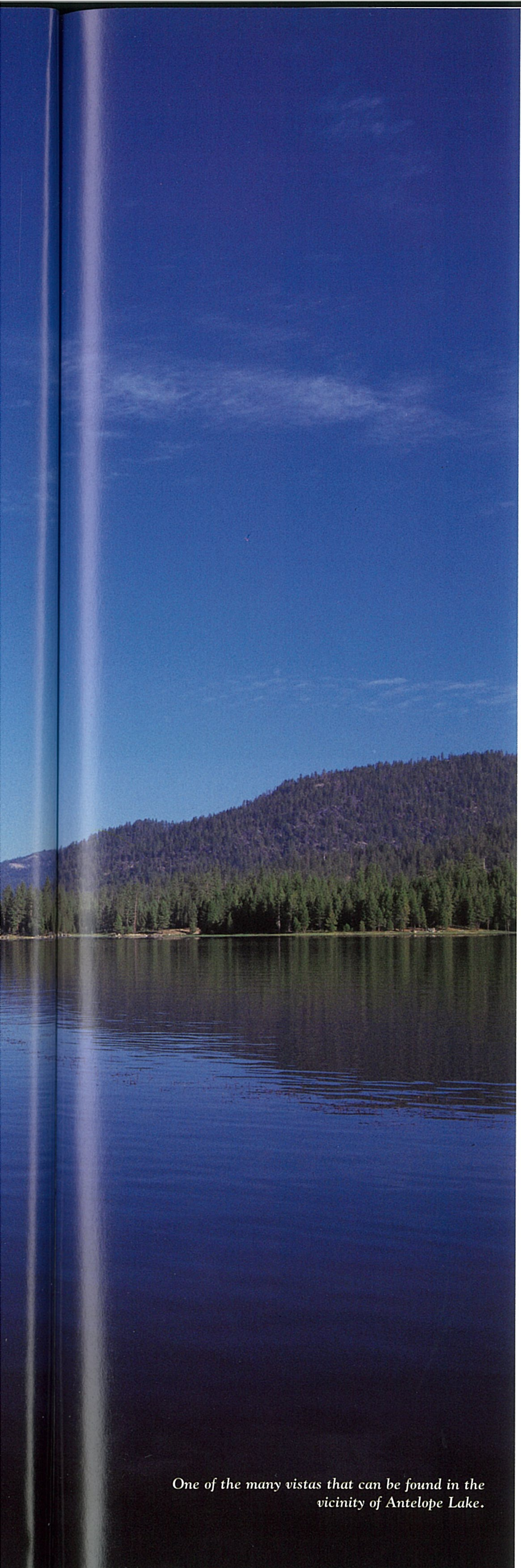
Number of units	*2*
Normal static head	*120 ft*
Total flow at design head	*16 cfs*
Motor ratings	*2 @ 150 hp*

CRAFTON HILLS RESERVOIR

Type: zoned embankment dam

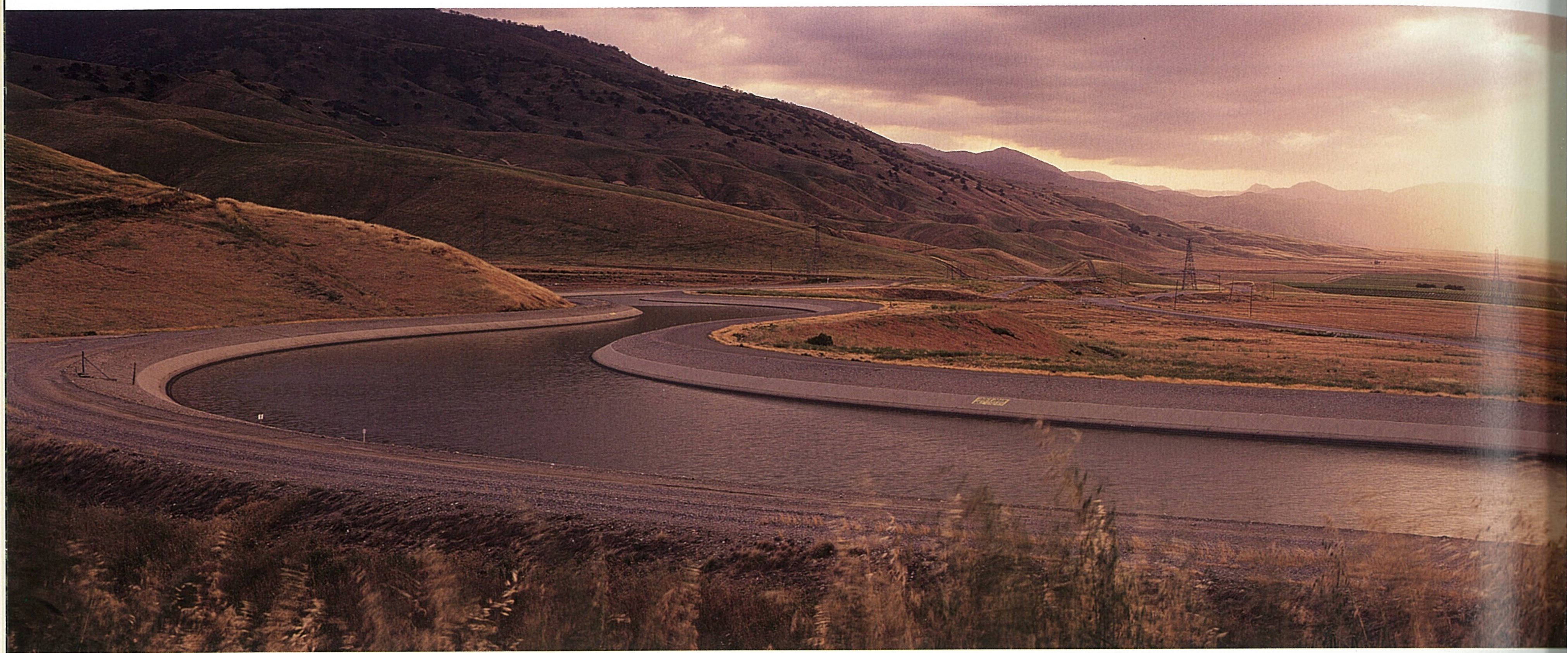
Active storage	*90 acre-feet*
Height	*95 feet*
Crest width	*25 feet*
Crest length	*500 feet*





One of the many vistas that can be found in the vicinity of Antelope Lake.

APPENDIX



1919 – Statewide water planning is initially started by Colonel Robert B. Marshall, chief geographer of the USGS. He outlines a plan in a bulletin sponsored by the California State Irrigators Association.

1921 – State Legislature authorizes state water officials, then in the Department of Public Works, to conduct a statewide water resources investigation. The Department makes its first report on this investigation in 1923.

1931 – State Engineer Edward Hyatt makes a report to the Legislature on first State Water Plan, which details a plan of dams and aqueducts needed to transfer water from the north to the south end of the Central Valley.

1933 – Central Valley Project Act is passed by the State Legislature and the voters. The Great Depression prevents sales of bonds to start the project. The federal government begins to build the project in 1937.

1951 – Bulletin No. 1, "Water Resources of California" is published, detailing data on precipitation, runoff, flood and drought frequencies, water storage, and water quality.

State Engineer A.D. Edmonston presents the first complete proposal for a "Feather River Project" to the State Legislature.

1955 – Bulletin No. 2, "Water Utilization and Requirements of California" is published with data on water use and forecasts on future water needs. The Legislature receives a revised Feather River Project proposal. Its review finds the project engineeringly and financially feasible and starts an intensive search for a final project alignment.

1956 – The State Department of Water Resources is created by the Legislature.

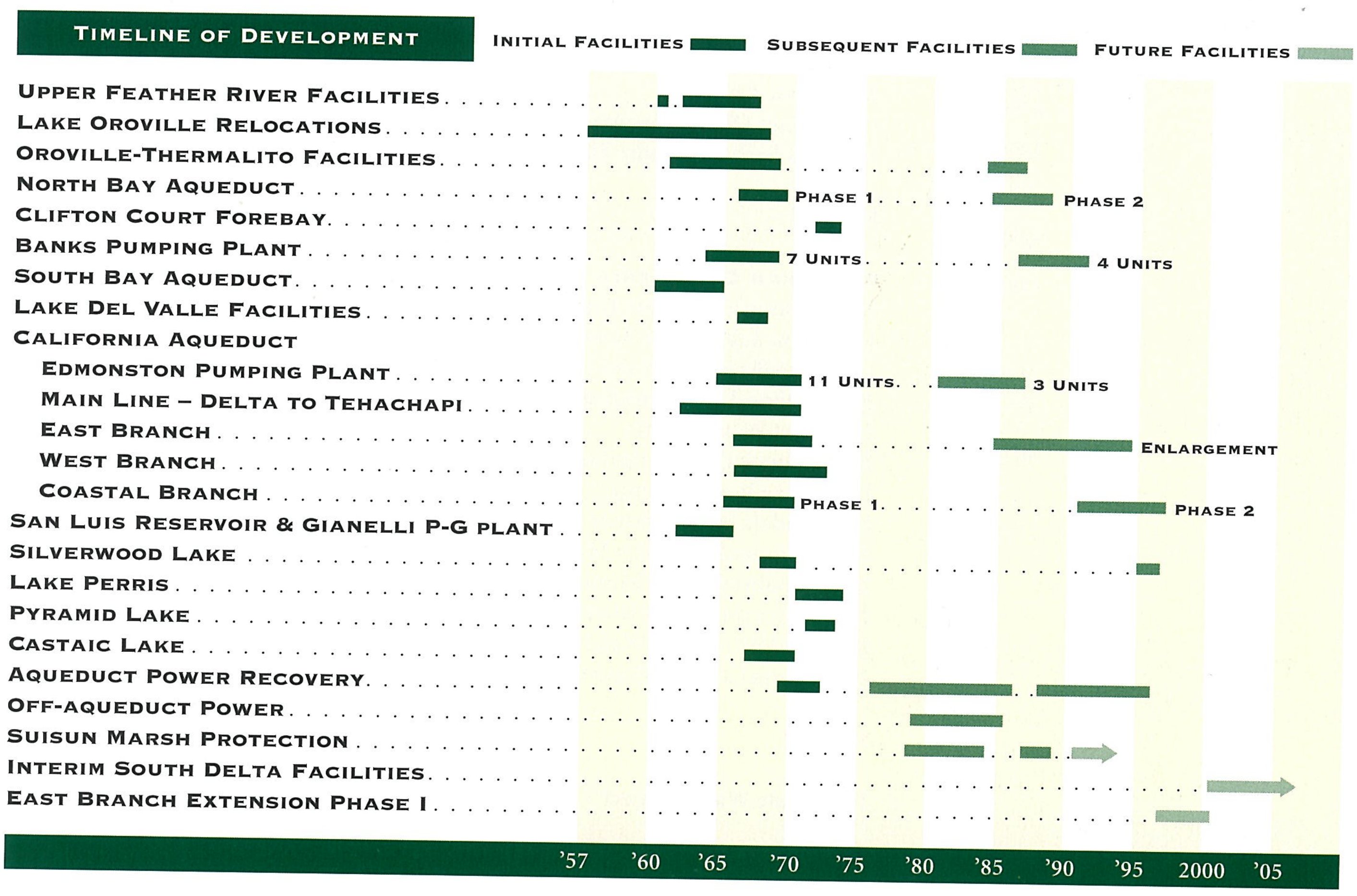
1957 – Bulletin No. 3, "The California Water Plan" is completed. It lays out preliminary plans for full development of the state's water resources to meet its projected needs. The Legislature, reacting to disastrous winter floods of the previous year, makes a first emergency appropriation ($25,190,000) to begin work on Oroville facilities.

1959 – Legislature enacts Burns-Porter Act, authorizing initial facilities for the State Water Project.

1960 – California voters approve $1.75 billion in general obligation bonds under the Burns-Porter Act to finance construction of the State Water Project.

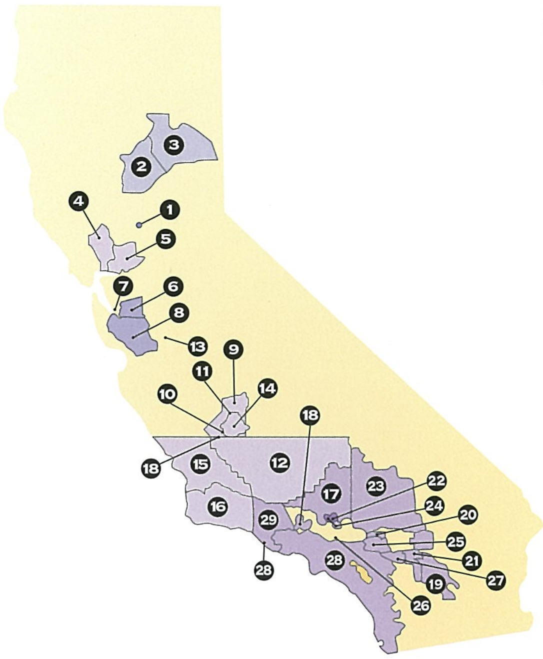
1961 – Construction begins on SWP facilities, including Oroville Dam, a key water storage facility on the Feather River in the upper Sacramento Valley.

The move to develop the state's water resources started in the early 1900s. California's first attempt to build a project was defeated by the Great Depression. The State Water Project was finally authorized in the late 1950s. Today the SWP serves areas in Northern California, San Francisco Bay area, San Joaquin Valley, Central Coast, and Southern California.



The SWP facilities are being built in stages. Initial construction provided urgently needed flood control on the Feather River and delivery of water to areas of pressing need in the South Bay area. In 1973, water began flowing to Lake Perris, the SWP's southernmost facility. Construction began in 1999 on the latest SWP facility, the East Branch Extension.

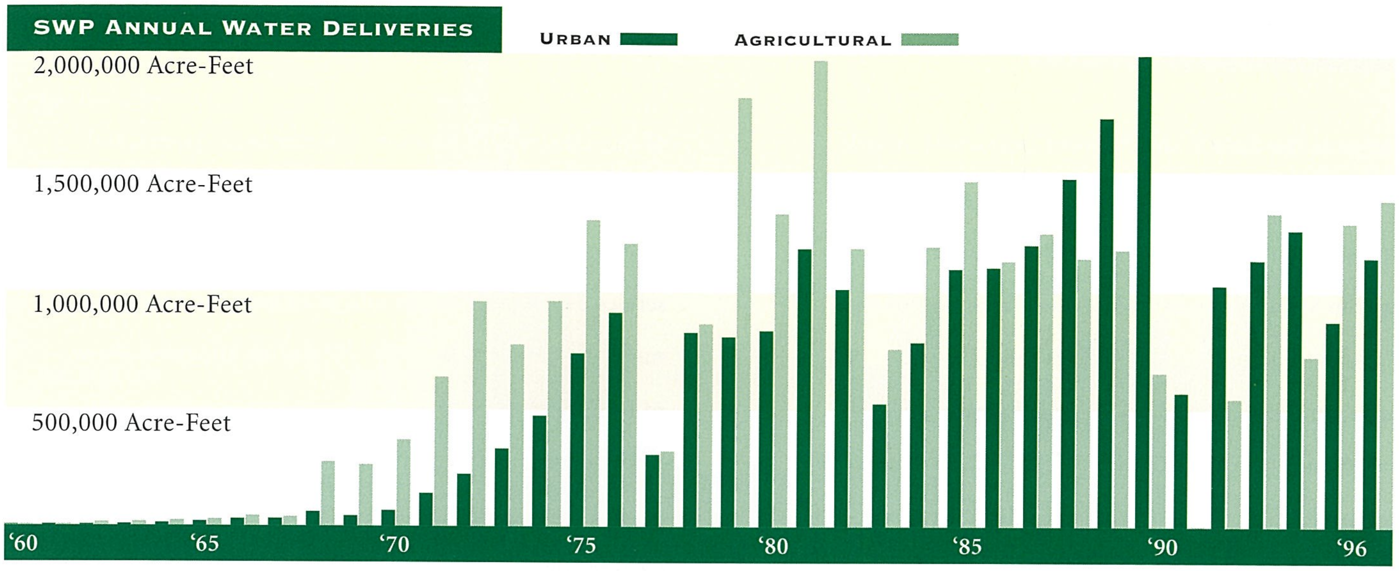
WATER CONTRACTORS



Twenty-nine water agencies have long-term contracts for water entitlements and repayment of facilities through the year 2035. Whether they receive their annual entitlements depends on available water supply and local water demands.

CONTRACTING AGENCY	MAXIMUM ANNUAL ENTITLEMENT (ACRE-FEET)
UPPER FEATHER RIVER	
1. City of Yuba	9,600
2. County of Butte	27,500
3. Plumas County Flood Control & Water Conservation District	2,700
Subtotal	**39,800**
NORTH BAY AREA	
4. Napa County Flood Control & Water Conservation District	25,000
5. Solano County Water Agency	42,000
Subtotal	**67,000**
SOUTH BAY AREA	
6. Alameda County Flood Control & Water Conservation District, Zone 7	46,000
7. Alameda County Water District	42,000
8. Santa Clara Valley Water District	100,000
Subtotal	**188,000**
SAN JOAQUIN VALLEY	
9. County of Kings	4,000
10. Dudley Ridge Water District	53,370
11. Empire West Side Irrigation District	3,000
12. Kern County Water Agency	1,046,730
13. Oak Flat Water District	5,700
14. Tulare Lake Basin Water Storage District	118,500
Subtotal	**1,231,300**
CENTRAL COAST	
15. San Luis Obispo County Flood Control & Water Conservation District	25,000
16. Santa Barbara County Flood Control & Water Conservation District	45,486
Subtotal	**70,486**
SOUTHERN CALIFORNIA	
17. Antelope Valley-East Kern Water Agency	138,400
18. Castaic Lake Water Agency*	95,200
19. Coachella Valley Water District	23,100
20. Crestline-Lake Arrowhead Water Agency	5,800
21. Desert Water Agency	38,100
22. Littlerock Creek Irrigation District	2,300
23. Mojave Water Agency	75,800
24. Palmdale Water District	17,300
25. San Bernadino Valley Municipal Water District	102,600
26. San Gabriel Valley Municipal Water District	28,800
27. San Gorgonio Pass Water Agency	17,300
28. The Metropolitan Water District of Southern California	2,011,500
29. Ventura Country Flood Control District	20,000
Subtotal	**2,576,200**
Total State Water Project	**4,172,786**

**Note: Castaic Lake Water Agency acquired Devil's Den W.D. entitlement in 1992.*



(Top) Deliveries to urban users have gradually increased over the years as cities and industries developed. During the recent drought, water deliveries were substantially reduced.

Water Supply Contractors of Joint-Use Facilities

U.S. Bureau of Reclamation Water Supply Contractors	Maximum Annual Entitlement (Acre-Feet)
California Department of Fish and Game (water rights)	1,800
California Department of Parks and Recreation (recreation water)	2,250
Cities of Coalinga, Avenal and Huron	16,500
Pacheco Water District	10,080
Panoche Water District	94,000
San Luis Water District	125,000
Westlands Water District	1,150,000
San Felipe Unit	
San Benito	43,800
Santa Clara	152,500
Total	**1,595,930**

Note: The Bureau contractors take their annual diversions from the joint-use facilities.
(No SWP deliveries are made from the joint-use facilities.)

(Left) SWP facilities in the San Luis Field Division jurisdiction serve federal Central Valley Project water users through facilities built by state and federal governments.

Charges to the State Water Project Contractors include the costs of facilities for the conservation and development of a water supply and the conveyance of such supply to SWP service areas. These facilities are classified as "Project Conservation Facilities" and "Project Transportation Facilities." The standard provisions of the water supply contracts provide for a Delta Water Charge and a Transportation Charge for SWP water.

Delta Water Charge is a unit charge applied to each acre-foot of SWP water the contractors are entitled to receive according to their contracts. The unit charge, if applied to each acre-foot of all such entitlements for the remainder of the project repayment period, is calculated to repay all outstanding reimbursable costs of the Project Conservation Facilities, with appropriate interest, by the end of the repayment period (2035).

The **Transportation Charge** is for use of facilities to transport water to the vicinity of each contractor's turnout. Generally, the annual charge represents each contractor's proportionate share of the reimbursable capital costs and operating costs of the Project Transportation Facilities. Each contractor's allocated share of those reimbursable capital costs is amortized for repayment to the state, with certain variations allowed in the amortization methods. Essentially, the contractors' shares of reimbursable operating costs are repaid in the year such costs are incurred by the state.

Seven Southern California contractors pay the **East Branch Enlargement Transportation Charge**. The enlargement increases the aqueduct's capacity for delivering water to those contractors and includes raising sections of canal lining and construction of new facilities. Each contractor also will pay an allocated share of the minimum operation, maintenance, power, and replacement (OMP&R) costs of the enlargement. The seven contractors will pay an allocated share of the debt service on revenue bonds sold to finance the enlargement. Each contractor also will pay an allocated share of the minimum operation, maintenance, power, and replacement (OMP&R) costs of the enlargement.

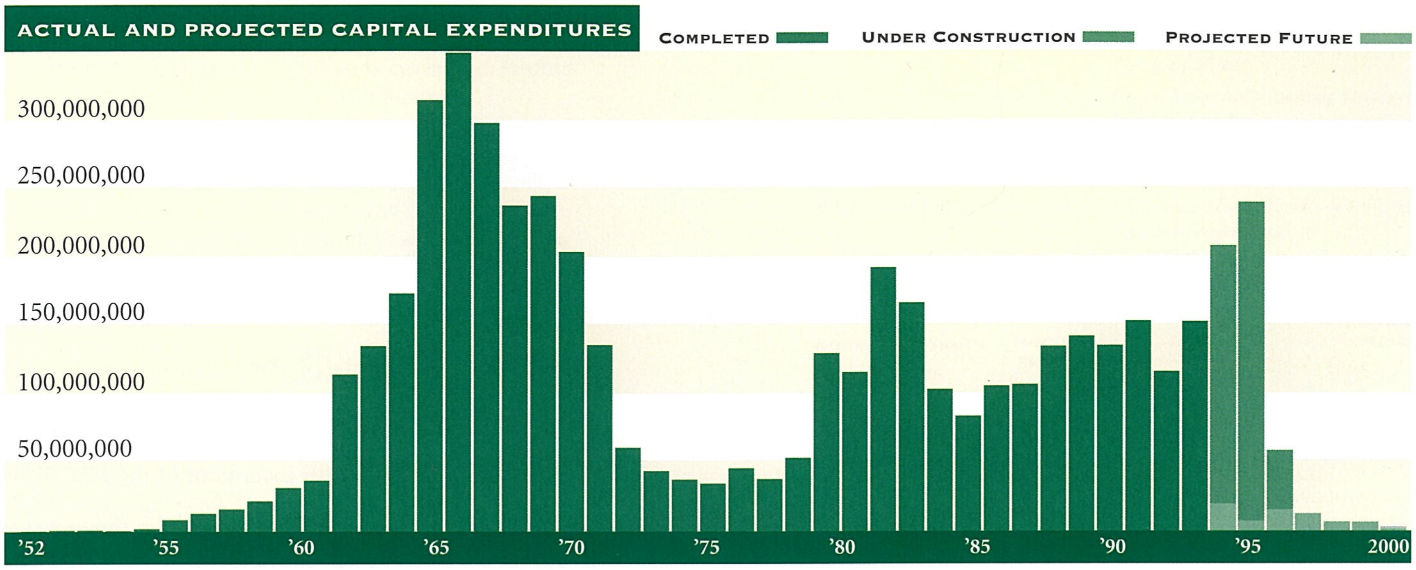
The Delta Water Charge and the Transportation Charge consist of the following three components:

1. Conservation and Transportation capital cost components, which will result in a return to the state of all reimbursable capital costs (such as planning, design, right of way, and construction costs of conservation/transportation facilities; operations and maintenance costs for newly constructed facilities prior to initial operation; activation costs of new facilities; and a portion of program costs to mitigate impacts of SWP pumping on Delta fish populations prior to 1986);

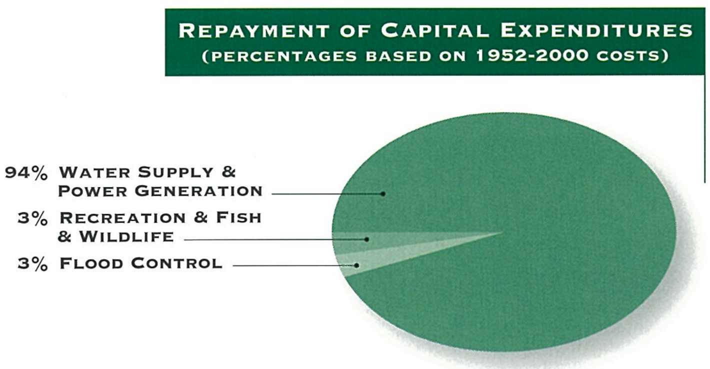
2. Conservation and Transportation minimum OMP&R components (includes direct O&M costs of conservation/transportation facilities, general O&M costs such as financial, contract administration, contract accounting, water rights, and power planning allocated to conservation/transportation facilities; and program costs to offset annual fish losses resulting from pumping at Banks Pumping Plant), which are designed to return to the state all reimbursable operating costs that do not depend on or vary with quantities of water actually delivered to the contractors; and

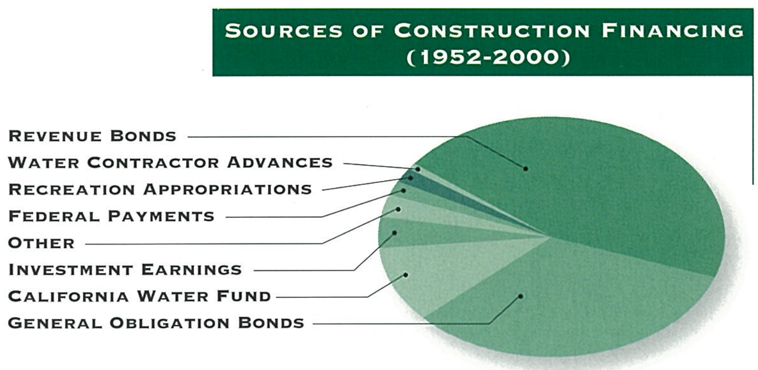
3. A Transportation variable OMP&R component, which will return to the state all reimbursable operating costs (includes power purchase costs, power generation credit at power plant reaches and charged to aqueduct pumping plants; replacement costs for pumping and power plant equipment; credit from sale of excess SWP power; and program costs to offset annual fish losses resulting from pumping at Banks Pumping Plant) that depend on, and vary with, quantities of water actually delivered to the contractors.

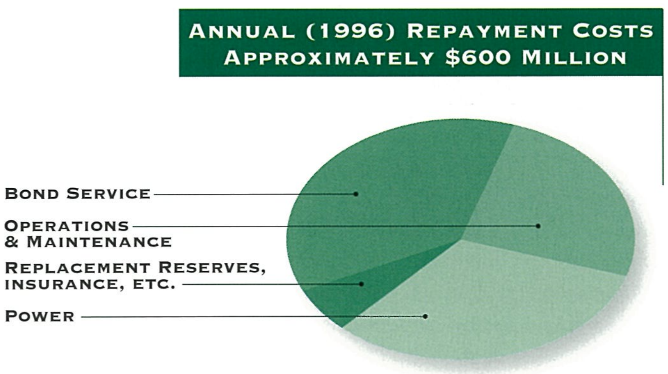
**Note: For a detailed explanation, refer to Appendix B in the Bulletin 132 series.*



A $1.75 billion bond initially financed the construction of the SWP. Contracting agencies repaid the bond plus interest and continue to fund operations and maintenance, as well as the building of new facilities.







The state's general fund helps pay for recreation costs as well as for fish and wildlife enhancement and protection. Contracting agencies also pay for numerous environmental projects such as restoration of salmon spawning grounds and research to develop effective fish screens.

REPAYMENT REACHES

Repayment reaches were established to allocate, as equitably as possible, State Water Project costs to the contracting agencies. Such facilities include the pipelines, canals, power and pumping plants, and reservoirs.

A repayment reach is an increment of the State Water Project aqueduct system that is defined for the purpose of allocating project costs to project beneficiaries. Varying in length, the reaches begin at the Delta and are generally numbered consecutively. Reaches in the North Bay and South Bay Aqueducts are numbered separately from the reaches along the California Aqueduct.

North Bay Aqueduct

Mile Post		
0.00 – 10.54	Reach 1	Barker Slough through Fairfield/ Vacaville Turnout
10.54 – 21.23	Reach 2	Fairfield/Vacaville Turnout to Cordelia Forebay
21.23 – 21.33	Reach 3A	Cordelia Forebay through Benicia and Vallejo Turnouts
21.23 – 27.62	Reach 3B	Cordelia Forebay through Napa Turnout Reservoir

South Bay Aqueduct

0.00 – 7.21	Reach 1	Bethany Reservoir through Altamont Turnout
7.21 – 9.50	Reach 2	Altamont Turnout through Patterson Reservoir
9.50 – 18.63	Reach 4	Patterson Reservoir to Del Valle Junction
18.63	Reach 5	Del Valle Junction through Lake Del Valle
18.63 – 19.20	Reach 6	Del Valle Junction through South Livermore Turnout
19.20 – 22.47	Reach 7	South Livermore Turnout through Vallecitos Turnout
22.47 – 28.97	Reach 8	Vallecitos Turnout through Alameda-Bayside Turnout
28.97 – 42.89	Reach 9	Alameda-Bayside Turnout through Santa Clara Terminal Facilities

California Aqueduct

North San Joaquin Division

0.00 – 4.65	Reach 1	Delta through Bethany Reservoir
4.65 – 51.31	Reach 2A	Bethany Reservoir to Orestimba Creek
51.31 – 66.74	Reach 2B	Orestimba Creek to O'Neill Forebay

San Luis Division

66.74	Reach 3A	Sisk Dam, San Luis Reservoir & William R. Gianelli Pumping-Generating Plant
66.74 – 86.47	Reach 3	O'Neill Forebay to Dos Amigos Pumping Plant
86.47 – 108.56	Reach 4	Dos Amigos Pumping Plant to Panoche Creek
108.56 – 143.29	Reach 5	Panoche Creek to Check 18
143.29 – 155.70	Reach 6	Check 18 to Arroyo Pasajero
155.70 – 172.44	Reach 7	Arroyo Pasajero to Kettleman City

South San Joaquin Division

172.44 – 172.66	Reach 8C	Kettleman City through Milham Avenue
172.66 – 184.84	Reach 8D	Milham Avenue through Avenal Gap
184.84 – 197.07	Reach 9	Avenal Gap through Twisselman Road
197.07 – 210.31	Reach 10A	Twisselman Road through Lost Hills
210.31 – 217.81	Reach 11B	Lost Hills to 7th Standard Road
217.81 – 229.71	Reach 12D	7th Standard Road through Elk Hills Road
229.71 – 238.13	Reach 12E	Elk Hills Road through Tupman Road
238.13 – 249.46	Reach 13B	Tupman Road to Buena Vista Pumping Plant
249.46 – 261.77	Reach 14A	Buena Vista Pumping Plant through Santiago Creek
261.77 – 271.33	Reach 14B	Santiago Creek through Old River Road
271.33 – 277.47	Reach 14C	Old River Road to John R. Teerink Wheeler Ridge Pumping Plant
277.47 – 280.07	Reach 15A	John R. Teerink Wheeler Ridge Pumping Plant to Ira J. Chrisman Wind Gap Pumping Plant
280.07 – 293.34	Reach 16A	Ira J. Chrisman Wind Gap Pumping Plant to A.D. Edmonston Pumping Plant

Tehachapi Division

293.34 – 298.66	Reach 17E	A.D. Edmonston Pumping Plant to Carley V. Porter Tunnel
298.66 – 304.04	Reach 17F	Carley V. Porter Tunnel to Junction, West Branch, California Aqueduct

Mojave Division

304.04 – 305.75	Reach 18A	Junction, West Branch, California Aqueduct through Alamo Powerplant
305.75 – 323.84	Reach 19	Alamo Powerplant to Fairmont
323.84 – 336.73	Reach 20A	Fairmont through 70th Street West
336.73 – 348.17	Reach 20B	70th Street West to Palmdale
348.17 – 354.97	Reach 21	Palmdale to Littlerock Creek
354.97 – 360.00	Reach 22A	Littlerock Creek to Pearblossom Pumping Plant
360.00 – 403.40	Reach 22B	Pearblossom Pumping Plant to West Fork Mojave River
403.40 – 405.58	Reach 23	West Fork Mojave River to Silverwood Lake
405.58 – 407.63	Reach 24	Cedar Springs Dam and Silverwood Lake

Santa Ana Division

407.63 – 411.46	Reach 25	Silverwood Lake to South Portal, San Bernardino Tunnel
411.46 – 412.88	Reach 26A	South Portal, San Bernardino Tunnel through Devil Canyon Powerplant
412.88 – 425-46	Reach 28G	Devil Canyon Powerplant to Barton Road
425.46 – 440.26	Reach 28H	Barton Road to Lake Perris
440.26 – 443.44	Reach 28J	Perris Dam and Lake Perris

West Branch, California Aqueduct

0.01 – 1.90	Reach 29A	Junction, West Branch, California Aqueduct through Oso Pumping Plant
1.90 – 7.82	Reach 29F	Oso Pumping Plant through Quail Embankment
7.82 – 14.10	Reach 29G	Quail Embankment through William E. Warne Powerplant
14.10 – 18.19	Reach 29H	Pyramid Dam and Lake
18.19 – 25.83	Reach 29J	Pyramid Lake through Castaic Powerplant
25.83 – 31.50	Reach 30	Castaic Dam and Lake

Coastal Branch, California Aqueduct

0.02 – 14.86	Reach 31A	Avenal Gap to Devil's Den Pumping Plant
14.86 – 27.81	Reach 33A	Devil's Den Pumping Plant through Tank 1
27.81 – 69.31	Reach 33B	Tank 1 through Chorro Valley Turnout
69.31 – 85.86	Reach 34	Chorro Valley Turnout through Lopez Turnout
85.86 – 102.70	Reach 35	Lopez Turnout through Guadalupe Turnout
102.70 – 111.05	Reach 37	Guadalupe Turnout to SPRR Crossing near Casmalia
111.05 – 115.46	Reach 38	SPRR Crossing near Casmalia through Terminas at Tank 5

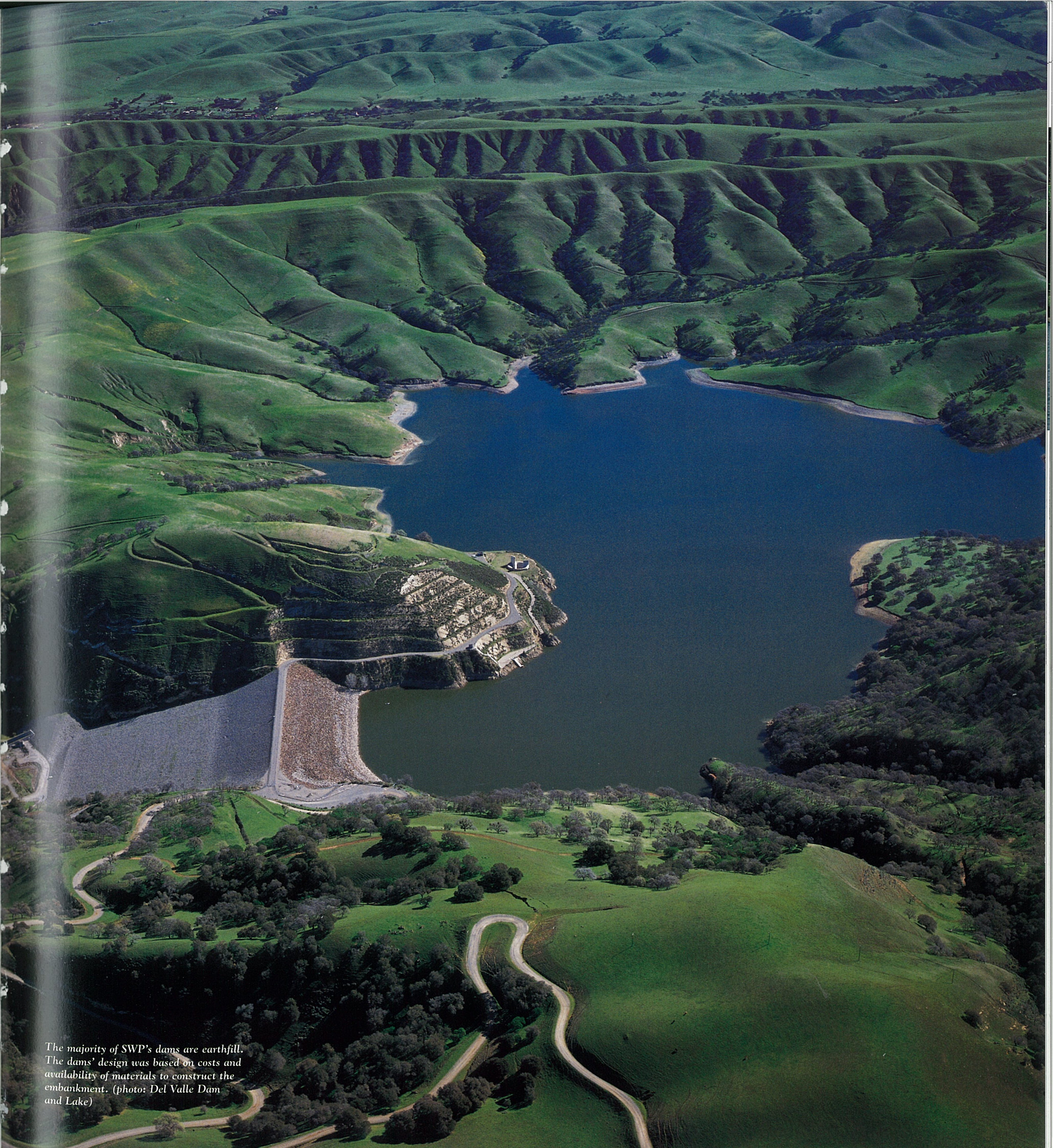
The SWP's storage facilities have a combined total capacity of approximately 5.8 million acre-feet. Lake Oroville is the largest; Santa Clara Terminal Reservoir, a steel tank, is the smallest. (photo: Castaic Lagoon)

Reservoirs	Gross Storage Capacity (acre-feet)	Conservation Storage (acre-feet)	Flood Control Allocation (acre-feet)	Dead Storage (acre-feet)	Surface Area (acres)	Shoreline (miles)
Antelope Lake	22,570	–	–	500	930	15
Bethany Reservoir	5,070	–	–	150	180	6
Castaic Lake	323,700	–	–	18,590	2,240	29
Castaic Lagoon	5,560	–	–	–	200	3
Clifton Court Forebay	31,260	–	–	–	2,180	8
Coastal Branch Tank Sites 1,2, & 5	146	–	–	–	–	–
Cordelia Pumping Plant Forebay	11	–	–	–	2	0.3
Devil Canyon Afterbay	50	–	–	–	4	–
and Second Afterbay	980	–	–	–	36	–
Elderberry Forebay	32,480	–	–	811	500	7
Feather River Fish Barrier Pool	580	–	–	–	50	1
Frenchman Lake	55,480	–	–	1,840	1,580	21
Lake Davis (Grizzly Valley Dam)	84,370	–	–	90	4,030	32
Lake Del Valle	77,110	40,000	38,000	3,317	1,060	16
Lake Oroville	3,537,580	2,778,000	750,000	29,638	15,810	167
Little Panoche Reservoir	5,580	–	–	315	190	6
Los Banos Reservoir	34,560	–	–	8,000	620	12
Napa Turnout Reservoir	22	–	–	–	0.7	–
O'Neill Forebay	56,430	–	–	10,220	2,700	12
Patterson Reservoir	100	–	–	–	4	0.3
Perris Lake	131,450	–	–	4,100	2,320	10
Pyramid Lake	171,200	–	–	4,798	1,300	21
Quail Lake	7,580	–	–	–	290	3
Santa Clara Terminal Reservoir	9	–	–	–	0.5	–
San Luis Reservoir (Sisk Dam)	2,027,840[1]	–	–	8	12,520	65
Silverwood Lake (Cedar Springs Dam)	74,970	–	–	3,967	980	13
Tehachapi Afterbay	550	–	–	–	40	2.9
Thermalito Afterbay	57,040	–	–	753	4,300	26
Thermalito Diversion Pool	13,350	–	–	5,849	320	10
Thermalito Forebay	11,770	–	–	15	630	10

[1] SWP share is 1,062,183 acre-feet.

Dams	Type	Height (feet)	Crest Elevation (feet)	Crest Length (feet)	Crest Width (feet)	Spillway Elevation (feet)	Freeboard (feet)	Dam Volume (cu. yard)
Antelope Dam	zoned earthfill	120	5,025	1,320	30	5,002.0	23.0	380,000
Bethany Dams	homogeneous earthfill	121	250	3,940	25	245.0	5.0	1,400,000
Castaic Dam	zoned earthfill	425	1,535	4,900	40	1,515.0	20.0	46,000,000
Cedar Springs Dam (Silverwood Lake)	zoned earth and rockfill	249	3,378	2,230	42	3,355.0	23.0	7,600,000
Clifton Court Forebay Dam	zoned earthfill	30	14	36,500	20	–	8.0	2,440,000
Del Valle Dam	zoned earthfill	235	773	880	25	745.0	28.0	4,150,000
Devil Canyon Afterbay Dam	earthen excavated	23	1,940	–	–	1,937.0	3.0	–
and Second Afterbay Dam	excavated, multi-element asphalt-lined	88	1,940	–	–	1,931.0	–	–
Elderberry Forebay Dam	zoned earthfill	200	1,550	1,990	25	1,530.0* 1,540.0	10.0	6,000,000
Feather River Fish Barrier Dam	concrete gravity	91	181	600	10	148.5	–	9,300
Frenchman Dam	homogeneous earthfill	139	5,607	720	30	5,588.0	19.0	537,000
Grizzly Valley Dam (Lake Davis)	zoned earth and rockfill	132	5,785	800	30	5,775.0	10.0	253,000
Little Panoche Detention Dam	zoned earthfill	151	676	1,440	30	641.5	34.5	1,210,000
Los Banos Detention Dam	zoned earthfill	167	384	1,370	30	353.5	30.5	2,100,000
O'Neill Dam	homogeneous earthfill	88	233	14,350	30	225.0	8.0	3,000,000
Oroville Dam	zoned earthfill	770	922	6,920	50.6	813.6* 901.0	21.0	80,000,000
Patterson Dam	homogeneous earthfill	33	712	1,275	15	–	2.0	97,400
Perris Dam	zoned earthfill	128	1,600	11,600	40	1,590.0	10.0	20,000,000
Pyramid Dam	zoned earth and rockfill	400	2,606	1,090	35	2,548.0* 2,579.0	27.0	6,860,000
Quail Dam	homogeneous earthfill	45	3,330	6,600	22	3,327.0	3.0	1,900,000
Sisk Dam (San Luis Reservoir)	zoned earth and rockfill	385	554	18,600	30	543.9	10.1	77,645,000
Thermalito Afterbay Dam	homogeneous earthfill	39	142	42,000	30	113.0*	5.5	5,020,000
Thermalito Diversion Dam	concrete gravity	143	233	1,300	24	205.0*	8.0	154,000
Thermalito Forebay Dam	homogeneous and zoned earthfill	91	231	15,900	30	179.5*	6.0	1,840,000

*sill elevation of gated spillway or weir



The majority of SWP's dams are earthfill. The dams' design was based on costs and availability of materials to construct the embankment. (photo: Del Valle Dam and Lake)

Power Plant Characteristics, by Type of Facility

Type and Facility	Number of Units	Normal Static Head (feet)	Total Flow at Design Head (cfs)	Total Generator Rating (kW)	Penstock Diameter (feet)
Hydro					
Hyatt	6 (3p-g)	410-676	16,950	644,250	2 @ 22
Thermalito Diversion Dam	1	63-77	615	3,000	2 @ 5 to 1@ 7.5
Thermalito	4 (3p-g)	85-102	17,400	115,000	1 @ 24 to 21 / 3 @ 21 to 18
Gianelli SWP share	8 p-g	99-327	16,960	424,000 222,000	4 @ 17.5
Warne	2	719-739	1,564	74,300	1 @ 12
Castaic (LADWP)	7(6p-g)	1,048	17,840	1,247,000	6 @ 13.5 to 9 / 1 @ 9 to 7
Alamo	1	115-141	1,740	17,000	1 @ 12.0
Mojave Siphon	3	81-136	2,880	32,400	3 @ 12 to 10
Devil Canyon	4	1,406	2,940	280,000	1 @ 9.5 to 8/1 @ 12.5 to 8
Thermal					
Reid Gardner, Unit 4	1*			249,000	
(SWP share)				169,500	

*Life of the plant is expected to extend through 2013.

Pumping Plant Characteristics

Type and Facility	Number of Units	Normal Static Head (feet)	Total Flow at Design Head (cfs)	Total Motor Rating (hp)	Discharge Lines Diameter (feet)
Hyatt	3 p-g	500-660	5,610	519,000	2 @ 22
Thermalito	3 p-g	85-102	9,120	120,000	1 @ 24 to 21 / 3 @ 21 to 18
Barker Slough	9	95-120	228	4,800	1 @ 6
Cordelia	11	110-376	138	5,600	1 @ 3.5 / 1 @ 2.6 / 1 @ 3.33
Banks	11	236-252	10,670	333,000	1 @ 13.5 / 4 @ 15.0
South Bay	9	566	330	27,750	1 @ 4.5 / 1 @ 5.5
Del Valle	4	0-38	120	1,000	1 @ 5
Gianelli	8 p-g	99-327	11,000	504,000	4 @ 17.5
Dos Amigos	6	107-125	15,450	240,000	6 @ 18
Las Perillas	6	55	461	4,050	2 @ 6.5
Badger Hill	6	151	454	11,750	2 @ 6.5
Devil's Den*	6	521	134	10,500	1@4
Bluestone*	6	484	134	10,500	1 @ 4
Polonio Pass*	6	533	134	10,500	1 @ 4
Buena Vista*	10	205	5,405	144,500	8 @ 9
Teerink*	9	233	5,445	150,000	7 @ 9
Chrisman*	9	518	4,995	330,000	1 @ 9.5 / 3 @ 12.5
Edmonston*	14	1,926	4,480	1,120,000	2 @ 14.0 to 12.5
Oso	8	231	3,252	93,800	5 @ 9
Castaic (LADWP)	6 p-g	1,078	12,000	1,920,000	6 @ 13.5-9
Pearblossom	9	540	2,575	203,200	2 @ 9 / 1 @ 13

* These plants have one unit in reserve.

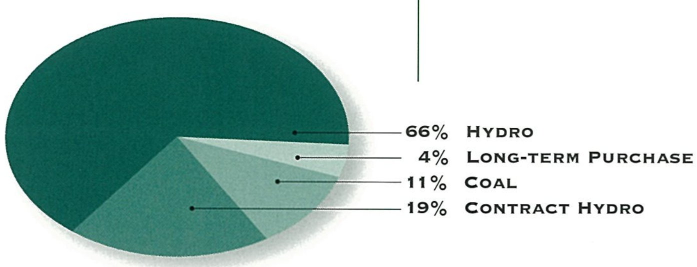
Total Miles of Aqueducts					
Facility	Channel & Reservoir	Canal	Pipeline	Tunnel	Total
North Bay Aqueduct	0.0	0.0	27.4	0.0	27.4
South Bay Aqueduct	0.0	8.4	32.9	1.6	42.9
Subtotal	**0.0**	**8.4**	**60.3**	**1.6**	**70.3**
California Aqueduct, Main Line					
Delta to O'Neill Forebay	1.4	67.0	0.0	0.0	68.4
O'Neill Forebay to Kettleman City	2.2	103.5	0.0	0.0	105.7
Kettleman City to Edmonston Pumping Plant	0.0	120.9	0.0	0.0	120.9
Edmonston Pumping Plant to Tehachapi Afterbay	0.0	0.2	2.5	7.9	10.6
Tehachapi Afterbay to Lake Perris	2.9	93.4	38.3	3.8	138.4
Subtotal	**6.5**	**385.0**	**40.8**	**11.7**	**444.0**
California Aqueduct Branches					
West Branch	9.2	9.1	6.4	7.2	31.9
Coastal Branch	0.0	15.0	97.9	2.7	115.6
Subtotal	**9.2**	**24.1**	**104.3**	**9.9**	**147.5**
Total	**15.7**	**417.5**	**205.4**	**23.2**	**661.8**


Northwest Power Transmission Access
Transmission Paths Connecting Power Resources and Power Delivery Points
SWP Powerplants
Contract Supplies
Bulk Power Delivery Points
Transmission By Others
Redding
Hyatt
Thermalito Diversion Dam
Thermalito
Sacramento
San Francisco
Gianelli
Pine Flat
Fresno
California Aqueduct
Reid Gardner Unit 4
Bakersfield
Alamo
Warne
Castaic
Mojave Siphon
Devil Canyon
Los Angeles
San Diego
N

Some of the SWP power plants generate electricity through pumped-back storage operations. Others, such as Alamo Powerplant (above), were constructed in locations to recover energy from falling water.

With the deregulation of the power industry in California, DWR must now compete with other electrical utilities to sell and buy power used to move water to its destinations.

State Water Project Power Resources



The 900-megawatt Oroville-Thermalito Complex (composed of the Hyatt and Thermalito Pumping-Generating Plants) generate about 2.2 billion kilowatthours in a median year, while the 3 MW Thermalito Diversion Dam Powerplant adds another 24 million kWh annually.

Generation at existing SWP aqueduct recovery power plants – Gianelli, Alamo, Devil Canyon, Mojave Siphon, and Warne – varies with the amount of water conveyed. These five plants generate about one-sixth of the total energy used by the SWP.

Conversion Factors				
Quantity	To Convert From Customary Unit	To Metric Unit	Multiply Customary	To convert To Customary Unit, Multiply Metric Unit By
Length	inches (in)	millimeters (mm)*	25.4	0.03937
	inches (in)	centimeters (cm)	2.25	0.3937
	feet (ft)	meters(m)	0.3048	3.2808
	miles (mi)	kilometers (km)	1.6093	0.62139
Area	square inches (in^2)	square millimeters (mm^2)	645.16	0.00155
	square feet (ft^2)	square meters (m^2)	0.092903	10.764
	acres (ac)	hectares (ha)	0.40469	2.4710
	square miles (mi^2)	square kilometers (km^2)	2.590	0.3861
Volume	gallons	liters (L)	3.7854	0.26417
	million gallons (10^6 gal)	megaliters (ML)	3.7854	0.26417
	cubic feet (ft^3)	cubic meters (m^3)	0.028317	35.315
	cubic yards (yd^3)	cubic meters (m^3)	0.76455	1.308
	acre-feet (ac-ft)	thousand cubic meters ($m^3 x 10^3$)	1.2335	0.8107
	acre-feet (ac-ft)	hectare-meters (ha-m) ■	0.1234	8.107
	thousand acre-feet (taf)	million cubic meters ($m^3 x 10^6$)	1.2335	0.8107
	thousand acre-feet (taf)	hectare-meters (ha-m) ■	123.35	0.008107
	million acre-feet (maf)	billion cubic meters ($m^3 x 10^9$) ◆	1.2335	0.8107
	million acre-feet (maf)	cubic kilometers (km^3)	1.2335	0.8107
Flow	cubic feet per second (ft^3/s or cfs)	cubic meters per second (m^3/s)	0.028317	35.315
	gallons per minute (gal/min)	litters per minute (L/min)	3.7854	0.26417
	gallons per day (gal/day)	liters per day (L/day)	3.7854	0.26417
	million gallons per day (mgd)	megaliters per day (ML/day)	3.7854	0.26417
	acre-feet per day (ac-ft/day)	thousand cubic meters ($m^3 x 10^3$ /day)	1.2335	0.8107
Mass	pounds (lb)	kilograms (kg)	0.45359	2.2046
	tons (short, 2,000 lb)	megagrams (Mg)	0.90718	1.1023
Velocity	feet per second (ft/s)	meters per second (m/s)	0.3048	3.2808
Power	horsepower (hp)	kilowatts (kW)	0.746	1.3405
Pressure	pounds per square inch (psi)	kilopascals (kPa)	6.8948	0.14505
	feet head of water	kilopascals (kPa)	2.989	0.33456
Specific Capacity	gallons per minute per foot of drawdown	liters per minute per meter of drawdown	12.419	0.08052
Concentration	parts per million (ppm)	milligrams per meter (mg/L)	1.0	1.0
Electrical Conductivity	micromhos per centimeter	microsiemens per centimeter (mS/cm)	1.0	1.0
Temperature	degrees Fahrenheit (°F)	degrees Celsius (°C)	(°F-32)/1.8	(1.8 x °C)+32

* When using "dual units," inches are normally converted to millimeters (rather than centimeters).

■ Not used often in metric countries, but is offered as a conceptual equivalent of customary Western U.S. practice (a standard depth of water over a given area of land).

◆ ASTM Manual E380 discourages the use of billion cubic meters since that magnitude is represented by *giga* (a thousand million) in other countries. It is shown here for potential use for quantifying large reservoir volumes (similar to million acre-feet).

Many of the facilities of the State Water Project are named to honor prominent people who exhibited outstanding leadership in planning, establishing the fiscal and political framework, and constructing and operating the Project. These facility names have been shortened for readability throughout this book, but are listed here to acknowledge the prominent role of the people for whom the facilities are named.

Abbreviated Name	Complete Name	Name and Position of Honoree
Banks Pumping Plant	Harvey O. Banks Delta Pumping Plant	**Harvey O. Banks**, first Director of the California Department of Water Resources, 1956-60.
California Aqueduct	Governor Edmund G. Brown California Aqueduct	**Edmund G. (Pat) Brown**, Governor of California, 1959-67, under whose leadership the Legislature authorized and the voters approved the State Water Project.
Chrisman Pumping Plant	Ira J. Chrisman Wind Gap Pumping Plant	**Ira J. Chrisman**, Member of the California Water Commission, 1960-76 (Chairman 1967-76).
Edmonston Pumping Plant	A.D. Edmonston Pumping Plant	**A.D. Edmonston**, State Engineer, Division of Water Resources, Department of Public Works, 1950-55.
Gianelli Pumping-Generating Plant	William R. Gianelli Pumping-Generating Plant*	**William R. Gianelli**, Director of California Department of Water Resources, 1967-73, and Assistant Secretary of the Army for Civil Works, 1981-84.
Hyatt Powerplant	Edward Hyatt Powerplant	**Edward Hyatt**, State Engineer, Division of Water Resources, Department of Public Works, 1927-50.
Lake Davis	Lake Davis	**Assemblyman Lester Thomas Davis**, California Legislature, 1947-52, and **Assemblywoman Pauline L. Davis**, California Legislature, 1953-72. Husband and wife were active in legislative water matters. Mrs. Davis coauthored the Davis-Grunsky and Davis-Dolwig Acts.
O'Neill Forebay	O'Neill Forebay*	**Jack Edward O'Neill**, a pioneer farmer in the San Joaquin Valley, who worked for authorization of the San Luis Division of the federal Central Valley Project.
Porter Tunnel	Carley V. Porter Tunnel	**Assemblyman Carley V. Porter**, California Legislature, 1949-72, coauthored the 1959 Water Resources Development Bond Act to help finance the State Water Project.
Silverwood Lake	Silverwood Lake	**W.E. "Ted" Silverwood**, a resident of Riverside County who worked unceasingly to promote the State Water Project.
Sisk Dam	B.F. Sisk San Luis Dam*	**Congressman B.F. Sisk**, U. S. Congress, 1955-79, introduced legislation authorizing the San Luis Unit of the federal Central Valley Project.
Skinner Fish Facility	John E. Skinner Delta Fish Protective Facility	**John E. Skinner**, California Department of Fish and Game, 1954-78, supervised the evaluation and improvements of the fish protective facility.
Teerink Pumping Plant	John R. Teerink Wheeler Ridge Pumping Plant	**John R. Teerink**, Director of the California Department of Water Resources, 1973-75.
Warne Powerplant	William E. Warne Powerplant	**William E. Warne**, Director of the California Department of Water Resources, 1961-66.

**A joint-use facility of the California State Water Project and the federal Central Valley Project*


Recreation Symbols
Boating
RV Facilities
Camping
Scenic Vista
Fishing*
Swimming
Picnicking
Visitors Center
*Fishing is available at additional State Water Project locations.
0
50
100 Miles
0
50
100 Kilometers
N
Redding
Sacramento River
Antelope Lake
Lake Davis
Frenchman Lake
Lake Oroville
Oroville
Sacramento
San Francisco
Bethany Reservoir
Lake del Valle
San Luis Reservoir
Los Banos Reservoir
California Aqueduct
Pyramid Lake
Castaic Lake
Los Angeles
Silverwood Lake
San Bernardino
Lake Perris
Riverside
San Diego
5
99
70
80

Although the State Water Project was not initially conceived with recreation in mind, its facilities were designed to accommodate such activities as camping, hiking, picnicking, swimming, boating, fishing, and other water-related activities.

Frenchman Lake was the first facility of the State Water Project to provide recreation. In 1962 when the lake first went into operation, 30,000 visitors were counted. Today the SWP has 37 recreation areas throughout California, including 16 fishing access sites, and welcomes an average of about 5 million visitors each year.

The public is also welcome at the Department's three visitors centers: Lake Oroville Visitors Center at Lake Oroville, Romero Overlook Visitors Center at San Luis Reservoir, and Vista del Lago Visitors Center at Pyramid Lake. Visitors are also invited, by appointment only, to the following locations: Delta Field Division (tours of the Banks Pumping Plant, Skinner Fish Facility, and other Delta facilities and sites) in Bryon, A.D. Edmonston Pumping Plant, south of Bakersfield, and Devil Canyon Powerplant in San Bernardino.
(See page 190 for locations and phone numbers.)

At the visitors centers, exhibits, films, and photos tell the story of the State Water Project and the importance of water in our lives. They are open daily, except some holidays, and admission is free.

Recreational facilities are financed through provisions of the Davis-Dolwig Act (1961) and later legislation that provided sources of funding.

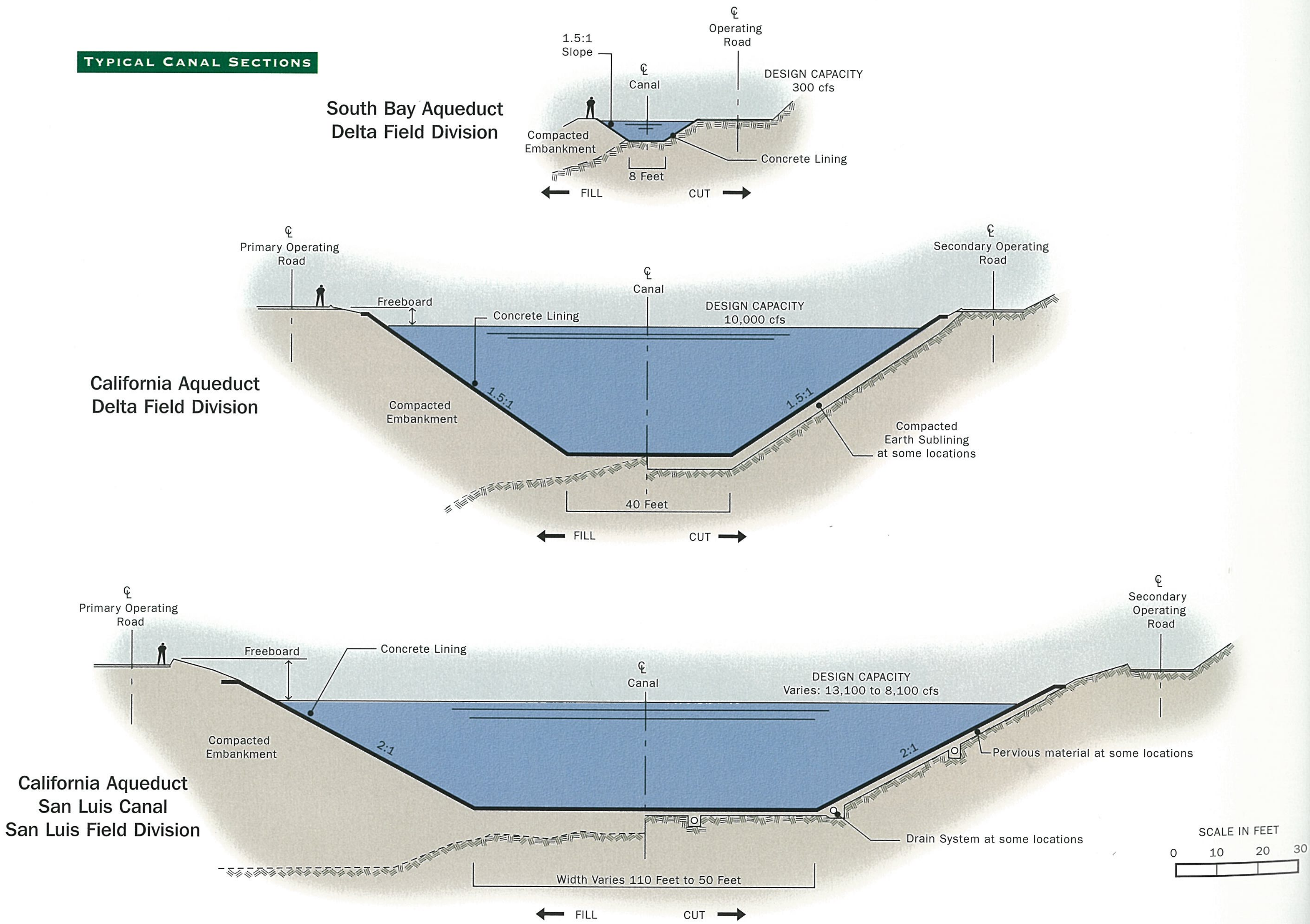
Water recreation of all kinds are available at most SWP lakes and reservoirs. DWR helps fund the development of recreation areas, while the California Department of Parks and Recreation or private concessionaires operate the facilities.

The Davis-Dolwig Act declared that providing for the enhancement of fish and wildlife and for recreation in connection with the SWP benefits all people of California and that the costs for such enhancement should be borne by them (through appropriations from the General Fund). The act also provided a procedure through which DWR was to be reimbursed for those project costs allocated to recreation and fish and wildlife enhancement and for costs of acquiring property for recreation development.

On the previous page is a map showing some of the SWP recreation areas and the recreational opportunities available. For more information, call 800-272-8869.

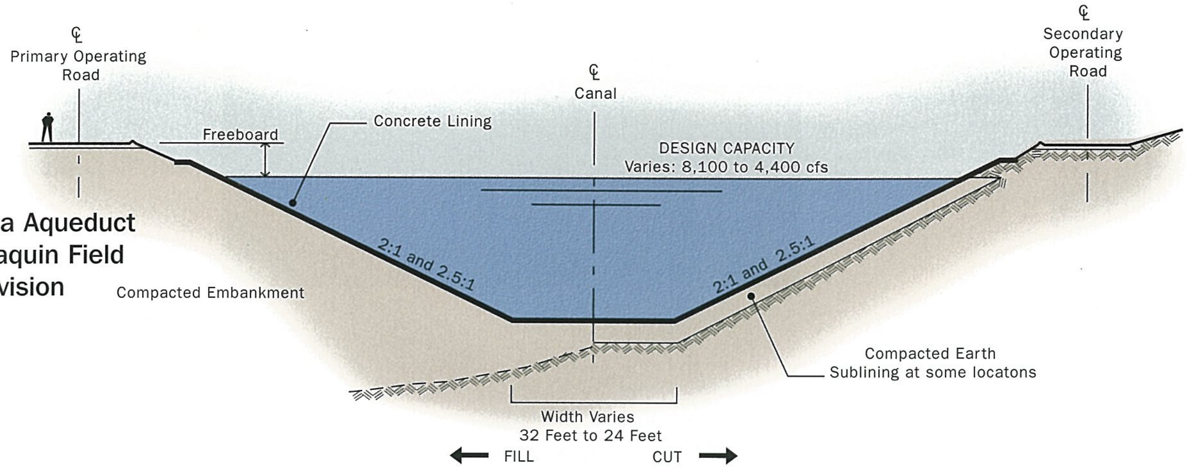
Canal prism dimensions depend on the following: required waterway area (capacity), side slope stability, water depth-to-width ratio, and freeboard. A side slope of 1:5:1 was considered the maximum practical, however flatter slopes were used extensively.

TYPICAL CANAL SECTIONS

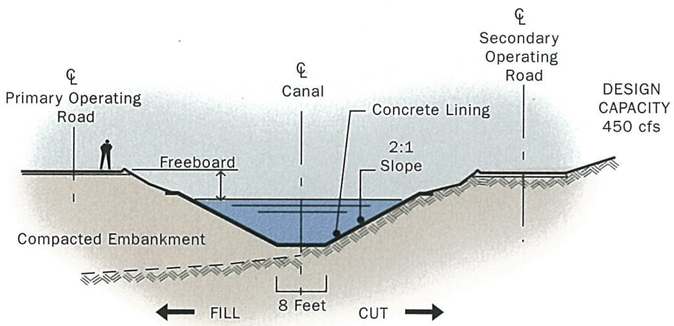


TYPICAL CANAL SECTIONS

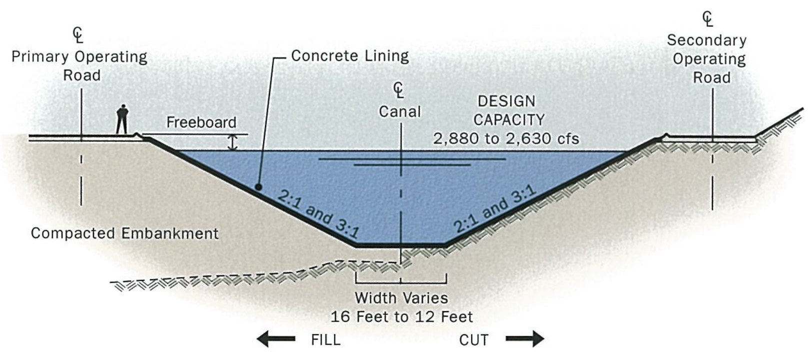
California Aqueduct
San Joaquin Field
Division



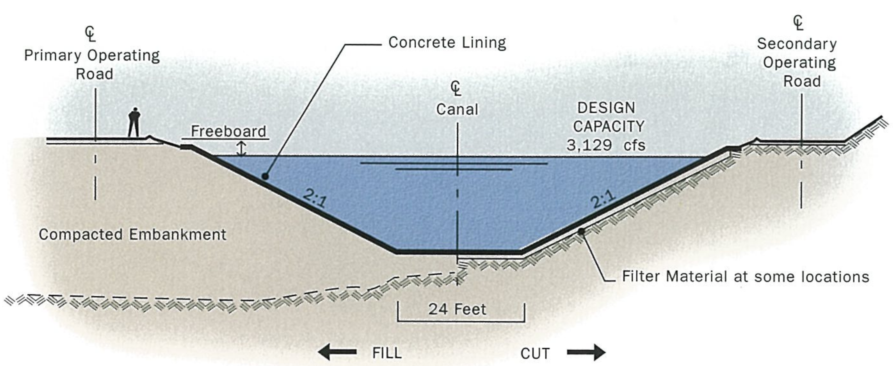
California Aqueduct
Coastal Branch
San Joaquin Field
Division

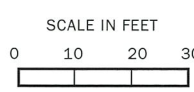


California Aqueduct
East Branch
Southern Field
Division



California Aqueduct
West Branch
Southern Field
Division

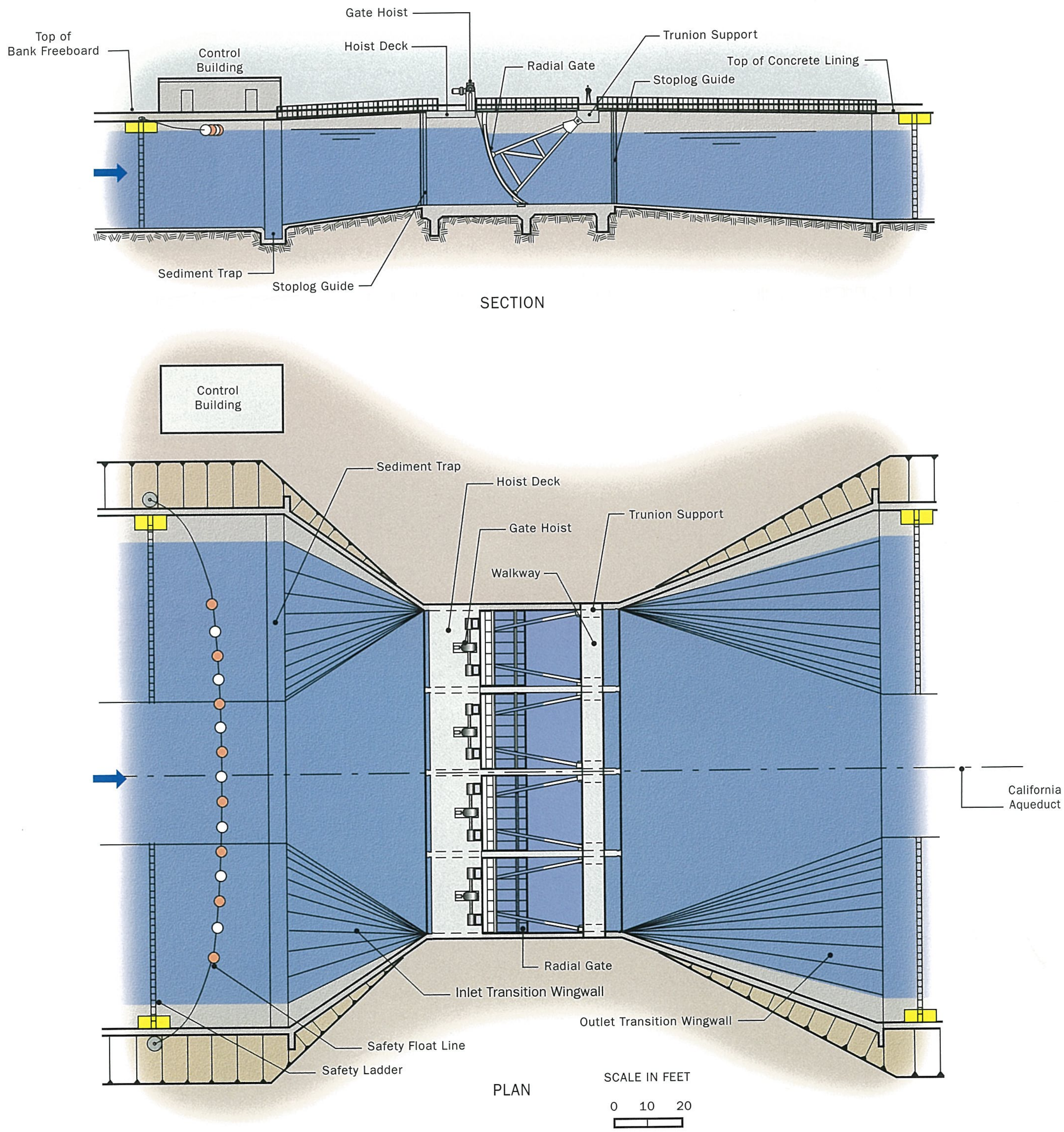




The decision to concrete-line the canal was based on lower friction loss (and therefore lower pumping costs), reliability, maintenance, and reduced seepage. An unreinforced concrete lining three to four inches thick was selected at most sites. The lining is not ordinarily a structural member under stress. Other lining design considerations included the slope and spacing of transverse and longitudinal grooves to control contraction and expansion, the type of sealant for the grooves, and the nature of the soil under the concrete lining. A firm, compacted, well-trimmed surface was essential to the lining's serviceability.

When groundwater was present, a drainage filter was installed behind the lining to reduce back pressure on the lining caused by water drawdown in the canal. Water surface fluctuations in the canal are minimized to reduce damage to the unreinforced concrete lining.

Typical Check Structure

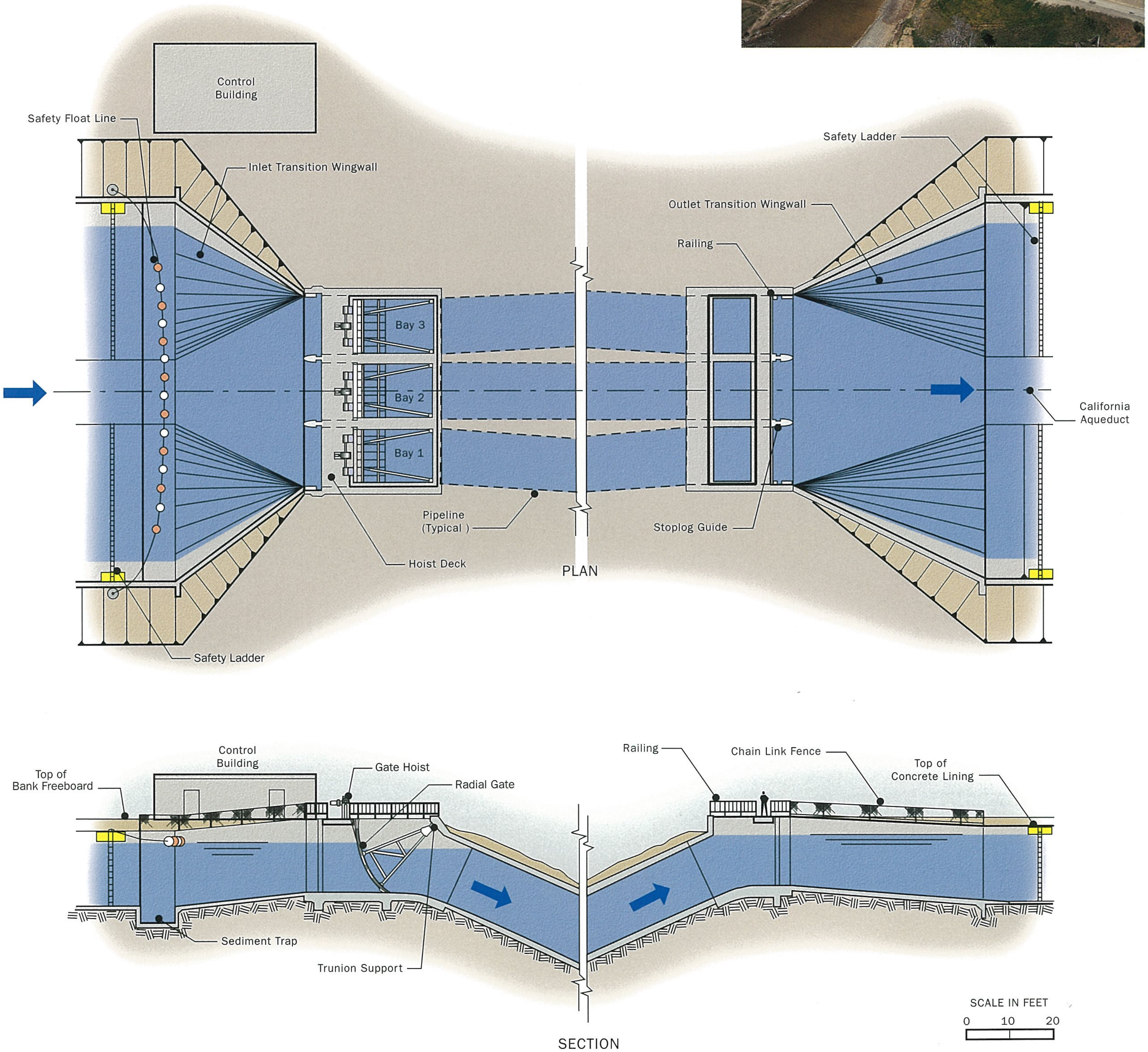


The check structures along the aqueduct system of the State Water Project control the flow of water. The structure consists of steel radial gates, within rectangular shaped channel sections, that open or close by remote control to maintain the water level in the aqueduct at the desired flow and depth at all times. Water surface fluctuations are typically restricted to a maximum of one foot over a 24-hour period to limit damage to the aqueduct's unreinforced concrete canal lining.

Check structures are equipped with one to five radial gates. Stoplogs placed in slots allow for dewatering of bays for gate servicing without full disruption of the entire structure and flows. The gates are designed for full hydraulic loading on either side.

Check siphon structures are located where large cross flow drainage is passed over the aqueduct. The check structure is split; the inlet transition and gate structure are located at the start of the siphon and the outlet structure and transition are located at the end of the siphon. The "inverted siphon" pipeline located between the check structure's inlet and outlet sections is several miles long in some areas.

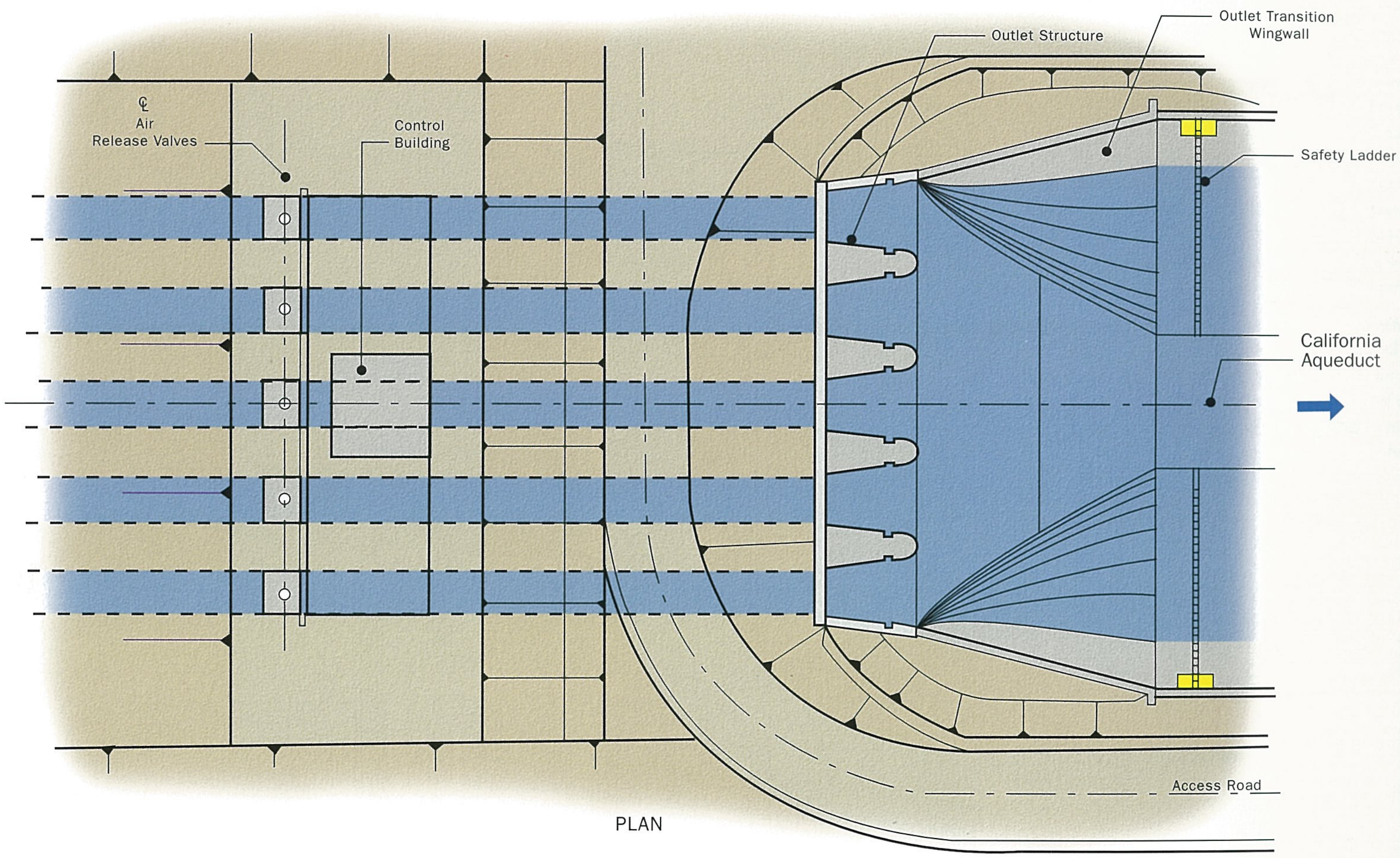
Typical Check Siphon Structure

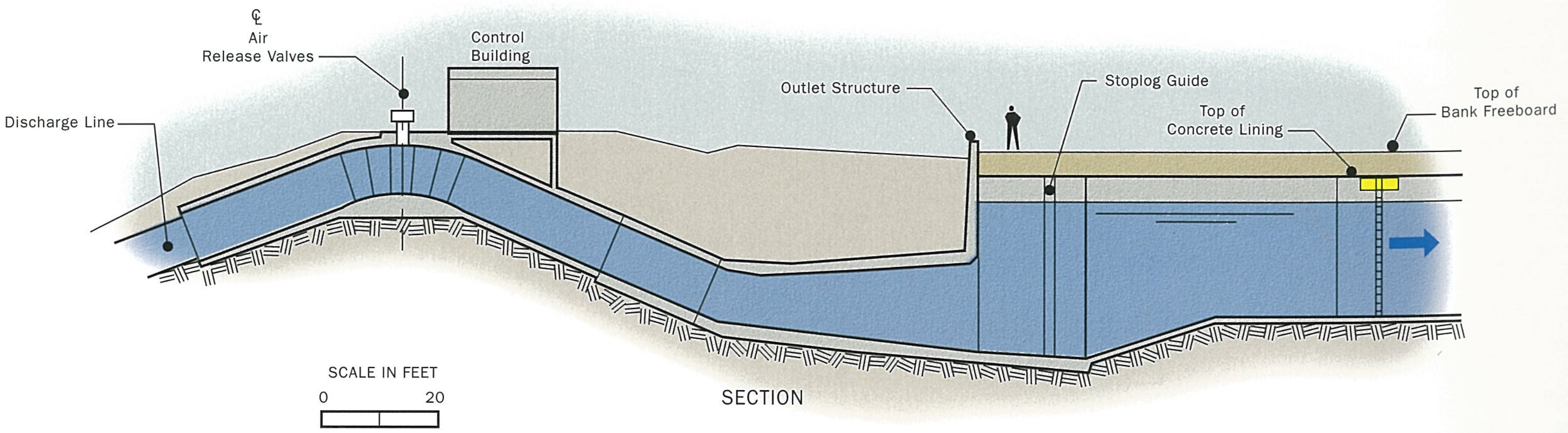


Siphon outlet structures are provided at the upper ends of the pump discharge pipelines. They are used in place of valves or gates to prevent backflow during pump outages and to provide for safer, more reliable aqueduct operation. Additional advantages of these outlets are elimination of water leaking from canal gates into empty discharge conduits during maintenance.

At each discharge line's crest, the invert elevation is at least 1.0 foot higher than the maximum water surface elevation of the canal. During operation a siphon condition (subatmospheric pressure) is created over this crest section. When flow in the discharge pipeline is stopped, a 30-inch air release valve at the siphon crown opens to admit air, raising the pressure in the siphon to atmospheric and preventing siphon action in either direction.

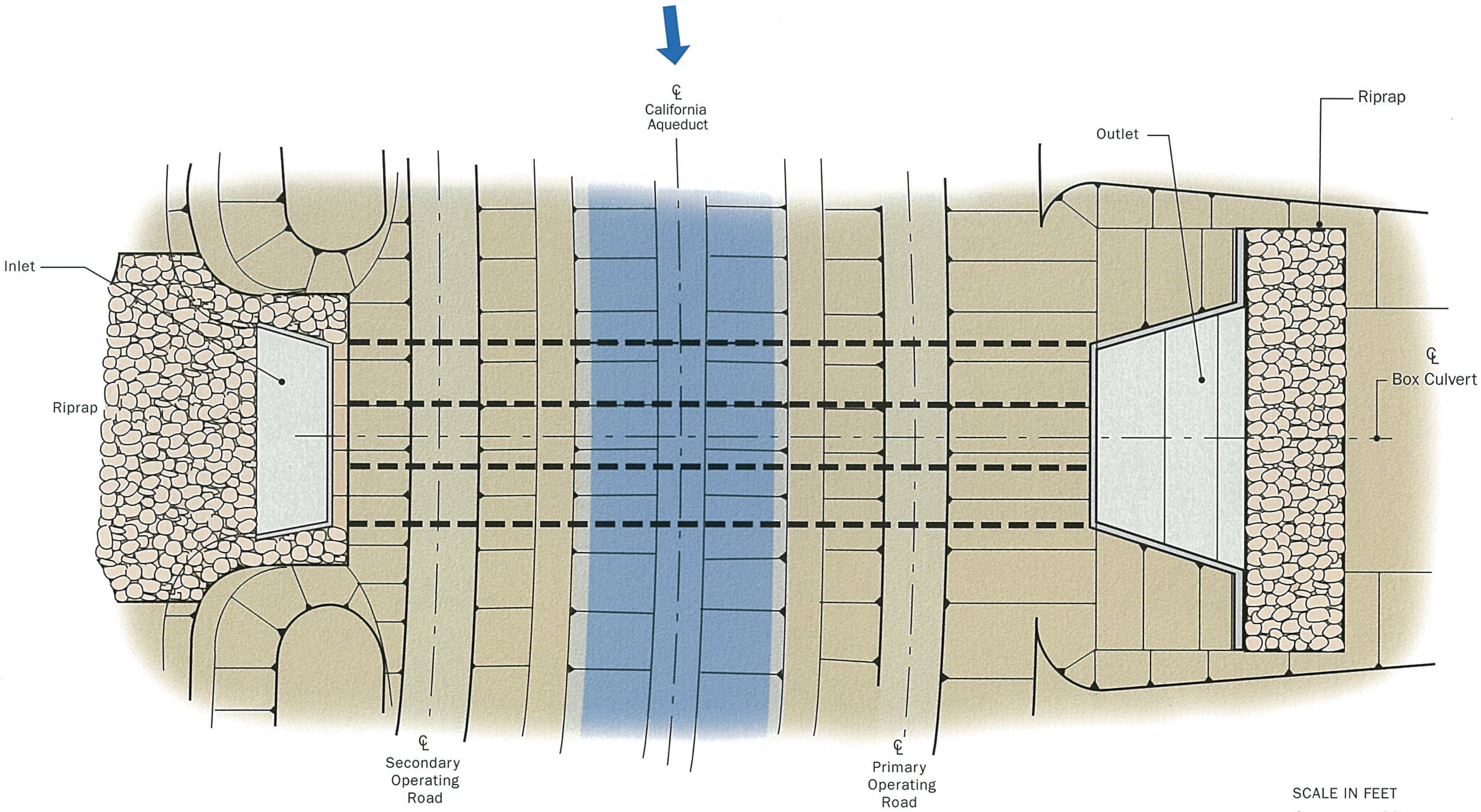
Typical Pumping Plant Siphon Outlet Structure



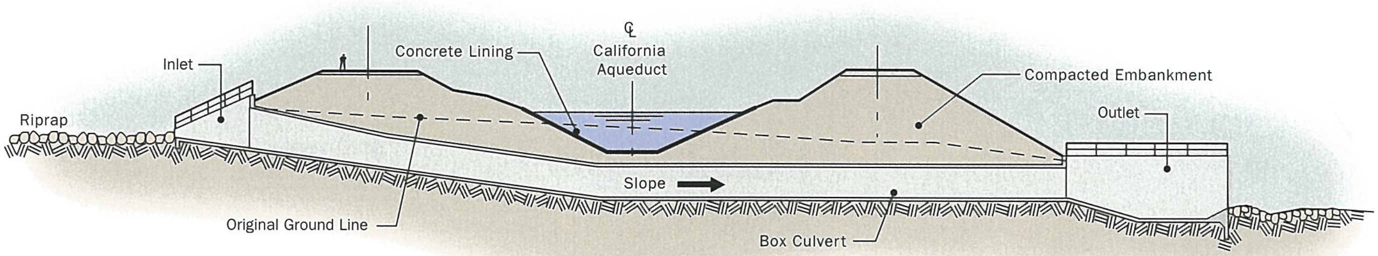


Culverts were used where a high canal embankment crossed a natural drainage course. Almost without exception, culverts were designed both for open-channel flow and full-pressure flow due to the wide range of flow conditions anticipated. The choice between a culvert undercrossing for drainage flows or a siphon undercrossing for canal flows largely was based on the volume of flow in the drainage course and the disturbance of the existing channel equilibrium with a culvert undercrossing. Large-volume cross flow was a prime consideration favoring a canal siphon.

Typical Box Culvert Cross Drainage



PLAN

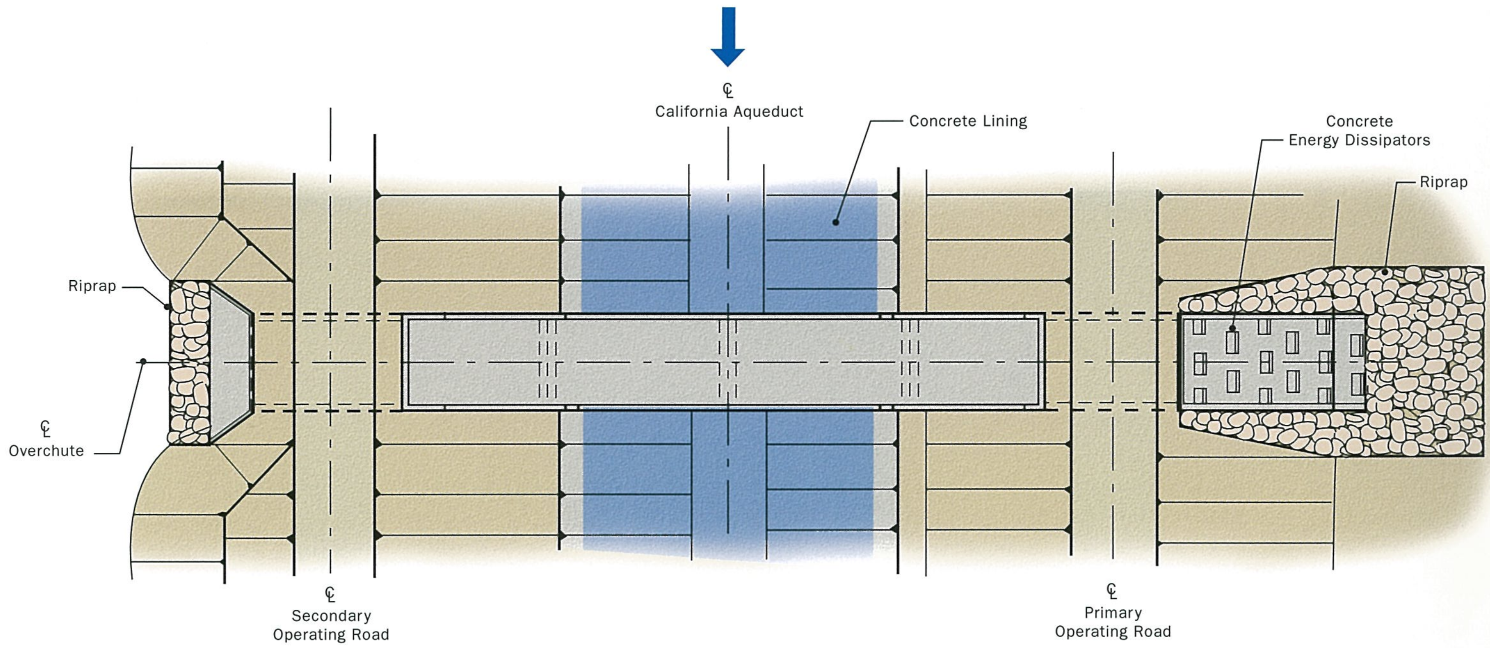


SECTION

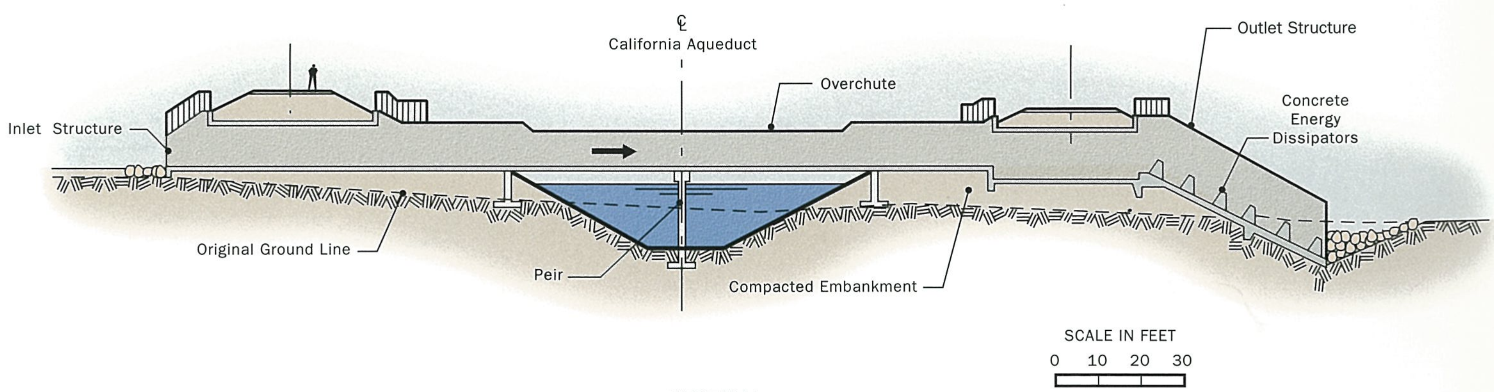
Overchutes were favored where the drainage channel invert was high enough that it could be easily carried across the open canal prism. Overchutes were designed to carry the drainage flows in a pipe or an open flume. They are usually supported by a single pier to minimize head loss in the aqueduct.

The inlet transition usually was dependent upon whether the chute portion was designed for subcritical or supercritical flow. As with culverts, the variation in design flows usually resulted in both types of flow occurring. The outlet transition was generally incorporated into the energy dissipator structure.

Typical Overchute



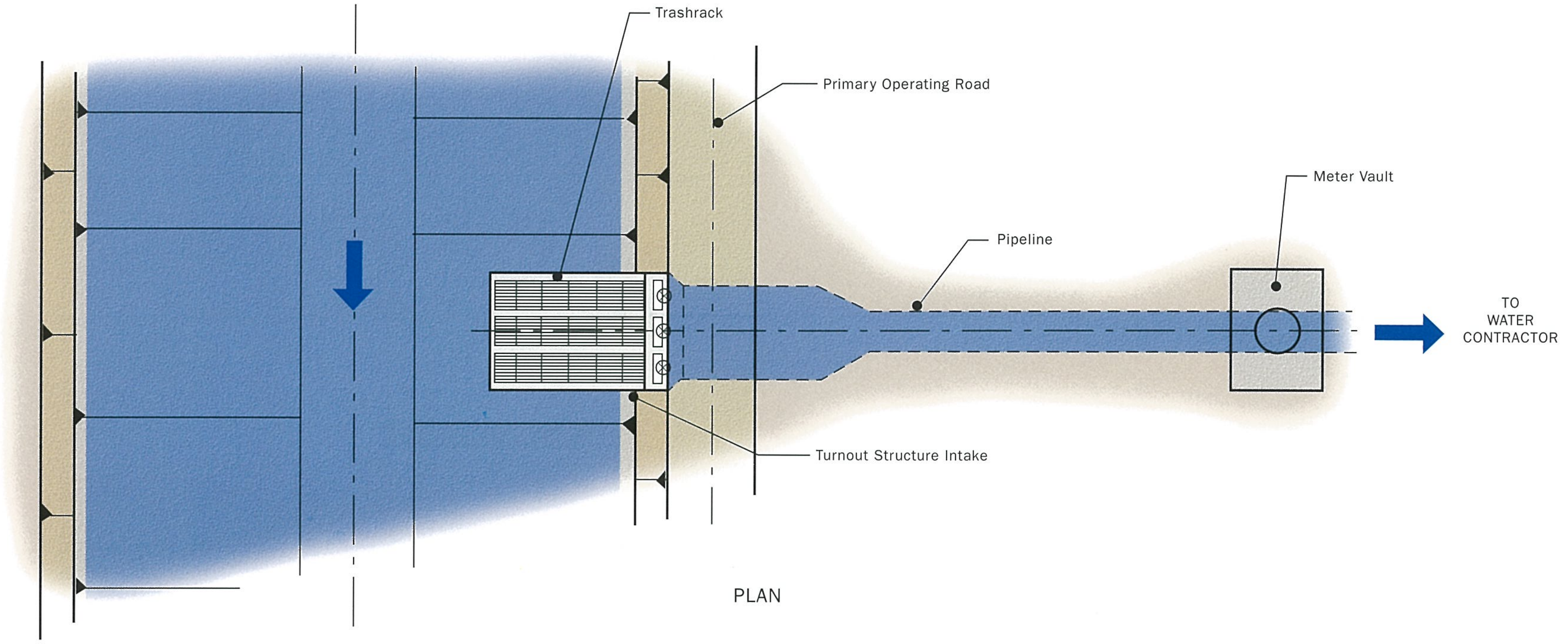
PLAN



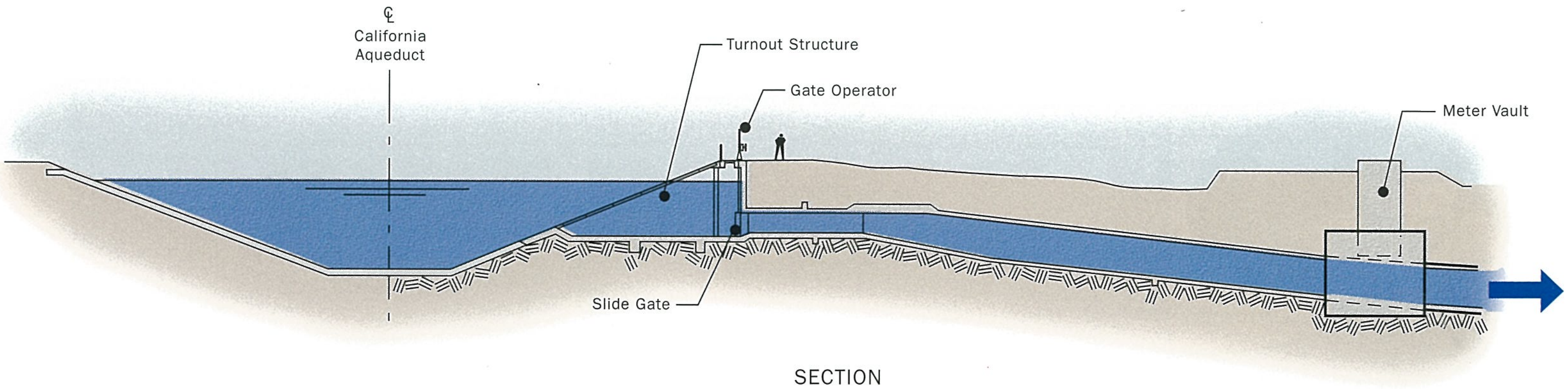
SECTION

Turnouts, or diversion structures, were designed for either gravity or pumped diversions. Used to deliver water to the SWP's contractors, the turnout's design required mutual approval of the water users and DWR. A turnout normally consists of an intake structure, with trashrack and slide gates, a pipeline or canal lateral, and a flow measuring facility.

TYPICAL TURNOUT



PLAN



SECTION

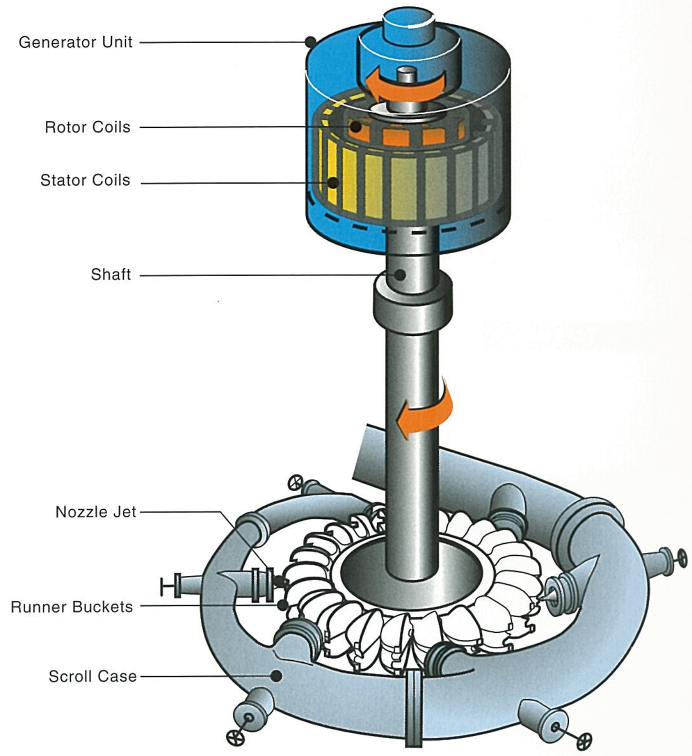
Types of Turbines Used By The SWP

Turbines commonly used in SWP power plants are the Pelton wheel (right), an impulse turbine, and two reaction turbines, the Francis and Kaplan (below).

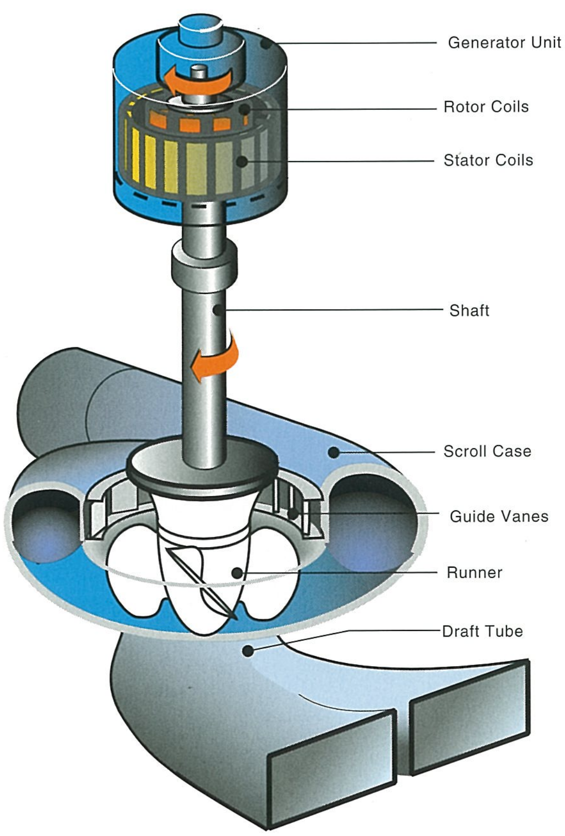
An impulse turbine, is turned by pressure from one or more stationary nozzles that direct a jet stream of water striking buckets that are arranged around the circumference of the wheel. It is generally used at power plants with relatively high heads, from 300 to over 2,000 feet.

Reaction turbines are of two general types: Francis (lower right) and Kaplan (lower left). Unlike the impulse turbines, the water passages are completely filled as the water passes through the turbine (see illustration on facing page). The water swirls into the runner's periphery from the scroll case. Guide vanes control the amount and angle of the flow into the turbines' runners from the scroll case. Kaplan units operate most efficiently in low head ranges up to 100 feet, while Francis units run efficiently at medium heads from 90 to 1,000 feet.

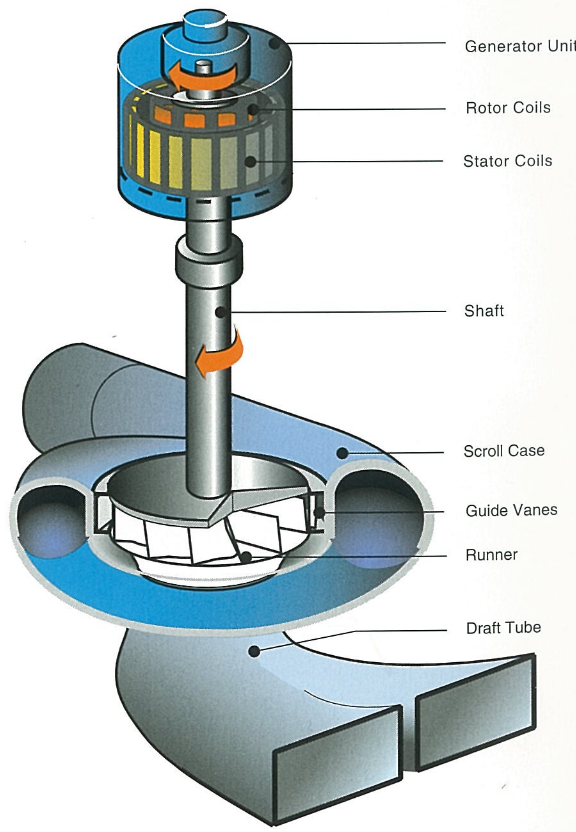
Pelton Wheel Turbine

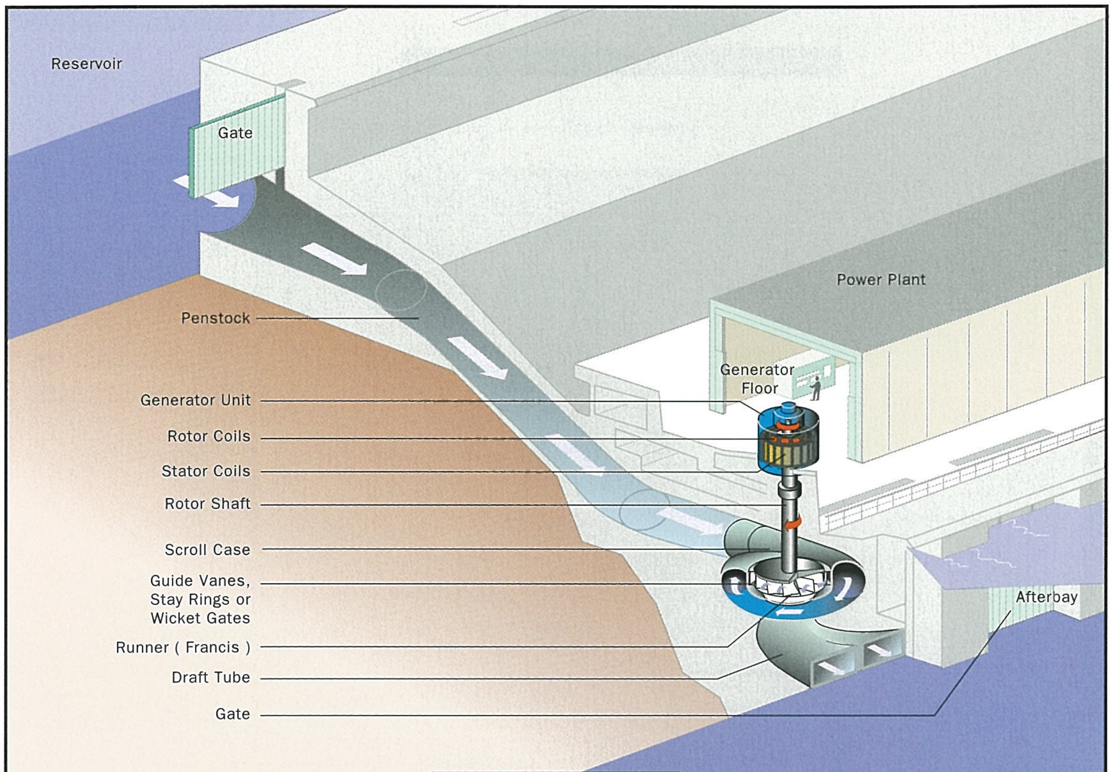


Kaplan Turbine



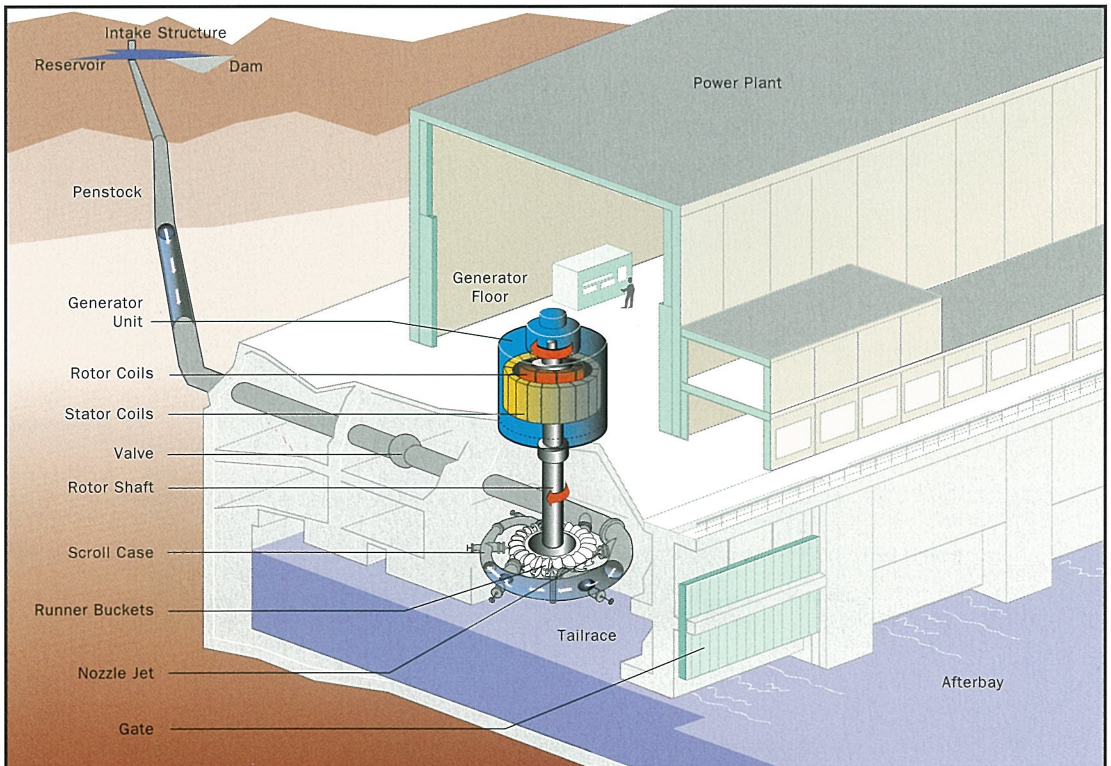
Francis Turbine





REACTION TURBINE

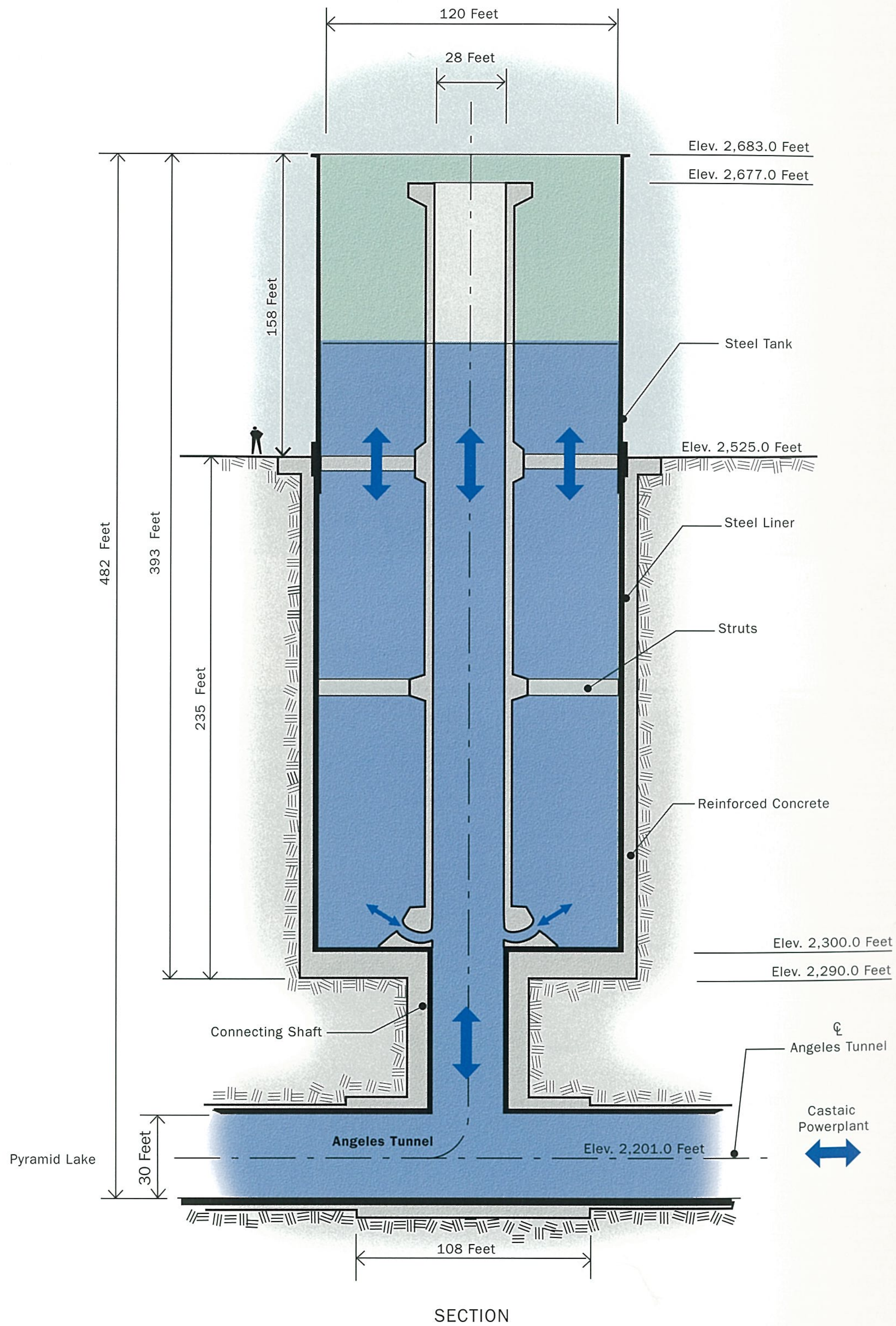
Some of the pumping-generating plants utilize a reversible Francis-type turbine, operating in one direction of rotation as a pump and the opposite direction as a turbine. The runner and shaft are connected to a synchronous generator/motor operating in one direction as a motor driving the pump and in the opposite direction providing power as a generator.



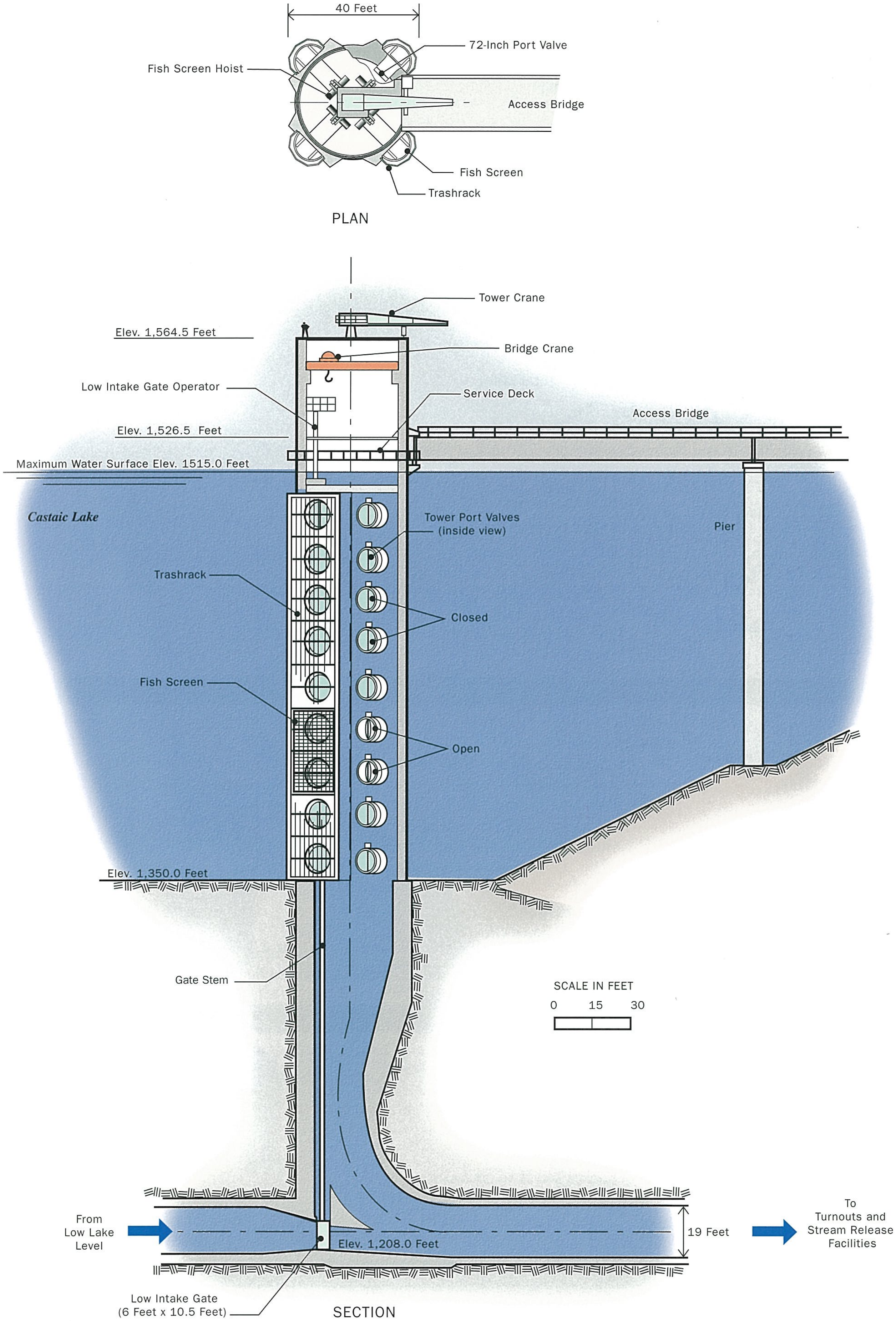
PELTON WHEEL TURBINE

Pyramid Lake water travels through the Angeles Tunnel before it enters Castaic Powerplant. The surge chamber, included in the construction of the tunnel, was designed and financed by the city of Los Angeles. It is 120 feet in diameter and 393 feet in height, of which 235 feet is underground. The steel tank lining extends 158 feet above ground. A supporting juncture structure is directly below the surge chamber on the tunnel alignment and connects the surge chamber and the tunnel with a 28-foot diameter riser.

ANGELES TUNNEL SURGE CHAMBER



Castaic Dam Intake Tower



A multiple-level, high intake tower is located above the diversion tunnel and is connected to it by a vertical shaft. An access bridge spans from the right abutment of the dam to the high intake tower. This facility is designed to regulate temperature and water quality for downstream uses by selectively opening discharge ports.

A fish screen was required to prevent the passing of fish from the reservoir into the discharge system. The fish screens are movable and cover operating ports. Trashracks protect the intake tower ports and traveling fish screens from logs and other debris.

DELTA STATISTICS*

DEMOGRAPHY

Population: *410,000 (1990)*

Counties: *Alameda, Contra Costa, Sacramento, San Joaquin, Solano, Yolo*

Incorporated Cities Entirely Within the Delta: *Antioch, Brentwood, Isleton, Pittsburg, Tracy*

Major Cities Partly Within the Delta: *Sacramento, Stockton, West Sacramento*

Unincorporated Towns and Villages: *14*

GEOGRAPHY

Area (acres, 1991):

Agriculture	538,000
Cities and Towns	64,000
Water Surface	61,000
Undeveloped	75,000
Total Acres	**738,000**

Levees (miles, 1987):

Project	165
Direct Agreement	110
Non-project	825
Total Miles	**1,100**

Rivers Flowing into the Delta: *Sacramento, San Joaquin, Mokelumne, Cosumnes, Calaveras (These rivers plus their tributaries carry 47 percent of the state's total runoff.)*

Diversions Via Aqueducts Through or Around the Delta:

San Francisco Public Utilities Commission
East Bay Municipal Utility District

Diversions Directly from the Delta:

Western Delta Industry
City of Vallejo
1,800+ Agricultural Users
Contra Costa Canal
State Water Project
Central Valley Project

ECONOMY

Recreation:

User days annually	12,000,000
Registered Pleasure Boats	82,000
Commercial Recreation Facilities	120
Public Recreation Facilities	20
Private Recreation Associations	20
Berths	8,500
Docks	120
Launch Facilities	30

Transportation:

Interstate Highways: 5, 80, 205
State Highways: 4, 12, 160
Railroads: Southern Pacific, Union Pacific, Atchison, Topeka, & Santa Fe, Sacramento Northern
Shipping: Deepwater ship channels to Sacramento and Stockton transport 5 million tons of cargo annually.

Agriculture (1990):

Average Annual Gross Value = *Over $500 million*
Main crops: *Corn, Grain and Hay, Sugarbeets, Alfalfa, Pasture, Tomatoes, Asparagus, Fruit, Safflower*

FISH AND WILDLIFE

Birds	230 species
Mammals	45 species
Fish	52 species
Reptiles and Amphibians	25 species
Flowering plants	150 species

Major Anadromous Fish: Salmon, Striped Bass, Steelhead Trout, American Shad, Sturgeon

**Chart is from the Sacramento-San Joaquin Delta Atlas, revised 7/95*

SACRAMENTO-SAN JOAQUIN DELTA

A

Abutment - The point of contact between objects or parts that are adjacent or next to each other.

Acre-foot - The amount of water that would cover one acre of land one foot deep. One acre-foot equals 325,900 gallons, 43,560 cubic feet, or 1,233 cubic meters.

Afterbay - A storage reservoir downstream of a power plant or large reservoir. It is used to regulate stream flow, provide a storage buffer, or control tailwater depths.

Alluvial - Sediment deposited by flowing water, such as in a riverbed.

Ampere - The basic unit of electric current flow.

Anadromous - Any fish that spends a portion of its life cycle in freshwater and a portion in the sea.

Aqueduct - A conduit (such as a pipeline) or artificial channel (such as a concrete-lined canal) for transporting water.

Aquifer - An underground layer of rock, sediment, or soil that is filled or saturated with water.

B

Backfill - To refill an excavated area with construction material; or the material itself that is used to refill an excavated area.

Beneficial Use (of water) - The use of water for any beneficial purpose often defined by statute or court decisions. Such uses include domestic use, irrigation, fish and wildlife, fire protection, navigation, power, industrial use, etc.

Bifurcation - To divide or fork into two branches, such as the section of the California Aqueduct that divides into the East Branch and West Branch, or division of a penstock into two pipes upstream of a power plant.

Bond - A certificate of debt issued by the government or corporation guaranteeing payment of the original debt plus interest by a specified future date. These certificates were used to finance the construction of SWP facilities.

Brackish - Water containing too much salt to be drinkable but having less salt than ocean water. Salinity may range from 0.5 to 17 parts per thousand.

Butterfly Valve - A valve that uses a turnable disk element to regulate flow in a pipeline.

Bypass System - Provides for the diversion of flood flows into floodways that carry a portion of floodwater and hence decrease the flow in the main channel downstream of the point of diversion. Also a diversionary flow path to avoid some device or obstruction. Also used to direct or divert fish in a flow path away from an intake screen.

C

Capability - The maximum load which a machine, apparatus, station, or system can carry under specified conditions for a given period of time.

Capacity - The greatest load for which a piece of machine, apparatus, station, or system is rated or can safely serve. Also for hydroelectric plants it is the maximum power which can be developed by the generators at normal head at full flow. For pumping plants, it is the maximum amount of flow that can be moved at normal head.

Capital Expenditures - Funds spent for permanent facilities and additions or improvements to plants or equipment.

Carry-Over Storage - Storage of precipitation held over in a water storage reservoir from one year to the next.

Central Valley Project - The largest water conveyance project in California with 20 reservoirs, 11 power plants, 500 miles of canals, and other facilities. Operated by the federal government, the CVP can deliver up to 7 million acre-feet annually. Its primary purpose is to provide water for irrigation within the state's Central Valley, as well as provide urban water supply in portions of the valley and the San Francisco Bay area, water quality, flood control, power, recreation, and fish and wildlife enhancement.

Channel - A course, such as a trench or aqueduct, through which water is moved or directed; the bed of a river or stream.

Check Pool - A segment of the canal between two check or control structures. These segments, or pools, in the SWP are identified by sequential numbers.

Check Structure - A structure that regulates water flow in an open channel. For the State Water Project, check structures consist of steel radial gates that open or close by remote control to maintain the water level in the aqueduct at design depth during normal operation.

Chute - A steep-sloped conduit conveying water at high velocities to a lower level. Usually of an open channel box-shape and constructed of reinforced concrete; conveys water such as spillway flows over the crest of a dam or between major changes in open channel elevation.

Conduit - Any channel or pipe used for conducting the flow of water or protecting electrical wires or cable.

Conjunctive Use - A water management strategy that combines the use of surface and groundwater resources.

Conservation Storage - That portion of water, stored in a reservoir, which is impounded for later use.

Consolidation - Adjustment of a saturated soil in response to increased load; involves squeezing water from the voids and a decrease in void ration.

Consumptive Use - Quantity of water discharged to the atmosphere (elevation), or incorporated in the products of processes connected with vegetative growth, food processing, or industrial processes. Or the total annual land water loss in an area due to evaporation, plant and industrial process loss.

Control System - (for DWR) Real-time computers in pumping or power plants and water control structures connected through communication links to Area Control Centers (ACC) and the Project Operations Center (POC).

Conveyance Facilities - Facilities, such as aqueducts and channels, used to transport or carry water from one location to another.

CRITERIA - Water quality conditions which are to be met in order to support and protect desired uses. Could also be criteria for design operations, maintenance, flood control, etc.

CREST (DAM) - A line running between abutments describing the upper limit of a dam.

CUBIC FEET PER SECOND - A unit of measurement describing the flow of water. A cubic foot is the amount of water needed to fill a cube that is one foot on all sides, about 7.5 gallons.

CULVERT - A transverse drain, concrete box, pipe, etc. that transports water.

CURTAIN GROUTING - The process of pressure grouting deep holes under a dam or in an abutment to form a watertight barrier and effectively seal seams, fissures, fault zones, or fill cavities in the foundation or abutment.

CUTOFF WALL - A wall of impervious material (e.g., concrete, asphaltic concrete, steel, impervious curtain grouting, etc.) located in the foundation beneath an embankment dam and which forms a water barrier and reduces seepage under a dam or spillway.

D

DAM - A barrier built across a valley or river for storing water.

DEAD STORAGE - That portion of reservoir storage which is not available for operational purposes; inactive storage.

DEMAND (ELECTRICAL) - The load that the terminals of an installation or system averaged over a specified interval of time. Demand is expressed in kilowatts, kilovolt amperes, or other suitable units.

DEMAND (WATER) - The amount of water necessary to satisfy reasonable local requirements of a given community or agricultural area.

DELIVERY (WATER) - The amount of water DWR conveys to a contracting agency according to specified conditions.

DESIGN HEAD - The head at which a hydroelectric facility is designed to operate at maximum efficiency. Also refers to the water pressure or water elevation a facility may be designed to withstand, measured from the free surface level to the free discharge point.

DETENTION DAM - A dam built to store streamflow or surface runoff, and to control the release of such stored water. The SWP contains two detention dams that are used for flood control.

DEWATER - Removing water by pumping, draining or evaporation, usually from a work site.

DISCHARGE - Rate of flow or volume per unit time of liquid flowing along a channel or through a pipe at a given instant.

DISCHARGE CAPACITY - The entire discharging capacity of a power plant's turbines or pumps.

DISCHARGE HEAD - Height between the water level at the pump intake and level at which it discharges freely to the atmosphere.

DISCHARGE VALVE - Valve used to control flow through a pipe.

DIVERSION - Refers to water diverted from a water source.

DIVERSION CAPACITY - The rate of flow which can be passed through a diversion facility under normal design conditions.

DIVERSION DAM - A weir or barrier created for the sole purpose of diverting flow away from its course.

DIVERSION INLET - A conduit or tunnel upstream from an intake structure. Diversion inlet may be integral with the outlet works or be part of a separate conveyance structure that will only be used during construction.

DIVERSION TUNNEL - A channel made to divert the flow of water from one course to another, or around a construction site.

DRAINAGE BASIN - The area drained by a river and all its tributaries; watershed.

DRAINAGE LAYER - A layer of pervious material in an earthfill dam to relieve pore pressures or to facilitate drainage of the fill.

DRAWDOWN - The magnitude of the change in water surface of a reservoir or canal pool as the result of the withdrawal of water.

E

EARTHFILL DAM - An embankment type dam in which more than 50 percent of the total volume is formed of compacted fine-grained material.

EARTHFILL DAM, HOMOGENEOUS - An embankment type dam constructed of only one type of material.

EARTHFILL DAM, ZONED - An embankment type dam composed of zones of selected materials where the permeability of the material increases to the upstream or downstream face of the relatively impermeable core material.

ECOSYSTEM - A functional system formed by the interaction of a community of organisms with its environment.

EFFLUENT - Partially or completely treated wastewater flowing out of a treatment facility, reservoir, or basin.

ELEVATION - Refers to the height of a particular object, measured from sea level to a specific point on the object.

EMBANKMENT - Fill material, usually earth or rock, constructed above the surrounding terrain to carry a roadway or to hold back water.

EMBANKMENT DAM (SEE EARTHFILL DAM) - Any dam constructed of excavated natural materials.

EMERGENCY SPILLWAY - A spillway which provides for additional safety should emergencies not contemplated by normal design assumptions be encountered, i.e. unanticipated amounts of flood flows. The crest is usually set at maximum design water surface.

ENERGY DISSIPATOR - A structure that reduces the force of water flowing down a spillway or through a channel to prevent erosion or other damage to the facility.

ENHANCEMENT - Improvement of a facility beyond its originally designed purpose or condition.

ENTITLEMENT - Amount of water a cooperator is entitled to buy from the Department of Water Resources over a specified time period, usually one year.

Entrainment - Process by which aquatic organisms, suspended in water, are pulled through a pump or other device.

Environmental Impacts - Factors that affect organisms and the surroundings of organisms.

Erosion - The wearing away of the land surface by wind, water, ice, or other geologic agents. Erosion occurs naturally from weather or runoff but is often intensified by human land use practice.

Estuary - A semi-closed coastal body of water which has a free connection to the open sea and within which seawater is diluted with fresh water.

Export - Refers to an amount of water transported from one source or location to another.

F

Fallow - Land plowed and tilled and left unplanted.

Fault - A fracture in rock along which the adjacent rock surfaces are differentially displaced, usually caused by a seismic event.

Fill - Manmade deposits of natural soils or the process of the depositing; and earth or broken rock structure or embankment.

Firm Power - Power intended to have assured availability to the customer to meet load requirements.

Fish Hatchery - A facility where salmon and other fish are artificially spawned and raised to be released in lakes, rivers, or estuaries.

Fish Ladder - An inclined trough in which fish can swim simulating upstream migration.

Fixed Operating Costs - Costs, other than those associated with investment in facilities, which do not vary or fluctuate with changes in operation or use of facilities.

Floodplain - A strip of relatively level land bordering a stream or river and is often inundated during times of high water.

Flood Storage Capacity - That portion of the reservoir capacity which is reserved for the temporary storage of flood waters to reduce downstream peak flows.

Flow - Refers to the movement of water through an open or closed channel or conduit, usually measured in cubic feet per second.

Flow Control Valve - A valve with a flow opening that is controlled by the rate of fluid through it.

Flume - An open channel or chute of wood, steel, or reinforced concrete for carrying water.

Fluvial - Refers to streams and stream processes.

Forebay - A storage reservoir upstream from a generating or pumping plant.

Foundation - The soil or rock that supports a dam or other structure.

Freeboard - The height between the normal water level at design flow and the top or storage capacity of a canal lining or dam.

G

Gage (gaging station) - Specific locations on a stream where systematic observations of hydrologic data are obtained through mechanical or electrical means.

Gallery - A passageway within the body of a dam, its foundation, or abutments.

Gate - A device that controls the flow in a conduit, pipe, or tunnel without obstructing any portion of the waterway when in the fully open position.

General Obligation Bonds - Bonds issued and backed by the State of California; were used to raise revenues for construction of the State Water Project.

Generation - The gross energy generated in kWh at a generating plant.

Generator - A machine powered by a steam or water turbine which produces electric current.

Groundwater - The inflow to a ground water aquifer. Water may be placed into the aquifer by artificial or natural means.

Groundwater - Water held in pores and crevices of the subsoil, mainly derived from rain or other water source that percolates (drains or seeps) from the surface.

Grout Curtain - Rows of holes drilled vertically downwards beneath the cut-off wall of a dam. These holes are spaced and filled with grout under pressure to fill voids and prevent water leakage.

H

Habitat - The natural environment of a plant or animal; a place that is natural for the life and growth of an organism.

Head - Refers to pressure exerted by a confined liquid, gas, or other substance used to produce energy.

Head, Gross - The difference between headwater level and tailwater level at the powerhouse.

Head Loss - The energy per unit weight of water lost due to friction, transitions, bends, etc.

Head, Net - That part of the gross head which is directly available for the turbines.

Head Pressure - Positive pressure at a given point in a liquid system, normally expressed in feet of water or pounds per square inch.

Headwall - Concrete retaining wall at an entrance to a conduit to stop erosion and seepage along the conduit. It usually acts as a transitional structure.

Head Water - The water upstream from a powerhouse, or generally water upstream from any hydraulic structure creating a head.

Headworks Structure (pumping plant) - Structure at high point of discharge penstocks to prevent backflow or siphoning of upper pool back through the pumping plant.

Heel of Dam - The junction of the upstream face of a gravity dam with the ground surface. For an embankment dam, the junction is referred to as the "upstream toe of the dam."

Horsepower - The English unit of power, equal to work done at the rate of 550 foot-pounds per second, approximately 746 watts.

Hydraulic Fill - Fill material that is transported and deposited using water.

Hydraulics - The physical science and technology of the static and dynamic behavior of fluids. Operated or affected by the action of water or other fluid.

Hydroelectric Power - The electric current produced by water power.

Hydrologic Cycle - Also known as the water cycle; the complete cycle of water passing (evaporation) from the oceans, through the atmosphere to the land (precipitation) and back to the ocean.

Hydroelectric Power Plant - A facility in which the energy of falling water is used to drive generators to produce electricity.

I

Impermeable - Having a texture that does not permit water to pass through.

Imported Water - Water brought into an area from a distant source, such as from one part of a state to another via an aqueduct.

Impoundment - A body of water confined by a dam, dike, floodgate, or other barrier for future use.

Impeller - Rotating wheel of a turbine; also known as a rotor.

Impervious - See impermeable

Inflow - Water that flows into a body of water.

Inlet Structure (channel) - Concrete-lined portion of the spillway between the approach channel and gate or crest structure.

In-Line - Part of a system of pumping plants arranged in a straight line.

Installed Capacity - Maximum runoff of a hydroelectric facility that can be constantly maintained and used by equipment; the total of the capacities as shown by the name plates of the pumping or generating units in a station or system.

Intake - A hydraulic structure built at the upstream end of the diversion canal; a tunnel or power plant for controlling the flow and preventing silt and debris from entering the diversion.

Intake Tower - A pressure tunnel intake erected separately in the reservoir for housing the flow control valves or gates.

Interconnection - A link between power systems, enabling them to draw on one another's reserves if necessary; a tie permitting a flow of energy between the facilities of two electric systems.

Irrigated Acreage - The irrigable acreage actually irrigated in any one year. It will include irrigated crop land harvested, irrigated pasture, crop land planted but not harvested, and acreage in irrigated rotation used for soil-building crops.

J

Joint-Use Facility - A facility that is operated by the Department of Water Resources in cooperation with the federal Bureau of Reclamation.

K

Kilovolt - One thousand volts.

Kilovolt-Ampere - One thousand volt-amperes.

Kilowatt-Hour - A unit of energy equal to 1,000 watt-hours. The corresponding SI term is megajoule (MJ). 1 kWh = 3.6 MJ

L

Land Retirement - Permanent removal of land from agricultural production.

Length (of dam) - The distance, measured along the dam's axis or centerline crest at the top of the dam's main body or of the roadway surface on the crest, from abutment contact to abutment contact. (The length includes the spillway if it lies wholly within the dam.)

Levee - A natural or manmade earthen barrier along the edge of a stream, river, or lake to prevent the flow of water out of its channel.

Lift - The amount of water that is raised in elevation by a pumping plant.

Lining - A layer of clay, concrete, brick, or other material placed over the bed of a canal to protect inner surfaces and reduce scour or leakage.

Live Storage - All water storage above dead storage; also called active storage.

Load (electrical) - The amount of electric power drawn from a power line, generator, or other power source.

Load Base - The minimum electrical load over a given period of time.

M

Main Channel - The deepest or central part of the bed of a stream, containing the main water flow.

Maintenance - All routine and extraordinary work necessary to keep the facilities in good repair and reliable working order to fulfill the intended design project purposes.

Manifold - A branch pipe arrangement connecting and gathering the discharge from several pumps to a common discharge line or for connecting a penstock to several generating units.

Mitigation - When used in the context of an environmental assessment, it refers to an action designed to lessen or reduce adverse impacts due to a project's implementation.

Morning Glory Spillway - A circular or glory hole form of a drop inlet spillway. Usually free standing in the reservoir and so called because of its resemblance to the morning glory flower.

Motor - A device that converts any form of energy into mechanical energy. An electric motor uses forces produced by magnetic fields on current-carrying conductors.

Multipurpose Reservoir - A reservoir capable of use for more than one purpose. Such purposes can include conservation, power, flood control, recreation, fish and wildlife, navigation, etc.

N

Nonconsumptive Water Uses - Water uses that do not substantially deplete water supplies, including swimming, boating, waterskiing, fishing, maintenance of stream-related fish and wildlife habitat, and hydropower generation.

Nonpoint Source - A contributing factor to water pollution that cannot be traced to a specific spot.

Normal Water Surface - The highest elevation that water is normally stored, or that elevation which the reservoir should be operated for conservation purposes.

O

Ogee - A double curve shaped like an elongated S, usually associated with a spillway configuration designed with optimal overflow characteristics.

Off-Peak Energy - Electric energy supplied during period of relatively low system demands as specified by the supplier.

Typically, these periods include nights and weekends.

ON LINE - Synchronized and connected electrically with the system, usually referring to a power generating facility.

ON-PEAK ENERGY - Electric energy supplied during periods of relatively high system demands as specified by the supplier. Typically, these periods include weekdays during daytime hours.

OPERATING SURFACE - The level of water in a reservoir or canal under normal operating conditions.

OPERATING STORAGE - Water stored in a reservoir or similar facility within a normal operating range.

OUTAGE - Period during which a generating unit, transmission line, or other facility is out of service.

OUTFLOW - The amount of water passing a given point downstream of a structure, expressed in acre-feet per day or cubic feet per second.

OUTLET WORKS - Usually a pipe or tunnel under a dam that allows water to be drawn from the reservoir as needed.

OUTPUT - The current, voltage, power, driving force or information delivered from a piece of equipment, station, or system.

OVERCHUTE - Drainage structure passing local drainage over a canal.

OVERLOAD - A load greater than the rated load of an electrical device.

OVERLOAD CAPACITY - The maximum load that a machine, apparatus, or device can carry when operating beyond its normal rating but within the limits of the manufacturer's guarantee.

P

PANOCHE FORMATION - Refers to geologic formation consisting mostly of sandstone, shale, and minor conglomerate.

PEAK LOAD - The maximum load consumed or produced by a unit or group of units in a stated period of time.

PELTON WHEEL (TURBINE) - An impulse hydraulic turbine in which water pressure is converted by a few stationary nozzles to a high velocity water jet, which hits a series of buckets mounted on the rim of a wheel. Usually used at high head power plants.

PENSTOCK - A pressurized pipeline conveying water between an intake and power plant.

PERVIOUS - Permeable, having openings that allow water to pass through.

PERVIOUS ZONE - A part of the cross section of an embankment dam comprising material of high permeability.

PHASE (ELECTRIC) - The fraction of the period of an alternating current which has elapsed since the current passed through the zero point of reference.

POTABLE WATER - Drinkable water.

POWER - The time rate of transferring or transforming energy. The normal electrical unit is watt. Mechanical power is often expressed in horsepower.

POWER PLANT - An installation that contains turbines and generators for the production of electrical power. Also known as a powerhouse.

POWER POOL (ELECTRIC) - Two or more electric systems interconnected and operating on a regional basis.

PRECIPITATION - A deposit on the earth of hail, rain, mist, sleet, or snow. It is the common process by which atmospheric water becomes surface or subsurface water.

PRECONSOLIDATION - Refers to any number of earthwork methods to consolidate (i.e., settle) the ground prior to the consolidation that will occur during the construction of a facility. Areas of subsidence along the aqueduct's alignment were preconsolidated using pools of water to accelerate soil settlement and slow or reduce subsidence when the canal was constructed.

PUMP - A machine used to raise or impel liquids through a pipe.

PUMPED-STORAGE - Refers to an operation in which a pumping-generating plant generates electricity for peak load, but, at off peak, water is pumped from the tailwater pool to the headwater pool for future use.

PUMPING-GENERATING PLANT- A plant with reversible turbine units that may be used to pump water or generate electricity, usually in pumped storage developments.

PUMP LIFT - The vertical distance that a pump will raise water.

PUMPING PLANT - An installation that contains motors and pumps for lifting water.

R

RACEWAY - A channel designed for holding wires, cables, or bus bars. Also a unidirectional flow channel to hold and raise fish at a fish hatchery.

RADIAL GATES - Used to control the flow of water from a reservoir or through a channel. They are watertight cylindrical-faced gates supported on a steel framework and pivoted on a horizontal axis on the downstream end of the gate. Each gate can close under its own weight and is operated independently by remotely controlled motors. Also called tainter gates.

RATING - A designated limit of operating characteristics of a machine or device based on defined conditions.

REACH - On the California Aqueduct, a specific segment of the canal, identified by a number.

RECLAIMED WATER - Wastewater that has been cleaned so that it can be reused for most purposes except drinking.

RELEASE - Water freed from storage for specified purposes such as delivery, water quality improvement, or fish and wildlife enhancement.

REPAYMENT PERIOD - Refers to the length of the long-term contracts that water agencies have with the State of California to pay back, with interest, the costs of the SWP conservation facilities. It ends in the year 2035.

RESERVE GENERATING CAPACITY - Extra generating capacity available to meet unanticipated capacity demand for power in the event of generation loss due to scheduled or unscheduled outages of regularly used generating capacity.

RESERVOIR - A human-made artificial lake, pond, tank, or basin into which water flows and is stored for future use.

RESERVOIR CAPACITY - Total storage space in a reservoir, below a designated elevation.

REVETMENT - An embankment or wall of sandbags, earth, etc., constructed to restrain material from being transported away. A facing of stone, cement, sandbags, etc., to protect a wall or embankment.

REWIND - Act of putting new copper insulated wire in the armature windings of a generator.

RIPARIAN - Living on or adjacent to a water supply such as a river, lake, or pond. Of, on, or pertaining to the bank of a river, pond, or lake.

RIPRAP - A layer of large uncoursed stones, broken rock, boulders, or precast blocks placed in random fashion on the upstream and downstream faces of embankment dams, stream banks, on a reservoir shore, on the sides of a channel, or other land surfaces to protect them from erosion caused by current, wind, wave, and/or ice action. Very large riprap is sometimes referred to as "armoring."

ROCKFILL DAM - An embankment type dam in which more than 50 percent of the total volume is comprised of compacted or dumped cobbles, boulders, rock fragments, or quarried rock.

ROLLED FILL DAM - An embankment dam of earth or rock in which the material is placed in layers and compacted by the use of rollers or rolling equipment.

RUNOFF - Water that drains or flows off, such as rain water flowing off from the land or water from snow draining from a mountain range.

S

SACRAMENTO-SAN JOAQUIN DELTA - A 738,000-acre region, interlaced with hundreds of miles of waterways, which receives runoff from 40 percent of California's land area, including runoff and flood flows from the Sacramento, San Joaquin, Mokelumne, Calaveras, and Cosumnes rivers. As part of an interconnected estuary system that includes Suisun Marsh and San Francisco Bay, the Delta supports hundreds of species of fish, wildlife, and plants. It also serves as part of an important water transport system which includes the SWP.

SADDLE DAM - A subsidiary dam of any type constructed across a saddle or low point on the perimeter of a reservoir.

SALINITY - Measure of saltiness.

SCHEDULED OUTAGE - Shutdown of a generating unit, or other facility, for inspection or maintenance, in accordance with an advance schedule.

SCOUR - Erosion of a river bed or bank or of a sea coast by action of flowing water and waves.

SEEPAGE - Water that has passed, flowed, or oozed gradually through a porous medium, such as a levee or the materials in a dam.

SILL - Horizontal overflow line of a measuring notch or spillway. Also a horizontal member on which a gate rests when closed.

SIPHON - Of an inverted enclosed pipeline structure to convey the water under roads, drainage channels, rivers, etc. Also used by DWR to describe a pipeline where water moves from a higher to a lower level by atmospheric pressure, forcing it up the short leg while the weight of water in the longer leg causes continuous downward flow.

SLIDE GATE - A steel gate that upon opening or closing slides on its bearings in edge guide slots.

SNOWPACK - The annual accumulation of snow in mountain areas.

SPILLWAY - Section of a dam designed to permit water to pass over its crest; a weir or channel taking overflow from the dam; serves as a safety channel to prevent erosion of the dam.

SPINNING RESERVES - Available capacity of generating facilities synchronized to the interconnected electric system where it can be called upon for immediate use in response to system problems or sudden load changes.

SPOIL - Dirt or rock which has been removed from its original location.

STANDBY RESERVES - Unused capacity in an electric system in machines that are not in operation but that are available for immediate use if required.

STATE WATER PROJECT CONTRACTORS - Agencies that have long-term contracts for water entitlements from the State Water Project.

STATIC HEAD - A fixed, nonvarying positive pressure at a given point in a liquid system, normally expressed in feet of water.

STILLING POOL - A pool located below a spillway, gate, or valve into which the discharge dissipates energy to avoid downstream channel degradation.

STOPLOG - A steel or concrete beam that fits into a groove between walls or piers to prevent the flow of water.

STREAM GAGING - A process of determining the rate of flow, or the discharge, of streams.

STRUCTURAL HEIGHT - When referred to dam sites, it is the distance between the lowest point in the excavated foundation and the top of the dam.

SUMP - A pit or pool for draining, collecting, or storing water.

SUPPLY CAPABILITY (SWP) - The amount of water available for delivery to SWP contractors. SWP delivery capabilities analysis takes into account storage levels at the beginning of the water year (October 1 to September 30), target storage levels at the end of the water year (including need for emergency reservoir storage and releases sufficient to protect Delta water quality), the probability of various levels of rainfall over the remainder of the water year, the operational capacity of SWP facilities, and federal and state operational mandates to protect the Bay-Delta estuary.

SURFACE WATER - Water on the earth's surface exposed to the atmosphere, e.g., rivers, lakes, streams, oceans, ponds, reservoirs, etc.

SURGE - Sudden changes of current or voltage, or of hydraulic pressure.

SURGE TANK - A standpipe or storage reservoir at the downstream end of a closed feeder pipe allowing upsurge and downsurge to take place thus reducing sudden variations in pressure within determined design parameters.

SWITCHYARD - An area where an electrical current, produced by a generating unit, is altered so that it can be transmitted to another location, or where it can be received and altered so that it can be used by pumping units.

T

TAILRACE - The channel into which water is discharged after passing through the turbines.

TAILWATER - Water that accumulates in depth downstream from any hydraulic structure.

Test Pit - Pit dug for geologic investigation or inspection and testing of earthwork placement.

Toe - The point of intersection between the upstream or downstream face of the dam and natural ground, for example, the upstream or downstream toe of dam.

Topography - Physical shape of the ground surface.

Transformer - An electrical device which by electromagnetic induction transforms electric energy from one or more circuits to one or more other circuits at the same frequency, usually with changed values of voltage and current.

Transition Zone (semipervious zone) - A substantial part of the cross section of an embankment dam comprising material whose grading is of intermediate size between that of an impervious zone and that of a permeable zone.

Transmission - The transporting or conveying of electric energy in bulk to a convenient point at which it is subdivided for delivery to the distribution system. Also used to indicate the conveying of electric energy over any or all of the paths from source to point of use.

Trashracks - Structural members so arranged in a waterway to prevent trash and objects from entering a conduit, channel, or a plant intake.

Tributary - A stream that flows into a larger stream or other body of water.

Trunion - A pin or pivot attached to a pier or dam face for rotating a radial gate.

Turbine - A device which produces power by diverting water through blades of a rotating wheel which turns a shaft to drive generators.

Turnout - A branch in the canal for diverting water to a specific destination; where water is diverted to users.

U

Underchute - A drainage culvert passing local drainage under a canal.

Unwatering - As opposed to dewatering, unwatering is the interception and removal of groundwater outside of excavations and the removal of ponded or flowing surface water from within excavations; to remove or drain off water.

Upstream Face - The inclined surface of the dam that is in contact with the reservoir.

V

Valve - A device to regulate or stop the flow of water or gas in a pipe.

Velocity - Rate of flow of water expressed in feet per second or miles per hour.

Volt - The unit of measurement of electromotive force. It is equivalent to the force required to produce a current on 1 ampere through a resistance of 1 ohm.

Voltage - Electrical pressure, i.e. the force which causes current to flow through an electrical conductor. The greatest effective difference of potential between any two conductors of a circuit.

Volt-Ampere - A unit of apparent power in an ac circuit containing reactance. It is equal to the potential in volts multiplied by the current in amperes, without taking phase into consideration.

Vortex - A revolving mass of water (whirlpool) in which the streamlines are concentric circles and in which the total head is the same. Water rotating about an axis.

W

Water Hammer - Any rapid increase of pressure in a pipeline caused by sudden flow changes. Surge tanks are used to counter water hammers.

Watermaster - An employee of a water department who distributes available water supply at the request of water right holders and collects hydrographic (changes in water flows or elevation of water level with respect to time) data.

Water Quality - A term used to describe the chemical, physical, and biologic characteristics of water with respect to its suitability for a particular use.

Water Right - A legally protected right, granted by law, to take possession of water occurring in a water supply and to divert the water and put it to beneficial uses.

Watershed - The area or region drained by a reservoir, river, stream, etc.; drainage basin.

Water Table - The surface of underground, gravity-controlled water.

Water Year - The 12-month period, usually October 1 through September 30 over which yearly hydrologic data is averaged. The water year is designated by the calendar year in which it ends and which includes nine of the 12 months. For example, the year ending September 30, 1989 is called the 1989 Water Year.

Watt - Basic unit of electrical power produced at one time. One watt equals one joule per second.

Wetlands - Land including swamps, marshes, bogs, and similar areas such as wet meadows, river overflows, mud flats, and natural ponds. An area characterized by periodic inundation or saturation, hydric soils, and vegetation adapted for life in saturated soil conditions.

Wheeling Service - An electric operation wherein transmission facilities of one system are used to transmit power of another system; can also refer to the use of conveyance facilities of one system used to transport water to another system.

Abbreviations

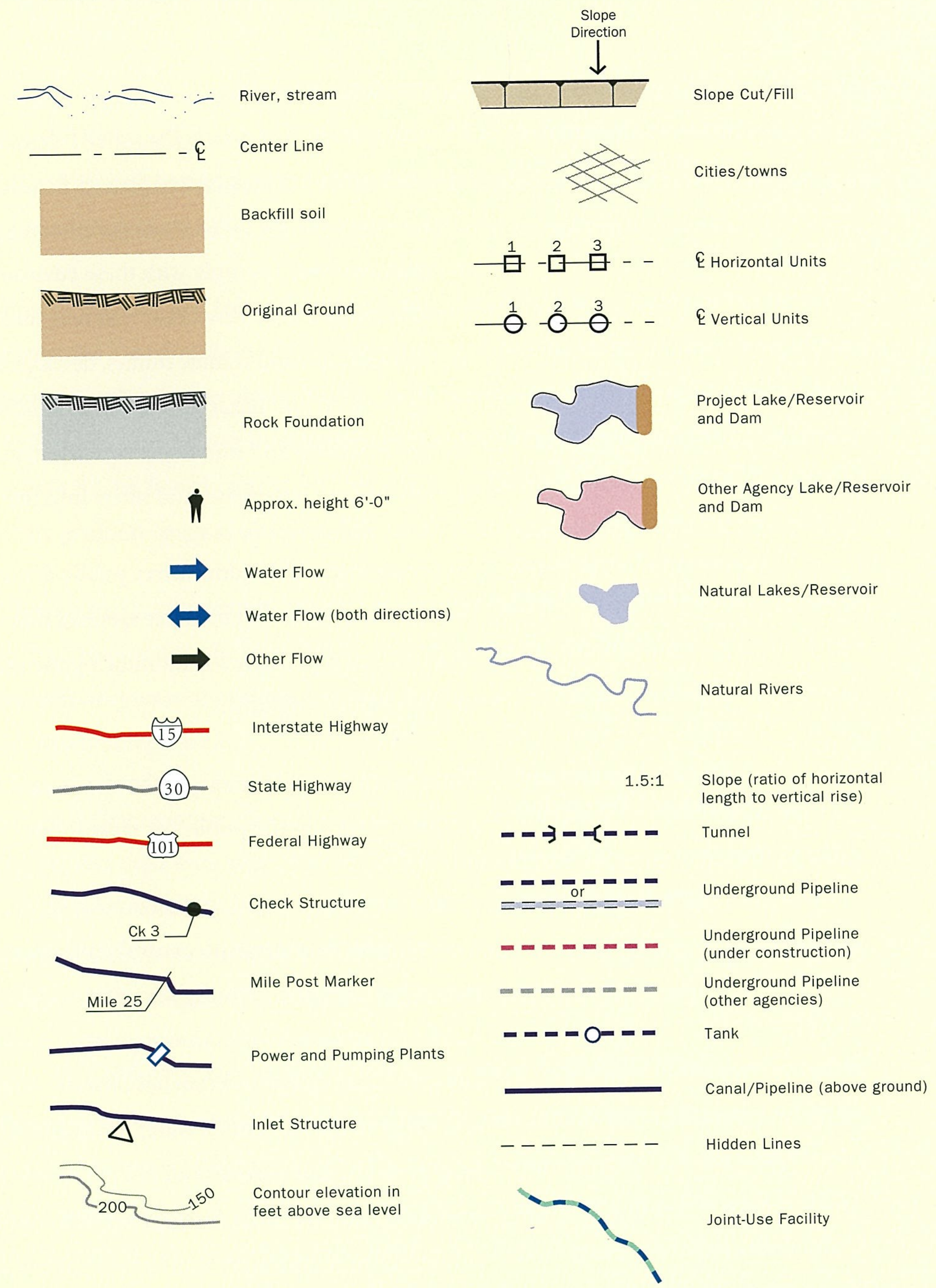
Measurements/Operational Terms

A	ampere
AF	acre-foot
cfs	cubic feet per second
hp	horsepower
kV	kilovolt
kVA	kilovolt ampere
kW	kilowatt
kWh	kilowatthour
MAF	million acre-feet
mos	maximum operating storage
MVA	megavolt ampere
MW	megawatt
MWh	megawatthour
p/g	pumping generating
rpm	revolutions per minute
TAF	thousand acre–feet
V	volt
W	watt

Agency Acronyms

BLM	U.S. Bureau of Land Management (federal)
COE	U.S. Army Corps of Engineers (federal)
CVP	Central Valley Project (federal)
CWC	California Water Commission (state)
DFG	Department of Fish and Game (state)
DHS	Department of Health Services (state)
DPR	Department of Parks and Recreation (state)
DWR	Department of Water Resources (state)
NOAA	National Oceanic and Atmospheric Administration (federal)
NMFS	National Marine Fisheries Service (federal)
SWP	State Water Project (state)
SWRCB	State Water Resources Control Board (state)
USBR	U.S. Bureau of Reclamation (federal)
USFWS	U.S. Fish and Wildlife Service (federal)
USGS	U.S. Geological Survey (federal)

Symbols Legend



State Government

California Department of Fish and Game

The department that directs the state's fish and wildlife programs and administers the regulations, such as the Endangered Species Act, that protect and enhance their populations. DFG works with the DWR to ensure that all projects (such as facility construction and maintenance work) comply with these environmental regulations. DFG personnel staff the Department's Feather River Fish Hatchery and the Skinner Fish Facility. The department also conducts fish and wildlife studies, develops and safeguards wildlife habitat, responds to off-highway oil and hazardous material spills and oversees cleanup operations, manages the state's fishing and hunting programs, regulates development in and alterations of streambeds and waterways, and offers interpretive programs to educate the public.

California Department of Health Services

The department that administers public drinking water programs and ensures health and safety standards are met by water agencies that distributes water to residences and businesses. DHS is also responsible for monitoring the effects of stormwater runoff and many other health-related programs.

California Department of Parks and Recreation

The department that manages the state's park lands, including the State Water Project reservoirs open to the public for recreation.

California Water Commission

A policy advisory board to the Director of the Department of Water Resources and the Governor on development, control and use of the state's water resources. CWC conducts public hearings and investigations statewide for the Department; provides a forum to California residents for examining water resources issues; acts as a liaison between the legislative and executive branches of state government; coordinates planning, funding, and construction of federal water development and flood control projects with state and local projects; and conducts an annual review of the progress of SWP construction and operation and reports its findings to DWR and the California Legislature. The commission consists of nine members appointed by the Governor.

The State Reclamation Board

Created in 1911 as part of a flood control plan for the Central Valley. The board provides a forum where all interests can voice their views to help solve flood control problems. It focuses on reducing flood damage by controlling development on floodplains, protecting land from erosion, and sponsoring construction of flood control projects such as channels, levees, bypasses, dams, and pumping plants. Although administratively under DWR, the board exerts its own authority. Its seven members are appointed by and serve at the pleasure of the Governor.

Resources Agency

The parent agency that oversees the operations of all state departments dealing with natural resources. The Departments of Water Resources, the State Water Resources Control Board, Fish and Game, and Parks and Recreation are included among them. Also included are departments responsible for forestry, air, energy, and navigation and ocean.

State Water Resources Control Board

A regulatory agency that has authority over the allocation of water rights and water quality to protect the beneficial uses of California's water. It has the ability to enforce regulations dealing with related water issues. SWRCB also oversees the work of regional water quality control boards that rule on local water rights and quality issues within their geographic jurisdictions. Its Board consists of five full-time, salaried members who fill specific specialty positions such as water quality, water rights, engineering, legal, and the public.

California Energy Commission

The agency that grants permits to build new power facilities. In 1975, the State Legislature gave the Commission the statutory authority to license thermal power plants of 50 megawatts or greater. It ensures that such facilities are in compliance with California's environmental regulation.

State Lands Commission

The agency that manages more than four million acres of land underlying the State's navigable and tidal waterways. Known as "sovereign lands," these include beds of many rivers, lakes, streams, sloughs, bays, lagoons, estuaries, and coastal offshore lands. The Commission protects the lands' public trust purposes, such as fishing, water-dependent commerce and navigation, ecological preservation, and scientific study.

Office of Historic Preservation

Under the California State Parks, OHP helps preserve California's history embodied in buildings, structures, sites, and objects. It administers preservation programs set up by federal and state law by reviewing federally assisted projects to assess whether they involve historic properties. OHP comments on the project's effects and suggests ways to avoid harmful impacts, assists with archeological and historical resources information and consultants, and identifies and records newly found or existing resources into the state's or federal government's list of historic properties.

Federal Government

U.S. Fish and Wildlife Service

A bureau within the Department of the Interior. Working with others, the agency's mission is to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people. Among its responsibilities is the administration of the federal Endangered Species Act to provide protection for terrestrial and aquatic plants and animals except anadromous fish. Within California, USFWS is responsible for biological opinions and critical habitat and recovery plans for listed species. Biological opinions, such as those issued for the Delta smelt, affect SWP and CVP operations. DWR works closely with USFWS to operate the SWP to conform to the biological opinion and to minimize and provide mitigation for environmental impacts related to SWP operations and maintenance. The agency also works with federal, state, and local agencies and interests on wetland protection issues.

U.S. Bureau of Reclamation A bureau within the Department of the Interior. The agency operates and maintains the Central Valley Project and the Colorado River system. Its mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. USBR and DWR signed a 1986 Coordinated Operation Agreement to meet Sacramento-San Joaquin Delta water quality standards and allow exchange of water supply and use of facilities. The Bureau also shares with DWR the Joint-Use Facilities, which include O'Neill Forebay, San Luis Canal, San Luis Reservoir, Gianelli Pumping-Generating Plant, and Dos Amigos Pumping Plant. USBR designed and constructed the facilities, and DWR operates and maintains them. Cost sharing is split 55 percent DWR, 45 percent USBR.

National Marine Fisheries Service As an agency within the Department of Commerce, NMFS has primary responsibilities for the conservation, management, and development of living marine resources and for the protection of certain marine mammals and endangered species under numerous federal laws. It provides services and products to support commercial and marine recreational fishing industries and the general public. It also administers the federal Endangered Species Act with respect to marine and anadromous species such as the winter-run salmon. NMFS issues biological opinions, critical habitat designations, and recovery plans on winter-run chinook salmon and other anadromous salmonids in California and ensures that the conditions specified in these opinions are met by agencies such as the Department of Water Resources.

U.S. Geological Survey The agency provides reliable, impartial information to describe and understand the Earth. In addition to other purposes, the information is used to manage water, biological, energy, and mineral resources. USGS, working with other agencies, places monitoring and recording equipment to gather information from and about California's waterways, precipitation, and geology.

U.S. Army Corps of Engineers The primary federal flood control agency. COE develops guidelines for flood control storage in federally funded reservoirs and monitors the operation of these reservoirs to assure compliance. It also constructs some Congressionally authorized flood control projects, operates multiple-purpose projects, and when asked by DWR, provides materials, equipment and personnel for flood fighting during emergencies. The federal government, through the Corps, contributes funds to local flood control projects.

Federal Energy Regulatory Commission An agency under the U.S. Department of Energy that regulates and licenses hydropower plants. FERC determines if proposed hydropower projects are best adapted for public purpose; assures that a proposed project balances environmental and other nondevelopmental values with developmental values and that regulated projects are constructed, operated, and maintained to protect life, health, and property; determines under what conditions a project should be operated; and ensures compliance with regulations and conditions of licenses, amendments, and exemptions.

Bureau of Land Management An agency under the U.S. Department of the Interior. BLM manages 270 million surface acres of public lands to accommodate many uses such as hiking, fishing, camping, boating, grazing, timber harvesting, and mining. These public lands, for which BLM issues permits of use, include reservoirs and lakes, riparian wetlands and streams, mineral estate, trails, cultural and historic sites, wilderness areas, and back country byways.

STATE-FEDERAL AGENCIES

CALFED Bay-Delta Program An interagency entity that represents the signers of the State-Federal Framework Agreement, which called for a cooperative, coordinated process to solve long-term water quality and ecosystem problems in the Bay-Delta Estuary. With assistance from urban, agricultural, and environmental interests, and other stakeholders concerned with Bay-Delta issues, the signers of the Agreement developed the Bay-Delta Accord, which set forth major issues of concern in the Delta and fostered a cooperative effort to address these issues. The CALFED Bay-Delta Program was established to investigate potential solutions and propose the long-term solution to fix the Delta.

Interagency Ecological Program An interagency program established to develop a better understanding of the estuary's ecology and the effects of the SWP and CVP operations on the physical, chemical, and biological conditions of the San Francisco Bay-Delta estuary. It consists of six federal agencies, three state agencies, and a nongovernmental organization. Member agencies work together to investigate such issues as fish facilities, agricultural and municipal diversions, South Delta barriers, contaminants, and fish movement and populations.

The following bulletins and reports are available free, with nominal charge, or for loan from DWR's Bulletins and Reports Unit, 1416 Ninth Street, Room 338, phone (916) 653-1097.

State Water Project

Bulletin No. 1, "Water Resources of California," 1951. Includes accumulation of data on precipitation, unimpaired stream runoff, floodflows and frequency, and water quality throughout the State.

Bulletin No. 2, "Water Utilization and Requirements of California," June 1955. Assesses the state's water uses and forecasts probable ultimate water requirements, based in general on the capabilities of lands for development.

Bulletin No. 3, "The California Water Plan," May 1957. Presents preliminary plans for full practical development of all the State's water resources to meet its ultimate water needs and describes plans for local water resource development together with facilities needed to convey water from Northern California to Southern California.

"Program for Financing and Constructing the Feather River Project," February 1955. Revisions to the initial proposal of the Feather River Project. Includes descriptions of project features and estimated costs, construction program, methods of financing, and financial analysis.

Bulletin 117 series, "Recreation Development at State Water Project Sites." Covers recreation plans for various facilities.

Bulletin 119 series, "Feasibility Studies of Serving Contractor Service Areas." Covers studies of various contractors' service areas in terms of background data, current and projected future economic conditions, and projection of future water needs.

State Water Project Analysis Office; Bulletin No. 132 series, "Management of California's State Water Project," published annually since 1963 and Appendices A, B, C, D, and E since 1964. Briefly discusses major events from various DWR divisions/programs and details operation and management aspects of the Project for the year covered. Appendix B, which covers data and computation used to determine water charges, is included in the bulletin. Appendices A, C, D, and E, bound separately, include the annual financial report, costs of recreation and wildlife enhancement, water operations in the Delta, and San Joaquin Valley Post-Project Impact, respectively.

Bulletin 200 series, "California's State Water Project," Volumes I-XI, 1974. Covers history and construction of the SWP from initial investigations of available water resources and planning efforts to construction details of individual facilities built during the period.

Vol. I, "History, Planning, and Early Progress"

Vol. II, "Conveyance Facilities"

Vol. III, "Storage Facilities"

Vol. IV, "Power and Pumping Facilities"

Vol. V, "Control Facilities"

Vol. VI, "Project Supplement," includes project management information system, right of way, relocations, project architecture, geologic and seismic investigations, Feather River Fish Facilities, Delta Fish Protective Facility, Operations and Maintenance facilities, visitor centers, archeology.

Division of Operations and Maintenance; Data Handbook, State Water Project 1997 (most recent edition). Includes statistics on project facilities, such as aqueduct conveyance facilities, aqueduct pools, pumping and power plants, plant hydraulic and electric diagrams, dams and reservoirs, flow measurement sites, delivery structures, recreation facilities, repayment reaches, water supply contractors of joint-use and SWP facilities, conversion tables, and maps showing facilities under the Department's field divisions.

Office of Water Education; "California's State Water Project," 1997. Contains brief descriptions about the history, construction, and financing of the SWP, as well as the State Water Contractors, coordination of operations with the Central Valley Project, named facilities, and a map and statistics on facilities.

Brochures on individual SWP facilities, with brief descriptions written for the general public, available from DWR Publications and the Office of Water Education. Additional DWR, SWP, and water-related information also available from OWE, 1-800-735-2922.

Videos on the State Water Project, Oroville Dam, A.D. Edmonston Pumping Plant, Feather River Fish Hatchery, and other SWP facilities and many DWR programs available from DWR's Audiovisual Library. Call Graphic Services Branch, (916) 653-4893, to purchase or loan (free).

Other References

Bulletin 160 series," California Water Plan." Published every five years since 1966, Bulletin 160-98 (most recent) assesses and evaluates California's water resources and requirements to predict future water shortages and recommend water management strategies to reduce such shortages.

"Sacramento-San Joaquin Delta Atlas," 1993. Contains maps and charts with information on various Delta topics, such as waterways, water quality, agriculture/soil, flood control, infrastructure, political, and Suisun Marsh.

Bulletin 120 series, "Water Conditions in California." Five reports during each water year offer data on forecasts of runoff, snowpack water content, precipitation, and reservoir storage for the State's ten hydrologic regions.

Bulletin 118 series, "Evaluation of Ground Water Resources." Covers California and specific study areas in Northern California.

Bulletin 130 series, "Hydrologic Data." Contains data on each water year from 1968 - 1975 for North Coastal Area, Northeastern California, Central Coastal Area, San Joaquin Valley, Southern California. Bulletin 230-81 covers index to sources of hydrologic data.

Other DWR bulletins/reports on a wide array of water issues and DWR programs are available from Bulletins and Reports. For a listing of publications (Bulletin 170 series) or more information contact the office located in the Resources Building, Room 338, 1416 Ninth Street, Sacramento, CA 95814; mailing address:
P.O. Box 942836, Sacramento, CA 94236-0001
phone: 916-653-1097
http://rubicon.water.ca.gov/#bulletins

Visitors Centers

Our three visitors centers offer general information on water, the SWP, and its facilities. Admission is free. Open daily from 8 a.m. to 5 p.m. at:

Lake Oroville Visitors Center
Lake Oroville (530) 538-2219

Romero Overlook Visitors Center
San Luis Reservoir (209) 827-5353

Vista del Lago Visitors Center
Pyramid Lake (661) 294-0219

**Visits to the following visitors facilities are by appointment only:*

Delta Field Division
Bryon, California (209) 835-7106

A.D. Edmonston Pumping Plant
South of Bakersfield (661) 858-5509

Devil Canyon Powerplant
North of San Bernardino (909) 886-5028

Contacts

The Office of Water Education offers a variety of publications on the SWP for the public.

Call 1-800-272-8869 for more information or if you need this publication in an alternate form.

For TTY phone service, call (916) 653-6226.

DWR's web site is <http://wwwdwr.water.ca.gov>. It provides information on DWR's mission, organization, and programs, plus links to other DWR web sites and databases.

Credits

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Index

*Bold-faced numbers indicate pages with facilities' technical drawings and statistics.

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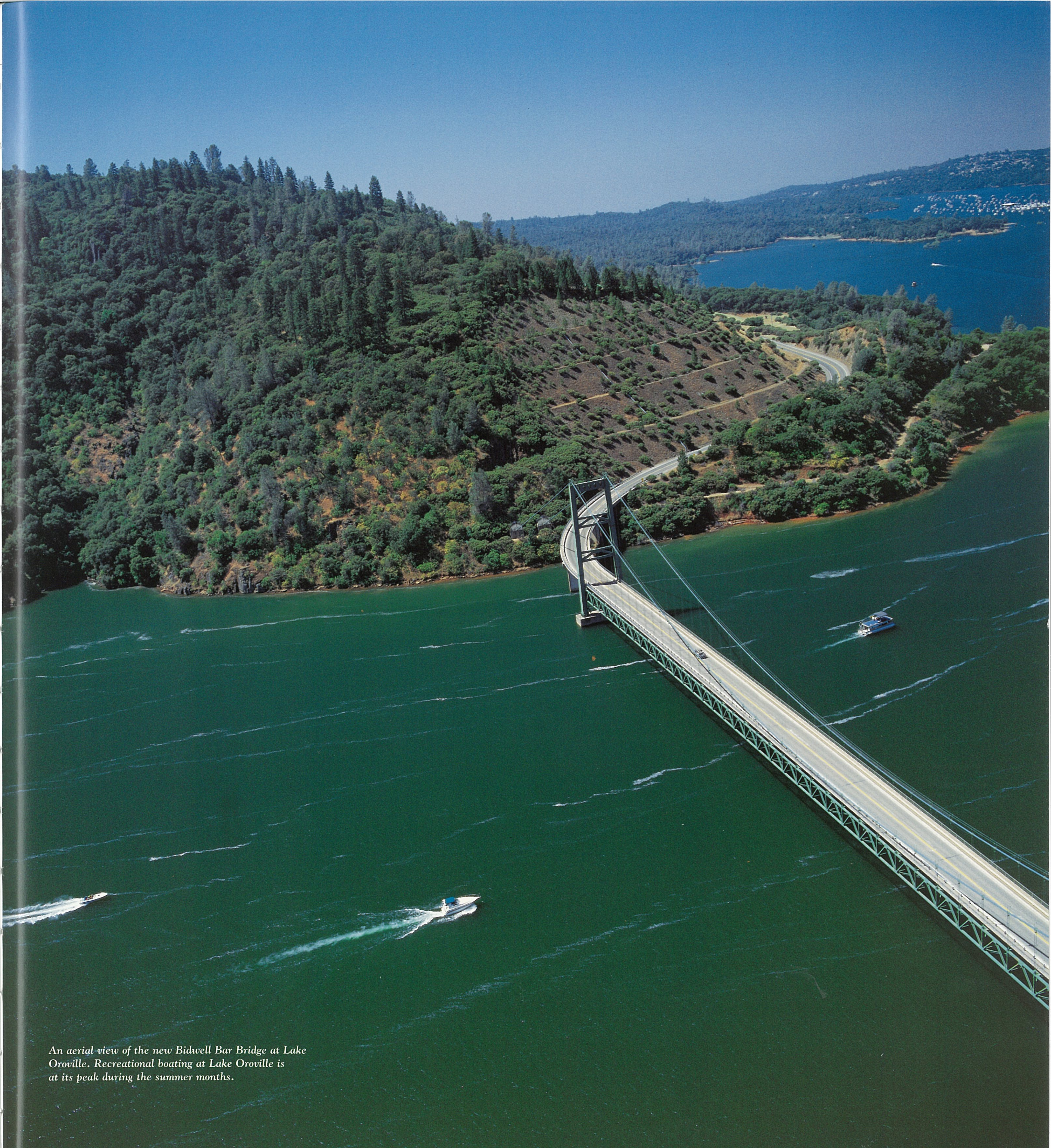

An aerial view of the new Bidwell Bar Bridge at Lake Oroville. Recreational boating at Lake Oroville is at its peak during the summer months.