Michigan Bar Reservoirs also would be operated to protect downstream areas from floods and to provide sustained flows for fish.

Plans to provide water for a portion of the irrigable lands in the Mokelumne and Calaveras River Basins include five reservoirs, of which two would be in the Mokelumne River Basin and three would be in the Calaveras River Basin. Certain lands in these basins also would receive water from developments on the North Fork of the Stanislaus River. The plans contemplate the enlargement of existing Middle Fork Reservoir, which is located on the Middle Fork of the Mokelumne River, and construction of Forest Creek and Jesus Maria Reservoirs on Forest Creek and on Jesus Maria Creek, respectively. Also included is the enlargement of the existing McCarty Dam, which is located on the North Fork of the Calaveras River in Calaveras Valley, and construction of San Domingo Reservoir on San Domingo Creek. Irrigable lands between the North and South Forks of the Mokelumne River would be supplied with water from Middle Fork and Forest Creek Reservoirs. Lands between the South Fork of the Mokelumne River and the Stanislaus River watershed divide would be supplied with water from Jesus Maria, McCarty, and San Domingo Reservoirs and direct diversions from the South Fork of the Mokelumne River and the North Fork of the Stanislaus River. The foregoing reservoirs also would be operated to enhance the fish, wildlife, and recreation potentials. There are, however, other tributaries of the rivers on which small reservoirs should be constructed in the headwaters to maintain flows for fish.

Developments on the Mokelumne River proposed by the East Bay Municipal Utility District include Railroad Flat Reservoir on the South Fork, and Middle Bar and Camanche Reservoirs on the main river, as well as enlargement of the existing Pardee Reservoir. These works would make additional water available for export to the East Bay area under water rights permits already granted. In operation studies of the reservoirs on the Mokelumne River, it was assumed that water in the firm annual amount of 364,000 acre-feet would ultimately be exported to the East Bay area. Storage in and operation of Camanche Reservoir for flood control is necessary if downstream areas are to be protected. Studies of the operation of Camanche Reservoir indicate that under ultimate conditions the reservoir releases in dry years probably will not support the anadromous fishery on the lower Mokelumne River. This problem should be given further study to determine steps that can be taken to protect and preserve the fishery.

Prospective major developments on the Calaveras River would be confined to the enlargement of existing Hogan Reservoir. Water released from the reservoir would be diverted at the dam and would be served to lands north of the river. New Hogan Reservoir would also be operated to protect downstream lands from floods.

Suggested works on the Stanislaus River would include the construction of three new reservoirs and the enlargement of two existing reservoirs. These works would be on the North and South Forks of the Stanislaus River, and would provide water for irrigable lands in the Stanislaus River Basin and in portions of the Mokelumne and Calaveras River Basins. Operation of these works would enhance the fish, wildlife, and recreation resources of the Calaveras and Stanislaus River Basins. Under the plan for the development of the North Fork of the Stanislaus River, an enlarged reservoir would be constructed at the existing Spicer Meadow reservoir site on Highland Creek, a tributary to the North Fork. Water released from the enlarged Spicer Meadow Reservoir would flow down the natural channel of Highland Creek and the North Fork to Ganns Reservoir, which would be constructed on the North Fork of the Stanislaus River about 1 mile downstream from the junction with Highland Creek. Water conserved in Ganns Reservoir would be augmented by these releases from Spicer Meadow Reservoir and by releases from existing Utica, Silver Valley, and Union Valley Reservoirs, which are located on the North Fork of the Stanislaus River. Releases from Ganns Reservoir would be discharged through a power plant and into Ramsey Reservoir, also on the North Fork. From Ramsey Reservoir, the water would be conveyed along the right bank of the North Fork of the Stanislaus River. A portion of the water would be discharged to a power house on Moran Creek and thence to existing Hunter Reservoir and to the existing Murphys Power Plant, from where it would be conveyed to San Domingo Reservoir. The remaining water from the North Fork of the Stanislaus River would be discharged through a proposed power plant on Jesus Maria Creek. From this power plant, a portion of the water would be conveyed to the proposed enlarged McCarty Reservoir on the North Fork of the Calaveras River to supply water to irrigable lands between the North Fork of the Calaveras River and the South Fork of the Mokelumne River. The remaining water would flow down the creek to Jesus Maria Reservoir. All of the foregoing reservoirs would be operated to enhance fish, wildlife, and recreation.

Suggested works on the South Fork of the Stanislaus River would include Big Dam Reservoir and enlarged Lyons Reservoir. Irrigable lands in the Stanislaus River Basin north of the Stanislaus River and its North Fork would receive water conserved in the enlarged Spicer Meadow Reservoir, Ganns Reservoir, Ramsey Reservoir, and in works on Moran Creek and existing Hunter Reservoir, all previously mentioned. These works would also furnish water to lands in the

Mokelumne River Basin which are south of the South Fork of the Mokelumne River. Irrigable lands between the Stanislaus River, the South Fork of the Stanislaus River, and the Tuolumne River watershed divide would receive water conserved in Big Dam and Lyons Reservoirs on the South Fork of the Stanislaus. Lyons Reservoir also would be used as a regulation reservoir for water developed by works on the Clavey River and the North Fork of the Tuolumne River. These waters, so regulated, would be conveyed from Lyons Reservoir in the existing Tuolumne Ditch to Phoenix Power Plant and thence to irrigable lands in Tuolumne County. In addition to providing water to irrigable lands, the foregoing works also would provide sustained flows to enhance fish, wildlife, and recreation.

Other works in the upper watershed of the Stanislaus River would be constructed primarily to produce hydroelectric power and to enhance fish, wildlife, and recreation benefits. They would include Kennedy Meadows and Griswold Reservoirs, Sand Bar and Griswold Power Plants, and the enlarged Stanislaus Power Plant. In addition, it is proposed to enlarge the existing Melones Reservoir to a capacity of 1,100,000 acre-feet to provide flood control and hydroelectric power, and to make additional water available for use on valley floor lands.

Works contemplated in the upper watershed of the Tuolumne River would include reservoirs at sites on the North and South Forks of the main river, on Lily Creek, Clavey River, and Hull and Sullivan Creeks, tributaries to the main stream, and on Big Creek, tributary to the South Fork. These works would enhance fish, wildlife, and recreation. In addition, after reregulation in Lyons Reservoir and discharge through the Phoenix Power Plant, the water would be available for use on irrigable lands in the Tuolumne River Basin.

Works on the South Fork of the Tuolumne River would consist of Hardin Flat and Burch Meadows Reservoirs. These reservoirs would serve water to irrigable lands in the basin which lie south of the main river, and would furnish a limited quantity of water for export to off-stream storage in Mariposa County. Much of the exported water, after reregulation in Coulterville Reservoir, would be returned to lower lands in the Tuolumne River Basin. Irrigable lands in the basin which lie north of the North Fork and north of the Tuolumne River would receive water from Lily Lake, Belle Meadows, Lords, Browns Meadow, and Phoenix Reservoirs, and from Lyons Reservoir as mentioned previously. Lily Lake Reservoir would be constructed on Lily Creek, a tributary of the Tuolumne River; Belle Meadows Reservoir would be on Clavey River, a tributary of the Tuolumne River; Lords Reservoir would be located on Rush Creek, a tributary of Clavey River; and Browns Meadow Reservoir would be located on the North Fork of the Tuolumne River. An enlargement of the existing Phoenix Reservoir, located on Sullivan Creek, is also contemplated. In addition to providing water for upstream lands, the foregoing reservoirs would be operated to enhance fish, wildlife, and recreation.

New power developments proposed by the City and County of San Francisco on the Tuolumne River would include the Hetch Hetchy Power Plant at Early Intake and Cherry Creek Power Plant on Cherry Creek. Existing power plants which logically could be enlarged include the Moccasin Creek, Phoenix, and Don Pedro Power Plants. Operation of Don Pedro Reservoir, enlarged to a capacity of about 1,950,000 acre-feet, would protect downstream lands from floods and provide additional regulation of water for use on valley floor lands.

In operation studies of works on the Tuolumne River, it was assumed that water in the firm annual amount of 450,000 acre-feet ultimately would be exported to the San Francisco Bay Area through the Hetch Hetchy Aqueduct by the City and County of San Francisco. In the event that the export would be increased above this amount, a similar increase would be required in the amount imported to the San Joaquin-Tulare Lake Basin through facilities of the California Aqueduct System. The City and County of San Francisco claims large rights of early priority to waters of the Tuolumne River.

Works contemplated to provide water for irrigable lands in the Merced River Basin lying north of the Merced River, as well as to enhance fish, wildlife, and recreation in this area, would include Coulterville, Butterfly, and Hayward Reservoirs. Lands in the basin lying south of the river could receive water diverted from the South Fork of the Merced River near Wawona and outside Yosemite National Park, and regulated in reservoirs on tributaries of the West Fork of the Chowchilla River, and on Mariposa and Bear Creeks. These reservoirs would enhance fish, wildlife, and recreation, and also would furnish water to certain land in the Chowchilla River Basin.

Coulterville Reservoir, in addition to conserving the runoff of its own watershed, would regulate water imported into the area from Hardin Flat Reservoir on the South Fork of the Tuolumne River, as previously mentioned. The water would be released from Coulterville Reservoir to Butterfly and Hayward Reservoirs for further regulation, and to serve irrigable lands and enhance fish, wildlife, and recreation. Water diverted from the South Fork of the Merced River at the Wawona diversion would be conveyed westerly in a tunnel into the upper watershed of the Chowchilla River Basin. As the water would be conveyed across the upper Chowchilla River watershed, some releases would be made for local application and to regulatory storage reservoirs in this basin, as is subsequently described. However, the major portion of the water would be conveyed out of the watershed and discharged into Aqua Fria and Upper Bear Creek Reservoirs, located on Mariposa Creek and Bear Creek, respectively, and served to lands in the vicinity of the two reservoirs.

In addition to the foregoing works, which would serve water to upper watershed lands and would enhance fish, wildlife, and recreation, a major reservoir, Virginia Point, with a storage capacity of about 1,000,000 acre-feet, would be constructed on the main stem of the Merced River immediately above the existing McClure Reservoir. Releases from Virginia Point Reservoir would be made through a new power plant into McClure Reservoir. From McClure Reservoir, the water would be discharged through an enlarged Exchequer Power Plant, the Merced Falls Power Plant, and then diverted for irrigation in the Merced Irrigation District and adjacent areas in the San Joaquin Valley. Reservoir space in the amount of 180,000 acre-feet would be reserved in Virginia Point Reservoir to control floods on the Merced River. Releases would be made from the reservoirs to sustain flows for the preservation of fish life.

As mentioned previously, a portion of the water diverted from the South Fork of the Merced River would be released in the upper Chowchilla River Basin. This water, which would be released to four small reservoirs, namely, Darrah, Magoon, Pegleg, and Humbug, and to farm-size reservoirs, would meet substantially all water requirements in the upper portions of the Chowchilla River Basin which have no alternative source of supply. Lower lands in the basin would receive water from Buchanan Reservoir on the Chowchilla River, which would also furnish water to and provide flood protection for lands on the San Joaquin Valley floor.

Irrigable lands in the Fresno River Basin would receive water conserved in three small reservoirs, namely, Miami, Lewis, and Nelder Creek, located on tributaries of the Fresno River. Irrigable lands in the lower reaches of the Fresno River Basin would receive water from Windy Gap Reservoir and from Hidden Reservoir. These latter reservoirs would also furnish water to lands in the San Joaquin Valley, and Hidden Reservoir would provide flood protection to the valley floor.

Prospective development of the San Joaquin River would be confined to the undeveloped tributaries of that portion of the main river watershed which extends north from the mouth of Big Creek, excluding the South Fork. The works would be constructed primarily to produce hydroelectric energy and to preserve and enhance the fish, wildlife, and recreation resources of the watershed. Suggested works would include Miller Bridge Dam and Reservoir, Miller Bridge Power Plant, Forks Dam and Reservoir, Forks Power Plant, Mammoth Pool Dam and Reservoir, Mammoth Pool Power Plant, Chiquito Creek Dam and Reservoir, and Chiquito Power Plant. The Southern California Edison Company is proposing the construction of Mammoth Pool Reservoir. No works are specifically contemplated herein to provide for future water requirements in the mountain and foothill watersheds of the San Joaquin River Basin, since such requirements are small and are for lands in scattered valleys adjacent to the main river and its tributaries, which lands could be served by direct diversions and from local farm-size reservoirs.

From Miller Bridge Reservoir on the Middle Fork, a tunnel would convey water to the Miller Bridge Power Plant, located on the Middle Fork about 2 miles above the confluence of the South Fork and on the flow line of Forks Reservoir. From Forks Reservoir a tunnel would convey the water to the Forks Power Plant, which would be located on the flow line of Mammoth Pool Reservoir. From Mammoth Pool Reservoir on the main San Joaquin River the water would be discharged through the Mammoth Pool Power Plant, located above the junction with Big Creek. The power plant would be connected with Mammoth Pool Reservoir by a tunnel. Releases from the power plant would be available for use in three existing downstream power plants before flowing into Millerton Lake.

Chiquito Reservoir on Chiquito Creek would conserve the runoff of its own watershed, plus diversions from West Granite and Jackass Creeks. A tunnel would convey the flow of West Granite Creek to Jackass Creek, where a second diversion would divert the combined flows of both creeks for discharge into Chiquito Reservoir. Water released from Chiquito Reservoir would be conveyed in a tunnel to Chiquito Power Plant, also on the flow line of Mammoth Pool Reservoir.

The new and existing works in the San Joaquin River Basin would produce large amounts of hydroelectric energy and would provide water to meet local water requirements, including that for enhancement of fish and wildlife resources and for development of the recreational potential. Water requirements in the service areas of the Madera and Friant-Kern Canals also would be met. A substantial amount of flood control is provided in the basin by reservation of storage space for that purpose in Millerton Lake.

The 57 prospective reservoirs which would accomplish the local objectives of The California Water Plan in the San Joaquin-Sierra Group, would have a total reservoir storage capacity of about 6,560,000 acre-feet. Their construction and operation in conjunction with existing works in the group would provide about 520,000 acre-feet of water each year to meet requirements in the foothill and mountain watersheds. They also would provide about 3,550,000

San Joaquin River Basin—Headwaters and Delta acre-feet of water for release to lands on the valley floor, together with large quantities of usable spill available for regulation in the ground water reservoir. The existing and new hydroelectric plants, with a total installed capacity of about 1,880,000 kilowatts, would produce about 8.8 billion kilowatt-hours of hydroelectric energy each year, of which 2.9 billion kilowatt-hours would be new energy. Operation of the units of The California Water Plan would provide reservoir pools and sustained stream flows to preserve and enhance the valuable fish, wildlife, and recreation resources in these Sierra watersheds. In addition, about 1,500,000 acre-feet of space would be provided in the major downstream reservoirs, which, when operated in conjunction with existing and proposed levee systems, would prevent flooding of valley lands.

Tulare-Sierra Group. The Tulare-Sierra Group includes all mountain and foothill lands on the east and south sides of the San Joaquin-Tulare Lake Basin lying south of the watershed divide between the San Joaquin and Kings Rivers. The group includes the portions of the Tehachapi Mountains tributary to the basin. The area is characterized by foothill and mountain topography, the peaks being some of the highest in the United States. Forest resources are extensive in the region north of the Kern River. Mineral resources are less fully exploited than in the San Joaquin-Sierra Group to the north. Recreational and scenic values are very high here, although they are less accessible than in other parts of the Sierra Nevada. The major recreational attractions in the group are Sequoia and Kings Canyon National Parks. The national forests are of lesser recreational importance than those farther north, but only because they are less well-developed by access roads.

Small parcels of irrigable land are found scattered throughout the lower portions of the Tulare-Sierra Group. These total about 243,000 acres. In 1950, however, only about 12,500 acres were being irrigated.

Streams of the Tulare-Sierra Group include several major rivers, namely, the Kings, Kaweah, Tule, and Kern; several intervening minor streams draining lower slopes of the Sierra Nevada; and a number of minor streams draining the Tehachapi Mountains from Caliente Creek westward to Bitterwater Creek. The aggregate runoff of these streams constitutes about 30 per cent of the total runoff of streams of the San Joaquin-Tulare Lake Basin as a whole. Present water requirements are met largely by pumping from ground water, inasmuch as the great majority of the irrigated lands is in the area south of the Kern River where surface supplies are limited. The major streams have been developed for hydroelectric power. Two major foothill reservoirs, Pine Flat and Isabella, have been built primarily for flood control on the valley floor, but with some conservation storage. Pine Flat Reservoir is also used to reregulate releases from upstream power developments.

Virtually all of the flow of the streams draining the Tulare-Sierra Group is utilized under prior vested rights on valley floor lands of the San Joaquin Valley. Such utilization is accomplished by surface diversions and widespread use of ground water. There is a need for initiating development of water for use on the irrigable watershed lands above the valley floor; however, such developments would require, in almost every case, the substitution of imported water in approximately an equivalent amount to valley floor lands under negotiated exchange agreements, since there is little, if any, unappropriated water left available for these upper lands.

Flood problems in the Tulare-Sierra Group are of local importance. Foothill reservoirs are now and in the future will be operated to provide flood protection for lands of the valley floor.

In 1950, water requirements for lands in the Tulare-Sierra Group were about 62,000 acre-feet annually. It is estimated that ultimate water requirements would total about 915,000 acre-feet per year. A large portion of the ultimate requirement would be for irrigable land contiguous to the valley floor, which could be served by pumping from major conduits and sources of supply on the valley floor. Another portion of the ultimate requirement would be for lands in scattered valleys and mountain meadows, only some of which could be irrigated by developing limited local water supplies; however, works to accomplish this are not described herein. The remaining portion would be for lands adjacent to and which could be irrigated from the major streams of the group. Works which are subsequently described would make available about 130,000 acre-feet of water each year, which is sufficient to serve such lands. The remaining water from streams in the group would be available to serve valley floor lands. As previously stated, any additional water to be supplied to the upper lands must be obtained through the medium of exchange contracts.

Existing developments and projects under construction on the Kings River include three reservoirs and three power plants. The three reservoirs are Helms and Wishon on the North Fork, presently under construction by the Pacific Gas and Electric Company, and Pine Flat on the main river, recently completed by the Corps of Engineers, U. S. Army, for flood control and irrigation. Releases from Helms and Wishon Reservoirs will pass successively through Haas, Balch, and Kings River Power Plants, finally discharging into Pine Flat Reservoir. These works when completed will provide almost complete development of the water resources of the Kings River and its tributaries. The upstream reservoirs will provide for the generation of power, will protect watershed lands from floods, and will preserve and enhance the fish, wildlife, and recreation resources. Pine Flat Reservoir provides irrigation water and flood protection to valley floor lands.

Existing developments on the Kaweah River consist of three run-of-river power plants located near the junction of the Middle and East Forks.

Existing developments on the Tule River are relatively minor. Two small run-of-river power plants are on the Middle Fork. Diversions are made from all forks of the river for irrigation of approximately 1,400 acres above the valley floor.

Existing developments on the Kern River, the most southerly of the large streams which rise in the Sierra Nevada, include the recently completed Isabella Dam, with a reservoir capacity of 570,000 acre-feet, and four hydroelectric plants. Prior to construction of Isabella Dam by the Corps of Engineers, U. S. Army, all of the works were dependent upon unregulated runoff for operation. Works on the South Fork of the Kern River consist of small diversions and canals to irrigate scattered lands above Isabella Reservoir. Other diversion structures and canals are located on the main stream for service to the valley floor.

Suggested plans for development of the water resources of the Tulare-Sierra Group contemplate the eventual construction of 11 reservoirs to make water available for use on mountain and foothill lands and to provide some additional regulation of water for valley floor lands. The reservoirs would also protect and enhance the watershed lands and the fish, wildlife, and recreation resources, and would provide flood protection to the valley floor. A number of the reservoirs would be operated either primarily or partly to produce hydroelectric energy. Works in each of the major river basins are described separately.

New developments contemplated on the Kings River as features of The California Water Plan would include: Cedar Grove Diversion Dam and Cedar Grove Power Plant on the South Fork; Tehipite Diversion Dam and Tehipite Power Plant on the Middle Fork; Junction Reservoir, located just below the confluence of the Middle and South Forks; Junction Power Plant on the main stream; Dinkey Meadow Reservoir and Dinkey Meadow and Ross Power Plants on Dinkey Creek; an enlarged Kings River Power Plant; and Pine Flat Power Plant immediately below Pine Flat Dam.

Water would be diverted at the Cedar Grove Diversion Dam into a tunnel leading to the Cedar Grove Power Plant, located on the flow line of Junction Reservoir. In the same manner, water would be diverted at the Tehipite Diversion Dam into a tunnel to be conveyed to the Tehipite Power Plant, which would also be located on the flow line of Junction Reservoir and adjacent to the Cedar Grove Power Plant. Junction Reservoir thus would regulate the flow of the Middle and South Forks and the releases from Tehipite and Cedar Grove Power Plants. From Junction Reservoir, a tunnel would convey the water to the Junction Power Plant, located on the main stream about 2 miles above the mouth of Mill Flat Creek. This plant would discharge to the main river.

To augment the inflow to Dinkey Meadow Reservoir, the runoff of Bear Creek, tributary to Dinkey Creek, would be diverted into the reservoir by means of a short conduit. From Dinkey Meadow Reservoir a tunnel would supply water to the Dinkey Meadow Power Plant downstream from the dam. A small diversion dam on Dinkey Creek immediately below the power plant would divert water into a tunnel extending to the Ross Power Plant on Dinkey Creek about 2.5 miles above its mouth. From Ross Power Plant the water would be conveyed by tunnel to the existing Kings River Power Plant, thus permitting an increase in the installed capacity of that plant. Water in the seasonal amount of about 30,000 acre-feet, which is required to irrigate scattered lands adjacent to the main tributaries in the basin, would be available by direct diversion or from small farm-size reservoirs. The remaining water developed by the foregoing works would be released through Pine Flat Power Plant, which would be located at Pine Flat Dam.

Construction of works of The California Water Plan in the Kings River Basin would provide some additional regulation of the runoff to effect better utilization in downstream areas. The works would also produce substantial amounts of hydroelectric energy. Pine Flat Reservoir would be operated to protect valley lands from floods, as at present, and the works would also provide sustained minimum flows in many reaches of the Kings River and its tributaries for the preservation and enhancement of fish, wildlife, and recreation.

The only project contemplated on the Kaweah River is the federally authorized Terminus Dam and Reservoir, located 20 miles east of Visalia. This project, now in the planning stage, will provide flood protection and will permit additional regulation for better service of irrigation water to lands on the valley floor. As in the case of the Kings River, the runoff of the Kaweah River has been almost entirely, if not completely, developed for use of the valley floor. Water for use on the small and scattered parcels of irrigable lands above Terminus Reservoir, which have an aggregate ultimate seasonal requirement of about 9,000 acre-feet, could be obtained by direct diversion or from small farm-size reservoirs; however, it would be necessary to substitute imported water for use on valley lands in approximately an equivalent amount under negotiated exchange agreements.

Developments on the Tule River would consist of Success Reservoir, presently under construction by the Corps of Engineers, U. S. Army, and two small upstream reservoirs, North Fork Reservoir and Middle Fork Reservoir. Success Dam is located about 6 miles east of Porterville and just below the junction of the South Fork with the main stream. The reservoir will provide flood protection and will permit additional regulation for better service of irrigation water to lands on the valley floor. North Fork and Middle Fork Reservoirs would supply water to irrigable lands which are adjacent to the main river above Success Reservoir and which have an annual water requirement of about 23,000 acre-feet. Other irrigable lands in the watershed, which are small in amount and scattered, would receive water from direct stream diversions and from local farm-size reservoirs. As in the case of the Kings and Kaweah Rivers, it would be necessary to substitute imported water in approximately an equivalent amount to valley floor lands under a negotiated exchange agreement, if these upper reservoirs were to be constructed. In the case of both the Kaweah and Tule Rivers, there is a need for small headwater reservoirs to sustain flows in the summer months to protect and enhance the fish, wildlife, and recreation resources.

Existing works in the Kern River-Tehachapi Mountains area and on the valley floor have fully developed the water resources of the Kern River and its tributaries. The works are operated to protect watershed and valley floor lands from floods, to provide irrigation water to valley floor lands, to provide hydroelectric power, and to preserve and enhance the fish, wildlife, and recreation resources of the watershed. New works contemplated as features of The California Water Plan would provide additional hydroelectric power and would make water available to serve foothill and mountain lands, although it would be necessary to substitute imported water in approximately an equivalent amount to valley floor lands under negotiated agreements.

Studies indicate that service of water to many of the irrigable lands in the Kern River-Tehachapi Mountains area would be difficult and expensive. There are 36,000 acres of irrigable land above the Kern Canyon Power House on the Kern River, with all but 2,400 acres lying above the existing Isabella Reservoir. These lands have an estimated ultimate seasonal water requirement of about 74,000 acre-feet. Water in the amount of about 50,000 acre-feet per season to meet a portion of these requirements could be furnished from reservoirs on the South Fork of the Kern River and its tributaries, which are subsequently described. The remaining higher lands could, in isolated cases, be irrigated from farm-size reservoirs which would develop limited local water resources, but expensive conduits and pumping would be required to irrigate most of these lands. Works to accomplish this are not described herein.

Lands contiguous to the valley floor and north of the Kern River could be served by local water resources and by pumping from the Friant-Kern Canal, if water could be made available from that source. Lands south of the Kern River and contiguous to the valley floor could be served, in part, by developing limited local waters; in part by the proposed Arvin-Edison Canal, which would divert from the Kern River at an elevation of 680 feet and which is described subsequently in connection with the South Valley Group; and in part from an extension of the Feather River Project Aqueduct around the southern end of the valley.

Service of water to the scattered irrigable valleys and meadows in the Tehachapi Mountains would be difficult and expensive, since most of the lands are above 2,500 feet in elevation. Some of these lands could be irrigated by development of the limited local water supplies, but irrigation of the remaining lands would require expensive pumping from water sources and conduits on the valley floor. Works to accomplish this are not discussed herein.

Major new works contemplated for the Kern River would include Rockhouse Reservoir and Power Plant, and Onyx Reservoir and Power Plant on the South Fork. In addition, three small reservoirs, Kelso, Canebrake, and Lamont Meadows, would furnish irrigation water to other lands above Isabella Reservoir.

Rockhouse Dam would be located on the South Fork. Water conserved in Rockhouse Reservoir would be conveyed in a tunnel to Rockhouse Power Plant for power generation. From Rockhouse Power Plant Afterbay the water would be diverted and conveyed in a tunnel to Onyx Power Plant for power generation. Releases from Onyx Power Plant would be stored in Onyx Reservoir and would be diverted for irrigation of lands in the South Fork Valley below an elevation of about 2,800 feet. Lands in the South Fork Valley above this elevation would receive water from Kelso, Canebrake, and Lamont Meadows Reservoirs.

Releases from Isabella Reservoir would be made to Borel Power Plant for power generation, as is done now. Likewise, the water would be diverted downstream from Borel Power Plant to Kern No. 1 Power Plant and thence to Kern Canyon Power Plant. The capacities of Borel and Kern No. 1 Power Plants would be increased. Below the Kern Canyon Power Plant water would be diverted through existing canals and to the Arvin-Edison Canal to serve the valley floor lands.

Construction of works of The California Water Plan in the Kern River Basin would provide water for watershed lands above and adjacent to Isabella Reservoir. The works would produce large amounts of hydroelectric energy. A flood control reservation would be maintained in Isabella Reservoir, as is provided at the present time. The works would also provide sustained minimum flows in many reaches of the Kern River and its tributaries for the preservation and enhancement of fish, wildlife, and recreation.

6—53479

In summary, the 11 reservoirs which would accomplish the objectives of The California Water Plan in the Tulare-Sierra Group would have a total reservoir storage capacity of about 432,000 acre-feet. Their construction and operation in conjunction with existing works in the group would provide about 136,000 acre-feet of water each year to meet requirements in the foothill and mountain watersheds, and would provide some additional regulation to water entering downstream reservoirs. These reservoirs would be operated, as the existing ones are at the present time, to serve valley floor lands. Operation of the reservoirs would make firm water supplies available in the amount of about 1,140,000 acre-feet, together with large quantities of usable spill which would be available for reregulation in the underground reservoir and for use on valley floor lands. As is described subsequently, the water made available at the eastern edge of the valley floor would be served at as high an elevation as possible in order to minimize pumping of imported water supplies. The existing and new hydroelectric plants, with a total installed capacity of about 725,000 kilowatts, would produce a total of about 3.4 billion kilowatt-hours of hydroelectric energy each year, of which about 2 billion kilowatt-hours would be new energy. Operation of these works would provide reservoir pools and sustained stream flows to preserve and enhance the valuable fish, wildlife, and recreation resources in these Sierra watersheds. In addition, about 750,000 acre-feet of space would be provided in the major downstream reservoirs, which, when operated in conjunction with existing and proposed levee systems and terminal reservoirs, would prevent flooding of valley lands.

West Side Group. The West Side Group includes a narrow strip of lands of the San Joaquin-Tulare Lake Basin which lie on the eastern slopes of the Coast Range and above the floor of the valley. The eastern boundary of the group ranges in elevation from less than 500 feet, southwest of the Delta, to about 1,500 feet at the southern end of the valley. The eastern crest of the Coast Range, which varies in elevation from about 2,000 to 4,000 feet, forms the western boundary of the group.

Present (1950) development in the West Side Group is quite minor. There is some mining, but practically no forestry. There are about 109,000 acres of irrigable land, of which only about 1,600 acres were irrigated in 1950. Mercury is mined in important quantities in San Benito County. Petroleum and natural gas are produced from the Coalinga West and Midway-Sunset fields in the southern portion of the group.

Average seasonal precipitation on lands of the West Side Group varies with elevation from less than 10 inches at the base of the foothills to somewhat more than 20 inches along the crest of the Coast Range. This precipitation is largely concentrated in the winter months, practically none of it falling as snow.

A large number of minor streams drain the West Side Group, from Marsh Creek on the northerly west side to Buena Vista Creek near Taft on the south. From north to south they include: Marsh, Del Puerto, Orestimba, San Luis, Los Banos, Ortigalita, Little Panoche, Panoche, and Cantua Creeks; Arroyo Pasajero; and Avenal, Buena Vista, and Bitterwater Creeks, as well as other small streams. Due to the sparse rainfall these streams carry little water. The total runoff of streams of this group is only slightly more than 1 per cent of that for the entire San Joaquin-Tulare Lake Basin. The 1,600 acres of land in the group which were irrigated in 1950 have a seasonal water requirement of about 4,000 acre-feet. It is estimated that this requirement might increase to about 366,000 acre-feet under full development.

Water problems of the West Side Group include a need for supplemental water for irrigable lands which are presently not irrigated. Local surface water supplies are very limited, and it is probable that ground water supplies are almost nonexistent. In addition, water of many streams of the group is characterized by relatively high amounts of dissolved minerals, including significant concentrations of boron in some cases. Floods on these streams are not a major problem because of the limited runoff and because most of the area is virtually undeveloped. However, future developments might, in some instances, warrant measures to control the occasional flood waters.

The total seasonal runoff of streams in the West Side Group is only about one-third of the probable ultimate requirement, and even now is largely utilized in replenishment of ground water supplies below the foothill line. Additional conservation is considered to be impracticable. Consequently, it is assumed that the objectives of The California Water Plan for this group would be met by deliveries through the Delta-Mendota Canal, the Feather River Project Aqueduct, and the San Joaquin-West Side Conduit, all facilities of the California Aqueduct System.

The authorized San Luis Reservoir will be physically located in the West Side Group, but it will have no specific function with respect to water requirements of the group, except to reregulate imported water supplies, nor is it expected to result in any appreciable additional conservation of runoff of San Luis Creek, which is believed to be fully utilized at the present time.

North Valley Group. The North Valley Group includes all valley floor lands of the San Joaquin-Tulare Lake Basin which lie north of that reach of the San Joaquin River between Friant Dam and the Mendota Pool. The southwesterly boundary of the group generally parallels the Delta-Mendota Canal west of Mendota Pool and includes within the group

San Joaquin River Basin—Cotton and Irrigated Pasture all lands adjacent to the canal which receive water pumped from Mendota Pool. The group is bounded on the south by San Luis Creek and the San Joaquin River.

The North Valley Group is highly developed for agricultural pursuits. Of about 3,142,000 acres of irrigable land in this area, 1,753,000 acres were irrigated in 1950. The principal urban centers are Stockton, Modesto, and Merced. The predominant manufacturing industry is food processing, although in Stockton there are several machinery manufacturing establishments whose principal products are farm implements. Natural gas from the Rio Vista field is the most important mineral product of the region.

Rainfall on lands in the North Valley Group is largely concentrated in the winter months, and varies from somewhat less than 10 inches per season in the southern portion to approximately 15 inches in the north. Major streams contributing to the water supplies of the group are, from north to south, the Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, Chowchilla, Fresno, and San Joaquin Rivers. Present and contemplated developments on these streams have been described in connection with developments in the San Joaquin-Sierra Group. The Sacramento-San Joaquin Delta, which is included in this group, also receives water from the north from the Sacramento River. A number of smaller tributary streams, as well as rainfall on the valley floor, also contribute to the fulfillment of water requirements.

The water requirements for lands in the North Valley Group were estimated to be about 5,790,000 acre-feet for 1950 conditions. Although local water supplies are highly developed, ground water overdrafts exist in several local areas and the supplemental requirement was estimated to be about 266,000 acre-feet for 1950 conditions. It is estimated that ultimate water requirements will total 6,470,000 acre-feet. Although the streams tributary to this group provide large quantities of water, nevertheless it will be necessary to import about 1,900,000 acre-feet of supplemental water each year to meet estimated ultimate requirements.

The present requirements for water in the North Valley Group are being met in several ways. First, there are diversions from Delta channels and from the Sierra streams, supplemented on the larger rivers by mountain and foothill reservoir storage. Second, there is considerable but scattered pumping from ground water throughout the group. And third, water from the Sacramento and San Joaquin Rivers is imported in the Delta-Mendota and Madera Canals, respectively, units of the Central Valley Project. Water has been imported in the Madera Canal since 1943, and in the Delta-Mendota Canal since 1951. Water is pumped into the Delta-Mendota Canal from Old River, a Delta channel, and is conveyed by the canal to Mendota Pool on the San Joaquin River, a distance of 117 miles. The Madera Canal conveys water from the San Joaquin River to serve lands of the North Valley Group. The canal, which is 37 miles in length, extends from Friant Dam northward through Madera County to Ash Slough, a channel of the Chowchilla River. In 1956, 675,000 acre-feet of water were imported in the Delta-Mendota Canal and 240,000 acre-feet were transported in the Madera Canal.

Several reclamation districts operate diversion works on channels of the Sacramento-San Joaquin Delta, in addition to their levee maintenance functions. Four irrigation districts divert from Old River in the southwestern portion of the Delta, as does the United States Bureau of Reclamation for the Contra Costa and Delta-Mendota Canals. About 20 public districts along the route of the Delta-Mendota Canal receive water by contract with the Federal Government.

The East Bay Municipal Utility District develops water from the Mokelumne River at Pardee Reservoir for export to cities in western Alameda and Contra Costa Counties. In addition to individual diversions downstream from Pardee Dam, the Woodbridge Irrigation District diverts for irrigation in the vicinity of Lodi. The water supply of the Calaveras River area is developed primarily by the Stockton and East San Joaquin Water Conservation District, which operates the conservation features of Hogan Reservoir in conjunction with diversion and ground water recharge works established, in part, by the Linden Irrigation District.

The Stanislaus River is the source of irrigation water for the Oakdale and South San Joaquin Irrigation Districts. Melones Reservoir provides conservation storage for both districts.

The South San Joaquin Irrigation District operates Woodward Reservoir on Simmons Creek for further regulation of its main supply. At present, the two districts are cooperating in the Tri-Dam Project to augment their water supplies by constructing Donnells, Beardsley, and Tulloch Dams and associated power developments on the Stanislaus River and its tributaries.

On the Tuolumne River the point of diversion for the Hetch Hetchy Aqueduct of the City and County of San Francisco is a considerable distance upstream from the foothill line. Don Pedro Reservoir, near the eastern edge of the valley floor, is operated jointly by the Modesto and Turlock Irrigation Districts. The Waterford Irrigation District also has a right to waters of the Tuolumne River.

The Merced Irrigation District operates McClure Reservoir on the Merced River. The Stevinson Water District diverts from the Merced River near its mouth. Individual diverters also utilize water of this stream. The El Nido Irrigation District, which obtains supplemental water from the Merced Irrigation District and from ground water, is located along the lower reaches of the Chowchilla River.

Two irrigation districts and six water companies, in addition to a large number of individual diverters, pump from the San Joaquin River between Tracy and the mouth of the Merced River. The San Luis Canal Company diverts from the west bank of the San Joaquin River near Dos Palos for irrigation of a large acreage between Los Banos and the river. Diversions are made at Mendota Pool on the San Joaquin River for the Firebaugh Canal Company, the Central California Irrigation District, the Grasslands and Panoche Water Districts, and other smaller districts. The Columbia Canal Company serves lands near Mendota by gravity diversions from Lone Willow Slough, and by pumping from the Mowry Canal and Mendota Pool.

The major users of water from the Madera Canal are the Madera Irrigation District and the Chowchilla Water District. The former district also has a diversion on the Fresno River.

Water problems of the North Valley Group include a need for further development and distribution of local water supplies to meet present and ultimate supplemental water requirements. Increased use of ground water has resulted in local overdrafts. Continued increases in development will aggravate these conditions unless additional water supplies are made available. There are also drainage problems in many areas which are receiving surface water supplies. In many instances increased use of ground water would alleviate such problems, in other areas surface drainage systems are needed.

Although water supplies of the North Valley Group are generally of excellent quality, certain limited areas yield ground water of doubtful quality. In addition, surface water supplies obtained from the lower reaches of the San Joaquin River contain excessive concentrations of mineral constituents during the late irrigation season, due to drainage and return flow from upstream use of the water. Flooding along major and minor streams and in the lowlands of the San Joaquin Valley has been a recurring problem since the first settlements. Existing levees and reservoirs and those now under construction afford a high degree of protection; however, dedication of additional flood control storage space in new and in certain existing reservoirs is necessary, and improved and coordinated levee systems are needed on some streams.

Under The California Water Plan the water to meet requirements of lands in the North Valley Group would be obtained from streams of the San Joaquin-Sierra Group, by imports through the Delta-Mendota, Madera, and proposed Folsom South Canals, and by further development of ground water. Runoff of streams of the Coast Range, although small in amount, would continue to contribute to the ground water supplies at the foothill line, as at the present time. Runoff of streams of the San Joaquin-Sierra Group which would be available for use would consist of the combined yield of foothill reservoirs and underground reservoirs operated coordinately in such a manner as to make available for use a large proportion of the mean seasonal natural runoff. Foothill reservoirs on streams tributary to this group, which have been described in connection with developments in the San Joaquin-Sierra Group, would furnish water in the amount of about 3,550,000 acre-feet each year on a firm yield basis, together with large quantities of usable spill available for reregulation in the ground water reservoir and use on valley floor lands.

Works contemplated in The California Water Plan in the North Valley Group would have five principal purposes: first, to convey and distribute water supplies from tributary streams for use on lands in the group; second, to distribute water supplies imported through facilities of the California Aqueduct System for use on lands in the group; third, to protect Delta lands from floods and from the encroachment of saline tidal waters; fourth, to collect and convey to tidal water sufficient quantities of drainage and waste waters to prevent water-logging of irrigated lands and to maintain a favorable salt balance; and fifth, to control floods. To accomplish the first two purposes, it would be necessary to further develop and utilize the underground reservoir.

Under The California Water Plan, water from tributary streams would be conveyed and distributed in existing and extended local canal and ditch systems. Works which would convey and distribute imported water supplies to lands of the North Valley Group would include the existing Delta-Mendota Canal, which conveys water pumped from the Delta to Mendota Pool; the existing Madera Canal, which conveys water northerly from the San Joaquin River; and the proposed Folsom South Canal and the projected Placerville South Conduit, both of which would convey water southward from the American River. In addition, the San Joaquin Waste Conduit would convey undesirable waters from lands of the North Valley Group.

The Delta-Mendota Canal would import about 1,780,000 acre-feet of water each year to the San Joaquin Valley, of which amount about 730,000 acre-feet would be diverted for use in the North Valley Group. The Madera Canal would import about 420,000 acre-feet each year to the group. The Folsom South Canal, described subsequently herein in connection with works of the Sacramento Division of the California Aqueduct System, would be operated to import about 640,000 acre-feet of water each year to the group. The Placerville South Conduit, already described in connection with works in the American River Unit of the Sacramento River Basin, would import about 76,000 acre-feet of water each year from that basin. The San Joaquin Waste Conduit would intercept, collect, and convey agricultural, municipal, and industrial waste waters, and other waters of degraded or impaired quality, to tidal waters, thus maintaining the quality of fresh-water supplies at acceptable levels for beneficial uses. The conduit would be a lined canal about 260 miles in length, and would extend from the vicinity of Buena Vista Lake on the south to its discharge into saline water channels of the Delta on the north.

Plans for the North Valley Group also include works in the Sacramento-San Joaquin Delta which would transport fresh water from the Sacramento River across the Delta, without loss or impairment in quality, to pumping plants along the southern boundary of the Delta; provide flood protection for Delta lands; and provide salinity repulsion. These objectives would be accomplished by the Biemond Plan, which is subsequently described under the Delta Division of the California Aqueduct System.

The estimated ultimate water requirements of the North Valley Group, amounting to about 6,470,000 acre-feet per season, could be met by full conservation of the runoff of the major tributary Sierra streams and by importing water in the Delta-Mendota, Madera, and Folsom South Canals, and in the Placerville South Conduit. The plans would provide for the full development of local water supplies for local use. Consideration was also given to a plan under which a portion of the waters of the Stanislaus, Tuolumne, and Merced Rivers would be diverted into a high-line canal along the east side of the valley for use in the South Valley Group, in exchange for water from Mendota Pool, which would be conveyed in a canal extending northward from Mendota Pool to the vicinity of Farmington. Such an exchange would result in substantial savings to the South Valley Group due to reduction in cost of pumping of imported water supplies, but would depend on the willingness of water users holding prior rights to the use of water from those streams, to enter into an exchange agreement.

Under ultimate conditions, existing, enlarged, and new conduits would convey and distribute local water supplies, together with an average seasonal amount of about 1,900,000 acre-feet of imported water supplies, to lands within the North Valley Group. Utilization of such water supplies would require the conjunctive and coordinated operation of surface reservoirs, surface conveyance systems, and the large underground reservoir. Conjunctive operation is discussed later in this chapter. Under such operation, surface reservoirs and conveyance systems would furnish water during the irrigation season to a portion of the irrigable lands in the group, and to stream channels and other percolating areas during the remainder of the year. The water not consumed would percolate to the underground reservoir and would be available to be pumped to serve the remaining irrigable lands. Present estimates indicate that the gross storage capacity of the underground reservoir of the North Valley Group is about 36,000,000 acre-feet between the limits of 10 and 200 feet below the ground surface. Operation studies indicate that adequate water conservation could be obtained by the use of a maximum of about 11,000,000 acre-feet, or 30 percent of such capacity. The total installed ground water pumping capacity would be about 11,000 second-feet.

Under ultimate conditions, the local and imported water supplies would be adequate, not only in quantity, but in quality, for all uses. Barriers and isolated channels in the Delta would operate to maintain the quality of the water therein. The San Joaquin Waste Conduit would intercept and convey to tidal water the poor-quality surface water wasting from the valley during the late irrigation season and during critical dry periods, thus preventing the mingling of such waters with irrigation supplies. The conduit would also convey sewage and industrial wastes, degraded surface waters of minor west side tributaries, drainage waters discharged to maintain proper salt balance, and poor-quality ground water pumped for quality control.

Flood waters of the major rivers would be impounded in foothill reservoirs, as discussed in connection with developments on those streams. During flood periods, all surface diversion and conveyance systems would operate to intercept and distribute waters released from the reservoirs for ground water recharge. Levees would add to the protection of the valley lands. Such works would include existing levees, those now under construction by the State of California on and adjacent to the San Joaquin River above the mouth of the Merced River, and new and improved levees on the lower San Joaquin River, such as those proposed by the Corps of Engineers.

South Valley Group. The South Valley Group includes all valley floor lands of the San Joaquin-Tulare Lake Basin which lie south of the San Joaquin River and south of the area receiving water from Mendota Pool and the Delta-Mendota Canal. The major economic pursuits in the South Valley Group are agriculture and the production of petroleum and natural gas. Of about 4,360,000 acres of irrigable land in this group, 2,310,000 acres were irrigated in 1950. Principal crops are cotton, potatoes, hay and grain, grapes, and alfalfa. Fresno and Bakersfield are the major urban centers of the group. Food processing is the most important manufacturing activity, followed by the manufacture of transportation equipment, principally aircraft, and petroleum refining.

Precipitation on lands of the South Valley Group averages from less than 5 inches to about 10 inches per season. Rainfall is concentrated almost entirely in the winter months and contributes little to surface runoff. Major streams contributing to the water supply for this group are the Kings, Kaweah, Tule, and Kern Rivers. Present and proposed developments on these streams have been described in connection with the Tulare-Sierra Group. Lesser streams, including Caliente Creek, Poso Creek, White River, Deer Creek, and others, also furnish water to this area. In addition, substantial quantities of water are presently imported from the San Joaquin River in the Friant-Kern Canal.

The water requirements for lands in the South Valley Group were estimated to be 4,850,000 acre-feet per season under 1950 conditions. Substantial overdrafts exist in all units of the group. The consequent supplemental water requirement, which was determined at about 1,400,000 acre-feet in 1950, is estimated to have increased to about 1,900,000 acre-feet in 1957. It is estimated that ultimate water requirements might total about 9,840,000 acre-feet. To meet such a requirement, it will be necessary to conserve fully the runoff of the tributary streams, and, in addition, to import about 7,200,000 acre-feet of water each year.

Present requirements in the South Valley Group are being met by surface diversions from all principal streams, until recently without reservoir storage; by imports, amounting to 1,365,000 acre-feet in 1956, from the San Joaquin River through the Friant-Kern Canal, a unit of the Central Valley Project; and by extensive pumping from ground water, with consequent overdrafts.

As mentioned previously, most lands of the South Valley Group are tributary to Tulare and Buena Vista Lakes, which are closed basins in the trough of the valley. Such conditions, together with a substantial development of use of ground water, have resulted in almost complete utilization of waters of tributary streams.

The waters of the Kings River are utilized by a large number of diverters, whose interests have been apportioned by court decrees and agreements. Most of these diverters have associated themselves into the Kings River Water Association, for the purpose of administering agreements called the Kings River Water Indentures. The parties at interest representing the largest acreages are the Alta, Consolidated, and Fresno Irrigation Districts, and the Tulare Lake Basin Water Storage District. The Kings River Conservation District has been organized by voters in the Kings River service area, and is currently negotiating a contract with the Federal Government for repayment of the irrigation allocation for Pine Flat Reservoir.

Westlands Water District in the western portion of Fresno and Kings Counties has been formed to obtain desperately needed supplemental water supplies. Between the Kings and Kaweah Rivers, the Orange Cove, Stone Corral, and Ivanhoe Irrigation Districts supplement private pumping from ground water with deliveries from the Friant-Kern Canal. The major agencies utilizing waters of the Kaweah River are the Lindsay-Strathmore and Tulare Irrigation Districts; the Wutchuma, Visalia, and Kaweah Water Companies; and the Consolidated Peoples, Farmers, and Lakeside Ditch Companies. The irrigation districts obtain supplemental water supplies from the Friant-Kern Canal. The Corcoran Irrigation District obtains water from the Kings River via Cross Creek, as well as occasional flows from the Kaweah River. The Exeter and Lindmore Irrigation Districts, located between the Kaweah and the Tule Rivers, distribute Friant-Kern Canal water to supplement ground water pumping.

The major diverters along the Tule River are the Porterville and Lower Tule River Irrigation Districts. These districts, as well as the Terra Bella and Delano-Earlimart Irrigation Districts, also obtain water from wells and from the Friant-Kern Canal.

The Saucelito Irrigation District obtains its water supplies from Deer Creek, from wells, and from the Friant-Kern Canal. The Southern San Joaquin Municipal Utility District distributes Friant-Kern Canal water to an area around Delano and McFarland, supplementing private supplies from wells.

Many of the canals diverting from the Kern River are operated by public districts. The North Kern Water Storage District operates the Lerdo and Calloway Canals. The Shafter-Wasco Irrigation District has executed a contract for Friant-Kern Canal water to supplement private pumping from wells. The Buena Vista Water Storage District stores and uses water reaching Buena Vista Lake from the Kern River. The Arvin-Edison Water Storage District is negotiating with the Federal Government and with other Kern River interests for an exchange of water involving importation through the Friant-Kern Canal. Isabella Reservoir on the Kern River is operated primarily for flood control purposes, and secondarily for conservation of irrigation water and to produce power.

Water problems of the South Valley Group include the urgent need for additional water supplies to meet present and ultimate supplemental water requirements, a need for additional flood control, and a need for drainage and maintenance of water quality. Overdrafts exist at the present time in all units of the group. Such annual overdrafts, accumulating over many years, have so depleted many portions of the ground water basins that pumping lifts are nearly prohibitive economically. The excessive pumping lifts are reducing net profits and will continue to do so indefinitely, until costly imported water, supplied in quantities in excess of actual water requirements, has refilled the basins. In addition to works to provide supplemental water supplies, other new physical works are needed to prevent flooding of valley lands.

Both surface and ground water supplies of lands in the eastern portion of the South Valley Group are generally of excellent quality. Water from the west side streams, although the combined flow is small and generally percolates into the alluvial cones, contains relatively high amounts of dissolved minerals, including in some cases significant concentrations of boron. West side ground waters are characterized by a high percentage of sulphate and an abnormal amount of boron, often in toxic concentrations. The usable zone of pumping along the west side is generally found between overlying unusable perched water and underlying brines. Improperly constructed and abandoned wells allow the intermingling of these waters, with consequent degradation of the usable aquifers.

Under The California Water Plan the water to meet requirements of lands in the South Valley Group would be obtained from streams of the Tulare-Sierra Group, by imports in several existing and new major conduits, and from ground water. Runoff of streams of the Coast Range, which is small in amount, would continue to be available to contribute to ground water supplies at the foothill line, as at the present time. Runoff of streams of the Tulare-Sierra Group which would be available for use would consist of the combined yield of foothill reservoirs and underground reservoirs operated, as at the present time, in such a manner as to make virtually all of the mean seasonal natural runoff available for use. Foothill reservoirs on streams tributary to this group, which have been described in connection with developments in the Tulare-Sierra Group, would furnish water in the amount of about 1,140,000 acre-feet each year on a firm yield basis.

Works of The California Water Plan in the South Valley Group would have four principal purposes: first, to convey and distribute water supplies from tributary streams for use on lands in the group; second, to distribute water imported through facilities of the California Aqueduct System, for use on lands in the the group; third, to collect and convey drainage and waste waters in sufficient quantities so as to improve water quality and to maintain favorable salt balance conditions; and fourth, to control floods. To accomplish the first two purposes it would be necessary to develop the underground reservoir further by increased utilization of ground water.

As mentioned previously, water in very large amounts must be imported to the San Joaquin-Tulare Lake Basin. A considerable portion of this water would have to be supplied to lands on the east side of the trough of the Tulare Lake Basin. In order to minimize the pumping of water from aqueducts along the west side of the valley to serve such lands, it was assumed that water supplies of the Kings, Kaweah, Tule, and Kern Rivers, and minor east side streams, and those imported and conveyed in the Friant-Kern Canal, would be served at as high an elevation as possible along the eastern edge of their respective service areas. Canals flowing north and south along the foothill line from Terminus and Success Reservoirs would facilitate such distribution. Remaining lands of the South Valley Group could then be served other imported water supplies which would be pumped from the Sacramento-San Joaquin Delta, conveyed along the west side of the valley, and then diverted or pumped to service areas in the west, central, and east portions of the group as required.

Under The California Water Plan, water from tributary streams would be conveyed and distributed in existing and extended local canal and ditch systems, and in the proposed Arvin-Edison Canal, which would divert from the Kern River. Works which would convey and distribute imported water supplies in the annual amount of about 7,200,000 acre-feet to lands of the South Valley Group include: the existing Friant-Kern Canal, which will deliver about 1,200,000 acre-feet of water each year from the San Joaquin River; the authorized Feather River Project Aqueduct, which will convey about 2,200,000 acre-feet of water pumped from the Sacramento-San Joaquin Delta, and which is described subsequently in connection with the San Joaquin Division of the California Aqueduct System; the San Joaquin-Tulare Basin Canal System, which would convey about 3,800,000 acre-feet and which would divert from the San Luis Forebay and extend southerly to Sand Ridge Reservoir at about the Kings-Kern county line, with a main pump lateral extending easterly along the north bank of the Kings River to the Fresno South Canal; the Fresno South Canal, which would extend from the Kings River south to Elk Bayou in the vicinity of Tulare; and the North Kings Canal, which would divert from the San Joaquin-Tulare Basin Canal and would flow northward to the San Joaquin River. Imported water could be diverted or pumped from the foregoing conduits to serve lands in all portions of the South Valley Group. In this manner, water requirements in the group would be met by water from tributary streams and by water pumped from the Sacramento-San Joaquin Delta.

In order to reduce the pumping of a portion of the water supply imported to the South Valley Group, further consideration should be given to a plan which would include a high-line canal extending south from the Stanislaus River along the east side of the valley to Elk Bayou near Tulare. A portion of the water from the Stanislaus, Tuolumne, and Merced Rivers would be diverted into the high-line canal for conveyance to and use in the South Valley Group, in exchange for water from Mendota Pool, which would be conveyed in a canal extending northward from

Mendota Pool to the vicinity of Farmington. It would be necessary to negotiate an exchange agreement with the holders of vested rights to the use of waters of these rivers.

Agricultural, municipal, and industrial waste waters, other waters of degraded or impaired quality, and drainage waters would be collected, often in lined or closed conduits, and discharged into the previously described San Joaquin Waste Conduit, a main drainage canal, which would extend along the trough of the valley from the vicinity of Buena Vista Lake to saline water channels in the Delta, and which was described in connection with works in the North Valley Group.

The foregoing major conduits would convey and distribute local water supplies, together with large quantities of imported water supplies, to lands within the South Valley Group. Full utilization of such water supplies would require the conjunctive and coordinated operation of surface reservoirs, surface conveyance systems, and underground storage. Under such operation, surface reservoirs and conveyance systems would furnish water during the irrigation season to a portion of the irrigable lands in the group, and to stream channels and other percolating areas during the remainder of the year. The water not consumed would percolate to the underground reservoir and would be available to be pumped to serve the remaining irrigable lands.

Present estimates indicate that the gross storage capacity of the underground reservoir of the South Valley Group is about 65,000,000 acre-feet between the limits of 10 and 200 feet below the ground surface. Operation studies indicate that adequate water conservation could be obtained by use of a maximum of about 15,000,000 acre-feet, or 23 percent of such capacity. The total installed ground water pumping capacity necessary for such operation is estimated at 17,000 second-feet.

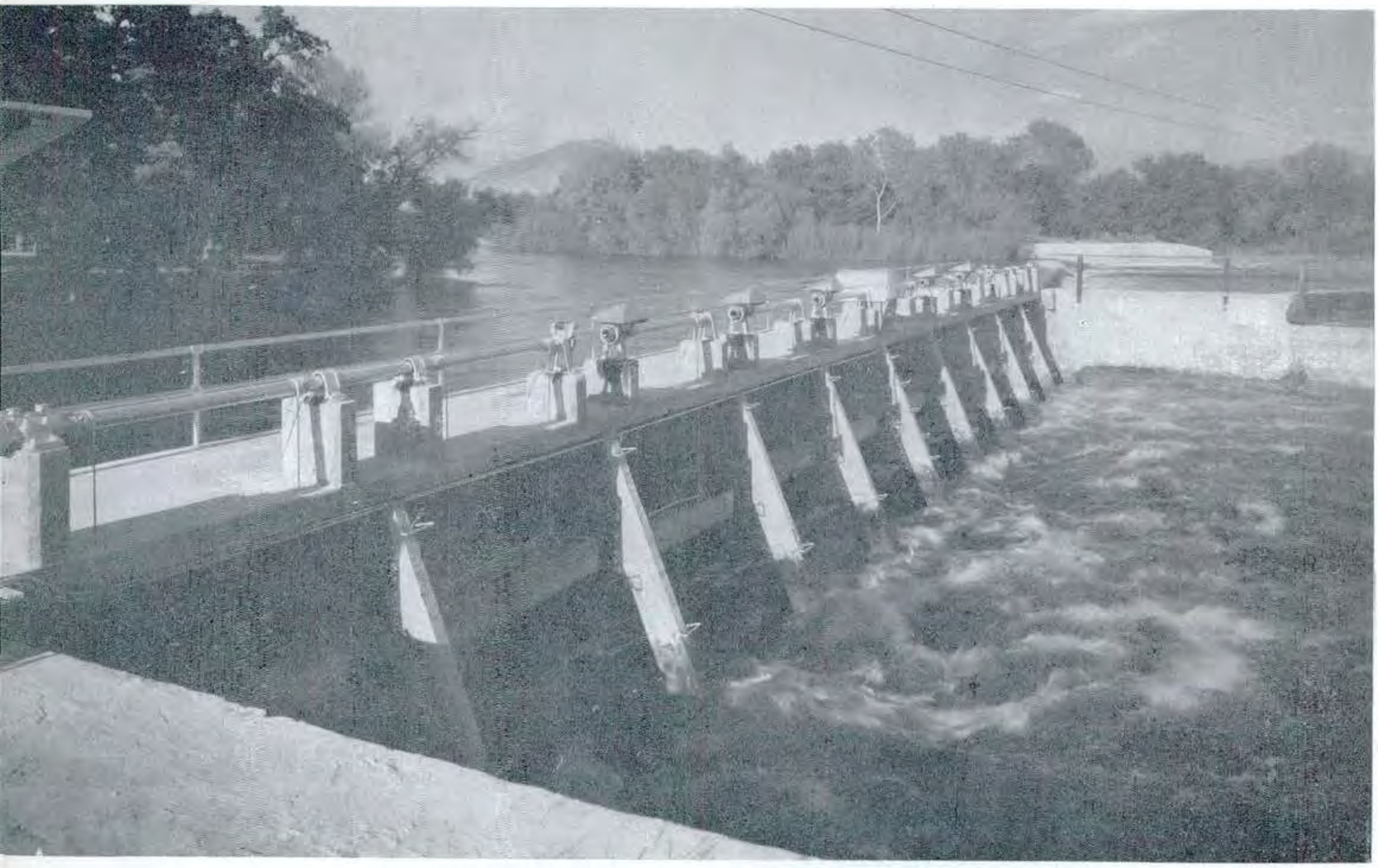
Flood waters of the Kings, Kaweah, Tule, and Kern Rivers would be impounded in Pine Flat, Terminus, Success, and Isabella Reservoirs, respectively, as discussed in connection with developments on those streams. During flood periods, all surface diversion and conveyance systems would operate to intercept and distribute waters released from the reservoirs for ground water recharge. The portion of rare flood flows, particularly snowmelt floods, which could not be thus controlled would, in the case of the Kings River, be discharged through Fresno Slough. No such outlet channel exists, however, for the discharge of unusual floods of the Kaweah, Tule, and Kern Rivers. Therefore, excess flood waters of these streams would be discharged into Sand Ridge Reservoir and would be impounded south of the natural sand ridge between Tulare and Buena Vista Lakes. The capacity of that reservoir would be about 1,400,000 acre-feet. It is considered that the works discussed herein would provide adequate flood control on these streams. An alternative method of disposing of such flood waters would involve the installation of pumping plants which could pump the flood waters into conduits of the California Aqueduct System.

Other streams of the South Valley Group which produce floods are Deer Creek, White River, and Pozo Creek north of the Kern River, and Caliente Creek, Tejon Creek, and other minor streams south of the Kern River. Under The California Water Plan, the plan for flood control on Deer Creek, White River, and Pozo Creek would include construction of a relatively small reservoir on each stream, minor channel improvements along the upper reaches of the streams, and leveed flood channels along the lower reaches which would convey the flood waters to Sand Ridge Reservoir. During floods, water would be released from the reservoirs at rates at which the water would percolate in the stream channels. Releases and spills in excess of these amounts would be conveyed to Sand Ridge Reservoir. In somewhat the same manner, small reservoirs on Caliente and Tejon Creeks and other minor streams of this group would be operated to release water at rates within the percolation capacity of the natural and artificial channels, for ground water recharge.

Summary of San Joaquin-Tulare Lake Basin. The San Joaquin-Tulare Lake Basin is California's principal area of present and ultimate water deficiency. Under The California Water Plan the ultimate requirements for water in the basin would be met by full development of local water resources, supplemented by substantial quantities of imported water. The California Water Plan contemplates the eventual import of 8,550,000 acre-feet of water per season, on the average, to the basin. Water in this amount would be conveyed and regulated by works of the San Joaquin Division of the California Aqueduct System, including San Luis Reservoir.

The California Water Plan also contemplates the eventual addition of about 8,400,000 acre-feet of storage capacity to the present basin reservoir system. This capacity would be contained in 76 strategically disposed storage, diversion, and regulatory reservoirs which would provide additional regulation and some additional conservation of local water supplies. Local water supplies already are substantially developed, but almost exclusively for use on the valley floor lands. The new reservoirs and related works would make available a portion of the local supplies for use in the foothill and mountain watersheds. They would also produce large amounts of hydroelectric energy, preserve and enhance fish, wildlife, and recreation resources, and, together with existing reservoirs, would provide a total of about 3,700,000 acre-

Exchequer Dam on Merced River



Diversion Dam and Irrigation Canal Headgates on Kings River feet of storage space specifically reserved to protect valley lands from floods.

In addition to construction of the local reservoirs and import conduits of the California Aqueduct System, The California Water Plan also contemplates an increased and coordinated use of the underlying ground water basin. It would not be possible by use of surface reservoirs alone to regulate adequately the local and imported water supplies so that water needs could be met as they occur over long-time climatic cycles. However, there is every indication, based upon conservative assumptions, that the necessary regulation of local and imported water supplies could be attained by conjunctive operation of surface and ground water reservoirs.

Collectively, the present and future local reservoirs, the import conduits of the California Aqueduct System, and the ground water basin would provide water in the amount of 16,305,000 acre-feet each season to the San Joaquin-Tulare Lake Basin. In addition, 812,-000 acre-feet would be exported each season to the San Francisco Bay Area. The new local reservoirs would have a combined yield of about 4,600,000 acre-feet per year. Their cost would be in the order of $500,000,000.

There would be about 32 new and enlarged hydroelectric power plants associated with the new reservoirs. These plants would have a combined installed power capacity of about 1,100,000 kilowatts and would generate an average of about 4.7 billion kilowatt-hours per year. Their cost would be in the order of $120,000,000.

Other local works in the San Joaquin-Tulare Lake Basin would consist of new and enlarged main conveyance and service canals for irrigation; wells for irrigation and urban purposes in some areas; additional levees, floodway channels, and retention reservoirs; distribution and drainage systems; and a main drainage conduit extending northward from Buena Vista Lake to discharge into the lower Sacramento-San Joaquin Delta. The cost of this conduit and the main water supply conduits and pumping plants on the valley floor and in the foothill and mountain areas of the basin would be in the order of $300,000,000. No estimates of cost were made for the various drainage and distribution systems and other local works that would be required for complete service and development of the land and water resources of the basin.

The total cost of all the described local development works of The California Water Plan in the San Joaquin-Tulare Lake Basin would be about $920,000,000.

The general features and costs of the local development works of The California Plan in the San Joaquin-Tulare Lake Basin are presented in Table 14. Similar information for the import facilities pertinent to the basin are presented later in this chapter in Tables 23 through 26, under the Delta and San Joaquin Divisions of the California Aqueduct System. The locations and layouts of all of the facilities described in the foregoing sections are delineated on Sheets 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, and 21 of Plate 5.

Lahontan Area

The Lahontan Area comprises the easterly slope of the Sierra Nevada, and reaches from the Oregon border on the north to and including the Mojave River drainage basin and Antelope Valley on the south. The area extends over approximately 33,000 square miles, of which about 10,000 square miles are classified as valley and mesa lands, most of which are considered irrigable. The area, as a whole, is one of gross water deficiency insofar as potential development is concerned, although a few of the included stream basins have ample water supplies for their ultimate needs.

The majority of the water resources of the Lahontan Area have been extensively developed in the past. The Truckee, Carson, and Walker Rivers have, for many years, been developed for utilization in both California and Nevada. There are about 80 reservoirs presently located in the area, with an aggregate storage capacity of approximately 1,400,000 acre-feet. More than half of this storage is provided by Lake Tahoe. Reservoirs in the Truckee River Basin, and Topaz and Bridgeport Reservoirs on the Walker River, are used principally to conserve and regulate irrigation water supplies for lands in Nevada.

About 11,000 acre-feet of water per season is imported into the Lahontan Area from the Pit River Basin. For many years, about 7,000 acre-feet of water from the Little Truckee River and 2,000 acre-feet of water from the Echo Lake Basin have been exported to the Central Valley Area. The major export of water from the Lahontan Area is made by the City of Los Angeles, which diverts about 320,000 acre-feet per season from Mono Lake Basin and Owens Valley for municipal use in the Los Angeles metropolitan area.

Because of the inland position of the Lahontan Area, and the high elevation of much of the valley and mesa lands, precipitation generally occurs in the form of snow, which delays the bulk of the resultant runoff to the late spring and early summer months. However, in spite of this natural regulation, deficiencies in water supply for the support of the local economy are felt in many areas during the late summer period. In the desert areas comprising the southern portion of the Lahontan Area, precipitation is generally light, although localized areas have often suffered damaging floods from cloudbursts of extreme intensity.

The estimated mean seasonal natural runoff of streams in the Lahontan Area is about 3,180,000 acre-feet, and, even if fully developed, would constitute

TABLE 14

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SAN JOAQUIN-TULARE LAKE BASIN

(These works show future development possibilities. They are not project proposals.)

Dam and reservoir	Stream	Dam: Location, MDB&M, and sheet of Plate 5 on which shown	Dam: Type	Dam: Height, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active	Seasonal yield, in acre-feet [a]	Purpose	Place of water use	Capital cost [b]
San Joaquin-Sierra Group											
Nashville	Cosumnes River	Sec. 14, T8N, R10E 8	CG	310	1,065	450,000	440,000	115,000	I,U,P,R, FC,F	San Joaquin Valley	$20,430,000
Michigan Bar	Cosumnes River	Sec. 36, T8N, R8E 8	E	105	285	84,000	81,000	56,000	I,U,R, FC,F	San Joaquin Valley	2,900,000
Deer Creek	Deer Creek	Sec. 11, T8N, R8E 8	CE	80	440	30,000	30,000	30,000	I,U,F	San Joaquin Valley	281,000
Irish Hill	Dry Creek	Sec. 1, T6N, R9E 8	E	134	520	28,000	28,000	14,000	I,U,F	San Joaquin Valley	1,320,000
Capps Crossing	North Fork Cosumnes River	Sec. 11, T9N, R14E 8	R	155	5,205	19,000	19,000	13,000	I,U,R,F	Cosumnes River Basin	6,738,000
Middle End	North Fork Cosumnes River	Sec. 34, T10N, R13E 8	ER	180	3,350	7,000	7,000	6,000	I,U,R,F	Cosumnes River Basin	1,456,000
Bakers Ford	Middle Fork Cosumnes River	Sec. 19, T9N, R12E 8	R	110	1,750	16,000	16,000	8,000	I,U,R,F	Cosumnes River Basin	1,531,000
Bridgeport	South Fork Cosumnes River	Sec. 14, T8N, R11E 8	ER	130	2,090	36,000	36,000	12,000	I,U,R,F	Cosumnes River Basin	1,103,000
Pi Pi	Middle Fork Cosumnes River	Sec. 4, 9, T8N, R14E 8	ER	260	4,090	42,000	42,000	21,000	I,U,R,F	Cosumnes River Basin	4,608,000
Sopiago	Sopiago Creek	Sec. 10, T8N, R13E 8	R	170	3,680	12,000	12,000	7,000	I,U,R,F	Cosumnes River Basin	1,693,000
Case Valley	South Fork Cosumnes River	Sec. 33, T8N, R13E 8	E	190	3,040	16,000	16,000	14,000	I,U,R,F	Cosumnes River Basin	2,186,000
Volcano	Sutter Creek	Sec. 29, T7N, R12E 8	E	210	1,920	15,000	15,000	8,000	I,U,R,F	Cosumnes River Basin	3,229,000
Railroad Flat	South Fork Mokelumne River	Sec. 23, T6N, R13E 8	E	339	2,460	80,000	80,000	41,000	I,U,R,F	San Francisco Bay Area	13,656,000
Middle Bar	Mokelumne River	Sec. 16, T5N, R11E 8	CG	190	690	46,000	30,000	275,000	I,P,U,R, F	San Francisco Bay Area	4,876,000
Camanche	Mokelumne River	Sec. 6, T4N, R9E 8	E	140	202	285,000	244,000	74,000	I,U,R,F	San Joaquin Valley	13,850,000
New Hogan	Calaveras River	Sec. 31, T4N, R11E 8	E	201	711	325,000	310,000	95,000	I,U,R, FC,F	San Joaquin Valley	9,768,000
Middle Fork	Middle Fork Mokelumne River	Sec. 9, T6N, R14E 8	E	200	3,130	10,000	10,000	7,000	I,U,R,F	Mokelumne and Calaveras River Basins	1,882,000
Forest Creek	Forest Creek	Sec. 34, T7N, R14E 8	ER	148	3,388	5,000	5,000	4,000	I,U,R,F	Mokelumne and Calaveras River Basins	2,304,000
Jesus Maria	Jesus Maria Creek	Sec. 23, T5N, R13E 8	CE	130	2,315	8,000	8,000	17,000	I,U,R,F	Mokelumne and Calaveras River Basins	1,165,000
Jesus Maria Forebay		Sec. 13, T5N, R14E 8	CG		4,500				P	Supplies Jesus Maria Power House	40,000
Jesus Maria Afterbay	Jesus Maria Creek	Sec. 11, T5N, R14E 8	CG		3,300				S	Supplies Jesus Maria Reservoir	30,000
Mokelumne Hill Feeder Canal Diversion	North Fork Calaveras River	Sec. 5, T5N, R13E 8	CO	5					D	Mokelumne and Calaveras River Basins	10,000
San Domingo	San Domingo Creek	Sec. 36, T4N, R13E 8	ER	245	1,940	25,000	25,000	52,000	I,U,R,F	Mokelumne and Calaveras River Basins	3,225,000
McCarty	North Fork Calaveras River	Sec. 35, T6N, R13E 8	E	130	2,817	15,000	15,000	15,000	I,U,R,F	Mokelumne and Calaveras River Basins	1,254,000
Black Creek Diversion	Black Creek	Sec. 22, T2N, R12E 8	CO	8					D	Mokelumne and Calaveras River Basins	12,000
New Melones	Stanislaus River	Sec. 11, T1N, R13E 11	CG	447	962	1,100,000	974,000	510,000	I,U,P,R, FC, F	San Joaquin Valley	39,185,000
Kennedy Meadows	Middle Fork Stanislaus River	Sec. 2, T5N, R20E 9	R	121	6,408	10,000	10,000		I,U,R,F	San Joaquin Valley (Partial regulation of inflow to Donnell's Reservoir)	2,379,000
Spring Gap Afterbay	Middle Fork Stanislaus River	Sec. 21, T4N, R17E 9	CG	120	3,005	2,000	2,000		S, F	Supplies Sand Bar Tunnel	500,000
Sand Bar Afterbay	Middle Fork Stanislaus River	Sec. 19, T4N, R17E 9	CG	120	2,750	2,000	2,000		S, F	Supplies Stanislaus Power House	800,000
Stanislaus Afterbay	Stanislaus River	Sec. 7, T3N, R15E	CG	60	1,100	3,000	3,000		S, F	Supplies New Melones Reservoir	150,000
Griswold	Griswold Creek	Sec. 33, T5N, R16E 9	R	180	4,480	10,000	10,000	17,000	I,U,R,P, F	San Joaquin Valley	3,500,000

TABLE 14—Continued

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SAN JOAQUIN-TULARE LAKE BASIN

(These works show future development possibilities. They are not project proposals.)

Dam and reservoir	Stream	Dam: Location, MDB&M, and sheet of Plate 5 on which shown	Dam: Type	Dam: Height, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active	Seasonal yield, in acre-feet[a]	Purpose	Place of water use	Capital cost[b]
San Joaquin-Sierra Group—Continued											
Griswold Creek Diversion	Griswold Creek	Sec. 5, T4N, R16E 9	CO	10	4,100				D	Supplies Griswold Canal	$10,000
Soap Creek Diversion	Soap Creek	Sec. 18, T4N, R16E 9	CO	10	4,055				D	Supplies Griswold Canal	10,000
Griswold Forebay		Sec. 24, T4N, R15E 8	CE	50	4,055				P	Supplies Griswold Power House	100,000
Griswold Afterbay	Middle Fork Stanislaus River	Sec. 25, T4N, R15E 8	CG	40	1,600				S	Supplies New Melones Reservoir	50,000
Big Dam	South Fork Stanislaus River	Sec. 9, T4N, R19E 9	R	120	7,425	16,000	16,000		I,U,R,F	Stanislaus River Basin (Partial regulation of inflow to Strawberry Reservoir)	2,505,000
Spicer Meadow	Highland Creek	Sec. 3, T6N, R18E 9	R	130	6,500	38,000	38,000	55,000	I,U,R,F	Mokelumne, Calaveras and Stanislaus River Basins	3,326,000
Ganns	North Fork Stanislaus River	Sec. 3, T6N, R17E 9	R	270	5,720	21,000	20,000	94,000	I,U,R,P, F	Mokelumne, Calaveras and Stanislaus River Basins	9,665,000
Ramsey	North Fork Stanislaus River	Sec. 23, T6N, R16E 9	R	205	4,740	32,000	31,000	120,000	I,U,P,R, F	Mokelumne, Calaveras and Stanislaus River Basins	9,231,000
Moran Creek Forebay		Sec. 22, T5N, R15E 8	CE	40	4,526				P	Supplies Moran Creek Power House	115,000
Lyons	South Fork Stanislaus River	Sec. 24, T3N, R16E 9	R	270	4,340	63,000	62,000	75,000	I,U,R,F,	Stanislaus River Basin	7,298,000
Hetch Hetchy Forebay	Middle Fork Tuolumne River	Sec. 14, T1S, R18E 11	CE	----	3,450	2,000	2,000		P,F	Supplies Early Intake Power House	1,000,000
Cherry Creek Forebay		Sec. 25, T1N, R18E 11	CE	----	4,400	2,000	2,000		P,F	Supplies Cherry Creek Power House	500,000
Cherry Creek Afterbay	Cherry Creek	Sec. 36, T1N, R18E 11	CG	----	2,400	2,000	2,000		S,F	San Francisco Bay Area	500,000
Phoenix	Sullivan Creek	Sec. 28, T2N, R15E 8	E	110	2,434	25,000	25,000	62,000	I,U,R,F	Stanislaus and Tuolumne River Basins	2,020,000
New Don Pedro	Tuolumne River	Sec. 35, T2S, R14E 11	CG	515	830	1,952,000	1,610,000	675,000	I,U,P,R, FC,F	San Joaquin Valley	82,315,000
Lily Lake	Lily Creek	Sec. 4, T3N, R19E 9	R	115	7,015	9,000	9,000	9,500	I,U,R,F	Tuolumne River Basin	2,156,000
Belle Meadows	Clavey River	Sec. 36, T4N, R18E 9	R	150	6,410	10,000	10,000	20,000	I,U,R,F	Tuolumne River Basin	3,104,000
Lords	Rush Creek	Sec. 2, T2N, R17E 9	R	130	5,455	10,000	10,000	31,000	I,U,R,F	Tuolumne River Basin	1,500,000
Browns Meadow	North Fork Tuolumne River	Sec. 22, T3N, R17E 9	R	135	4,790	14,000	14,000	46,000	I,U,R,F	Tuolumne River Basin	3,303,000
Hardin Flat	South Fork Tuolumne River	Sec. 35, T1S, R18E 11	ER	215	3,660	40,000	40,000	44,000	I,U,R,F	Tuolumne and Merced River Basins	2,290,000
Burch Meadows	Big Creek	Sec. 32, 33, T1S, R17E 11	ER	140	3,110	25,000	25,000	13,600	I,U,R,F	Tuolumne River Basin	2,691,000
Virginia Point	Merced River	Sec. 26, T3S, R16E 11	CE	540	1,255	1,000,000	755,000	464,000	I,U,P,R, FC, F	San Joaquin Valley	50,150,000
Coulterville	Maxwell Creek	Sec. 34, T2S, R16E 11	CE	200	1,990	22,000	22,000	14,000	I,U,R,F	Merced River Basin	1,436,000
Butterfly	Browns Creek	Sec. 7, T4S, R15E 11	ER	105	520	10,000	10,000	8,000	I,U,R,F	Merced River Basin	828,000
Hayward	Hayward Creek	Sec. 24, T3S, R14E 11	E	75	870	5,000	5,000	4,000	I,U,R,F	Merced River Basin	467,000
Wawona Diversion	South Fork Merced River	Sec. 13, T4S, R20E 11	CO	30	3,665				D	Merced, Chowchilla and Fresno River Basins	287,000
Aqua Fria	Mariposa Creek	Sec. 15, T6S, R18E 11	R	130	1,430	15,000	15,000	13,000	I,U,R,F	Merced River Basin	1,687,000
Upper Bear Creek	Bear Creek	Sec. 10, T5S, R17E 11	ER	240	1,850	50,000	48,000	45,000	I,U,R,F	Merced River Basin	3,416,000
Buchanan	Chowchilla River	Sec. 22, T8S, R18E 11	CE	167	557	94,000	92,000	23,000	I,U,R,FC, F	San Joaquin Valley	4,166,000
Darrah	Tributary of Snow Creek	Sec. 1, T5S, R19E and Sec. 6, T5S, R20E 11	CE	130	3,450	5,500	5,100	5,100	I,U,R,F	Chowchilla and Fresno River Basins	1,114,000
Magoon	Magoon Creek	Sec. 18, T5S, R20E 11	CE	90	3,180	5,500	5,100	4,500	I,U,R,F	Chowchilla and Fresno River Basins	567,000
Pegleg	Pegleg Creek	Sec. 21, T5S, R19E 11	CE	60	2,420	6,000	5,900	3,500	I,U,R,F	Chowchilla and Fresno River Basins	494,000
Windy Gap	Fresno River	Sec. 2, T7S, R20E 11	CE	180	2,045	32,000	30,000	13,000	I,U,R,F	Chowchilla and Fresno River Basins	2,122,000

TABLE 14—Continued

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SAN JOAQUIN-TULARE LAKE BASIN

(These works show future development possibilities. They are not project proposals.)

Dam and reservoir	Stream	Dam: Location, MDB&M, and sheet of Plate 5 on which shown		Dam: Type	Dam: Height, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active	Seasonal yield, in acre-feet[a]	Purpose	Place of water use	Capital cost[b]
San Joaquin-Sierra Group —Continued												
Hidden	Fresno River	Sec. 34, T9S, R19E	11	CE	139	524	75,000	74,000	11,000	I,U,R,FC,F	San Joaquin Valley	$11,229,000
Humbug	Humbug Creek	Sec. 9, T6S, R21E	11	CE	120	1,850	10,000	10,000	10,000	I,U,R,F	Chowchilla and Fresno River Basins	846,000
Miami	Miami Creek	Sec. 14, 15, T6S, R21E	11	CE	120	3,710	5,000	4,500	3,000	I,U,R,F	Chowchilla and Fresno River Basins	713,000
Lewis	Lewis Creek	Sec. 36, T6S, R21E	11	CE	125	3,075	15,000	14,500	7,000	I,U,R,F	Chowchilla and Fresno River Basins	1,873,000
Nelder Creek	Nelder Creek	Sec. 36, T6S, R21E	11	CE	160	3,100	15,000	14,000	7,000	I,U,R,F	Chowchilla and Fresno River Basins	1,728,000
Miller Bridge	Middle Fork San Joaquin River	Sec. 11, T5S, R25E	12	CG	200	4,790	25,000	25,000	140,000	I,U,R,F	San Joaquin River Basin	5,808,000
Forks	San Joaquin River	Sec. 4, T6S, R25E	11	R	300	3,950	35,000	35,000	204,000	I,P,R,F	San Joaquin Valley	10,039,000
Mammoth Pool	San Joaquin River	Sec. 14, T7S, R24E	11	R	325	3,330	123,000	123,000	360,000	I,P,R,F	San Joaquin Valley	15,629,000
Chiquito	Chiquito Creek	Sec. 17, T6S, R24E	11	R	200	4,980	75,000	75,000	72,000	I,P,R,F	San Joaquin Valley	6,004,000
Granite Creek Diversion	West Fork Granite Creek	Sec. 36, T4S, R24E	11	CO	9	7,200				D	Supplies Chiquito Reservoir	20,000
Jackass Creek Diversion	Jackass Creek	Sec. 26, T5S, R24E	11	CO	11	6,620				D	Supplies Chiquito Reservoir	20,000
Cedar Grove Diversion	South Fork Kings River	Sec. 10, T13S, R30E	14	CG	40	4,480	300	300		D,F	Supplies Cedar Grove Tunnel	650,000
Tehipite Diversion	Middle Fork Kings River	Sec. 14, T12S, R29E	14	CG	45	4,085	300	300		D,F	Supplies Tehipite Tunnel	870,000
Tulare-Sierra Group												
Junction	Kings River	Sec. 35, T12S, R28E	14	CA	240	2,370	14,000	14,000	270,000	I,P,R,F	Tulare Lake Basin	6,500,000
Dinkey Meadow	Dinkey Creek	Sec. 21, T10S, R26E	12	R	305	5,637	60,000	60,000	54,000	I,P,R,F	Tulare Lake Basin	10,800,000
Dinkey Meadow Afterbay	Dinkey Creek	Sec. 15, T11S, R26E	14	CG		3,600				S	Supplies Ross Tunnel	50,000
Ross Power House Afterbay	Dinkey Creek	Sec. 34, T10S, R26E	14	CG		1,750				S	Supplies Kings River Tunnel	50,000
Bear Creek Diversion	Bear Creek	Sec. 22, T10S, R26E	12	CO		5,660				D	Supplies Dinkey Meadow Reservoir	3,000
Terminus	Kaweah River	Sec. 25, T17S, R27E	14	E	208	690	145,000	145,000	115,000	I,U,P,R,FC,F	San Joaquin Valley	16,166,000
Success	Tule River	Sec. 35, T21S, R28E	14	E	120	645	75,000	75,000	24,000	I,U,R,FC,F	San Joaquin Valley	8,350,000
North Fork	North Fork Tule River	Sec. 23, T20S, R29E	14	CE	136	1,400	12,000	12,000	9,000	I,U,R,F	Tule River Basin	2,554,000
Middle Fork	Middle Fork Tule River	Sec. 6, T21S, R30E	14	CE	140	1,289	13,000	13,000	14,000	I,U,R,F	Tule River Basin	3,516,000
Rockhouse	South Fork Kern River	Sec. 34, T23S, R35E	17	R	150	5,640	72,000	72,000	36,000	I,P,R,F	Kern River Basin	4,500,000
Rockhouse Afterbay	South Fork Kern River	Sec. 22, T24S, R35E	17	CG	50	4,600	300			S	Supplies Onyx Tunnel	258,000
Onyx	South Fork Kern River	Sec. 24, T25S, R35E	17	E	150	2,990	25,000	25,000	41,000	I,P,R,F	Kern River Basin	4,660,000
Kelso	Kelso Creek	Sec. 20, T27S, R35E	17	CE	60	3,390	6,000	6,000	3,400	I,U,R,F	Kern River Basin	1,471,000
Canebrake	Canebrake Creek	Sec. 25, 26, T25S, R36E	17	CE	100	4,200	5,000	5,000	2,800	I,U,R,F	Kern River Basin	1,340,000
Lamont Meadow	Chimney Creek	Sec. 25, T24S, R36E	17	R	200	5,485	5,000	5,000	2,800	I,U,R,F	Kern River Basin	3,001,000
South Valley Group												
Sand Ridge		T. 24, 25, 26S, R20 21, and 22E	17	E	40	235	1,400,000	1,400,000		FC,F		15,500,000
White River-Deer-Pozo Creek Project	White River, Deer Creek, and Pozo Creek		17	--			36,000	36,000		FC,F		5,200,000
Caliente-Tejon Creek Stream Group Project			17	--			10,000	10,000		FC,F		20,940,000
Totals							8,443,900	7,632,700				$ 506,772,000

TABLE 14—Continued

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SAN JOAQUIN-TULARE LAKE BASIN

(These works show future development possibilities. They are not project proposals.)

Power plants	General location and sheet of Plate 5 on which shown		Average head, in feet	Installed capacity, in kilowatts	Annual energy production, in kilowatt-hours	Capital cost[b, c]
San Joaquin-Sierra Group						
Nashville	Cosumnes River	8	465	15,000	62,000,000	$1,724,000
Middle Bar	Mokelumne River	8	97	10,000	50,000,000	1,810,000
Jesus Maria	Jesus Maria Creek	8	1,200	10,000	56,000,000	1,170,000
New Melones[d]	Stanislaus River	11	389	34,000	135,000,000	2,840,000
Sand Bar	Middle Fork Stanislaus River	9	180	10,000	44,000,000	1,715,000
Stanislaus[d]	Stanislaus River	8	1,499	35,000	34,000,000	4,225,000
Griswold	Middle Fork Stanislaus River	8	2,400	10,000	47,000,000	1,418,000
Ganns	North Fork Stanislaus River	9	868	20,000	91,000,000	2,356,000
Moran Creek	Moran Creek	8	575	6,000	33,000,000	1,086,000
Murphys[d]	Angels Camp	8	685	6,000	13,000,000	1,039,000
Early Intake	Tuolumne River	11	1,060	75,000	429,000,000	9,550,000
Cherry Creek	Tuolumne River	11	2,000	100,000	530,000,000	10,174,000
Moccasin Creek[d]	Moccasin Creek	11	1,275	30,000	17,000,000	2,230,000
Phoenix[d]	Sullivan Creek	8	1,180	13,000	52,000,000	2,180,000
New Don Pedro[d]	Tuolumne River	11	425	73,000	192,000,000	7,762,000
Virginia Point	Merced River	11	442	50,000	232,000,000	4,260,000
Exchequer[d]	Merced River	11	252	4,000	32,000,000	582,000
Miller Bridge	San Joaquin River	11	850	30,000	140,000,000	2,908,000
Forks	San Joaquin River	11	520	35,000	149,000,000	3,425,000
Mammoth Pool	San Joaquin River	11	1,032	125,000	500,000,000	12,637,000
Chiquito	San Joaquin River	11	1,600	30,000	123,000,000	3,652,000
Tulare-Sierra Group						
Cedar Grove	Kings River	14	2,070	60,000	298,000,000	6,255,000
Tehipite	Kings River	14	1,670	50,000	245,000,000	4,440,000
Junction	Kings River	14	1,163	70,000	359,000,000	7,890,000
Dinkey Creek	Dinkey Creek	14	1,850	25,000	103,000,000	3,386,000
Ross	Dinkey Creek	14	1,790	25,000	123,000,000	3,560,000
Pine Flat	Kings River	14	315	60,000	304,000,000	5,693,000
Kings River[d]	Kings River	14	710	10,000	56,000,000	2,177,000
Rockhouse	South Fork Kern River	17	940	10,000	38,000,000	1,787,000
Onyx	South Fork Kern River	17	1,630	15,000	69,000,000	2,104,000
Borel[d]	Kern River	17	264	7,000	34,000,000	983,000
Kern No. 1[d]	Kern River	17	877	5,000	68,000,000	699,000
Totals				1,058,000	4,657,000,000	$117,717,000

(Table 14 continued on following page)

only a portion of the estimated ultimate possible mean seasonal water requirements, aggregating about 6,740,000 acre-feet.

The objectives of The California Water Plan for the Lahontan Area cannot be fully met by local development works, as the available water resources are insufficient to provide for the needs of the area and much of the area is remote from areas of surplus in other parts of the State. Because of the difficulty and cost of providing imported water supplies, possible means of importation of sufficient water to the various areas within the Lahontan Area to meet the ultimate possible requirements have not been planned as they have been for other hydrographic areas. Rather, the direction of future development has been indicated, with further plans left for future investigation.

For planning purposes the Lahontan Area has been subdivided into four groups, designated the "Lassen Group," "Alpine Group," "Mono-Owens Group," and "Mojave Group," and their locations are shown on Plate 3. Physical features and costs of all suggested local works for the Lahontan Area are presented in Table 15, following the summary of works for the Lahontan Area.

Lassen Group. The Lassen Group comprises the Surprise Valley, Madeline Plains, and Honey Lake areas, with a combined area of about 3,800 square miles. The group is located in the extreme northeastern portion of the State, lying between the California-Nevada boundary and the crests of the Warner Mountains and the Sierra Nevada. Each of the foregoing areas in this group is essentially a closed and internally draining watershed. The Susan River, largest stream in the group, rises on the eastern slopes of the Sierra Nevada and flows eastward through Susanville, terminating in Honey Lake. Some of the streams draining the Warner Mountains into Surprise Valley provide excellent trout fishing in the mountain reaches.

Approximately 90,000 acres are presently (1950) irrigated in the Lassen Group, and about 2,500 acres are occupied by urban and suburban developments. The present (1950) mean seasonal water requirement is estimated to be about 268,000 acre-feet per

TABLE 14—Continued

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SAN JOAQUIN-TULARE LAKE BASIN

(These works show future development possibilities. They are not project proposals.)

Conduit	Length of conduit, in miles				Capital cost[b]
	Canal	Pipe	Tunnel	Flume	
San Joaquin-Sierra Group					
Cosumnes River development	105	----	1.0	----	$6,082,000
Mokelumne-Calaveras River development	88	4	1.6	----	8,162,000
Stanislaus River development	37	----	6.6	----	10,683,000
Tuolumne River development	60	----	14.1	1.8	29,505,000
Merced River development	70	----	7.0	----	14,675,000
Chowchilla-Fresno River development	2	----	----	----	100,000
San Joaquin River development	----	----	23.3	----	32,672,000
Tulare-Sierra Group					
Kings River development	38	----	----	1.0	44,203,000
Kaweah River development	----	----	----	----	0
Tule River development	----	----	----	----	0
Kern River development	----	----	9.5	----	10,800,000
North Valley Group					
San Joaquin Waste Conduit	260	----	----	----	54,200,000
South Valley Group					
Arvin-Edison Canal	45	----	----	----	7,140,000
San Joaquin-Tulare Basin Canal	157	----	----	----	38,910,000
North Kings Canal	28	----	----	----	2,515,000
Fresno South Canal	25	----	----	----	4,450,000
Totals	915	4	63.1	2.8	$264,097,000

Pumping plant	Sheet of Plate 5 on which shown	Installed capacity, in kilowatts	Seasonal power consumption, in kilowatt-hours	Capital cost[b]
San Luis Forebay Pumps	11	90,000	260,000,000	$18,600,000
San Joaquin-Tulare Canal Pumps	14	30,000	80,000,000	9,400,000
Kettleman City Pumps	14	20,000	60,000,000	3,400,000
Totals	--	140,000	400,000,000	$31,400,000

Symbols of Type of Dam
- CG—Concrete gravity
- E—Earthfill
- CO—Concrete overpour
- CE—Composite earthfill
- R—Rockfill
- ER—Earth-rock
- CA—Concrete arch

Symbols of Purpose
- I—Irrigation
- U—Urban
- FC—Flood control
- P—Power generation
- R—Recreation
- F—Enhancement of fish environment
- OP—Regulation for use of off-peak power
- S—Reregulation of waters to local demand schedules
- D—Diversion

[a] Includes yield of upstream works, if any.
[b] At 1955 price levels.
[c] Cost of each plant includes associated works except reservoirs.
[d] Tabulated data pertain to enlargement of existing plant.

season, while the yield of the presently developed works, including wells and surface diversions, has been estimated to be only about 172,000 acre-feet.

The short, steep slopes of the easterly face of the Warner Mountains render impracticable the provision of major storage facilities for the conservation of runoff in Surprise Valley. Possible sources of future supplemental supplies for that area include an inter-basin importation by tunnel through the Warner Mountains from Goose Lake and importation of water from Cowhead Lake in Oregon to the northeast of Surprise Valley, which are interstate problems; and increased utilization and development of the local ground water supplies. With the exception of the ground water development, however, provision of other water supplies for Surprise Valley would be extremely costly, and no definite development plans have been formulated.

Plans for the provision of supplemental water supplies in the Madeline Plains area have not been prepared. Due to the remoteness of the area, the elevation of the agricultural lands, and the short growing season, irrigable lands in this area have a limited adaptability to general agricultural development. The area is closely associated with the economy of western Nevada, and the lands are currently utilized for sum-

Lahontan Area—Donner Summit

Lahontan Area—Arid Lands in Mono County

mer forage for cattle. A possibility exists of importation of supplemental water supplies from the Pit River or from the area tributary to Eagle Lake, if justified.

Local development works in the Honey Lake area could provide for the conservation of available water supplies though a system of reservoirs and appurtenant facilities. These works would consist of Devils Corral Reservoir on Susan River; Long Valley Dam on Long Valley Creek; and the Pete's Valley-Eagle Lake development, comprising a dike confining the waters of Eagle Lake to the southerly part of the present lake bed, and a dam and reservoir on Willow Creek. All of the foregoing reservoirs would supply about 59,000 acre-feet of water annually for use in the Honey Lake area. However, only a portion of this water supply could be considered to be new water, as most of the flow of the Susan River and the many creeks in the area are presently utilized for the irrigation of crops. The principal benefits to be derived from these works would be the more advantageous regulation of the water supply in accordance with agricultural demands; the provision of adequate water supplies during recurrent periods of deficiency; and the development of additional water supplies, approximately equivalent to the amounts now wasted to Honey Lake, and a portion of that consumed in present evaporation from the surface of Eagle Lake.

It is reported that Eagle Lake is of great scientific interest, particularly to biologists. Varieties of prehistoric aquatic life are found in the waters of the lake and thus provide a definite link with the distant past. Improvements designed to increase the utility of the waters of the lake from a water supply standpoint should be so designed, constructed, and operated as to result in a minimum adverse effect on the existing fish and aquatic specimens. The growing economy of California and the demands of the people of the State for recreational developments will require the maximum utilization of all available facilities. The improvement would provide an excellent opportunity for additional developments of a recreational nature in the Susanville area.

It is probable that the future development of ground water resources in the Honey Lake area may provide an appreciable portion of the ultimate water requirements of the area. Some development of this source has taken place in the past, and ground water is now being utilized for domestic, industrial, and agricultural purposes.

Alpine Group. The Alpine Group, located in the central Sierra Nevada, comprises the California drainage of the Truckee, Carson, and Walker Rivers. Lake Tahoe with its surrounding drainage area, part of which lies in the State of Nevada, forms the headwaters of the Truckee River. This area, centered about Lake Tahoe, has developed into a recreation area and vacation land of major importance, and includes many outstanding and internationally known ski areas. Numerous back trails and some secondary roads provide access to the high mountain valleys.

The existing economy of most lands in the Carson and Walker River Basins is based on the livestock industry, supplemented by recreational activities. The irrigated lands are used both for the production of hay for winter feeding of livestock and for summer pasture for cattle, the majority of which are brought in from Nevada. Recreational opportunities are centered around the fishing, hunting, and scenic attractions of the high mountain areas.

Existing water development works in the Truckee River Basin principally benefit lands in the State of Nevada. About 7,000 acre-feet of water per season is diverted from the Little Truckee River to Sierra Valley in the upper Feather River watershed. Boca Reservoir on Little Truckee River and Independence and Donner Lakes have been developed to provide supplemental water for areas in Nevada. Lake Tahoe, with a storage capacity of 732,000 acre-feet in the 6.1-foot operating range permitted under a federal court decree, conserves and regulates the seasonal snowmelt in the upper basin areas. Releases from the lake, supplemented by water stored in Boca Reservoir and in Donner and Independence Lakes, are utilized for power production in five hydroelectric generating plants of the Sierra Pacific Power Company which are situated on the Truckee River between Floriston, California, and Reno, Nevada. No major water developments have been constructed in the upper Carson River Basin. The minor developments which presently exist are privately constructed diversions, small reservoirs, and ditch systems, which utilize the available flows in the various streams. In the Walker River Basin, the principal existing development is for the benefit of lands in Nevada. Topaz Reservoir, an off-stream development on the West Walker River, and Bridgeport Reservoir on the East Walker River, have been constructed by the Walker River Irrigation District, a Nevada agency. These reservoirs store available winter runoff for use as irrigation water supplies during the following growing season.

As stated previously, the Truckee, Carson, and Walker Rivers have been developed for utilization in California to some extent, and in Nevada to a considerably greater extent. At the present time there is a shortage of water from these three stream systems to supply the lands in Nevada which have been developed thereunder. In addition, there is a large acreage of undeveloped land within the basins of these three rivers in both states which could use the water if it were available.

The States of California and Nevada, in 1955, created similar interstate compact commissions to deal with the problems created by the needs in both states for the waters of these three interstate streams. These commissions were formed to cooperate in the formulation of an interstate compact relative to the distribution and use of the waters of Lake Tahoe and of the Truckee, Carson, and Walker Rivers. Meetings held to date between the two commissons have pointed up the fact that there are insufficient water resources in these three interstate watersheds to meet fully the ultimate water requirements of the areas in both California and Nevada.

It is anticipated that the compact negotiations will be governed in the first instance by the necessity for preserving the existing economy, including the use of water for domestic purposes, irrigation, power, recreation, and the preservation of fish and wildlife. The allocation under the compact between the two states of water available for future development would determine to what extent the ultimate water requirements of lands in California could be met from the local stream systems.

Major flood damage in the Alpine Group is experienced from time to time in the Lake Tahoe area. High-water stages on the lake cause destruction of beaches and boating facilities as well as damage to septic tank installations. Suggested solutions for alleviating this damage include reduction of the maximum operating limit of the water surface from its present elevation of 6,229.1 feet above sea level. On the other hand, extremely low water surface elevations are detrimental to the recreation values of the lake by making boat dock facilities unusable and exposing bottom areas not suitable for recreation. A solution to this problem could be achieved by changing the maximum and minimum operating limits of the lake level. However, any reduction in usable storage resulting from the change in operating limits would appear to require that equivalent storage be substituted elsewhere in the area to replace present storage in Lake Tahoe.

Flood damage to agricultural and urban development elsewhere in the Alpine Group is not expected to be of major importance. Minor channel improvements would probably provide adequate protection against all but extreme flood occurrences. Channel improvement on the Truckee River below Lake Tahoe has been authorized by Congress for construction by the Corps of Engineers, U. S. Army.

The Washoe Project was authorized by the Congress in 1956 for construction by the United States Bureau of Reclamation. Among the features of this project located in the Truckee River Basin is Stampede Reservoir on the Little Truckee River, with a capacity of 126,000 acre-feet. Water from this reservoir would be discharged through a tunnel and penstock to the 20,000-kilowatt Calvada Power Plant on the Truckee River. The discharge from this power plant would flow through the Truckee River channel and existing facilities to meet and supplement established rights in Nevada.

In addition to these previously described works, Congress also provided for a fish and wildlife benefit of $2,000,000, part of which is to be used to improve the Truckee River fishery. The works to be constructed for improvement of the fishery were not described in the authorizing act. However, the Bureau of Reclamation has proposed a reservoir on Prosser Creek in order to maintain minimum flows in the Truckee River below Lake Tahoe by means of an exchange of water with Lake Tahoe. The act further provides that Stampede Reservoir shall be constructed in such a manner that it can be raised at a later date to a capacity of 175,000 acre-feet, in conformity with The California Water Plan.

The Washoe Project Act also states:

> "The use of waters of the Little Truckee River solely for the generation of electric power by the Washoe project shall not impair or preclude the appropriation of such waters in the future for beneficial consumptive use within the Little Truckee River watershed in California to the same extent as such waters may be presently available for such appropriation in the State of California: *Provided,* That if and when an interstate compact covering the distribution and use of the waters of the Truckee and Carson Rivers is approved by the Legislatures of the States of California and Nevada and is consented to by Congress, the operation of the Washoe reclamation project shall be in conformance with such compact, and the foregoing restriction shall not apply."

In the Carson River Basin, Watasheamu Reservoir on the East Fork of the Carson River has been authorized for construction under the Washoe Project. Watasheamu Reservoir would be constructed to a capacity of 115,000 acre-feet, and would regulate flood flows now running to waste, together with water presently used by the Newlands Project which would be replaced by Washoe Project water from the Truckee River. Releases from Watasheamu Reservoir would pass through the 8,000-kilowatt Watasheamu Power Plant at the base of the dam. The water then would be reregulated at the 1,040 acre-foot Dressler Diversion Dam and afterbay. Water would be diverted to the proposed Carson Canal, serving new lands along its course through the Carson Valley. Water would also be delivered to the West Fork of the Carson River for distribution by existing canals diverting from that stream.

The Washoe Project Act provides that water users in Alpine County, California, shall have the first opportunity to purchase a water supply from the water made available by Watasheamu Reservoir before such water is available for the development of new lands in Nevada. This would probabaly also involve an exchange of such East Carson River water from Watasheamu Reservoir for West Carson River water now used in Nevada.

In addition to an adequate water supply for habitable (not alone irrigable) lands, the objectives of The California Water Plan in the Alpine Group include: (1) preservation and enhancement of the recreational value of Lake Tahoe and the surrounding areas; (2) preservation and enhancement of the fish and wildlife resources of the streams and surrounding areas; (3) preservation and enhancement of the recreational value of the entire group; and, (4) provision of the maximum assistance to the general economy of the entire group through utilization of the opportunities for the generation of hydroelectric power.

These objectives could be met by further development of the water resources in each of the three watersheds of the group. In general, the waters of each stream system would be utilized to meet supplemental water requirements in its own drainage area, taking full cognizance of the interstate character of present and future water development.

The Lake Tahoe-Union Mills development consists of a diversion from the north shore of Lake Tahoe, connected by tunnel and canal to the Union Mills Power Plant. The water supply developed by this project would be used for the production of about 36,000,000 kilowatt-hours of hydroelectric energy annually.

The Lake Tahoe-Farad development includes the Lake Tahoe-Union Mills development, as described above, and, additionally, would involve a diversion from Truckee River about 3.5 miles downstream from the City of Truckee, connecting with Boca Reservoir through canal and tunnel. A tunnel from Boca Reservoir would transfer the flow to a contemplated hydroelectric plant located near Farad on the Truckee River. Water diverted from the Truckee River below Union Mills and routed through Boca Reservoir would produce about 66,000,000 kilowatt-hours of hydroelectric energy annually.

Preliminary operation studies of this development indicate that in addition to the production of needed power for the Tahoe-Reno area, the problems engendered by high and low stages on Lake Tahoe would be greatly alleviated.

The Stampede-Calvada development would divert flows from Prosser Creek, a tributary of the Truckee River, into a canal terminating at Stampede Reservoir, which would then be enlarged to a total storage capacity of about 175,000 acre-feet. The average seasonal yield for all beneficial purposes would approximate 120,000 acre-feet, of which 20,000 acre-feet could be utilized in service areas in California. Seasonal release of 9,300 acre-feet would be made for maintenance of fish life in the Little Truckee River. The hydroelectric generating facilities of the Calvada Power Plant, under such a plan, would generate about 165,000,000 kilowatt-hours of electrical energy seasonally. Should the Prosser Creek works proposed by the United States Bureau of Reclamation be constructed, the Stampede-Calvada development would probably not be possible of accomplishment.

Hope Valley Reservoir on the West Carson River would provide a firm water supply to meet the irrigation requirements of the 8,000 acres lying in Diamond Valley and in the Fredricksburg area. The reservoir would furnish an estimated firm seasonal yield of 55,000 acre-feet of water. The major portion of this supply would be available for generation of hydroelectric energy at the Paynesville and Woodfords Power Plants and for subsequent application to domestic and agricultural purposes. In addition, releases from the reservoir of about 5,000 acre-feet per season would provide to some extent for the maintenance of fish and wildlife below the dam.

The remaining 5,300 acres of irrigable land in the Carson River Basin, located principally on the East Carson River, would experience a deficiency in supply in most seasons due to practical difficulties and costs of supplying irrigation water requirements to small and isolated tracts.

In California, the flow of the East Carson River would be principally devoted to recreational uses. However, the stream flow would be depleted to an extent of about 5,300 acre-feet annually to provide water on about 4,500 acres of irrigable land. Silver King Reservoir on East Carson River would provide an ample water supply to furnish the necessary flow for maintenance of fish life at all times, except in the driest years of record.

Developments contemplated on the West Walker River include reservoirs at Leavitt and Pickle Meadows, diversion of the Little Walker River into Pickle Meadows Reservoir, and Pickle Meadows and Antelope Valley Power Plants, of 5,000- and 25,000-kilowatt capacity, respectively.

Leavitt Meadows Dam, located at the lower end of Leavitt Meadows, would form a reservoir with a storage capacity of 20,000 acre-feet. Water released from Leavitt Meadows Reservoir would pass through the Pickle Meadows Power Plant prior to being discharged into Pickle Meadows Reservoir, located at the lower end of Pickle Meadows. Stored water from the latter reservoir would be released for production of hydroelectric energy at the Antelope Valley Power Plant, with subsequent use for irrigation in Antelope Valley in California and lower areas in Nevada.

Much of the flow of the Little Walker River above its junction with the West Walker River would be diverted into the 125,000 acre-foot capacity Pickle Meadows Reservoir for storage and use. Storage of available runoff would contribute to flood protection in Antelope Valley and in lower areas in Nevada. In addition to the hydroelectric power and irrigation benefits there would be incidental fishery benefits.

consisting largely of protection of the channel and fish habitat from scouring flood flows.

No developments are contemplated above Bridgeport Valley on the East Walker River. However, a hydroelectric generating plant, utilizing the available head between Bridgeport Dam and the state line, of 8,200-kilowatt capacity, could develop 39,700,000 kilowatt-hours of electrical energy per year. Bridgeport Valley forms an excellent potential ground water unit. Bridgeport Reservoir, at the lower end of the valley, has caused high ground water elevations under the town of Bridgeport. Use of the ground water basin might tend to lower such existing water levels. Both the United States Bureau of Reclamation and the Walker River Irrigation District have investigated the possibility of raising Bridgeport Dam. A project of that nature should include works necessary to protect the town of Bridgeport from further damage by high ground water levels.

Mono-Owens Group. The Mono-Owens Group comprises the Mono Lake, Adobe Valley, and Owens River areas in the central part of the State, adjacent to the California-Nevada boundary. The westerly boundary of the group lies along the crest of the Sierra Nevada. The gross area of this group in California is about 4,112 square miles, of which about 984 square miles are valley and mesa lands. Mt. Whitney, the highest peak in the continental United States, rising 14,500 feet above sea level, is the outstanding topographic feature.

Mono Lake is a perennial lake with a surface area of about 88 square miles, at an elevation of 6,400 feet above sea level. The lake waters are highly saline and unsuitable for general use. Many small reservoirs and lakes in the upper reaches of Rush, Leevining, Parker, Walker, and Mill Creeks afford excellent opportunities for fishing and recreation. Grant Lake on Rush Creek, and Walker and Sardine Lakes on Walker Creek are owned by the City of Los Angeles and are operated to facilitate the exportation of water to Los Angeles. Several reservoirs in Mono Lake Basin, used primarily for hydroelectric power production, are owned and operated by the California Electric Power Company. The several small reservoirs in the basin have an aggregate storage capacity of about 90,000 acre-feet.

The Owens River rises in volcanic formations to the north of Owens Valley, flowing across the broad upland meadows of Long Valley. The river then drops steeply through the Owens River Gorge, arriving at the head of Owens Valley at an elevation of about 4,400 feet. The fall through the gorge has been utilized for the production of hydroelectric energy. From the mouth of the gorge, the river follows a meandering course through the valley, finally terminating in Owens Lake. Exportation of water to the City of Los Angeles has reduced the inflow to the lake, and a brine processing industry now conducts extensive operations on the lake bed.

The many lakes and small reservoirs in the Mono-Owens Group provide excellent and much-needed recreational opportunities. In addition to the existing facilities for fishing and camping, the organization and provisioning of groups formed for fishing and hunting is a major activity. Much of the present economy of the group is based upon these recreational aspects, factors which are expected to be of increasing importance to the area. Long Valley Reservoir, also known as Lake Crowley, is a very important recreational asset to the Mono-Owens Group.

Long Valley, Tinemaha, and Haiwee Reservoirs regulate the runoff of the Owens River and the imported waters from Mono Lake Basin. The City of Los Angeles purchased some 300,000 acres of lands in Owens-Mono Basin to obtain water rights for its project. The city now leases lands under agreements which contemplate applying water to varying acreages of these lands, depending upon the availability of water in excess of the carrying capacity of the Los Angeles Aqueduct, which now delivers 320,000 acre-feet per annum, approximately its full capacity.

No plans have been prepared for further local development in the Mono-Owens Group as the City of Los Angeles claims rights to the use of most of the waters of these basins. It is expected, however, that some agricultural development on the more favorable lands will occur in the future, utilizing water presently wasted by phreatophyte infestation. Importation of additional water would be extremely difficult and costly. Every effort must be made to preserve and enhance the fish and wildlife resources of the area and to expand the recreational opportunities.

Mojave Group. The Mojave Group comprises Death Valley, the Mojave River Basin, and Antelope Valley. The group is located in the southern part of the Lahontan Area and is bounded on the west and south by the crest of the Sierra Nevada and other drainage divides separating the Lahontan and Colorado Desert Areas. The group contains a total of about 22,700 square miles, of which 6,800 square miles are valley and mesa lands. Death Valley National Monument, an outstanding vacation land, is located in this group and is bordered on the west by the imposing Panamint Range.

The Mojave Group is unique because all drainage is internal, the streams terminating in dry lakes, or sinks, which are subject to inundation in the occasional periods of exceptionally high runoff. The principal streams in the group, all of which are comparatively minor, are the Mojave River, draining the northerly slopes of the San Bernardino Mountains, Big and Little Rock Creeks in Antelope Valley, and the Amargosa River, draining Death Valley.

Tremendous expansion has taken place in the desert areas during the past few years. Camp Irwin and the Naval Ordnance Test Station at Inyokern are located in the Mojave Group. The recent acceleration of activities of these and other military installations has caused a major influx of population into adjacent urban areas. Antelope Valley has experienced some agricultural expansion during the last decade, but the principal development has been due to expansion of industry with the accompanying commercial development to support the urban growth. In the Palmdale and Lancaster areas, the advent of military and related aircraft industrial installations has resulted in a great increase in population. Major industries in the Mojave Group are the manufacture of portland cement, the production of crops by irrigated agriculture, and the operation and maintenance of railroad plant and equipment. Commercial development has expanded rapidly, due to the growth of population and the increased tourist trade that is being experienced in this group.

Water quality problems are inextricably connected with the development of the native water resources of the Mojave Group and the provision of additional imported supplies. Poor-quality ground water is presently found in many of the individual ground water basins. The existence of borax mines is indicative of present and future problems associated with excessive boron content of otherwise usable water supplies. It is anticipated that other problems will develop as the expansion of economic activity occasions the further development of ground water resources.

Future development of available ground water storage capacity, involving the utilization of large quantities of imported water supplies, would require adequate control over the maintenance of salt balance. This is a serious and aggravated problem under conditions of internal drainage such as are found in the Mojave Group, where all drainage water remains in the immediate vicinity of the primary supply. Salt balance in the usable ground water reservoirs must be maintained by providing facilities to export, or transfer, from the underground basins as great a quantity of salts as is added in the processes of use and re-use.

Flood problems in this group are those principally connected with the Mojave River. Occasional floods on this stream have in the past caused extensive damage in the valley areas. In 1956 the Corps of Engineers, U. S. Army, investigated the problem of floods, and recommended construction of a flood control reservoir on the West Fork of the Mojave River.

In common with most other arid areas, the Mojave Group is subject to cloudbursts, which cause flash floods, during which a large volume of water is discharged down a normally dry stream bed. Floods of this type have caused considerable damage in localized areas, but are so erratic in time and place as usually to make infeasible the provision of adequate safeguards against the prospective flood damage.

The irrigated area in the Mojave Group amounted to about 99,000 acres in 1950. The water supplies required to support this agricultural development, together with necessary urban and suburban requirements, have been principally secured by development of available underground water supplies.

In Antelope Valley, the Little Rock Creek and Palmdale Irrigation Districts have developed available surface supplies originating in the San Bernardino Mountains. In addition to the development of surface supplies, ground water has been extensively developed to supply most of the 74,000 acres presently under irrigation in 1950. As a consequence, an annual overdraft of about 160,000 acre-feet existed at that time; the ground water resources were overdrawn prior to 1946, at least. As a result, ground water levels now (1957) average 176 feet below ground surface. It has been estimated that, under 1950 conditions, the water requirements for the then existing development in Antelope Valley amounted to about 226,000 acre-feet per season. It is estimated that the probable ultimate habitable water service area in Antelope Valley would total about 725,000 acres, of which about 610,000 acres would be irrigated, or approximately eight times the 1949-50 area of irrigated lands. The estimated probable ultimate mean seasonal water requirement is about 1,520,000 acre-feet, of which 1,490,000 acre-feet might be used for irrigated agriculture. Since the native water supply amounts to only about 66,000 acre-feet, it is apparent that, for all practical purposes, the water supplies necessary to support the potential economic development of this area would have to be imported through the facilities of the California Aqueduct System.

It is estimated that the yield available from native water supplies in the Mojave Group is about 200,000 acre-feet per season, including about 135,000 acre-feet from the Mojave River and 66,000 acre-feet from watersheds tributary to Antelope Valley. Although the Amargosa River, draining Death Valley, contributes an unknown amount to the water supply of the area, its effect, in relation to the magnitude of the estimated requirement, is believed to be small.

The objectives of The California Water Plan for the Mojave Group would be met by the importation of about 4,835,000 acre-feet of supplemental water supplies per season from areas of surplus in California through the facilities of the California Aqueduct System, and the transmission and distribution of such water supplies to local agencies throughout the area. It is contemplated that water would be supplied on a constant-flow basis, and that reregulation to the monthly demand schedule prevailing in the service areas would be accomplished by utilization of available ground water storage. The flow in excess of requirements during the winter months would be placed in underground storage, and, during periods when the demand for water would be greater than the delivered flow, supplemental water supplies would be pumped from the underground reservoirs and distributed through the existing system.

It is pointed out that the cost of importing water to this area would be high because of the elevations and distances involved. This cost might well be beyond the repayment capacity of irrigated agriculture under current economic conditions. On the other hand, it is believed that urban communities, military activities, and industrial developments could bear these costs. The feasibility of providing adequate water supplies for the Mojave Group in the near future, at least, will be largely dependent upon the probable future trend of economic development, whether it be principally urban and industrial or agricultural. The Department of Water Resources is currently (1957) giving further and intensive study to the matter.

A unit of the California Aqueduct System would enter the Lahontan Area at the Antelope Afterbay. It is described hereafter under the heading "Buena Vista-Cedar Springs Aqueduct." It would traverse the area along the southerly edge of Antelope Valley and leave the area at Mojave Junction, from whence it would proceed into the South Coastal Area. Diversion of necessary water supplies for the Mojave Group would be made as required at various points along the line of the California Aqueduct route.

Summary of Lahontan Area. Objectives of the California Water Plan in the Lahontan Area would be met by further development of local water resources, supplemented with imported water delivered through facilities of the California Aqueduct System in the southerly portion of the area. Deficiencies in developed water supplies to support the existing municipal and agricultural development in the area have increased rapidly in the past few years, particularly in the Mojave Group. The population in the Lahontan Area was about 126,000 in 1955, with much of the increase since 1950 occurring in the southerly portion of the area.

Local water resources in the Lassen Group are insufficient to provide for the water requirements of this group. Projects contemplated herein, while augmenting the present development, would not suffice to meet the probable ultimate requirements. However, provision of imported water supplies to this area is not considered feasible of accomplishment due to its remote geographical location and the difficulties attendant on exporting required water supplies from sources of the Central Valley.

In the Alpine Group the yield from local works would accrue largely to the benefit of lands lying in the State of Nevada. Contemplated works could provide water supplies adequate to meet the estimated ultimate requirements in this group. However, the considerations involved in the distribution of waters of an interstate stream will probably govern the amount of water which could be made available for the ultimate development of the lands in the California portion of the stream system. Projects included in The California Water Plan, together with existing works in this area, would provide a high degree of conservation of surface water resources, developing a yield of about 310,000 acre-feet of water per season. This yield would be additional to the yield from Bridgeport Reservoir on the Walker River and the proposed Watasheamu Reservoir on the East Carson River. In contrast, the estimated probable water requirements of lands in California included in this group are about 144,000 acre-feet per season.

The possible yield from development of local water supplies in the Mojave Group is estimated to be about 200,000 acre-feet of water per season. Required supplemental water supplies in this group would be largely provided from imported water delivered through the facilities of the California Aqueduct System. This would be accomplished principally through the use of ground water storage in conjunction with supplemental water supplies amounting to 4,835,000 acre-feet per season, which would ultimately be imported into the group through the California Aqueduct System, if determined to be feasible, and be distributed by local water service agencies.

The future growth of California will necessitate a considerable increase in the development of recreational areas and facilities. Water development must provide specific features for the enhancement of the sport fishery and the wildlife of California. The recreational aspect of anticipated water development is of outstanding importance in the Lahontan Area, particularly in the Lassen, Alpine, and Mono-Owens Groups. This region of the State has many almost unparalleled advantages for recreational development. Much of the present economic development is based upon supplying the recreational needs of California's population, and it is expected that this activity will increase at a rapid rate in the future.

The general features and costs of the local development works contemplated as features of The California Water Plan in the Lahontan Area are presented in Table 15. The location and layouts of all these facilities are delineated on Sheets 4, 6, and 9 of Plate 5.

Colorado Desert Area

The Colorado Desert Area comprises all lands draining directly into the Colorado River, together with a number of centrally drained desert basins without outlet. The area includes a total of 19,400 square miles, of which about one-half consists of valley and mesa lands. The climate of the area is arid,

TABLE 15

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN LAHONTAN AREA

(These works show future development possibilities. They are not project proposals.)

Dam and reservoir	Stream	Dam: Location, MDB&M, and sheet of Plate 5 on which shown	Dam: Type	Dam: Height, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active	Seasonal yield, in acre-feet	Purpose	Place of water use	Capital cost[a]
Lassen Group											
Devils Corral	Susan River	Sec. 5, T29N, R11E 4	E	189	4,737	30,000	29,500	31,000	I	Honey Lake area	4,649,000
Long Valley	Long Valley Creek	Sec. 10, T23N, R17E 6	E	104	4,700	20,000	19,100	8,000	I	Long Valley	827,000
Pete's Valley	Willow Creek	Sec. 1, T30N, R13E 4	E	133	4,543	22,000	19,800 }	20,000	{ I,R	Willow Creek-Honey Lake area	{ 1,404,000
Eagle Lake Dike	Eagle Lake	Sec. 16, 17, T32N, R11E 4	E,R	30	5,102	83,000	83,000 }				848,000
Alpine Group											
Stampede[b]	Little Truckee River	Sec. 20, 21, 29, T19N, R17E 6	E	207	5,932	175,000	174,000	120,000	I,P,F,R	Little Truckee-Prosser Creek area	6,375,000
Hope Valley	West Carson River	Sec. 25, T11N, R18E 9	E	176	7,166	100,000	95,000	55,000	I,P,F,R	Carson Valley-Diamond Valley	5,101,000
Silver King	East Carson River	Sec. 2, T8N, R21E --	E	75	6,430	8,000	7,900	7,900	F,R	East Carson River area	465,000
Leavitt Meadows	West Walker River	Sec. 27, T6N, R22E 9	E	103	7,183	20,000	19,200 }	127,000	{ I,P,F,R	Antelope Valley	1,106,000
Pickle Meadows	West Walker River	Sec. 18, T6N, R23E 9	R	173	6,833	125,000	124,000 }		I,P,F,R	Antelope Valley	7,867,000
Mono-Owens Group	(no local works)										
Mojave Group	(no local works)										
Totals						583,000	571,500				$28,642,000

Power plants and conduits	Location, MDB&M, and sheet of Plate 5 on which shown		Average head, in feet	Installed capacity, in kilowatts	Average annual energy generation, in kilowatt-hours	Length of conduit, in miles: Canal	Tunnel	Pipe	Total	Capital cost[a]
Lassen Group										
Diversion conduits						5.0	----	----	5.0	Included in cost of dams
Alpine Group										
Union Mills	Sec. 8, T17N, R17E	6	500	10,000	36,200,000	5.7	3.8	0.4	9.9	$5,960,000
New Farad	Sec. 12, T18N, R17E	6	425	14,000	66,400,000	2.9	4.4	----	7.3	7,640,000
Calvada[b]	Sec. 31, T19N, R18E	6	890	20,000	81,000,000	----	4.5	----	4.5	8,792,000
Woodfords	Sec. 1, T10N, R19E	9	1,100	10,300	47,200,000	----	4.1	----	4.1	4,932,000
Paynesville	Sec. 17, T11N, R20E	9	952	6,500	24,400,000	----	6.1	----	6.1	1,160,000
Pickle Meadows	Sec. 25, T6N, R22E	9	300	5,000	18,600,000	----	----	1.1	1.1	805,000
Antelope Valley	Sec. 28, T8N, R23E	9	1,184	25,000	116,600,000	----	8.9	1.0	9.9	14,279,000
Bridgeport	Sec. 31, T7N, R26E	9	500	8,200	39,800,000	8.5	----	0.3	8.8	2,073,000
Diversion conduits						14.7	0.3	----	15.0	731,000
Totals				99,000	430,200,000	36.8	32.1	2.8	71.7	$46,372,000

Symbols of Type of Dam
E—Earthfill
R—Rockfill

Symbols of Purpose
I—Irrigation
P—Power
F—Enhancement of fish environment
R—Recreation

[a] At 1955 price levels.
[b] Stampede-Calvada Project under construction by U. S. Bureau of Reclamation, with Stampede Reservoir storage capacity of 125,000 acre-feet.

typified by short, mild winters and exceptionally hot, dry summers. In the higher mountain regions, particularly in the coastal ranges, precipitation frequently occurs in the form of snow. A large portion of the rainfall in the valley areas originates from localized thunderstorms, resulting in extreme variability and maldistribution in precipitation. The rainfall on valley and mesa lands is generally so minor in amount that it has little practical significance with respect to the water resources of the area.

The economy of the Colorado Desert Area is based principally upon agricultural development in the Imperial, Coachella, and Palo Verde Valleys, and in the Yuma Project, all of which have developed a stable agricultural economy dependent upon Colorado River water. The mild winter climate and long growing seasons have produced a great variety and abundance of crops, and have permitted the expansion of specialty produce, such as off-season truck crops, citrus, dates, cotton, and table grapes. Much of the irrigable land in this area is included within the service area of agencies holding rights in and to the waters of the Colorado River. The remaining lands, two-thirds of which are located in the northerly portion of the area, could be supplied with their ultimate water requirements through major export projects from areas of surplus in northern California.

The Colorado Desert Area has taken its place in recent years as one of the nation's outstanding resort areas. Recreational resorts are located principally in and adjacent to Palm Springs, Desert Hot Springs, and Twentynine Palms. The development of dude ranch resorts and other desert types of recreational facilities has attracted thousands of seasonal visitors. The principal resort season covers the winter months, although there is an appreciable year-round influx of tourists and visitors to the area.

Population in the Colorado Desert Area, with the exception of urban and recreational areas in the Coachella Valley, as of 1950, had not kept pace with the large over-all growth which occurred in other areas of the State. With exception of the resort communities, urban developments are, for the most part, adjuncts to the agricultural activity, which did not change greatly in the decade from 1940 to 1950. Population in the several resort areas, however, more than doubled in the decade preceding 1950, and has continued its rapid growth to the present time. It should be noted that population in Palm Springs and other similar areas is subject to wide seasonal variation.

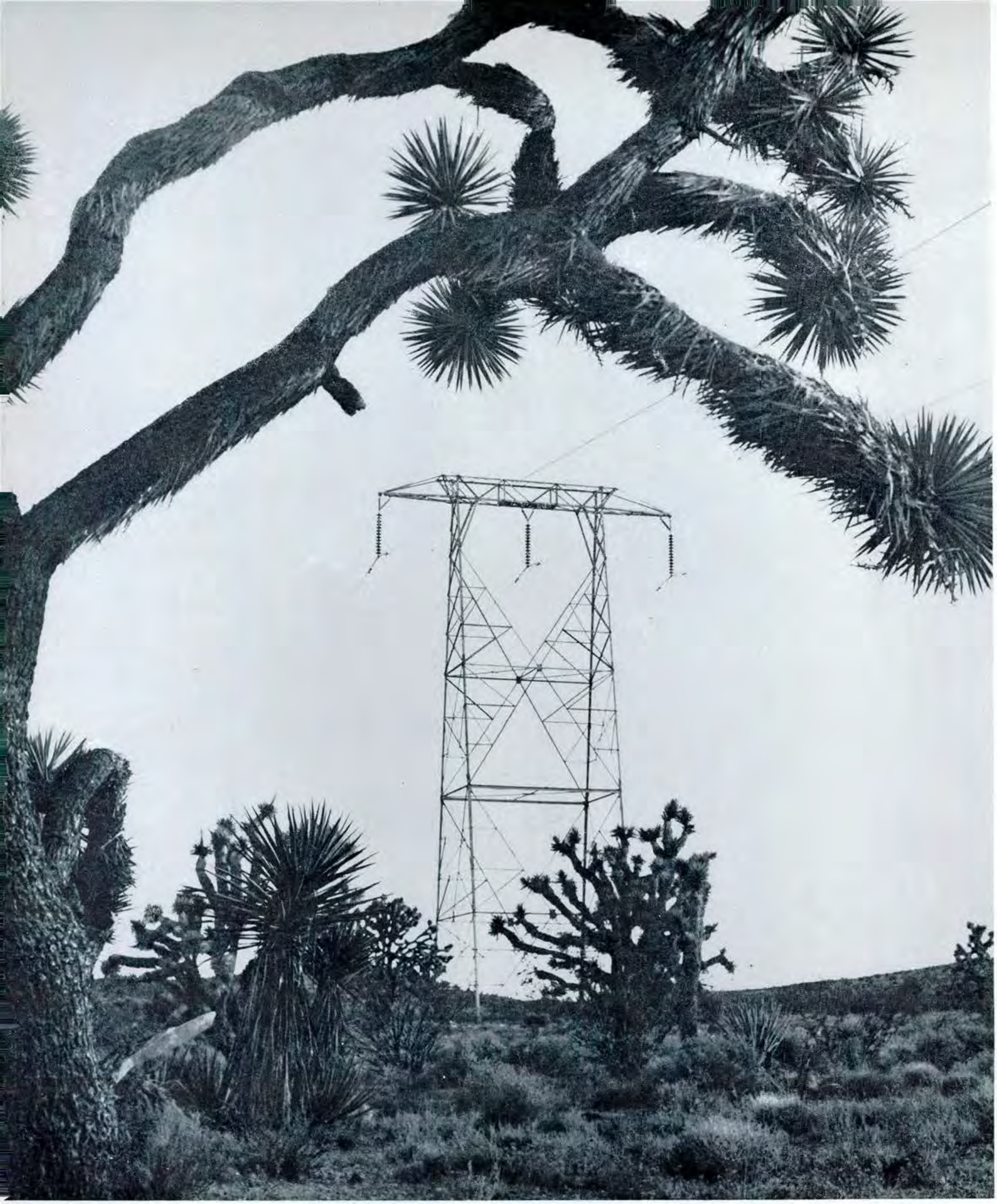
The estimated mean seasonal natural runoff in the Colorado Desert Area is about 221,000 acre-feet. This meager runoff, even if fully conserved, would supply only a small fraction of the total seasonal water requirements. The principal streams are the Whitewater River and San Felipe Creek, both of which drain into the Salton Sea. The stream flow in this area is not ordinarily available for surface diversion, due to the extreme variability in time and amount of its occurrence.

Continued utilization of irrigable lands within the areas presently served from the Colorado River, and which are traversed by or accessible to main canals already constructed, must depend upon the continued availability of Colorado River water to the full extent of California's established rights. California is limited by the Boulder Canyon Project Act and the California Limitation Act to the annual consumptive use of 4,400,000 acre-feet of the waters apportioned to the Lower Colorado River Basin by Article III (a) of the Colorado River Compact, plus not more than one-half of any excess or surplus waters unapportioned by the compact. California considers its entitlement under these statutes to aggregate not less than 5,362,000 acre-feet per annum of beneficial consumptive use, as covered by contracts of California agencies with the Federal Government for the storage and delivery of water, confirming prior appropriations under the laws of California. Of this, districts in the Colorado Desert Area hold contracts aggregating 4,150,000 acre-feet per annum. This figure derives from a "Seven-Party Agreement" among the California users of Colorado River water, made in 1931.

The continued use of ground water is vital to the existing urban and agricultural development in portions of the Colorado Desert Area, although quantities of ground water available are small in comparison to the large surface diversions from the Colorado River. The primary sources of ground water in the area are seepage from the Colorado River into basins bordering the river, precipitation, and percolation of runoff from tributary drainage areas. Ground water use for agricultural purposes is centered principally in the Coachella, Borrego, and Lucerne Valleys. The safe annual yield of these developed ground water basins, however, is only about 78,000 acre-feet, indicating that development may not safely continue without an imported supplemental water supply.

Ground water quality varies greatly both in composition and concentration throughout the Colorado Desert Area, and often within the individual ground water basin. In general, ground water quality is suitable for all uses except in the Imperial Valley, Chuckawalla Valley, and the ground water basins bordering the Salton Sea on the east and west. However, localized areas of poor-quality water are encountered throughout the area.

If the Colorado River represented an unlimited source of supply, the entire Colorado Desert Area, because of geographical proximity, would look to that river for the satisfaction of its needs. The Colorado River is not an inexhaustible river, however, and California's entitlement to the use of its waters has been limited, since 1929, as has been previously stated.



Colorado Desert Area—Power From the Colorado River

These factors, together with the obvious difficulties and cost of importing water from other sources, will probably retard further agricultural development in the Colorado Desert Area.

The total potential water service area in the Colorado Desert Area, as shown in Table 16, aggregates about 1,856,000 acres of lands considered suitable for agricultural and urban development, with an estimated total ultimate seasonal water requirement of about 6,300,000 acre-feet. These totals include three separate components, as follows:

1. The districts served from the Colorado River, which consider that acreage aggregating about 1,065,000 acres within their service areas may ultimately be developed, and for which full development is dependent upon the sufficiency of the 4,150,000 acre-feet per annum to which these areas are entitled from the Colorado River;

2. An additional 566,000 acres, as shown on Sheets 22 through 26 of Plate 5, classified as water service areas by the Department of Water Resources under criteria adopted during the State-wide Water Resources Investigation, with a seasonal water requirement of 1,467,000 acre-feet; and

3. A further additional 224,000 acres, considered by the Colorado River Board of California as susceptible of development, based on planning reports and other material utilizing varying criteria with regard to land use, with an estimated seasonal water requirement of 685,000 acre-feet if Colorado River water were available, as explained later.

In addition to the water supply available from the Colorado River under California's entitlement, the objectives of The California Water Plan in the Colorado Desert Area ultimately could be met by utilization of ground water resources and by imports through facilities of the California Aqueduct System. However, the latter sources would be insufficient to provide fully for the needs of all lands considered susceptible of water service. Further development in the area will be conditioned principally upon the economic feasibility of these contemplated import works.

The ground water storage capacity of the Colorado Desert Area is vital to life and culture. Continued and expanded development of ground water resources is anticipated. There are large areas of irrigable land which, if developed, must depend at least in part on ground water. Ground water is known to occur in each of the 46 hydrologic units which have so far been identified. With the exception of a few basins along the Colorado River, supplied by underflow from that source, the primary source of ground water in all units is precipitation and percolation of runoff from tributary drainage areas. Precipitation throughout the desert area is scanty and irregular and ground water supplies are therefore generally limited. The California Water Plan envisions the utilization of existing ground water storage capacity for the regulation of imported supplemental water supplies.

For planning purposes, the Colorado Desert Area has been subdivided into four groups, designated as the "Whitewater Group," "San Felipe Group," "Colorado River Group," and "Desert Valley Group." The locations of these groups are shown on Plate 3. Physical features and costs of the works which could make water available to the Colorado Desert Area are presented later in Tables 27 and 28, which describe facilities of the Southern California Division of the California Aqueduct System.

Whitewater Group. The Whitewater Group consists of the Coachella Valley and the watersheds tributary thereto. It is located to the northwest of the Salton Sea, principally in Riverside County, and is bounded by the Santa Rosa, San Jacinto, and Little San Bernardino Mountains.

The principal stream in the Whitewater Group is the Whitewater River, with an estimated mean natural seasonal runoff of about 62,000 acre-feet. Seasonal runoff from Snow Creek and Palm Canyon Creek also contributes appreciable amounts to the water supply available in the group. The Coachella Valley constitutes a major ground water unit, and surface runoff from the mountains disappears rapidly after reaching the valley floor. It is estimated that the present safe yield of the ground water basin underlying the Coachella Valley is about 60,000 acre-feet per season.

The total area within the Whitewater Group is about 1,223,000 acres. About 32,000 acres of land were irrigated in 1950, principally by diversions from the Coachella Main Canal, which derives its supply from the Colorado River. The ultimate mean seasonal water requirement, exclusive of requirements of land served from the Colorado River, is estimated to be about 485,000 acre-feet.

Available information indicates that some surface soils in the lower Coachella Valley possess infiltration rates too low to maintain acceptable salt balance relationships in the soil profile. However, most of the saline soils can be, and are being, reclaimed through use of an imported water supply of low sodium percentage. This requires that the water table be kept some distance below the root zone. Drainage, either by means of deliberate pumping from wells in order to lower the ground water table, or by the use of intercepting drains, is a necessary part of any irrigation development program for this area. Additional pumping from wells located in the upper Coachella Valley may assist in lowering piezometric levels in the lower areas. It can be expected, however, that localized tem-

TABLE 16

LAND USE AND WATER REQUIREMENTS, COLORADO DESERT AREA

Hydrographic unit		Gross area, in acres	Ultimate water service areas, in acres				Ultimate mean seasonal water requirements, in acre-feet			
Area number on Plate 3	Name		California Water Plan [a]	Colorado River service area districts [b]	Miscel-laneous [c]	Total	California Water Plan [a]	Colorado River service area districts [b]	Miscel-laneous [c]	Total
	Whitewater Group									
2	Coachella Valley	1,223,000	50,100	129,800	53,000	232,900	235,500		249,000	
	San Felipe Group									
3	Salton Sea	1,919,000	87,300	17,400	0	104,700	226,900		0	
4	Imperial Valley	1,107,000	12,500	[d]785,000	0	797,500	63,900	[e]4,150,000	0	5,157,300
	Subtotals	3,026,000	99,800	802,400	0	902,200	290,800		0	
	Colorado River Group									
5	Colorado River	2,265,000	30,300	[d]133,200	40,000	203,500	99,700		132,300	
	Desert Valley Group									
1	Twentynine Palms	3,867,000	168,800	0	131,200	300,000	388,700	0	303,300	692,000
6	Lanfair Valley	2,035,000	217,000	0	0	217,000	449,100	0	0	449,100
	Subtotals	5,902,000	385,800	0	131,200	517,000	837,800	0	303,300	1,141,100
	Totals	12,416,000	566,000	1,065,400	224,200	1,855,600	1,463,800	[e]4,150,000	684,600	6,298,400

[a] Gross area of ultimate water service areas to be supplied by The California Water Plan, and ultimate mean seasonal water requirements for those areas, as determined by Department of Water Resources.
[b] Ultimate water service areas in Colorado River service area districts and ultimate mean seasonal water requirements for those areas determined by Imperial Irrigation District, Palo Verde Irrigation District, and Coachella Valley County Water District.
[c] Areas and water requirements of "miscellaneous areas" as determined by Colorado River Board that could be served if additional Colorado River water were available; not included in The California Water Plan. See text.
[d] Pilot Knob Mesa area of Imperial Irrigation District included in Hydrographic Unit No. 4 instead of No. 5.
[e] This quantity represents the minimum contract rights with the Federal Government, as expressed in the Seven-Party Agreement.

porary perched water tables, requiring individual treatment, will occur throughout the irrigated area.

Plans for importation of supplemental water supplies to the Whitewater Group provide for about 168,000 acre-feet per season through facilities of the California Aqueduct System, augmented by the safe yield of the Coachella Valley ground water basin. Distribution of this water would be accomplished by a main transmission canal originating near Banning and terminating approximately 5 miles east of Cabazon. Water remaining in the canal at its terminus would be released for percolation in the bed of the San Gorgonio River, to provide for augmentation of the ground water supply and permit subsequent re-pumping for use in the upper Coachella Valley. The main transmission canal would be about 25 miles in length from the point of diversion from the California Aqueduct route to the San Gorgonio River, and would be constructed with a maximum capacity of about 230 second-feet. Four power plants with a total installed capacity of 22,000 kilowatts could be located along the conduit route. Of the total import of 168,000 acre-feet per season, 92,000 acre-feet would be served to local agencies for distribution along the length of the conduit. Generation of hydroelectric energy in connection with operation of the proposed works would amount to about 150,000,000 kilowatt-hours annually.

About 1,900 acres of the irrigable lands in the Coachella Valley, with an annual water requirement of 8,000 acre-feet, lie adjacent to the boundary between the Colorado Desert Area and the South Coastal Area, principally at elevations of 4,000 to 5,000 feet. These tracts could be advantageously served in connection with the service of required water supplies to adjacent area in the South Coastal Area, and capacity for the delivery of such supplies is provided in the California Aqueduct System.

San Felipe Group. The San Felipe Group is located in the southwestern portion of the Colorado Desert Area and includes the Salton Sea and Imperial Valley. The total area encompassed within the group is 3,026,000 acres, of which about 902,000 acres are considered susceptible of ultimate water service.

The mean seasonal full natural runoff in the San Felipe Group is estimated to be about 32,000 acre-feet, most of which results from localized thunderstorms and disappears rapidly through evaporation and by percolation to ground water. San Felipe Creek, the principal stream in the group, frequently continues as a live stream, particularly in its upper reaches, after other drainage channels have ceased to flow.

Little agricultural development has taken place to date in the area lying outside of the Imperial Irrigation District. The principal exception is found in Borrego Valley, where about 2,700 acres are presently under irrigation. The chief source of water supply for this development is the ground water reservoir underlying Borrego Valley. The present pumpage in this area is estimated to be about 10,000 acre-feet annually, which is believed to approximate the safe yield.

About 20,000 acres of irrigable lands are in scattered tracts lying along the western boundary of the Colorado Desert Area between the San Jacinto Mountains and the Mexican border. These lands, with an estimated seasonal water requirement of 52,300 acre-feet, are so located physically and geographically that they could be served with greater facility from works which may be constructed for service of supplemental water supplies in the South Coastal Area. These lands have therefore not been considered in plans for the importation of supplemental water supplies into the Salton Sea and Imperial Valley areas.

Ground water in the Imperial Valley is not suitable for consideration as a source for required supplemental water in the San Felipe Group, due to its poor quality characteristics. Water from deeper wells in this valley, many of which are artesian, is normally warm and contains high concentrations of boron, chloride, and fluoride, and is generally considered unsuitable for either agricultural or domestic use. In areas of the valley where subsurface drainage is good, the quality approaches that of the applied irrigation water. However, in areas where drainage is poor, total dissolved solids may range as high as 73,000 parts per million, which is more than twice as saline as sea water.

Supplemental water supplies, amounting to about 229,000 acre-feet annually, required for the probable ultimate development in the San Felipe Group, could be imported by diversion from the San Diego High-Line Aqueduct of the Southern California Division of the California Aqueduct System in the vicinity of Lake Henshaw. Water thus diverted would be distributed by a system of canals, tunnels, and regulating reservoirs to irrigable areas in the group. At the terminus of the prospective conduits, the remaining flow would be percolated for augmentation of ground water supplies in the lower valley areas.

Primary regulation of the imported supplies would be accomplished in San Felipe Reservoir. Three power plants with a total installed capacity of 35,000 kilowatts could be operated in connection with the import project. Generation of electrical energy could amount to about 162,000,000 kilowatt-hours annually.

Desert Valley Group. The Desert Valley Group comprises the vast undeveloped desert region lying in the northerly portion of the Colorado Desert Area. The group embraces a total area of about 5,900,000 acres, of which about 517,000 acres are classed as ultimate water service areas. The group is composed of typical desert-type lands, with scattered mountain ranges interspersed by arid valleys and dry stream beds. There are an estimated 2,000 acres of presently irrigated lands, located in the Lucerne Valley area east of Victorville, where irrigation is accomplished through the utilization of ground water.

Under The California Water Plan, supplemental water supplies estimated at about 840,000 acre-feet per season, to serve approximately 386,000 acres not served from the Colorado River for reasons previously stated, could be imported through facilities of the California Aqueduct System. Except for about 7,800 acres near Desert Center, these water supplies would be imported into the area through lateral canals diverting from the main California Aqueduct System. Three major conduits, branching from the proposed main transmission canal serving the eastern Mojave Desert, would comprise the principal elements of the plans for importation of water supplies. The conduits would be operated on a constant-flow basis, with regulation to demand schedules effected in the available ground water basins. Here again, it is pointed out that the cost of importing water would be high; probably beyond the repayment capacity of irrigated agriculture as far as can be foreseen now.

Colorado River Group. The Colorado River Group embraces all the drainage tributary to the Colorado River in California (other than the area draining into the Salton Sea) with a total area of about 3,540 square miles. The westerly boundary of the group roughly parallels the Colorado River from Mexico to the California-Nevada state line, a distance of about 175 miles.

The major present agricultural developments in the Colorado River Group are located in the Palo Verde Valley and in the Yuma area. Water supplies required for the irrigation of lands in the Palo Verde area are furnished through the works of the Palo Verde Irrigation District. The permanent Palo Verde Weir on the Colorado River is under construction by the United States Bureau of Reclamation. In the Yuma area, the Yuma Project is operated in both Arizona and California under the jurisdiction of the United States Bureau of Reclamation.

About 70,000 acres of irrigable lands in the Colorado River Group lie outside the area having rights in and to the waters of the Colorado River. The ultimate mean seasonal water requirements of these lands are estimated to be about 232,000 acre-feet, of which about 1,000 acre-feet are presently developed from local sources. Of this requirement, capacity for the provision of about 100,000 acre-feet of water seasonally is provided in the California Aqueduct System. No plans have been prepared for delivery of the water supplies to the Colorado River Group from the main route of the California Aqueduct System.

Summary of Colorado Desert Area. In the Colorado Desert Area, The California Water Plan would provide for the development of local ground water supplies to the maximum practicable extent, and the importation of large supplemental water supplies through the facilities of the California Aqueduct System. Deficiencies in developed water supplies to support the existing uses in the area have increased rapidly in the past few years, particularly in the Coachella and Imperial Valleys. Population in the Colorado Desert Area amounted to about 92,000 in 1950 and is estimated to have been about 141,000 in 1955. Much of this increase occurred in the Coachella Valley and Borrego Valley areas.

Of a total water service area of about 1,856,000 acres, the water which may be imported to the Colorado Desert Area by facilities of the California Aqueduct System, together with the rights of the existing agencies in the Colorado River, could provide for about 1,631,000 acres, assuming that the rights in the Colorado River are sufficient for some 1,065,000 acres. The remaining lands, totaling about 224,000 acres, would have an estimated seasonal water requirement of 685,000 acre-feet. The latter lands, all within 50 miles of the Colorado River, might have been developed, based on a water supply from that river, but for the ceiling on uses imposed under the Boulder Canyon Project Act and the California Limitation Act, as implemented by the Seven-Party Agreement.

In all parts of the Colorado Desert Area, local water supplies are grossly deficient when considered with relation to the probable ultimate demands for water. In the Whitewater and San Felipe Groups, works under The California Water Plan for the importation of the required supplemental water supplies are contemplated for areas not included in the lands having rights in the Colorado River. It is envisioned that the development of local supplies in practically all areas would be accomplished by continued development of the ground water resources. Importation of the required supplemental water supplies could be accomplished by diversion from the California Aqueduct System.

The difficulty and cost of providing required water supplies to meet ultimate development in the Colorado Desert Area underscore the essentiality to the area of continued availability of Colorado River water to the full extent of California's existing rights. Works have already been constructed to accommodate these rights, which are utilized by projects comprising about 9 per cent of the total Colorado Desert Area.

General features and costs of the works necessary for the delivery of water supplies to portions of the Colorado Desert Area under The California Water Plan are presented in Tables 27 and 28, and the location of these facilities are shown on Sheets 24 and 25 of Plate 5.

Colorado Desert Area—Colorado River Aqueduct Intake From Lake Havasu and Date Culture Near Indio

CALIFORNIA AQUEDUCT SYSTEM

The State-wide Water Resources Investigation has shown conclusively that, although California's water resources are adequate to satisfy ultimate requirements on a state-wide basis, surplus water in significant amounts exists in only the North Coastal Area and Sacramento River Basin, while deficiencies in supply will ultimately occur in all other areas of the State. It has also been shown that the nature of occurrence of California's water resources is extremely variable, both within the season and from year to year, thus necessitating vast amounts of reservoir storage for the required control and conservation. These large disparities in both the geographical and seasonal distribution could be equalized by the California Aqueduct System, which would comprise a complex system of works extending from the Oregon line to the Mexican border, providing adequate water supplies for all areas.

The California Aqueduct System would be unprecedented in its concept and scope. It would include many large dams, canals, tunnels, streamways, hydroelectric power plants, pumping plants, drainage ways, and other structures proposed to supplement existing water resource development works. It would ultimately develop nearly 22,000,000 acre-feet of surplus water each year, on the average, about half of which would be from the North Coastal Area and half from the Sacramento River Basin, and would transport this water to deficient areas to the south, as well as providing local benefits in the areas of surplus. The operation of the interbasin transfer facilities of the aqueduct system would assume a major role in coordinating the operation of all features of The California Water Plan. However, as previously explained, the works comprising the California Aqueduct System, hereinafter described, are not to be considered as definite project proposals. These works must be considered as subject to such modifications in design, location, and function as future studies, changed conditions, improved techniques, and other presently unforeseen factors may indicate as necessary or desirable.

It is further contemplated that these facilities would be built progressively, as needed and justified, to supply the water needs of the deficient areas of the State. Continuing, detailed study will be required in order to determine which unit or units should be built, the order in which they should be constructed, and the timing thereof.

These works would provide water supplies to meet the ultimate requirements as determined under the assumption that all habitable and irrigable areas would be utilized. It is quite probable that it will be many years in the future, if ever, before some of the areas which have been classed as irrigable, particularly in the remote desert areas, are developed for irrigated agriculture, especially in view of the high cost of providing water for such areas. Because of this as well as other presently unforeseen contingencies, some of the more difficult and expensive of these works may never be necessary. Nonetheless, this investigation and the facilities discussed herein demonstrate that the capability does exist of meeting all foreseeable water needs in all areas of the State.

Many of the structures discussed in the following sections are of very large size, in fact nearly unprecedented. The preliminary designs developed for purposes of this report are based upon the best information currently available. However, much more geological and foundation investigation would be necessary before final designs could be made. This is particularly true for those facilities to be located in the North Coastal Area, where geological and foundation conditions are relatively poor as compared to the Sierra Nevada, for instance.

For purposes of presentation in this section, this immense interbasin water conservation and transportation system has been divided into six components, or divisions, designated as follows: Klamath-Trinity Division, Eel River Division, Sacramento Division, Delta Division, San Joaquin Division, and Southern California Division. The locations of these divisions are shown on Plate 6, entitled "The California Aqueduct System."

Klamath-Trinity Division

The Klamath-Trinity Division of the California Aqueduct System comprises those features necessary to conserve surplus waters of the Klamath, Trinity, Van Duzen, Mad, and South Fork of the Smith Rivers, as well as the pumping plants, conduits, tunnels, and hydroelectric power plants required for the conveyance of these surplus waters to the Sacramento Valley. This division would include a series of major reservoirs which, for the most part, would be located contiguously along the Klamath and Trinity Rivers upstream from the vicinity of their junction. It would also include: a reservoir below the confluence of the two streams to conserve surplus flows originating below the mouth of the Trinity River; a reservoir on the South Fork of the Smith River; two reservoirs on the headwaters of the Mad and Van Duzen Rivers; and a reservoir on the South Fork of the Trinity River. Finally, a series of dams and power plants would be constructed on Clear Creek in the Sacramento River Basin for the principal purpose of utilizing the considerable drop in elevation to the floor of the Sacramento Valley for development of hydroelectric power.

The operation of the contemplated system of dams, reservoirs, and conveyance facilities would be principally for conservation of water. However, secondary but by no means minor beneficial results from their operation would include hydroelectric power generation and flood control. Additional benefits in the interests of fish, wildlife, and recreation would also accrue.

For purposes of description, the Klamath-Trinity Division is discussed in the ensuing sections under three groupings of works. These consist of developments on, or associated with, the Klamath River, the Trinity River, and Clear Creek.

Klamath River Development. Structures included in the Klamath River Development comprise Hamburg, Happy Camp, Slate Creek or substitute therefor, and Humboldt Dams and Reservoirs on the Klamath River, and their associated power plants; Canthook and Blackhawk Dams and Reservoirs on the South Fork of the Smith River; Blackhawk Pumping Plant at the base of Blackhawk Dam; and Beaver Pumping Plant, located on the Trinity River immediately upstream from its confluence with the Klamath River. Cantpeak Tunnel, connecting the Smith and Klamath Rivers, as well as Deerhorn Tunnel, connecting the Klamath and Trinity Rivers, are also included as features of this development. Recent geologic exploration at the Slate Creek dam site has unearthed unfavorable foundation conditions which indicate that it may be more economical to select an alternative site.

Runoff of the upper Klamath River would first be regulated in Hamburg Reservoir immediately below the confluence of the Scott and Klamath Rivers. It would be a large reservoir with a net storage capacity of 1,570,000 acre-feet. Releases from Hamburg Reservoir would flow through Hamburg Power Plant and then into Happy Camp Reservoir, formed by Happy Camp Dam located about 3 miles downstream from Happy Camp.

Happy Camp Reservoir, the largest reservoir of the Klamath River Development, would have an active storage capacity of 3,488,000 acre-feet. Releases from the reservoir would flow through Happy Camp Power Plant, thence downstream into the Klamath River for further regulation in Slate Creek Reservoir.

It should be pointed out that an initiative measure approved by the electorate in 1924 prohibits the construction of a dam at any point on the Klamath River below its confluence with the Shasta River. There is, however, some doubt as to whether this statute applies to the State or its agencies. This matter will be discussed in more detail in Chapter V.

Surplus flows of the South Fork of the Smith River could be conserved in Canthook Reservoir, located about 10 miles upstream from the main stem of the river. Blackhawk Dam would also be constructed on the South Fork of the Smith River immediately upstream from Canthook Reservoir. The primary purpose of Blackhawk Reservoir would be to provide direct gravity diversion from the South Fork of the Smith River to Slate Creek Reservoir on the Klamath River through a connecting conduit, Cantpeak Tunnel. Waters would be lifted from Canthook Reservoir into Blackhawk Reservoir by Blackhawk Pumping Plant, located within Blackhawk Dam.

Releases from Hamburg and Happy Camp Reservoirs on the Klamath River, Canthook Reservoir on the South Fork of the Smith River, and surface inflow from drainage areas below Happy Camp Reservoir would be further regulated in Slate Creek Reservoir, located on the Klamath River about 7 miles above the mouth of the Trinity River. Slate Creek Reservoir would have an active storage capacity of 1,566,000 acre-feet, and would impound and divert reregulated water in the average seasonal amount of 4,700,000 acre-feet for conveyance by means of Deerhorn Tunnel into Beaver Reservoir on the Trinity River.

Unregulated flows of the Klamath River would be controlled by Humboldt Dam, located on the Klamath River just below its confluence with the Trinity River, nearly on the Del Norte-Humboldt county line. Humboldt Reservoir would back water up the river to the downstream toes of both Beaver and Slate Creek Dams. The waters conserved by Humboldt Reservoir, amounting to about 1,205,000 acre-feet per season, would be lifted into Beaver Reservoir by Beaver Pumping Plant, located just below Beaver Dam. Thus, a total of 5,900,000 acre-feet per season would be delivered to Beaver Reservoir from the facilities of the Klamath River Development, which facilities are shown on Sheets 1 and 3 of Plate 5.

Trinity River Development. The Trinity River Development would involve the construction of Beaver, Burnt Ranch, and Helena Dams on the Trinity River; Eaton Dam on the Van Duzen River; Ranger Station Dam, or a substitute therefor, on the Mad River; and Eltapom Dam on the South Fork of the Trinity River. The development would also include the construction of Helena Power Plant on the Trinity River; Sulphur Glade and Eltapom Power Plants on the South Fork of the Trinity River; and Burnt Ranch Pumping Plant on the Trinity River. Three major tunnels, the Sulphur Glade, War Cry, and Big Flat, would be required to convey conserved surplus waters from the proposed reservoirs to the Sacramento River Basin.

Beaver Reservoir would receive water pumped from Humboldt Reservoir, located downstream on the Klamath River, and all water developed in the Klamath River above Humboldt Reservoir and conveyed by means of Deerhorn Tunnel to Beaver Reservoir, all as previously described under the Klamath River Development. In addition, Beaver Reservoir would conserve the natural runoff from the Trinity River drainage below Burnt Ranch and Eltapom Reservoirs. Beaver Dam would be located on the Trinity River just below Hoopa Valley, about 6 miles up-

7—53479

stream from the confluence of the Trinity and the Klamath Rivers.

Burnt Ranch Pumping Plant, located at the upper end of Beaver Reservoir and at the downstream of Burnt Ranch Dam, would lift water from Beaver Reservoir to Burnt Ranch Reservoir. Water would be pumped into Burnt Ranch Reservoir on a uniform monthly flow basis, and off-peak electric energy would be utilized in the interest of minimizing power costs.

Waters of the Van Duzen River would be developed by Eaton Dam and Reservoir, located about 2 miles downstream from the community of Dinsmores, about 4 miles west of the Humboldt-Trinity county line. Surplus flows of the Mad River could similarly be developed by a reservoir on that stream between Butler Valley and the Ruth site. The Ranger Station site was first selected as having several advantages due to its strategic location. However, preliminary geological examination indicated conditions which appear somewhat unfavorable to the most economic construction and, in consequence, further study is in process to find a more favorable alternative. At this time (May, 1957) it appears that satisfactory alternatives to Ranger Station can be found.

The yield from Eaton Reservoir could be conducted by tunnel to the Mad River, and the yield from the two reservoirs could be conveyed by tunnel into the South Fork of the Trinity River above Eltapom dam site. The most advantageous location would be at the Sulphur Glade tunnel site, which would permit construction of the Sulphur Glade Power Plant to make use of the head differential between the Mad River and the South Fork of the Trinity River.

Eltapom Dam and Reservoir, located on the South Fork of the Trinity River immediately downstream from Hyampom Valley, would regulate runoff of the South Fork of the Trinity River, and the releases from Eaton and Ranger Station Reservoirs which, as previously stated, would pass through the Sulphur Glade Power Plant. The total waters thus collected in Eltapom Reservoir would be released through Eltapom Power Plant, located at the base of the dam, and thence diverted through War Cry Tunnel into Burnt Ranch Reservoir on the Trinity River.

Helena Dam and Reservoir, constructed on the Trinity River above Burnt Ranch Reservoir, would conserve the natural flows of the Trinity River and generate hydroelectric energy by releases through Helena Power Plant located at the base of the dam. The reservoir would have a capacity of 3,050,000 acre-feet.

Burnt Ranch Reservoir, formed by Burnt Ranch Dam, located on the Trinity River about 3 miles upstream from the mouth of New River, would be the keystone reservoir of the Klamath-Trinity Division, as it would serve as a point of convergence for all surplus water delivered from the Klamath, Smith, Trinity, Mad, and Van Duzen Rivers. Although the reservoir would have a gross storage capacity of 246,000 acre-feet, only 36,000 acre-feet would be utilized for active storage, in the interest of maintaining maximum water surface elevation to assure necessary discharge into Big Flat Tunnel.

Thus, Burnt Ranch Dam and Reservoir would serve primarily as a forebay for Big Flat Tunnel, the principal interbasin export conduit, which would convey water to Clear Creek in the Sacramento Valley. Because of the tremendous quantities of waters involved under ultimate conditions and the magnitude of the cost of works required to transfer this water from Burnt Ranch Reservoir to Clear Creek, it is proposed that Big Flat Tunnel be constructed in two parallel stages, or bores, each being 35 miles in length. The first bore would have a capacity of about 3,200 second-feet and the second bore would have a capacity of 8,100 second-feet. Big Flat Tunnel would discharge into Kanaka Reservoir on Clear Creek in the Sacramento Valley.

Fairview and Lewiston Dams and Reservoirs, which divert water from the Trinity River to the Sacramento Valley through Tower House Tunnel, are presently under construction by the United States Bureau of Reclamation. This project, known as the Trinity River Division of the Central Valley Project, is considered a feature of The California Water Plan. The operation of this project could be coordinated with the Klamath-Trinity Division of the California Aqueduct System.

Clear Creek Development. The Clear Creek Development would involve construction of Kanaka and Saeltzer Dam on Clear Creek in the Sacramento River Basin, and an appurtenant power plant at each of the dams. Kanaka Dam and Reservoir, impounding water delivered from Burnt Ranch Reservoir as well as runoff from Clear Creek, would be located on Clear Creek about 8 miles east of Redding.

Water released from Kanaka Reservoir would flow through the Kanaka Power Plant, located near the base of the dam, into Saeltzer Reservoir located immediately downstream. Saeltzer Dam would be situated at the present site of the Saeltzer Diversion Dam, about 6 miles upstream from the confluence of Clear Creek with the Sacramento River. Saeltzer Dam would function primarily for development of the remainder of the power head on Clear Creek below Kanaka Dam, and the final generation of power by facilities of the Klamath-Trinity Division would be accomplished by Saeltzer Power Plant, located at the base of Saeltzer Dam. The water released from Saeltzer Power Plant would flow into Girvan Reservoir, which is a part of, and is subsequently described under, the Sacramento Division of the California Aqueduct System.

Klamath-Trinity Division—Head of Tower House Tunnel of the Trinity Diversion Project

TABLE 17

SUMMARY OF KLAMATH-TRINITY DIVISION, CALIFORNIA AQUEDUCT SYSTEM

(These works show future development possibilities. They are not project proposals.)

Dam and reservoir	Stream	Dam			Normal pool elevation, in feet	Storage capacity, in acre-feet		Seasonal yield, in acre-feet	Purpose	Place of water use
		Location, HB&M, and sheet of Plate 5 on which shown	Type	Height, in feet		Gross	Active			
Klamath River Development										
Hamburg	Klamath River	Sec. 31, T46N, R10W, MDB&M 1	CG	445	1,960	1,850,000	1,570,000	1,136,000	I,U,FC,R,F,P	Klamath River Basin and California Aqueduct service area
Happy Camp	Klamath River	Sec. 33, T16N, R7E 1	CG	625	1,570	4,120,000	3,490,000	761,000	I,U,FC,R,F,P	
Slate Creek	Klamath River	Sec. 19, T10N, R5E 1	R	775	1,000	5,480,000	1,570,000	1,985,000	I,U,FC,R,F	
Canthook	Smith River	Sec. 10, T15N, R2E 1	CG	623	1,095	1,230,000	1,030,000	830,000	I,U,FC,R,F	Smith River Basin and California Aqueduct service area
Black Hawk	Smith River	Sec. 19, T15N, R3E 1	CG	413	1,123	88,000	48,000	none	Diversion to Cantpeak Tunnel	
Humboldt	Klamath River	Sec. 10, T12N, R2E 1	CG	410	430	1,940,000	1,330,000	1,205,000	I,U,FC,R,F	Klamath River Basin and California Aqueduct service area
Trinity River Development										
Beaver	Trinity River	Sec. 2, T8N, R4E 1	CG	730	950	7,760,000	1,600,000	720,000	I,U,FC,R,F	Trinity River Basin and California Aqueduct service area
Burnt Ranch	Trinity River	Sec. 13, T5N, R6E 3	CA	355	1,220	245,000	36,000	none	Diversion to Big Flat Tunnel	
Helena	Trinity River	Sec. 36, T34N, R12W, MDB&M 3	CG	575	1,852	3,050,000	2,670,000	611,000	I,U,FC,R,F,P	
Eaton	Van Duzen River	Sec. 5, T1N, R5E 3	E	396	2,700	730,000	500,000	398,000	I,U,FC,R,F,P	Van Duzen and Mad River Basins and California Aqueduct service area
Ranger Station	Mad River	Sec. 17, T1N, R6E 3	E	323	2,700	500,000	435,000			
Eltapom	South Fork Trinity River	Sec. 3, T3N, R6E 3	R	420	1,620	1,260,000	680,000	536,000	I,U,FC,R,F,P	Trinity River Basin and California Aqueduct service area
Eltapom Afterbay	South Fork Trinity River	Sec. 28, T4N, R6E 3	GG	225	1,264	26,000	6,000	none	Afterbay	
Clear Creek Development										
Kanaka	Clear Creek	Sec. 22, T31N, R6W, MDB&M 3	E	460	1,135	415,000	105,000	none	I,U,FC,R,F,P	Sacramento River Basin and California Aqueduct service area
Saeltzer	Clear Creek	Sec. 31, T31N, R5W, MDB&M 3	E	107	650	32,000	6,000	none	P	Conveyance facility only
Totals						28,726,000	15,076,000			

TABLE 17—Continued

SUMMARY OF KLAMATH-TRINITY DIVISION, CALIFORNIA AQUEDUCT SYSTEM

(These works show future development possibilities. They are not project proposals.)

Power plant	Location, HB&M, and sheet of Plate 5 on which shown	Average head, in feet	Installed capacity, in kilowatts	Average annual energy generation, in kilowatt-hours
Klamath River Development				
Hamburg	Sec. 31, T46N, R10W, MDB&M 1	388	67,000	384,000,000
Happy Camp	Sec. 33, T16N, R7E 1	476	135,000	787,000,000
Trinity River Development				
Helena	Sec. 36, T34N, R12W, MDB&M 3	468	42,000	248,000,000
Sulphur Glade	Sec. 25, T2N, R6E 3	1,007	94,000	355,000,000
Eltapom	Sec. 3, T3N, R6E 3	324	52,000	266,000,000
Clear Creek Development				
Kanaka	Sec. 22, T31N, R6W, MDB&M 3	473	1,025,000	3,420,000,000
Saeltzer	Sec. 31, T31N, R5W, MDB&M 3	148	330,000	1,110,000,000
Totals			1,745,000	6,570,000,000

Pumping plant	Location, HB&M, and sheet of Plate 5 on which shown	Average head, in feet	Installed capacity, in kilowatts	Seasonal power consumption, in kilowatt-hours
Klamath River Development				
Black Hawk	Sec. 19, T15N, R3E 1	81	72,000	98,000,000
Beaver	Sec. 2, T8N, R4E 1	536	254,000	937,000,000
Trinity River Development				
Burnt Ranch	Sec. 13, T5N, R6E 3	289	762,000	2,792,000,000
Totals			1,088,000	3,827,000,000

Tunnel	Average flow, in second-feet	Length, in miles
Klamath River Development		
Cantpeak	1,147	15.3
Deerhorn	6,500	10.3
Trinity River Development		
Mad	240	0.4
Sulphur Glade	1,375	4.6
War Cry	1,291	9.7
Big Flat	11,300	35.4
Total		75.7

Symbols of Type of Dam
E—Earthfill
R—Rockfill
CG—Concrete gravity
CA—Concrete arch

Symbols of Purpose
I—Irrigation
U—Urban (domestic, municipal, industrial
FC—Flood control
R—Recreation
F—Enhancement of fish environment
P—Power generation

Summary of Klamath-Trinity Division. The Klamath-Trinity Division would involve the construction of 15 major dams and reservoirs with aggregate active storage capacity of about 15,000,000 acre-feet; 7 hydroelectric power plants with installed power capacity of about 1,700.000 kilowatts; 3 pumping plants with total installed capacity of approximately 1,100,000 kilowatts; and 6 tunnels having a total length of about 76 miles. The works would make available some 9,055,000 acre-feet of water annually for export, including the exportable yield estimated at 872,000 acre-feet from the Trinity River Division of the Central Valley Project. The hydroelectric facilities of the Klamath-Trinity Division would generate about 6.6 billion kilowatt-hours of electrical energy each year. Of this amount, 3.8 billion kilowatt-hours of energy would be required to pump water to Burnt Ranch Reservoir, from which it would flow through Big Flat Tunnel beneath the Trinity Divide into the Sacramento Valley.

Construction of the facilities of the Klamath-Trinity Division would be susceptible of logical, progressive staging as the need for water and power in California develops. The major reservoirs would accomplish substantial local benefits in the North Coastal Area in providing control of the very large rain floods characteristic of the area.

The surface elevations of most of the major reservoirs would fluctuate through a relatively limited range and, consequently, would constitute an outstanding recreational attraction.

Under ultimate conditions of development, nearly the entire course of the Klamath River and the greater part of the course of the Trinity River would be inundated, thus necessitating the development of a new environment for the anadromous fish now using those streams. It is planned that conditions will be improved on other smaller coastal streams of the area through construction of stream flow maintenance dams and other measures. It is expected that this will result in an increased anadromous fish population in these streams, thereby compensating, to some extent, for the loss of the famed Klamath system runs. Additionally, the various reservoirs would support fish populations that, while of a different type, would provide a probably greater fishing opportunity than is now available.

It should be pointed out that during the earlier stages of development large reaches of stream channel could be improved by releases from initial upstream reservoirs. Such releases, in conjunction with the operation of fish hatcheries, could possibly improve the present anadromous fishery for a substantial period of time, and it would not be until later stages of development that the Klamath and Trinity Rivers would be inaccessible to the migratory fish.

The general features of the facilities of the Klamath-Trinity Division are presented in Table 17, and their capital costs are shown in Table 18. The component features of the division are delineated on Sheets 1 and 3 of Plate 5.

TABLE 18

SUMMARY OF CAPITAL COSTS, KLAMATH-TRINITY DIVISION, CALIFORNIA AQUEDUCT SYSTEM

Item	Capital cost*
Klamath Development	
Hamburg Dam and Reservoir	$57,480,000
Hamburg Power Plant	10,030,000
Happy Camp Dam and Reservoir	96,090,000
Happy Camp Power Plant	17,210,000
Slate Creek Dam and Reservoir	151,230,000
Canthook Dam and Reservoir	92,190,000
Black Hawk Dam and Reservoir	49,660,000
Black Hawk Pumping Plant	13,840,000
Cantpeak Tunnel	36,800,000
Humboldt Dam and Reservoir	70,300,000
Relocation of state highway	35,000,000
Deerhorn Tunnel	78,830,000
Beaver Pumping Plant	26,620,000
Subtotal	$735,280,000
Trinity Development	
Beaver Dam and Reservoir	165,310,000
Burnt Ranch Dam and Reservoir	15,550,000
Burnt Ranch Pumping Plant	73,150,000
Helena Dam and Reservoir	86,260,000
Helena Power Plant	6,510,000
Eaton Dam and Reservoir	15,500,000
Mad Tunnel	650,000
Ranger Station Dam and Reservoir	17,050,000
Sulphur Glade Tunnel	18,690,000
Sulphur Glade Power Plant	16,210,000
Eltapom Dam and Reservoir	41,210,000
Eltapom Power Plant	7,280,000
Eltapom Afterbay	7,630,000
War Cry Tunnel	44,810,000
Big Flat Tunnel	823,440,000
Relocation of state highways	68,000,000
Subtotal	$1,407,250,000
Clear Creek Development	
Kanaka Dam and Reservoir	21,500,000
Kanaka Power Plant	106,000,000
Saeltzer Dam and Reservoir	2,000,000
Saeltzer Power Plant	43,070,000
Subtotal	$172,570,000
Total	$2,315,100,000

* At 1955 price levels.

Eel River Division

The Eel River Division comprises those features of the California Aqueduct System which would develop the waters of the Eel River system. This division would convey the conserved surplus waters to the Sacramento Valley for further transport to areas of deficiency, and would furnish water for local use, particularly in Round Valley in Mendocino County. The Eel River Division would include a series of major conservation reservoirs and associated pumping plants on the Eel River; a reservoir and power plant on the Middle Fork of the Eel River; a 12-mile tunnel to convey water to Clear Lake in the Sacramento River Basin; a short diversion tunnel from Cache Creek to Putah Creek; and a series of reservoirs and power plants along Putah Creek. Also included as features of the Eel River Division are a diversion into the Russian River Basin for delivery of water to the North Bay area, and a diversion into Napa Valley.

The works of the Eel River Division would be operated primarily for water conservation, but would be modified to the extent necessary to permit stabilization of the water surface levels of Clear Lake, the development of hydroelectric energy, and the control of floods in the Eel River Basin. The facilities of this division would be susceptible of staged construction as the need for additional water arises. Initial units would consist of structures on the upper reaches of the Eel River and a diversion to convey the conserved waters to Clear Lake. The power potential of the diverted waters could, at that time, be developed in the drop to the floor of the Sacramento Valley. Finally, as the need for surplus waters would increase, the remaining storage units and pumping plants would be constructed farther downstream on the Eel River.

As described earlier in this chapter, the South Fork of the Eel River, as well as other nearby streams, would be developed either solely or primarily in the interests of enhancement of the fishery and of wildlife and recreational opportunities. This would compensate to some extent for the loss to the anadromous fishery due to the major developments on the Eel River.

For descriptive purposes, proposed features of the Eel River Division are discussed herein under three groupings of works. These consist of the Eel River Development, the Putah Creek Development, and the Russian River Diversion.

Eel River Development. Facilities of the Eel River Development would consist of Willis Ridge, Bell Springs, and Sequoia Dams and Reservoirs on the Eel River, Etsel Dam and Reservoir on the Middle Fork of the Eel River, and Clear Lake on the headwaters of Cache Creek. The associated features of this development would comprise Bell Springs and Willis Ridge Pumping Plants, Etsel Power Plant, Garrett Tunnel from Willis Ridge Reservoir to a tributary of Clear Lake, and Soda Creek Tunnel from Clear Lake to the Putah Creek Basin.

Sequoia Dam and Reservoir would be the lowermost facility of the Eel River, being located about 10 miles above the confluence with the South Fork of the Eel River. The reservoir would have a gross storage capacity of about 5,610,000 acre-feet. Water developed by Sequoia Dam and Reservoir would be pumped into Bell Springs Reservoir located immediately upstream.

Bell Springs Dam, located about 5 miles south of the Mendocino-Trinity county line, would develop a storage capacity of about 2,860,000 acre-feet in Bell Springs Reservoir. Water would be pumped from Sequoia Reservoir into Bell Springs Reservoir by Bell Springs Pumping Plant, located at the base of Bell Springs Dam.

Etsel Reservoir would be located on the Middle Fork of the Eel River immediately upstream from the easterly arm of Bell Springs Reservoir. The reservoir would have a capacity of about 1,180,000 acre-feet. Franciscan Dam would be required on Short Creek to prevent flooding of lands in Round Valley. This auxiliary dam, which was discussed earlier in this chapter as the initial development on the Middle Fork, would furnish a water supply for Round Valley. Water released from Etsel Reservoir would pass through Etsel Power Plant, located at the base of the dam, and discharge into Bell Springs Reservoir for regulation.

Willis Ridge Reservoir, located on the main stem of the Eel River directly upstream from Bell Springs Reservoir, would impound water pumped from Bell Springs Reservoir, and would develop natural tributary runoff. The reservoir would have a capacity of 2,230,000 acre-feet and would be formed by Willis Ridge Dam. Willis Ridge Pumping Plant, located at the base of Willis Ridge Dam, would lift the water developed in downstream reservoirs from Bell Springs Reservoir into Willis Ridge Reservoir.

Waters developed on the Eel River and collected in Willis Ridge Reservoir would be conveyed in Garrett Tunnel from Willis Ridge Reservoir to Middle Creek, a tributary of Clear Lake. Garrett Tunnel would be about 12 miles in length and have a capacity of about 2,900 second-feet. About 2,140,000 acre-feet annually could be exported from the Eel River to Clear Lake through this tunnel.

Clear Lake would be utilized to convey water released from Garrett Tunnel to the portal of Soda Creek Tunnel at Clear Lake Dam. Actually, Clear Lake would serve as a forebay to Soda Creek Tunnel. The present outlet of Clear Lake would be improved to permit reduced fluctuations of the water surface of the lake, thus effecting flood control around the rim of the lake, if existing court decrees can be modified.

Soda Creek Tunnel would convey the Eel River water from Clear Lake to Stienhart Reservoir, located on Soda Creek, a tributary to Putah Creek. Soda Creek Tunnel would be about 2.6 miles in length and would be initially constructed to its ultimate capacity of about 2,900 second-feet. As stated, a total of about 2,140,000 acre-feet per season would be delivered from the Eel River to the Putah Creek Basin in the Sacramento Valley Area by facilities of the Eel River Development, which facilities are shown on Sheets 3, 5, and 7 of Plate 5.

Putah Creek Development. The primary purpose of the Putah Creek Development would be for production of hydroelectric energy by development of the available head in the drop to the floor of the

Sacramento Valley. The features of this development would include Stienhart, Jerusalem, Noyes, Snell, and Monticello Dams and Reservoirs, and power plants below each of the dams. An afterbay to reregulate releases from Monticello Reservoir, the lowermost of the chain of reservoirs along Putah Creek, would also be provided below Monticello Dam.

Water conveyed from Clear Lake through Soda Creek Tunnel would be reregulated in Stienhart Reservoir, located on Soda Creek about 7 miles southeast of the town of Lower Lake. Stienhart Reservoir would serve primarily as a forebay to Stienhart Power Plant, located at the base of the dam. Releases from Stienhart Power Plant would be discharged into Jerusalem Reservoir, located immediately downstream.

Jerusalem Dam would be constructed on Soda Creek about 1 mile upstream from its confluence with Putah Creek. Additional hydroelectric energy would be developed by Jerusalem Power Plant, located at the base of Jerusalem Dam. Water released from Jerusalem Power Plant would be further regulated in Noyes Reservoir, located on Putah Creek about 2 miles west of the Napa-Lake county line. Noyes Reservoir would similarly serve as a forebay to the Noyes Power Plant located at the base of the dam.

Water discharged from Noyes Power Plant would flow a short distance down Putah Creek to Snell Reservoir, formed by Snell Dam about 3 miles above Berryessa Valley. Additional hydroelectric energy would be developed by releasing the water through the Snell Power Plant at the base of Snell Dam. From Snell Power Plant, the water from the Eel River would be released into Monticello Reservoir.

Monticello Dam and a downstream diversion structure, presently under construction by the United States Bureau of Reclamation, would be integrated with the Eel River Division as a feature of the California Aqueduct System. The operation for conservation contemplated by the Bureau of Reclamation would not be interfered with under The California Water Plan. However, a power plant would be constructed at a future time at the base of the dam, to develop the energy potential of the water transported from the Eel River.

The final development on Putah Creek would consist of Monticello Afterbay, formed by a dam about 5 miles below Monticello Dam. This afterbay would provide reregulation of power releases from Monticello Power Plant, and would develop the last increment of energy from the Eel River water by releasing it through a power plant located at the base of the dam. The water from this point would flow down Putah Creek to be diverted into the Sacramento West Side Canal, a feature of the Sacramento Division next described.

Napa Valley would be supplied with 224,000 acre-feet of water annually by a diversion from Monticello Reservoir and conveyance westerly by a tunnel through Cedar Roughs Ridge to Conn Creek in Napa Valley. The Cedar Roughs Tunnel would be about 7 miles long and have a capacity of 290 second-feet. It would deliver water from the west shore of Monticello Reservoir to Lake Hennesey, formed by Conn Creek Dam on Conn Creek. The operation of Lake Hennesey, owned and operated by the City of Napa, would be coordinated with that of the Cedar Roughs Diversion.

Conveyance of Eel River water from Clear Lake to the floor of the Sacramento Valley by way of Cache Creek has been considered as a possible alternative to the Putah Creek Development. However, the planning relative to this conveyance is quite preliminary, and would require considerable geologic exploratory work as well as further engineering studies before its feasibility could be established. The alternative development would consist of a series of dams and power plants down the course of Cache Creek in stairstep fashion, very similar to the Putah Creek system.

Briefly, the alternative proposal would consist of five dams on Cache Creek consisting, in descending order down the creek, of Dead Man, Wilson Valley, Glascock, Rumsey, and Guinda Dams and Reservoirs. A power plant would be constructed at the base of each dam, and a canal and flume would convey the water from the Guinda Power Plant along the east side of Cache Creek to a power plant just east of Brooks, thence to a diversion structure and canal leading through the Hungry Hollow area north of Cache Creek to a final power plant on Oat Creek.

Facilities of the Putah Creek Development and of the alternative possibilities on Cache Creek are delineated on Sheets 5, 7, and 8 of Plate 5.

Russian River Diversion. Supplemental requirements for water in Marin and Sonoma Counties in the seasonal amount of 422,000 acre-feet would be supplied by a diversion from Willis Ridge Reservoir on the Eel River through an enlarged Potter Valley Tunnel to the East Fork of the Russian River, and a rediversion from the Russian River near Geyserville and conveyance via the Sonoma Aqueduct to the North San Francisco Bay area. In addition to providing supplemental water, hydroelectric energy could be generated by utilizing the drop from Willis Ridge Reservoir to the East Fork of the Russian River in the operation of an enlarged Potter Valley Power Plant.

The new Potter Valley Tunnel would be about 0.9 mile in length and would convey a continuous flow of about 740 second-feet from Willis Ridge Reservoir to the new Potter Valley Power Plant, located in Potter Valley at the site of the existing power plant, which is owned and operated by the Pacific Gas and Electric Company. The releases from the new Potter Valley Power Plant would be reregulated in an afterbay and conveyed by canal along the east side of Potter

TABLE 19

SUMMARY OF EEL RIVER DIVISION, CALIFORNIA AQUEDUCT SYSTEM

(These works show future development possibilities. They are not project proposals.)

Dam and reservoir	Stream	Dam: Location, MDB&M, and sheet of Plate 5 on which shown	Dam: Type	Dam: Height, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active	Seasonal yield, in acre-feet	Purpose	Place of water use
Eel River Development										
Sequoia	Eel River	Sec. 6, T2S, R4E, HB&M 3	R	640	750	5,610,000	2,350,000	826,000	I,U,FC,R,F	Eel River watershed and California Aqueduct service area
Bell Springs	Eel River	Sec. 19, T24N, R14W 5	R	635	1,250	2,860,000	2,280,000	818,000	I,U,FC,R,F	
Willis Ridge	Eel River	Sec. 32, T21N, R13W 5	R	619	1,600	2,230,000	1,000,000	363,000	I,U,FC,R,F	
Etsel	Middle Fork Eel River	Sec. 13, T22N, R12E 5	E	435	1,670	1,180,000	1,040,000	523,000	I,U,FC,R,F,P	
Putah Creek Development										
Stienhart	Soda Creek	Sec. 27, T12N, R6W 7	E	285	1,321	99,000	23,000	0	P	Conveyance facilities only
Jerusalem	Soda Creek	Sec. 14, T11N, R6W 7	R	160	1,045	46,000	0	0	P	
Noyes	Putah Creek	Sec. 30, T11N, R5W 7	E	255	900	110,000	0	0	P	
Snell	Putah Creek	Sec. 5, T9N, R4W 7	R	315	650	394,000	0	0	P	
Monticello Afterbay	Putah Creek	Sec. 36, T8N, R2W 8	CG	75	210	29,000	14,000	0	P	
Russian River Diversion										
Stemple	Stemple Creek	Sec. 10, T5N, R8W 7	E	104	190	57,000	52,000	0	S	Tomales-Bodega and North San Francisco Bay areas
Totals						12,615,000	6,759,000			

TABLE 19—Continued

SUMMARY OF EEL RIVER DIVISION, CALIFORNIA AQUEDUCT SYSTEM

(These works show future development possibilities. They are not project proposals.)

Power plant	Location, MDB&M, and sheet of plate 5 on which shown		Average head, in feet	Installed capacity, in kilowatts	Average annual energy generation, in kilowatt-hours
Eel River Development					
Etsel	Sec. 13, T22N, R11W	5	365	25,200	166,000,000
Putah Creek Development					
Stienhart	Sec. 27, T12N, R6W	7	272	137,000	517,000,000
Jerusalem	Sec. 14, T11N, R6W	7	139	75,000	253,000,000
Noyes	Sec. 30, T11N, R5W	7	244	130,000	452,000,000
Snell	Sec. 5, T9N, R4W	7	227	110,000	405,000,000
Monticello	Sec. 29, T8N, R2W	8	226	100,000	409,000,000
Monticello Afterbay	Sec. 36, T8N, R2W	8	67	10,800	118,000,000
Russian River Diversion					
New Potter Valley	Sec. 31, T18N, R11W	5	565	36,000	254,000,000
East Fork	Sec. 5, T16N, R11W	5	134	7,000	59,000,000
Totals				631,000	2,633,000,000

Conduit	Average flow, in second-feet	Length, in miles	
		Canal	Tunnel
Eel River Development			
Garret Tunnel	2,900		12.0
Soda Creek Tunnel	2,900		2.6
Putah Creek Development			
Cedar Roughs Tunnel	290		7.2
Russian River Diversion			
Potter Valley Tunnel	738		0.9
Sonoma Aqueduct	720	39.3	
Totals		39.3	22.7

Pumping plant	Location, MDB&M, and sheet of plate 5 on which shown		Average head, in feet	Installed capacity, in kilowatts	Seasonal power consumption, in killowatt-hours
Eel River Development					
Bell Springs	Sec. 30, T24N, R14W	5	475	142,500	574•000,000
Willis Ridge	Sec. 32, T21N, R13W	5	404	372,000	1,282,000,000
Russian River Diversion					
Cotati	Sec. 31, T6N, R7W	7	80	7,400	56,000,000
Totals				521,900	1,912,000,000

Symbols of Type of Dam
E—Earthfill
R—Rockfill
CG—Concrete gravity

Symbols of Purpose
I—Irrigation
U—Urban (domestic, municipal, industrial)
FC—Flood control
R—Recreation
F—Enhancement of fish environment
P—Power generation
S—Reregulation of waters to local demand schedules

Valley, where the water would drop through the East Fork Power Plant, located on the shore of Coyote Valley Reservoir.

The operation of the Russian River Diversion would be coordinated with the operation of Coyote Valley Reservoir, presently under construction by the Corps of Engineers, U. S. Army, as a conservation and flood control project. Water would pass through Coyote Valley Reservoir and be released into the East Fork of the Russian River, where it would flow down the natural channel to a point near Geyserville.

A diversion structure on the Russian River about a mile north of Geyserville would transfer the commingled Eel River water into the Sonoma Aqueduct, which would convey the water in a general southerly direction about 40 miles in canal, tunnel, and pipe line, where it would finally be pumped into a terminal reservoir on Stemple Creek about 3 miles south of the community of Cotati.

Stemple Dam and Reservoir on Stemple Creek would be operated for terminal storage only. There would be two outlet works, one for release of water westward to the Tomales-Bodega area, and one for release of water southward to the San Francisco Bay Area.

Summary of Eel River Division. The Eel River Division would consist of 10 reservoirs, including 4 major conservation reservoirs on the Eel River, 5 regulation reservoirs for power generation on Putah Creek, and a terminal reservoir in the Russian River Basin; 9 hydroelectric power plants, including 1 on the Eel River, 6 on Putah Creek, and 2 on the East Fork of the Russian River; 3 pumping plants, including 2 on the Eel River and 1 on the Sonoma Aqueduct; and 4 tunnels having a total length of 22 miles. The four major conservation reservoirs on the Eel River would have a gross storage capacity of 11,880,000 acre-feet and a net storage capacity of 8,676,000 acre-feet, and would develop a yield of 2,566,000 acre-feet annually. The nine hydroelectric power plants would have an installed power generating capacity aggregating about 650,000 kilowatts and would generate about 2.7 billion kilowatt-hours of electric energy per season. The three pumping plants would have a total installed capacity of about 522,000 kilowatts and would require about 1.9 billion kilowatt-hours of electric energy annually to lift the water over the divide to the Sacramento Valley and the San Francisco Bay Area.

The Eel River Division would be adaptable to logical staged construction as the need for water and power in California develops. The initial stages would furnish water for domestic, agricultural, and industrial purposes in the Eel River Basin, and would control the large rain floods such as occurred during December, 1955. Furthermore, a large block of hydroelectric power would be developed locally in the area to facilitate industrial growth and development. Reservoir releases would also be made to maintain summer and fall stream flow to enhance fish, wildlife, and recreational values. The foregoing objectives do not include the operation of Monticello and Coyote Valley Reservoirs which are under construction by federal agencies.

Pertinent features of the Eel River Division are presented in Table 19, and the capital costs of its component facilities are shown in Table 20. The facilities of the Eel River Division are delineated on Sheets 5, 7, and 8 of Plate 5.

TABLE 20

SUMMARY OF CAPITAL COSTS, EEL RIVER DIVISION, CALIFORNIA AQUEDUCT SYSTEM

Item	Capital cost*
Eel River Development	
Sequoia Dam and Reservoir	$96,820,000
Bell Springs Pumping Plant	23,270,000
Bell Springs Dam and Reservoir	102,750,000
Etsel Power Plant	4,290,000
Etsel Dam and Reservoir	47,530,000
Willis Ridge Pumping Plant	61,510,000
Willis Ridge Dam and Reservoir	112,200,000
Railroad and highway relocation	107,000,000
Subtotal	$555,370,000
Putah Creek Development	
Garrett Tunnel	$67,670,000
Middle Creek Channel improvement	500,000
Soda Creek Tunnel	10,120,000
Stienhart Dam and Reservoir	10,060,000
Stienhart Power Plant	16,240,000
Jerusalem Dam and Reservoir	3,190,000
Jerusalem Power Plant	11,850,000
Noyes Dam and Reservoir	7,630,000
Noyes Power Plant	16,180,000
Snell Dam and Reservoir	28,470,000
Snell Power Plant	12,310,000
Monticello Power Plant	11,920,000
Cedar Roughs Tunnel	11,070,000
Monticello Afterbay Dam and Reservoir	4,120,000
Monticello Afterbay Power Plant	2,900,000
Davis Diversion Dam	6,600,000
Subtotal	$220,830,000
Russian River Diversion	
Potter Valley Tunnel and Power Development	$9,590,000
Sonoma Aqueduct	22,370,000
Stemple Dam and Reservoir	4,090,000
Subtotal	$36,050,000
Total	$812,250,000

* At 1955 price levels.

Sacramento Division

The Sacramento Division of the California Aqueduct System comprises the works in the Sacramento River Basin necessary to develop and regulate the surplus waters of the basin for export, and the natural and artificial channels required to convey these waters, together with imports from the North Coastal Area, to Montezuma Reservoir and to the Delta for further transport to areas of deficiency. Part of the export supply developed on the American River by features of the Sacramento Division would be diverted directly from that stream before reaching the Delta. Similarly, a small quantity of export water developed in Monticello Reservoir of the Eel River Division would be diverted directly from Putah Creek before entering the Delta. The power plants associated with the export reservoirs of the Sacramento Division and certain conduits associated with delivery of export water to nearby deficient areas are also included as features of the division. The provision of a trunk line waste conduit along the trough of the valley to prevent pollution of the local and export water supply is considered earlier in this chapter under the discussion of local works.

In the following discussion, consideration is given first to the works above and along a main west side conduit route that would develop surplus waters of the Sacramento River Basin above Red Bluff, and convey these and imported supplies southward along the west side of the Sacramento Valley into Montezuma Reservoir for further disposition. Other features of the Sacramento Division, not directly on the main west side conduit route, are discussed under a separate heading. Except for the direct diversions from the American River and Putah Creek, water developed for export by these latter features would flow through the natural drainage system of the Sacramento Valley to the Delta for further disposition, with the Sacramento River serving as the main conduit. The discussion concludes with a resume of the works of the division and their costs and accomplishments.

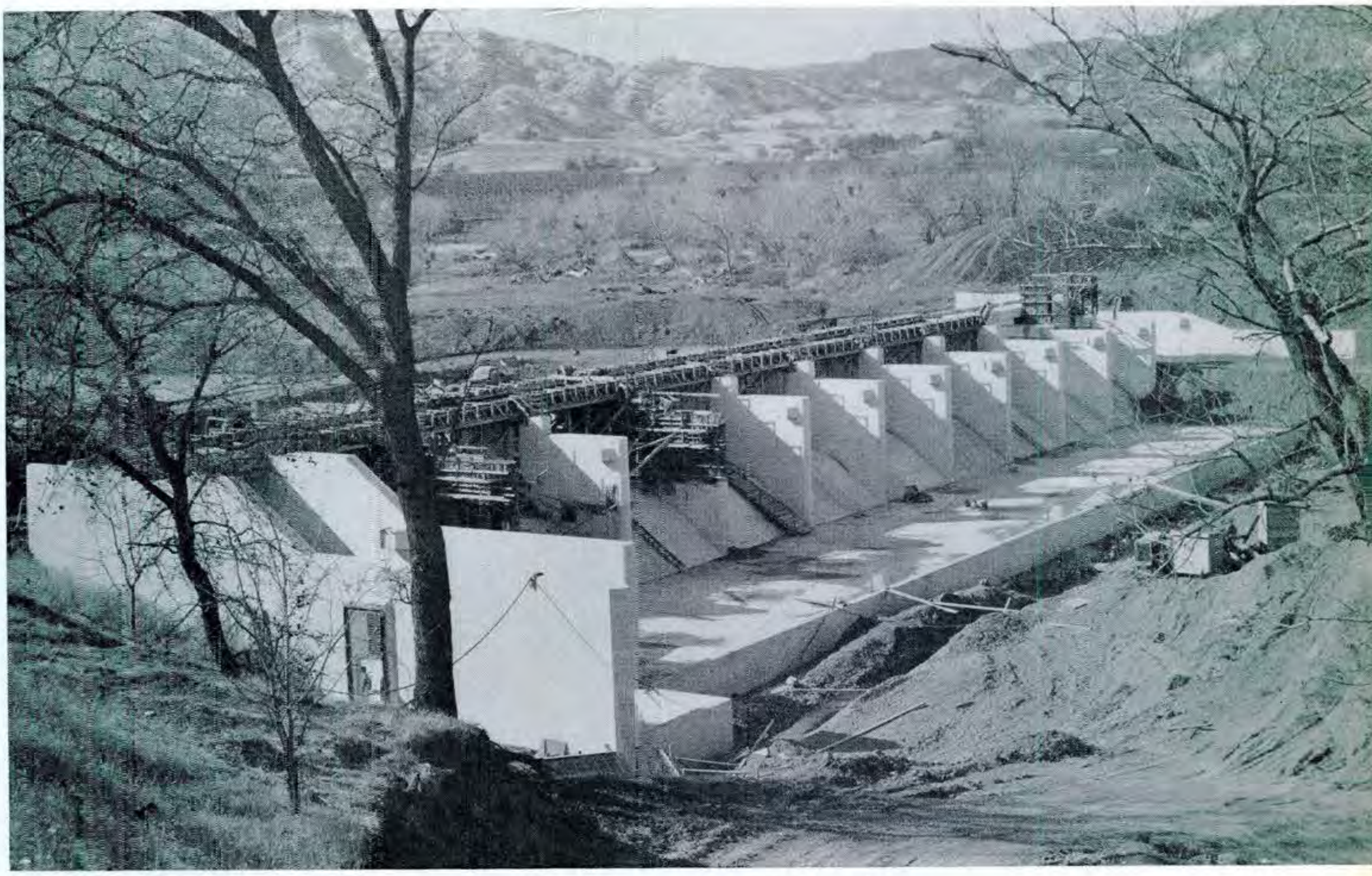
Main West Side Conduit Route. The Main West Side Conduit Route of the Sacramento Division would originate below Keswick Dam at a diversion point on the Sacramento River near the mouth of Salt Creek west of Redding. Here, the Redding Diversion Dam would be constructed and operated to divert the stream flow southward 7 miles through the Redding Conduit to Girvan Reservoir on Clear Creek, where a junction would be made with the imported waters of the Klamath-Trinity Division. From Girvan Reservoir the combined flow would be further conveyed about 11 miles southeasterly through the Anderson Conduit, skirting the foothills south of Redding and west of U. S. Highway 99, to the headworks of the Cottonwood Power Plant, located about 2 miles northeast of the town of Cottonwood. Releases from the Cottonwood Power Plant would enter the Cottonwood arm of Iron Canyon Reservoir through an excavated tailrace channel about a mile in length. The water would then flow through the reservoir about 18 miles to Iron Canyon Dam and through Iron Canyon Power Plant, near the base of the dam, into the proposed Redbank Diversion Reservoir of the United States Bureau of Reclamation, all on the Sacramento River near Red Bluff.

After releases of mandatory requirements to the Sacramento River below the Redbank Diversion Dam and to the Tehama-Colusa and Corning Canals of the Bureau of Reclamation, the remaining water would be diverted into the Sacramento West Side Canal and conveyed southward along the west side of the Sacramento Valley about 146 miles to a junction with the imported waters of the Eel River Division of the California Aqueduct System at Putah Creek near Davis. Power drops would be taken along the route of the canal at Willows and Dunnigan. From the Putah Creek junction, the combined waters of the upper Sacramento River Basin and the North Coastal Area would be further conveyed by canal about 21 miles southerly to Montezuma Reservoir in southern Solano County. There they would be available for export westward through the North Bay Aqueduct of the Sacramento Division and southward through an element of the Delta Division of the California Aqueduct System. In the reach between the Redbank diversion point and the junction with the Eel River Division near Davis the Sacramento West Side Canal would, at times, receive inflow of surplus water from streams draining the easterly slope of the Coast Range.

With the exception of Iron Canyon Dam and the 950,000 acre-foot reservoir it would create under The California Water Plan, none of the foregoing works would present unusually difficult construction or consequent problems. Because of especially adverse foundation conditions at the Iron Canyon site, earthfill dam construction would probably be employed, with the reservoir area blanketed near the dam to reduce seepage to safe limits. In the design of the dam and appurtenant works, the first and paramount consideration would be that of safety. Inundation of upstream lands would be limited, insofar as possible by construction of dikes, with new lands brought under irrigation by the construction of associated local reservoirs on Cottonwood Creek and other streams draining into Iron Canyon Reservoir. The anadromous fishery would be preserved to the highest possible degree by construction of a large hatchery downstream and a fish ladder around the dam, together with development of spawning gravels at the hatchery site and along regulated streams entering the reservoir. All of these measures are considered to be warranted because of the strategic location of the reservoir and its importance in any truly comprehensive water development and flood control plan. Although no satisfactory alternative to the use of the Iron Canyon site has as yet been found, continued study in this direction should be undertaken in any future, more detailed investigation of Iron Canyon Reservoir.

The Redding Conduit, consisting of 2 miles of tunnel followed by 5 miles of open channel, would have a capacity of about 13,000 second-feet, and would con-

Shasta Dam, Sacramento River



Putah Diversion Dam, Putah Creek
Sacramento Division—Constructed Features of the California Aqueduct System

vey an average of about 5,600,000 acre-feet of water per year to Girvan Reservoir. The Anderson Conduit would be an open channel with a capacity of about 40,000 second-feet, corresponding to the peaking requirements of the Cottonwood Power Plant. It would convey an average of about 13,800,000 acre-feet of water per year to this 400,000-kilowatt power plant and, by intercepting local drainage, would also afford flood protection for the Anderson-Cottonwood area. The Cottonwood Power Plant would generate an average of about 1.5 billion kilowatt-hours per year.

Operating through a range of only 50 feet, Iron Canyon Reservoir would be utilized for power, conservation, and flood control. Because of this narrow operating range it would also afford unusual opportunities for fishing and recreational development. After accounting for ultimate local water use in upstream areas and the regulatory effects of existing and prospective upstream storage works, as well as unregulated local inflow and imports, releases from Iron Canyon Reservoir would average about 16,850,000 acre-feet per year. Of this, about 13,300,000 acre-feet would be a firm supply, 2,700,000 acre-feet would be secondary yield obtained through the beneficial use of regulated flood releases, and 850,000 acre-feet would be classified as spill. All of this water, except spill, would be released through the Iron Canyon Power Plant. This would be a base load plant with an installed capacity of about 200,000 kilowatts and an annual generation of about 1.7 billion kilowatt-hours.

At the Redbank diversion point on the Sacramento River about 9,850,000 acre-feet per season of the firm water supply would be diverted into the Sacramento West Side Canal, for further conveyance southward along the west side of the Sacramento Valley. This canal would have a capacity of about 15,000 second-feet to its junction with the Eel River Division at Putah Creek, and about 18,000 second-feet between that point and Montezuma Reservoir. The Willows and Dunnigan Power Plants along the canal would have capacities of about 90,000 and 76,000 kilowatts respectively and would generate an average of some 0.7 and 0.6 billion kilowatt-hours per year, respectively.

With the Eel River import, and with accretions enroute assumed to balance losses, the Sacramento West Side Canal would deliver about 11,770,000 acre-feet of water per year to Montezuma Reservoir. Of this, about 11,250,000 acre-feet would be released to the Delta Division of the California Aqueduct System for further conveyance southward; 208,000 acre-feet would be diverted for local use; and 308,000 acre-feet would be released to the North Bay Aqueduct for delivery to the North Bay area, comprising lands in Solano, Napa, Sonoma, and Marin Counties. The North Bay Aqueduct, consisting of alternating sections of canal and pipe line, with a few miles of tunnel, would extend westward about 59 miles past Fairfield and Cordelia to a small terminal reservoir about 2 miles northeast of Novato. Its capacity would progressively decrease from about 900 second-feet at the point of diversion to about 100 second-feet at the terminal near Novato.

The reservoirs along the main conduit route, namely, Redding Diversion, Girvan, Iron Canyon, Redbank Diversion, and Montezuma, would have a combined gross storage capacity of 1,336,000 acre-feet, of which about 355,000 acre-feet would be inactive, and 250,000 acre-feet would be reserved in Iron Canyon Reservoir for flood control. Additional flood control storage space, in the amount of about 300,000 acre-feet, would be available in Kanaka Reservoir on Clear Creek and in the local reservoirs of the Redding Stream Group, all draining into Iron Canyon Reservoir. The reservation of a total of 550,000 acre-feet of storage space for flood control in the reservoirs between Red Bluff and Shasta Dam may make it possible in the future to reduce the amount of such space now reserved in Shasta Reservoir, with consequent increased power and conservation benefits. The four power plants along the Main West Side Conduit Route would have a combined installed capacity of about 766,000 kilowatts and would generate an average of about 4.5 billion kilowatt-hours per year. The continuance of mandatory releases to the Sacramento River below Redbank Diversion Dam, together with the conveyance of sewage and industrial wastes from the Redding area by separate channel, would preserve the quality of water in the river and maintain its highly important fishery and recreational status.

Other Features of Sacramento Division. The works considered under this heading comprise both existing and prospective surface and ground water storage reservoirs in the Sacramento River Basin that would develop and regulate water for export from the Delta and from the American River; the power plants associated with these reservoirs; the Sacramento River and streams tributary thereto, through which the regulated water would flow to the Delta; and the Folsom South Canal, diverting from Lake Natoma on the American River into the lower east side of the San Joaquin Valley. Water supplies for export are presently or will in the near future be developed in Shasta, Folsom, and Monticello Reservoirs. These reservoirs and the new reservoirs considered herein would also perform important local as well as export functions. They have been described, together with their associated power plants, earlier in this chapter under the heading of "Development to Meet Local Requirements."

Prospective new reservoirs would consist of Guinda on Cache Creek, or alternative thereto, Wilson Valley or Blue Ridge, both on Cache Creek; Black Butte on Stony Creek; Brush Creek Basin comprising off-stream storage principally for Mill and Deer Creeks; Castle Rock on Butte Creek, with connecting diversion tunnel from Big Chico Creek; Oroville on the Feather River, including afterbay power and regulatory facilities; Parks Bar on the Yuba River; Waldo on Dry Creek, a tributary of the Bear River, providing off-stream storage for Yuba River water; Camp Far West on the Bear River; Auburn on the North Fork of the American River; and Salmon Falls on the South Fork of the American River or, alternative thereto, Nashville on the Cosumnes River which would provide off-stream storage for water from the South Fork of the American River. All of these reservoirs would be located at or near the foothill line. On the major streams they would be large multipurpose reservoirs; and on less important streams their principal local function would be irrigation and/or flood control. Together with Folsom and Shasta, these reservoirs would have a combined capacity of nearly 12,000,000 acre-feet, of which about 1,250,000 acre-feet would be inactive and 2,700,000 acre-feet would be reserved for flood control. Additional flood control storage space in the amount of about 1,000,000 acre-feet would be reserved in all other reservoirs of the Sacramento River Basin, including the 550,000 acre-feet previously accounted for in Iron Canyon and associated reservoirs.

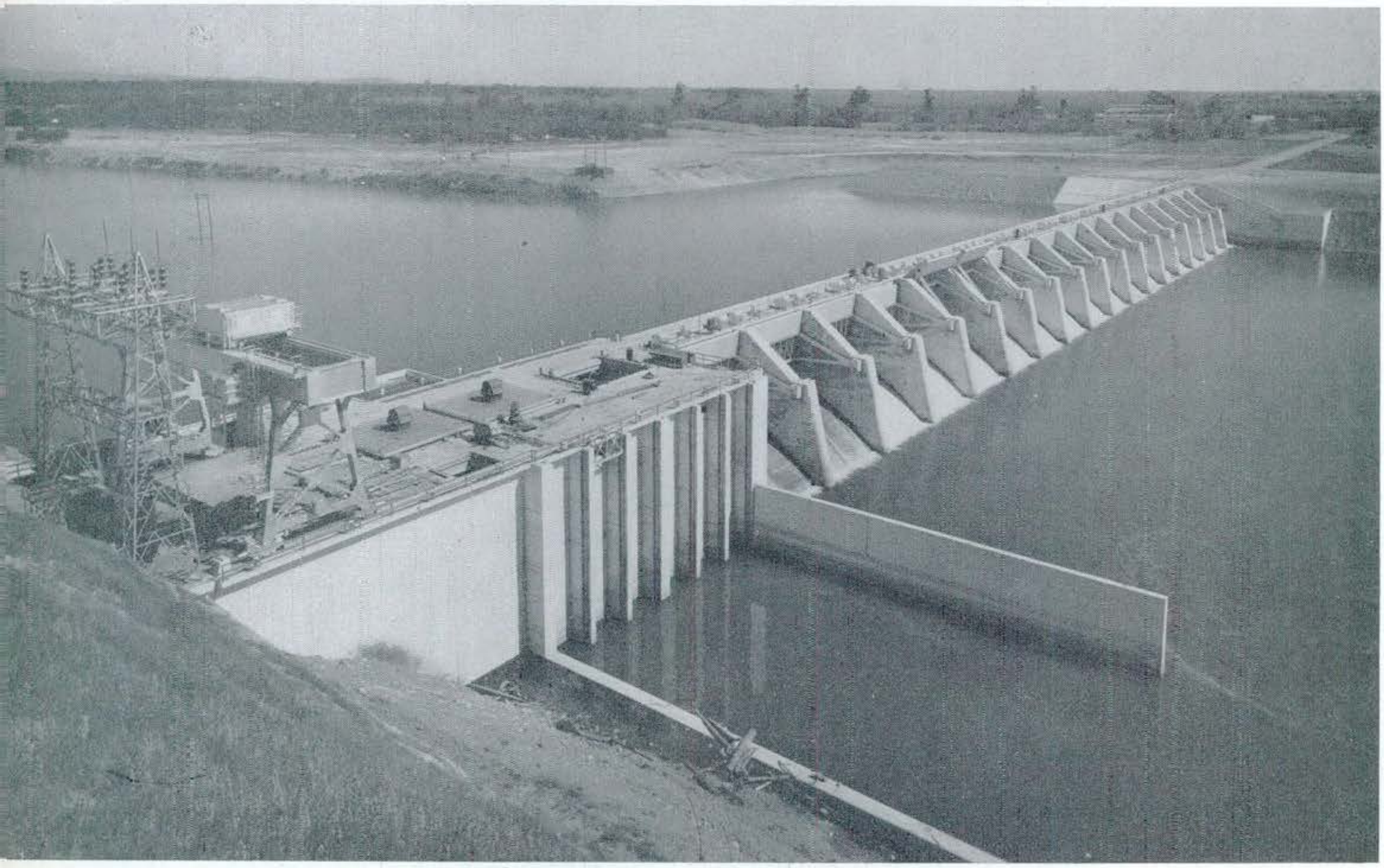
After taking into account the requirements for local use in upstream areas and on the Sacramento Valley floor, the existing and prospective reservoirs considered under this heading would make available for use in the Delta and for export from the Delta and from the American River, an average of about 9,300,-000 acre-feet of water per year. Depending upon the manner in which the reservoirs may eventually be operated in conjunction with ground water storage in the alluvium of the Sacramento Valley, 60 to 80 per cent of the water would be made available for export on a firm basis each year, while the remainder would be a variable supply available only in years of heavy runoff. Further firming of the variable supply would be accomplished by operation of ground water storage in the San Joaquin Valley. The subject of conjunctive operation has been briefly considered earlier in this chapter in connection with developments to meet local requirements in the Sacramento River Basin. The subject is also discussed more fully later in this chapter under the heading "Utilization of Ground Water Storage."

New power plants associated with the prospective reservoirs would be located at the bases of Oroville, Parks Bar, Auburn, and Salmon Falls or Nashville Dams. The Parks Bar Power Plant, however, would utilize water diverted by tunnel from Englebright Reservoir, instead of a direct connection to Parks Bar Reservoir. The power head available below Oroville Dam would be developed by one or more power plants located on the Thermalito Power Canal, between a diversion dam on the river below the main Oroville Power Plant and an off-stream afterbay reservoir. The new power plants would have a combined installed capacity of about 710,000 kilowatts and would generate an average of about 2.9 billion kilowatt-hours per year. Of this amount about 0.6 billion kilowatt-hours would be required for operation of ground water pumping facilities. New power developed by releases from Shasta Reservoir at the Cottonwood and Iron Canyon Power Plants is credited to works along the Main West Side Conduit Route.

About 640,000 acre-feet per season of the export supply would be diverted from Lake Natoma, afterbay for Folsom Reservoir, into the lower east side of the San Joaquin Valley through the Folsom South Canal, currently proposed for construction by the United States Bureau of Reclamation. This canal would divert with a capacity of about 3,550 second-feet and terminate at Lone Tree Creek, 63 miles to the south, with a capacity of 330 second-feet. An additional quantity of water amounting to about 76,000 acre-feet per season would be diverted from the South Fork of the American River into the upper Cosumnes River Basin.

If off-stream storage for water from the South Fork of the American River is obtained in Nashville Reservoir on the Cosumnes River instead of in Salmon Falls Reservoir, a far larger quantity of water would be diverted from the South Fork into the upper Cosumnes River Basin. Similarly, subsequent studies may indicate the desirability of doubling the diversion southward from Lake Natoma; but it is assumed for purposes of this report that the bulk of the export supply from the American River would flow to the Delta for further conveyance to other areas of the State. All of the remaining export supply of the Sacramento River Basin, not previously accounted for, would flow to the Delta through the Sacramento River and tributary channels. Releases from Shasta Reservoir, for example, after further regulation in Iron Canyon Reservoir, would flow down the Sacramento River to the Delta with diversions enroute for local use, as at present. In this connection, it is pertinent to note that the present deleterious effects of seepage from the river may be alleviated to a considerable degree by lowering of ground water levels along the river as a consequence of the planned utilization of ground water storage.

Summary of Sacramento Division. The Sacramento Division comprises the storage, power, and conveyance facilities in the Sacramento River Basin that would conserve and regulate the surplus waters of the basin and convey these and imported supplies to terminal diversion points for export. There would be 15 major reservoirs, including Shasta and Folsom which presently serve these purposes; 4 diversion dams and



Sacramento Division—Constructed Features of the California Aqueduct System, Folsom and Nimbus Dams (top and bottom) on the American River

TABLE 21

SUMMARY OF SACRAMENTO DIVISION, CALIFORNIA AQUEDUCT SYSTEM

(These works show future development possibilities. They are not project proposals.)

Dam and reservoir	Stream	Dam				Normal pool elevation, in feet	Storage capacity, in acre-feet		Seasonal yield, in acre-feet	Purpose	Place of water use
		Location, MDB&M, and sheet of Plate 5 on which shown		Type	Height, in feet		Gross	Active			
Redding	Sacramento River	Sec. 27, T32N, R5W	3	CG	50	513			[a]	D	[1]
Girvan	Clear Creek	Sec. 26, T31N, R5W	3	E	70	500	26,000	6,000	[a]	P	[1]
Iron Canyon	Sacramento River	Sec. 35, T28N, R3W	4	E	155	400	950,000	750,000	[a]	I,U,P,FC,R,F	[1]
Red Bank	Sacramento River	Sec. 33, T27N, R3W	4	CG	50	252			[a]	D	[1]
Montezuma	Montezuma Slough	Sec. 14, 23, T4N, R1W	8	E	54	50	360,000	225,000	[a]	S	[1]
Guinda [c]	Cache Creek	Sec. 32, 33, T12N, R3W	7	E	170	510	303,000	295,000	[b]	I,U,P,FC,R,F	[2]
Black Butte	Stony Creek	Sec. 31, T23N, R4W	5	E	115	474	160,000	145,000	[b]	I,U,P,FC,R,F	[2]
Brush Creek Basin	Brush Creek	——T23, 24N, R1W	6	E	62	278	100,000	92,000	[b]	I,U,P,FC,R,F	[2]
Castle Rock	Butte Creek	Sec. 36, T22N, R2E	6	E	178	503	100,000	90,000	[b]	I,U,P,FC,R,F	[2]
Oroville	Feather River	Sec. 1, 2, T19N, R4E and Sec. 35, T20N, R4E	6	CG	730	900	3,523,000	3,068,000	[b]	I,U,P,FC,R,F	[2]
Oroville Afterbay No. 1	Feather River	Sec. 5, T19N, R4E	6	CG	126	220			[b]	P	[2]
Oroville Afterbay No. 2	Feather River (off-stream)	Sec. 31, 32, 33, T19N, R3E	6	E	29	125			[b]	P	[2]
Parks Bar	Yuba River	Sec. 29, T16N, R6E	6	E	300	480	243,000	200,000	[b]	I,U,P,FC,R,F	[2]
Waldo	Dry Creek	Sec. 33, T15N, R6E	6	E	227	437	300,000	290,000	[b]	I,U,P,FC,R,F	[2]
Enlarged Camp Far West	Bear River	Sec. 21, T14N, R6E	6	E	225	350	242,000	240,000	[b]	I,U,P,FC,R,F	[2]
Auburn	North Fork American River	Sec. 26, T12N, R8E	8	E&R	480	920	868,000	768,000	[b]	I,U,P,FC,R,F	[2]
Salmon Falls	South Fork American River	Sec. 30, T11N, R9E	8	R	395	830	630,000	600,000	[b]	I,U,P,FC,R,F	[2]
Totals							7,805,000	6,769,000			

TABLE 21—Continued

SUMMARY OF SACRAMENTO DIVISION, CALIFORNIA AQUEDUCT SYSTEM

(These works show future development possibilities. They are not project proposals.)

Power plant	Location, MDB&M, and sheet of Plate 5 on which shown		Average head, in feet	Installed capacity, in kilowatts	Average annual energy generation, in kilowatt-hours
Cottonwood	Sec. 6, T29N, R3W	3	120	400,000	1,500,000,000
Iron Canyon	Sec. 4, T27N, R3W	4	120	200,000	1,700,000,000
Willows	Sec. 13, T18N, R4W	5	80	90,000	700,000,000
Dunnigan	Sec. 21, T12N, R1W	8	68	76,000	600,000,000
Oroville	Sec. 2, T19N, R4E	6	558	440,000	1,720,000,000
Thermalito	Between Oroville Power Plant and Afterbay Dam		90	68,000	230,000,000
Parks Bar	Sec. 20, T16N, R6E	6	270	48,000	172,000,000
Auburn	Sec. 26, T12N, R8E	8	439	110,000	485,000,000
Salmon Falls	Sec. 31, T11N, R9E	8	358	43,000	235,000,000
Totals				1,475,000	7,342,000,000

Conduits	Maximum capacity in second-feet	Length, in miles			
		Canal	Tunnel	Pipe	Total
Redding	13,000	5	2	--	7
Anderson	40,000	11	--	--	11
Sacramento West Side Canal					
Red Bluff to Putah Creek	15,000	146	--	--	146
Putah Creek to Montezuma Reservoir	18,000	21	--	--	21
North Bay Aqueduct	1,000	40	3	11	54
Folsom South Canal	3,600	63	--	--	63
Totals		286	5	11	302

[a] Including imported supplies from the North Coastal Area, these reservoirs would make 11,708,000 acre-feet of water per year available for export from Montezuma Reservoir to the North Bay area and other deficient areas south of the Delta.

[b] These reservoirs, operated in conjunction with Shasta and Folsom Reservoirs and with ground water, would, after full satisfaction of local requirements, develop an average of 8,579,000 acre-feet of water per year.

[c] Wilson Valley or Blue Ridge Reservoir, alternative to Guinda Reservoir.

[1] South of Delta and in North San Francisco Bay area.

[2] Sacramento Valley and south of Delta.

Symbols of Type of Dam
E—Earthfill
R—Rockfill
CG—Concrete gravity

Symbols of Purpose
D—Diversion to conduit
P—Power generation
R—Recreation
F—Enhancement of fish environment

Symbols of Purpose
I—Irrigation
FC—Flood control
U—Urban (domestic, municipal, industrial)
S—Reregulation of waters to local demand schedule

afterbays; 9 or 10 hydroelectric power plants; 185 miles of large-capacity conduit that would convey part of the surplus waters of the basin and imports from the North Coastal Area to Montezuma Reservoir; 117 miles of delivery conduit; and the Sacramento River and other natural channels of the basin used for conveyance of water to the Delta.

The reservoirs of the Sacramento Division would have a combined storage capacity of about 13,300,000 acre-feet, of which about 1,600,000 acre-feet would be inactive and 11,700,000 acre-feet would be used for conservation and flood control. These reservoirs would be operated in conjunction with local storage works and eventually with part of the available ground water storage in the Sacramento Valley. After allowing for ultimate requirements in upstream areas and on the Sacramento Valley floor, and taking into account the availability of return flow, these reservoirs would be instrumental in developing an average of about 10,280,000 acre-feet of water per season for export. Of this amount, about 790,000 acre-feet would be diverted from the Sacramento River near Red Bluff and conveyed, together with imported supplies from the North Coastal Area, to Montezuma Reservoir for further distribution. About 720,000 acre-feet of the remaining export supply would be diverted from the American River, and about 8,700,000 acre-feet would serve present and future local and export requirements at the Delta. Another 55,000 acre-feet per season, not previously accounted for in this discussion, would be diverted from Putah Creek below Monticello Reservoir of the Eel River Division. Local and imported water supplies made available for export from Montezuma Reservoir would aggregate about 11,770,000 acre-feet per year. In their local function the reservoirs of the Sacramento Division would provide opportunities for recreational development, regulate water supplies for local use, enhance and improve stream flow for fish, wildlife, and recreation, and maintain navigable depths on the Sacramento River, as required by law.

The new power plants of the Sacramento Division would have a combined installed capacity of about 1,476,000 kilowatts. They would generate an average of about 7.4 billion kilowatt-hours per year, of which about 0.6 billion killowatt-hours would be required to operate the ground water pumping facilities in the Sacramento Valley associated with development of the export supply.

Features of the Sacramento Division could be constructed singly or in combination, on a logical and orderly basis, as demands for water, power, and flood control develop. The works of the Main West Side Conduit Route, for example, between the Redding and Red Bank diversions, could be undertaken to conserve the local water supply, develop the present power potential between these points, provide flood protection for the Sacramento Valley, and afford opportunities for recreational development. These facilities would then be available to accommodate the future imports from the Klamath-Trinity Division if and when these works become necessary.

The general features of the Sacramento Division are presented in Table 21, and the capital costs are summarized in Table 22. The facilities comprising the Sacramento Division are shown on Sheets 3 through 8 of Plate 5.

TABLE 22

SUMMARY OF CAPITAL COSTS, SACRAMENTO DIVISION, CALIFORNIA AQUEDUCT SYSTEM

Item	Capital cost*
Features Along Main West Side Conduit Route	
Redding Diversion Dam	$1,000,000
Redding Conduit	18,750,000
Girvan Dam and Reservoir	4,650,000
Anderson Conduit (including measures to prevent seepage)	14,700,000
Cottonwood Power Plant	55,000,000
Iron Canyon Dam and Reservoir	61,000,000
Fish facilities at and below Iron Canyon Dam	12,500,000
Iron Canyon Power Plant	32,000,000
Redbank Diversion Dam	5,600,000
Sacramento West Side Canal	293,000,000
Willows Power Plant	24,200,000
Dunnigan Power Plant	23,100,000
Montezuma Dam and Reservoir	14,600,000
North Bay Aqueduct	26,700,000
Local diversions from Montezuma Reservoir	1,900,000
Other Features	
Guinda Dam and Reservoir, or alternative at Wilson Valley or Blue Ridge	14,000,000
Black Butte Dam and Reservoir	17,000,000
Brush Basin Dam and Reservoir, including floodway channels from Mill, Deer, and Rock Creeks	12,200,000
Castle Rock Dam and Reservoir, including diversion tunnel from Big Chico Creek	8,700,000
Oroville Dam and Reservoir	374,000,000
Oroville Power Plant	37,000,000
Oroville Diversion Dam	5,000,000
Oroville Afterbay Dam and Reservoir	5,500,000
Thermalito Power Plant	13,000,000
Thermalito Power Canal	9,000,000
Parks Bar Dam and Reservoir	16,900,000
Parks Bar Power Plant	3,000,000
Waldo Dam and Reservoir, including diversion conduit from Yuba River and Deer Creek Diversion	14,450,000
Camp Far West Dam and Reservoir	15,550,000
Auburn Dam and Reservoir	36,000,000
Auburn Power Plant	11,000,000
Salmon Falls Dam and Reservoir	22,500,000
Salmon Falls Power Plant	5,100,000
Folsom South Canal	40,000,000
Ground water pumping facilities	36,400,000
Total	$1,285,000,000

* At 1955 price levels.

Delta Division

The Delta Division of the California Aqueduct System would accomplish the transfer of water across the Sacramento-San Joaquin Delta on its journey from northern areas of water surplus to central and southern areas of deficiency. It would be the "hub" of the California Aqueduct System, bringing together the surplus waters developed by the Klamath-Trinity, Eel River, and Sacramento Divisions, and lifting these waters from the southerly side of the Delta into major conduits for conveyance southward and westward. It would also provide urgently needed flood protection and salinity control for the Delta lands.

The major works of the Delta Division would consist of two features: first, the Cross-Delta Canal of the Biemond Plan, utilizing natural and modified channels hydraulically isolated from the remainder of the Delta, and a siphon under the San Joaquin River to transfer the greater portion of the water developed in the Sacramento River Basin; and second, a conduit leading from Montezuma Reservoir to the southerly edge of the Delta, and including a siphon beneath the Sacramento and San Joaquin Rivers near Antioch to transfer the water developed in the North Coastal Area and the upper Sacramento River Basin and delivered to the Delta by the Sacramento West Side Canal. Hydraulic separation is necessary to prevent undue loss in transit and impairment in quality. Associated facilities of the Biemond Plan would include control structures on the Sacramento River and Steamboat Slough, a system of master levees along flood channels, floodways and control structures at several locations, barge locks, and fishways to pass anadromous fish. These facilities are described herein under the heading "Trans-Delta System."

Other features of the Delta Division are the South Bay Aqueduct and the Kirker Pass Aqueduct, which would serve the southern portions of the San Francisco Bay Area and the northern portions of the Central Coastal Area. Both of these aqueducts are distribution features of the Delta Division, as contrasted with other features designed as primary transmission facilities. They are subsequently discussed in this section under their respective headings.

The general location of the Delta Division is shown on Plate 6, and its component facilities are delineated on Sheets 8, 10, and 13 of Plate 5.

Trans-Delta System. Facilities of the Trans-Delta System would ultimately transfer some 18,330,000 acre-feet of water per season, on the average, across the Delta for conveyance to areas of deficiency in central and southern California and in the San Francisco Bay Area. The ultimate transfer across the Delta of water developed in the Sacramento River Basin would be accomplished by construction of an isolated canal and control structures, as hereinafter explained. As unregulated flows of the Sacramento and San Joaquin Rivers are reduced in the future by increased upstream storage developments for local use and for export of water, it will become necessary to segregate and prevent commingling, during transit, of the imported and locally developed waters of high quality with the drainage and flushing waters of poor quality which occur in and drain to the Delta. Segregation of these waters would be accomplished by facilities of the Biemond Plan. Controlled releases of water to Suisun Bay for salinity repulsion would likewise be reduced.

1. *Biemond Plan.* Alternative barrier plans for salinity control in the Delta and for transfer of water across the Delta were studied under authorization of the Abshire-Kelly Salinity Control Barrier Act of 1953. Ir. Cornelus Biemond, Consulting Engineer from The Netherlands, who was retained during that investigation, recommended a plan with facilities for fresh-water transfer in an isolated system of channels and a master levee system along principal flood channels for flood protection to the Delta islands. The details of that investigation are presented in the report of the Water Project Authority of California entitled "Feasibilty of Construction by the State of Barriers in the San Francisco Bay System," dated March 1955. In 1955, the Legislature enacted the Abshire-Kelly Salinity Control Barrier Act of 1955, which directed further study of barrier plans, and the Biemond Plan, as presently proposed, was developed during this investigation, currently (1957) in progress. Details of this investigation are presented in a report of the Department of Water Resources, Bulletin No. 60, entitled "Salinity Control Barrier Investigation."

The Biemond Plan was designed to transfer water across the Delta, to provide flood protection to the Delta, and to conserve salinity control flows. Some flood flows would be conveyed through the Cross-Delta Canal, thereby reducing the lengths of master levees and the costs of construction and maintenance.

The Biemond Plan would have control structures on the Sacramento River and Steamboat Slough to divert water through the existing Delta Cross Channel into the proposed Cross-Delta Canal, and to provide sufficient hydraulic gradient in the canal to convey water to the major pumping plants on the southern fringe of the Delta. A barge lock and fishway would be located at the Sacramento River control structure. The Cross-Delta Canal would follow improved existing channels, and water would pass under the Stockton Deep Water Channel in large, inverted siphons located near Little Venice Island in the center of the Delta. Flood flows of the Mokelumne and Cosumnes River would be conveyed in the Cross-Delta Canal to Little Venice Island where the flood waters would be discharged through a floodway structure into the San Joaquin River. All or a portion of these flows could be conveyed to the major pumping plants. A fishway would also be provided at Little Venice Island. A portion of the flood flows of the San Joaquin River would be diverted via Paradise Cut and Grant Line Canal to the major pumping plants. The portion of the flows not required for diversion by the major pumping plants would be discharged from the Cross-Delta Canal through a floodway structure into Franks Tract and then into the San Joaquin River. A barge lock would also be located at this structure. The structure at the head of Paradise Cut would be designed to divert San Joaquin River water whenever the quality is satisfactory. The portion of the flood flows not diverted into Paradise Cut would be carried in the San Joaquin River channel.

A system of master levees would be constructed on the Cross-Delta Canal, on Paradise Cut, on Grant Line Canal, and on the San Joaquin River. Bear Creek would be diverted to the Calaveras River which discharges into the San Joaquin River near Stockton. Master levees would also be constructed on the Calaveras River. During flood periods on the Sacramento River, the control structure on the river and on Steamboat Slough would be opened to permit unimpeded passage of flood waters. A system of master levees would restrict the flood water of the Sacramento River system to the river, to Steamboat Slough, and to the Yolo By-Pass.

The system of master levees throughout the Delta would reduce the length of levees now requiring maintenance against flood and tidal forces from about 1,000 miles to 450 miles. The interior channels, which would be severed during construction of the master levee system and would not be subject to tidal or flood waters, would continue to serve as irrigation and drainage channels. Water would be released into these channels from the Cross-Delta Canal, and facilities would be provided for pumping drainage water out of the channels. Operation of the Biemond Plan would provide adequate circulation and high-quality water in the interior channels.

Salinity intrusion into the Delta from sea water would be controlled under operation of the Biemond Plan by regulated outflows into Suisun Bay. Under operation of the Biemond Plan, salinity could be controlled at the western end of the Delta with an average outflow of about 1,200 second-feet as compared to an average outflow of about 3,800 second-feet for comparable control under present conditions. This major reduction in outflow would result from the reduction in the tidal prism, or the volume of water which flows into and out of the Delta during a tidal cycle, by severing many Delta channels from tidal action. The reduction in required outflow under operation of the Biemond Plan would be a measure of the conservation by that plan. This conserved water would be available for distribution to water-deficient areas.

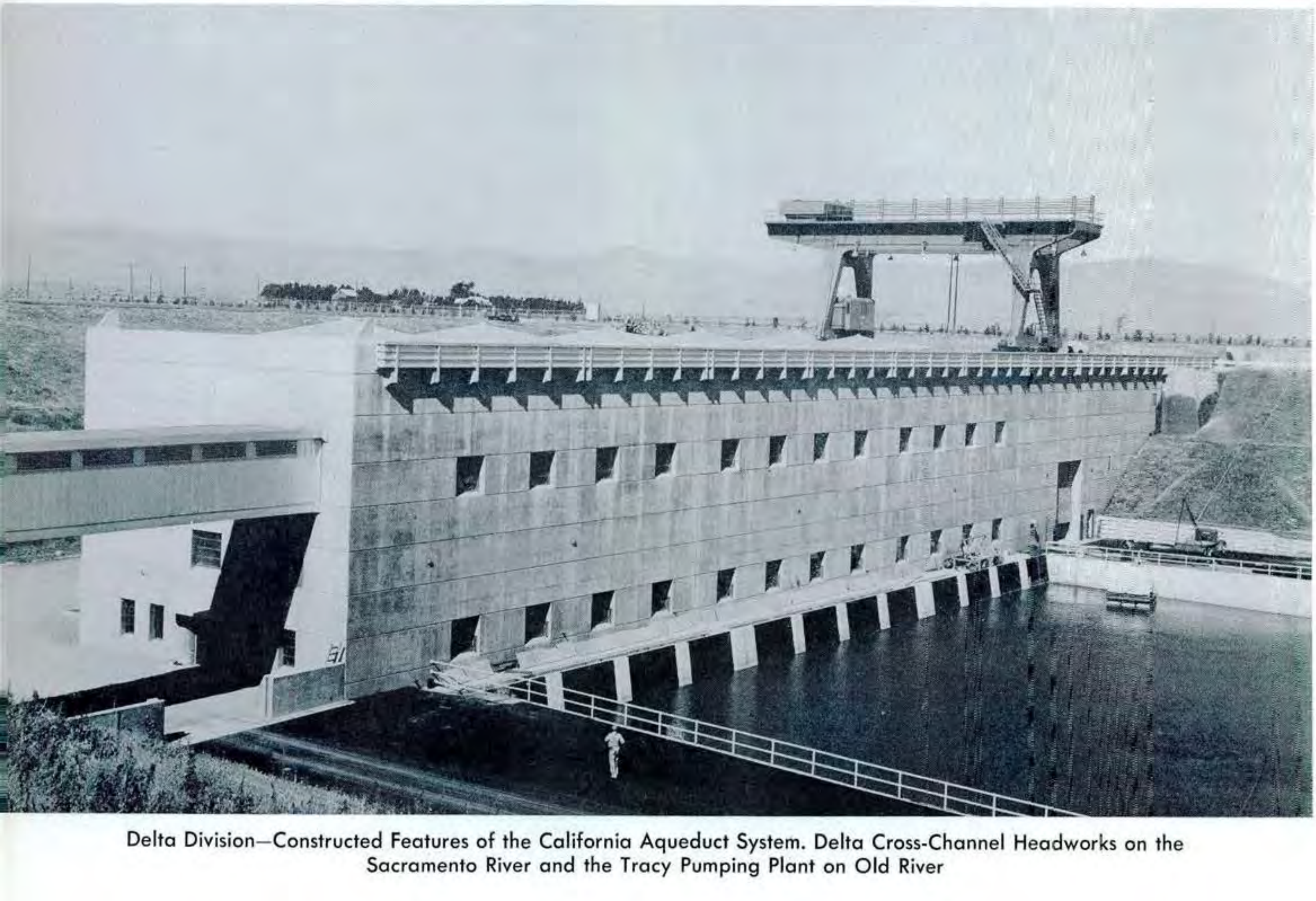
The Biemond Plan would ultimately transport some 7,080,000 acre-feet of water per season, on the average, across the Delta. Facilities also would be provided to distribute some 756,000 acre-feet per season to meet consumptive use requirements of agricultural lands in the Delta. Finally, it would provide releases of water averaging 876,000 acre-feet per season, for repulsion of sea water from the Delta, which would be substantially less than the presently required releases, as previously explained.

2. *Antioch Crossing.* The Antioch Crossing, comprising the second major feature of the Trans-Delta System, would provide the means by which waters developed in the North Coastal Area and the upper Sacramento River Basin, and conveyed through the Sacramento Valley in the Sacramento West Side Canal, would be transported across the Delta. It would convey the water in a canal from Montezuma Reservoir, the terminus of the Sacramento West Side Canal, southeasterly to the Sacramento River about 4 miles east of Collinsville. It would then pass beneath the Sacramento River in a 3,000-foot siphon consisting of four 25-foot diameter concrete pipes. After crossing the western portion of Sherman Island it would pass beneath the San Joaquin River in a similar siphon, discharging into two parallel, concrete-lined canals near the town of Antioch.

The Antioch Crossing would then skirt the southwesterly edge of the Delta, finally terminating in the intake channel of the Mountain House Pumping Plant at approximately sea level elevation. The total length of the crossing would be 33 miles. It would have a capacity of 17,000 second-feet, and would transport about 11,250,000 acre-feet per season. Installation of identical parallel conduits would lend itself to staged construction of the Antioch Crossing.

3. *Delta Pumping Plants.* Virtually all water conveyed across the Sacramento-San Joaquin Delta by the Trans-Delta System would be lifted from the Delta by three pumping plants: the existing Tracy Pumping Plant which is a part of the Central Valley Project; the proposed Delta Pumping Plant of the Feather River Project; and the Mountain House Pumping Plant. All three would be located in close proximity to each other in an area about 10 miles northwest of the town of Tracy. Water transported through the Biemond Plan facilities would be lifted into the Delta-Mendota Canal and the Feather River Aqueduct by the Tracy and Delta Pumping Plants, respectively. The Mountain House Pumping Plant would lift water from the Antioch Crossing into the San Joaquin West Side Conduit. The Feather River Project Aqueduct and the San Joaquin West Side Conduit are described as part of the San Joaquin Division of the California Aqueduct System.

In summary, the Trans-Delta System would be comprised of three major facilities. These are: (1) the Biemond Plan, which would transfer water across the heart of the Delta in an isolated channel, and provide flood protection and salinity control for the Delta, (2) the Antioch Crossing, which would convey water beneath the Sacramento and San Joaquin Rivers by siphon, and (3) the Delta Pumping Plants, which would lift some 18,020,000 acre-feet per season, into facilities of the San Joaquin Division.



Delta Division—Constructed Features of the California Aqueduct System. Delta Cross-Channel Headworks on the Sacramento River and the Tracy Pumping Plant on Old River

Kirker Pass Aqueduct. The Kirker Pass Aqueduct would consist of those facilities necessary to serve areas in Contra Costa County not considered susceptible to service by the East Bay Municipal Utility District or the Contra Costa Canal. This aqueduct would convey about 164,000 acre-feet of water per season from the Antioch Crossing of the Delta Division in a general southwesterly direction about 21 miles to a terminal storage reservoir located about 2 miles west of the community of Clayton.

In pipe line and canal, water would be pumped from the Antioch Crossing siphon on the south shore of the San Joaquin River, about 4 miles east of Antioch, through a series of three pumping plants to an elevation of 500 feet to the portal of a tunnel through Kirker Pass, generally south of Camp Stoneman.

The water would flow by gravity through the 2 miles of Kirker Pass Tunnel, and then would be conveyed by canal to Lime Ridge Reservoir. Lime Ridge Reservoir would be a terminal reservoir, with water surface elevations varying from a maximum of about 470 feet to a minimum of 370 feet, which would be sufficient to serve most of the water service areas by gravity.

South Bay Aqueduct. The South Bay Aqueduct of the Delta Division would pump and deliver 755,000 acre-feet of water per season from the Feather River Project Aqueduct to the service areas in the Southeast Bay Group of the San Francisco Bay Area and in the San Benito and Santa Cruz-Pajaro Groups of the Central Coastal Area. The necessity of avoiding conflict or duplication between the service area of the City of San Francisco for municipal and industrial water and the proposed service area of the South Bay Aqueduct is recognized. Any deviation from the foregoing should be made only after a showing of convenience and necessity. The aqueduct would be built in two stages. The initial stage would comprise the Alameda-Contra Costa-Santa Clara-San Benito Counties Branch of the authorized Feather River Project Aqueduct. Deliveries of water would be increased to the ultimate stage by subsequent construction of additional diversion and conveyance works which would parallel the facilities of that branch.

The initial stage of the South Bay Aqueduct would divert water from the Feather River Project Aqueduct about 2 miles south of the aqueduct headworks, about 8 miles west of Tracy. A re-lift pumping plant at that location would lift the water from the Feather River Project Aqueduct to a tunnel through Brushy Peak in the Coast Range at an elevation of about 705 feet. From Brushy Peak Tunnel water would be conveyed by canal, tunnel, and pipe line around the east and south sides of Livermore Valley, through Mission Pass. The conduit, in pipe line, would then continue southerly, passing to the east of Mission San Jose and Warm Springs to the proposed Airpoint Reservoir on Arroyo de las Coches, 2 miles east of Milpitas, and to Evergreen Reservoir on Silver Creek, about 6 miles southeast of San Jose. These reservoirs, with storage capacities of 23,000 and 32,500 acre-feet respectively, would be constructed for regulation of the continuous diversion to the variable monthly demands in the Santa Clara Valley and San Benito County. Recent subsurface exploration at Airpoint dam site indicates that considerable leakage might develop through the fractured rocks that comprise its abutments. Further investigation of this site may indicate the desirability of selecting an alternative reservoir.

A conduit, principally canal section, would extend southeasterly along the base of the hills on the east side of Santa Clara Valley to a terminus near Pacheco Creek north of Hollister. Water would be released into Pacheco Creek from the terminus of the South Bay Aqueduct for use in the San Benito and Santa Cruz-Pajaro Groups in the Central Coastal Area.

The initial stage of the South Bay Aqueduct would deliver 195,000 acre-feet per season to units of the Southeast Bay Group and 50,000 acre-feet to the San Benito and Santa Cruz-Pajaro Groups in the Central Coastal Area. The remaining ultimate supplemental requirements in those units, amounting to an estimated 510,000 acre-feet per season, would be provided by construction of additional diversion and conveyance facilities which would parallel and supplement deliveries by the initial stage. The additional works would comprise a diversion from the Feather River Project Aqueduct and conveyance facilities of the same types, lengths, and locations previously described for the initial stage between the point of diversion and Evergreen Reservoir.

Water for the San Benito and Santa Cruz-Pajaro Groups would be conveyed at a uniform rate in the canal of the initial stage of the South Bay Aqueduct southward to the Harper Canyon regulatory storage reservoir on Pacheco Creek. At a future time the canal of the initial stage of the South Bay Aqueduct would be extended 7 miles to Harper Canyon Reservoir. Additional regulatory storage would also be constructed on Arroyo del Valle in Livermore Valley.

Under ultimate operation of the South Bay Aqueduct, the major portion of storage in Sanatorium Reservoir on Arroyo del Valle would be utilized to regulate the continuous flow to the variable monthly demand schedule in Livermore Valley and southern Alameda County. Deliveries to the San Benito and Santa Cruz-Pajaro Groups in the Central Coastal Area would be increased from the initial quantity of 50,000 acre-feet per season, to an ultimate quantity of 128,000 acre-feet per season, and would be regulated in Harper Canyon Reservoir on Pacheco Creek about 12 miles east of Gilroy. Harper Canyon Reservoir

TABLE 23

SUMMARY OF DELTA DIVISION, CALIFORNIA AQUEDUCT SYSTEM

(These works show future development possibilities. They are not project proposals.)

Conveyance facilities	Conduits						Pumping plants		
	Maximum capacity, in second-feet	Length, in miles					Total number	Total installed capacity, in kilowatts	Total seasonal power consumption, in kilowatt-hours
		Canal	Tunnel	Pipe	Siphon	Total			
Trans-Delta System									
Cross-Delta Canal	20,000	54.9			0.1	55.0	2	378,000	1,607,000,000
Antioch Crossing	17,500	32.0			4.0	36.0	1	276,000	2,080,000,000
Kirker Pass Aqueduct	220	15.2	1.0	3.7		19.9	3	17,000	130,000,000
South Bay Aqueduct	1,040	73.8	2.3	31.3		107.4	4	67,000	456,000,000
Totals		175.9	3.3	35.0	4.1	218.3	10	738,000	4,273,000,000

Dam and reservoir*	Location, MDB&M, shown on Sheet 10 of Plate 5	Type of dam	Height of dam, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet	Place of water use
Trans-Delta System (transmission only)						
Kirker Pass Aqueduct						
Lime Ridge Reservoir	Sec. 16, T1N, R1W	E	148	472	12,100	Contra Costa County
South Bay Aqueduct						
Sanatorium Reservoir	27,000 acre-feet of storage allocated to regulation of deliveries by South Bay Aqueduct, 17,000 acre-feet to local development. See Table 10.					Livermore Valley
Airpoint Reservoir	Sec. 4, T6S, R1E	E	250	611	22,500	Santa Clara County
Evergreen Reservoir	Sec. 29, T7S, R2E	E	197	538	31,700	Santa Clara County
Harper Canyon Reservoir	Sec. 5, T11S, R6E	E	150	413	65,000	San Benito and Santa Cruz Counties
Total					148,300	

Symbol of Type of Dam
E—Earthfill

*Provide regulation of imported water to monthly schedule at place of water use.

would permit the conveyance of water to the Central Coastal Area on a continuous-flow basis, rather than on a variable monthly demand schedule.

Should the need be indicated, water could be delivered to the northern portion of Livermore Valley and the southern portion of Contra Costa County by an alternative route of the South Bay Aqueduct. This alternative would convey water from Brushy Peak Tunnel along the northern edge of Livermore Valley to a regulatory reservoir in Doolan Canyon, and would then proceed southwesterly across the valley to the main alignment west of La Costa, as shown on Sheet 10 of Plate 5.

Summary of Delta Division. The Delta Division would transfer some 18,330,000 acre-feet of water developed in the North Coastal Area and Sacramento River Basin, across the Sacramento-San Joaquin Delta for further conveyance to areas of deficiency. The crossing of the Delta would be accomplished by facilities of the Trans-Delta System, utilizing two major routes. One route, the Biemond Plan, would consist of an isolated fresh-water channel and flood channels, with master levees, and control structures at several locations to facilitate the transfer of water and the control of flood flows. Salinity intrusion into the Delta would be controlled by regulated outflow into Suisun Bay. About 7,080,000 acre-feet of water per season would be conveyed across the Delta by this route. The other route, the Antioch Crossing, would consist of a canal from Montezuma Reservoir to the vicinity of Collinsville, a number of siphons under the Sacramento and San Joaquin Rivers to the vicinity of Antioch, and a canal skirting the edge of the Delta to a terminus at Mountain House Pumping Plant. About 11,250,000 acre-feet of water per season would be transferred across the Delta by this route.

Water delivered to the southern edge of the Delta by facilities of the Trans-Delta System would be lifted into conduits of the San Joaquin Division by three major pumping plants, namely (1) the Tracy Pumping Plant of the Central Valley Project, (2) the Delta Pumping Plant of the authorized Feather River Project, and (3) the Mountain House Pumping Plant. These pumping plants would lift 1,780,000 acre-feet, 6,055,000 acre-feet, and 10,185,000 acre-feet, respectively, from the Delta to facilities of the San Joaquin Division.

An additional 164,000 acre-feet per season would be diverted from the Antioch Crossing and conveyed by the Kirker Pass Aqueduct to service areas in Contra Costa County not considered susceptible of service by the East Bay Municipal Utility District or the Contra Costa Canal. Finally, the South Bay Aqueduct would pump and deliver about 755,000 acre-feet of water per season to the Southeast Bay Group of the San Francisco Bay Area and to the San Benito and Santa Cruz-Pajaro Groups of the Central Coastal Area.

The general features of the Delta Division are presented in Table 23 and the capital costs of its component facilities are shown in Table 24. The facilities comprising the Delta Division are shown on Sheets 8, 10, and 13 of Plate 5.

TABLE 24

SUMMARY OF CAPITAL COSTS, DELTA DIVISION, CALIFORNIA AQUEDUCT SYSTEM

Item	Capital cost*
Trans-Delta System	
Biemond Plan	
Control structures	$16,340,000
Cross-Delta Canal	39,830,000
Flood control channel levees	12,500,000
Irrigation and drainage	1,170,000
Antioch Crossing	212,840,000
Pumping Plants	
Tracy Pumping Plant	existing facility
Delta Pumping Plant (Feather River Project)	37,260,000
Mountain House Pumping Plant	57,300,000
Subtotal	$377,240,000
Kirker Pass Aqueduct	
Pumping plants	$2,610,000
Conduit	6,030,000
Lime Ridge Reservoir	4,340,000
Subtotal	$12,980,000
South Bay Aqueduct	
Initial stage (Alameda-Contra Costa-Santa Clara-San Benito Counties Branch of Feather River Project Aqueduct)	
Pumping plants	$3,510,000
Conduit	37,440,000
Airpoint Reservoir	8,820,000
Evergreen Reservoir	7,090,000
Additional works under ultimate stage	
Pumping plants	5,780,000
Conduit	27,980,000
Santorium Reservoir (see Table 10)	----------------
Harper Canyon Reservoir	7,560,000
Subtotal	$98,180,000
Total	$488,400,000

* At 1955 price levels, with exception of Biemond Plan which is based on 1956 levels.

San Joaquin Division

The San Joaquin Division of the California Aqueduct System would accomplish two objectives in the disposition of regulated surplus waters from the northern part of the State, delivered to the southerly end of the Delta by the previously described Delta Division. First, it would convey and deliver supplemental water to deficient areas in the San Joaquin Valley and the Central Coastal Area; and second, it would transport water to the Buena Vista Forebay of the Southern California Division for delivery to areas south of the Tehachapi Mountains. In the delivery of water to the San Joaquin Valley, substantial use would be made of the extensive ground water storage capacity beneath the valley floor, particularly for providing final regulation of the variable seasonal secondary waters imported from the Sacramento River Basin during wet years.

The San Joaquin Division would consist of the existing Delta-Mendota Canal of the Central Valley Project and the authorized Feather River Project Aqueduct as its initial features, and an additional conduit under ultimate operation. These facilities will be described herein under the heading "Main Aqueduct Route." Also included as features of the division are the Central Coastal Aqueduct, which would divert water from the Main Aqueduct Route in Kings County near Devils Den to serve San Luis Obispo and Santa Barbara Counties, and the Carrizo-Cuyama Aqueduct, which would divert water from the California Aqueduct about 5 miles south of Buena Vista Lake to serve lands in southeastern San Luis Obispo County and the eastern portion of Santa Barbara County. It should be pointed out that the Carrizo-Cuyama Aqueduct would actually divert water from facilities of the Southern California Division; but since the aqueduct would serve the Central Coastal Area, it has been included as a feature of the San Joaquin Division. These additional features of the San Joaquin Division will be described herein under their respective titles.

Further and more detailed investigations of the Feather River Project Aqueduct System are currently (May, 1957) in progress as part of the final engineering studies looking toward construction of the project. These studies may result in substantial modification of the system as it relates to service of water to lands south of Devils Den in the San Joaquin Valley and to southern California, from that described herein. Water may be supplied to central coastal areas from the Feather River Project if justified by the demand there. These studies have not yet been sufficiently completed to enable the inclusion of any results herein.

The general location of the San Joaquin Division is shown on Plate 6, and its component facilities are delineated on Sheets 8, 10, 13, 14, 16, 17, and 20 of Plate 5.

Main Aqueduct Route. In addition to the existing Delta-Mendota Canal, features of the Main Aqueduct Route would ultimately include three parallel concrete-lined canals extending some 250 miles southward from the Delta Pumping Plants to the Buena Vista Forebay near Taft in the upper end of the San Joaquin Valley. These are the Feather River Project Aqueduct, comprising the initial stage, and two additional parallel canals, designated the "San Joaquin West Side Conduit," which would complete the Main Aqueduct Route to its ultimate stage. San Luis Reservoir would be operated to provide required regulation in conjunction with all these facilities.

The location of the Feather River Project Aqueduct, and of the two canals of the San Joaquin West Side Conduit between San Luis Reservoir and Buena Vista Forebay, as shown on Sheets 11, 13, 16, and 17, of Plate 5, is tentative only, and is possibly subject to considerable future modification. Subsidence of the land surface on west side lands has been observed in several areas and could markedly affect the final selection of the route and detailed location of these canals. Further geological, topographic, engineering, and cost investigations and studies will be necessary to resolve the problem and to provide the basic information for selecting the most economic location for construction.

The Delta-Mendota Canal presently conveys water from the Tracy Pumping Plant south along the west side of the San Joaquin Valley to Mendota Pool on the San Joaquin River near the community of Mendota. The design capacity of the canal at its head is about 4,600 second-feet. It is contemplated that the canal would convey about 1,780,000 acre-feet per season for use in the San Joaquin Valley under ultimate operation.

The authorized Feather River Project Aqueduct will begin at the Delta Pumping Plant, located about 11 miles northwest of Tracy. The aqueduct will be a concrete-lined canal with a capacity of 11,000 second-feet, and will generally parallel the Delta-Mendota Canal southerly to San Luis Creek. Water will be delivered by gravity to the San Luis Forebay on San Luis Creek at an elevation of about 225 feet. The forebay will extend upstream along San Luis Creek to a pumping plant located near San Luis Dam, where pumping units will lift the water into San Luis Reservoir or directly into the extension of the Feather River Project Aqueduct at an elevation of about 360 feet, for further conveyance southward.

San Luis Dam and Reservoir will be located about 12 miles west of the City of Los Banos, and have an ultimate storage capacity of about 2,100,000 acre-feet with a water surface elevation of 550 feet. This reservoir will regulate the variable flows pumped from the Delta to the irrigation demand schedule in the San Joaquin Valley and to a continuous flow in the aqueduct to southern California. In the operation of the Feather River Project Aqueduct, the bulk of the water delivered to the San Luis Forebay will be pumped directly into the southerly continuation of the aqueduct which will originate at San Luis Reservoir. The remainder of the water delivered to the forebay, or that quantity exceeding the demand at the particular time, will be pumped into San Luis Reservoir where it will be held in storage until such time as diversion from the Delta is insufficient to meet the demand. Releases of water from San Luis Reservoir will be made directly into the continuation of the aqueduct.

The operation of the San Luis Forebay in conjunction with San Luis Reservoir will enable the utilization of off-peak power for pumping into the reservoir,

San Joaquin Division—The Delta-Mendota Canal and the Irrigated San Joaquin Valley with resultant reduction in pumping costs. The San Luis Afterbay, located near San Luis Reservoir at an elevation of about 352 feet, will similarly enable the utilization of off-peak power for pumping water directly into the continuation of the Feather River Project Aqueduct.

From San Luis Reservoir the Feather River Project Aqueduct will continue southward along the west side of the San Joaquin Valley, passing west of Westhaven, Kettleman City, Lost Hills, and Tupman to the Buena Vista Hills. At this point it will discharge into the Buena Vista Forebay at an elevation of about 310 feet. As previously noted, further studies of the Feather River Project Aqueduct system are now (1957) in progress, which may lead to some modifications as to locations and areas served. Lands in the San Joaquin Valley along the aqueduct route, and those above the aqueduct, will be served directly from the aqueduct, while lands lying at lower elevations will be served by easterly extending laterals.

The San Joaquin West Side Conduit would complete the Main Aqueduct Route to its ultimate stage. This conduit would comprise two parallel concrete-lined canals, each with a capacity of 7,200 second-feet, which would originate at the Mountain House Pumping Plant at an elevation of about 167 feet. The conduit would convey about 10,185,000 acre-feet of water per season, on a continuous-flow basis, for use in the San Joaquin Valley and Central Coastal Area and for further delivery to southern California. It would follow, on grade, the general route of the Feather River Project Aqueduct, but at a slightly lower elevation.

A pumping plant located near the San Luis Forebay at an elevation of about 150 feet would lift the water from the San Joaquin West Side Conduit into the forebay. An additional plant located on the forebay would lift the water further to an elevation of 350 feet into the continuation of the conduit, which, in parallel canals, would convey the water by gravity to the base of the Buena Vista Forebay at an elevation of about 300 feet. At this point a pumping plant would lift the water into the Buena Vista Forebay for further conveyance over the Tehachapi Mountains.

Initial operation of the Main Aqueduct Route would be as proposed for the Feather River Project Aqueduct. About 3,700,000 acre-feet would be taken from the Delta on a constant seasonal basis, but on a "when available" monthly basis. Storage space in San Luis Reservoir would be utilized to regulate the variable monthly deliveries to the monthly demand schedule satisfactory to the needs of the San Joaquin Valley, and for delivery at a uniform rate to the Buena Vista Forebay for further conveyance to southern California.

Under ultimate operation, conveyance of water in the Feather River Project Aqueduct would be increased from the initial operation of 3,700,000 to 5,300,000 acre-feet per season. The Delta-Mendota Canal would be coordinated with the Feather River Project Aqueduct, and would deliver 1,780,000 acre-feet per season into the San Joaquin Valley, a portion of which would be lifted into San Luis Forebay by means of a pumping plant and conduit. Thus, the two interconnected systems would ultimately convey an average of about 7,080,000 acre-feet per season from the Delta to the San Luis Forebay. Delivery of a portion of this water would occur on a variable yearly schedule, because of the irregularity of occurrence of surplus secondary waters in the Sacramento Valley. While temporary regulation of these waters would be provided in San Luis Reservoir, final regulation would be accomplished by the vast natural underground storage of the San Joaquin Valley.

Detailed studies of the growth of irrigation demands, the economic staging of construction, and the routing of seasonally variable water imported from the Sacramento River Basin are necessary to a final determination of the amount of regulatory surface storage required in the San Joaquin Basin. These studies were beyond the scope of the current investigation. Should the requirement for regulatory surface storage exceed that which can be furnished at San Luis Reservoir, it may be necessary to utilize a reservoir site at Avenal Gap, capable of maximum storage of 500,000 acre-feet. The operation of Avenal Gap Reservoir for regulation would be similar to that described for San Luis Reservoir. Avenal Gap Forebay, presently included as a feature of the Central Coastal Aqueduct, would, in such an eventuality, serve as a forebay for off-peak pumping to Avenal Gap Reservoir. Necessary diversions through the Central Coastal Aqueduct would then be made directly from Avenal Gap Reservoir.

As future water demands in the San Joaquin Valley and southern California increase to their ultimate potential, the Antioch Crossing and Mountain House Pumping Plant of the Delta Division would deliver an additional 10,185,000 acre-feet per season which would be transported southward along the west side of the San Joaquin Valley by the San Joaquin West Side Conduit. This water would be conveyed on a continuous-flow basis, both monthly and from year to year, and would require no regulatory storage.

Folsom South Canal, previously described as a feature of the Sacramento Division, would deliver an additional 640,000 acre-feet per season, on the average, to the eastern portion of the lower San Joaquin Valley on a variable yearly schedule. Ground water storage in the valley would be utilized to accomplish the final regulation of the water delivered by that conduit.

Central Coastal Aqueduct. The Central Coastal Aqueduct of the San Joaquin Division would divert from the Main Aqueduct Route in the San Joaquin

Valley near Devils Den, and would deliver a seasonal amount of 760,000 acre-feet of water to deficient areas in San Luis Obispo and Santa Barbara Counties. This delivery would meet the ultimate supplemental water requirements in those counties, with the exception of the Cuyama Valley and Carrizo Plain. Possible service to the Central Coastal Area under the Feather River Project is now (1957) being studied.

The Central Coastal Aqueduct would begin at a diversion from the San Joaquin West Side Conduit near Avenal Gap. Water would be pumped from the conduit and conveyed westerly to Avenal Gap Forebay, from which it would be lifted through a series of pumping plants and short canals up the easterly slope of the Cholame Hills to a 5.5-mile tunnel passing westerly through the hills into the Salinas Basin at an elevation of about 1,180 feet. From the westerly portal of the tunnel the aqueduct, in canal, would pass south of the communities of Shandon and Cholame and would discharge into Shedd Canyon Reservoir on Indian Creek. An irrigation supply of 60,000 acre-feet per season would be released for use on lands near the community of Cholame. The capacity of this initial reach of the aqueduct would be 2,200 second-feet, or twice the average flow rate, in order to utilize off-peak power, with resultant reduction in costs of electric energy.

Shedd Canyon Reservoir would provide regulation for delivery of 160,000 acre-feet per season for irrigation of lands along the easterly slope of upper Salinas Valley. The aqueduct would continue westerly from Shedd Canyon Reservoir to a crossing of Huerhuero Creek where a release of 115,000 acre-feet would be made to Huerhuero Reservoir, which would regulate the supply to a suitable demand schedule for delivery to lands along the upper Salinas River.

The Central Coastal Aqueduct would then continue from Huerhuero Creek westerly and southerly, passing east of Templeton, Atascadero, and Santa Margarita. An extended series of tunnels, totaling about 16 miles in length, would convey the water from the vicinity of Santa Margarita through the Santa Lucia Range to Tar Springs Reservoir, located on a tributary to Arroyo Grande Creek, about 8 miles east of Arroyo Grande. Tar Springs Reservoir would provide regulation for delivery of 30,000 acre-feet per season to the Arroyo Grande Valley and Nipomo Mesa on a monthly demand schedule. The aqueduct would then continue southerly, releasing 35,000 acre-feet per season for delivery to lands in the Nipomo Valley. After crossing the Cuyama River about 8 miles southeast of Nipomo, the aqueduct would convey water southeasterly along the edge of Sisquoc Valley to the Sisquoc River. Here 105,000 acre-feet per season would be released into Round Corral Reservoir for regulation and delivery to the Santa Maria Valley.

From the Sisquoc River the Central Coastal Aqueduct would pass southward through the Solomon Hills to San Antonio Creek, where a seasonal amount of 50,000 acre-feet would be released into the creek for delivery to lands in San Antonio Valley, thence southward an additional 12 miles to the vicinity of Los Olivos, where 100,000 acre-feet per season would be released in the Santa Rita Valley and in the Santa Ynez upland. The aqueduct would finally terminate at the existing Cachuma Reservoir, into which it would deliver a seasonal amount of 105,000 acre-feet. Cachuma Reservoir would reregulate this water and deliver it through the existing Tecolote Tunnel to the south slope of the Santa Ynez Mountains on a monthly demand schedule. Passage of peak flows through the tunnel would require installation of pumping facilities which would subject the tunnel to a 95-foot head, corresponding to the present operating head on the tunnel when water levels in Cachuma Reservoir are at maximum stage.

In providing the foregoing seasonal deliveries of 760,000 acre-feet of water to the Central Coastal Area, the Central Coastal Aqueduct would successively decrease from an initial capacity of 2,200 second-feet, representing an average flow of 1,100 second-feet, to a capacity of 300 second-feet at its terminus at Cachuma Reservoir. The total length of the aqueduct from the diversion point on the Main Aqueduct Route in the San Joaquin Valley to the terminus at Cachuma Reservoir would be about 207 miles.

Carrizo-Cuyama Aqueduct. The Carrizo-Cuyama Aqueduct would divert from the California Aqueduct route in the San Joaquin Valley about 5 miles south of the Buena Vista Forebay, and would deliver a seasonal amount of 325,000 acre-feet to water-deficient areas in the Cuyama Valley and Carrizo Plain, which delivery would meet the ultimate supplemental water requirements in those areas.

The Carrizo-Cuyama Aqueduct would begin at a canalside pumping plant located about 2 miles northeast of Maricopa. Water would be lifted up the easterly slope of the Temblor Range to an elevation of 2,500 feet by a series of four pumping plants so designed that they would operate only during periods of off-peak power demand. The final pumping plant would discharge water into two separate pipe lines. One line, the Carrizo Lateral, would continue westward and would discharge into a channel leading through the Elkhorn Plain to Elkhorn Reservoir about 8 miles southwest of Taft. The other line, the Cuyama Lateral, would turn southward to Bitterwater Afterbay on Bitterwater Creek, about 5 miles southwest of Maricopa. From this afterbay a 4-mile tunnel would pass southwesterly through the ridge to the Cuyama Valley.

Water would be diverted into the Cuyama Lateral only when needed and only in the amounts needed. Daily and weekly flow variations due to off-peak operation would be regulated in Bitterwater Afterbay. A total of 80,000 acre-feet of water per season would be delivered to Cuyama Valley, comprising 53,000 acre-feet for consumptive use, 4,000 acre-feet for evaporative losses, and 23,000 acre-feet for over-applications of irrigation water. These over-applications would return to the Cuyama River, thereby maintaining a favorable salt balance in the Cuyama Basin, and would become available for use downstream in the Santa Maria Valley.

The remaining 245,000 acre-feet of water per season delivered by the Carrizo-Cuyama Aqueduct would be conveyed in the Carrizo Lateral to Elkhorn Reservoir which would regulate the supply to a monthly demand schedule for the Carrizo Plain.

In order to provide for off-peak operation, the conveyance capacity of the Carrizo-Cuyama Aqueduct would be 900 second-feet, or twice the average diversion rate of 450 second-feet.

Summary of San Joaquin Division. The San Joaquin Division would deliver some 8,165,000 acre-feet per season of regulated waters from northern areas of surplus to the San Joaquin Valley and Central Coastal Area, and would transport an additional 9,100,000 acre-feet of water to the Buena Vista Forebay for delivery to areas south of the Tehachapi Mountains. Facilities of the division would consist of the Main Aqueduct Route, the Central Coastal Aqueduct, and the Carrizo-Cuyama Aqueduct. The Main

TABLE 25

SUMMARY OF SAN JOAQUIN DIVISION, CALIFORNIA AQUEDUCT SYSTEM

(These works show future development possibilities. They are not project proposals.)

Conveyance facilities	Conduits					Pumping plants		
	Maximum capacity, in second-feet	Length, in miles				Total number	Total installed capacity, in kilowatts	Total seasonal energy required, in kilowatt-hours
		Canal	Tunnel	Pipe	Total			
Main Conduit Route								
Delta-Mendota Canal	4,600	103			103	1	16,000	70,000,000
Feather River Project Aqueduct	11,000	264			264	2	450,000	920,000,000
San Joaquin West Side Conduit	14,400	245			245	3	409,000	3,100,000,000
Central Coastal Aqueduct	2,200	154.2	37.7	14.8	206.7	5	224,000	985,000,000
Carrizo-Cuyama Aqueduct	820			7.2	7.2	4	177,000	776,000,000
Cuyama Lateral	74		4.1	0.7	4.8			
Carrizo Lateral	338		0.5	0.7	1.2			
Totals		766.2	42.3	23.4	831.9	15	1,276,000	5,851,000,000

Reservoir[a]	Location, MDB&M, and sheet of Plate 5 on which shown		Type of dam	Storage capacity, in acre-feet	Normal pool elevation, in feet	Height of dam, in feet	Place of water use
Main Conduit Route							
San Luis Forebay[b]	Sec. 1, 12, T10S, R8E	11	E	[b]	225	60	[b]
San Luis Reservoir	Sec. 15, T10S, R8E	11	E	2,174,000	550	310	San Joaquin Valley and southern California
San Luis Afterbay[b]	Sec. 15, T10S, R8E	11	E	[b]	400	75	[b]
Central Coastal Aqueduct							
Avenal Gap Forebay[b]	Sec. 16, T24S, R19E	16	E	[b]			[b]
Shedd Canyon Reservoir	Sec. 26, T26S, R14E	16	E	81,000	1,188	188	Upper Salinas Valley
Huerhuero Reservoir	Sec. 9, T27S, R13E	16	E	40,000	997	144	Upper Salinas Valley
Tar Springs Reservoir	Sec. 15, T32S, R14E	16	E	10,000	650	140	Arroyo Grande Valley and Nipomo Mesa
Round Corral Reservoir	Sec. 22, T9N, R31W, SBB&M	20	E	45,000	875	226	Santa Maria Valley
Carrizo-Cuyama Aqueduct							
Elkhorn Reservoir	Sec. 4, 5, T32S, R22E	17	E	134,000	2,500	120	Carrizo Plain
Bitterwater Afterbay	Sec. 6, T10N, R24W, SBB&M	20	E	1,000	2,500	10	Cuyama Valley
Total				2,485,000			

Symbol of Type of Dam
E—Earthfill

[a] Provide regulation of imported water to monthly schedule in area served. San Luis Reservoir would also provide regulation for conveyance southward at a constant rate, and for ground water replenishment in San Joaquin Valley.

[b] Provide regulation for use of off-peak power.

Aqueduct Route would comprise the existing Delta-Mendota Canal and the proposed Feather River Project Aqueduct as its initial features, and the San Joaquin West Side Conduit which would complete the Main Aqueduct Route to its ultimate stage.

Combined seasonal conveyances to service areas in the San Joaquin Valley by the Delta-Mendota Canal and the Feather River Project Aqueduct would amount to some 7,080,000 acre-feet. An additional 640,000 acre-feet per season would be transferred from the Sacramento Valley to the easterly side of the lower San Joaquin Valley by the Folsom South Canal. Finally, the San Joaquin West Side Conduit would convey 10,185,000 acre-feet per season, of which 1,085,000 acre-feet would be delivered to the Central Coastal Area by the Central Coastal and Carrizo-Cuyama Aqueducts, and the foregoing 9,100,000 acre-feet would be transported to the Buena Vista Forebay of the Southern California Division. Thus, the total seasonal transfer of waters south of the Delta, with the exception of deliveries to the San Francisco Bay Area, would aggregate 17,905,000 acre-feet.

The total diversion capacity of the Main Aqueduct Route from the Delta would be 30,000 second-feet, distributed as follows: Delta-Mendota Canal, 4,600 second-feet; Feather River Project Aqueduct, 11,000 second-feet; and San Joaquin West Side Conduit, 14,400 second-feet, divided equally between its two component canals. The Delta-Mendota Canal is 103 miles in length, and terminates at Mendota Pool. The Feather River Project Aqueduct and the San Joaquin West Side Conduit, consisting of three generally parallel concrete-lined canals, would extend southward along the west side of the San Joaquin Valley about 70 miles to the San Luis Forebay, at which point the water would be lifted about 200 feet and the conduits would continue southerly an additional 180 miles to the Buena Vista Forebay.

San Luis Reservoir, a feature of the Main Aqueduct Route, would serve a three-fold purpose in providing temporary regulation of the water delivered by the foregoing facilities; namely (1) regulation to the variable monthly demand in the San Joaquin Valley, (2) regulation to a continuous flow to Buena Vista Forebay, and (3) regulation to rates within the absorptive capacity of soils overlying the ground water basin in San Joaquin Valley. Final regulation of the variable deliveries of water developed in the Sacramento Valley would be accomplished by the extensive ground water storage in the San Joaquin Valley.

The Central Coastal Aqueduct, diverting from the Main Aqueduct Route near Avenal Gap, would deliver 760,000 acre-feet per season over and through the Cholame Hills to the upper Salinas Basin and coastal area of San Luis Obispo County and the westerly portion of Santa Barbara County. The aqueduct would be 207 miles in length from the diversion point to its terminus at Cachuma Reservoir.

The Carrizo-Cuyama Aqueduct, diverting from the California Aqueduct route 5 miles south of the Buena Vista Forebay, would deliver 325,000 acre-feet of water through the Temblor Range at an elevation of 2,500 feet to the Cuyama Valley and to Carrizo Plain.

The general features of the San Joaquin Division are presented in Table 25 and the capital costs of its component facilities are shown in Table 26. The facilities comprising the division are shown on Sheets 8, 10, 11, 13, 14, 16, 17, and 20 of Plate 5.

TABLE 26

SUMMARY OF CAPITAL COSTS, SAN JOAQUIN DIVISION, CALIFORNIA AQUEDUCT SYSTEM

Item	Capital cost*
Main Conduit Route	
Feather River Project Aqueduct	
Conduit	$114,690,000
San Luis Reservoir	94,350,000
San Luis Forebay	1,520,000
Pumping Plant No. IIA	38,120,000
Pumping Plant No. IIB	30,930,000
San Joaquin West Side Conduit	
Conduit	505,190,000
Delta-Mendota Relift Pumping Plant	6,810,000
San Luis Pumping Plant No. 1	35,000,000
San Luis Pumping Plant No. 2	49,300,000
Buena Vista Pumping Plant	25,560,000
Subtotal	$901,470,000
Central Coastal Aqueduct (to Cachuma Reservoir)	
Conduit	$113,540,000
Avenal Gap Forebay	2,110,000
Shedd Canyon Reservoir	9,620,000
Huerhuero Reservoir	2,770,000
Tar Springs Reservoir	2,030,000
Round Corral Reservoir	6,660,000
Avenal Gap Pumping Plant	3,380,000
Badger Hill Pumping Plant	7,420,000
Wagon Wheel Pumping Plant	12,520,000
Sawtooth Pumping Plant	8,880,000
Aido Pumping Plant	8,280,000
Subtotal	$177,210,000
Carrizo-Cuyama Aqueduct	
Conduit	$16,940,000
Elkhorn Reservoir	6,210,000
Bitterwater Afterbay	1,160,000
Pumping Plant No. 1	5,240,000
Pumping Plant No. 2	5,240,000
Pumping Plant No. 3	5,240,000
Pumping Plant No. 4	8,700,000
Subtotal	$48,730,000
Total	$1,127,410,000

* At 1955 price levels.

Southern California Division

The Southern California Division of the California Aqueduct System would extend southward from Buena Vista Forebay through the Tehachapi Mountains to the Mexican border, and would serve supplemental water to the South Coastal Area, the southern portion of the Lahontan Area, and the Colorado Desert Area, excepting that portion having rights in and to the waters of the Colorado River. A supply of water in the amount of about 9,100,000 acre-feet per season would be conveyed through facilities of this division. Of this amount, about 2,880,000 acre-feet would be supplied to the South Coastal Area and the remainder would be delivered to the Lahontan and Colorado Desert Areas.

The Department of Water Resources is currently (May, 1957), conducting further engineering, geologic, and economic investigations of the Feather River Project Aqueduct system to determine the most feasible aqueduct routes to serve San Luis Obispo, Santa Barbara, and Kern Counties, Antelope Valley, and the South Coastal Area, preparatory to construction. Results of these studies are not yet sufficiently complete for inclusion herein, except with respect to the Second San Diego Aqueduct, subsequently described. Substantial modification of some of the aqueducts described herein, which are based on prior engineering studies, may be necessary, at least insofar as the Feather River Project is concerned. Should these studies demonstrate an advantage in utilizing the coastal route as the principal aqueduct location as compared to the so-called "high-line" route, the facilities leading to the South Coastal Area could be constructed on the alternative coastal alignment, as shown on Sheets 16, 20, and 21 of Plate 5, or along some modification of that alignment. However, the basic concepts and the areas to be served will remain the same, irrespective of the final locations of the aqueducts, when constructed.

The Tehachapi Mountains at the southern end of the San Joaquin Valley constitute a formidable barrier to transfer of water from the valley to the South Coastal Area. Prior studies for the Feather River Project demonstrated the engineering feasibility of an aqueduct route passing through the Tehachapi Mountains at an elevation of about 3,350 feet, crossing Antelope Valley, passing along the north edge of the San Gabriel and San Bernardino Mountains, and leading into the South Coastal Area at Cajon Pass near San Bernardino.

The Southern California Division, as presently conceived, would include pumping facilities and tunnels through the Tehachapi Mountains. Off-peak power would be utilized to lift the water to the tunnels, and the more valuable on-peak power would be generated by that portion of the water supply delivered to lands at lower elevations in the South Coastal Area. In order to make it possible to pump only during periods of off-peak power demand, thereby minimizing demand charges for pumping power, forebay and afterbay storage reservoirs would be provided along the aqueduct route. Deliveries of supplemental water to the service areas of the Southern California Division would be effected at various strategic locations by several aqueduct routes. These routes and points of delivery were selected mainly on the basis of integration with and utilization of existing water supply and distribution facilities, in order to avoid unnecessary overlap and duplication of such works. The effects of the physical characteristics of the service areas with respect to regulation and distribution of the supplemental supply were also considered.

For purposes of presentation herein, the Southern California Division has been divided into seven units, which are discussed in the following order: Buena Vista-Cedar Springs Aqueduct, which, in addition to carrying water to aqueducts farther south, would serve the extreme southern portion of San Joaquin Valley, the Antelope Valley, and the desert areas to the east; San Fernando-Ventura Aqueduct which would serve the San Fernando Valley, the coastal plains of Los Angeles and Ventura Counties, the Malibu area, and upper Santa Clara River Valley; Devil Canyon Power Development, which would deliver water through the San Bernardino Power Plant to spreading grounds in upper Santa Ana Valley and to the Chino-San Gabriel and Barona Aqueducts; Chino-San Gabriel Aqueduct, which would serve upper Santa Ana and San Gabriel Valleys; Second San Diego Aqueduct, which, by coordinated operation with the existing San Diego Aqueduct, the Barona Aqueduct, and the facilities of the San Diego High-Line Aqueduct, could supply the ultimate requirements in San Diego and southwestern Riverside Counties; Barona Aqueduct, which would serve lower-lying lands in upper Santa Ana Valley, San Jacinto Valley, and in Orange, San Diego, and southwestern Riverside Counties; and San Diego High-Line Aqueduct, which would serve the higher portions of the upper Santa Ana and San Jacinto Valleys, the San Gorgonio Pass area and desert lands to the east, high lands in Riverside and San Diego Counties, and the Borrego Valley area.

The general location of the Southern California Division is shown on Plate 6, and its component features are delineated on Sheets 17, 20, 21, 22, 24, 25, and 26 of Plate 5.

Buena Vista-Cedar Springs Aqueduct. The Buena Vista-Cedar Springs Aqueduct would comprise two conduits extending from Buena Vista Forebay in the San Joaquin Valley to Cedar Springs Forebay on the desert side of the San Bernardino Mountains, and a system of lateral aqueducts serving the Lahontan and Colorado Desert areas. One of these conduits, designated the "Upper Aqueduct," would comprise the facilities under consideration for the high-line route of the Feather River Project Aqueduct as far as Quail Lake Reservoir, and would be the initial stage of the Buena Vista-Cedar Springs Aqueduct. A second conduit would be required in the future for ultimate delivery of water to Cedar Springs Forebay. This conduit is designated the "Lower Aqueduct," and would generally parallel the alignment of the Upper Aqueduct, but at a lower elevation.

The Upper Aqueduct would convey water from Buena Vista Forebay at a minimum elevation of 327 feet, through a series of 4 pumping plants and some 45 miles of canal, tunnel, and pipe line, to the inlet portal of a tunnel through the Tehachapi Mountains at an elevation of 3,357 feet, about 6 miles east of Grapevine. The aqueduct would pass about 3 miles northeast of Maricopa and 2 miles west of Wheeler Ridge on its course up the northerly slope of the Tehachapis. Two consecutive tunnels, totaling 10.5 miles in length, would deliver the water southeasterly through the Tehachapis to Quail Lake Reservoir, which would be formed by enlarging the existing Quail Lake. About 1,000,000 acre-feet of water per season would be diverted from Quail Lake Reservoir into the San Fernando-Ventura Aqueduct, as hereinafter described.

As stated, the section of the Upper Aqueduct from Buena Vista Forebay to Quail Lake Afterbay would comprise the facilities of the high-line route for the Feather River Project Aqueduct. It would have a conveyance capacity of 6,000 second-feet, and would deliver a seasonal supply of about 1,800,000 acre-feet to Quail Lake Reservoir, at an elevation of about 3,300 feet. The aqueduct and pumping plants would be designed to operate to the greatest extent feasible during periods of off-peak power demand, in order to utilize less costly electric energy available during such periods. In addition to the large forebay and afterbay capacities required for off-peak pumping, small reservoirs at each pumping plant would provide for the necessary flexibility of operation.

From Quail Lake Reservoir the Upper Aqueduct would extend southeasterly along the south edge of Antelope Valley, and would terminate in Cedar Springs Forebay, about 9 miles south of Hesperia in the southern portion of the Mojave Desert, at an elevation of 3,252 feet. The Upper Aqueduct between Quail Lake and Cedar Springs Forebay would be constructed on grade, and would consist of cut-and-cover conduit, tunnels, and canal sections. The capacity of the aqueduct in this reach would be 1,300 second-feet, and it would deliver about 800,000 acre-feet per season to Cedar Springs Forebay.

Construction of the Lower Aqueduct would complete the Buena Vista-Cedar Springs Aqueduct to its ultimate stage. The Lower Aqueduct would have a greater capacity than the Upper Aqueduct, diverting a seasonal supply of 7,301,000 acre-feet. The Lower Aqueduct would generally parallel the route of the Upper Aqueduct, at a higher elevation north of Wheeler Ridge and at a lower elevation south of that point. As presently conceived, the Lower Aqueduct would be constructed in stages and would probably consist of two aqueduct units.

The Lower Aqueduct would convey water from Buena Vista Forebay to Antelope Afterbay, located about 3 miles northeast of Quail Lake Reservoir, in twin parallel conduits. Between Buena Vista Forebay and the tunnels through the Tehachapi Mountains, the aqueduct would consist of about 45 miles of canal, pipe line, and short tunnels through the Buena Vista Hills and Wheeler Ridge. Three pumping plants would lift the water from an elevation of 327 feet in the Buena Vista Forebay to 3,140 feet at the inlet portal of the Tehachapi tunnels. These tunnels would be approximately 9 miles in length, and would terminate at the Antelope Afterbay, with a maximum water surface elevation of 3,095 feet. The reach of the Lower Aqueduct just described would have a design capacity of 24,600 second-feet, equally divided between component twin conduits. The aqueduct and pumping plants would also be operated to utilize off-peak energy, and the necessary forebay and afterbay capacity would be provided.

From Antelope Afterbay, the Lower Aqueduct would extend southeasterly nearly 100 miles along the southerly edge of the Antelope Valley, terminating in Cedar Springs Forebay. This section of the aqueduct would consist of a single canal with an initial capacity of 9,000 second-feet at the Antelope Afterbay, and would be progressively reduced to 2,500 second-feet at the point of discharge in Cedar Springs Forebay. Diversions totaling 5,710,000 acre-feet per season would be made along the route to laterals comprising the Antelope-Majove Aqueduct system. The remaining 1,535,000 acre-feet per season would be lifted into Cedar Springs Reservoir at an elevation of 3,253 feet, by a pumping plant near Hesperia.

San Fernando-Ventura Aqueduct. The San Fernando-Ventura Aqueduct would extend southerly from Quail Lake Reservoir and then westerly to deliver about 1,000,000 acre-feet of water per season from the Buena Vista-Cedar Springs Aqueduct to San Fernando Valley and the coastal plain of Los Angeles County, Ventura County, the Malibu area, and the upper Santa Clara River Valley.

Beginning at Quail Lake Reservoir at an elevation of 3,300 feet, the San Fernando-Ventura Aqueduct would pass southerly about 22 miles to Castaic Creek Reservoir in a short canal section and a series of tunnels through the divide between Antelope Valley and the Santa Clara River drainage area. Castaic Creek Reservoir would be located on Castaic Creek, a tributary of the Santa Clara River, about 3 miles north of Castaic Junction. Power would be developed enroute along the aqueduct by a power drop of about 700 feet into Liebre Gulch, where regulatory storage capacity would be provided by construction of the Liebre Gulch Afterbay. Power would also be developed by construction of a power plant at Castaic

Creek Reservoir, utilizing available head of about 1,100 feet.

The San Fernando-Ventura Aqueduct between Quail Lake and Castaic Creek Reservoirs would have a capacity of 3,100 second-feet, and would be operated only during periods of on-peak power demand. Castaic Creek Reservoir would provide regulation of the fluctuating discharge of the aqueduct to the monthly demand schedules in the aqueduct service area. The upper Santa Clara River Valley would be served 68,000 acre-feet of water per season directly from this reservoir.

From Castaic Creek Reservoir the San Fernando-Ventura Aqueduct, with an initial elevation of 1,250 feet, would continue southerly to a 5-mile tunnel, in the vicinity of Newhall, passing through the divide between the upper Santa Clara River and San Fernando Valleys. The tunnel outlet portal would be about 1 mile to the west of the existing Upper San Fernando Reservoir of the City of Los Angeles Department of Water and Power. Here a seasonal supply of water of 717,000 acre-feet would be delivered, at an elevation of 1,160 feet, on a monthly demand schedule, for use in the San Fernando Valley and coastal plain of Los Angeles County.

From the tunnel portal, the San Fernando-Ventura Aqueduct, with a capacity of 300 second-feet, would continue westerly, delivering 215,000 acre-feet per season into Ventura County on a uniform flow basis. Enroute, the aqueduct would pass through the Simi Hills, near the town of Chatsworth, and into the Simi Valley. It would extend along the southerly side of Simi Valley to terminate in Conejo Reservoir, immediately above Santa Rosa Valley about 6 miles east of Camarillo. Conejo Reservoir, with a maximum water surface elevation of 398 feet, would provide terminal storage for aqueduct supplies delivered to the Ventura County service area. Deliveries to lands between the Simi Hills tunnel and the reservoir would be made directly from the aqueduct. Water service would be provided from Conejo Reservoir to the Oxnard Plain area, the Calleguas Creek drainage area, and the Ventura River Basin. If desired, water deliveries could also be made to the vicinity of Santa Barbara by extending the aqueduct and increasing its capacity.

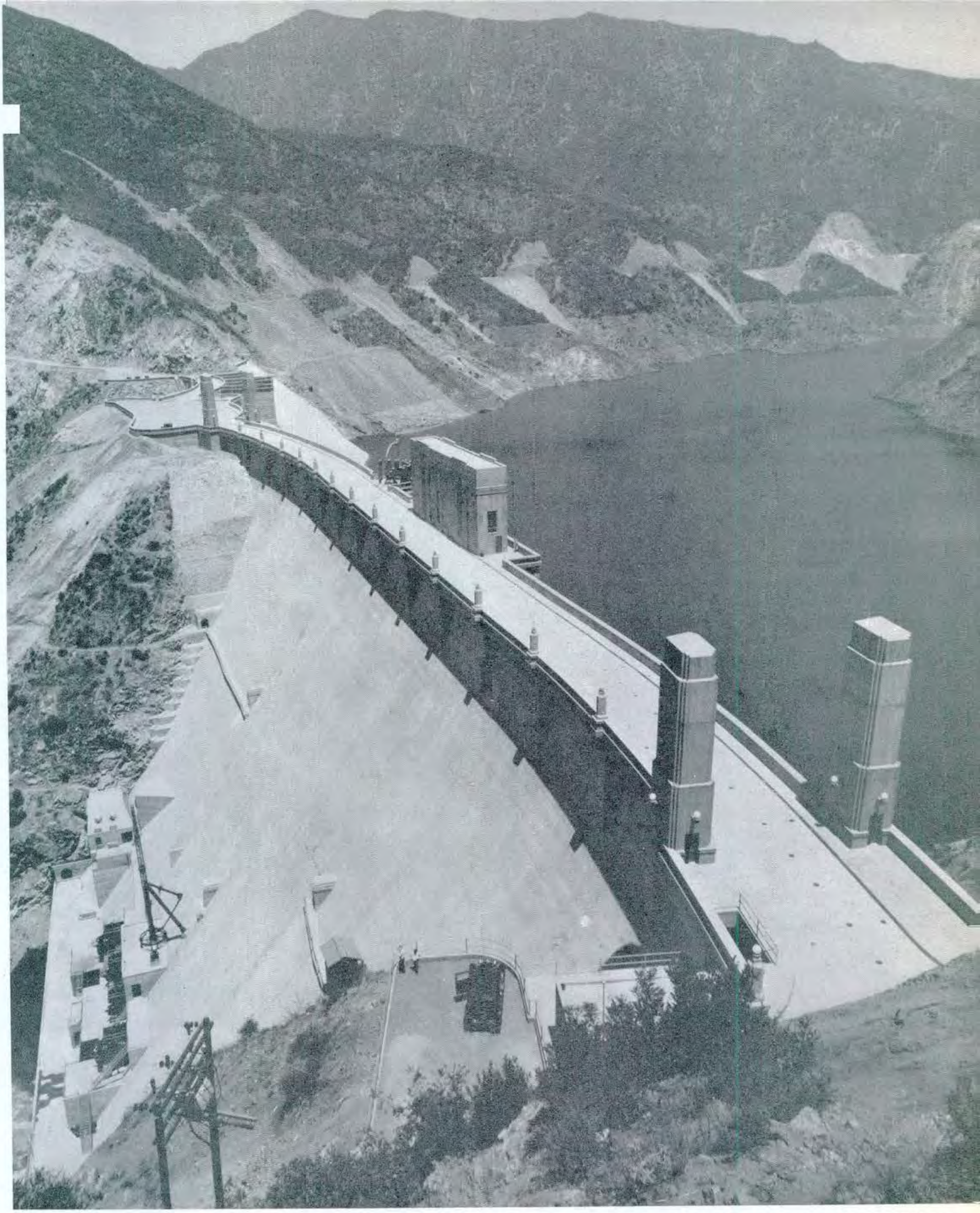
Devil Canyon Power Development. Facilities of the Devil Canyon Power Development would generate power by a 1,340-foot drop through the San Bernardino Power Plant at the base of the San Bernardino Mountains, and would deliver about 1,510,000 acre-feet per season for further conveyance by the Chino-San Gabriel and Barona Aqueducts, subsequently described. The power development aqueduct would lead southerly from Cedar Springs Reservoir, at an elevation of about 3,222 feet, through the San Bernardino Mountains in a 5-mile tunnel parallel to that of the previously mentioned San Diego High-Line Aqueduct. From the tunnel outlet near the junction of Devil Canyon with its east fork, the aqueduct would continue southward, crossing the east fork in siphon and entering penstocks to the San Bernardino Power Plant immediately north of the City of San Bernardino. The aqueduct would extend eastward from the power plant tailrace by pipe line to the Arrowhead Springs Afterbay on East Twin Creek. The Twin and Waterman spreading grounds in the upper Santa Ana Valley would be supplied about 64,000 acre-feet per season directly from the reservoir.

The San Bernardino Power Plant would be operated only during periods of peak power demand, and would have an installed capacity of 400,000 kilowatts. Arrowhead Springs Afterbay would provide reregulation of the power releases to a uniform delivery for further conveyance to service areas.

Chino-San Gabriel Aqueduct. The Chino-San Gabriel Aqueduct would divert at a hydraulic grade line elevation of about 1,760 feet from a low point in the pipe line connecting the tailrace of the San Bernardino Power Plant and Arrowhead Springs Afterbay, and would proceed, in pipe line, westerly along the base of the San Bernardino Mountains a distance of 35 miles, to a terminus in the existing Morris Reservoir on the San Gabriel River at an elevation of about 1,150 feet. The aqueduct would deliver a seasonal supply of 429,000 acre-feet to the upper Santa Ana and San Gabriel Valleys.

Arrowhead Springs Afterbay would provide regulation of the tailwater from the San Bernardino Power Plant to a continuous flow in the Chino-San Gabriel Aqueduct by releases thereto during periods when the power plant would not be in operation, thus reversing the direction of flow. Water would be released from the aqueduct to spreading grounds overlying the Chino and other smaller ground water basins for regulation and distribution by underground storage. Direct water service could also be provided from the aqueduct to lands in the vicinity. By terminating the aqueduct in Morris Reservoir, a physical connection would be provided with the artificial recharge facilities of the Los Angeles County Flood Control District in the San Gabriel Valley and Montebello Forebay area of the coastal plain of Los Angeles County and to the facilities of The Metropolitan Water District of Southern California.

Second San Diego Aqueduct. Pursuant to provisions of the Budget Act of 1956 of the California Legislature, the Department of Water Resources recently completed a detailed investigation of alternative routes for the next aqueduct to San Diego County and the most economical capacity thereof. The facilities of the Second San Diego Aqueduct described in



Southern California Division—The Proposed Terminal for the Chino-San Gabriel Aqueduct—Morris Reservoir Near Pasadena the ensuing paragraphs were developed from this more detailed investigation.

The Second San Diego Aqueduct would originate at the west portal of the San Jacinto Tunnel of the Colorado River Aqueduct with a hydraulic grade line elevation of 1,500 feet, and would extend southerly, to the west of and generally paralleling the existing San Diego Aqueduct, to a terminus in Minnewawa Reservoir on Jamul Creek, a few miles southwest of the City of San Diego. Although located at a lower elevation, the aqueduct generally would have a hydraulic gradient equivalent to that of the existing San Diego Aqueduct.

The Second San Diego Aqueduct would follow a generally southwesterly alignment to Auld Valley Reservoir and then would continue south and west to Rainbow Pass. At this point, it would generally parallel U. S. Highway 395 South, passing to the west of the City of Escondido and crossing the San Dieguito River about 1 mile west of Lake Hodges. The aqueduct would cross the San Diego River in the vicinity of Mission Gorge, extending southerly immediately above Murray Reservoir, and would cross the Sweetwater River immediately below Sweetwater Reservoir. It would then bear easterly to terminate in Minnewawa Reservoir with a hydraulic grade line elevation of about 700 feet. The aqueduct would consist of canal and pressure conduit and would have a capacity varying from 1,000 second-feet at San Jacinto Junction to 196 second-feet at Minnewawa Reservoir.

By originating at the west portal of the San Jacinto Tunnel, the Second San Diego Aqueduct would be so located as to enable physical connection with the facilities of existing water service agencies, as well as to make available supplemental water to lands not now provided with water service. Initially, the aqueduct could take surplus water from the Colorado River Aqueduct. Then at a future time, upon construction of the Barona Aqueduct, Colorado River water could be replaced by water transported from northern California by facilities of the California Aqueduct System. By coordinated operation of the Second San Diego Aqueduct with the facilities of the existing San Diego Aqueduct, the Barona Aqueduct, and the San Diego High-Line Aqueduct, the ultimate requirements for imported water in San Diego and southwestern Riverside Counties, in the amount of about 1,300,000 acre-feet per season, could be supplied.

Because of the urgency of need for additional water in San Diego County, The Metropolitan Water District of Southern California and the San Diego County Water Authority, as stated earlier in this chapter, propose to start construction in 1957 of an aqueduct along the same general alignment as herein discussed for the Second San Diego Aqueduct, but, at least in part, at about half the capacities contemplated herein. This aqueduct will convey temporarily surplus Colorado River water to San Diego County, and could later be used, as previously discussed, for conveyance of northern California water when it becomes available. Although there is now available surplus Colorado River water which can be used in San Diego County on an interim basis, it is not a firm supply because of the growing needs for Colorado River water by other entities in The Metropolitan Water District of Southern California. As previously stated, the estimated entitlement of the San Diego County Water Authority to water from the Colorado River is substantially less than is now being delivered through existing facilities.

Barona Aqueduct. The Barona Aqueduct is the major conveyance facility by which northern California waters would be delivered to the lower-lying lands south of the San Bernardino Mountains. From this aqueduct about 1,020,000 acre-feet of water per season would be delivered to the upper Santa Ana Valley, San Jacinto Valley, and to Orange, San Diego, and southwestern Riverside counties.

The Barona Aqueduct would originate at the Arrowhead Springs Afterbay of the Devil Canyon Power Development, at an elevation of 1,760 feet, and would extend southerly along the easterly periphery of upper Santa Ana Valley in pressure conduit and a 3.6-mile tunnel through the Badlands area south of San Timeteo Creek. It would then continue southeasterly along the San Jacinto River to a connection with the Colorado River Aqueduct of The Metropolitan Water District of Southern California at the westerly portal of the San Jacinto Tunnel, at an elevation of about 1,700 feet.

From the San Jacinto Junction the Barona Aqueduct, in pressure conduit, would parallel the existing San Diego Aqueduct southwesterly for a distance of about 15 miles to a point in French Valley within the watershed of Temecula Creek. The elevation of the hydraulic grade line in the foregoing reach would be about 200 feet above that of the existing San Diego Aqueduct. From French Valley, the aqueduct would continue southerly to a terminus in Barona Reservoir, a distance of 48 miles, again generally paralleling the existing San Diego Aqueduct, but at a distance of from 2 to 3 miles to the east. The hydraulic grade line elevation of this aqueduct generally would be 200 feet above that of the San Diego Aqueduct, with the difference increasing to about 750 feet at their respective points of terminus in San Vicente and Barona Reservoirs.

The Barona Aqueduct would terminate at Barona Reservoir at an elevation of 1,390 feet. Barona Reservoir would be located on Barona Creek, a tributary of San Vicente Creek which, in turn, is part of the San Diego River watershed. The Barona dam site is but a short distance easterly of the existing San Vicente Reservoir, presently utilized for regulatory storage for the existing San Diego Aqueduct supply.

The Barona Aqueduct would have an initial capacity of 1,540 second-feet, decreasing to 350 second-feet at Barona Reservoir. Between Arrowhead Springs Afterbay and the San Jacinto Junction, 200,000 acre-feet of water per season would be delivered to spreading grounds in the Bunker Hill Basin of San Bernardino County and to water service areas in that vicinity. Direct deliveries from the aqueduct in the amount of about 60,000 acre-feet per season would also be made to the San Jacinto Valley. The residual capacity at the San Jacinto Junction would be 1,400 second-feet, and a seasonal supply of 757,000 acre-feet would be provided at this point for delivery to the San Jacinto Valley and to areas to the south in San Diego County.

At the San Jacinto Junction it would be physically possible to deliver water to Lake Mathews through the existing Colorado River Aqueduct, the existing San Diego Aqueduct, and the proposed second San Diego Aqueduct of the San Diego County Water Authority.

The Colorado River supply of The Metropolitan Water District of Southern California could, if desired, be pumped into the Barona Aqueduct for delivery to the south. Thus, the San Jacinto Junction would provide a physical connection with the facilities of major distributors of imported water in the South Coastal Area, thereby allowing flexibility of operation.

As described earlier in this chapter under the heading "Development to Meet Local Requirements," the Barona Aqueduct south of the San Jacinto Junction, the existing San Diego Aqueduct, and the Second San Diego Aqueduct would be operated as an integrated system. Direct water service would be provided to lands along the Barona Aqueduct route and through distributaries southerly of the Barona Reservoir.

San Diego High-Line Aqueduct. The San Diego High-Line Aqueduct would extend southerly from Cedar Springs Forebay, terminal of the Buena Vista-Cedar Springs Aqueduct, through the San Bernardino Mountains, generally following the alignment of the high-line route of the Feather River Project Aqueduct to a terminus at Horsethief Canyon in San Diego County, near the Mexican border. This aqueduct would convey about 825,000 acre-feet per season, of which 368,000 acre-feet would be delivered to the South Coastal Area and 457,000 acre-feet would be conveyed to the Colorado Desert Area.

A 3.9-mile tunnel and 0.5-mile section of cut-and-cover conduit would convey water southerly from the Cedar Springs Forebay at an elevation of 3,222 feet, to Devil Canyon. The San Diego High-Line Aqueduct would then continue generally on grade through a series of tunnels passing to the north and east of the Cities of San Bernardino and Redlands, and crossing San Gorgonio Pass in a siphon between the Cities of Beaumont and Banning. From San Gorgonio Pass, the aqueduct would bear southerly along the westerly slope of the San Jacinto Mountains, passing above Lake Henshaw on the San Luis Rey River, and extending through a series of tunnels to a terminus at Horsethief Canyon, a tributary of Cottonwood Creek above Barrett Reservoir. Regulatory storage would be provided along the aqueduct route by Santa Ysabel Reservoir on Santa Ysabel Creek, a tributary of San Dieguito River. This reservoir would have a maximum water surface elevation of 2,975 feet, which would be about 250 feet above the hydraulic gradient of the aqueduct at this point.

The San Diego High-Line Aqueduct would have an initial capacity of 1,300 second-feet, and would progressively reduce to a terminal capacity at Horsethief Canyon of 180 second-feet, at an elevation of 2,600 feet. Deliveries to high lands in the upper Santa Ana and San Jacinto Valleys, to the San Gorgonio Pass area and desert lands to the east, and to high lands in Riverside and San Diego Counties, would be made directly from the aqueduct. Near Lake Henshaw, a diversion by tunnel on a continuous flow basis would be made to the Borrego Valley area.

During winter months of low demand, flow in the San Diego High-Line Aqueduct in excess of demand would be pumped into Santa Ysabel Reservoir for storage. During summer months, when deliveries from the aqueduct north of Santa Ysabel Reservoir would be at a maximum, releases would be made from the reservoir to meet demands of areas to the south. About 85,000 acre-feet of water per season would also be provided from the aqueduct to Barona Reservoir by the Barona High-Line Interconnection for use on lower-lying lands.

Summary of Southern California Division. The Southern California Division would deliver some 9,100,000 acre-feet per season through the Tehachapi Mountains to the South Coastal Area, the southern portion of the Lahontan Area, and portions of the Colorado Desert Area. Of this amount, 2,880,000 acre-feet would be supplied to the South Coastal Area, 4,830,000 acre-feet would be delivered to the Lahontan Area, and 1,390,000 acre-feet would be available for use in the Colorado Desert Area. Off-peak power would be utilized to lift the water to tunnels through the Tehachapi Mountains, and on-peak power would be generated by that portion of the water supply delivered to lands at lower elevations in southern California.

The Buena Vista-Cedar Springs Aqueduct would extend from Buena Vista Forebay in the San Joaquin Valley to Cedar Springs Forebay on the desert side of the San Bernardino Mountains. It would comprise two conduits, the Upper Aqueduct and the Lower Aqueduct. The Upper Aqueduct would consist of the facilities of the high-line route of the Feather River Project Aqueduct as far as Quail Lake Reservoir, and would deliver 1,800,000 acre-feet of water per season to that reservoir. The Lower Aqueduct would complete the Buena Vista-Cedar Springs Aqueduct to its ultimate stage, conveying a seasonal supply of 7,300,000 acre-feet through the Tehachapi Mountains, for service to the Antelope Valley and desert areas to the east in the amount of 5,710,000 acre-feet, and delivering 1,560,000 acre-feet to Cedar Springs Reservoir.

The San Fernando-Ventura Aqueduct would deliver about 1,000,000 acre-feet of water per season from Quail Lake Reservoir to the San Fernando Valley and coastal plain of Los Angeles County, Ventura County, the Malibu area, and the upper Santa Clara River Valley.

The Devil Canyon Power Development would generate power by dropping 1,510,000 acre-feet per season of water from the Cedar Springs Forebay through the San Bernardino Power Plant at the base of the San Bernardino Mountains. The water would then be conveyed easterly to the Arrowhead Springs Afterbay on East Twin Creek.

The Chino-San Gabriel Aqueduct would divert from the aqueduct of the Devil Canyon Power Development, and would deliver a seasonal supply of about 429,000 acre-feet to the upper Santa Ana and San Gabriel Valleys, terminating in Morris Reservoir.

The Second San Diego Aqueduct would extend generally southerly about 90 miles from the west portal of the San Jacinto Tunnel of the Colorado River Aqueduct to a terminus in Minnewawa Reservoir on Jamul Creek near the City of San Diego. The aqueduct would generally parallel the route of the existing San Diego Aqueduct, and its coordinated operation with facilities of the existing San Diego Aqueduct, the Barona Aqueduct, and the San Diego High-Line Aqueduct would make available 1,300,000 acre-feet of water per season to lands in San Diego and southwestern Riverside Counties.

The Barona Aqueduct would deliver about 1,020,000 acre-feet of water per season to the lower-lying lands south of the San Bernardino Mountains. The aqueduct would originate at the Arrowhead Springs Afterbay of the Devil Canyon Power Development, and would extend southerly to a connection with the Colorado River Aqueduct at the westerly portal of the San Jacinto Tunnel. From this point the aqueduct would continue southerly some 50 miles, generally paralleling, but to the east of, the existing San Diego Aqueduct, and would terminate in Barona Reservoir near Ramona. The Barona Aqueduct would make seasonal deliveries of 200,000 acre-feet to the water-spreading grounds in the Bunker Hill Basin of San Bernardino County, and 820,000 acre-feet to the San Jacinto Valley and to areas to the south in San Diego County. The Barona, existing San Diego, and Second San Diego Aqueducts would be operated on an integrated system.

The San Diego High-Line Aqueduct would extend southerly from Cedar Springs Forebay, through the San Bernardino Mountains, generally following the alignment of the high-line route of the Feather River Project Aqueduct, to a terminus at Horsethief Canyon in San Diego County, near the Mexican border.

TABLE 27

SUMMARY OF SOUTHERN CALIFORNIA DIVISION, CALIFORNIA AQUEDUCT SYSTEM

(These works show future development possibilities. They are not project proposals.)

Conveyance facilities	Conduits					Pumping plant		
	Maximum capacity, in second-feet	Length, in miles				Total number	Total installed capacity, in kilowatts	Total seasonal power consumption, in kilowatt-hours
		Canal	Tunnel	Pipe	Total			
Buena Vista-Cedar Springs Aqueduct								
Feather River Project Aqueduct	6,000	163.8	14.6	6.3	184.7	4	837,000	6,874,000,000
Lower Aqueduct	24,600	160.9	3.9	3.9	168.7	4	7,114,000	23,635,000,000
Antelope-Mojave Aqueduct system	7,420	1,081.2	6.7	44.8	1,132.7	7	537,000	2,064,000,000
San Fernando-Ventura Aqueduct	3,100	1.9	19.3	39.4	60.6			
Devil Canyon Power Development	4,680		4.8	5.8	10.6			
Chino-San Gabriel Aqueduct	600		1.8	33.6	35.4			
Second San Diego Aqueduct	500			90.6	90.6			
Barona Aqueduct	1,540		4.3	96.3	100.6			
San Diego High-Line Aqueduct (Feather River Project)	1,300	33.2	91.4	15.0	139.6	1	7,000	20,000,000
Whitewater Aqueduct	229	24.2		1.1	25.3			
San Felipe Aqueduct	316	53.4	9.0	2.5	64.9			
Barona-High Line Interconnection	140			8.4	8.4			
Totals		1,518.6	155.8	347.7	2,022.1	16	8,495,000	32,593,000,000

TABLE 27—Continued

SUMMARY OF SOUTHERN CALIFORNIA DIVISION, CALIFORNIA AQUEDUCT SYSTEM

(These works show future development possibilities. They are not project proposals.)

Power plant	Location, SBB&M, and sheet of Plate 5 on which shown		Average head, in feet	Installed capacity, in kilowatts	Average annual energy generation, in kilowatt-hours
Buena Vista-Cedar Springs Aqueduct					
Antelope-Mojave Aqueduct System[a]		b	a	222,000	1,090,000,000
San Fernando-Ventura Aqueduct					
Liebre Gulch	Sec. 4, T6N, R17W	21	737	168,000	651,600,000
Castaic Creek	Sec. 2, T5N, R17W	21	1,077	244,000	951,900,000
Devil Canyon Power Development					
San Bernardino	Sec. 31, T2N, R4W	22	1,337	400,000	1,570,500,000
San Diego High-Line Aqueduct					
Banning	Sec. 5, T3S, R1E	24	500	8,200	67,800,000
Hathaway	Sec. 35, T2S, R1E	24	144	2,200	14,500,000
Cabazon	Sec. 9, T3S, R2E	24	691	9,400	54,500,000
Whitewater	Sec. 9, T3S, R3E	24	339	2,100	14,600,000
San Felipe	Sec. 33, T12S, R5E	25	407	12,900	54,000,000
Narrows	Sec. 12, T12S, R6E	25	494	17,400	68,300,000
Kane Springs	Sec. 34, T12S, R8E	25	572	4,600	40,000,000
Totals				1,090,800	4,577,700,000

[a] From preliminary plans prepared for water distribution in the high desert areas when the need develops. Individual works are not shown.
[b] Not shown on Plate 5.

TABLE 27—Continued

SUMMARY OF SOUTHERN CALIFORNIA DIVISION, CALIFORNIA AQUEDUCT SYSTEM

(These works show future development possibilities. They are not project proposals.)

Reservoir	Location, SBB&M, and sheet of Plate 5 on which shown		Type of dam	Height of dam, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet	Purpose	Place of water use
Buena Vista-Cedar Springs Aqueduct Route								
Quail Lake Reservoir	Sec. 13, T8N, R18W	21	E	29	3,343	16,200	OP	
Buena Vista Forebay	Sec. 26, T31S, R24E, MDB&M	17	E	55	350	49,000	OP	
Antelope Afterbay	Sec. 3, T8N, R17W	21	E	100	3,095	42,000	OP	
Cedar Springs Forebay	Sec. 32, T3N, R4W	22	E	111	3,252	14,200	OP	
San Fernando-Ventura Aqueduct								
Liebre Gulch Afterbay	Sec. 9, T6N, R17W	21	E	250	2,500	9,400	P	
Castaic Creek Reservoir	Sec. 18, T5N, R16W	21	E	192	1,377	100,000	S	Upper Santa Clara Valley-Los Angeles County
Conejo Reservoir	Sec. 25, T2N, R20W	21	E	185	398	37,000	S	Ventura County
Devil Canyon Power Development								
Arrowhead Springs Afterbay	Sec. 11, T1N, R4W	22	E	313	1,850	12,200	P	Los Angeles County
Chino-San Gabriel Aqueduct (transmission only)								
Second San Diego Aqueduct								
Keys Canyon Reservoir	Sec. 18, T10S, R2W	24	E	270	765	70,000	S	San Diego County
Enlarged Lower Otay Reservoir	Sec. 18, T18S, R1E	26	CG	200	527	112,000	S	San Diego County
Barona Aqueduct								
Barona Reservoir	Sec. 28, T14S, R1E	26	E	150	1,390	55,000	S	San Diego County
San Diego High-Line Aqueduct								
San Felipe Reservoir	Sec. 22, T12S, R5E	25	E	103	2,237	10,000	S	Salton Sea area
Santa Ysabel Reservoir	Sec. 19, T12S, R3E	24	E	240	2,975	75,000	S	San Diego County
Total						602,000		

Symbols of Type of Dam
E—Earthfill
CG—Concrete gravity

Symbols of Purpose
OP—Regulation for use of off-peak power
P—Power generation
S—Reregulation of waters to local demand schedule

This aqueduct would convey about 825,000 acre-feet per season, of which 368,000 acre-feet would be delivered to the South Coastal Area and 457,000 acre-feet would be conveyed to the Colorado Desert Area.

TABLE 28

SUMMARY OF CAPITAL COSTS, SOUTHERN CALIFORNIA DIVISION, CALIFORNIA AQUEDUCT SYSTEM

Item	Capital cost*
Buena Vista-Cedar Springs Aqueduct	
Feather River Project Aqueduct	$251,470,000
Pumping Plant No. III	13,060,000
Pumping Plant No. IV	16,790,000
Pumping Plant No. V	31,560,000
Pumping Plant No. VI	74,410,000
Quail Lake Reservoir	500,000
Cedar Springs Forebay	4,870,000
Upper Aqueduct	593,820,000
Pumping Plant No. 4	79,640,000
Pumping Plant No. 5	123,400,000
Pumping Plant No. 6	406,000,000
Pumping Plant No. 7	11,290,000
Buena Vista Forebay	6,940,000
Antelope Afterbay	10,330,000
Antelope-Mojave Aqueduct System	410,000,000
Subtotal	$2,034,080,000
San Fernando-Ventura Aqueduct	
Conduit	$142,570,000
Liebre Gulch Power Plant	17,720,000
Liebre Gulch Reservoir	3,130,000
Castaic Creek Power Plant	23,590,000
Castaic Creek Reservoir	18,740,000
Conejo Reservoir	5,030,000
Subtotal	$210,780,000
Devil Canyon Power Development	
Conduit	$87,161,000
San Bernardino Power Plant	41,320,000
Arrowhead Springs Afterbay	16,500,000
Subtotal	$144,981,000
Chino-San Gabriel Aqueduct	
Conduit	$16,153,000
Second San Diego Aqueduct	
Conduit	$63,700,000
Keys Canyon Reservoir	5,701,000
Enlarged Lower Otay Reservoir	3,045,000
Subtotal	$72,446,000
Barona Aqueduct	
Conduit	$178,934,000
Barona Reservoir	2,156,000
Subtotal	$181,090,000
San Diego High-Line Aqueduct (Feather River Project)	
Conduit	$230,880,000
Santa Ysabel Pumping Plant	1,450,000
Santa Ysabel Reservoir	7,230,000
Whitewater Aqueduct	
Conduit	5,140,000
Banning Power Plant	920,000
Hathaway Power Plant	440,000
Cabazon Power Plant	1,000,000
Whitewater Power Plant	330,000
San Felipe Aqueduct	
Conduit	21,800,000
San Felipe Dam and Reservoir	970,000
San Felipe Power Plant	1,440,000
Narrows Power Plant	1,690,000
Kane Springs Power Plant	570,000
Subtotal	$273,860,000
Total	$2,933,390,000

* At 1955 price levels.

Deliveries to high lands in the upper Santa Ana and San Jacinto Valleys, to the San Gorgonio Pass area and desert lands to the east, and to high lands in Riverside and San Diego Counties, would be made directly from the aqueduct. Near Lake Henshaw, a diversion by tunnel on a continuous flow basis would be made to the Borrego Valley area. About 85,000 acre-feet of water per season would also be provided from the San Diego High-Line Aqueduct to Barona Reservoir by the Barona High-Line Interconnection, for use on lower-lying lands.

The general features and capital costs of the California Aqueduct System in the Southern California Division are presented in Tables 27 and 28. The location of these facilities are delineated on Sheets 16, 17, 20, 21, 22, 24, 25, and 26 of Plate 5.

UTILIZATION OF GROUND WATER STORAGE

Inherent in the concept of development, and vitally necessary to the successful implementation and operation of The California Water Plan, is the availability of adequate facilities for storage, regulation, and transportation of the developed water supplies. Transportation facilities would consist of the many local and transbasin conduits, and the California Aqueduct System. Because of the many possible alternative means of accomplishing the transfer of water from areas of surplus to areas of deficiency, both on a local and on a state-wide scale, the problem of water transportation, from an engineering point of view, is not likely to present insurmountable difficulties in the implementation of The California Water Plan.

There are, on the other hand, no alternative means of developing the physical storage space required to provide the necessary control and regulation of the large volumes of water over long climatic cycles. Early in the studies concerning The California Water Plan it became apparent that such control and regulation cannot be accomplished by surface storage alone, within foreseen economic limits. It was therefore necessary to examine in detail the feasibility of utilizing the natural storage capacity available in underground basins in order to supplement the available surface storage. Based on such examination, there is every indication that storage capacity, adequate by a relatively safe margin, exists in California's major underground basins to enable the necessary regulation, and that such regulation is physically possible under conservative assumptions.

Under The California Water Plan, sufficient reservoir storage capacity would be necessary in regions of water surplus to so regulate water supplies that they may be exported at a nearly uniform rate, thus reducing the sizes of transport conduits. Similarly, in addition to further conservation of local water resources, reservoir storage space would be necessary in the areas of water deficiency to provide reregulation of imported water, since such a rate of water delivery does not correspond to the demand rates. Adequate surface reservoir storage capacity was found to be available in the North Coastal Area to accomplish the required regulation. However, in the Sacramento and San Joaquin-Tulare Lake Basins and in the Lahontan, Colorado Desert, and South Coastal Areas, the large volumes of required storage could not be provided entirely in surface reservoirs.

In the case of the Sacramento River, San Joaquin River, and Tulare Lake Basins, studies of the relation which would exist between historical inflow and estimated ultimate water requirements indicate that a maximum of approximately 53,000,000 acre-feet of cyclic storage capacity would be required to regulate the water supply so that water demands could be met as they occur, without shortages. It is further indicated that foothill storage reservoirs could be economically constructed in the basins to an aggregate regulatory capacity of about 22,000,000 acre-feet. Consequently, the additional 31,000,000 acre-feet of required storage space necessarily would be provided through utilization of ground water basins. Estimates of the storage capacity existing in the alluvium of the Central Valley, made by the United States Geological Survey and the Department of Water Resources, indicate that some 133,000,000 acre-feet of gross storage capacity is available within 200 feet of the land surface. Taking into consideration areas of questionable water quality and areas where rates of recharge and extraction might present problems, it is indicated that the usable storage capacity might amount to about 98,000,000 acre-feet.

Use of Ground Water Storage

For the most part, the total storage capacity which is available in the alluvial valley fills is the sum of the volumes of the innumerable small pore spaces, or voids, that exist around the particles comprising the alluvial fill. Not all of this volume, however, is usable; in clays and fine silts, the interparticle spaces are too minute to permit sufficient rates of water movement. Moreover, not all of the water stored in the interstices of the alluvium will drain out as the water table drops. Primarily, the larger pore spaces found in sand and gravel strata and deposits provide the usable underground storage space. Even in these larger interstices, the movement of ground water is so slow that rates of placing surface water in storage, flow within the ground water basin itself, and rates of extracting water from storage by means of wells are prime problems in the utilization of the storage capacity of a ground water basin.

In addition to the physical problems, economic and water quality criteria must be considered fully in estimating usable ground water storage capacity and in selecting water supply sources. For each water use and for each source of supply there is an economic limit to the price which could be paid for the supply. Thus, there is a limiting depth from which ground water could be obtained economically. This economic depth, of course, varies with the use of the water. Profitable agricultural endeavors in certain areas of the State are now obtaining water from depths in excess of 600 feet. However, under The California Water Plan pumping depths of such magnitude are not envisaged.

If parts of the alluvium contain water of unsuable quality, or if soluble minerals exist within the subsurface basin which would degrade water placed in storage, these volumes of the alluvium cannot be considered as usable for water storage. In time, such zones or areas might be flushed of their degradants and become usable. However, since sufficient information is not now available concerning these processes, such areas are presently classed as unusable. In those areas where the upper fresh ground waters are underlain by connate saline water or where the possibility of sea-water intrusion exists, the draft on the usable ground water must be controlled, as to both rate and total annual amount, to the extent necessary to maintain the quality of those waters at acceptable levels. Operators of a ground water basin must exercise constant care to assure that usable storage space is not rendered unusable by an accumulation of damaging concentrations of undesirable minerals. This can be accomplished by controlling the quality of water placed in storage; by adjusting the relative use of surface and ground water throughout the basin; by controlling the rate, amount, and areal pattern of extractions; and by providing requisite drainage or outflow from the basin to maintain salt balance. The California Water Plan envisions the maintenance of the utility of ground water basins in perpetuity.

Surface reservoirs and subsurface basins are similar in that they each have replenishment and discharge characteristics. Surface reservoirs will store water as fast as the inlet channels permit, and may be designed to discharge at any rate. In the case of ground water basins, however, the recharge or replenishment capacities are not so completely subject to artificial control. At the same time, they constitute primary factors in determining the utility of the basin. Under natural conditions water enters the ground by infiltration from direct precipitation and by percolation from streams and ponds. Under artificial development, additional important means of recharge, namely, canal seepage, deep percolation of unconsumed applied irrigation water, return flow from cesspools and the like, become effective, as well as does artificial recharge by spreading and other means. In addition, an area lying at higher elevations that receives an abundance of surface water may serve as a source of replenishment to a lower-lying area by providing subsurface flow to the lower area.

The significance of the problem of ground water recharge rates is apparent when a comparison is made between the short duration and large volume of flood flows, or even the usual peaks of seasonal runoff, and the low rates at which stream percolation occurs. Furthermore, this problem is exaggerated where surface reservoirs capture all but the larger flows, thus reducing the ground water recharge period to a relatively few days of peak discharge. In addition, there are many instances where the natural recharge opportunity is so limited that additional capacity must be developed artificially. Artificial recharge may take the form of stream channel modification to increase the wetted stream bed area; construction of spreading ponds or ditches, recharge wells, and shafts; and operation of the irrigation canal system during the nonirrigation season to effect recharge during the period when canals and ditches normally would not be full. Such operation would provide additional opportunity for seepage from the surface distribution system.

Artificial recharge operations should be so located with respect to the geologic structure of the ground water basin as to achieve the most efficient utilization of the storage capacity and of the transmissibility of the aquifers. In selecting a location, consideration must likewise be given to the surface soil texture and subsurface structure in order to obtain the best percolation rates. Artificial recharge works may involve considerable areas of land, with consequent cost and possible interference with other potential land uses. There are other problems involved which necessitate careful consideration, including: construction and maintenance of diversion works from streams; control of silting; maintenance of percolation rates; and prevention of nuisance and protection of the public health through adequate mosquito control and other measures.

Storage of water underground through artificial recharge has been widely practiced in California since 1895. Much information and data are available both from actual operating experience and from controlled research, but further study and evaluation are needed. It is emphasized that thorough knowledge of the physical characteristics and geologic structure of a ground water basin is a prerequisite to successful artificial recharging operations therein.

Deep percolation of unconsumed applied irrigation water is an important means of ground water recharge. Drainage problems frequently develop in areas receiving abundant supplies of surface water, and the possibility that such problems may arise must be considered in planning the utilization of ground water basins. Such problems, however, can be prevented by controlled pumping of water from the ground water basin so as to maintain a lowered water table. The water thus pumped could be discharged from the area as drainage water, or could be utilized to irrigate adjacent or overlying lands, thus reducing the amount of the required surface supply. For example, if only the water requirement necessary to satisfy consumptive uses were imported to an area, and surface and ground water service areas were properly balanced, the amount of water entering ground water storage would be equal to the amount leaving ground water storage and water levels would not fluctuate appreciably from season to season, thereby preventing serious drainage problems. However, with such constant recharge and constant discharge, no cyclic regulation would be provided, and the underground basin would be ineffective in providing beneficial regulation of water supplies over long-time climatic cycles. Problems of salt accumulation in the ground water would undoubtedly arise.

On the other hand, if the entire service area were supplied with surface water to the maximum extent possible during wet periods and the ground water drawn upon to a much greater degree during dry periods, the ground water basin operated in conjunction with surface reservoirs could serve to regulate the available water supply over long-time climatic cycles.

Under the concept of planned utilization, the ground water in storage would be deliberately drawn down for beneficial use either on overlying lands or by export during dry periods, thus creating greater storage space to be refilled with excess runoff during ensuing wet periods under a carefully planned and managed program. The operation of available surface and ground water storage reservoirs would be so coordinated as to achieve the maximum feasible degree of conservation. This method of operation has been used in the studies for the Central Valley which are described subsequently.

In some regions, such as the South Coastal Area, where the runoff is extremely erratic both in season and from year to year, with dry periods of several years' duration, and where surface storage is very limited, the ground water basins must be relied upon for long-time cyclic storage. Under such circumstances, surface reservoirs are often used primarily to regulate the runoff to the extent necessary to enable the storage of the water underground through artificial recharge operations. It is anticipated that this practice will become increasingly prevalent in the more arid portions of the State in order to obtain the maximum practicable conservation of local water resources.

Under conditions of full development and planned utilization of ground water resources, the rate, the amount, and the areal pattern of extractions must be carefully planned and controlled if most efficient use is to be made of a basin. These withdrawal factors must be properly related to: the geologic structure, both areally and vertically, of the basin; the areas of greatest potential usable storage capacity; the sources and areas of recharge; the transmissibility and permeability of the aquifers; the areas of water use; the possibility of water-logging in the lower portions of the basin; and the necessity of controlling subsurface outflow and effluent seepage from the basin. Here again it is obvious that full knowledge of the characteristics of the ground water basin is a prerequisite.

Certain legal and financial problems involved in the planned utilization of ground water basins are discussed in Chapter V.

Conjunctive Operation in the Central Valley

The coordinated operation of surface reservoirs with underground storage basins in the manner described, to produce the desired yield at minimum cost, is termed "conjunctive operation." Several trial operation studies were made for assumed conditions of ultimate development in the Central Valley. In these studies, the costs of operation with various combinations of surface reservoir release schedules and surface water transport capacities were compared with the costs of required ground water pumping, in order to determine the most economical, or optimum, balance between the two. The method of operation thus selected, and described in part herein, is presented not as the only method which would serve the purpose, but rather to illustrate in a general manner that the required conservation results could be attained.

The conjunctive operation of the entire Central Valley would not involve completely untried and unproved principles, but, before being put into practice, would require much additional study and investigation, particularly as to geologic conditions and economics. The only new aspects would be the valley-wide application of the operation and, to a certain extent, the flexibility in serving irrigated areas from both surface and ground water sources. However, in the operation herein described, provision was made for service to portions of the valley entirely from either surface sources or from ground water, where topographic, geologic, and ground water quality considerations dictate. Recharge to the ground water basins would occur mainly from deep percolation of the unconsumed surface application of water for irrigation and from seepage from unlined canals and distribution systems. In localized areas where normal ground water recharge is limited, artificial methods would be employed.

For studies of conjunctive operation, the Central Valley was separated into four parts: the Sacramento Valley, the Delta-Mendota Area, the San Joaquin Valley-West Side Area, and the San Joaquin Valley-East Side Area. The location of the four areas, and the major foothill storage reservoirs that were utilized in the studies, are depicted schematically on Plate 7, entitled "Conjunctively Operated Storage in the Central Valley."

The period chosen for detailed study of conjunctive operation of foothill and ground water reservoirs in the Central Valley was the 10-year period 1926-27 through 1935-36. This period includes the 6-year critical drought period, 1928-29 through 1933-34. In addition, water supply conditions prior to the 10-year period were such that the ground water reservoir could be considered to be full at the beginning of the period if conjunctive operation had been practiced on a long-term basis. Assuming an available water supply equivalent to the 10-year operation period, and assuming conditions of ultimate water demand, the operation study demonstrated that it would be possible to provide not only the ultimate water requirements for the entire Central Valley but also to provide a seasonal export to other areas of the State in excess of 1,700,000 acre-feet of water from the Sacramento Valley. Moreover, studies indicated that the ground water basins would again fill to the levels existing at the beginning of the 10-year period. A summary of results of the operation study is given in Table 29.

Several of the values given in Table 29 merit comment. For instance, the studies indicate that under the method of operation discussed herein, only 32 per cent of the usable ground water storage capacity within 200 feet of the ground surface would be required to accomplish the necessary cyclic regulation. Furthermore, since the selected 10-year period includes the most critical years during the 50-year mean period 1897-98 through 1946-47, from a water supply standpoint, it follows that the indicated maximum depths to ground water may occur about once in 50 years.

Under conjunctive operation, ground water pumping units would be distributed more uniformly over the underground basins, in comparison to the present over-concentration of wells in regions that derive their entire supply from underground sources. Furthermore, through use of an integrated surface distribution system, wells could be operated on a more continuous basis, thus reducing the number of installations required, and also reducing the unit costs of pumping by savings in stand-by charges.

In summary, utilization of the ground water storage capacity of the Central Valley is essential to the full ultimate development of the water resources of the State. There is economically available about 98,000,000 acre-feet of usable ground water storage capacity in the Central Valley, of which only 31,000,000 acre-feet would be required in the operation of The California Water Plan. In order to utilize effectively this subsurface reservoir, its conjunctive operation with the foothill surface reservoirs of the Central Valley would be required. A possible means of ob-

"Storage of water underground through artificial recharge has been widely practiced in California since 1895."

Hansen Spreading Grounds Near Burbank

TABLE 29

SUMMARY OF RESULTS OF CONJUNCTIVE OPERATION OF SURFACE RESERVOIRS AND GROUND WATER BASIN OF THE CENTRAL VALLEY UNDER CONDITIONS OF ULTIMATE WATER REQUIREMENTS DURING THE CRITICAL OPERATION PERIOD 1926-27 THROUGH 1935-36

Item	Main subdivisions				Total Central Valley
	Sacramento Valley	Delta-Mendota Area	San Joaquin Valley		
			West Side Area	East Side Area	
Available foothill reservoir storage capacity, in millions of acre-feet	13.8	------	2.1	6.5	22.4
Required ground water storage capacity, in millions of acre-feet	4.0	6.8	6.4	13.7	30.9
Estimated usable ground water storage capacity within 200 feet of land surface, in millions of acre-feet	27.7	10.9	15.3	43.8	97.7
Portion of usable ground water storage required, in per cent	14	62	42	31	32
Portion of gross local water demand satified by ground water, in per cent, in:					
Dry season	80	74	53	68	67
Wet season	30	31	35	14	25
Average season	60	38	38	42	45
Maximum gross seasonal recharge of ground water basin, in millions of acre-feet	7.2	1.3	2.8	5.0	16.3
Maximum seasonal depletion of ground water in storage, in millions of acre-feet	3.1	1.3	1.1	3.1	8.6
Maximum installed ground water pumping capacity, in millions of gallons per minute	6.2	2.3	2.5	7.5	18.5
Approximate number of pumping plants required	6,000	3,250	2,500	7,500	19,250
Average depth to ground water, in feet from ground surface	25	60	40	30	30
Maximum mean depth to ground water, in feet	50	130	90	70	70

taining much of the recharge capacity necessary to operate the ground water basins of the Central Valley would be to have sufficient distribution capacity to enable, on occasion, the service of about 75 per cent of the area from surface supplies. Thus, the seepage from canals and deep percolation of unconsumed applied irrigation water, plus certain artificial recharge works, would recharge the underground basins so that they would be filled and be available for heavy draft during drought periods.

Studies of conjunctive operation indicate that in most areas where considerable present development exists, the average depth to ground water would be less than at present and, in areas where little ground water development has occurred, the depths to ground water would be reasonable.

As pointed out, there are actually no new principles involved in the operations just described. Furthermore, there is every indication that the required ground water storage capacity is available and that the required recharge rates could be obtained. A somewhat similar method of operation is being practiced at the present time in parts of the Tulare Lake Basin, notably in the service areas of the Kaweah, Tule, and Kern Rivers. The Raymond Basin area in southern California has been operated since 1945 on such a planned basis.

Based upon present knowledge and the assumptions that have been made regarding available water supplies and ultimate water requirements, it is indicated that it will be necessary to operate the underground basins in coordination with foothill reservoirs in somewhat the manner which has been described. Furthermore, there is every reason to believe that such operation could develop by local initiative and under local control to a considerable degree, although region-wide guidance in planning and control in operation would be necessary for most effective results. The legal problems involved in conjunctive operation are discussed in Chapter V.

SUMMARY OF THE CALIFORNIA WATER PLAN

There has been described in this chapter a vast system of integrated works, both local and interbasin, which serves to demonstrate that the objectives of The California Water Plan are physically possible of accomplishment within the limits of available water resources. While it is acknowledged that ultimate development of the land and other resources of the State may be achieved by works differing in many respects from those described herein, certain basic factors will remain essentially the same, regardless of the actual works ultimately selected for construction. Among these factors are: the probable ultimate water deficiency in the central and southern parts of the State; the ultimate surplus in the North Coastal Area and the Sacramento River Basin; the total storage requirement for the necessary regulation and control of water; and the approximate lengths and sizes of major aqueducts required to equalize geographically the water resources and the ultimate water requirements in California. In view of these factors, and of the inherent limitations of any plan for the indefinite future, it is considered that the works summarized in this section are as realistic as can now be foreseen.

TABLE 30

SUMMARY OF FEATURES, ACCOMPLISHMENTS, AND COSTS OF PHYSICAL WORKS UNDER THE CALIFORNIA WATER PLAN

(Excluding existing works)

Feature	Reservoirs				Conduit length, in miles			Pumping plants			Power plants			Capital costs of all works
	Total number	Capacity, in acre-feet		Mean annual yield, in acre-feet				Total number	Installed capacity, in kilowatts	Average seasonal pumping requirements, in millions of kilowatt-hours	Total number	Installed capacity, in kilowatts	Average seasonal power generation, in millions of kilowatt-hours	
		Gross	Active		Canal	Pipe	Tunnel							
Local Development Works														
North Coastal Area	50	3,652,000	3,100,000	1,295,000	47	13	3	12	91,900	158	1	90,000	344	274,425,000
San Fracisco Bay Area	11	235,000	231,000	103,000	10	43		10	4,500	24				34,064,000
Central Coastal Area	30	1,850,000	1,800,000	364,000	119	95		3	5,700	7				172,884,000
South Coastal Area	9	1,063,000	1,020,000	93,000		32								93,386,000
Sacramento River Basin	102	8,661,000	7,861,000	3,746,000	1,073	75	189				45	1,594,500	7,213	1,307,295,000
San Joaquin-Tulare Lake Basin	95	8,444,000	7,633,000	4,639,000	915	4	63	3	140,000	400	32	1,058,000	4,657	919,986,000
Lahontan Area	9	583,000	572,000	369,000	37	3	32				8	99,000	430	75,014,000
Colorado Desert Area														
Subtotal	306	24,488,000	22,217,000	6,863,000	2,201	265	287	28	242,100	589	86	2,841,500	12,644	2,877,054,000
California Aqueduct System														
Klamath-Trinity Division	15[a]	28,726,000	15,076,000	8,182,000			76	3	1,088,000	3,827	7	1,745,000	6,570	2,315,100,000
Eel River Division	10[b]	12,615,000	6,759,000	2,530,000	39		23	3	522,000	1,912	9	631,000	2,633	812,250,000
Sacramento Division	17[c]	7,805,000	6,769,000	6,395,000	286	5	11				9	1,475,000	7,342	1,285,000,000
Delta Division	5	148,000		Regulatory	176	39	3	10	738,000	4,273				488,400,000
San Joaquin Division	10	2,485,000		Regulatory	766	23	42	15	1,276,000	5,851				1,127,410,000
Southern California Division	13	602,000		Regulatory	1,519	348	156	16	8,495,000	32,593	11	1,091,000	4,578	2,933,390,000
Subtotal	70	52,381,000	28,604,000	17,107,000	2,786	415	311	47	12,119,000	48,456	36	4,942,000	21,123	8,961,550,000
Totals	376	76,869,000	50,821,000	23,970,000	4,987	680	598	75	12,361,100	49,045	122	7,783,500	33,767	11,838,604,000

[a] Includes two regulatory reservoirs.
[b] Includes six regulatory reservoirs.
[c] Includes six regulatory reservoirs.

The general features of the local development works and facilities of the California Aqueduct System, their requirements for pumping and accomplishments in terms of power generation, and their capital costs are presented in Table 30. Of a total of 376 reservoirs shown in Table 30, 282 would be conservation reservoirs, 30 would be operated primarily for power generation, 60 would serve as regulatory or diversion reservoirs, and 4 would be operated solely for flood control.

Water transferred through conduits of the California Aqueduct System would be captured, controlled, and regulated by 26 major reservoirs, of which 15 would be in the North Coastal Area and 11 in the Sacramento River Basin. The reservoirs in the Sacramento River Basin would be operated in conjunction with ground water storage capacity in the Central Valley for the regulation of additional variable seasonal surplus flows. Of the remaining reservoirs of the California Aqueduct System, 11 would be operated primarily for generation of power, 4 would serve as diversion reservoirs, and 29 would be operated for regulation of imported water to the demand schedule prevailing in the particular area served.

Of the total of 49 billion kilowatt-hours of energy per season required to deliver water to all potential service areas in the State, about 30 billion kilowatt-hours would be required to serve the high desert areas in southern California. However, the total seasonal energy production of about 34 billion kilowatt-hours, assuming all facilities of The California Water Plan to be in operation, would be reduced by nearly 11 billion kilowatt-hours, should the facilities which would develop and distribute waters to the high desert areas not be constructed. Thus, the net seasonal energy requirement associated with the service of the high desert areas would be 19 billion kilowatt-hours.

Based on present price levels, the total cost of all the features of The California Water Plan would be about $11,900,000,000, of which the facilities of the California Aqueduct System would cost an estimated $9,000,000,000. The cost of the Plan, as its component features become successively implemented over an indefinite number of years, would be borne by the Federal Government, the State Government, and local agencies, in a coordinated and cooperative common effort to solve California's water problems.

Data on the accomplishments of The California Water Plan in terms of development and transfer of water are presented in Table 31. As shown in that table, about 7,000,000 acre-feet of new yield would be developed by local works, and nearly 22,000,000 acre-feet per season would be developed and transferred from areas of surplus to areas of deficiency by facilities of the California Aqueduct System, for a total of some 29,000,000 acre-feet per season of water, which would be made available by The California Water Plan. The development of this quantity of water cannot be accomplished by surface storage alone. It is estimated that some 31,000,000 acre-feet of ground water storage capacity would ultimately be utilized in the Central Valley to achieve the required degree of control and regulation of the water resources of the Sacramento River and San Joaquin-Tulare Lake Basins. Furthermore, operation of substantial ground water storage capacity in other parts of the State would be required in conjunction with the delivery of imported water supplies.

TABLE 31

SUMMARY OF ULTIMATE DEVELOPMENT AND TRANSFER OF WATER UNDER THE CALIFORNIA WATER PLAN

(In acre-feet per season)

Hydrographic area	Water requirements		Supplemental water requirements		Requirement met by existing local development works	Potential transfer under existing or claimed rights[a]		Additional yield from prospective local development works	Development and transfer of water by facilities of California Aqueduct System		Total ultimate available water supplies
	Present, 1950	Probable ultimate	Present, 1950	Probable ultimate		Export	Import		Export	Import	
North Coastal	513,000	2,064,000	13,000	1,564,000	500,000	------	------	1,564,000	11,620,000	------	2,064,000
San Francisco Bay	710,000	3,512,000	42,000	[b]2,257,000	420,000	------	835,000	103,000	------	2,154,000	3,512,000
Central Coastal	630,000	2,246,000	65,000	1,681,000	565,000	------	------	468,000	------	1,213,000	2,246,000
South Coastal	1,907,000	5,552,000	370,000	3,027,000	1,066,000	------	[c]1,459,000	149,000	------	2,878,000	5,552,000
Sacramento River Basin	3,819,000	7,427,000	124,000	3,732,000	3,668,000	34,000	27,000	3,732,000	10,274,000	------	7,427,000
San Joaquin-Tulare Lake Basin (excluding Delta)	8,539,000	15,549,000	1,661,000	8,671,000	6,878,000	830,000	------	877,000	------	7,794,000	15,549,000
Sacramento-San Joaquin Delta	834,000	756,000	------	[d]756,000	------	------	------	------	------	756,000	756,000
Operation of Salinity Control Barrier	------	876,000	------	876,000	------	------	------	------	------	876,000	876,000
Lahontan	741,000	6,736,000	279,000	6,148,000	451,000	329,000	11,000	126,000	------	4,835,000	5,423,000
Colorado Desert	3,340,000	6,410,000	------	2,181,000	79,000	------	[e]4,150,000	------	------	1,388,000	5,617,000
Totals	21,033,000	51,128,000	2,554,000	30,893,000	13,627,000	1,193,000	[f]6,482,000	7,019,000	21,894,000	21,894,000	49,022,000

[a] Does not include imports or exports of water by facilities considered as features of the California Aqueduct System.
[b] Includes delivery of 146,000 acre-feet per season through Contra Costa Canal, considered a feature of the California Aqueduct System.
[c] Does not include conveyance and regulation loss of 73,000 acre-feet from Colorado River Aqueduct.
[d] Under ultimate conditions, Delta would be served an imported water supply.
[e] From Colorado River Aqueduct.
[f] Includes California's rights in and to the waters of the Colorado River, amounting to 5,362,000 acre-feet per year.

CHAPTER V
IMPLEMENTATION OF THE CALIFORNIA WATER PLAN

There have been discussed and described so far in this bulletin the water problems of California and a vast system of physical works which could accomplish the objectives of The California Water Plan. Briefly, the Plan has as its objectives the full satisfaction of present and future water requirements for all beneficial purposes and uses in all parts of the State to the maximum practicable extent. It has been pointed out that development and operation of facilities to accomplish these objectives would bring about additional engineering problems which must be considered and reconciled.

This chapter discusses certain considerations which are basic to implementation of The California Water Plan, and without which the Plan could never be effectuated. These considerations, which are essentially of a nonengineering nature but which govern all engineering considerations, are described under the general heading "Prerequisites to Implementation of The California Water Plan." In addition, this chapter discusses various other considerations which, although not essential to the implementation of the Plan, could exert a considerable effect on its scope and accomplishments. These are discussed herein under the heading "Other Considerations Affecting The California Water Plan."

PREREQUISITES TO IMPLEMENTATION OF THE CALIFORNIA WATER PLAN

Transformation of a system of physical works, such as those described in Chapter IV, from a plan to a reality, will require careful study and evaluation of legal and economic problems. Legal problems which must be reconciled involve the inadequacy of present law for accomplishment of comprehensive coordinated water resource development, and the requirements for amendment thereof or addition thereto. Economic problems involve determinations of the need for specific water development projects, benefits as compared to costs, and appropriate means of financing. Finally, and this cannot be emphasized too strongly, the solution of engineering, legal, and economic problems would be of little avail toward actual implementation of The California Water Plan without a high degree of cooperation and close coordination of efforts of all agencies and individuals at the local, state, and federal levels.

Legal Considerations

State-wide coordinated development of California's water resources, as contemplated under The California Water Plan, will necessarily pose many legal problems. Such problems relate to inadequacies and uncertainties of present statutes; the required procedure for acquisition of water rights in furtherance of the coordinated plan; the nature and extent of vested rights to use of surface and ground water; the extent of unavoidable interference with any such rights and the methods by which such rights may be compensated or otherwise adjusted in order to permit full operation of the Plan; preferential rights of areas in which water originates; effectiveness of contract rights in assuring areas of deficiency of a dependable water supply; and relations between the State and other agencies.

No attempt is made in this discussion to consider all legal problems that might arise. As might be expected, many of the legal questions connected with such a vast undertaking have not been resolved by the courts and the Legislature, and many of the questions which may arise cannot now even be anticipated. It has been necessary, therefore, in many cases merely to identify the problem and to limit the discussion to problems having the most general application and interest.

As previously stated, The California Water Plan is designed to include and supplement, rather than to supersede, existing water resource developments, and incorporates certain of the planned works now proposed or authorized for construction by public and private agencies and individuals. Agencies of the State and Federal Governments and water users' organizations may all construct and operate features of the Plan. The legal considerations vary considerably with the agency involved, but generally they fall within the same framework of law.

Water Rights. Any agency constructing or operating a unit of The California Water Plan would have to acquire or adjust water rights. If the operating agency were not the user, it would acquire and hold water rights for the benefit of the actual users. To the extent that unused water not now subject to vested rights would be made available by construction of storage and diversion facilities, the law pertaining to acquisition of rights to the use of unappropriated water would be applicable. Where necessary, vested rights might be acquired either by agreement or condemnation.

1. *Appropriative Rights.* The Legislature has established procedures for the appropriation of surplus water. Water flowing in a natural channel not already subject to appropriative or riparian rights is public water of the State and subject to appropriation in accordance with the provisions of the Water Code (Water Code § 1201). However, the statutory provisions relate only to surface water in a stream, lake, or other body of water, and to subterranean streams flowing through known and definite channels (Water Code § 1200).

The foregoing requirements are applicable to state agencies, as well as to private corporations, organizations, and individuals, and to the United States. There is no provision for withdrawing water from appropriation; a priority may be preserved, however, by filing an application to appropriate unappropriated water and following the procedures prescribed by law.

The Department of Water Resources is authorized by the provisions of Part 2, Division 6 of the Water Code, to file applications to appropriate water which "in its judgment is or may be required in the development and completion of the whole or any part of a general or coordinated plan looking toward the development, utilization or conservation of the water resources of the State . . ." (Water Code § 10500). Such applications are, in general, subject to the requirements and rules which govern applications by others, except that the Legislature has provided from time to time that they are not subject to the statutory requirements relating to diligence.

A number of applications have been filed since 1927 pursuant to the foregoing authorization. Provision has been made by the Legislature for assignment of or release from priority under any such applications when the release or assignment is for a "development not in conflict with such general or coordinated plan" (Water Code § 10504). The assignee of any such application is subject to the requirements of diligence provided in Part 2 of Division 2 of the Water Code. A number of these applications have been assigned, including some to the United States as operator of the Central Valley Project.

The foregoing procedure, whereby the Department of Water Resources may file applications to appropriate unappropriated water for general or coordinated plans of development, is the only presently authorized method whereby rights to the use of unappropriated water may be preserved in furtherance of planning by the State.

The California Water Plan involves utilization of much of the remaining surpluses in California streams. As the Plan is carried forward, consideration must be given to the filing of additional applications to appropriate the water covered by it, or in the alternative, to some other method of insuring orderly development and maximum beneficial use of this resource.

2. *Acquisition of Existing Rights.* The California Water Plan is designed to minimize interference with vested water rights, but a few instances of conflict with senior rights would be inevitable in a plan of such magnitude. Water rights are property within the meaning of the rule that private property may not be taken or damaged for public use without payment of just compensation. This means that to the extent vested water rights might be adversely affected by operation of The California Water Plan, they must be acquired either by agreement, purchase, or condemnation.

Some theoretical problems arise in connection with the purchase or condemnation of riparian rights; but in practice if all the riparian owners adversely affected are compensated or otherwise satisfied, there is no one to complain. One who acquires an appropriative water right may change the point of diversion and the place and purpose of use to conform with his project, provided other lawful users are not injured thereby. Permission to make such changes with respect to appropriations initiated under provisions of the Water Code must be secured from the State Water Rights Board in accordance with the provisions of Sections 1700 through 1705 of the Water Code.

The power of eminent domain may be exercised in favor of a public use of water. The State Constitution provides that the use of all water appropriated for sale, rental, or distribution is a public use and subject to the regulation and control of the State, in the manner prescribed by law (Constitution, Article 14, Section 1).

The power of eminent domain may be exercised by the State or Federal Governments directly through their immediate officers or agents, or the power may be exercised by public agencies, private corporations, and individuals when delegated by statute. If water rights are damaged without compensation having been made, the owner may file an action in inverse condemnation to recover compensation.

3. *Exchange of Water.* It is probable that full operation of The California Water Plan would require exchanges of water between watersheds in some instances in order to achieve the most effective and economical distribution to areas of need. An exchange of existing supplies for water imported from another source has previously been effected by agreement between the United States, as operator of the Central Valley Project, and certain water users in the San Joaquin Valley. Of course, there is no legal obstacle to such agreements, and it is contemplated that any exchange necessary would be effected under negotiated agreements. Whether an exchange could be imposed in the absence of agreement and, if so, upon

what conditions and under what circumstances under present law, is open to question. Although it is stated in negative terms, the Department of Water Resources may be authorized to effect exchanges of water in the Central Valley Project by Section 11463 of the Water Code. This section provides that in the construction and operation of the project no exchange of the water of any watershed or areas for the water of any other watershed or area may be made unless the water requirements of the watershed or area in which the exchange is made are at all times met and satisfied to the same extent as though the exchange had not been made, and no right to the use of water shall be gained or lost by reason of any such exchange. No comparable provision in present law would govern units of The California Water Plan not included in the Central Valley Project. Further consideration must be given to the problem as water development in California proceeds.

4. *Rights of Areas of Origin and Areas of Deficiency.* For purposes of analysis, the so-called "county of origin" problem may be divided into two parts: first, the problems with respect to the *areas of origin;* and, second, those with respect to the *areas of deficiency.* As these terms are generally used, the principal areas of origin occur in the northern portion of the State above the latitude of Sacramento. In these northern California areas water occurs in excess of the ultimate requirements of the areas, and the surplus could be exported and used in other portions of the State without detriment to the areas of surplus. There are, however, localized areas within the areas of origin which may be correctly termed areas of deficiency, due to either their geographic location or the time of the occurrence of water.

The areas of deficiency include, generally speaking, the areas south of the latitude of Sacramento including the San Joaquin Valley, the San Francisco Bay Area, the Central Coastal Area, the desert areas, and southern California.

The county of origin problem had its beginning about 30 years ago when plans for the Central Valley Project were being developed. Insofar as the areas of origin are concerned, the problem is one of insuring the reservation of adequate water for their future development. It is generally recognized that efficient utilization of the State's water resources requires reservations now for the future needs of mountain and foothill areas. Unless this is done, difficult exchange of water or expensive pumping installations might become necessary when these needs develop. With respect to the areas of deficiency, the problem is one of having reasonable assurance of a dependable water supply. The problem is basically physical in nature, having been created by unequal distribution of the State's water supplies, both as to time and place of occurrence. A full solution will require not only changes in the existing law, but, more importantly, the construction of physical works to meet the water needs in all areas of the State as such needs arise. With the ever-increasing competition among areas and uses for available water resources, a solution must be reached now. The solution to the problem must be state-wide in scope and must stem from attack of the whole problem rather than of the individual problems created by any specific project. It must be workable and must permit continued development of the State's water resources.

The only legal protection now afforded the counties or areas of origin for water for their future development is contained in Section 10505 and Sections 11460 through 11463 of the Water Code. As previously noted, the Department of Water Resources is authorized to file applications to appropriate water which is necessary for the coordinated development of the State's water resources. Applications have been filed by the State in furtherance of state plans. Some of these state filings have been assigned to the United States to be used as a basis for water rights in connection with the Central Valley Project, and others have been or are in the process of being assigned for various other projects. However, under the so-called "county of origin" law, the department is expressly prohibited from assigning or releasing the priority under any such application when, in its judgment, the effect would be to deprive the county in which the water originates of any such water necessary for its development (Water Code § 10505). Consequently, several of the assignments that have been executed contain conditions either reserving a specific amount of water for future use in the counties of origin, or making a reservation in terms of the law. To the extent, therefore, that a unit of The California Water Plan must depend upon a State application for necessary water rights, under present law, only water in excess of that necessary for development of the counties of origin would be availabe for use elsewhere.

The "county of origin" law under Section 10505 of the Water Code has the following marked limitations:

1. Section 10505 is applicable only where State filings have been made under Section 10500 of the Water Code, and can be effective only where an assignment or release of these filings is made. The streams upon which there are no State filings are not included under the so-called "county of origin" law as set forth in Section 10505.

2. The exemption from the ordinary legal requirements of diligence under State applications filed pursuant to Section 10500 of the Water Code is subject to renewal periodically by the Legislature. Should the Legislature fail to renew this exemption from diligence, the protection afforded to the counties of origin thereunder would probably be lost. The current ex-

tension of exemption from diligence expires on September 30, 1959.

3. There is the further problem as to how water reserved under State filings which have been assigned would be made available to users within the county of origin. There is some question at the present time as to whether any reservations for areas of origin would be effective as against anyone other than the assignee of State filings.

Under Water Code Sections 11460 through 11463, commonly referred to as the "watershed protection law," it is provided that, in the operation of the Central Valley Project, water may not be transported from a watershed in which it originates to other areas if it would deprive that watershed or areas adjacent thereto of water necessary for their future development. These sections of the code are limited in their applicability to the Central Valley Project, and present very serious problems for the operator of that project, since it is entirely conceivable under these sections that the substantial quantities of water developed under the Central Valley Project, and contracted for by numerous water users' organizations in the San Joaquin Valley, could be recalled for use in the watersheds of origin or areas immediately adjacent thereto. With such uncertainties, it is extremely difficult for the State or the Federal Government to plan intelligently or to operate the facilities of the Central Valley Project.

In addition to the cited problems, the question has been raised as to whether the existing county of origin and watershed protection statutes are in accordance with Article 14, Section 3, of the California Constitution.

As indicated by the foregoing discussion, there are now no constitutional guarantees for either the areas of origin or the areas of deficiency. The present statutes, insofar as the areas of origin are concerned, in some instances afford no protection and in other instances the protection is uncertain. The uncertainty created by the existing law makes any protection afforded to the areas of deficiency indefinite to the point where it is impossible to determine with certainty the quantities of water to be made available from certain projects for a specific service area on a continuing basis. This uncertainty with respect to the operation of any project has been of grave concern not only to the State but also to the Federal Government, and to local agencies attempting to construct water projects of their own.

In summary, the present statutes afford only limited and decidedly uncertain protection to the areas of origin with respect to reservation of adequate water for the future development of those areas. Water rights adverse to the future needs of the areas of origin continue to become vested. These areas now have no assurance that they will receive any assistance in the future in the construction of needed water development projects. They cannot depend upon unregulated stream flow for their future water supplies; conservation works must be constructed to regulate and conserve the natural stream flow. The present statutes create serious problems and uncertainties in the planning and operation of projects; these difficulties affect not only the State, but also the Federal Government and local agencies.

The areas of deficiency which may obtain water supplies under contract with the State as the operator of an export project now have no positive assurance that they will continue to receive a right to a dependable water supply under those contracts. Furthermore, some concern has been expressed that under the principles of a recent California court decision [*Mallon* v. *Long Beach*, 44 Cal. 2d. 199, 282 P. 2d. 4818 (1955)], the State may, with complete immunity, abrogate its contracts with its political subdivisions.

It has become increasingly clear that the only final solution lies in the adoption of a proper constitutional amendment and of implementing legislative enactments. The solution must provide: (1) positive assurance to the areas of origin that adequate water will be reserved for their future development, (2) positive assurance to the areas of deficiency that when they contract with the State for water they can depend upon the right to that supply, (3) removal of the uncertainty inherent in existing statutes, and (4) an adequately financed, continuing program of water development to meet the needs for water in all areas of the State, as those needs arise and as projects to satisfy them are found to be feasible.

Power of Eminent Domain. The power of eminent domain is necessary in constructing water projects, not only for the acquisition of water rights but also for the acquisition of other real property. The Federal Government and most water users' organizations possess this power with few restrictions. The Department of Water Resources is specifically empowered to condemn property in the name of the State for construction and operation of the Central Valley Project, including the Feather River Project. (Water Code § 11575 et seq.) There are certain restrictions upon its power to condemn rights to water appropriated to public use prior to January 13, 1934, and to condemn appurtenant works which were dedicated to public use prior to July 1, 1933. Also, in the absence of agreement, the department may not take or destroy the line or plant of a common carrier railroad, public utility, or state agency, or the appurtenances thereof, until new facilities of like character and equal usefulness have been provided. The department also has authority, without these restrictions, to condemn rights of way for flood control works (Water Code § 8304). It has not been granted authority, however, to condemn land and water rights for features of The California Water Plan not included in the Central

Valley Project, nor has it been specifically authorized to acquire excess lands or lands required for future use.

Planned Utilization of Ground Water Basins. Conservation of the State's water resources to the extent that ultimately may be necessary would require conjunctive operation of surface and underground storage capacity and use of the underground storage potential as terminal storage, as well as full development of local ground water resources, under a carefully planned and managed method of operation. The general manner in which these objectives could be accomplished and some possible methods of operation are described in other sections of this report. Planned operation of ground water storage would result in temporary lowering of ground water levels during dry periods, possibly lower than the levels that otherwise would have occurred, until replenishment could be effected during later periods of surplus water supply. Present statutory law (Water Code § 1242) recognizes the storing of water underground as a beneficial use if such water is later applied to a beneficial purpose.

Each owner of land which overlies a ground water basin has a right correlative with the similar right of each other such owner, to the reasonable beneficial use of water upon his land from the common ground water supply. This right is closely analogous to the riparian right pertaining to surface streams, and is a vested property interest which cannot lawfully be taken or damaged without observing the requirements of due process of law.

Although some cases look in that direction, it is not definitely settled that a particular entity could obtain a right to place water imported from another source into a ground water basin for purposes of storage, and to subsequently withdraw an equivalent quantity of the resultant commingled water, even if there were no material impairment of vested rights to the use of the natural supply. Legal problems would also be encountered if an attempt were made to create storage space in a ground water basin by deliberately lowering the water level, even though the withdrawn water were put to beneficial use. Present law realistically recognizes that minor inconvenience to existing rights caused by subsequent uses may be unavoidable and is not actionable so long as it is not unreasonable. Any substantial diminution of the available water supply or unreasonable interference with means of diversion, however, entitles owners of prior rights to appropriate relief either by injunction or, where a public use has attached, to compensation. Substantial lowering of ground water levels, with consequent material increase in pumping lifts, would fall within one or the other of these rules, depending on the degree.

From the foregoing it is clear that major changes in the regimen of ground water basins must be accompanied or preceded by a determination of the rights of the water users. Such determination by the courts is the only method of control over the operation and management of a ground water basin which is possible under existing statutes. An efficient method of determining rights to the use of ground water should be available.

There are two procedures provided by present statutes whereby the State Water Rights Board may assist the courts in the adjudication of water rights. Only one of these procedures, notably the "court reference" procedure, can be applied to percolating ground water. Under the court reference procedure, any action for the determination of water rights may be referred by the court to the board. Another procedure, commonly referred to as a "statutory adjudication," is restricted to surface bodies of water and to subterranean streams flowing through known and definite channels. Under this procedure, all claimants to water from a stream system can be brought before the State Water Rights Board upon petition filed with the board and signed by one or more claimants to the waters involved; and upon the filing of the board's findings with the Superior Court, a judgment that is conclusive on all parties can be entered. A large number of the smaller stream systems, particularly in northern California, have been adjudicated under the statutory procedure. A number of ground water adjudications have been completed and others are in process under the court reference procedure. Conclusions relative to ground water adjudications which appear to be warranted by the considerable experience of the State Water Rights Board and the Department of Water Resources in this field are:

(a) The boundaries of ground water basins can be determined only after competent and thorough geologic and hydrologic investigations.

(b) The safe yield of a ground water basin is not a fixed quantity but varies with (among other factors) the state of development in the basin and in the watersheds tributary thereto. Accordingly, periodic redeterminations must be made of the allowable extractions of water from the basin if effective utilization of the ground water is to be achieved.

(c) It will invariably take a considerable period of time and substantial expense to obtain the data necessary to determine the safe yield of a ground water basin with reasonable accuracy, but without these data the basin cannot be operated properly.

(d) Because of the obscurities inherent in the occurrence of ground water and the multiplicity and variable nature of the factors affecting the safe yield of a ground water basin, measurement and collection of the basic data required for adjudication should be initiated long prior to the actual adjudication and carried on continuously, so that, when the need therefor arises, the information will be available for use.

(e) In many instances it would be difficult to establish that excessive extractions of water have resulted in irreparable damage to a basin. Some basins could be pumped substantially dry without irreparable damage resulting to such basins, for upon cessation of pumping, the basin would gradually refill with water of satisfactory quality by natural processes. On the other hand, where compaction and subsidence occurs, or in coastal ground water basins where sea-water intrusion occurs due to overdraft, or in other special cases, a finding of irreparable damage might be made.

A program should be adopted for continuing investigation of the ground water areas of the State, particularly those determined to be required for effective operation of The California Water Plan, supported by adequate appropriations. By this means, as and when it becomes necessary to adjudicate rights to the use of these ground water basins, to the extent the necessary data are available, the expense and delay of adjudication thereof would be minimized.

In 1955, Part 5 was added to Division 2 of the Water Code, providing a procedure for filing notices with the State Water Rights Board by every person who extracts ground water in excess of a certain minimum amount in the Counties of Riverside, San Bernardino, Los Angeles, Ventura, and Santa Barbara. Any person may request the board to investigate and determine the facts stated in a notice. The determination of the board is prima facie evidence of such facts in any action or proceeding in which they are material. By operation of this procedure, there will in time be accumulated much relevant information concerning rights to the use of ground water, which will be available if and when it becomes necessary to adjudicate such rights, and which will serve to minimize expense and delay in such adjudications.

In proceeding with The California Water Plan, consideration should be given to the adequacy of existing law and administrative procedures to accomplish its purposes. Over the course of time, it is believed that it will become necessary to adjudicate the rights to ground water in most of the underground basins in the State. Among other things, consideration should now be given to existing procedures for the collection of data concerning ground water, existing procedures to determine rights to its use, existing procedures for handling overdraft situations, and to the adequacy of present law to allow full utilization of ground water basins. The following modifications to the court reference and statutory adjudication procedures have been proposed in order to simplify, improve, and minimize the expense involved,[1] and careful consideration should be given to legislation to accomplish them.

(a) A practical lis pendens procedure should be supplied. This should apply to both the court reference and statutory procedures.

(b) The trial court should be authorized to refer any case involving the determination of water rights, surface or underground, at any time after filing of the complaint, to the State Water Rights Board, with direction to follow either the statutory adjudication procedure or the court reference procedure. This would supply a most desirable flexibility.

(c) The trial court should be authorized to impose, from time to time, trial distribution schedules. This also should apply to both procedures.

(d) The State Water Rights Board should be authorized to investigate and report upon all rights to the use of water, including ground water rights. This modification is necessary only in the statutory adjudication procedure.

(e) Provision should be added to the statutory adjudication procedure to the effect that initiation of a proceeding tolls the statute of limitations, and that, on motion of the Water Rights Board, an action to adjudicate the rights, in whole or in part, involved in any such proceeding, filed during the pendency thereof, shall be abated.

(f) The trial court should be authorized to impose a physical solution, either as recommended by the referee or as suggested by the parties, and to enter any other order as the interests of justice may require. This should apply to both procedures.

(g) In entering its judgment the trial court should retain broad jurisdiction, in accordance with the principles approved by the Supreme Court of California. This also should apply to both procedures.

In 1955 the Legislature enacted the Water Replenishment District Act as Division 18 of the Water Code. Although various other types of districts are authorized to replenish ground water, water replenishment districts organized under the provisions of this act would have the advantage of being authorized to levy assessments in proportion to water pumped from the underground. This is particularly important in making equitable assessments of those holding appropriative and prescriptive rights to use water on non-overlying land. These water users might not be adequately assessed on an ad valorem basis.

The organization of water replenishment districts is limited to the Counties of Santa Barbara, Ventura, Los Angeles, San Diego, Riverside, San Bernardino, and Orange. As yet, no water replenishment district has been organized, so it cannot be said definitely

[1] Based on statement of Henry Holsinger, then Principal Attorney, Division of Water Resources (now Chairman, State Water Rights Board), before the Joint Legislative Interim Committee on Water Problems, December 14, 1954.

whether this will be an effective type of organization for utilizing a ground water basin. If it should prove to be so, consideration should be given to extending the coverage of the Water Replenishment District Act to other areas of the State.

In 1953, The Orange County Water District Act (Stats. 1933, Ch. 924) was amended to give the district similar assessment powers. The validity of these powers was sustained in *Orange County Water District* v. *Farnsworth,* 138 Cal. App. 2d. 518, 292 P. 2d. 927 (1956).

While it is not an immediate problem, it is evident that effective administration of the development and utilization of ground water resources, either by the State or by local agencies, or by both, will become mandatory as the stage of full water development is approached. When it becomes necessary to operate the major ground water basins for import-export purposes, as envisioned under The California Water Plan, the requisite authority to do so must exist. Studies should be initiated now as to the adequacy of existing statutes to accomplish these ends, so that the necessary amendments and additions thereto may be made at the appropriate time. The following items are suggested for consideration in this connection:

1. A constitutional amendment to authorize and accompanying statutes to set up procedures for (a) the planned utilization of ground water basins for carry-over storage, and (b) adjustment of conflicts with existing rights either by delivery of water or by cash compensation.
2. The requirement of permits and licenses for the appropriation of ground water.
3. Control and supervision of recharge of depleted ground water basins.

To protect and maintain the quality of the State's ground water resources, it is believed that minimum standards of water well construction and adequate procedures for the maintenance and abandonment of wells should be enforced as necessary throughout the State. This cannot be done under existing state law; consideration should be given to the enactment of necessary legislation at an early date.

Relationships With Other Agencies. 1. *Integration With Projects of Other Agencies.* Features of The California Water Plan constructed and operated by the Department of Water Resources would of necessity be integrated with features already constructed and to be constructed by other agencies. This is particularly important in connection with projects operated by the Federal Government.

The Sacramento River and Delta channels will be used as a common water conveyance system by both the Central Valley Project and the Feather River Project. The San Luis Reservoir would also be utilized by both projects under current proposals. It is apparent that detailed operational agreements will be necessary for the integrated operation of these features, so as to avoid conflict and to obtain the highest degree of beneficial use of water in an efficient manner. Both the Central Valley Project and the Feather River Project rely in part on water right applications filed by the State on the same day. In general, use of natural stream flow by the two projects will be inextricably interrelated. Both projects require an agreement or determination as to the water available for their use—as between each other, and in relation to water users in the Sacramento-San Joaquin Stream System holding senior rights. There is no reason to believe that all of these problems cannot be solved by agreement if all of the parties approach them in good faith.

2. *The Federal Power Act.* The Federal Power Act authorizes the Federal Power Commission to issue preliminary permits and licenses for the purpose of investigating, constructing, operating, and maintaining project works "necessary or convenient for the development and improvement of navigation and for the development, transmission and utilization of power" in navigable waters of the United States or upon public lands and reservations of the United States (except national parks and monuments), or to utilize surplus water or water power from any government dam [41 Stat. 1063, 1065 (1920) as amended, 16 U.S.C. s. 797 (e) (1952 ed.)]. Construction, operation, or maintenance of any such project works by any person, state, or municipality without first securing a license from the Commission is unlawful. The act also contains provisions designed to accommodate state and federal law. Since the Federal Power Commission has authority over the planning and construction of certain hydroelectric projects within the states, conflicts may occur if the projects licensed by the commission differ from those approved by the state by the granting of necessary water rights. If conflicts should occur between federal power projects and The California Water Plan, they would have to be settled by the courts or by the Congress.

Water Development for Fish and Wildlife and for Recreational Use. In order to provide sufficient flowing water in a stream for fish and wildlife and for the enhancement of recreational aspects of a stream, it may be necessary to store water in headwater reservoirs to permit planned releases during low-water periods. The combined releases and natural flows would be planned for a desirable all-year regimen of flow in the interests of protection and enhancement of fish, wildlife, and recreation.

In order to accomplish the foregoing objectives, the planned stream flows should be protected against appropriations of water for other purposes. However, present law does not provide positive and reliable protection for such natural or unregulated flows in a watercourse where such flows are not otherwise taken under control. As is elsewhere pointed out, there is no method for broadly reserving unappropriated water from appropriation under the general law pertaining to that subject. Furthermore, continuance of the unobstructed natural flow of a stream probably cannot be assured by making an appropriation of water for that purpose, because an essential element of an appropriation is generally considered to be the exercise of physical control and dominion over an identifiable quantity of water by either diverting it from the stream channel or by artificial regulation of the flow within the channel.

Section 525 of the Fish and Game Code requires the owner of a dam to allow sufficient water to pass the dam to keep fish in good condition below the dam. Other sections of the code permit the planting of fish or construction of a hatchery in lieu of a fishway over or around a dam in certain instances. Section 526.5 of the code prohibits issuance of a permit or license to appropriate water in Fish and Game District 4½ (Inyo and Mono Counties), unless conditioned upon full compliance with Section 525. These sections have not been construed by California courts, but the Attorney General has concluded that Section 525 "is not a reservation of water for the preservation of fish life but is rather a rule for the operation of dams where there will be enough water below the dam to support fish life, i.e., it is a standard for the release of water in excess of what is needed for domestic and irrigation purposes so that what is available for fish life shall not be wastefully withheld" [18 Ops. Cal. Atty. Gen. 31, 37 (1951)].

Statutory Restrictions Upon Projects. 1. *Klamath River.* A restriction upon the construction and maintenance of dams and other obstructions on the Klamath River is contained in an initiative measure approved by the electorate on November 4, 1924, which provides in part:

> "Section 2. Every person, firm, corporation or company who constructs or maintains any dam or other artificial obstruction in any of the water of said Klamath river fish and game district [The Klamath River below its confluence with the Shasta] is guilty of a misdemeanor . . . and any artificial obstruction constructed, placed or maintained in said district is hereby declared to be a public nuisance." [Cal. Stat. (1925), p. XCIII, Deering's Gen. Laws, Ann., Act 2941.]

Whether the prohibition of the statute applies to the State or its agencies is an undetermined question. It assumes importance since The California Water Plan contemplates dams on the Klamath River at some future date, as yet undetermined. It is well established that a sovereign is not bound by general words limiting the rights and interests of its citizens, unless such sovereign is included within the limitation, expressly or by necessary implication. Assuming that the State and its agencies are bound by the statute, its amendment or repeal would be a prerequisite to construction of dams within the specified reach of the river. Such action would require favorable vote of the electorate. On the other hand, assuming the statute does not have that effect, legislation might be enacted authorizing an agency of the State to construct one or more dams and diversion works at designated points on the river, and such construction could proceed without further authorization.

2. *American River.* By California Statutes of 1955, Chapter 1583, Section 10001.5 was added to the Water Code excluding the Coloma Dam and Reservoir Project from the State Water Plan, and providing that no permit to appropriate water shall be issued by the State for the purposes of a project which will flood any portion of the Gold Discovery Site State Park at Coloma "unless such issuance is specifically authorized by law." Under The California Water Plan a dam at this site, or a more expensive alternative means of storage by a diversion from the South Fork of the American River to Nashville Reservoir on the Cosumnes River, is considered to be necessary in the future for full conservation of the waters of the American River. It is believed that this situation should be reviewed again by the Legislature at the appropriate time when a choice between these two alternatives must be made.

Summary. The accomplishment of a plan which would make possible the maximum utilization of California's water resources presents a large number of legal problems, many of which can, at present, only be posed. Those of most immediate interest are of two types: (1) questions as to the adequacy of present law for the accomplishment of integrated water resource development, and (2) situations in which the law has not yet been definitely determined by the Legislature or the courts.

Some of the questions in the first class are as follows:

Are administrative procedures for the appropriation of unappropriated water, including the authority of the Department of Water Resources to file and assign applications, adequate to bring about the orderly development and maximum beneficial use of California's water resources? Is present law adequate to make possible the highest development of California's recreational resources under The California Water Plan, and, in particular, is it adequate to allow maintenance of stream flow for the purpose of preserving and enhancing fishing and recreational uses of California streams?

Still more numerous are the important questions as to which the controlling law has not been clearly formulated. Foremost among these is that pertaining to rights of counties and areas of water origin. A solution to this problem which will provide guarantees to the areas in which water originates that they will have enough water for their development, but at the same time will allow acquisition of firm contract rights to exported water, is for consideration by the Legislature and the electorate. Also unresolved is the question as to whether an owner of water rights could be required to accept a substitute water supply of comparable quality and quantity to that to which his rights attach. The California Water Plan has been developed so as to minimize interference with existing water rights, and where these rights are adversely affected, adequate adjustments must be made or the rights must be acquired either by purchase or condemnation.

Other unresolved questions concern relationships with other agencies. They involve settlements of water rights in the Sacramento-San Joaquin Stream System and operational agreements with other agencies, including the Federal Government. Close coordination must be maintained with the Federal Power Commission because of its jurisdiction over hydroelectric power developments on many of the State's streams.

Some Economic Considerations

If the sources of capital funds needed by any entity to construct features of The California Water Plan were unlimited, the attendant problems of implementation would be obviously simplified. However, in the allocation of scarce resources, such as capital and labor, among the various projects of the Plan, there should be simultaneous consideration of criteria for priority, justification, and scale of projects. While reasonable theoretical criteria may be used to accomplish orderly development of the State's water resources, it must be recognized that political, operational, and other considerations may alter the theoretical optimum.

Basically, the over-all objective of The California Water Plan is to enhance the general welfare of the people of the State; that is, to satisfy their needs and desires. These needs and desires are being continually increased by nearly half a million new people each year. This results, among other things, in the necessity of making available more than 500,000 acre-feet of new water each and every year if the growth trend is to continue. Consequently, the work that should be undertaken in the field of water resource development is of too large a magnitude to be pre-empted by any single agency, be it local, federal, or state. The efforts and capabilities of all agencies must supplement rather than supplant each other.

Some Considerations in Implementation of The California Water Plan. Implementation of The California Water Plan poses a number of major questions, such as: (1) why implement the Plan; (2) who should control the Plan and construct its component projects; (3) how should need and priority of construction be determined; and (4) how might projects of the Plan be financed.

1. *Why Implement the Plan.* Regarding the first question, Chapter II and III of this bulletin have stressed California's water problems and the resulting need for The California Water Plan. Hence, only two further comments are required. First, it is believed that coordinated, comprehensive, and progressive development as envisioned in the Plan would greatly increase the efficiency of use of the required capital, labor, land, and water.

Secondly, it should also be stated that as a result of California's water problems being so varied both in their nature and occurrence, and of such large magnitude, there is a strong state-wide interest in their solution, an interest long recognized by the Legislature. The state-wide interest implicit in implementing the Plan includes: effecting a balanced use of water resources for all purposes; obtaining maximum benefit from the use of storage capacity; resolving conflicts between groups representing particular purposes and/or particular areas; protecting the interests of future generations of Californians; accepting responsibility for those effects of a project which extend beyond the boundaries and/or jurisdiction of the project-sponsoring agency; and, for those projects which receive state financial aid, effecting the equitable distribution of benefits and costs, and avoiding the concentration of gains at public expense, insofar as possible.

2. *Control and Construction.* In order to receive the greatest value from The California Water Plan, basic responsibility for and control thereof should be vested in an agency which is state-wide in scope. The State of California is the logical, in fact the only, agency in a position to assume the leadership in the required coordination and control. The State is interested in the solution of all the water problems in all parts of California. The several agencies of the Federal Government which by law are engaged in water resource development are each interested only in certain phases of that development, within the limitations of federal policy and appropriations. Local groups, of course, are primarily concerned with the problems which face them locally. However, it is acknowledged that financial and other recognized limitations preclude any single agency from being able to carry out the financing, construction, and operation of all of the yet-to-be completed features of the Plan. Instead, leadership and participation by the State Government and continued participation by local water-using organizations and the Federal Government

will be needed to implement the Plan if the primary objectives thereof are to be substantially obtained.

3. *Determination of Need and Priority of Construction.* This refers to economic evaluation of water resources projects. In this regard, recommended criteria to be used by both the State and federal agencies in their evaluation of such projects were submitted to the United States Senate in a report entitled "Views of the California State Department of Water Resources on United States Senate Resolution 281, 84th Congress, 2d Session," dated November, 1956. Comments which follow on this subject are substantially contained in the foregoing report.

Construction of component projects of The California Water Plan should take place when a need for the products and services thereof is demonstrated. Once this is determined, then choice of the particular project to be constructed should be established by considering alternative sites and methods of providing the equivalent products or services. That is, each project chosen should accomplish the purpose or purposes intended more economically than by any other means.

A proper evaluation of any project requires balanced consideration of (1) an economic appraisal of those benefits and costs which are reasonably measurable in monetary terms, and (2) adequate consideration of all values and aspects not measurable in monetary terms. Policy determinations of what constitutes "benefits" and "costs" will have a great influence upon estimating both economic justification and financial feasibility. The question of "what project should be built" involves one of the most important matters of all, that of project selection.

In order to facilitate the ensuing discussion of some aspects of economic evaluation of projects, several of the terms used are defined as follows:

"Project"—any integral physical unit or several component and closely related units or features required for the control or development of water and/or related land resources within a specific area, and which can be considered as a separate entity on the basis of physical characteristics, functional accomplishments, or economic evaluation.

"Benefits"—all the net (gross gain less associated costs) identifiable gains or values which are measurable in monetary (tangible) or nonmonetary (intangible) terms which accrue to a project. Obviously, a benefit-cost ratio can include monetary values only.

"Primary Benefits"—all identifiable net gains or values which are realized directly by project beneficiaries through use of products or facilities of the project, but which may or may not be measurable in monetary terms.

"Secondary Benefits"—all net gains or net values which may or may not be measurable in monetary terms, which are properly creditable to the project, and which are realized over and above those included in primary benefits.

"Intangible Benefits"—all net gains or values attributable to a project which are not measurable in monetary terms, but which are nevertheless entitled to qualitative consideration on the basis of significant contributions to the economic strength, social structure, and welfare of the State or Nation.

"Economic Costs"—all of the monetary costs associated with construction, operation, and maintenance of a project, as well as all other identifiable expenses, losses, and liabilities, whether measurable in monetary or nonmonetary terms, that are associated therewith.

An economic approach to the development of water resources is essential, for such a study not only will substantially show whether benefits exceed costs, but comparison of such studies made of different projects will show the order of their economic desirability.

Determination of the relative merits of projects, and selection from alternative projects, are usually best accomplished by comparing the benefits with the costs of each project. A benefit-cost ratio greater than 1 to 1 is generally desirable in selecting a project for further consideration, but it never should be the sole determinant. Such a ratio cannot reflect intangible values which may be of substantial significance, nor can it reflect completely the public interest. However, if projects are proposed which do not show an excess of benefits, expressed in monetary terms, over costs, the reasons for such should be clearly stated. Main reliance for project selection should be placed on a comparison of primary benefits with primary project costs, although secondary benefits and costs, when properly evaluated, may be separately considered.

Project costs are relatively simple to ascertain, insofar as the application of principles and concepts are concerned. Most of the project costs would usually be incurred over a short period of time and in the near-term future. On the other hand, project benefits can be of great variety and character, as can the project detriments which also must be considered; they can be both measurable and immeasurable; and they usually occur in increasing quantity over time and continue to occur over the useful life of the project. Consequently, sound analysis of benefits becomes of the utmost importance, because the findings of such an analysis provide the most substantial answer as to whether the project should be built either now or later, or not built at all.

Benefits stemming from a project of The California Water Plan could include some or all of the following: an increase in net income to the farmer using irrigation water; a reduction in flood damages and improvement in possible land use; augmentation of municipal water supplies so that new factories and shops and homes may be built; increase in the availability of hydroelectrical energy for peak-load purposes; prevention of encroachment of saline waters into a ground water basin; maintenance of more favorable stream flows than under natural conditions, for enhancement of fish and wildlife values; increases in water recreational opportunities other than those derived from fish and wildlife; creation of more economically stable irrigated agricultural areas and adjacent urban communities; enhancement of the navigability of certain waterways; improvement in water quality brought about by project releases of water downstream during otherwise low-flow periods; and the increase in supplies of food and fiber which tends to reduce price increases that would occur otherwise during periods of full or near-full employment.

After appraisal has been made of the costs and benefits of a project, the need for cost allocation then arises when a project serves two or more purposes. The object of cost allocation is to provide for equitable distribution of the total multipurpose cost among the purposes served. The use of one structure to serve several purposes generally involves less total cost than if separate structures were provided for each purpose. An equitable distribution of multipurpose project costs should rest on the values created by the project. Benefits are the measure of these values, but they may be limited by the alternative cost of producing them. No one method of cost allocation is suitable for all conditions. However, on the basis of comparative advantages and disadvantages, the separable cost-remaining benefit method is generally recommended for use in the cost allocation of large projects; but in certain cases other methods of cost allocation may prove of value. Only after project costs have been allocated can repayment policies be selected within the framework of the laws and policies of the project-sponsoring agency.

The project should not be built until financial feasibility, that is, the sources of required capital funds and repayment of the reimbursable costs, is indicated. Such a feasibility study should indicate: the costs to be repaid; the contemplated repayment period; the probability of repayment; the rates to be charged for water and power to pay off their allocated share of the costs; and the extent to which each project purpose would have to be subsidized, if any, and, if so, the source of the subsidizing funds. Reimbursable project costs should be repaid by the beneficiaries of the project goods and services.

4. *How Projects of the Plan Could Be Financed.* As has been stated heretofore, it is contemplated that local water service agencies, the Federal Government, and the State would participate in financing and construction of The California Water Plan. Each of these groups has its own methods of raising capital funds and disbursing them.

Districts and cities customarily finance their projects by means of the issuance and sale of general obligation bonds and revenue bonds. Whereas revenue bonds are redeemed from project revenues only, general obligation bonds may be redeemed both from project revenues and from taxation of property in the district or city.

In the recent past the Federal Government has been assisting in the development of the State's water resources to the extent of about $70,000,000 a year, through appropriation by the Congress for reclamation and flood control projects. The Federal Government finances, constructs, and in some cases operates, its own works. It also appropriates certain nonreimbursable funds for its own water projects and for certain of those sponsored by non-federal entities, such as for flood control. Loans and grants are also made to non-federal public entities through such means as Public Law 566, 83rd Congress, the Watershed Protection and Flood Prevention Act, the Small Reclamation Projects Act of 1956, and Public Law 130, 84th Congress, which latter law provides for loans for the construction of distribution systems on authorized federal reclamation projects.

With respect to state financing and construction of some of the contemplated projects of The California Water Plan, methods to be used in raising funds and repaying them will depend upon policies yet to be established by the Legislature. However, a course of action should be followed which will expedite the objectives of the Plan. There are several possibilities by which the State could raise funds to be used in financing water development projects. These include provision of funds derived from current revenue, including oil royalty revenues, from the sale of general obligation and/or revenue bonds, and from the use of state trust funds backed by state guarantee.

It is proposed that the State immediately embark upon a long-range water resources development program which perforce would require a long-range financing program. A Water Development Fund is needed to finance and operate state-constructed water developments, to aid political subdivisions of the State in the construction of such developments, and to assist joint-use projects between the State and the Federal Government, or between the State and political subdivisions thereof.

Governor Goodwin J. Knight has recommended the creation of a water development fund, and on April 9, 1957, he further recommended to both houses of the Legislature that this fund should include the following moneys:

(1) Uncommitted tidelands oil revenues and income from this source through July 1, 1958. These will amount to approximately $101,000,000 after deducting the $38,000,000 appropriation now (May, 1957)

pending for continuation of the preparatory work at the Oroville Dam and Reservoir site.

(2) Future revenues from tidelands oil revenues in excess of $10,000,000 per year.

(3) The $75,000,000 now in the Revenue Deficiency Reserve Fund ("rainy day" fund), in the State Treasury.

(4) Moneys from the General Fund in amounts to be determined by the Legislature.

(5) Such moneys in other funds as may be determined by the Legislature to be available for this purpose.

(6) Net revenues derived from water projects operated by the State. In this regard, project revenues would be used first to pay for operation, maintenance, replacement costs and secondly for debt service charges before being transferred to the Water Development Fund.

(7) Proceeds from any bond issues that may be voted and sold in the future for construction of the Feather River Project and of other elements of The California Water Plan as they are authorized, and for financial participation in projects of the Federal Government and local agencies.

(8) Interest derived from the investment of moneys held in the Water Development Fund.

It is believed the most desirable method of obtaining the moneys for the Water Development Fund would be from current funds and revenue and by sale of bonds as and when needed to make up the balance of the total capital required. It would result in a combination of pay-as-you-go and pay-as-you-use. The use of current funds and revenues provides equity capital and reduces the over-all project costs to the State through large savings in interest payments that would otherwise have to be paid by the State. By holding down the total amount of bonds that must be sold by the State, it also mitigates any possible adverse effect on the current state program of selling general obligation bonds for school building and veterans' loan purposes.

Related to the State's proposed financing and construction activity are a number of most important policy matters, most of which are not as yet defined by statute. These include the question of whether certain of the project capital costs should be nonreimbursable or reimbursable. Should the State declare as public policy that project costs allocated to flood control, recreation, fish and wildlife, and water quality protection be nonreimbursable, due partly to the state-wide and also the federal interest inherent in such matters, and due partly to the difficulty in collecting the costs thereof from the beneficiaries? In this regard, it is believed that the State should consider the following as nonreimbursable: costs of flood control features of a project in those instances in which federal flood control contributions are unavailable; costs of lands, easements, rights of way, and utility relocations required for flood control projects, as have been assumed in the past pursuant to Part 6 of Division 6 of the Water Code; costs of lands, easements, rights of way, and utility relocations required for major projects having a high degree of state-wide interest; costs associated with the protection and enhancement of fish and wildlife; and at least a large proportion of the recreational costs associated directly with water development projects, provided there is a large state-wide interest, and further provided that the operation and maintenance costs thereof be not assumed by the foregoing Water Development Fund.

It is also believed that the reimbursable costs allocated to irrigation and municipal and industrial uses of water, as well as for hydroelectric power generation, should be repaid by the users thereof with interest.

Another policy matter is that of pricing or rate fixing with respect to the sale of power and marketing of water. It is considered that rates for sale of hydroelectric power should properly be based upon the cost of competitive thermal power for the same type of service, including taxes, as if it were under a privately owned utility. Full advantage should be taken of the increased values of hydroelectric energy as peaking power in establishing rates. First priority for vendible power, that is, power not required for project purposes, and in accordance with Part 3 of Division 6 of the Water Code, should be given to public agencies at established rates. Rates for irrigation and other vendible uses of water should be sufficient to cover all appropriate capital and annual operating, maintenance, and replacement costs required to make the water available; provided, that irrigation water rates should not be in excess of the water user's ability to pay after allowance for a reasonable margin of profit; and further provided, that net surplus revenues derived from the sale of power and other sources should be applied toward repayment of the capital costs associated with water deliveries for beneficial use, with preference being given to irrigation use.

All of the foregoing, as well as other policy matters, require much more thorough study than has been possible in the preparation of this bulletin. They are discussed briefly herein to outline the problems and to indicate the trend of current thinking by the Department of Water Resources.

There is within the State property estimated to have a current market value of about $100,000,000,000. From the income-generating portion of this value, the people who work with it produce an annual current disposable income of about $30,000,000,000. Under conditions of the State's population increasing ultimately to about 40,000,000 and the irrigated area expected to increase to about 20,000,000 acres, the market value of property in the State is expected to amount to at least $300,000,000,000 and the annual disposable income to increase to at least $90,000,000,-000, assuming current purchasing power values. For this as well as for other reasons, it is believed that adding a $12,000,000,000 system of major water works over a period of many decades by state, federal, and local agencies would not require appreciable financial sacrifices on the part of the people of California. Indeed, the incurring of such costs could be regarded as income-generating or opportunity investment.

Cooperation

It has been estimated that the over-all value in terms of present costs of all of California's water resource development works up to the present time is in the order of $6,000,000,000. These works have been achieved by individuals, private enterprise, public utilities, public districts, cities, and counties, with active participation by the State. Much has also been done by the several agencies of the Federal Government, including the Departments of Agriculture, Army, and Interior, under administrative control by the State through the mechanism of water rights. All of these enterprises required and received a high degree of cooperation among the participating groups to bring them into being and to keep them in operation. This cooperation usually began at grass roots level among the people affected, and in one way or another extended through all the participating agencies. Development began with simple, near-by, single-purpose water projects. As these opportunities progressively became scarcer, development inevitably moved into the larger, more difficult, and more expensive works, involving greater numbers of people and agencies. This in turn called for the addition of more purposes and water uses. Thus, the multipurpose projects of great size and relative economy, compared to a series of single-purpose works, have evolved. The need for cooperation between the large number of groups and agencies involved in the multipurpose project of today is readily apparent.

Cooperation between the Federal Government and local agencies has been manifested in the construction of flood control projects, and of multipurpose projects incorporating flood control features. Cooperation between local, State, and Federal Governments is exemplified in the Sacramento River Flood Control Project, in which all have participated in financing the construction, and in operation and maintenance of project facilities. The State has made substantial contributions to certain local districts in southern California for the repair of damaged flood control works, and, under provisions of the State Water Resources Act of 1945, has participated in the costs of lands, easements, and rights of way required of local agencies in connection with authorized federal flood control projects throughout the State.

There has also been cooperation between the Federal, State, and local governments in the planning and construction of major water conservation projects, of which the Central Valley Project is the most outstanding example. Mutual cooperation in the planning efforts of the Federal and State Governments is evidenced by federal statutes requiring the submission of certain federal reports to the states affected, for review and comment prior to their final release, and by the attendance by state representatives at pertinent congressional hearings in connection with water resources development planning. This mutual cooperation between all levels of government is not only highly desirable, but vitally necessary, and must continue.

Important as cooperation has been in the past and is at present, it will undoubtedly play an even more prominent role in the future development of California's water resources. The full development and proper use of the remaining uncontrolled waters of the State will require the construction of many projects which will be state-wide in scope. Close coordination in the planning, financing, construction, and operation by all agencies in the water development field will be necessary, in order to avoid overlapping of activities and duplication of effort, with resultant unnecessary cost increases, and to ensure optimum stream basin development. The State should logically assume the responsibility as coordinator of all activities, to the end that optimum water resource development is achieved by proper implementation of local, state, and federal policies. The basis for state responsibility for development of the water resources of California is set forth in Sections 100, 102, 104, and 105 of the State Water Code, which are discussed in Chapter I. The California Water Plan would serve as the framework for guidance and coordination of the activities of all agencies.

Notwithstanding the trend toward the need for state-wide water development projects, construction by local agencies will continue to play an important part in California's future. However, construction of major features of the California Aqueduct System would probably be beyond the capacity of local agencies, and would require the efforts of the State and Federal Governments. Moreover, the State should implement a program for furnishing assistance to local development, in the interest of the general welfare, to assure optimum development when such is beyond the capacity of local interests. An example of this might be the granting of state assistance to provide for the construction of a multipurpose project at a site where a local agency might have need or the means for construction only of a single-purpose project. The role of the State should fit into the existing framework of local-federal relationships.

Finally, in order that a construction program may be implemented so that the objectives of The California Water Plan can be accomplished, harmony and mutual good faith must be achieved between the various interests in different areas of the State to ensure passage of enabling legislation for authorizing, financing, and operating state-wide water development projects. Thus, with The California Water Plan to set the goal and to serve as a guide, the people of California can move forward with confidence and assurance that the water requirements of all areas in all parts of the State will be adequately provided for.

OTHER FACTORS AFFECTING ACCOMPLISHMENTS OF THE CALIFORNIA WATER PLAN

As previously stated, the water development works described in Chapter IV demonstrate one way believed practicable of accomplishing the objectives of The California Water Plan. It is acknowledged, however, that additional knowledge gained in the future, coupled with advancements in technology, may disclose more suitable alternatives to the works described herein. Moreover, continuing study of water requirements throughout the State as the future unfolds, may reveal that the requirements in certain areas may never eventuate in the amounts forecast herein. On the other hand, ultimate water requirements in other areas may possibly exceed the forecast amounts. In either of these eventualities, the water development works and conveyance facilities would have to be modified accordingly if and when the need arises.

In further investigation and planning for projects under The California Water Plan, every reasonable effort must be made to minimize the taking of irrigable and habitable land out of productive use, either present or future. To do otherwise might well penalize future Californians.

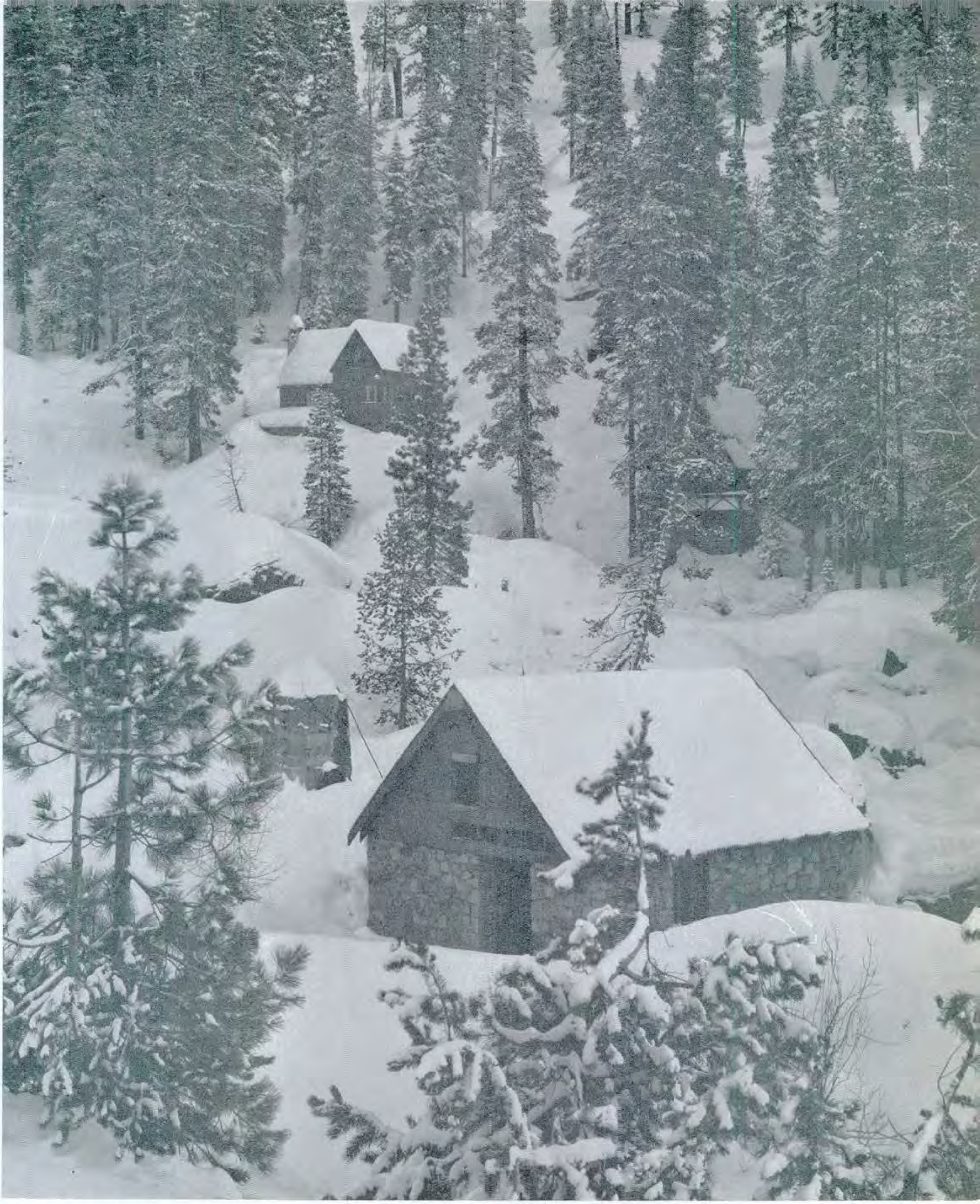
Advances in technology which would have a substantial influence upon The California Water Plan might be, among others, improvement in watershed management practices, which might increase the available water resources and decrease the destructive sedimentation in reservoirs. Also, the development of lower-cost energy in abundance might exert a vast influence over the selection of major aqueduct routes and the balance between pumping lifts and tunnel lengths, as well as the capacities of reservoirs for maintenance of elevation to reduce pumping lifts. Furthermore, discovery of an economically feasible method of saline water conversion and the provision of adequate supplies of energy therefor, might well decrease the total amount of water that would otherwise have to be imported ultimately to coastal metropolitan areas. The United States Department of The Interior and the University of California and other agencies are actively engaged in research in the field of conversion of saline to fresh water. At the present time, it does not appear that there is much prospect of providing significant amounts of additional water by this means, at economically competitive costs, within the next 25 years, at least. In another field of technology, effective methods of weather modification on a large scale may be found which would increase the total amount of water available for use. Several of these significant factors are further discussed hereafter.

Watershed Management

The impact of watershed management upon The California Water Plan would be manifested in several possible ways: first, by the influence on the regimen and characteristics of runoff following storms, with the consequent effect on erosion and resultant silt deposition in storage reservoirs; and second, by the influence on the quantity of water available for capture and regulation. The objectives of watershed management in relation to The California Water Plan would be (1) to reduce the silt deposition, or sedimentation, which impairs or destroys the effectiveness of expensive and frequently irreplaceable reservoirs, and clogs stream channels, and (2) to increase watershed yield by improving the regimen and characteristics of runoff and, perhaps, by increasing the total water production as well.

Fortunately, these two objectives are generally compatible, in that the measures taken to reduce destructive soil erosion, which not only reduces reservoir storage capacity but results in an economic loss from reduced productive capacity of watershed lands, would also improve the regimen of runoff. Although the over-all effects of various soil conservation measures have not been conclusively evaluated from the standpoint of their effects on water yield, there is universal agreement regarding the need for reduction in soil erosion which is detrimental from all aspects.

The effects of erosion, with resulting sedimentation of streams and, more particularly, of the reservoirs built on those streams, can be illustrated by two typical examples. Sweasey Reservoir on the Mad River was constructed in 1938 at a cost of a million dollars, to provide water for the City of Eureka. Today this reservoir is virtually filled with stream debris and has no effective storage capacity. Its regulatory effect has been rendered useless, and the dam serves only to divert into a pipe line whatever water is available in the stream. Another such example is evidenced by Gibraltar Reservoir on the Santa Ynez River, which serves water to the community in and adjacent to the City of Santa Barbara. Gibraltar Dam was constructed in 1920 with an initial storage capacity of 15,000 acre-feet. By 1950, the accumulation of silt



"The objectives of watershed management . . . to reduce sedimentation . . . to improve the regimen of stream flow . . ."
Sierra Nevada Snowfield

and debris had reduced available capacity to 7,000 acre-feet, and it was necessary to raise the dam 15 feet to restore the original capacity. These are only two of many similar occurrences in the State. Inasmuch as good dam and reservoir sites are becoming increasingly difficult to find, and are becoming exceedingly costly, it is apparent that an effective means of reducing reservoir sedimentation is an important consideration in present and future water resource development. In addition, sediment transport and deposition in stream channels adds significantly to flood control problems.

From yet another important viewpoint, erosion and subsequent silt deposition in streams is of serious concern in the northern part of the State. Silt deposits are harmful to the spawning activities of anadromous fish such as steelhead and salmon, and detract from the recreational value of the streams. Much of the future economy of the northern areas has been forecast to be recreational, and the streams and watersheds are key assets to recreation. Preservation of the recreational value of California's streams is important to the present and future welfare of the people.

It is generally known that proper watershed management, in terms of its effects on downstream reservoirs, are those which will tend to minimize erosion. It is also generally agreed by the operators of watershed lands—the ranchers, stockmen, and foresters—that the most desirable watershed management practices are those which preserve the valuable soil mantle. To this extent, the objectives of both the operator of the watershed and the operator of the downstream reservoir are in harmony. However, a very real need exists for long-range research, and for objective investigation and study of the many factors involved in soil erosion on watershed lands and silt deposition in streams and reservoirs.

In addition to the purely soil conservation practices, other aspects of watershed management are of importance in relation to California's future water supply. Forest and range management and snowpack management offer possibilities for improvement in water yields by a more favorable seasonal distribution in most cases, and by an increase in quantity of runoff under some conditions. However, sufficient knowledge has not been gained in these fields to permit evaluation of their effects.

Forest and range management consists of the adoption of good logging and lumbering practices, prevention and control of fire, and the control of recreation, mining, road building, and other types of miscellaneous human activity. Major fires can be extremely damaging to watersheds, as has been recently demonstrated again in southern California. The overall effects of controlled light burning under certain conditions are not known exactly. Lumbering and logging activities, if not managed carefully, can contribute seriously to erosion, particularly from tractor operations, skid trails, and logging roads. More efficient range management, in terms of replacement of uneconomic brush lands by annual and perennial grasses, offers a possibility for increasing the water yield. However, there is considerable lack of agreement on the effects of such practices on the yield of water and on erosion.

A new concept in the field of watershed management involves the manipulation of snowpack in such a way that it can be made to contribute more effectively to downstream water supplies. The objectives of snowpack management would be to direct logging operations in the snowpack areas in such a manner as to (1) maximize the accumulation of snow on the ground by minimizing losses of water from evaporation and transpiration, and (2) extend the snowmelt period. With respect to the first objective, conifers, particularly spruces and firs, intercept a significant portion of the snowfall, which is then lost through direct evaporation. Provision of adequate amounts of open space would increase the amount of snowpack by decreasing this direct evaporation. With respect to the second objective, studies indicate that snow accumulates to greater depths in more open areas, but that melting is more rapid. Recent studies have also indicated that melting occurs less rapidly when the snow has accumulated in drifts than when it is in an even blanket. There is a possibility of increasing the water supply and prolonging the snowmelt period by narrow strip clearings, taking advantage of prevailing winds to form drifts which would be protected by the shade from the bordering forests.

Research with respect to snowpack management has recently been undertaken by the California Forest and Range Experiment Station of the United States Forest Service in cooperation with the State Department of Water Resources, and by the United States Forest Service in the Fraser Experimental Forest in Colorado.

Future Development of Electric Power

The concept of electric power as an essential partner in water resource development is not new in California. The early and extensive use of electric power for pumping water at reasonable cost has contributed much to the development of irrigation and municipal water supplies, and the inclusion of hydroelectric generation in multiple-purpose developments has resulted in moderate charges for water.

The California Water Plan contemplates a large total output of hydroelectric power, and an even greater power requirement for pumping associated with the transfer of water from areas of surplus to areas of deficiency. Because of these considerations and the large capital costs of the water development works involved, it is imperative that The California

Water Plan make maximum use of revenue from hydroelectric generation and of low-cost off-peak power for pumping. It therefore is evident that the future development of electric power, as it relates to the market for and value of hydroelectric output, and to the availability and cost of off-peak power for pumping, is a vital consideration affecting the Plan.

The magnitude of new power generation and power required for pumping under operation of The California Water Plan will be more readily grasped by comparison with the total California power load in the year 1955, which was 7,800,000 kilowatts and 44 billion kilowatt-hours. The estimated new installed hydroelectric capacity under operation of the Plan would coincidentally be 7,800,000 kilowatts and the energy output would be 34 billion kilowatt-hours, while the estimated ultimate pumping capacity would be 12.3 million kilowatts and the energy requirement would be 49 billion kilowatt-hours.

One of the factors to be considered in estimating the market for hydroelectric power output and the availability of off-peak pumping power is the power load growth, which is closely related to California's industrial expansion, rapidly increasing population, and the marked trend toward greater per capita consumption of power. It is estimated that by the year 2000 the State's power load will have increased to more than 10 times the present load. In such terms the power output and the pumping requirement of The California Water Plan would be relatively moderate portions of the total.

Inherent Advantages of Hydroelectric Power Plants. Hydroelectric power plants based upon stored water have several inherent advantages over steam-electric plants which, for all practical purposes, are now the only other source of electric power production. Among the more important advantages are: (a) outstanding operating flexibility; (b) significantly greater reliability; (c) lower cost of incremental capacity; (d) higher adaptability to automatic operation and production of peaking power; (e) greater resistance to inflationary trends, due to longer life and lesser proportion of nonfixed charges; and (f) less vulnerability to wartime exigencies of scarcity of fuel, fuel transportation bottlenecks, and bombing.

Hydroelectric Power Plants for Peaking Operation. The magnitude of the system electric power load varies continuously throughout the day. These varying demands, plotted against hours of the day, comprise the daily load curve. The continuous, or base load, portion of the daily load curve is equal in magnitude to the minimum demand, which occurs during the early morning hours. This period of the day is frequently referred to as the period of "off-peak power." The period of maximum demand is also referred to as the period of "peak load and power." No two daily load curves are identical, and there is considerable variation throughout the week and from month to month.

The usual measure of the value of hydroelectric power output is the cost of alternative steam-electric production. This cost, or value, has two parts: first, a capacity component, equal to the total annual fixed cost associated with each kilowatt of dependable steam capacity; and, second, an energy component, which is the variable cost, largely fuel, of a kilowatt-hour of energy. It follows that those hydroelectric power plants having low incremental capacity costs are most economic when developed to the maximum capacity which is dependable in supplying a definite part of the varying load requirements. Such plants may be operated at full capacity for only a few hours each day in supplying the extreme peak of the daily load. Other hydroelectric power plants and steam-electric plants must be operated for longer periods in supplying the base load and the remainder of the peak of the load.

The degree of peaking is designated by the term "plant load factor," which is defined as the ratio of the average load on the plant (for a specific time period) to the dependable capacity of the plant. Low plant load factor signifies a high degree of peaking.

The effect of the degree of peaking upon hydroelectric power revenues can be illustrated with the aid of the two-part cost of producing alternative steam-electric power, as was used for estimating the value of hydroelectric power output under The California Water Plan, which was, as follows:

Capacity component	$22.00 per kilowatt-year
Energy component	2.8 mills per kilowatt-hour

The composite values of revenue corresponding to a wide range of plant load factors are:

Plant load factor, in per cent	80	60	40	20	15	10
Approximate total unit value, in mills per kilowatt-hour	6	7	9	15	20	28

It is apparent that the incremental capacity costs of many existing and proposed hydroelectric power plants would be such that plant load factors of 20 per cent or less could be justified for total unit values in the range of 15 to 30 mills per kilowatt-hour.

Hydroelectric power plants have great advantages for peaking, in addition to their low incremental capacity costs. They have marked operating advantage since they can pick up or drop load almost instantaneously, whereas large modern steam boilers and turbine-generators are relatively inflexible. The latter, moreover, must be operated as nearly continuously as possible in order to capitalize on the high efficiency which is built into them at considerable cost, whereas the intermittent operation of hydroelectric power plants involves no sacrifice in efficiency. In addition, the simple, low-speed, rugged construction of hydroelectric plants provides outstanding reliability in comparison with the high-speed, increasingly complicated steam-electric plants.

Hydro-Steam Ratio and Prospects for Hydroelectric Peaking. The ratio of dependable hydroelectric capacity to steam-electric capacity is of great importance in relation to the degree of hydroelectric peaking with its favorable effect on revenue, and also with respect to the availability of low-cost off-peak power for pumping. The role of hydroelectric power has changed markedly in recent years. Prior to World War II the hydro-steam ratio in California was about 2 to 1, and hydroelectric power plants commonly were used to supply the base load. Following the war, with rapid construction of steam-electric power plants to keep pace with the increasing load, the ratio declined sharply, until by 1953 it was less than 1 to 1, and hydroelectric capacity normally was used for peaking operation. The hydro-steam ratio in northern California as of the end of 1956 was 1 to 1.4; that in southern California was 1 to 2.0. The southern California ratio is expected to continue its rapid decline. The hydro-steam ratio in northern California probably will remain fairly constant until about 1965; thereafter, the ratio should resume its downward course.

With the decline in the hydro-steam ratio, steam-electric capacity has supplied more and more of the base load, and now also supplies a portion of the peaking requirement. This permits hydroelectric power plants to operate higher in the peak of the load, at lower plant load factor. In this way, water which at one time would have been utilized for base-load generation now is stored during off-peak hours and used to generate more of the high-value on-peak power than formerly.

By projecting present power load, resource, and operating characteristics into the future, and also by allowing for further decline in the hydro-steam ratio, it can be seen that there will be continuing need for much additional hydroelectric power capacity for peaking at low plant load factors Because of this need, and the fact that water supplies and economic sites for conventional types of hydroelectric power plants are relatively limited, the future role of pumped storage hydroelectric power plants is of interest.

Pumped Storage Hydroelectric Power Plants. Pumped storage hydroelectric power plants are peaking plants which pump all or a portion of their own water supply, requiring only afterbay and forebay reservoirs. Low-cost, off-peak, steam-generated energy, or seasonal hydroelectric energy, is used to pump water from the afterbay to the forebay. The pumped water then is used to generate higher-value on-peak energy by reversing the pumping units and operating them as generating units as the water is released to the afterbay. In the extreme case of pure pumped storage, the drainage area or other source of water must be sufficient merely to make up water losses.

A corollary to pumped storage hydroelectric power would be found in the Californa Aqueduct System. One instance would occur in crossing the Tehachapi Mountains. In this case, using off-peak energy, water would be pumped to an elevation where the topography and geology is favorable for an economical crossing, and then would be released to generate on-peak energy as it descends to lower elevations on the other side of the mountain range. Of course, forebay and afterbay storage and larger pumping and generating capacities would be required for the off-peak operation.

Pumped storage plants generally would have an over-all efficiency of about 67 percent. This means that, currently, the economic balance of pumped storage in northern California is not as favorable as would be the case when a higher degree of peaking becomes possible due to a further decline in the hydro-steam ratio. It is possible that for southern California, with its rapidly declining hydro-steam ratio and limited supply of water, it may be possible to justify a considerable amount of pure pumped storage in the near future. An increase in the difference between the value of on-peak energy and the cost of off-peak energy also would encourage installation of pumped storage plants.

Cost of Fossil Fuels and the Hydro-Steam Ratio. Fossil fuels comprise coal, petroleum, and natural gas. Although California does not have commercial deposits of coal, many persons have assumed that this State was blessed with ample oil and natural gas reserves for decades to come. The fact is that these reserves have always been limited in comparison to today's rate of use. Currently California imports some oil and the major part of the natural gas to meet its requirements.

Having in mind the continuing rapid increase in total energy requirement, it is clear that increases in fossil fuel cost may be expected, limited by the availability of Utah coal, the oil shale deposits of northwestern Colorado and vicinity, and the importation of foreign oil. It appears inevitable that the fuel component of fossil steam-electric power cost will increase in spite of continued increase in efficiency of steam plants.

One effect of disproportionate increases in fossil fuel costs would be to encourage construction of conventional hydroelectric power plants. However, such fuel cost increases would tend to increase the cost of off-peak energy for pumping, and would thereby tend to discourage development of pumped storage hydroelectric power plants. In view of the fact that most of the State's undeveloped hydroelectric power resources are in northern California and that southern California, because of limited opportunities for further development of hydroelectric power resources, should experience an earlier development of pumped storage hydroelectric power, it appears that the net effect of fossil fuel cost increases would be to moderate the decline of the hydro-steam ratio in northern California, but accelerate the decline in southern California.

Market for Hydroelectric Power Output. With a power load that has been doubling each 10 years and which is estimated to reach 85,000,000 kilowatts by the year 2000, there is no question about there being a market ultimately for all of the hydroelectric power output of The California Water Plan. While the ultimate market for power is significant, the market during the next two or three decades presently is also important.

Currently the dependable hydroelectric generating capacity in northern California is about 2,000,000 kilowatts. Is is estimated that by 1980 the total hydroelectric power capacity may be 6,500,000 kilowatts, or approximately one-third of the total capacity required to supply a forecast load of 17,000,000 kilowatts. By using load, resources, and operating characteristics similar to those estimated by the Pacific Gas and Electric Company for its power system in 1961, and by assuming the peak of the load to be supplied by hydroelectric power, the plants supplying the top 27.3 per cent of the load, or about 4,600,000 kilowatts, would, on the average, operate at the low-plant load factor of about 15 per cent. Of course, portions of both the new and existing hydroelectric power capacity would not be used for high-degree peaking. For the assumed condition the hydro-steam ratio in northern California would be 1 to 2 in 1980, compared to the current ratio of 1 to 1.4.

The foregoing illustration clearly points up the fact that in northern as well as southern California a ready market for the power output of hydroelectric plants of multiple-purpose developments may be expected at considerably higher degrees of peaking and value than were assumed in the estimates for The California Water Plan. The minimum plant load factor assumed in the Plan was 40 per cent under adverse hydroelectric power conditions.

Value of Hydroelectric Power Output. The usual measure of the value of hydroelectric power output, as stated earlier, is the cost of alternative steam-electric production; and, as stated, the two-part rate used for evaluating the hydroelectric power output under The California Water Plan was:

Capacity component	$22.00 per kilowatt-year
Energy component	2.8 mills per kilowatt-hour

This value was applied at the high-voltage side of the transformers at the hydroelectric power plant, and included allowance for a transmission distance of 100 to 150 miles. For convenience, the rate was applied uniformly to all projects.

Looking to the future, it appears probable that the capital costs (in constant value dollars) of steam-electric power plants will be relatively constant. The cost of fuel per kilowatt-hour, however, is expected to increase, in spite of continuing improvement in efficiency, due to probable increases in the cost of fossil fuels. Inasmuch as no credit was taken for the comparative advantages of hydroelectric power in deriving the capacity component of value, it appears that the two-part rate for value of hydroelectric power output used in studies for The California Water Plan is conservative. On this account and in view of the probable utilization of higher degrees of peaking than were assumed, it appears that the estimated hydroelectric power revenues under the Plan also are conservative.

Availability and Cost of Off-Peak Steam-Electric Energy for Pumping. The annual pumping energy requirement, largely off-peak, of the initial unit of The California Water Plan—the Feather River Project—is estimated to be about 5 billion kilowatt-hours by 1980 and nearly 10 billion by 1991. It is possible, also, that by 1980 the total requirement for off-peak pumping energy for pumped storage hydroelectric power plants may be appreciable.

In order that off-peak steam-electric energy may be available for pumping, the total system steam-electric capacity, including steam reserve, must exceed the system base, or continuous, load. This condition now exists in California. As yet the margin in some months of a dry year is not great in northern California. However, it is estimated that by the end of 1957 southern California will have an energy margin of 4.2 billion kilowatt-hours under adverse hydroelectric power conditions. Assuming no change in the hydro-steam ratio, the increase in the supply of surplus energy would be roughly proportional to the increase in power load. It is further estimated that in southern California alone some 20 billion kilowatt-hours of surplus energy should be available annually by 1980. A considerable portion of this surplus energy would be usable as off-peak energy for pumping. It is expected that higher-voltage transmission lines, interconnecting major loads and generating sources, will be available to a much greater degree than at present (1957) for transmitting both on-peak and off-peak energy throughout the State. It therefore appears that ample off-peak energy will be available for all pumping requirements as they develop.

Impact of Atomic-Electric Power. The discussion to this point has assumed no appreciable expansion of the atomic-electric industry. This approach was followed not because of any doubt that safe, competitive atomic power plants ultimately will be built; rather, it stemmed from uncertainty as to when this goal will be attained and as to the rate of expansion of this industry.

With respect to timing, the future supply of fossil fuel in relation to the rapidly expanding total energy requirement is of great significance. Development of atomic-electric energy is desirable to avoid rising fuel costs, and to conserve the relatively limited supply of nonrenewable fossil fuels for special, higher-value applications.

Presently a few small pilot-type atomic power plants are planned or are under construction in the United States, including two in California. Numerous difficult problems must be solved before safe, competitive atomic plants can become a reality. Because of the many uncertainties involved, forecasts as to when such plants would be in common use are still of doubtful value. In view of expected population and power load growth, it appears reasonable to assume that California would ultimately experience an atomic power industry expansion comparable, percentage-wise, to that of the United States as a whole.

Initially, the fixed or capacity costs of atomic-electric power plants probably would be higher than for fossil-electric plants, but it is claimed in some quarters that ultimately such costs may decrease to the level of fossil-electric capacity costs. It may be assumed that the operation of atomic-electric power plants would be similar to fossil-electric plants, in that they would be less adapted to noncontinuous operation, that is, on peak load. Therefore, hydroelectric power peaking plants would complement atomic-electric plants in the same manner that they now complement fossil-steam electric plants.

Summary. Generally speaking, with the rapidly expanding power load, there will be a market for the hydroelectric power output contemplated under operation of The California Water Plan, when and as that output becomes available. The great advantages of hydroelectric power, particularly for peaking operation, coupled with a declining hydro-steam ratio, will enable it to complement rather than compete with atomic-electric power plants, just as it now does with fossil-steam electric power plants. This is especially true of multiple-purpose projects having low incremental capacity costs and adequate water control. Single-purpose power projects which are not suited to high-degree peaking operation may feel the impact of competition provided by pumped storage hydroelectric power plants utilizing low-cost off-peak energy for pumping. It is concluded that ample off-peak energy will be available for pumping as required under The California Water Plan.

As conceived and formulated, The California Water Plan is a flexible pattern of water development which can be modified to fit changing conditions. It now appears that the declining hydro-steam ratio and future expansion of the atomic-electric power industry may lead to the modification of some contemplated hydroelectric power projects. The principal change would be in the direction of a higher degree of peaking, with lower plant load factors, including wide application of the pumped storage principle.

Needed Basic Investigation and Research

In spite of the years of experience and the store of knowledge that have been accumulated, there still are many factors or facets of the occurrence and use of water about which comparatively little is known. For instance, most of the water falling on the land as precipitation is disposed of by consumptive use. Yet the fundamental data upon which estimates of consumptive use of water must be based are quite meager and limited in duration. An extensive program to obtain more reliable basic data on consumptive use for a wide variety of vegetative cover and crops under different conditions and over a considerable period of time is urgently needed.

In the water quality field, more information is required concerning the effects of differing concentrations of various dissolved minerals on the yields of different agricultural crops under varying conditions of soil, drainage, climate, irrigation practices, and the like. More study is needed of the tolerances of various kinds of fish life to the many materials which may be added to streams by the disposal of sewage and industrial wastes, even though treated. With the increasing complexity of industrial wastes, this is a pressing problem if fishery resources are to be preserved.

Much remains to be learned about drainage, the characteristics of water-bearing materials in ground water basins, artificial recharge of ground water basins, methods to achieve more efficient use of water, sewage reclamation, saline water conversion, possibilities of utilization of atomic energy, decreasing evaporation from reservoirs, and a host of other factors, all of which are important to the implementation of The California Water Plan. Carefully controlled experimental work and evaluation of weather modification procedures over a period of several years and involving several large watersheds should be undertaken. Study is being devoted to these now to some extent, but it should be expanded and expedited.

The foregoing by no means encompass all the factors involved in the supply, distribution, utilization and disposal of water, concerning which current basic data are quite inadequate. They do serve to illustrate the scope of needed investigations and research and the urgency thereof. Research programs, adequately financed, must be prosecuted diligently to supply the needed information; the need for more data concerning consumptive use of water is particularly urgent.

Alternative of Lower Dams in North Coastal Area

Considerable question has been raised regarding the feasibility of the high dams discussed herein as features of the California Aqueduct System in the North Coastal Area. The opinion has been expressed that the objectives of The California Water Plan, particularly in terms of water conservation, could be more satisfactorily achieved by a greater number of dams of conventional heights and types, instead of the fewer structures of unprecedented size.

Although it has been reiterated several times hereinbefore, it is again emphasized that the works described in Chapter IV represent only one possible means of achieving the required degree of development of California's water resources. These works have been selected as a result of preliminary studies as constituting the most feasible over-all development scheme. The choice between the "super" and the conventional dams remains for future determination, based upon intensive geologic, engineering, and economic studies, to be made as the need for exported water supplies from the North Coastal Area develops. However, some of the more pertinent factors bearing on the selection of heights of dams in studies basic to the preparation of this bulletin are worthy of discussion.

Features of the Klamath-Trinity and Eel River Divisions of the California Aqueduct System were selected on the basis of net unit cost of water delivered to the Sacramento Valley. The major items considered in the evaluation of various alternative schemes were: (1) capital costs of dams and associated facilities, (2) cost of electric energy for pumping, and (3) revenue from power developed. The plans selected and presented in this bulletin were those which would develop the required amounts of water at the lowest over-all cost, considering these factors. As a result of these preliminary studies, certain of the reservoirs contemplated on the Klamath River would have large amounts of inactive storage for maintenance of minimum heads for power generation. Likewise, certain of the prospective reservoirs on the Trinity and Eel Rivers would have high percentages of inactive storage in order to minimize pumping lifts to the tunnels leading to the Sacramento Valley.

Geologic information available in the North Coastal Area is meager, and knowledge to be gained from detailed geologic exploration may definitely preclude high dams at certain locations, thus forcing the selection of alternative sites or the choice of lower dams. Other presently indeterminate factors, such as the possibility of low-cost electric energy, might so affect the present economic balance between pumping lifts and capital costs of dams and tunnels as to change substantially the most feasible heights of dams.

In conclusion, the facilities herein described as features of the California Aqueduct System in the North Coastal Area serve only to demonstrate the physical possibility of developing and exporting some 11,000,000 acre-feet of water per year. While it is not known with certainty at the present time by just which means this water will be developed, it is reasonably certain that essentially the same aggregate amount of active reservoir storage capacity would be required, regardless of the final plan selected.

Alternative Future Development of High Desert Areas

As has been stated, The California Water Plan is an ultimate plan under which water supplies adequate for the development of the land and other resources of the State to their full potential could be provided. It is realized that the works required to conserve and convey water long distances to irrigate certain lands of limited crop adaptability, or lands lying at high elevations, or both, are not now, and may possibly never be, within limits of economic justification and financial feasibility. However, the economics of the distant future cannot now be foreseen, and the planning effort is deemed necessary in order that provision may be made for serving such lands, if and when the need arises.

As the future unfolds, The California Water Plan, by its inherent flexibility, would enable the staging of construction of those works which would most economically meet the increasing water requirements of all areas of the State, wherever and at whatever rates such increases may occur. In this respect, the probability of future development of the high desert areas of central and southern California is of interest. The effect upon estimated capital costs of The California Water Plan of inclusion of works to provide for the forecast ultimate development of those areas is significant.

The forecast ultimate full development of high-elevation desert areas of central and southern California might require an aggregate seasonal water import of about 6,000,000 acre-feet, distributed as follows:

Area	*Acre-feet per season*
Inyo-Kern area	1,600,000
Antelope and Mojave Valleys	2,250,000
Southeastern Lahontan area	1,850,000
Carrizo-Cuyama Valleys	300,000
Total	6,000,000

With exception of an anticipated import need for municipal-industrial purposes of about 200,000 acre-feet of water per season in the Antelope and Mojave Valleys the foregoing import requirements are based upon essentially a possible agricultural water demand. Present economics appear unfavorable for further extensive development of irrigated agriculture in these areas, due primarily to the limited local water supplies, the high cost of imported water, and climatic limitations. These economic factors, however, are not expected to control the already mushrooming urban, industrial, and military development in the Antelope and Mojave Valleys; in fact, such development may well continue to expand, and water to meet its requirements could be made available at costs well within the repayment capacity.

Should the projected agricultural development of the high-elevation desert areas fail to materialize, expansion of the California Aqueduct System would stop some 5,800,000 acre-feet per season short of its contemplated ultimate capacity of about 22,000,000 acre-feet per season. It is estimated that in this event the capital cost of the California Aqueduct System, constructed to a capacity of about 16,000,000 acre-feet per season, would aggregate about $5,100,000,000, or approximately $3,860,000,000 less than the capital cost of the system to meet all the forecast requirements, as summarized in Table 30.

The foregoing estimate is based upon the premise that construction of the California Aqueduct System would be orderly, in planned stages, with the timing of each stage dictated by needs for water and by economics. For purposes of illustration of this premise, assume that a point of time is reached when all water-deficient areas of the State would be receiving the forecast ultimate water service, except the high desert areas wherein demand for agricultural water would not have developed. In such a case, all prospective facilities of The California Water Plan would have been constructed, except those necessary to conserve and transport agricultural water for the high desert areas. The amount of this water, as has been stated, is estimated to be about 5,800,000 acre-feet a season. Let it be further assumed that, under such conditions, the relatively inexpensive export yields of the Sacramento Division of the California Aqueduct System would have been developed. This would leave certain of the most costly projects of the North Coastal Area undeveloped because of their physical location. These distant works would probably be the last in the chain of developments of the Klamath-Trinity and Eel River Divisions. In addition, the affected transport features of the California Aqueduct System would have been constructed to appropriately smaller capacities.

Features which could either be deleted from The California Water Plan or reduced in capacity, through elimination of service of irrigation water to the high desert areas of central and southern California, if such should prove unnecessary, and the magnitude of the resulting reduction in capital costs of the California Aqueduct System, are listed in Table 32.

TABLE 32

REDUCTION IN ESTIMATED CAPITAL COST OF THE CALIFORNIA WATER PLAN, ASSUMING PROJECTED AGRICULTURAL DEMAND OF HIGH-ELEVATION DESERT LANDS FAILS TO DEVELOP

Eliminated feature of California Aqueduct System	Reduction in capital cost
Klamath-Trinity Division	
Unconstructed features:	
Smith River (Canthook Dam and Reservoir; Black Hawk Dam, Reservoir, and Pumping Plant; Cantpeak Tunnel)	$190,000,000
Klamath River (Hamburg Dam, Reservoir, and Power Plant; Happy Camp Dam, Reservoir, and Power Plant; Humboldt Dam, Reservoir; Beaver Pumping Plant)	300,000,000
Mad, Van Duzen, and Trinity Rivers (Eaton Dam and Reservoir; Mad Tunnel; Ranger Station Dam and Reservoir; Sulphur Glade Tunnel and Power House; Eltapom Dam, Reservoir, Power House, and Afterbay; War Cry Tunnel)	170,000,000
Transport features constructed to partial capacity	620,000,000
Subtotal	$1,280,000,000
Eel River Division	
Unconstructed features:	
Eel River (Sequoia Dam and Reservoir; Bell Springs Pumping Plant)	$120,000,000
Transport features constructed to partial capacity	80,000,000
Subtotal	$200,000,000
Sacramento Division	
Unconstructed features:	
(Sacramento West Side Canal)	$360,000,000
Transport features constructed to partial capacity	40,000,000
Subtotal	$400,000,000
Delta Division	
Unconstructed features:	
(Antioch Crossing)	$210,000,000
Transport features constructed to partial capacity	30,000,000
Subtotal	$240,000,000
San Joaquin Division	
Unconstructed features:	
Carrizo-Cuyama Aqueduct	$50,000,000
Transport features constructed to partial capacity	350,000,000
Subtotal	$400,000,000
Southern California Division	
Unconstructed features:	
Antelope-Mojave Aqueduct System	$410,000,000
Transport features constructed to partial capacity	900,000,000
Subtotal	$1,310,000,000
Total Reduction in Capital Cost	$3,830,000,000

The reduction in capital costs shown in Table 32 is based upon the premise that the Sacramento West Side Canal and the Antioch Crossing would not be constructed, should the agricultural demands of the high desert lands fail to develop. Without these features, conveyance of export water from Iron Canyon Reservoir on the Sacramento River the Mountain House Pumping Plant near Tracy would be accomplished through natural channels of the Sacramento River and the Sacramento-San Joaquin Delta. However, even with the deletion of 5,800,000 acre-feet of water per season from contemplated deliveries from the North Coastal Area, there would still remain some 6,000,000 acre-feet of largely urban water supplies to be transported to and conveyed across the Delta. Protection of the quality of this water might, at some future time, require the construction of an isolated conduit along the west side of the Sacramento Valley and across the Delta.

In addition to the cited delivery of agricultural water to the high desert areas, a substantial portion of the contemplated deliveries by the San Diego High-Line Aqueduct of the Southern California Division would be for the service of agricultural lands in the Whitewater and San Felipe Groups of the Colorado Desert Area. Should these lands fail to develop, the necessity of constructing the San Diego High-Line Aqueduct might never materialize, as the greater portion of water delivery by that aqueduct would be for that agricultural purpose. However, water service which would have been provided to urban and industrial areas by the San Diego High-Line Aqueduct would have to be met from an alternative source, namely, by pumping from the Barona Aqueduct, for which purpose additional aqueduct capacity would be required.

Based upon studies of a preliminary nature, it is indicated that the further reduction in capital costs of The California Water Plan by eliminating the contemplated delivery, through the San Diego High-Line Aqueduct, of some 500,000 acre-feet of water per season to agricultural lands in the Whitewater and San Felipe Groups, would be on the order of $600,000,000.

In summary, the deletion of those facilities of The California Water Plan which would develop and convey some 5,800,000 acre-feet of water per season to the high desert areas in southern California would reduce the total capital cost of the Plan by about $3,900,000,000. In the event that the San Diego High-Line Aqueduct is not constructed, due to the failure of agricultural lands in the Whitewater and San Felipe Groups of the Colorado Desert Area to develop, water deliveries under The California Water Plan would be further reduced by some 500,000 acre-feet per season, and the capital cost of the Plan would be correspondingly reduced by an additional $600,000,000. Thus, by eliminating water service to all agricultural lands requiring high pump lifts in southern California, the total amount of water developed and transferred by facilities of The California Water Plan would be reduced by 6,300,000 acre-feet per season, and the total capital cost of the Plan would be reduced by some $4,400,000,000.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

In 1947, the California Legislature authorized the initiation of the State-Wide Water Resources Investigation to formulate a comprehensive master plan for the full control, conservation, protection, distribution, and utilization of all the State's water resources, both surface and underground, to meet the present and future needs for water for all beneficial purposes and uses in all areas of the State to the maximum practicable extent. As a result of intensive study, analysis of engineering and geologic data, and information made available during the planning phase of that investigation, and on the basis of estimates and assumptions discussed hereinbefore, the following summary, conclusions, and recommendations are presented.

SUMMARY

Problems

1. California's rapid and continuing population, agricultural, and industrial growth of recent years has given rise to unprecedented expansion in the needs for water for consumptive demands, comprising those for agricultural, industrial, and municipal purposes, and nonconsumptive uses, including those for flood control, hydroelectric power, recreation, and fish and wildlife. Corollary problems have developed, such as overdraft on ground water basins, intrusion of saline and other degraded waters into ground water basins, problems of control of mineral and organic quality of surface and underground waters, drainage, and related problems.

2. California's water problems result primarily from the unbalanced distribution of its water resources and water requirements. The major sources of water are in northern California where the waters of many streams now waste into the ocean virtually unused. The major urban areas and productive agricultural lands of California are in that portion of the State to the south in which occurs only 30 per cent of the total natural runoff. Great distances and rugged mountains separate source areas from areas of demand. About 70 per cent of the total stream flow occurs north of the latitude of Sacramento, but 77 per cent of the present use of water, and 80 per cent of the forecast ultimate use lie south of that line.

3. Water problems of California are further intensified by the large variations of runoff within the season and from year to year. Most of the runoff occurs during the winter and spring when the demand for water is least. Runoff is also subject to marked annual variations, with droughts of several years' duration characteristically being followed by one or more years of above-normal runoff. The periodic droughts impose the need for very large reservoir storage capacity for cyclic regulation, in addition to lesser storage requirements for seasonal regulation.

4. The largest problems of water deficiency occur in the San Joaquin Valley and southern areas of the State, the areas of greatest water demand. However, water deficiencies do occur in all areas throughout the State, especially in connection with seasonal unbalance of available water. In many instances, increasing water requirements have been provided for by drawing on the large but presently diminishing supplies available in ground water reservoirs. Withdrawals from ground water storage presently (1957) exceed mean annual replenishment by an estimated 4,000,000 acre-feet for the State as a whole, with resultant perennial lowering of ground water levels.

5. Periodic floods from rivers and streams throughout the State, in the valleys and flood plains where most of the 14,000,000 population live, have resulted in major damage and loss of life. Some of the flood problems have been solved. However, with the intensification and expansion of urban and industrial areas, many flood problems will become more severe until remedial action is taken. As land becomes more of a limiting factor in the ultimate development of the State, it will be increasingly important to prevent creation of blighted areas subject to recurring uncontrolled floods.

6. Deleterious effects on the quality of natural water supplies have resulted from deficiencies in surface and ground water development, from lack of drainage, and from improper disposal of wastes. Quality problems are common to nearly all other water problems. In several locations in the coastal plain, excessive draft has resulted in the intrusion of sea water into underground aquifers, thus impairing valuable sources of water supply. In many parts of the Central Valley, continuing ground water overdraft threatens quality degradation of fresh-water aquifers by upward movement of deep connate brines which were entrapped in underground basins in past geologic ages. In other areas, unfavorable salt balance is a practical certainty as the result of persistent overdraft conditions, unless additional water is imported and used. When more salt is brought into a basin than is carried out of it by the outgoing water, the salt balance is termed unfavorable. Another phase

ing water resource development works. It also incorporates certain of the planned works now proposed or authorized by public and private agencies and individuals. Of special significance in this respect is the authorized Feather River Project, which is the initial unit for construction under the Plan, and on which construction will start in May, 1957.

5. Although The California Water Plan is capable of accomplishment from an engineering standpoint, its component features have widely variant relationships to present concepts of economic and financial feasibility. It is realized that certain of the works would be extremely costly under present value criteria. Such works are for the indefinite future, and their need may never materialize. However, the economics of the distant future cannot be foreseen, and the planning effort is deemed necessary at this time in order that provision may be made for such developments, if and when they become needed and justified.

6. The California Water Plan gives full consideration to the use of water for agricultural, domestic, and industrial purposes; to hydroelectric power development; to flood control and protection; to drainage; to salinity control; to protection of the quality of water; and to the interests of fish, wildlife, and recreation.

7. Under The California Water Plan, water would not be taken from those who will need it; rather, it would provide for the needs of areas of inherent deficiency by transfer only of excess or surplus water from areas of abundance. Legislative acceptance of the Plan, and firm provisions for its progressive implementation as successive component projects become feasible, would tend toward elimination of sectional concern as to future availability of necessary water supplies.

8. The California Water Plan is neither an inflexible regulation nor a construction proposal as it is presented herein. It does not purport to include all possible water development projects in the State. Rather, it serves to demonstrate that the full satisfaction of ultimate water requirements in all parts of the State is physically possible of accomplishment. Therefore, the omission of any project from description in this bulletin does not preclude its future integration into the Plan.

The California Water Plan

1. The full natural seasonal runoff of streams in California, amounting to about 71,000,000 acre-feet on the average, is sufficient to provide for the full satisfaction of ultimate water requirements for all areas of the State, considering California's rights in and to the waters of the Colorado River in the amount of 5,362,000 acre-feet per season.

2. Existing and potential areas of intensive water service in California total about 23,600,000 acres, of which approximately 20,000,000 acres are classified as suitable for irrigated agriculture, and 3,600,000 acres for urban, suburban and industrial types of development. It is expected that under ultimate development, the majority of the remaining 77,300,000 acres of land will be only sparsely settled and will have only very minor requirements for water service. The remaining areas of California for the most part include only scattered water service areas, largely in mountainous and desert regions and in national forests and monuments, public beaches and parks, private recreational areas, wildlife refuges, and military reservations.

3. Water requirements in California will aggregate some 51,100,000 acre-feet per season under ultimate conditions of development. Of this amount, irrigated lands will require about 41,100,000 acre-feet; urban, suburban, and industrial areas will use 8,300,000 acre-feet; and 1,700,000 acre-feet will be utilized for other miscellaneous purposes.

4. The extreme seasonal and cyclic variation, and the geographic maldistribution in the occurrence of California's water resources, will necessitate:

a. The development and use of vast regulatory and carry-over storage capacity, both surface and underground, in order to attain the degree of conservation required to meet water needs under ultimate conditions of development; and

b. The construction and operation of a major system of works to convey the regulated excess waters from areas of inherent surplus to areas of inherent deficiency.

These major conservation and conveyance facilities, collectively designated the "California Aqueduct System," would constitute a coordinated comprehensive system of works, reaching from Oregon to Mexico.

5. The ground water storage capacity underlying the floor of the Central Valley, the key ground water basin in the State under operation of The California Water Plan, is estimated to exceed 130,000,000 acre-feet within 200 feet of the ground surface. Regulation of water supplies in the Central Valley would be accomplished by conjunctive operation of some 31,000,000 acre-feet of available ground water storage capacity with 22,000,000 acre-feet of storage capacity in major surface reservoirs. In addition to the Central Valley, there are more than 200 significant valley fill areas capable of conserving and regulating substantial amounts of water in other parts of California.

6. The California Water Plan would provide for:

a. Development of the water resources of the North Coastal Area to meet all future local needs in that area, and to furnish about 11,600,000 acre-feet of surplus water per season for export to other areas of the State;

b. Development of the water resources of the Sacramento River Basin to meet all future local needs within that basin, and to furnish about 10,300,000 acre-feet of surplus water per season for export to other areas of the State; and

c. Full practicable development of local water resources in all remaining areas of the State, to assist in meeting future needs in those areas.

7. Local developments to meet local water requirements under The California Water Plan would make available some 7,000,000 acre-feet of new yield per season. In addition, the surplus waters from the North Coastal Area and Sacramento River Basin, amounting to some 21,900,000 acre-feet per season, would be developed by the California Aqueduct System and distributed to areas of deficiency as follows: San Francisco Bay Area, 2,200,000 acre-feet; Central Coastal Area, 1,200,000 acre-feet; South Coastal Area, 2,900,000 acre-feet; San Joaquin-Tulare Lake Basin, 8,600,000 acre-feet; Lahontan Area, 4,800,000 acre-feet; Colorado Desert Area, 1,400,000 acre-feet. An additional 900,000 acre-feet of water per season would be required for operation of a salinity control barrier in the Sacramento-San Joaquin Delta.

8. The California Water Plan would involve the eventual construction of:

a. Some 376 new reservoirs throughout the State, with a total gross storage capacity of about 77,000,000 acre-feet to be added to the 20,000,000 acre-feet of storage capacity in existing reservoirs;

b. New hydroelectric power generating facilities in connection with the water development works, with a total installed power capacity of about 7,800,000 kilowatts and a seasonal energy production of about 34 billion kilowatt-hours;

c. Pumping installations with an aggregate installed capacity of about 12,300,000 kilowatts, and a seasonal energy requirement of about 49 billion kilowatt-hours.

Of the total energy requirement for pumping, about 30 billion kilowatt-hours per season would be needed for conveyance of water to the high desert areas of southern California, the development of which cannot be foreseen at the present time. However, some 11 billion kilowatt-hours of this energy would be recovered by power generation from the water involved in the drops to the Sacramento Valley floor and on the southern side of the Tehachapi Mountains, thus reducing the net seasonal energy requirement to 19 billion kilowatt-hours for service to those high desert areas.

9. The Feather River Project will conserve Feather River water and convey flows of water across the Delta, thence along the west side of the San Joaquin Valley and over the Tehachapi Mountains into southern California. It will furnish supplemental water supplies to the San Francisco Bay Area, the San Joaquin Valley, and southern California. This project was authorized by the Legislature in 1951 for construction by the State as the initial unit of The California Water Plan. Urgent need will exist for the supplemental water supplies this project will transport to water-deficient areas by the time it can be constructed. It is estimated that supplemental water supplies can be provided in the San Joaquin Valley in 1963 and in southern California by 1970.

10. Construction of all features of The California Water Plan, which would be accomplished over a long period of time, would involve a total capital expenditure of some $11,800,000,000, based upon present (1955) price levels and economic conditions. Of this total amount, the cost of developments to meet local water requirements would aggregate some $2,800,000,000, and the California Aqueduct System would cost about $9,000,000,000. Of this latter amount, about $4,400,000,000 would be required to develop and convey agricultural water to the high desert areas of southern California. Development of the demand for this water service cannot be foreseen at the present time.

11. The prospective market for hydroelectric energy generated under The California Water Plan would be favorable because of:

a. The advantages of hydroelectric power as an ideal working partner with fossil or atomic thermal power, wherein the inherent capability of hydroelectric plants for generation of on-peak energy would be employed; and

b. The advantages of hydroelectric power in connection with pumped storage projects.

Implementation of The California Water Plan

1. There exists immediate and urgent need for construction and operation of major water development works in California, particularly in the interests of water conservation and utilization, and in the interests of flood control and protection. The agricultural and urban economy of the State is threatened with the dangerous consequences of continuing and rapidly increasing overdrafts on the developed water supplies. These overdrafts, resulting largely from excessive use of ground waters, are now (1957) estimated to aggregate some 4,000,000 acre-feet per season, an amount equivalent to the anticipated new seasonal yield of the Feather River Project. The needs of the people and the economy for protection from the ravages of uncontrolled flood waters was tragically demonstrated by the flood of December, 1955.

2. The present and future protection of the high quality of the waters of the State must be assured. Without this safeguard, full implementation of The California Water Plan will not be possible. Required

objectives for maintenance of the quality of water should not apply only to current water uses but also should provide protection under future projects and developments.

3. Sound implementation of The California Water Plan will require the intensive and continuing program of investigation and planning by the Department of Water Resources, known as the "California Water Development Program." This program, using The California Water Plan as a guide, would: ascertain the specific local and state-wide water projects next needed for development; analyze and determine their engineering practicability, economic justification, and financial feasibility; and determine the logical priority of their construction. This program would enable the planning endeavor to keep in step with the rapidly expanding water needs of the State.

4. State-wide coordinated development of California's water resources under The California Water Plan will require the solution of a number of legislative and legal problems, including the following:

a. The adoption of a proper constitutional amendment and implementing legislative enactments which must provide: (1) positive assurance to the areas of origin that adequate water will be reserved for their future development; (2) positive assurance to the areas of deficiency that when they contract with the State for water they can depend upon the right to that supply; (3) removal of the uncertainty inherent in existing statutes; and (4) an adequately financed, continuing program of water development to meet the needs for water in all areas of the State, as those needs arise and as projects to satisfy them are found to be feasible.

b. The definition and determination of the nature and extent of vested rights to the use of surface and ground water, and the establishment of methods and procedures by which such rights as are affected may be compensated or otherwise adjusted in order to permit full operation of the Plan, including conjunctive operation of surface and ground water basins;

c. The authorization of eminent domain for water development projects not included in the Central Valley Project, as authorized by the State;

d. The definition of federal, state, local public, and private responsibilities in connection with water development projects, and establishment of procedures governing the several relationships; and

e. The re-evaluation of statutory restrictions upon certain water development projects.

5. The adoption of sound economic criteria, and the wise and just application of those criteria to projects of The California Water Plan are essential to success of the Plan.

6. The adoption of policies and methods that will provide for the repayment of reimbursable costs of The California Water Plan is required for implementation of the Plan.

7. It is essential that a course of action for state financing of projects of The California Water Plan be adopted in order to achieve the objectives of the Plan. Reference is made to the recommendations of Governor Goodwin J. Knight to the State Legislature for financing The California Water Plan through establishment of the Water Development Fund, as set forth in Chapter V.

CONCLUSIONS

It is concluded that:

1. The future growth of California will depend in large measure upon the early acceptance and implementation of a coordinated, state-wide, multipurpose program of water control, conservation, protection, and utilization.

2. The California Water Plan constitutes such a program, and should be accepted and implemented now as the master plan to guide and coordinate the planning, construction, and operation by all agencies of works required for the control, protection, conservation, and distribution of the water resources of California for all people and beneficial uses in all areas of the State.

3. Critical and increasing needs for supplemental water supplies, for flood control, and for preservation and protection of water resources now exist in many areas of California.

4. The waters originating in California, together with the rights of California in and to the waters of the Colorado River, are adequate in quantity and quality to satisfy all water requirements of the State after it has reached full development, if the waters are properly controlled, conserved, protected, and distributed.

5. The control of floods to provide protection to the growing population and expanding economy of the State must be attained and at all times maintained at a degree commensurate with the need therefor.

6. The quality of waters which are available to meet the full ultimate requirements of all parts of California must be protected and maintained at requisite high levels to make this achievement possible.

7. Minimum standards of well construction and proper procedures for the abandonment of wells should be enforced in order to protect adequately the quality of the State's ground waters.

8. Water development works to satisfy present and future needs of local areas are an essential part of any comprehensive plan for solution of the water problems of the State.

9. Solution of California's water problems must assure adequate provision for municipal, industrial,

and agricultural water supplies, quality of water control and protection, flood control and protection, drainage, navigation, hydroelectric power generation, and protection and enhancement of recreation and fish and wildlife resources, and other related water use activities.

10. The authorized Feather River Project, the first unit of The California Water Plan, should be financed and constructed at so vigorous a rate as will assure delivery of water to the San Joaquin Valley not later than 1963 and to southern California not later than 1970.

11. The California Water Development Program should be financed and prosecuted on a continuing basis adequate to provide plans for meeting the growth in demand for water resource development in California.

12. Immediate action should be taken by the Legislature and the people of the State of California to provide the constitutional amendment, and by the Legislature to provide the enabling legislation necessary for early and orderly implementation of The California Water Plan.

13. The Legislature should provide for the financing, on an adequate and continuing basis, of the State's share of costs of construction, operation, and maintenance of projects under The California Water Plan, as such projects are authorized by the Legislature.

RECOMMENDATIONS

It is recommended that:

1. The California Water Plan be accepted by the Legislature as the general and coordinated master plan for the progressive and comprehensive future development of the water resources of California by all agencies, subject to: (a) more detailed investigation and study of component features of the Plan to determine their need, engineering feasibility, economic justification, financial feasibilty, and recommended priority of construction; and (b) continuing review, modification, and improvement of the Plan in the light of changing conditions, advances in technology, additional data, and future experience.

2. Projects to achieve the objectives of The California Water Plan be constructed as their need, engineering feasibility, economic justification, and financial feasibility are demonstrated by further investigation.

3. Adequate funds be provided by the Legislature, on an assured and continuing basis, for support of the California Water Development Program, comprising: (a) continuation of the compilation and publication of basic water resource data necessary for implementation of The California Water Plan; (b) more detailed investigation and study of component features of the Plan, to determine their need, engineering feasibility, economic justification, financial feasibility, and recommended priority of construction; and (c) continuing review, modification, and improvement of The California Water Plan in the light of changing conditions, advances in technology, additional data, and future experience.

4. Research programs to supply needed basic and experimental data concerning hydrology, hydraulics, water quality, and other pertinent matters be given authorization and adequate financial support.

5. The efforts of all agencies and entities engaged in the planning, financing, construction, and operation of water development projects be coordinated within the framework of The California Water Plan to the end that maximum ultimate objectives may be achieved.

6. The quality of the water resources of the State be protected against unreasonable deterioration from all sources of impairment. In the administration of the statutes governing the disposal of sewage and industrial wastes to waters of the State, consideration should be given not only to the present uses of the waters concerned but also to the future developments and uses envisioned in The California Water Plan. In planning for future urban and industrial developments, consideration should be given to the necessity of adequate waste disposal without endangering the future utility of the State's waters.

7. Proper watershed management practices and methods be formulated and followed to protect and enhance the State's water resources.

8. Positive assurances, to the maximum practicable extent, be provided, by constitutional amendment and legislative enactments, that water required to meet all future beneficial uses in all areas of the State will be available in adequate quantity and quality, when and where needed, and on a dependable basis.

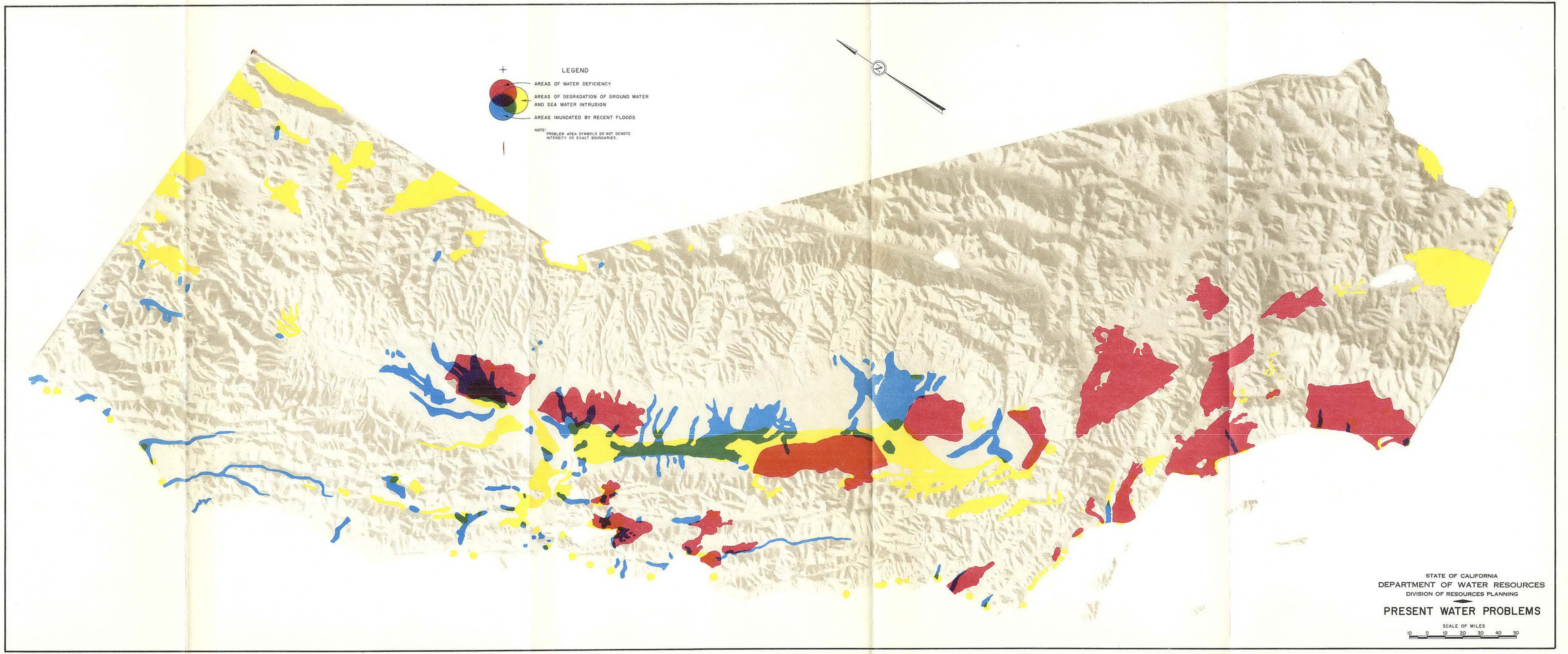
9. A long-range water development fund and enabling policies to assure the financing and construction of needed water development works in California on a continuing, progressive basis be established by the Legislature at the earliest practicable date.

10. The financing and construction of the authorized Feather River Project, the initial unit of The California Water Plan, be expedited in order that urgently needed flood protection will be provided at an early date, and in order that supplemental water supplies will be available to areas of serious water deficiency in the San Francisco Bay Area and in the San Joaquin Valley not later than 1963, and in southern California not later than 1970. The financing and construction of other presently needed water development works should likewise be undertaken immediately.

11. Study be initiated now of the additional legislation that will be necessary for progressive imple-

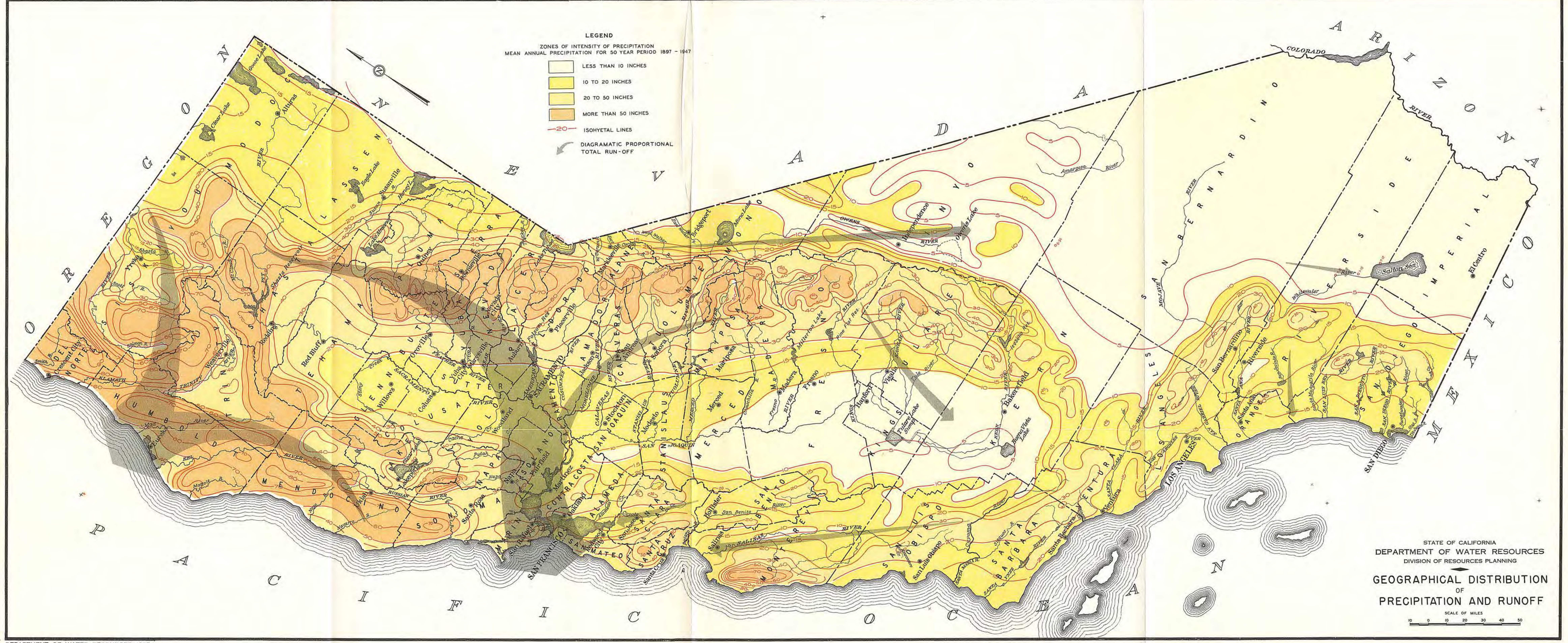
mentation of The California Water Plan, and that such legislation be enacted when and as required. This includes policy recognition of the interests of recreation, fish, and wildlife as important and necessary factors in water development, and the maintenance of live stream flow in the interests of fish, wildlife, and recreation as a beneficial use of water. It further includes: provisions authorizing and implementing administration of ground water development and utilization; the planned operation of ground water basins as storage reservoirs, when necessary in the public interest; the enforcement of minimum standards of well construction and of adequate procedures for abandonment of wells; and legislation to simplify and strengthen the current procedures for the determination of water rights.

printed in CALIFORNIA STATE PRINTING OFFICE
53479 5-57 7500



DEPARTMENT OF WATER RESOURCES 1957

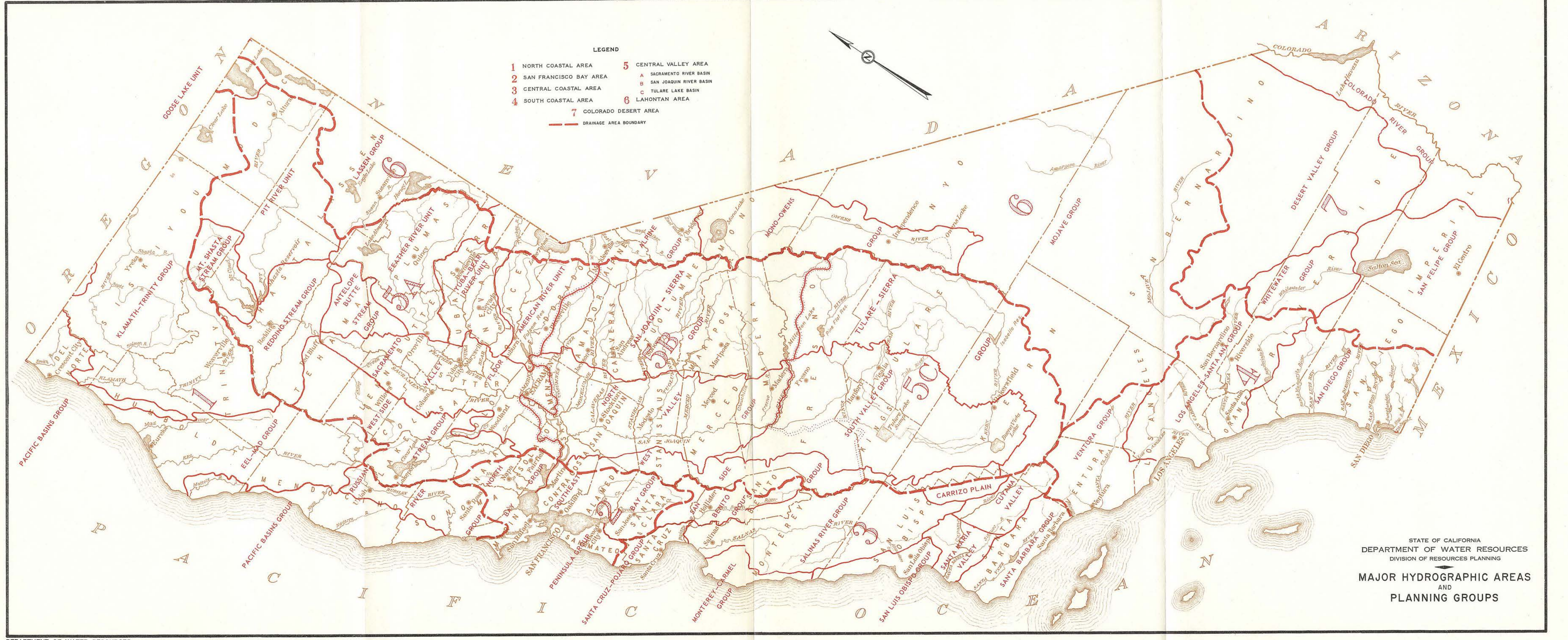
53479-C



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

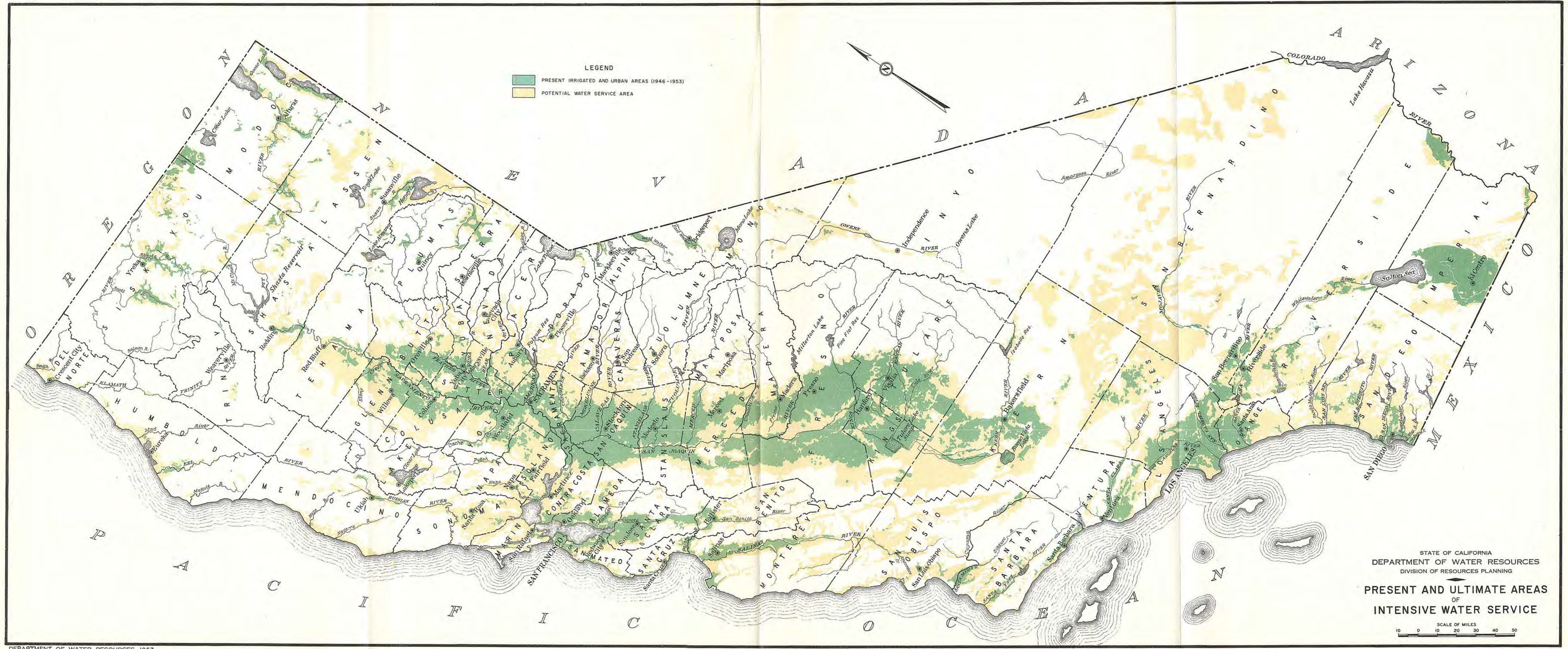
GEOGRAPHICAL DISTRIBUTION OF PRECIPITATION AND RUNOFF

SCALE OF MILES



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

MAJOR HYDROGRAPHIC AREAS AND PLANNING GROUPS



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

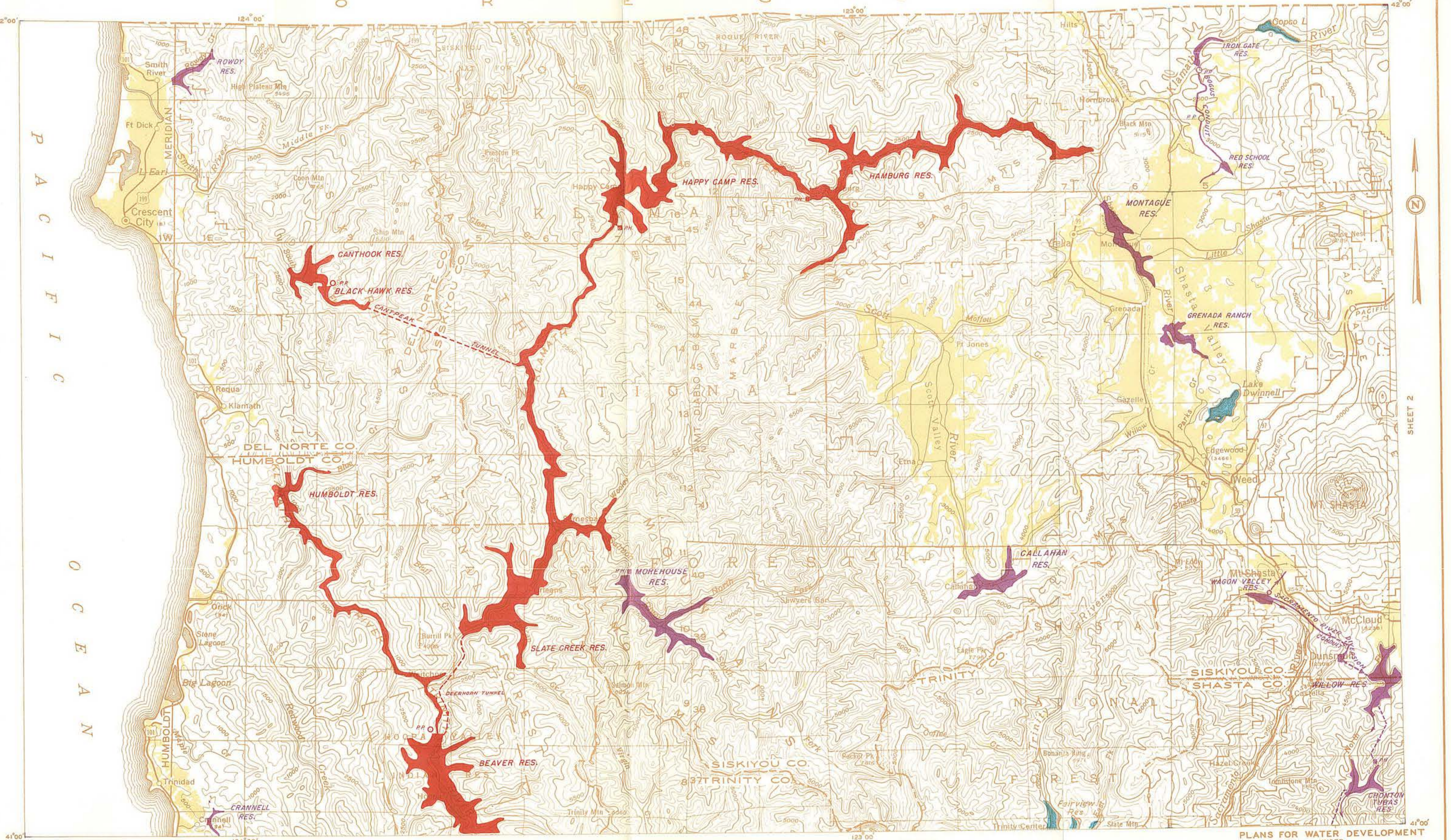
PRESENT AND ULTIMATE AREAS OF INTENSIVE WATER SERVICE

DEPARTMENT OF WATER RESOURCES 1957

INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM — FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM — ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	PH		PH	PH	PH	
PUMPING PLANT	PP		PP	PP	PP	
LEVEE						
IMPROVED CHANNEL						
ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL						
AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN						



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

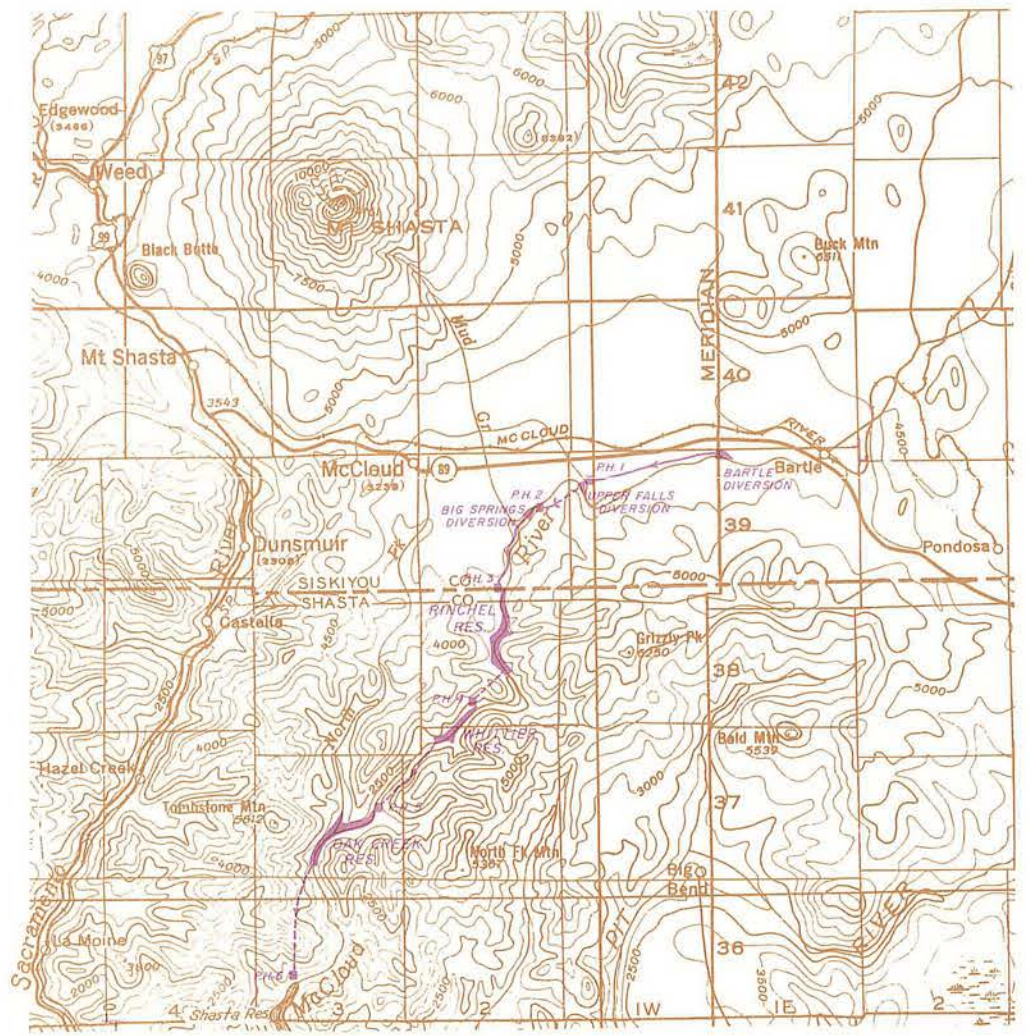
PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 1 OF 26 SHEETS

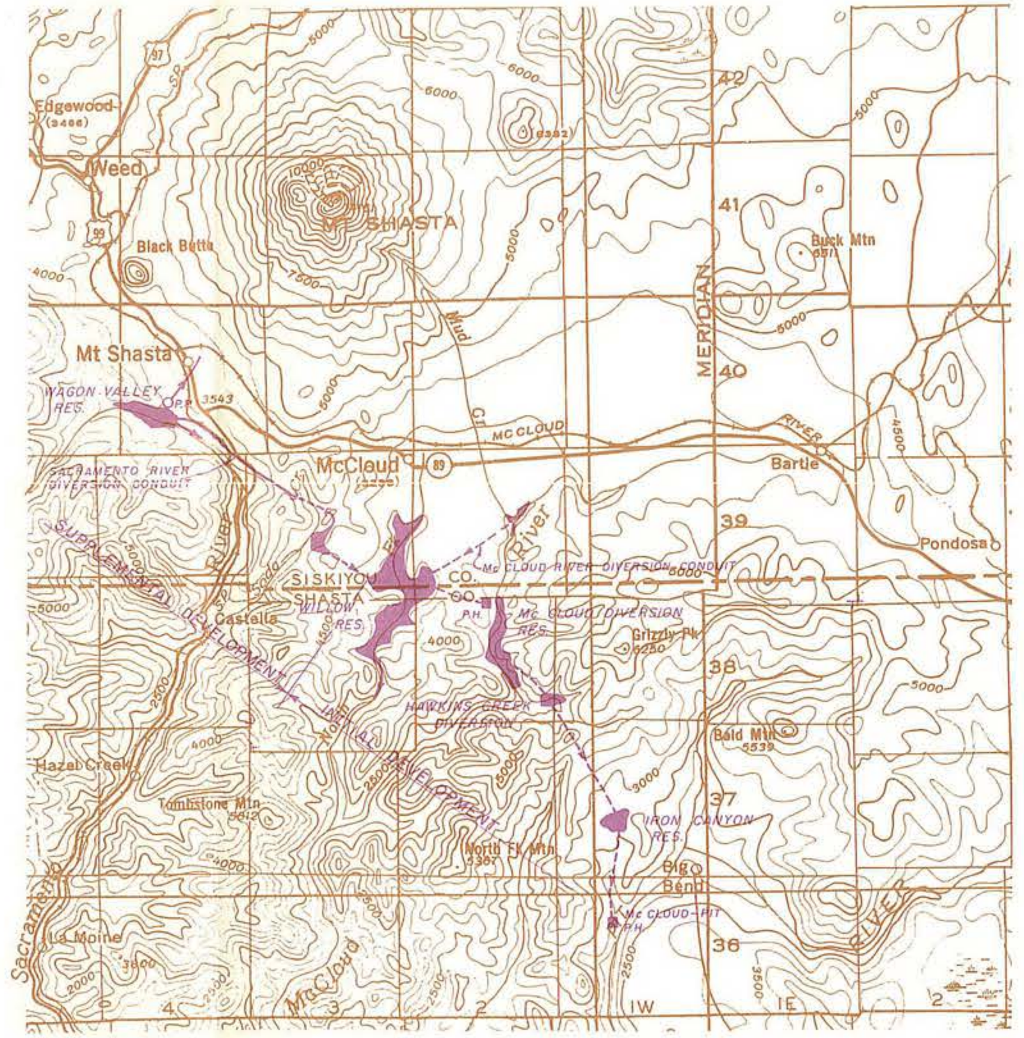
LEGEND

FEATURE	EXISTING WORKS		PROSPECTIVE WORKS			
	CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	FLOOD CONTROL ONLY	THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	DEVELOPMENT FOR LOCAL NEEDS	FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

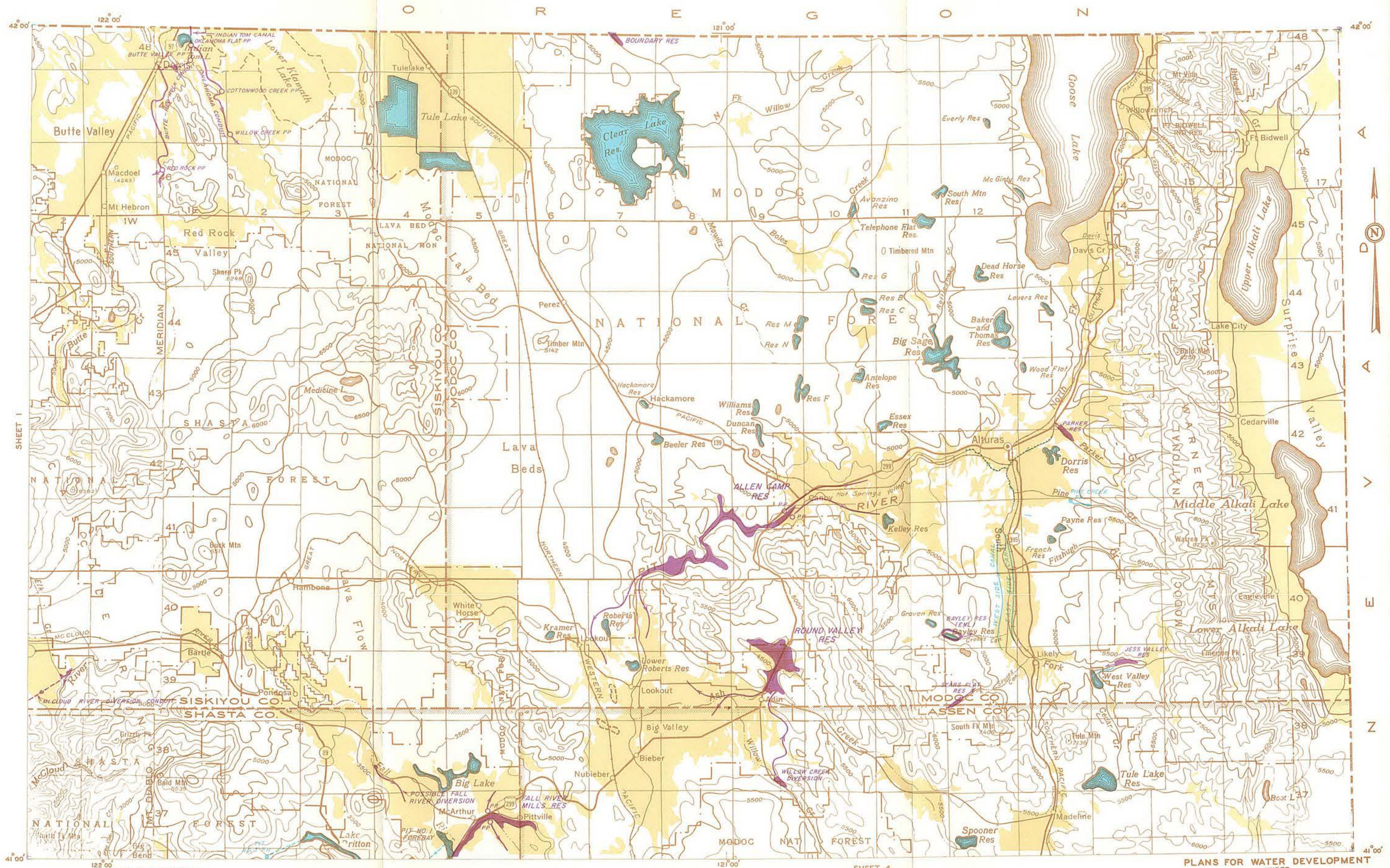
ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN





ALTERNATIVE PLANS FOR McCLOUD RIVER DEVELOPMENT



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 2 OF 26 SHEETS

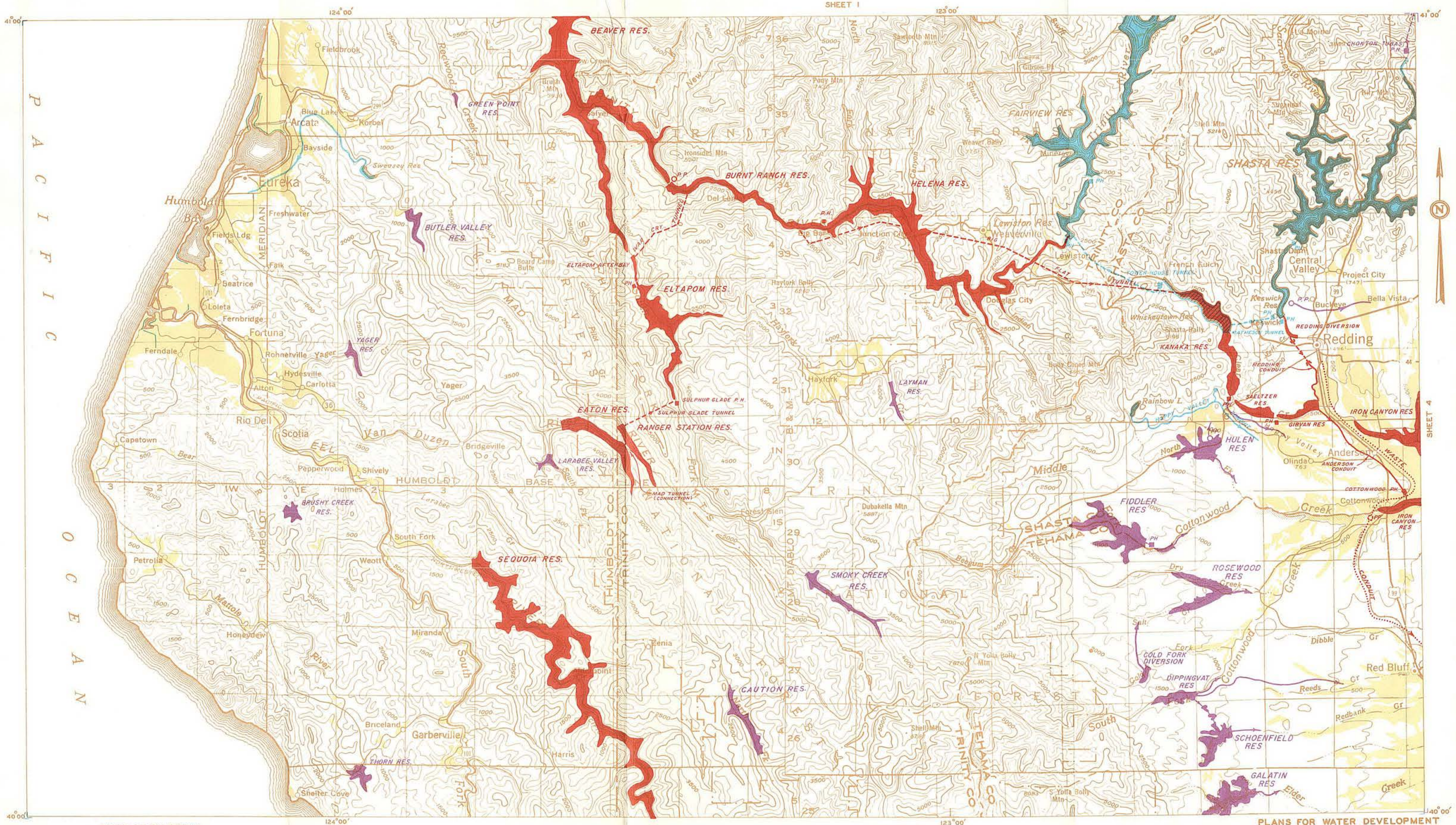
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

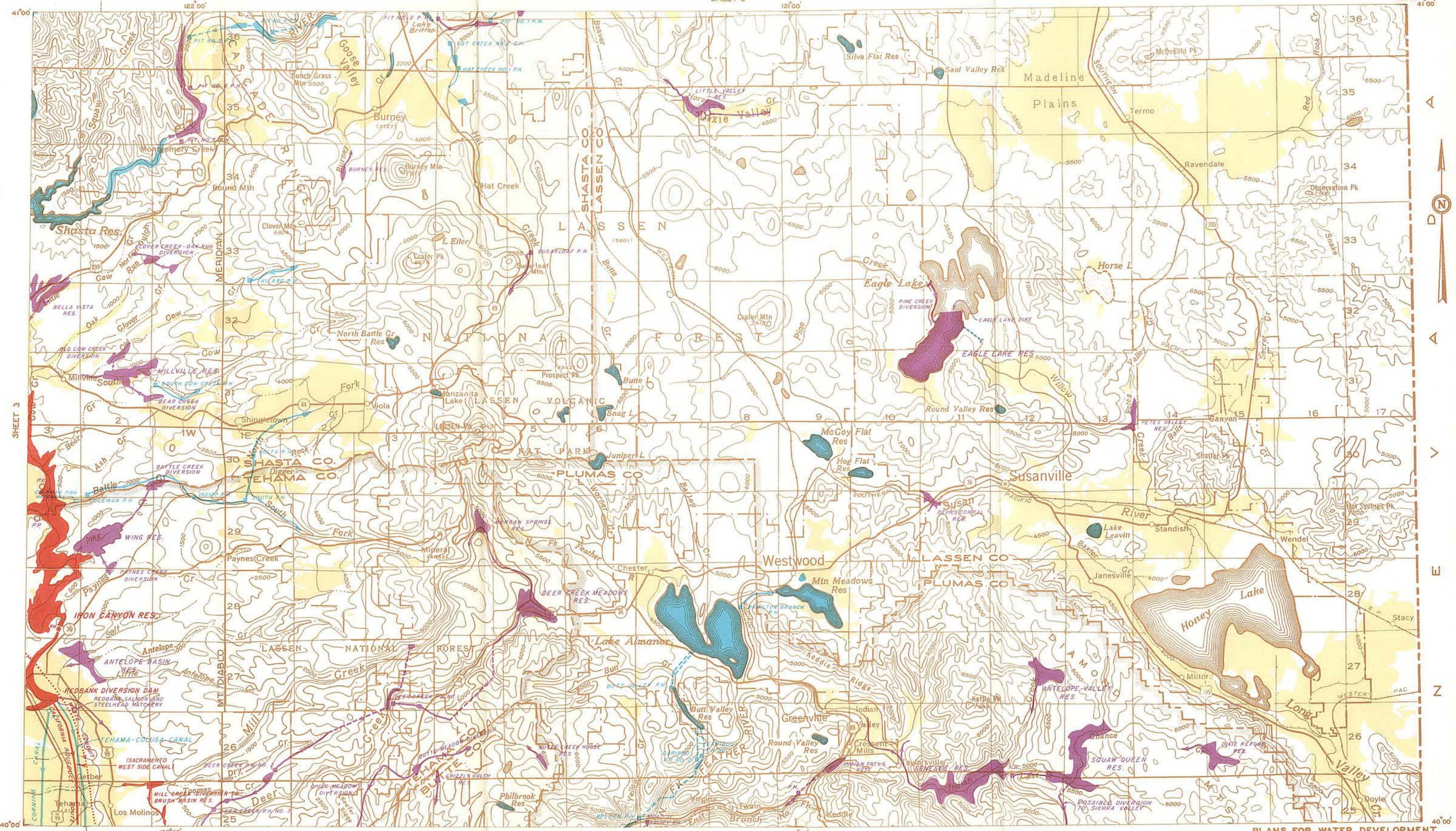
PLANS FOR WATER DEVELOPMENT UNDER THE CALIFORNIA WATER PLAN
SHEET 3 OF 26 SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	PH		PH	PH	PH	
PUMPING PLANT	PP		PP	PP	PP	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 4 OF 26 SHEETS

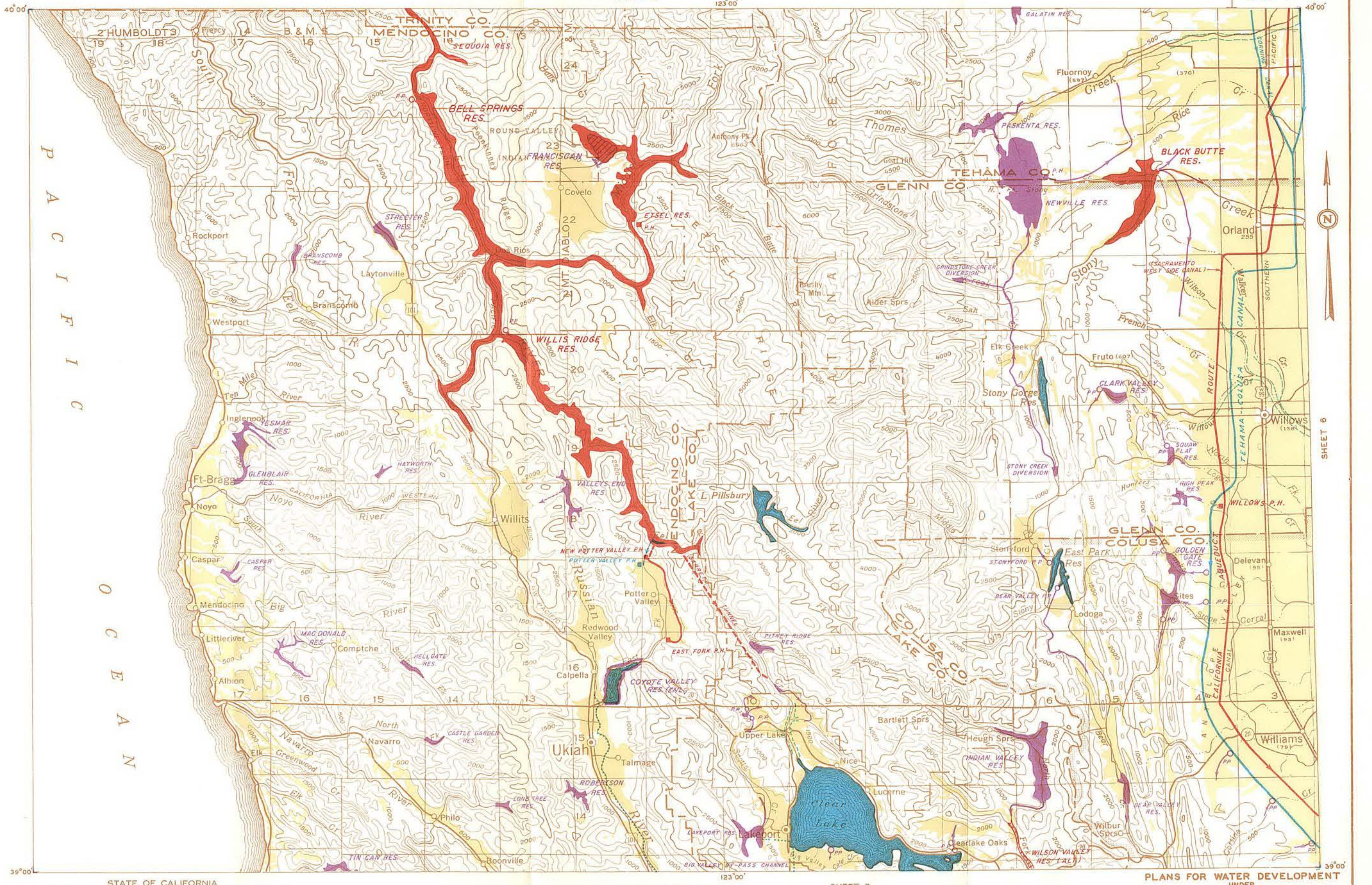
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

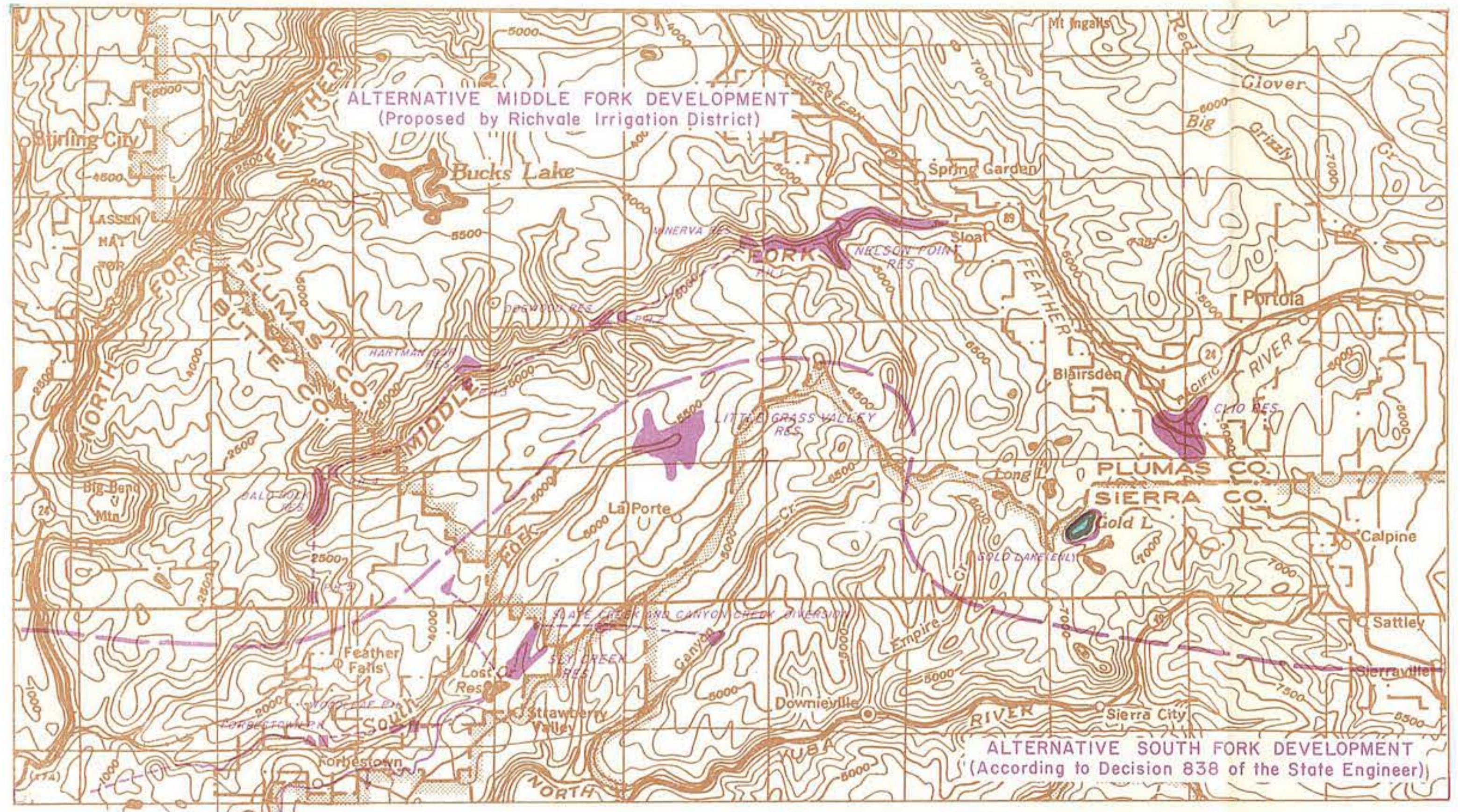
ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

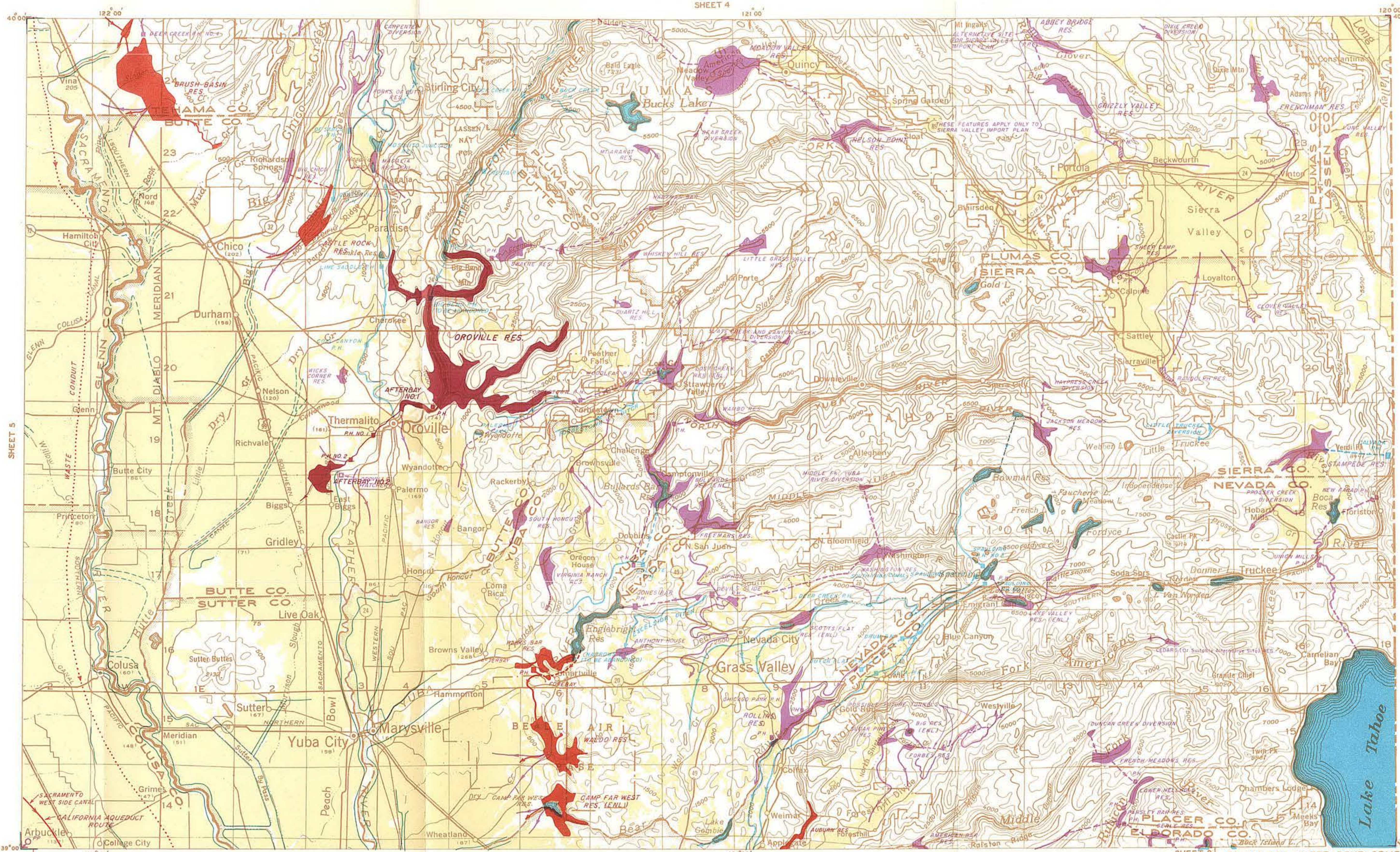
PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 5 OF 26 SHEETS



ALTERNATIVE PLANS FOR FEATHER RIVER DEVELOPMENT

LEGEND

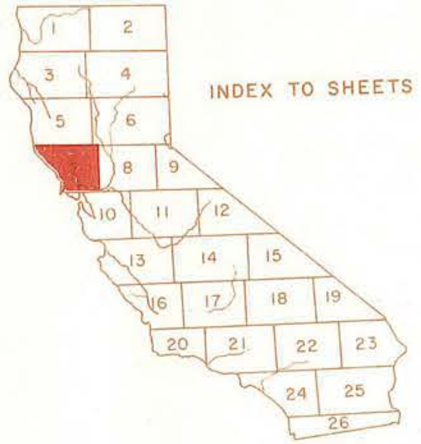
FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	PH		PH	FH	PH	
PUMPING PLANT	PP		PP	PP	PP	
LEVEE						
IMPROVED CHANNEL						
ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL						
AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN						



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 6 OF 26 SHEETS

INDEX TO SHEETS

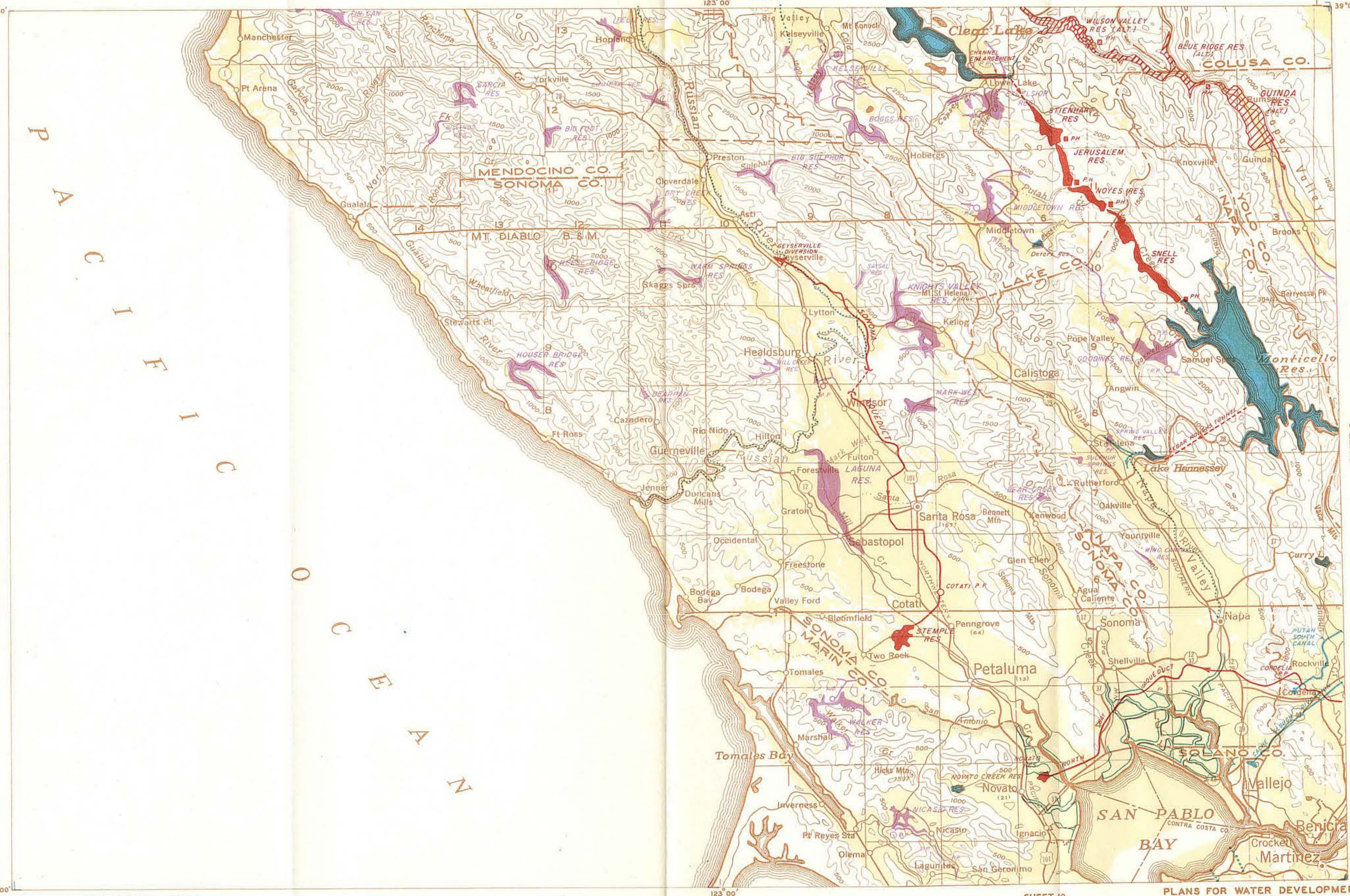


LEGEND

FEATURE	EXISTING WORKS		PROSPECTIVE WORKS			
	CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	FLOOD CONTROL ONLY	THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	DEVELOPMENT FOR LOCAL NEEDS	FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	PH		PH	PH	PH	
PUMPING PLANT	PP		PP	PP	PP	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT UNDER THE CALIFORNIA WATER PLAN
SHEET 7 OF 26 SHEETS

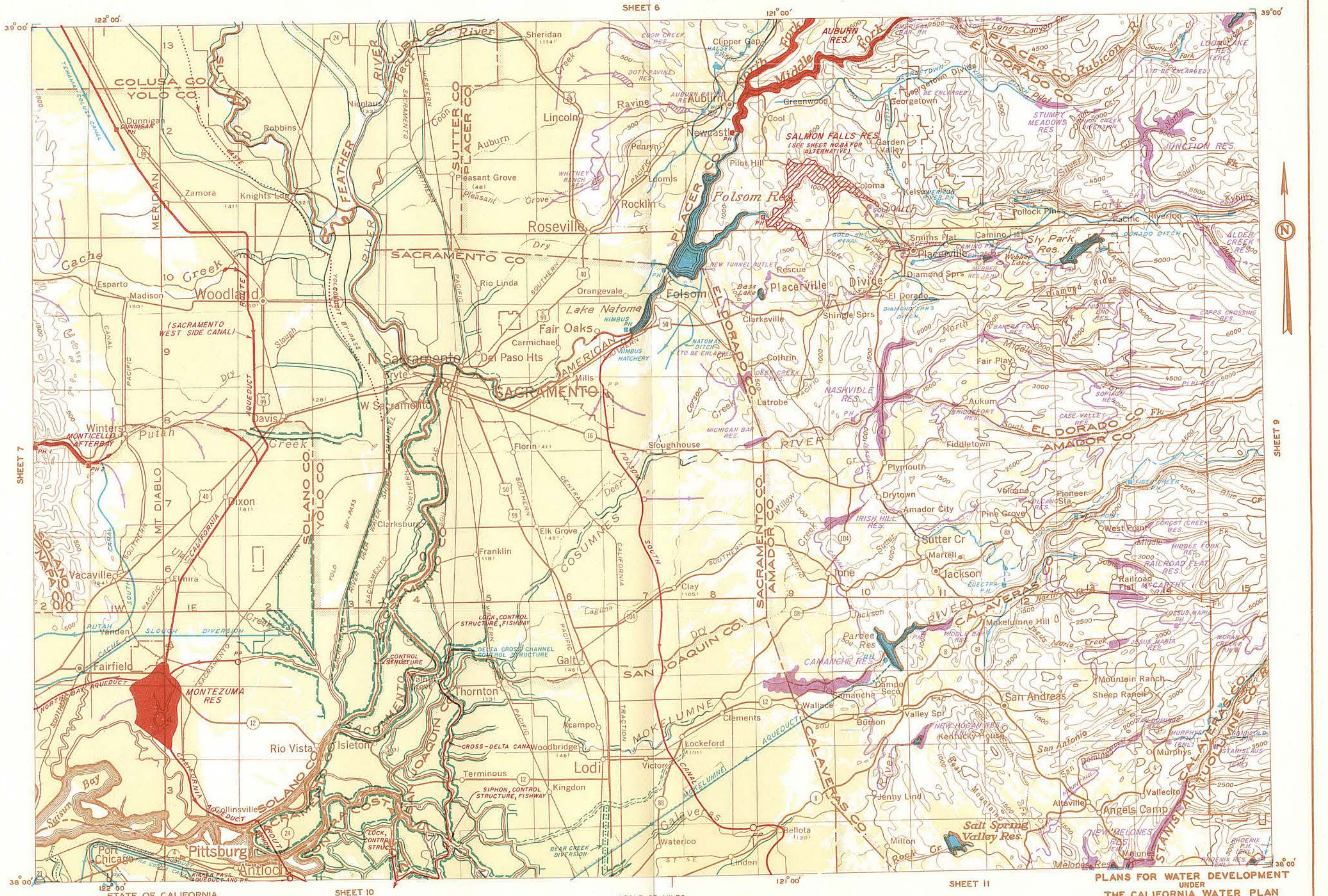
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS		PROSPECTIVE WORKS			
	CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	FLOOD CONTROL ONLY	THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	DEVELOPMENT FOR LOCAL NEEDS	FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



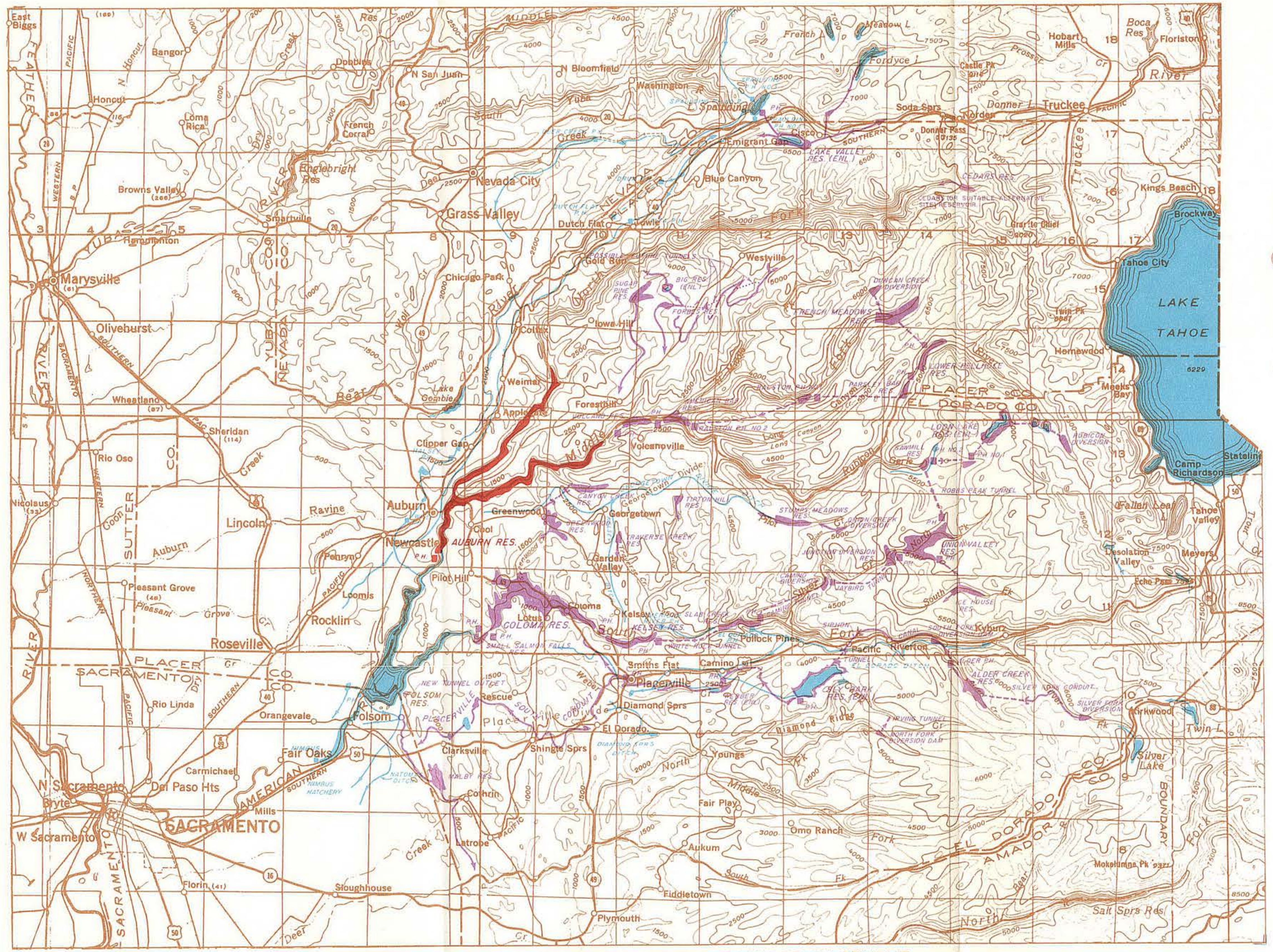
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 8 OF 26 SHEETS

LEGEND

FEATURE	EXISTING WORKS		PROSPECTIVE WORKS			
	CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	FLOOD CONTROL ONLY	THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	DEVELOPMENT FOR LOCAL NEEDS	FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

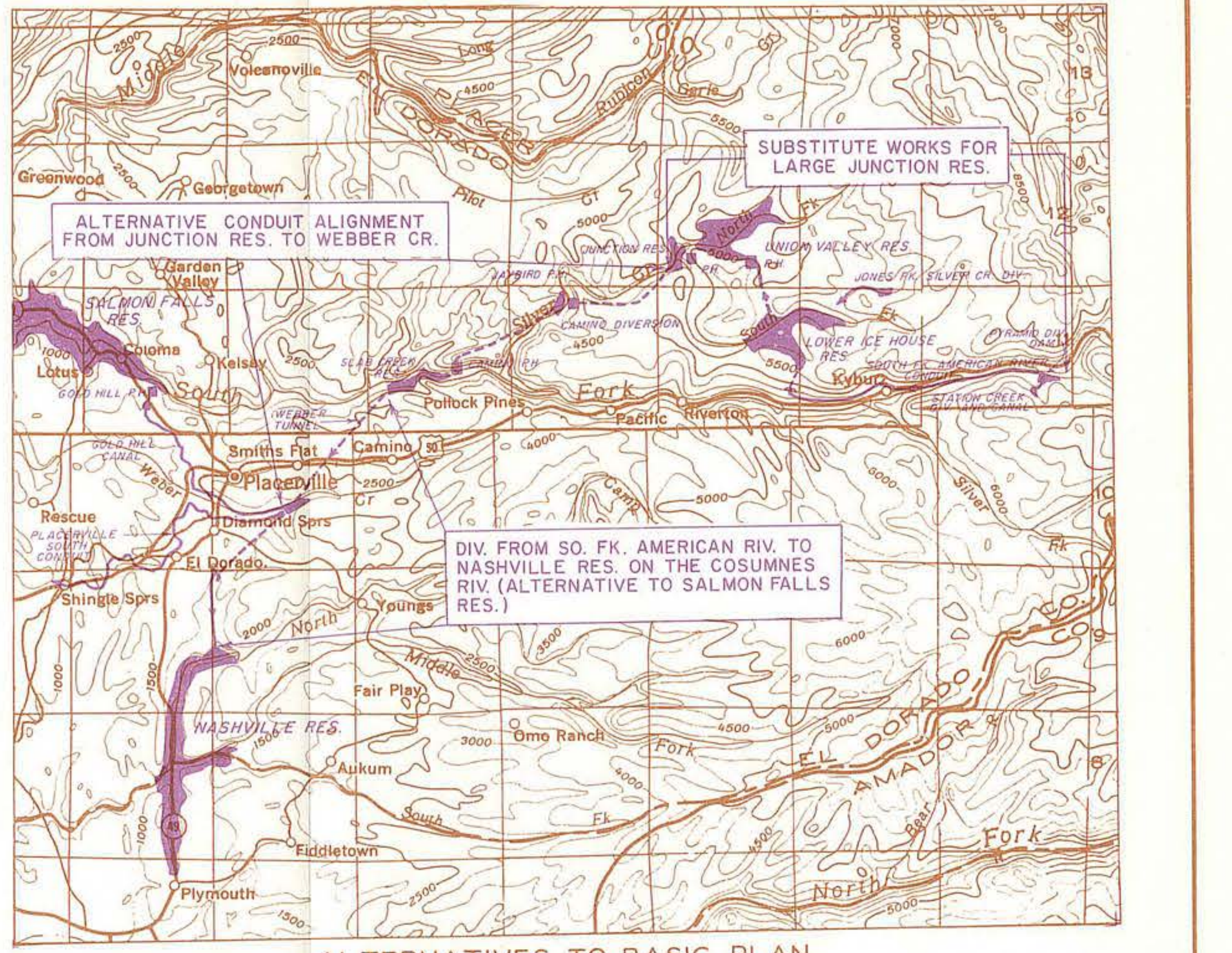
ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL



MODIFIED PLAN FOR THE AMERICAN RIVER BASIN DEVELOPMENT
AS PROPOSED BY THE SACRAMENTO MUNICIPAL UTILITY DISTRICT

SCALE OF MILES

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957



ALTERNATIVES TO BASIC PLAN
FOR THE AMERICAN RIVER BASIN DEVELOPMENT

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 8A OF 26 SHEETS

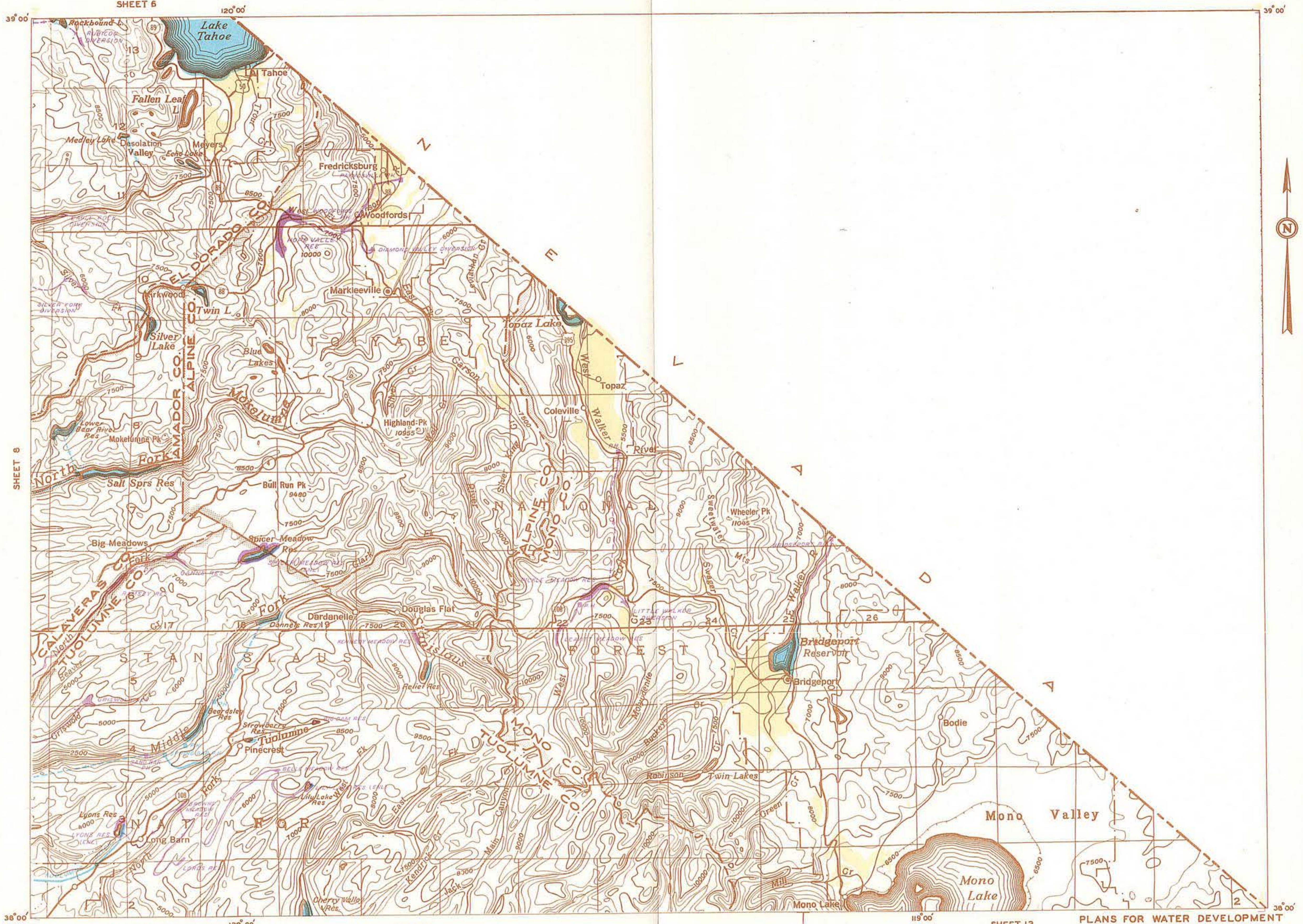
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 9 OF 26 SHEETS

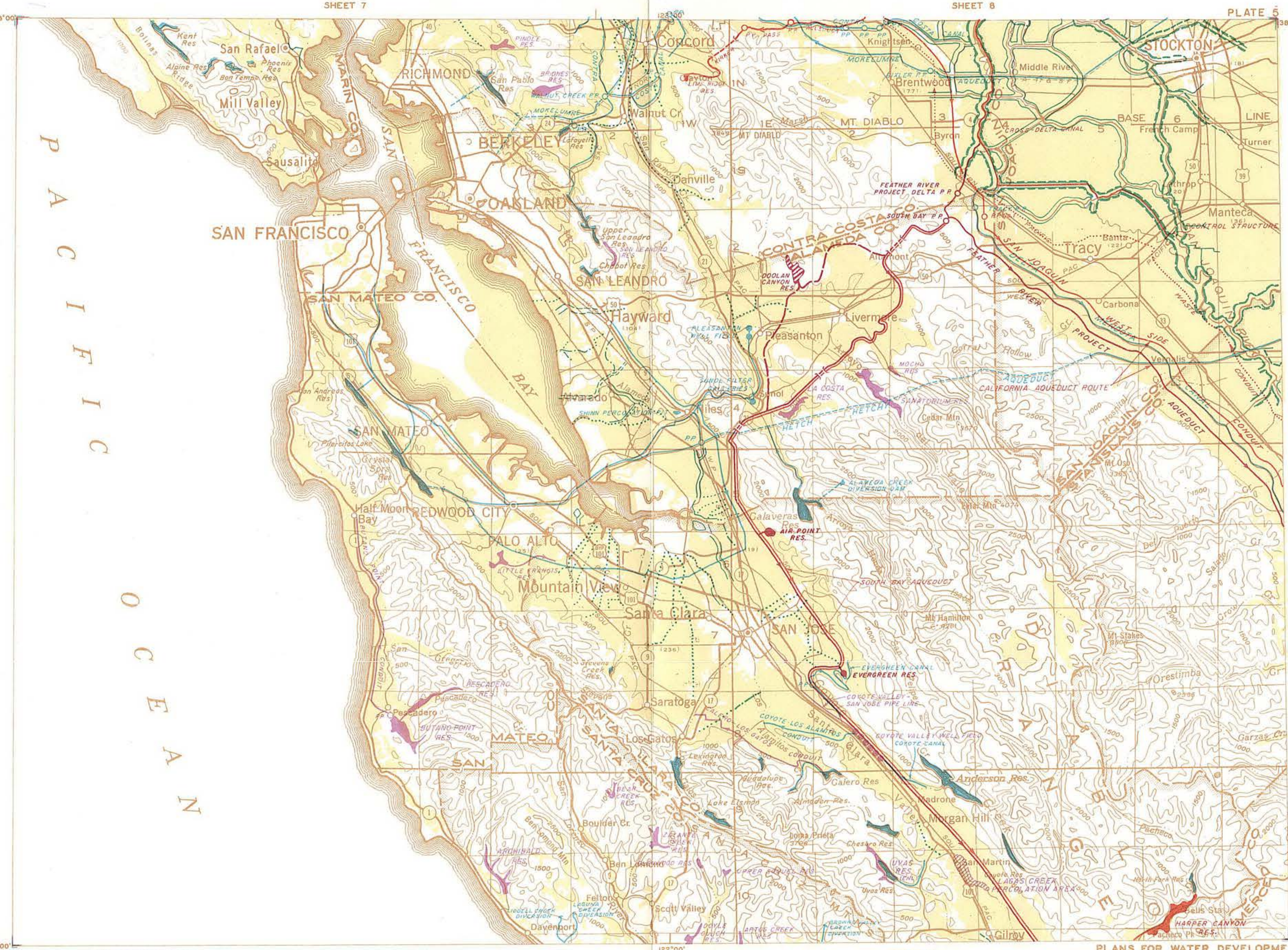
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS		PROSPECTIVE WORKS			
	CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	FLOOD CONTROL ONLY	THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	DEVELOPMENT FOR LOCAL NEEDS	FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

SCALE OF MILES
4 0 4 8 12

SHEET 13

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 10 OF 26 SHEETS

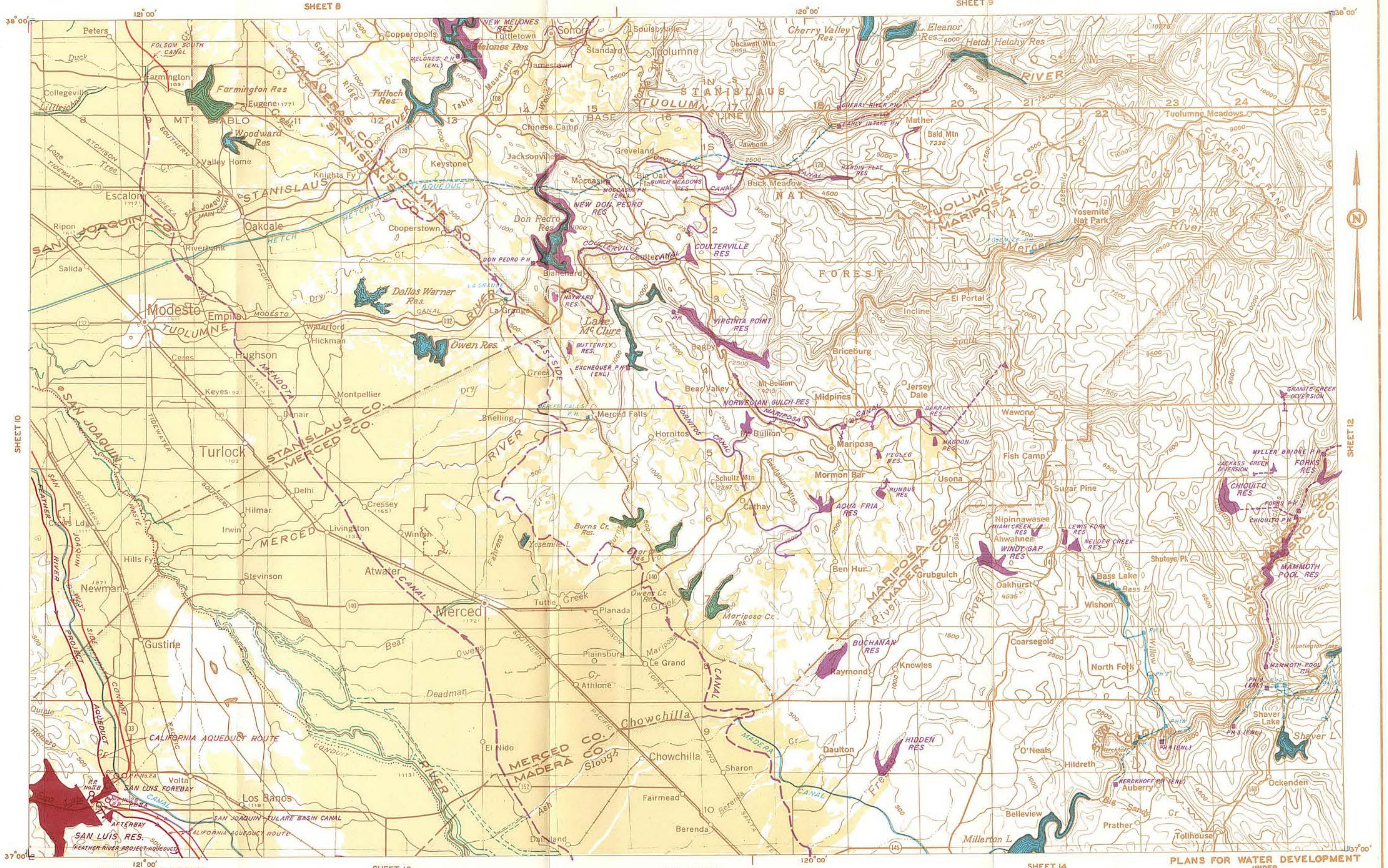
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

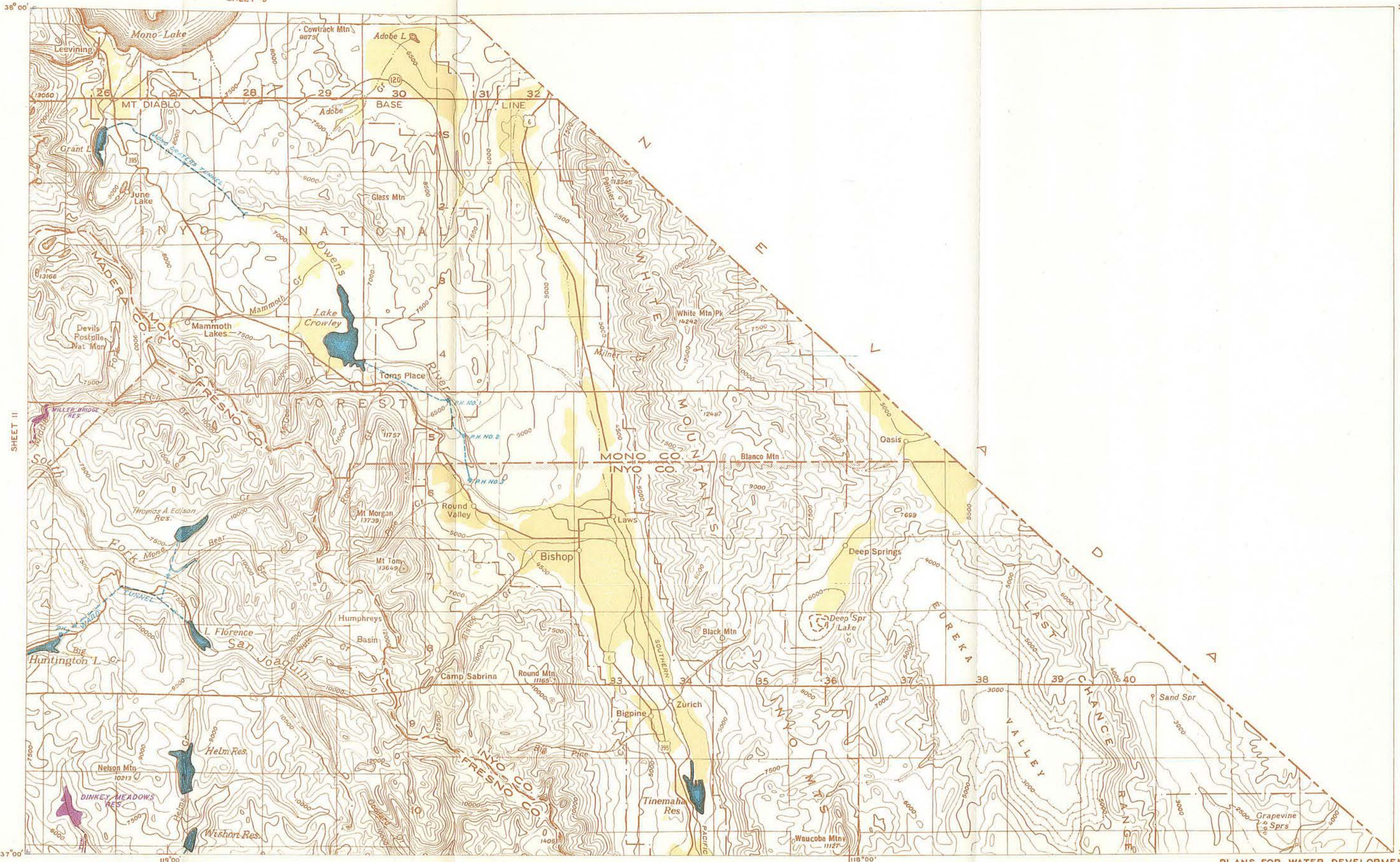
PLANS FOR WATER DEVELOPMENT UNDER THE CALIFORNIA WATER PLAN
SHEET 11 OF 26 SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT UNDER THE CALIFORNIA WATER PLAN
SHEET 12 OF 26 SHEETS

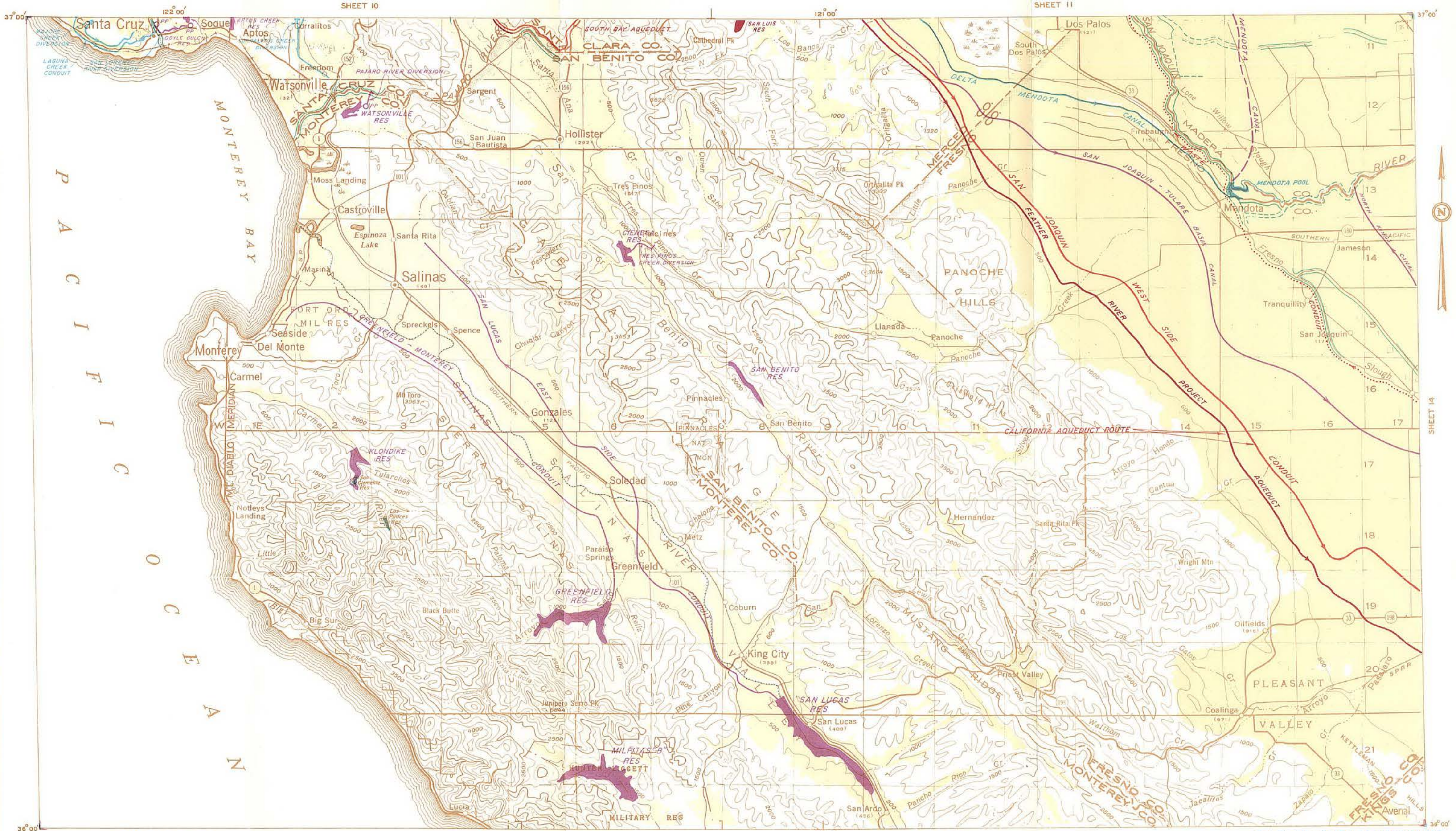
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS		PROSPECTIVE WORKS			
	CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	FLOOD CONTROL ONLY	THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	DEVELOPMENT FOR LOCAL NEEDS	FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	PH		PH	PH	PH	
PUMPING PLANT	PP		PP	PP	PP	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

SCALE OF MILES

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 13 OF 26 SHEETS

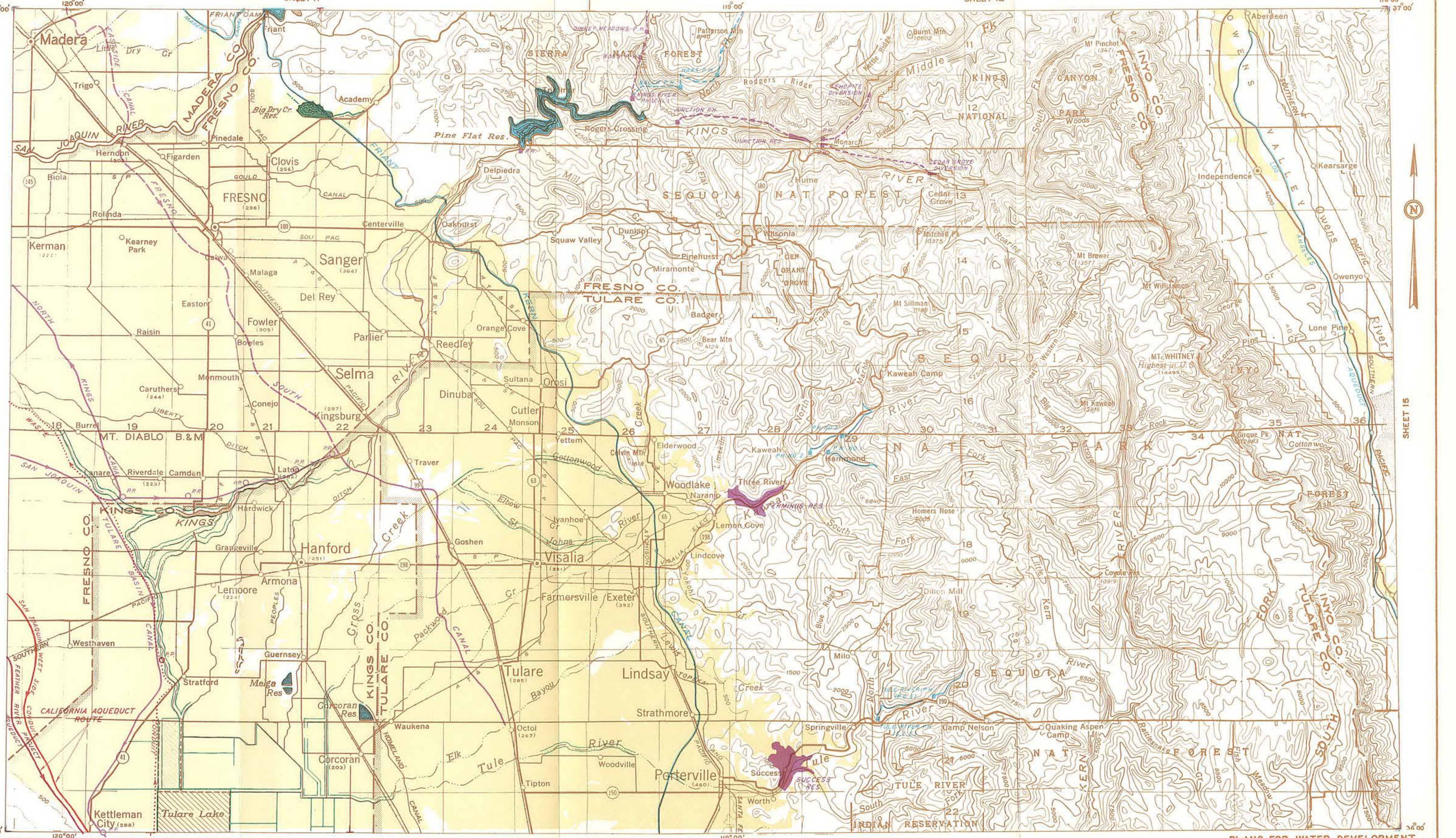
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM — FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM — ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



SHEET 16 STATE OF CALIFORNIA SHEET 17

DEPARTMENT OF WATER RESOURCES

DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT UNDER THE CALIFORNIA WATER PLAN

SHEET 14 OF 26 SHEETS

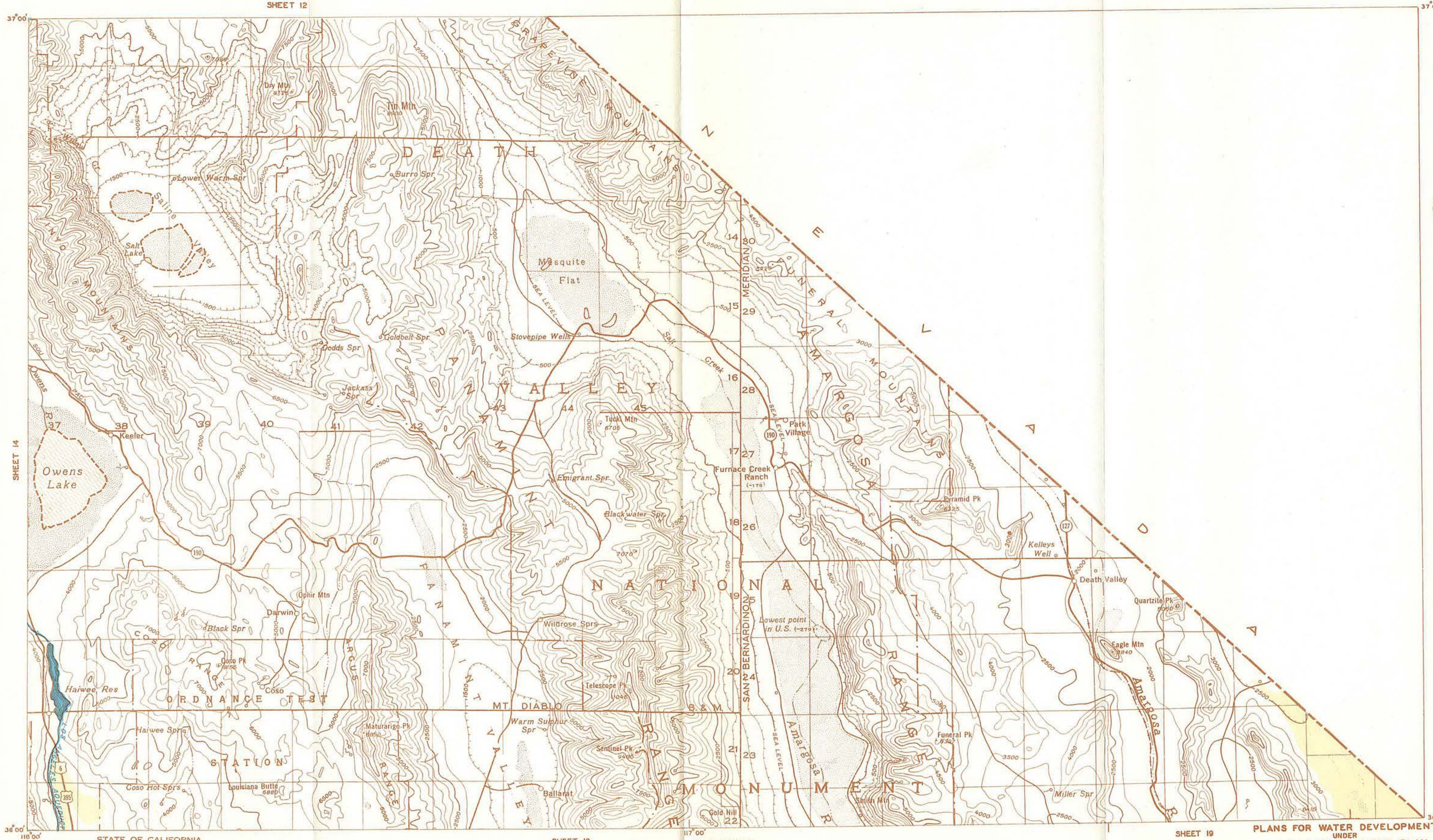
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS		PROSPECTIVE WORKS			
	CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	FLOOD CONTROL ONLY	THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	DEVELOPMENT FOR LOCAL NEEDS	FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT UNDER THE CALIFORNIA WATER PLAN
SHEET 15 OF 26 SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	PH		PH	PH	PH	
PUMPING PLANT	PP		PP	PP	PP	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

SCALE OF MILES
4 0 4 8 12

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 16 OF 26 SHEETS

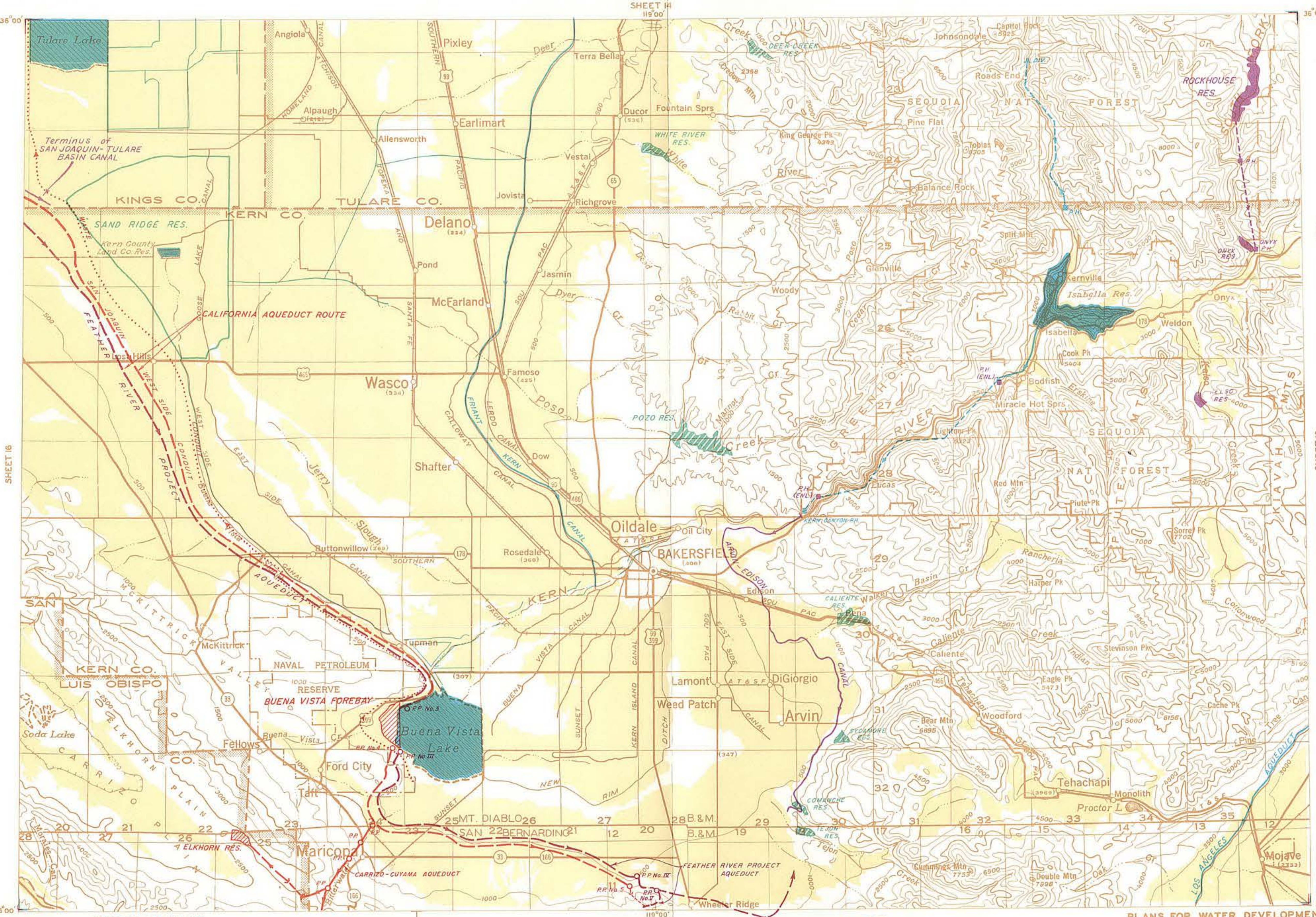
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

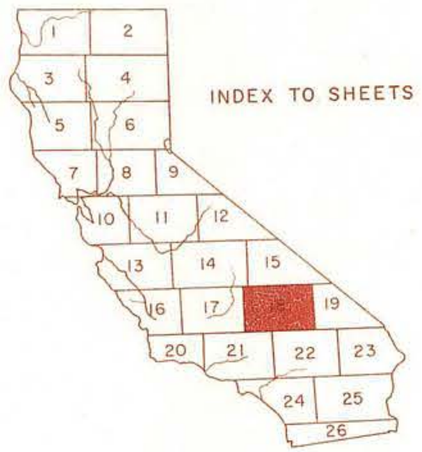
AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



SCALE OF MILES
4 0 4 8 12

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 17 OF 26 SHEETS

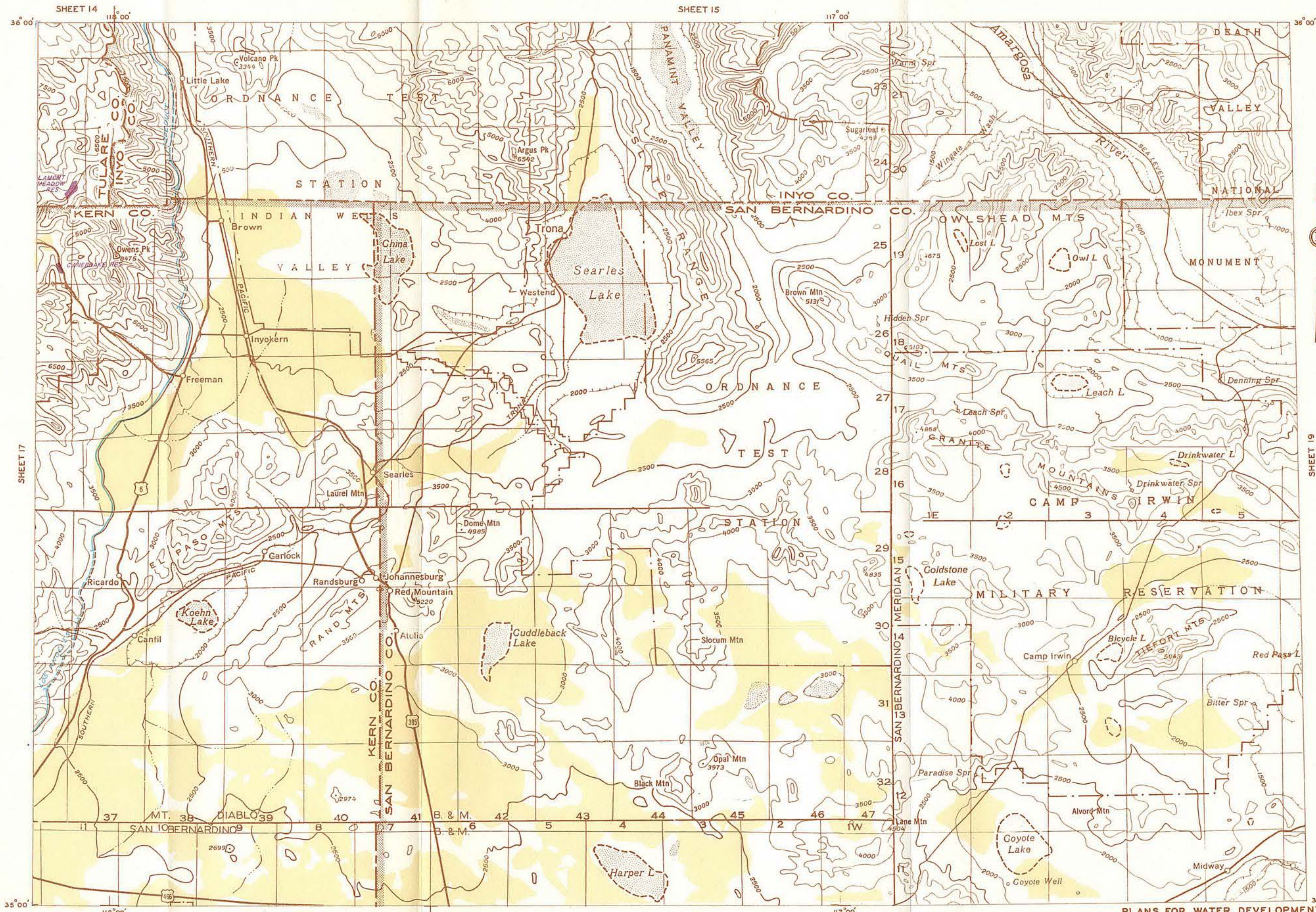


LEGEND

FEATURE	EXISTING WORKS		PROSPECTIVE WORKS			
	CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	FLOOD CONTROL ONLY	THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	DEVELOPMENT FOR LOCAL NEEDS	FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT UNDER THE CALIFORNIA WATER PLAN
SHEET 18 OF 26 SHEETS

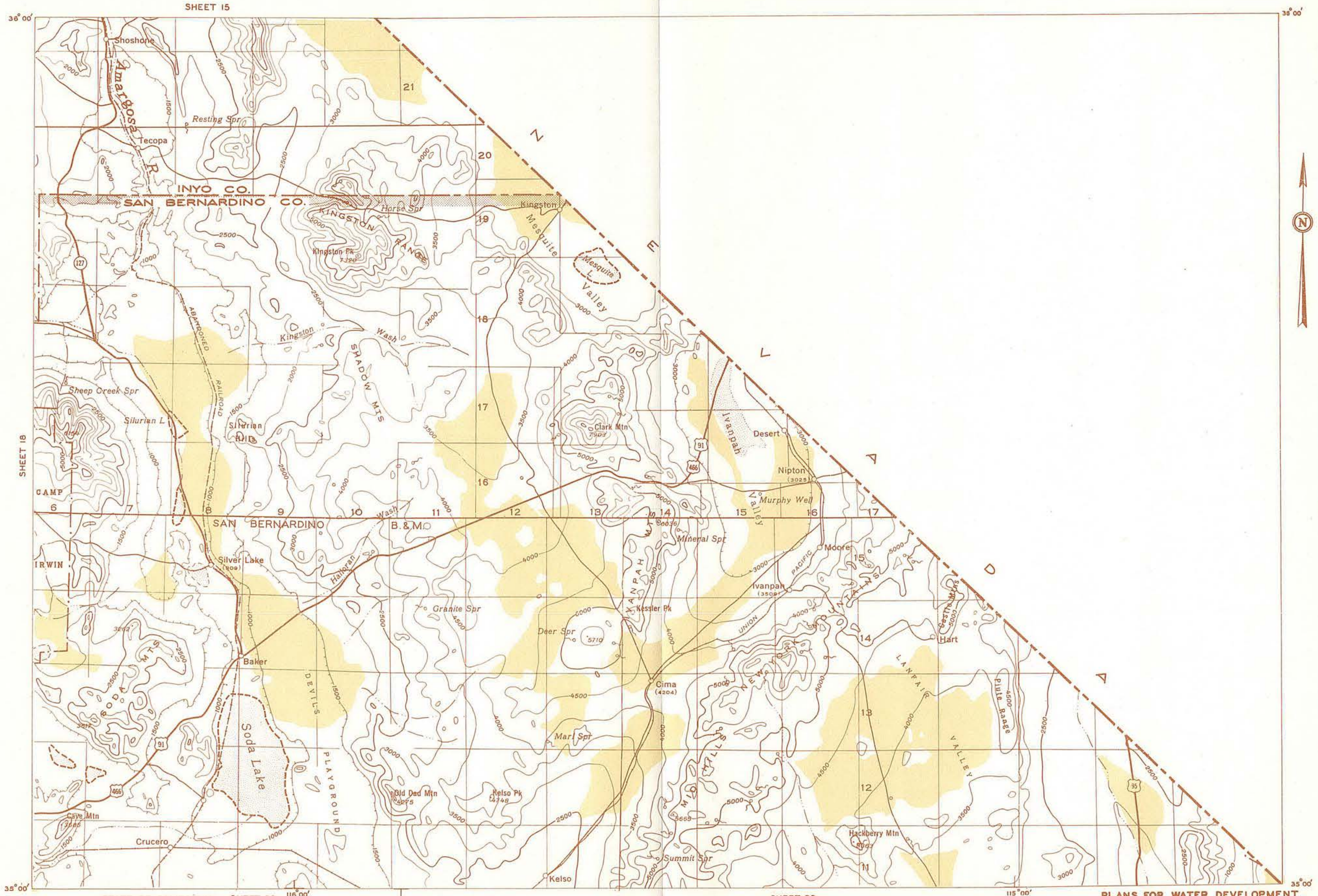
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS		PROSPECTIVE WORKS			
	CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	FLOOD CONTROL ONLY	THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	DEVELOPMENT FOR LOCAL NEEDS	FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT		NO EXISTING OR PROSPECTIVE WORKS ON THIS SHEET				
TUNNEL						
POWER HOUSE						
PUMPING PLANT						
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT UNDER THE CALIFORNIA WATER PLAN
SHEET 19 OF 26 SHEETS

INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	PH		PH	PH	PH	
PUMPING PLANT	PP		PP	PP	PP	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 20 OF 26 SHEETS

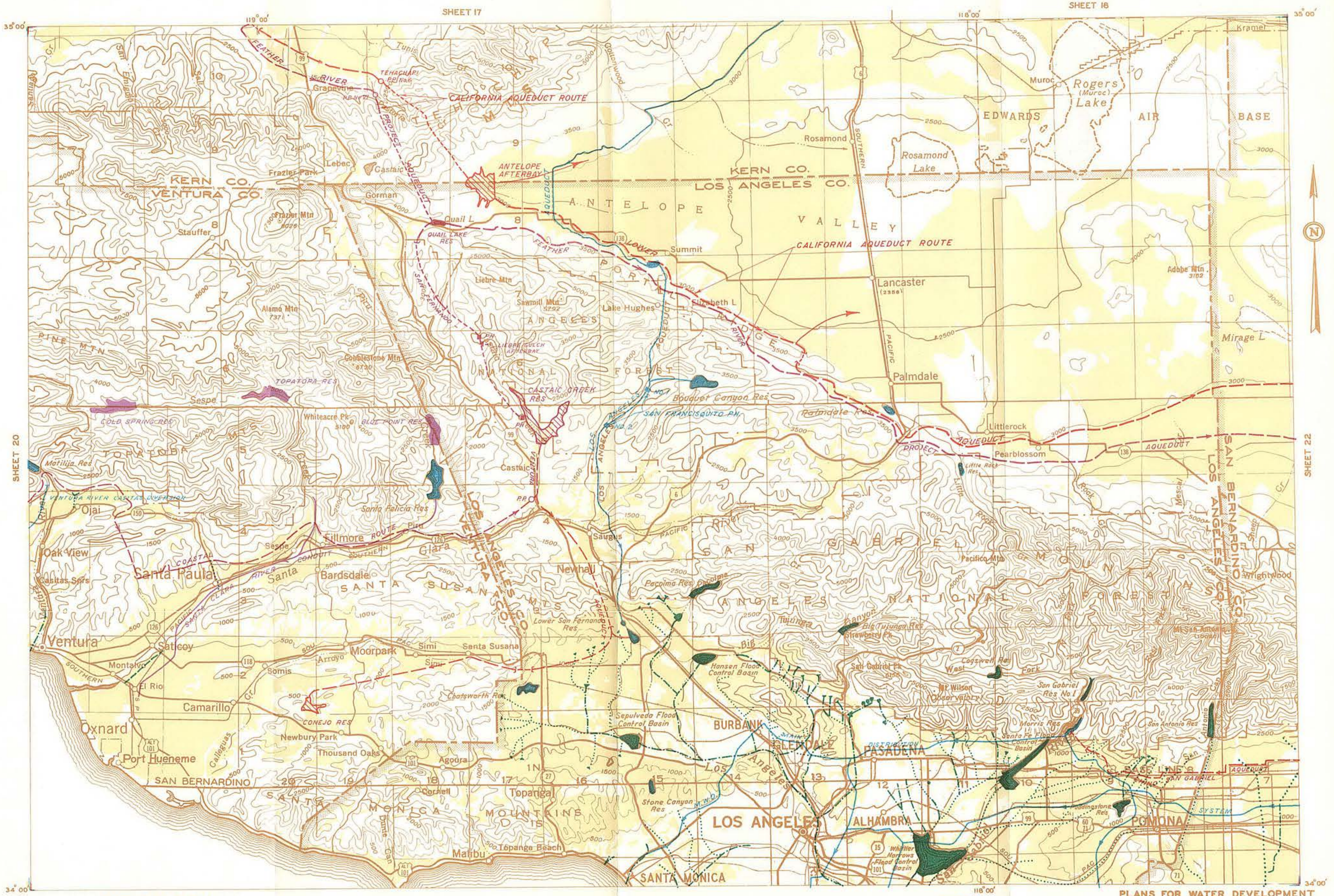
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	PH		PH	PH	PH	
PUMPING PLANT	PP		PP	PP	PP	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



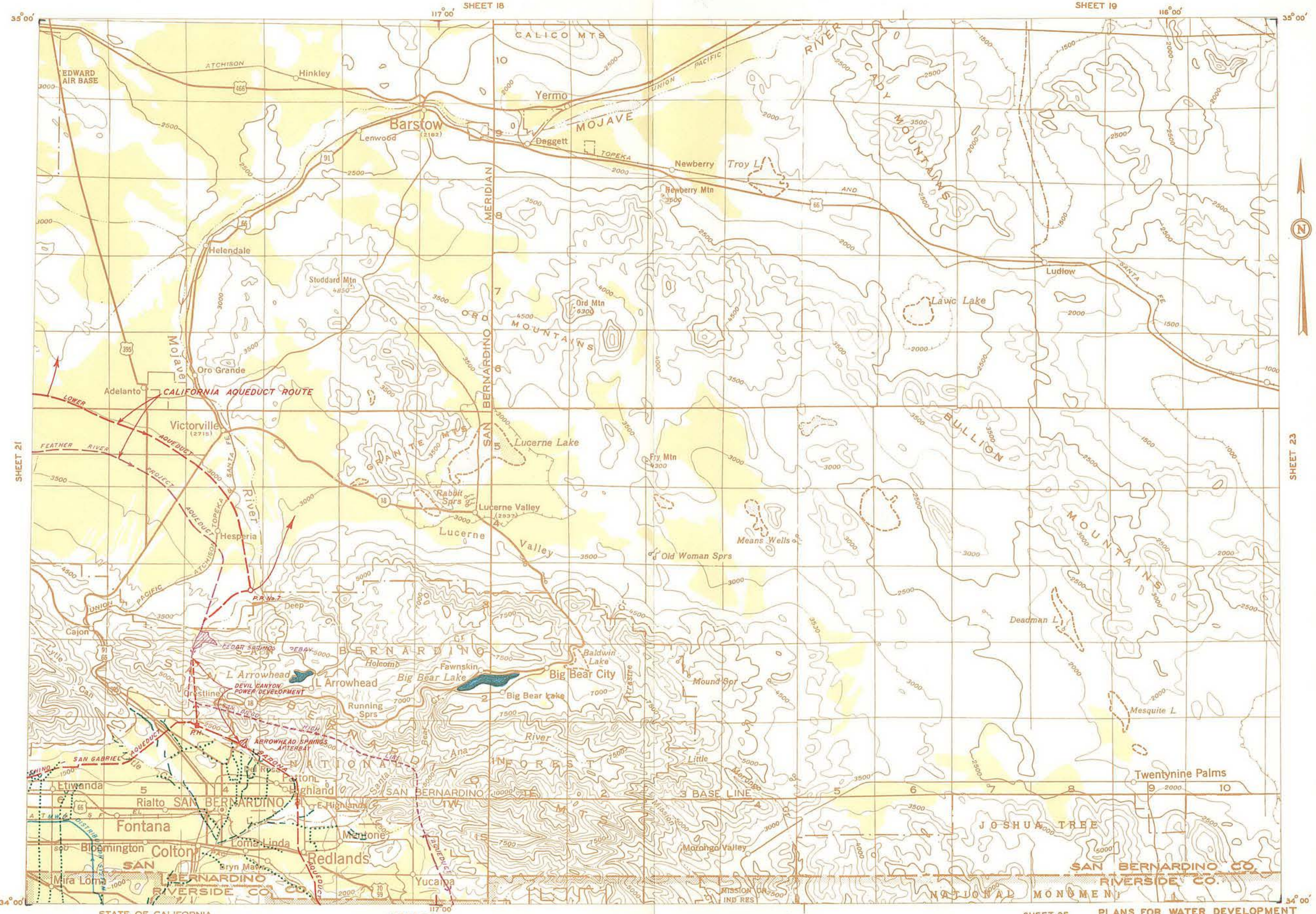
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT UNDER THE CALIFORNIA WATER PLAN
SHEET 22 OF 26 SHEETS

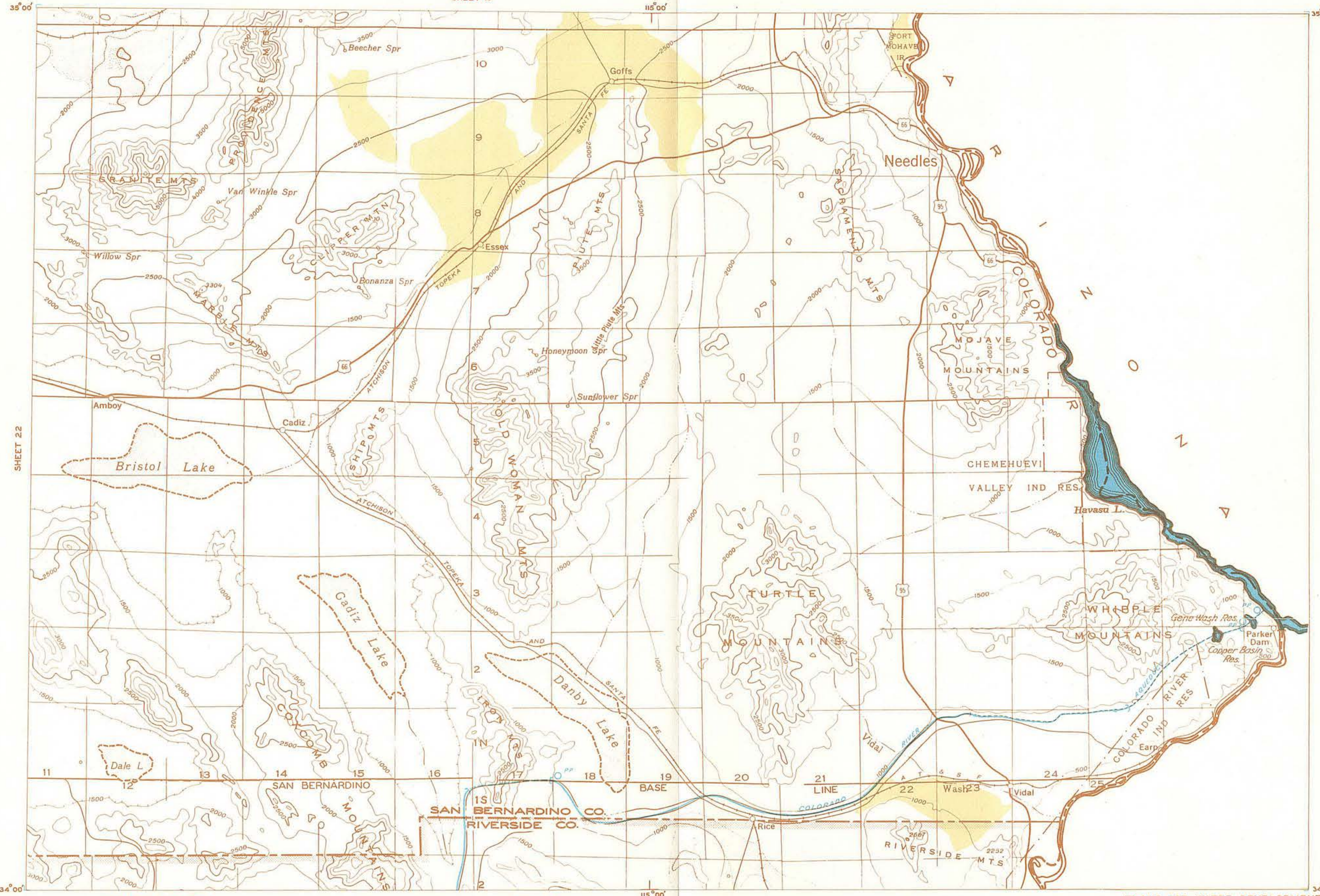
INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 23 OF 26 SHEETS

INDEX TO SHEETS

LEGEND

FEATURE	EXISTING WORKS: CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	EXISTING WORKS: FLOOD CONTROL ONLY	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	PROSPECTIVE WORKS: THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	PROSPECTIVE WORKS: DEVELOPMENT FOR LOCAL NEEDS	PROSPECTIVE WORKS: FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	P.H.		P.H.	P.H.	P.H.	
PUMPING PLANT	P.P.		P.P.	P.P.	P.P.	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

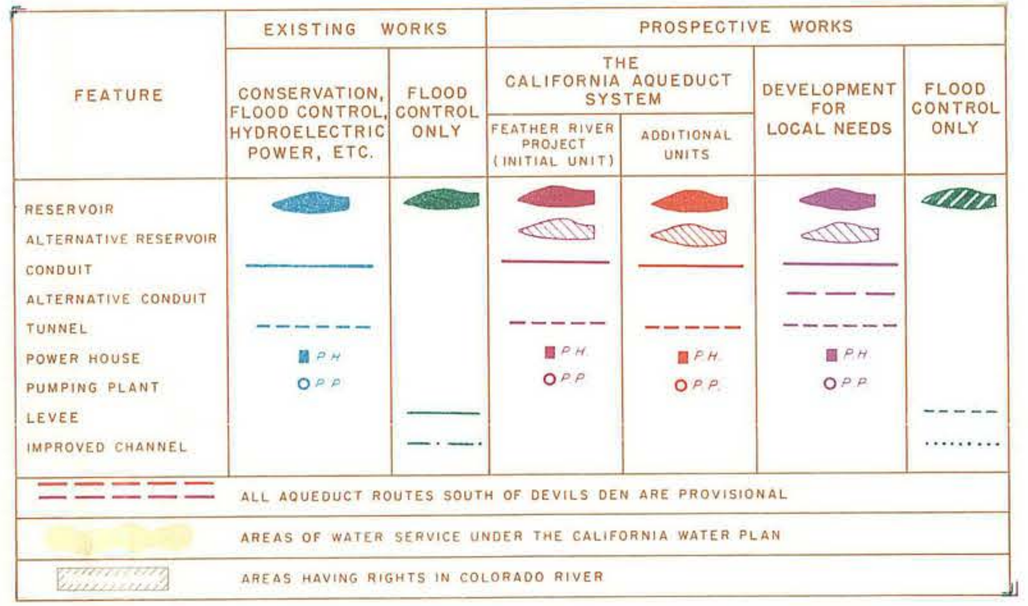
AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN

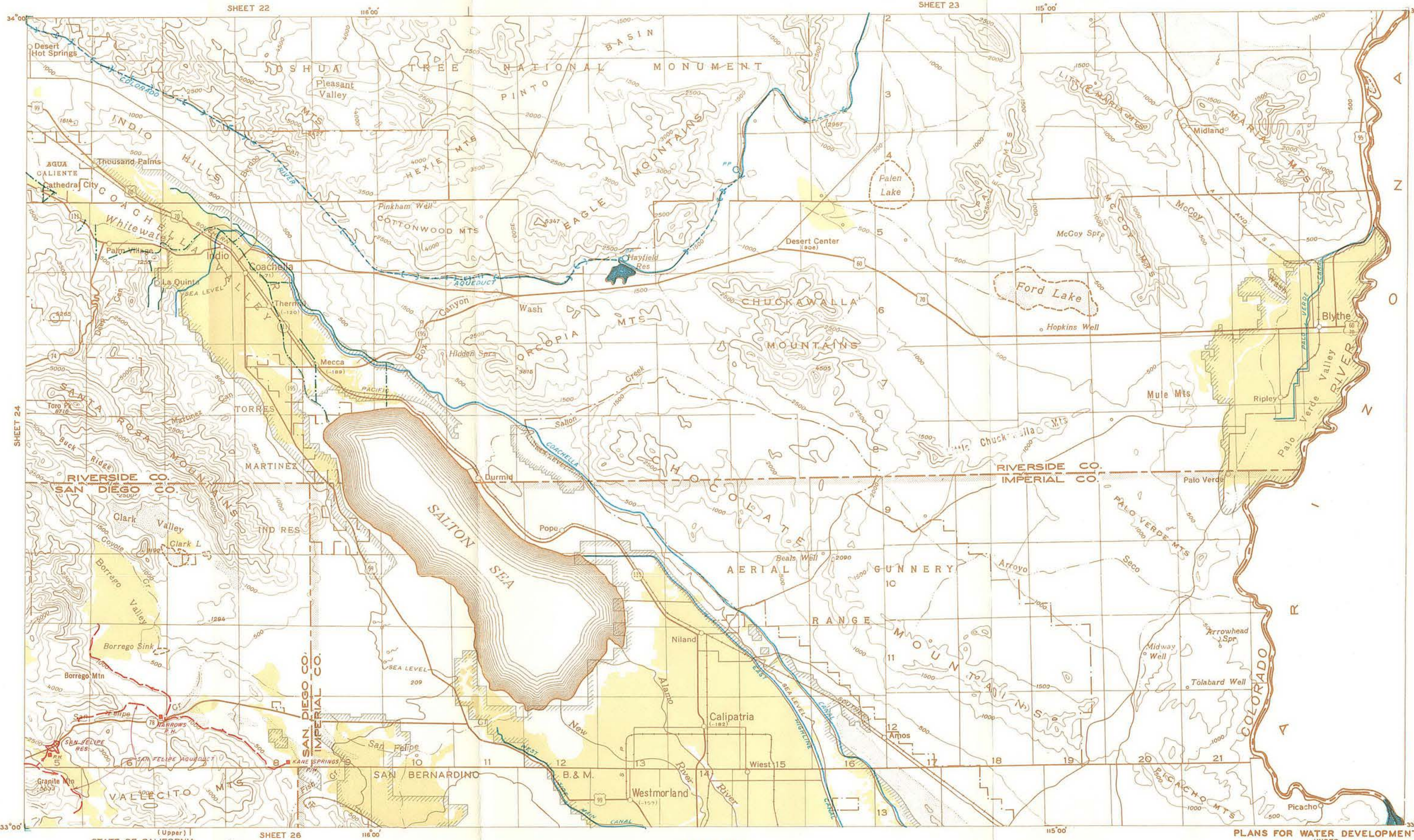
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

PLANS FOR WATER DEVELOPMENT UNDER THE CALIFORNIA WATER PLAN
SHEET 24 OF 26 SHEETS

INDEX TO SHEETS

LEGEND





STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

SCALE OF MILES
4 0 4 8 12

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 25 OF 26 SHEETS

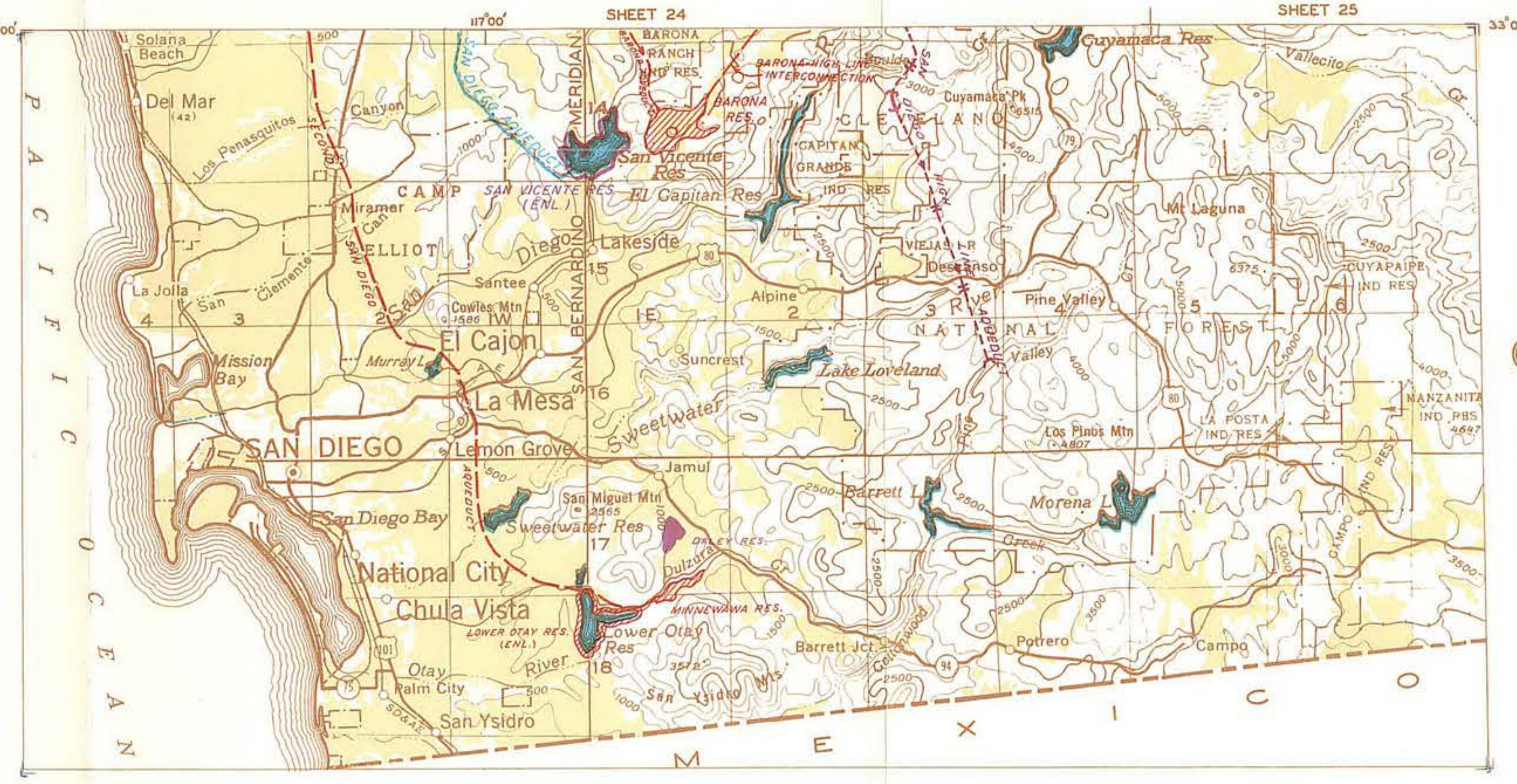
LEGEND

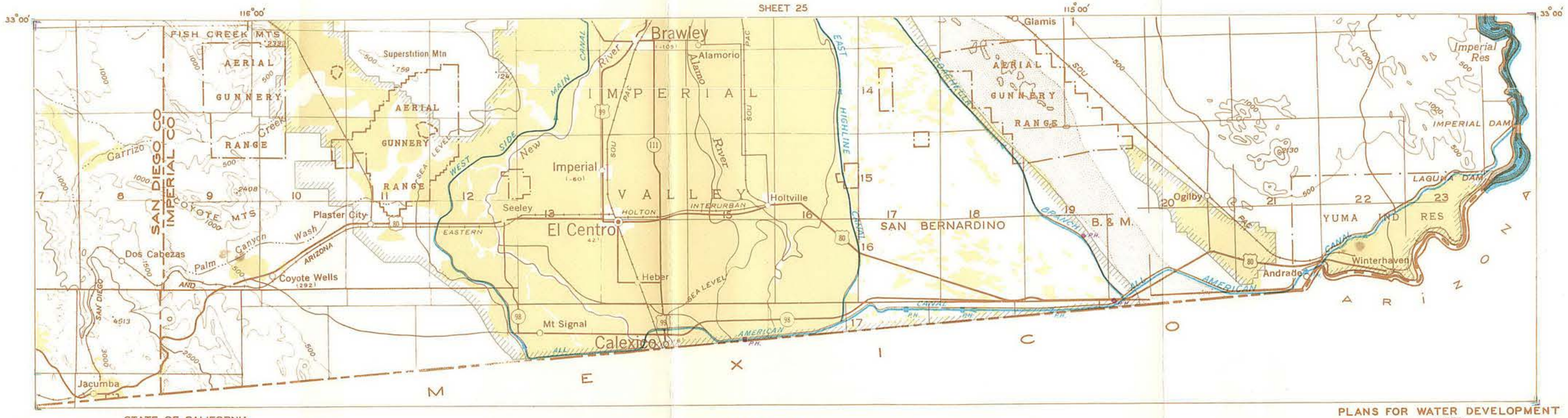
FEATURE	EXISTING WORKS		PROSPECTIVE WORKS			
	CONSERVATION, FLOOD CONTROL, HYDROELECTRIC POWER, ETC.	FLOOD CONTROL ONLY	THE CALIFORNIA AQUEDUCT SYSTEM: FEATHER RIVER PROJECT (INITIAL UNIT)	THE CALIFORNIA AQUEDUCT SYSTEM: ADDITIONAL UNITS	DEVELOPMENT FOR LOCAL NEEDS	FLOOD CONTROL ONLY
RESERVOIR						
ALTERNATIVE RESERVOIR						
CONDUIT						
ALTERNATIVE CONDUIT						
TUNNEL						
POWER HOUSE	PH		PH	PH	PH	
PUMPING PLANT	PP		PP	PP	PP	
LEVEE						
IMPROVED CHANNEL						

ALL AQUEDUCT ROUTES SOUTH OF DEVILS DEN ARE PROVISIONAL

AREAS OF WATER SERVICE UNDER THE CALIFORNIA WATER PLAN

AREAS HAVING RIGHTS IN COLORADO RIVER

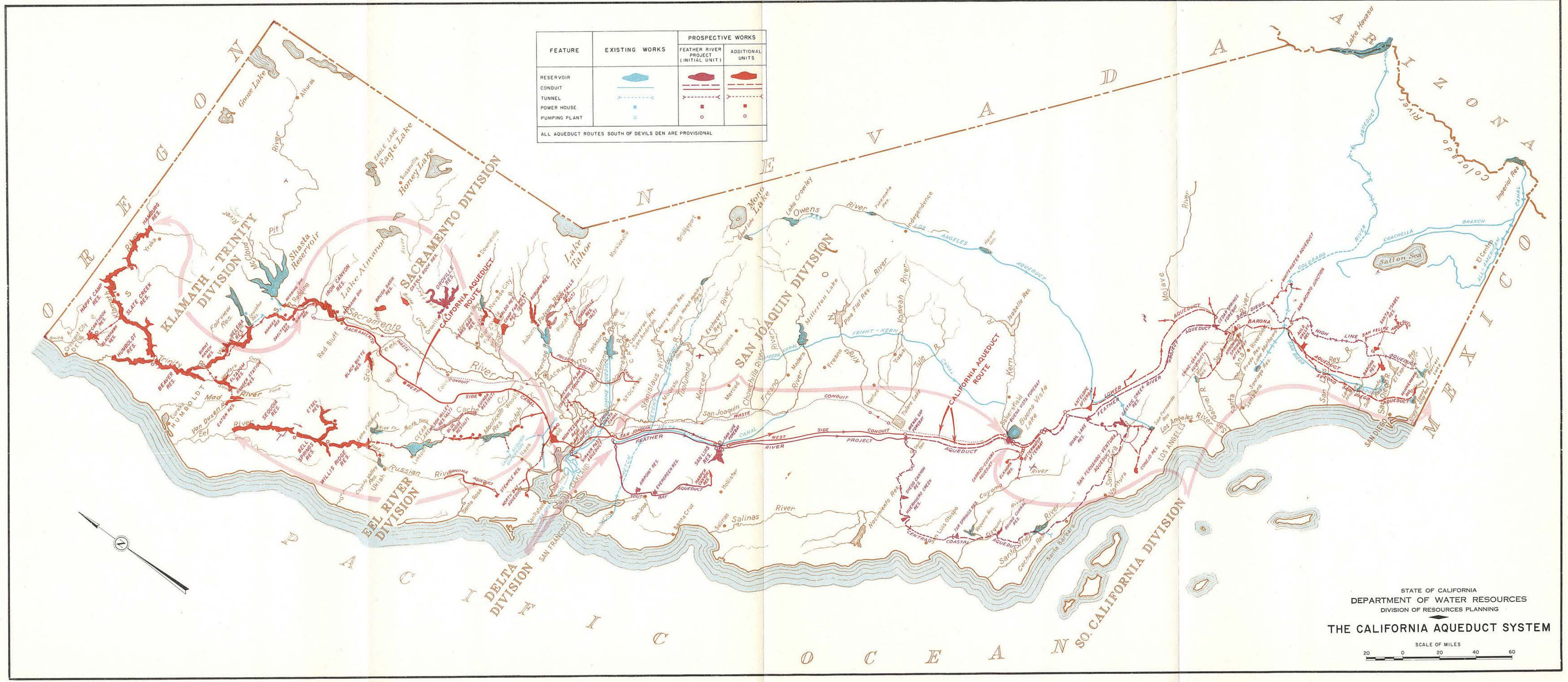




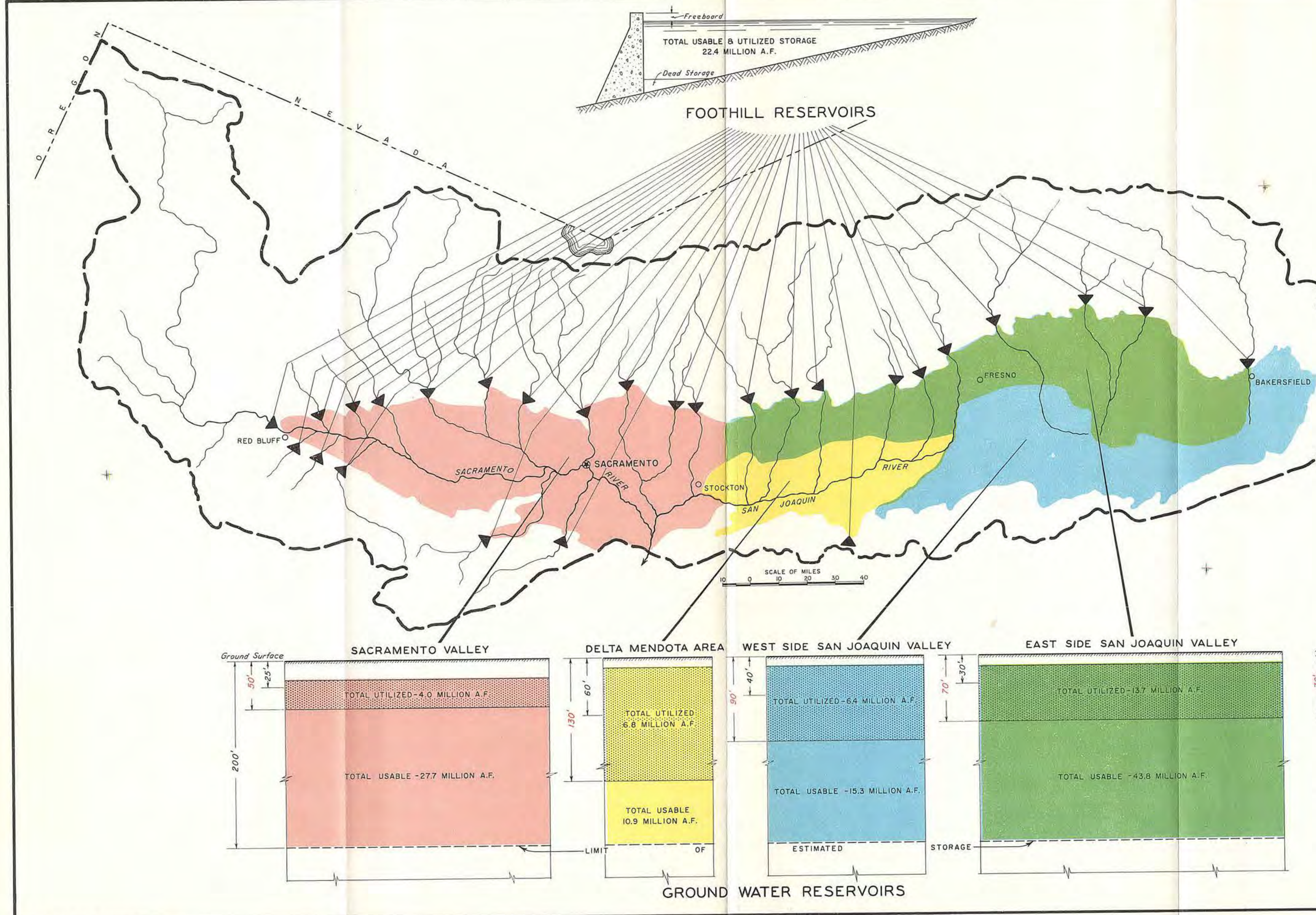
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING 1957

SCALE OF MILES
4 0 4 8 12

PLANS FOR WATER DEVELOPMENT
UNDER
THE CALIFORNIA WATER PLAN
SHEET 26 OF 26 SHEETS



DIVISION OF RESOURCES PLANNING 1957



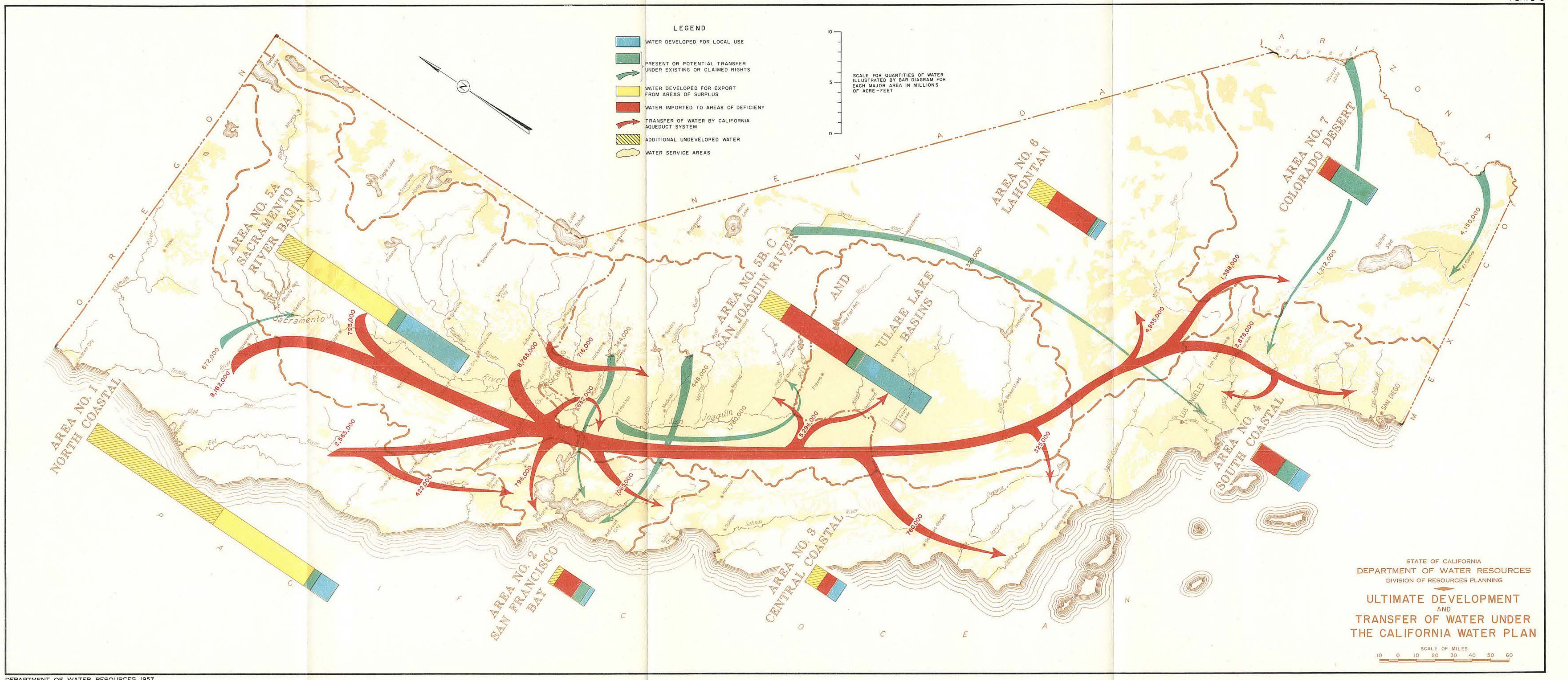
EXPLANATION

30' — LONG TERM MEAN DEPTH TO STATIC GROUND WATER LEVEL OPERATED UNDER ULTIMATE DEVELOPMENT

70' — MAXIMUM DEPTH TO STATIC GROUND WATER LEVEL UNDER ULTIMATE DEVELOPMENT

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

CONJUNCTIVELY OPERATED STORAGE IN THE CENTRAL VALLEY


STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
ULTIMATE DEVELOPMENT
AND
TRANSFER OF WATER UNDER
THE CALIFORNIA WATER PLAN
SCALE OF MILES
10 0 10 20 30 40 50 60
LEGEND
WATER DEVELOPED FOR LOCAL USE
PRESENT OR POTENTIAL TRANSFER UNDER EXISTING OR CLAIMED RIGHTS
WATER DEVELOPED FOR EXPORT FROM AREAS OF SURPLUS
WATER IMPORTED TO AREAS OF DEFICIENCY
TRANSFER OF WATER BY CALIFORNIA AQUEDUCT SYSTEM
ADDITIONAL UNDEVELOPED WATER
WATER SERVICE AREAS
SCALE FOR QUANTITIES OF WATER ILLUSTRATED BY BAR DIAGRAM FOR EACH MAJOR AREA IN MILLIONS OF ACRE-FEET
10
5
0
AREA NO. 1 NORTH COASTAL
AREA NO. 2 SAN FRANCISCO BAY
AREA NO. 3 CENTRAL COASTAL
AREA NO. 4 SOUTH COASTAL
AREA NO. 5A SACRAMENTO RIVER BASIN
AREA NO. 5B, C SAN JOAQUIN RIVER AND TULARE LAKE BASINS
AREA NO. 6 LAHONTAN
AREA NO. 7 COLORADO DESERT
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
8,182,000
872,000
783,000
2,350,000
422,000
796,000
8,765,000
716,000
1,080,000
448,000
1,760,000
5,256,000
325,000
780,000
4,835,000
1,388,000
2,878,000
1,212,000
4,150,000
Sacramento
Joaquin
LOS ANGELES
SAN DIEGO
Salton Sea