pipe, with the main conduit and the lateral to the Ventura River having 10-inch diameters, and the westerly lateral having an 8 inch diameter. The main conduit, with capacity of 3.0 second-feet, would deliver a seasonal supply of about 1,160 acre-feet. Capacities of the lateral to the Ventura River and of the westerly lateral would be about 2.0 and 1.0 second-feet, respectively. A pumping plant, required to lift the water about 1,000 feet to an elevation of 1,375 feet at Casitas Summit, would consist of three pumps installed in series, each equipped with a motor of 150 horsepower.

The capital cost of the distribution system for Casitas Reservoir was estimated to be about $2,954,000. The annual costs, including interest on and amortization of the capital investment, operation and maintenance, replacement, and electrical energy charges for pumping, were estimated to be about $252,000. Detailed estimates of cost of the distribution system are presented in Appendix C.

Casitas-Oxnard Plain Diversion. In view of the fact that net safe yields that would be developed by the considered sizes of Casitas Reservoir substantially exceed present requirements for supplemental water in the Ventura Hydrologic Unit, consideration was given to the diversion of a portion of this excess water supply to the Oxnard Plain Subunit. It was realized that ultimately the entire net safe yield available from Casitas Reservoir site would be required in the Ventura Hydrologic Unit. However, for an interim period, possibly as long as 20 years, a surplus of water would exist. For cost estimating purposes, it was assumed that for a 20-year period subsequent to the reservoir construction it would be possible to divert an average seasonal supply of 10,000 acre-feet of water from Casitas Reservoir to the Oxnard Plain Subunit for use therein.

It was assumed that the Casitas-Oxnard Plain Diversion Conduit would extend from the outlet control house at Casitas Dam in a pipe line, independent of the one previously described for the distribution system for the Ventura Hydrologic Unit, to a terminus in a regulating reservoir north of the City of Oxnard. From the dam, the line would parallel Coyote Creek downstream, and would follow the Casitas Pass Road to Foster Park, crossing the Ventura River near the existing highway road bridge. The crossing would be in a conduit buri to a depth of 10 feet beneath the stream bed and encased in concrete. The line would then turn southerly and generally parallel the Southern Pacific Railroad tracks to the Ventura County Fair Grounds. At the fair grounds it would turn southeasterly, continue generally parallel to the Southern Pacific Railroad tracks to the Ventura Municipal Golf Course, about 3,000 feet southwest of the community of Montalvo. The line would cross the Santa Clara River at a point about one-half mile downstream from the U.S. Highway 101 bridge. The crossing would be effected in a buried conduit, encased in concrete, with 20 feet of cover. From the Santa Clara River, the line would extend to the aforementioned regulating reservoir near the intersection of Gonzales and Rose Roads, about 1.3 miles southeast of the community of El Rio. This reservoir, designated the Oxnard Reservoir, would have a storage capacity of 100 acre-feet, and a normal water surface elevation of about 85 feet.

The Casitas-Oxnard Plain Diversion Conduit would comprise a total length of about 96,300 lineal feet, consisting of about 49,000 lineal feet of 3 inch diameter, and about 47,300 lineal feet of 27-inch diameter lock joint concrete cylinder pipe. The pipe line would have a capacity of about 25 second-feet, and would deliver a seasonal supply of about 10,000 acre-feet. It would be capable of delivering about 15 per cent of the total seasonal supply in the month of maximum demand.

The capital cost of the Casitas-Oxnard Plain Diversion Conduit was estimated to be about $1,671,000. Based upon an assumed 20-year life and a 4 per cent interest rate, annual costs were estimated to be about $127,000, including interest on and amortization of the capital investment, and operation and maintenance. On this basis, that portion of the average annual unit cost of water delivered through the conduit to the Oxnard Plain Subunit attributable to the costs of the conduit was estimated to be about $12.70 per acre-foot. The proposed alignment of the Casitas-Oxnard Plain diversion is shown on Plate 42. Detailed estimates of cost of the diversion conduit are presented in Appendix C.

Santa Clara River Conduit. It has been demonstrated that to realize maximum benefit from reservoirs constructed on tributaries of the Santa Clara River, the conserved waters must be conveyed to areas of need in the Oxnard Plain and Pleasant Valley Subunits in a conduit. Consideration was given, therefore, to the construction of a pipe line from Piru Creek down the Santa Clara River Valley to a terminus in the aforementioned Oxnard Reservoir near El Rio. The general alignment of this Santa Clara River Conduit, as designed for cost estimating purposes, is shown on Plate 42. For illustrative purposes, a conduit that would extend from the proposed Devil Canyon Dam is described herein. If dams and reservoirs were to be constructed on Sespe or Santa Paula Creeks, feeder lines would be required to connect with the main conduit. Such a feeder line from Sespe Creek is contemplated for the described conduit. Provision would be made for release from the conduit to meet the requirements of prior water rights, as necessary.

From the outlet works at Devil Canyon Dam to a point about 0.3 mile west of the community of Sespe Village, where a feeder line from Sespe Creek would connect with the main line, the Santa Clara River Conduit would consist of about 63,600 lineal feet of 36-inch diameter, and 26,600 lineal feet of 42-inch diameter reinforced concrete cylinder pipe. The line would extend southerly from Devil Canyon Dam along the left bank of Piru Creek for about 24,000 feet. At this point, it would cross the creek and thence, passing though the town of Piru, would generally follow the alignment of State Highway 126 to the town of Fillmore and to Sespe Village. The conduit would cross Sespe Creek southwest of Fillmore. At all major stream crossings, the pipe line would be encased in reinforced concrete and buried under 20 feet of cover. It was assumed that the foregoing pipe line, with a capacity of 65 second-feet, would deliver a seasonal supply at its juncture with the Sespe Feeder of about 22,000 acre-feet. This capacity was based upon an assumed maximum monthly demand of about 12 per cent of the seasonal total, with an additional allowance for weekly demand peaks.

It was assumed that water released from reservoirs to be constructed on Sespe Creek, other than the Fillmore Reservoir, would be diverted into the Sespe Feeder by a concrete diversion weir of ogee section founded on bedrock at a point about 800 feet upstream from the U.S.G.S. stream gaging station on Sespe Creek near Fillmore. The weir would be 6 feet in height above stream be[d] and would have a crest length of about 200 feet. An intake structure, sand trap, and sluiceways, similar to those described for the Ventura River-Casitas Diversio[n] would be provided. The diverted water would be conveyed through a 36-inch diameter reinforced concrete cylinder pipe, about 28,800 feet in length, to the juncture with the Santa Clara River Conduit. It was assumed that the feeder lin[e] would deliver seasonal supply of about 18,000 acre-feet. It would have a capaci[ty] of 55 second-feet, based upon the previously described criteria utilized in design of the main conduit from Devil Canyon Dam.

From the point of connection with the Sespe Feeder the Santa Clara River Conduit would generally follow the alignment of State Highway 126 to the City of Santa Paula, and thence, following a generally southwesterly route along the right bank of the Santa Clara River, would cross the river near the existing diversion works of the Saticoy spreading grounds. Near these diversion works, a bifurcation structure in the conduit would permit releases to the spreading grounds. Such releases would be controlled by two 48-inch diameter gate valves. The conduit would then extend generally along the alignment of Ditch Road to Oxnard Reservoir. From its juncture with the Sespe Feeder, the Santa Clara River Conduit would consist of about 67,500 lineal feet of 54-inch diameter, 15,000 lineal feet of 48-inch diameter, and 10,000 lineal feet of 42-inch diameter reinforced concrete cylinder pipe. The conduit would have a capacity of 120 second-feet, and would deliver a seasonal supply to Oxnard Reservoir of 40,000 acre-feet.

Presented in the following tabulation is a summary of estimated capital and annual costs of the Santa Clara Conduit. Detailed estimates of costs are presented in Appendix C.

Portion of Santa Clara River Conduit	Estimated Costs Capital	Estimated Costs Annual
Devil Canyon Dam to Sespe Creek	$2,012,000	$107,000
Sespe Creek to Oxnard Reservoir	2,907,000	154,000
Sespe Feeder	844,000	47,000
TOTALS	$5,763,000	$308,000

Oxnard Plain-Pleasant Valley Distribution System. As discussed in a later section of this chapter, it was concluded that ground water overdraft in Oxnard Plain and Pleasant Valley Basins, resulting in part from the lack of aquifer transmissibility, will necessitate the construction of a surface distribution system to serve supplemental water to certain lands in the Oxnard Plain and Pleasant Valley Subunits now supplied by pumping from ground water. There follows a description and preliminary cost estimates for a possible distribution system to serve supplemental water to about 21,600 net acres of agricultural land in the Oxnard Plain and Pleasant Valley Subunits, together with the Cities of

Oxnard and Port Hueneme, and the United States Navy Advance Base at Port Hueneme. The system would deliver a maximum seasonal supply during drought periods of abou 45,000 acre-feet. The location of the lands to be served and the general alignment of the major distributaries are shown on Plate 42.

Choice of a distribution system capacity of 45,000 acre-feet per season was based on the following consideration. The total present requirement for supplemental water in the Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits was estimated to be about 74,000 acre-feet per season during drought period However, in arriving at this estimate, direct evaluation of all items of water supply to these subunits could not be made. It is entirely possible that there i a substantial contribution to the confined aquifers of the Oxnard Plain and Pleasant Valley Basins from percolation of rainfall and of the unconsumed portion of applied water. If this should prove to be the case, the estimates of supplemental water requirement should be reduced accordingly. For this reason, and in light of the determined magnitude of local supplemental water supplies that appea to be feasible of development, the initial works to distribute supplemental water in the Oxnard Plain and Pleasant Valley Subunits were designed with the capacity indicated.

In design of the distribution system, it was assumed that an irrigating head of one second-foot for every 80 acres of agricultural land would be required. From analysis of agricultural power consumption data, and the results of studies of water use practice conducted by the Division of Water Resources, it was estimated that during the month of maximum water demand about 40 per cent of the agricultural lands served would require water service at a given time. Thus, the tota required capacity of the distribution system was estimated to be one second-foot for each 200 acres of service area, or about 120 second-feet in all, including a small additional allowance for peaking capacity. Lands that would be served y the system, as designed, are largely those that were underlain by a landward radient in the piezometric surface in the Oxnard and Fox Canyon aquifers during he drought period.

The distribution system to serve agricultural lands would commence at he Oxnard Reservoir, which is the terminus for conduits considered for supplying upplemental water to the Oxnard Plain and Pleasant Valley Subunits. It was ssumed that this reservoir would have a storage capacity of about 100 acre-feet, ith inside dimensions of 450 by 450 feet and a normal depth of water of 20 feet. xcavation for the reservoir would extend to a depth of 8 feet below ground surface. The excavated material would be used in a rolled earthfill embankment, orming the sides of the reservoir. This embankment would be about 14 feet in eight above ground surface, with 1.5:1 side slopes and a 20-foot top width, and feet of freeboard would be provided above the normal water surface. Seepage rom the reservoir would be prevented by a buried asphaltic concrete membrane. eservoir releases would be effected by a 60-inch diameter reinforced concrete ylinder pipe placed through the embankment, regulated by a slide gate at the ntake of the pipe. Additional control would be obtained by a gate valve at the utlet end of the pipe.

From Oxnard Reservoir, two major laterals were considered. One line ould extend westerly from the reservoir along Gonzales Road to Ventura Road, here a wye would be placed in the line. From this point, one branch would ontinue westerly to serve the area along the Gonzales Road, and the other branch ould extend in a generally southerly direction to serve the area west of the ity of Oxnard. The second major lateral would extend southerly from Oxnard eservoir and east of the City of Oxnard, and would serve the area east of the ities of Oxnard and Port Hueneme and generally west of Revolon Slough. An dditional regulating reservoir to provide peaking capacity was considered to be necessary on this lateral, at the intersection of Pleasant Valley and Rice Roads. This reservoir would have a storage capacity of about 50 acre-feet, and would be similar in construction to Oxnard Reservoir.

The major laterals and branches of the irrigation distribution system would be constructed generally of centrifugally spun reinforced concrete pipe, varying in diameter from 12-inches to 54-inches, and totalling 174,500 feet in length. The lines were located so that ties to existing irrigation systems served by wells would not exceed about one-half mile in length. It was estimate that about 190 such ties would have to be made to the distribution system.

In order to provide supplemental water requiring a minimum of treatmen to the Cities of Oxnard and Port Hueneme and to the United States Navy Advance Base at Port Hueneme, it was assumed that well fields would be constructed in Oxnard Forebay Basin, and that a conduit, independent of the agricultural distribution system, would be constructed to serve these entities. Supplemental water for this purpose could be discharged from the Santa Clara River Conduit to the Saticoy spreading grounds. Thus, Oxnard Forebay Basin would function as a slow sand filter for the supplemental municipal supplies.

The well fields would be located northeast of the community of El Rio, one at a site immediately west of Vineyard Avenue, and one at a site between Vineyard Avenue and Ditch Road. Each field would comprise about 20 acres of land, and would contain 8 wells. It was assumed that each well would be 18 inches in diameter and 250 feet deep, with pump bowls set at a depth of about 175 feet. The gravel packed and cased wells would be placed in two rows of four wells each, with a distance of 400 feet between wells. Each well would be equipped with a pump driven by a 75 horsepower motor. It was estimated that, with the lowest ground water levels expected to occur in this vicinity, each well would produce about 1,400 gallons of water per minute. With all wells in operation, the maximum discharge from the two fields would be about 50 acre-feet. Wells in the two fields would connect to a common pipe line, which would extend southerly along Ditch Road to the vicinity of Oxnard Reservoir, where, a connection would be made to the reservoir so that emergency interim supplies for agricultural use could be obtained from the well fields. From Oxnard Reservoir, the pipe line would continue southerly on Rose Road for a distance of about 6,500 feet, where a lateral would extend westerly to connect with the existing distribution system of the City of Oxnard. The main line would continue southerly, thence westerly to the United States Navy Advance Base, and thence southerly to Port Hueneme. A lateral extension would also be provided to serve the American Crystal Sugar Company's factory at Oxnard. Although not included as an initial feature of the considered municipal distribution system, a lateral could be constructed to meet presently relatively minor water requirements of the naval installation at Point Mugu. The over-all length of the municipal conduit, from the well field near Ditch Road to its terminus at Port Hueneme, would be about 45,000 feet.

It was assumed that at the present time the municipal conduit would serve about 10,000 acre-feet of water per season. From the well fields to the take-off of the City of Oxnard, the pipe line would have a capacity of 40 second-feet. From this point to the take-off for the American Crystal Sugar Company, its capacity would be 30 second-feet. From this point to a take-off for the Naval Advance Base, capacity of the pipe line would be 15 second-feet. The final portion of pipe line to Port Hueneme would have a capacity of 10 second-feet.

Presented in the following tabulation is a summary of estimated capital and annual costs of the proposed distribution system for the Oxnard Plain and Pleasant Valley Subunits. Detailed estimates of cost are presented in Appendix C,

Item	Capital	Annual	Average annual unit cost of supplemental water attributable to cost of distribution system, per acre-foot
	Estimated costs		
Agricultural system, including regulating reservoirs	$3,038,000	$169,000	$4.80
Municipal system, including well fields	1,318,000	94,000	9.40

Piru-Las Posas Diversion. As described heretofore, consideration was given to the operation of a Devil Canyon Reservoir, constructed to a storage capacity of 150,000 acre-feet, for the joint benefit of the Santa Clara River ar Calleguas-Conejo Hydrologic Units. In this connection, estimates of cost were prepared for seven capacities of the Piru-Las Posas Diversion Conduit to convey water from Devil Canyon Reservoir to the Calleguas-Conejo Hydrologic Unit. As an alternative to Devil Canyon Reservoir as a source of water supply, studies were also made of a conduit from Blue Point Reservoir to serve the Calleguas-Conejo Hydrologic Unit. For illustrative purposes, only those studies relating to utilization of Devil Canyon Reservoir for the purpose are described herein.

From reconnaissance type estimates of cost of several possible routes, it was concluded that the most economical conduit alignment would extend from th outlet works of the dam down Piru Creek to the town of Piru, and thence would follow the right bank of the Santa Clara River to a point immediately upstream from the State Fish Hatchery. At this point the conduit would cross the Santa Clara River, and then extend up Shiells Canyon to the northerly portal of a tunnel through Oak Ridge. This tunnel would extend southerly and terminate in Happy Canyo in the East Las Posas Subunit. Alternative conduits having capacities of 40, 60, 80, 100, 125, 150, and 200 second-feet were studied. For illustrative purposes, features of the Piru-Las Posas Diversion Conduit with capacity of 80 second-feet are described herein.

Water for the conduit would be discharged through the outlet works at Devil Canyon Dam at an elevation of about 1,090 feet. From Devil Canyon Dam to the northerly portal of the Happy Camp Canyon Tunnel, the conduit would consist of about 54,800 lineal feet of 60-inch diameter, and 12,700 lineal feet of 54-inch diameter lock joint concrete cylinder pipe. At the required crossings of Piru Creek and the Santa Clara River, the conduit would be buried to a depth of 20 feet and encased in concrete. Slope of the hydraulic gradient in the pipe line would be 1.2 feet per thousand feet. The Happy Camp Canyon Tunnel would be concrete line, of horseshoe section, 7 feet in diameter, and about 13,500 feet in length. Invert elevation of the northerly portal would be about 1,005 feet, and about 990 feet at the southerly portal. Water would flow by gravity in the tunnel at a normal depth of 5.7 feet, with a velocity of 5.2 feet per second.

Presented in Table 103 are estimated capital and annual costs of the Piru-Las Posas Diversion Conduit for the seven alternative conduit sizes studied. Also shown are estimates of the proportionate average annual costs of a Devil Canyon Reservoir, with 150,000 acre-feet of storage capacity operated for joint benefit of the Santa Clara River and Calleguas-Conejo Hydrologic Units, deemed chargeable to the latter hydrologic unit. These costs were proportioned on the basis of the amounts of net safe yield made available to each hydrologic unit. Table 103 also shows estimated unit costs of net safe yield made available to the Calleguas-Conejo Hydrologic Unit, on the same basis.

TABLE 103

SUMMARY OF ESTIMATED COSTS AND YIELDS OF PIRU-LAS POSAS DIVERSION CONDUIT

Discharge capacity of diversion conduit, in second-feet	Net safe yield from Devil Canyon Reservoir available to Calleguas-Conejo Hydrologic Unit, in acre-feet per season	Capital cost of conduit	Average annual costs				
			Diversion conduit	Proportional cost of Devil Canyon Reservoir	Total	Per acre-foot of net safe seasonal yield	Per acre-foot of incremental net safe seasonal yield
40	15,300	$5,714,600	$303,000	$423,900	$ 726,900	$48	$--
60	17,600	6,267,000	332,300	454,500	786,800	45	26
80	20,100	6,960,500	369,000	480,200	849,200	42	25
100	20,800	7,384,500	391,600	486,800	878,400	42	42
125	21,600	8,087,400	428,800	493,900	922,700	43	55
150	22,400	8,491,000	450,100	500,700	950,800	42	35
200	23,500	9,724,200	515,600	509,600	1,025,200	44	68

Planned Operation of Ground Water Storage

As described in Chapter II, certain of the major ground water basins in Ventura County are not presently utilized to the maximum practicable extent. Consideration was given to enhancement of presently developed yields of ground waters from these basins through their planned operation. Such operation would involve either the modification of present patterns of pumping or the increased use of water from the basins, or both, depending upon the individual characteristics of the basin under consideration. Development of increased yield of water through planned operation of ground water storage was determined to be the least expensive of all investigated sources of supplemental water available to Ventura County. In certain ground water basins of the County, such planned operation would result in the development of substantial quantities of new water with relatively small capital expenditures, in comparison with the costs of surface storage necessary to develop comparable amounts of supplemental water. In addition, as compared with water in surface storage, evaporation losses would be negligible, and with lowering of ground water levels through increased use of the basins, nonbeneficial consumptive use of water by native vegetation would be reduced or eliminated.

From a practical standpoint, however, there are legal considerations which must be recognized in any plan for operation of ground water storage. Under the law, an overlying user in a ground water basin has a paramount right, correlative with all other overlying users, to the reasonable and beneficial use of ground water in the basin. He is, therefore, entitled to the protection of the courts against any substantial infringement of his correlative right to the ground water which he reasonably and beneficially requires, and against any use of the ground water by an appropriator which would cause an impairment to his right. That type of planned operation of ground water storage which would involve increased use of water from the basin, and possibly that type which would modify the pumping pattern, would result in lowering of ground water levels. The attendant inconvenience or extra expense to an overlying user would not necessarily prevent such planned operation, providing it could be shown that such inconvenience or added expense were not unreasonable.

The question of what constitutes unreasonable inconvenience or expense is not subject to exact determination. However, it may be assumed that greater energy charges resulting from increased pumping lifts would not be considered an unreasonable expense or inconvenience, as long as presently installed pumping equipment of the overlying user could continue to be utilized. A material lowering of ground water levels that would necessitate deepening of wells and replacement of pumping equipment probably would be considered unreasonable. In any actual case, these matters would have to be determined by negotiated agreement or by the courts. In the studies described herein, it was not possible with data at hand to evaluate these factors. It is believed, however, that the success of planned operation of a given ground water basin would be contingent upon the voluntary negotiation of a mutually satisfactory agreement between the overlying ground water users and the operating agency.

Described in this section are studies relating to planned operation of ground water storage in Ventura County considered from the standpoints of both independent operation of the ground water basins and their operation in conjunction with existing or proposed surface storage developments.

Ojai Basin. The total ground water storage capacity of Ojai Basin was estimated to be of the order of 70,000 acre-feet, and the maximum ground water storage depletion of record therein, occurring in the fall of 1951, was estimated to have been about 28,000 acre-feet. In the latter years of the drought period fr 1944-45 through 1950-51, wells near the margin of Ojai Basin were dry. Based in part on this fact, it was estimated that the usable storage capacity in the basin, with the present pattern of pumping, is about 10,900 acre-feet. Thus, with the present pattern of pumping only about 15 per cent of the total available ground water storage capacity is usable, and it appears that utility of the basin could be enhanced by serving the marginal areas from water supplies pumped near the center of the basin.

Although storage depletion in Ojai Basin in the fall of 1951 was about 28,000 acre-feet and there is an estimated mean seasonal net draft on the ground water of approximately 3,500 acre-feet, the basin was essentially filled in 1952. This filling was undoubtedly accelerated by percolation and use of water diverted from Matilija Reservoir during 1952, but it is probable that during a wet period and with the present net draft the basin would fill naturally. Whether or not such filling would occur with a substantially greater net draft on the basin could not be determined. It is probable however, that perennial lowering of ground water levels would not result if the pumping pattern were shifted from the margins to the center of the basin, and if the present mean seasonal net draft were not exceeded. It is indicated that, were such a plan to be put into effect, the present ground water overdraft on Ojai Basin estimated to be about 2,000 acre-feet per season, would be eliminated.

Under the plan described in the preceding paragraph, it was estimated that about 1,200 net acres of land around the periphery of Ojai Basin would require water from wells located in the central portion. It is probable that in most cases the large capital expense involved in delivering the pumped ground water, in addition to the cost of drilling new wells, would prohibit execution of the plan by individual users. Furthermore, the success of such a plan would be contingent upon the willingness of ground water users overlying the center of the basin to permit drilling and subsequent operation of wells for the purpose of delivering water to the marginal areas.

Although not planned operation of ground water storage in the sense of the preceding discussion, an alternative solution to the problem of ground water overdraft in Ojai Basin lies in the spreading and percolation of water from Matilija Reservoir in the basin or its use in the Ojai Subunit. As described previously, such spreading was done by the Ventura County Flood Control District during 1952. During wet periods, Ojai Basin probably would fill naturally with the present pattern of land use and water supply development, and spreading or use of water from Matilija Reservoir would not in itself increase the yield of the basin. However, it would accelerate recovery of ground water levels therein During drought periods, when ground water levels in Ojai Basin would be drawn down below safe elevations, the net safe yield on Matilija Reservoir, in the estimated amount of about 1,400 acre-feet per season, could be delivered to and spread in Ojai Basin or used in the subunit. By this means, the present ground water overdraft would be substantially reduced.

With construction of a reservoir at the Casitas site on Coyote Creek, and augmentation of inflow to that reservoir by diversion of flood waters from the Ventura River, it would be possible for certain entities, including the City of Ventura, which have established rights to waters of Matilija Creek originating above the reservoir, to forego those rights in exchange for rights in water served from Casitas Reservoir. If, through negotiation, such a plan could be effected, sufficient additional water could be developed at Matilija Reservoir and delivered to the Ojai Subunit to eliminate present ground water overdraft and to provide some water for the needs of future development.

<u>Piru, Fillmore, and Santa Paula Basins.</u> It was stated in Chapter II that the utility of Piru, Fillmore, and Santa Paula Basins is believed to be limited by factors of economic pumping lift and mean seasonal recharge, rather than by storage capacity or configuration of the basins, and that the basins are not presently utilized to the maximum practicable extent. Consideration was

given to increased use of these basins for developing supplemental water to alleviate ground water overdraft conditions in the Oxnard Forebay, Oxnard Plain, and Pleasant Valley Basins. Such increased use would involve the construction of well fields in the upper basins and the conveyance of water extracted therefrom to areas of need in the lower subunits. Such planned operation would result in a greater lowering of ground water levels in Piru, Fillmore, and Santa Paula Basins than would occur with the present patterns of land use and water supply development. The lowered ground water levels, in turn, would provide greater underground storage space for the capture of waters that would otherwise waste to the ocean during wet periods.

Consideration was also given to the operation of potential surface storage reservoirs on tributaries of the Santa Clara River under the uniform release method, without release of water stored therein to maintain ground water in the three basins at historic levels. Such a method of surface reservoir operation would lower ground water levels in Piru, Fillmore, and Santa Paula Basins, create greater underground storage space for the capture of otherwise waste of flood flows, and would have the effect of operating the ground water basins. Also analyzed were the effects on ground water storage of coordinated operation of Piru, Fillmore, and Santa Paula Basins with potential surface storage developments on tributaries of the Santa Clara River.

In the various studies described in this section, consideration was not given to the increased costs that would be experienced by overlying ground water users as a result of lowered ground water levels caused by planned operation of the basins. Such costs were not subject to evaluation with data at hand.

There is presented in Table 104 the results of studies of the effects of operation of various capacities of reservoirs at the Topatopa, Devil Canyon and Santa Felicia sites, on ground water storage and levels in Piru, Fillmore, and

Santa Paula Basins. The surface reservoirs were operated under the uniform releas method and without the release of stored water for maintenance of historic water levels in the ground water basins. The results shown in Table 104 were determined from monthly operation studies for the base period, utilizing methods and procedures described in Chapter II. For all reservoir combinations shown, it was found that Piru, Fillmore, and Santa Paula Basins, although experiencing greater ground water storage depletions than the historical during the drought period, would nevertheless have filled during the wet period. Thus, ground water overdraf would not have resulted in either of the three basins from reductions in supply caused by reservoir operation, and the effect of the increased basin storage depletion would have been to further enhance the developed safe yield of the system. The amounts of net safe seasonal yield from Topatopa, Devil Canyon, and Santa Felicia Reservoirs, under this method of operation were shown in Tables 71 and 100, respectively.

ESTIMATED EFFECTS ON PIRU, FILLMORE, AND SANTA PAULA GROUND WATER BASINS OF OPERATING TOPATOPA AND SANTA FELICIA RESERVOIRS UNDER THE UNIFORM RELEASE METHOD DURING THE BASE PERIOD, WITHOUT RELEASES TO MAINTAIN HISTORIC GROUND WATER LEVELS

Reservoir storage capacity, in acre-feet		Ground water storage depletion in fall of 1951, in acre-feet			Increase in ground water storage depletion in fall of 1951 over present conditions, in acre-feet			Average lowering of ground water levels in fall of 1951, in feet[c]			Increase in average depth to ground water in fall of 1951 over present conditions, in feet		
Topatopa	Santa Felicia	Piru Basin	Fillmore Basin	Santa Paula Basin	Piru Basin	Fillmore Basin	Santa Paula Basin	Piru Basin	Fillmore Basin	Santa Paula Basin	Piru Basin	Fillmore Basin	Santa Paula Basin
0	0	94,300	61,000	22,600	---	---	---	110	40	25	--	--	--
0	100,000	110,200	67,100	29,000	15,900	6,100	6,400	130	45	35	20	5	10
100,000	100,000	110,200	68,200	31,300	15,900	7,200	8,700	130	45	40	20	5	15
100,000	0	94,300	62,400	24,700	0	1,400	2,100	110	40	30	0	0	5
100,000	50,000	106,300	66,700	29,700	12,000	5,700	7,100	120	45	35	10	5	10
100,000	75,000	108,200	67,400	30,500	13,900	6,400	7,900	125	45	35	15	5	10
50,000	100,000	110,200	67,900	30,800	15,900	6,900	8,200	130	45	35	20	5	10
75,000	100,000	110,200	68,000	31,000	15,900	7,000	8,400	130	45	35	20	5	10
0	150,000[a]	112,400	68,200	30,600	18,100	7,200	8,000	130	45	35	20	5	10
100,000	150,000[a]	112,400	69,300	33,000	18,100	8,300	10,400	130	50	40	20	10	15
0	150,000[b]	111,500	67,400	29,800	17,200	6,400	7,200	130	45	35	20	5	10
100,000	150,000[b]	111,500	68,500	32,100	17,200	7,500	9,500	130	45	40	20	5	15

[a] At Devil Canyon site (with 80 second-foot diversion to Calleguas-Conejo Hydrologic Unit).
[b] At Devil Canyon site (operated for benefit of Santa Clara River Hydrologic Unit only).
[c] To obtain average depth to ground water in fall of 1951, add 25 feet, 20 feet, and 30 feet to the figures given for average lowering of ground water levels in the Piru, Fillmore, and Santa Paula Basins, respectively.

A summary of the results of studies made to determine amounts of supplemental water that would be made available to the Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits through increased use of upstream ground water storage are presented in Table 105. These studies were conducted for the base period under four assumed conditions: (1) with no surface storage developments on tributaries of the Santa Clara River; (2) with Santa Felicia Reservoir constructed to a storage capacity of 100,000 acre-feet, and operated under the uniform release method, without releases for maintenance of historic ground water levels in Piru, Fillmore, and Santa Paula Basins; (3) with Santa Felicia and Topatopa Reservoirs each constructed to a storage capacity of 100,000 acre-feet, and with the same method of operation as in (2); and (4) with Devil Canyon Reservoir constructed to a storage capacity of 150,000 acre-feet and operated under the same criteria as in (2) both for the joint benefit of the Calleguas-Conejo and Santa Clara River Hydrologic Unit and for the sole benefit of the latter hydrologic unit.

It may be noted in Table 105 that consideration was not given to the operation of Piru Basin, other than would occur through the stated method of operating Devil Canyon and Santa Felicia Reservoirs. Examination of Table 104 indicates that the average depth to ground water in Piru Basin substantially exceeds that of both Santa Paula and Fillmore Basins. It is known that certain overlying users in Piru Basin at the present time are experiencing pumping lifts in in excess of 200 feet. Because of these relatively high pumping lifts, and because of the shorter distance required to convey ground water extracted from Santa Paula and Fillmore Basins to the Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits, further consideration was not given to planned operation of ground water storage in Piru Basin.

TABLE 105

SUMMARY OF ANALYSES OF PLANNED OPERATION OF FILLMORE AND SANTA PAULA GROUND WATER BASINS DURING BASE PERIOD, WITH PRESENT PATTERNS OF LAND USE

Average seasonal draft from ground water storage, in acre-feet		New water available to Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits, in acre-feet per season	Ground water storage depletion in fall of 1951, in acre-feet		Increase in ground water storage depletion over present conditions, in acre-feet		Average lowering of ground water levels in fall of 1951, in feet[c]		Lowering of ground water levels over present conditions, in feet	
Santa Paula Basin	Fillmore Basin		Santa Paula Basin	Fillmore Basin	Santa Paula Basin	Fillmore Basin	Santa Paula Basin	Fillmore Basin	Santa Paula Basin	Fillmore Basin
With no surface reservoirs										
0	0	---	22,600	61,000	---	---	25	40	--	--
5,000	0	1,500	31,400	61,000	8,800	0	40	40	15	0
10,000	0	4,900	48,200	61,000	25,600	0	60	40	35	0
15,000	0	9,100	67,700	61,000	45,100	0	95	40	70	0
20,000	0	13,500	88,500	61,000	65,900	0	130	40	105	0
0	5,000	2,700	27,500	67,000	4,900	6,000	30	45	5	5
0	10,000	6,000	36,200	77,400	13,600	16,400	45	55	20	15
0	15,000	9,800	44,000	87,000	21,400	26,000	55	65	30	25
0	20,000	13,800	52,900	98,300	30,300	37,300	70	75	45	35
With Santa Felicia Reservoir of 100,000 acre-foot storage capacity, uniform release operation, with no releases for maintenance of historic ground water levels										
0	0	---	29,000	67,100	6,400	6,100	35	45	10	5
5,000	5,000	6,500	52,400	75,600	29,800	14,600	70	55	45	15
7,500	7,500	10,600	66,700	80,500	44,100	19,500	95	60	70	20
10,000	10,000	14,800	81,800	85,400	59,200	24,400	120	65	95	25
15,000	15,000	23,300	116,300	97,100	93,700	36,100	175	75	150	35
9,000	15,000	18,200	90,400	97,100	67,800	36,100	135	75	110	35
5,000	0	2,800	42,900	67,100	20,300	6,100	55	45	30	5
10,000	0	6,400	60,200	67,100	37,600	6,100	85	45	60	5
15,000	0	10,700	80,400	67,100	57,800	6,100	115	45	90	5
20,000	0	15,200	101,400	67,100	78,800	6,100	150	45	125	5
0	5,000	3,200	36,500	76,000	13,900	15,000	45	55	20	15
0	10,000	6,800	43,500	85,000	20,900	24,000	55	65	30	25
0	15,000	10,500	52,000	95,000	29,400	34,000	70	75	45	35
0	22,000	16,000	62,000	115,500	39,400	54,500	85	85	60	45
With Santa Felicia and Topatopa Reservoirs, both of 100,000 acre-foot storage capacity, uniform release operation, with no releases for maintenance of historic ground water levels										
0	0	0	31,300	68,200	8,700	7,200	40	45	15	5
10,000	0	6,900	64,500	68,200	41,900	7,200	90	45	65	5
15,000	0	11,200	84,900	68,200	62,300	7,200	125	45	100	5
20,000	0	15,700	106,000	68,200	83,400	7,200	160	45	135	5
30,000	0	25,200	129,000	68,200	106,400	7,200	195	45	170	5
With Devil Canyon Reservoir of 150,000 acre-foot storage capacity, uniform release operation, with no releases for maintenance of historic ground water levels										
0	22,000[a]	16,000	64,500	117,000	41,900	56,000	90	85	65	45
0	22,000[b]	16,000	65,500	118,500	42,900	57,500	90	90	65	50

[a] Operated for benefit of Santa Clara River Hydrologic Unit.
[b] With 80 second-foot diversion to Calleguas-Conejo Hydrologic Unit.
[c] **To obtain average depth to ground water in fall of 1951, add 25 feet, 20 feet, and 30 feet to the figures given for average lowering of ground water levels in the Piru, Fillmore, and Santa Paula Basins, respectively.**

Because of lower specific yield of the water bearing formations and smaller areal extent, ground water levels in Santa Paula Basin experience a substantially greater lowering than do levels in Fillmore Basin for a given ground water draft. This is illustrated in Table 105. It is also shown that with planned operation of Fillmore Basin and lowering of water levels therein, water levels in Santa Paula Basin are also lowered. This effect is the result of reduction in that portion of water supply to Santa Paula Basin originating in Fillmore Basin. Since the objective of planned operation of ground water storage would be to develop as much new water as possible, with a minimum lowering of water levels in the basin being pumped, it would appear that most efficient operation would occur were Fillmore Basin to be operated alone.

For the purpose of cost analysis, it was assumed that an additional seasonal ground water draft of 22,000 acre-feet would be imposed on Fillmore Basin, and that this amount of water would be conveyed to the Oxnard Forebay Subunit in the Santa Clara River conduit, described previously. It was also assumed that Devil Canyon Reservoir would be constructed to a capacity of 150,000 acre-feet, and that this reservoir would be operated under the uniform release method for the joint benefit of the Calleguas-Conejo and Santa Clara River Hydrologic Units, without releases to maintain historic ground water levels in Piru, Fillmore, and Santa Paula Basins. As shown in Table 105, new water made available to the Oxnard Forebay Subunit, by such operation would amount to about 16,000 acre-feet per season. Average ground water levels in Santa Paula and Fillmore Basins would be lowered about 65 feet and 50 feet, respectively, below the levels that would have prevailed in the fall of 1951 with present patterns of land use and water supply development.

In the estimates of cost, it was assumed that about 30 acres of presently undeveloped land near the Santa Clara River channel in the westerly portion of Fillmore Basin, in Section 12, Township 3 North, Range 21 West, would be acquired for construction of a well field. The well field site is above the flood plain of the Santa Clara River, and is shown on Plate 42. The areal extent of the proposed field would be sufficient to allow placement of the wells at intervals great enough to eliminate substantial mutual interference during pumping periods. It was assumed that eighteen wells would be drilled, two of which would be used for standby purposes. The wells would be 18-inches in diameter, drilled to a depth of about 220 feet, and gravel packed. Each well pump would be equipped with a 75 horsepower electric motor. From examination of pump test data in Fillmore Basin, it was estimated that each well would produce a minimum of about 1,500 gallons of water per minute, or a little more than 3 second-feet of continuous flow. With 16 wells in operation, the field would be capable of producing about 3,300 acre-feet per month, or about 15 per cent of the total seasonal pumpage. Discharge from the wells would feed into a small regulating reservoir located near Willard Road, and thence into the Santa Clara River Conduit. The following tabulation presents a summary of physical features of the Fillmore Well Field and appurtenant works, as designed for cost estimating purposes:

Wells	
Number	18
Type	18-inch diameter, gravel packed, and cased
Average depth, in feet	220
Distance between wells, in feet	400
Pumping Plants	
Number	18
Horsepower of motors	75
Depth of bowls, in feet	150
Pump capacity	1,500 gallons per minute
Average pumping head, in feet	75
Regulating Reservoir	
Capacity, in acre-feet	10
Normal water surface elevation, in feet, U.S.G.S. datum	275

The capital cost of the Fillmore Well Field and appurtenances was estimated to be about $338,000, including cost of the regulating reservoir. The annual costs, including interest and amortization, operation and maintenance charges, replacement, and power charges, were estimated to be about $55,000. It was estimated that the cost of new water available for conveyance to the Oxnard Forebay Subunit would be about $3.50 per acre-foot. These costs do not include any compensation for unreasonable expense to overlying ground water users in Fillmore and Santa Paula Basins, resulting from the planned operation of Fillmore Basin. It is not believed that, with the aforementioned increased ground water level lowering of 65 feet and 50 feet, in Santa Paula and Fillmore Basins, respectively, any such unreasonable expense would occur.

Oxnard Forebay, Oxnard Plain, and Pleasant Valley Basins. It was shown in Chapter II that with the present pattern and rate of pumping from Oxnard Forebay, Oxnard Plain, and Pleasant Valley Basins, ground water storage depletion in Oxnard Forebay Basin must be limited to about 20,000 acre-feet to prevent formation of a trough in the piezometric surface in the Oxnard aquifer, and to prevent the intrusion of sea water to the aquifer. It appears that a trough also will form in the Fox Canyon aquifer if ground water storage in Oxnard Forebay Basin is depleted in excess of 20,000 acre-feet. The Oxnard and Fox Canyon aquifers apparently lack capacity to transmit water from the forebay to the pressure areas at sufficient rates to meet the demands of present pumping drafts. For this reason, consideration was given to modification of the present pattern of ground water pumping, so that lands near the coastal front would be served with water pumped from Oxnard Forebay Basin and conveyed thereto by surface conduit. In effect, an artificial surface conveyance unit of adequate capacity would be substituted for the presently utilized natural aquifers of inadequate conveyance capacity.

Under certain conditions, such a change in pumping pattern could eliminate the threat of sea-water intrusion to a confined aquifer. In the case of the three basins under consideration, however, there are several factors which appear to make such a plan infeasible. Without some provision for supplying Oxnard Forebay Basin with an additional water supply during drought periods, it is indicated that ground water levels in the basin would be drawn down below sea level. This would take place regardless of any modification in the pattern of pumping from the three basins. Cessation of ground water pumping near the coast, particularly in the vicinities of submarine canyons near Port Hueneme and Point Mugu, would tend to mitigate the immediate threat of loss of aquifer utility through sea-water intrusion. Nevertheless, from consideration of studies described in Chapter II, it appears that a trough would still form in the Oxnard aquifer, and that under conditions of longer and more severe droughts than that from 1944-45 through 1950-51, and with increased water supply utilization in the Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits, sea water might invade portions of the Oxnard and Fox Canyon aquifers still being actively pumped. Thus, regardless of instituted changes in the pattern of pumping from the three ground water basins, the threat of sea-water intrusion can only be eliminated with the development of supplemental water and its delivery to the Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits, during periods of drought.

With the development of supplemental water, either in upstream surface or ground water reservoirs, and conveyance of the water to the Oxnard Forebay Subunit, either by conduit or by natural channel of the Santa Clara River, two possible methods for its distribution in the Oxnard Plain and Pleasant Valley Subunits were given consideration: (1) Utilization of Oxnard Forebay Basin as a regulating reservoir, and conveyance of the supplemental water to and its distribution in areas of need by means of the presently utilized natural aquifers;

and, (2) conveyance of the supplemental water to and its distribution in areas of need by means of a surface distribution system similar to that described under the section of this chapter entitled "Conveyance and Distribution of Supplemental Water".

Under the first of the foregoing methods of conveyance and distribution, the present pattern of pumping ground water from the three basins would not be modified. However, to eliminate the problem of inadequate aquifer transmissibility, it would be necessary to maintain ground water levels in Oxnard Forebay Basin at 60 feet above sea level or higher, in order to maintain a seaward gradient in the piezometric surface of the Oxnard aquifer and to prevent formation of a trough therein. As stated, this would limit ground water storage depletion in Oxnard Forebay Basin to about 20,000 acre-feet. If these criteria could be met, such a plan of conveyance and distribution of supplemental water would be the least expensive to put into effect. However, studies described elsewhere in this chapter indicate that insufficient water can be developed either in upstream surface or ground water reservoirs to maintain ground water levels in Oxnard Forebay Basin at the prescribed elevation. Furthermore, with maintenance of ground water levels in Oxnard Forebay Basin at an elevation of 60 feet or higher, utility of the basin as a natural regulator of surface runoff in the Santa Clara River would be almost entirely destroyed. In addition, it was estimated that a substantial portion of the supplemental water supply stored in Oxnard Forebay Basin would be lost for beneficial use through increased subsurface outflow to the ocean. For these reasons, it was concluded that conveyance and distribution of supplemental water in areas of need in the Oxnard Plain and Pleasant Valley Subunits should be accomplished through the construction of a surface conveyance and distribution system. A description of general features and the estimated costs of such a system have been presented previously in this chapter.

Simi and East and West Las Posas Basins. Although it was estimated hat there is little opportunity for further conservation of local water supplies n the Calleguas-Conejo Hydrologic Unit, studies of the Division of Water esources and of the Soil Conservation Service of the United States Department f Agriculture indicated that presently dewatered ground water storage capacity n the Simi and East and West Las Posas Basins could be utilized to regulate mported water supplies. Utilization of these basins for such purpose would nvolve the construction of spreading facilities in areas where the soil profile s of such character as to allow rapid infiltration of water applied on the surace, and where no continuous underlying impervious strata exist that would revent water applied on the surface from reaching pumped aquifers. Furthermore, here would have to be adequate carry-over storage capacity available in the ewatered portions of the basins to satisfactorily regulate the imported water.

During 1951 and 1952, the Soil Conservation Service conducted an invesigation of possible spreading areas in Zone 3 of the Ventura County Flood ontrol District. This investigation included studies of infiltration rates and nvestigation of soil profiles to determine the suitability of various areas for preading. The results of these studies have been published in a report entitled Ground Water Replenishment by Penetration of Rainfall, Irrigation, and Water preading in Zone 3, Ventura County Flood Control District, California", dated pril, 1953. Although the studies encompassed most of the Calleguas-Conejo ydrologic Unit and a portion of the Pleasant Valley Subunit of the Santa Clara iver Hydrologic Unit, the ensuing discussion of their results refers only to the imi and East and West Las Posas Basins, wherein it was concluded the most avorable geologic conditions prevail for the spreading, infiltration, and storage f supplemental water.

The Soil Conservation Service estimated that there were about 725 acres of land overlying Simi Basin suitable for water spreading purposes. Of this area, it was concluded that about 590 acres would have a continuous infiltration capacity of about one foot of depth of water per day, and that about 135 acres would have a continuous capacity of about two feet of depth of water per day. In East Las Posas Subunit, about 2,320 acres of land were estimated to have a continuous infiltration capacity of about one foot of depth of water per day, with 2,480 acres having a capacity of about two feet of depth of water per day. Locations of these areas are shown on a plate in the foregoing report.

In Simi Basin, it was estimated that there were about 51,000 acre-feet of dewatered ground water storage capacity in the fall of 1951 between ground water levels prevailing at that time and a depth of 25 feet below ground surface. Similar estimates could not be made for the several aquifers in East and West Las Posas Basins, although the total dewatered storage capacity therein in the fall of 1951 was probably in the order of magnitude of that in Simi Basin.

As described earlier in this chapter, consideration was given to the utilization of Devil Canyon Reservoir with a storage capacity of 150,000 acre-feet, for the joint benefit of both the Santa Clara River and Calleguas-Conejo Hydrologic Units, and with diversion of a portion of the conserved water to the Calleguas-Conejo Hydrologic Unit through the Piru-Las Posas Conduit. It was indicated that the most economical capacity of this conduit would be about 80 second-feet. It was estimated that to equalize the discharge from an 80 second-foot conduit about 140,000 acre-feet of regulatory storage capacity would be required in the Calleguas-Conejo Hydrologic Unit. Regulation of the supplemental water supply could be effected either in surface storage or in ground water storage. Reconnaissance type investigation indicated that the cost of constructing such storage capacity in surface reservoirs would be prohibitive. Therefore, consideration was given to construction of water spreading facilities and obtaining the required regulation in ground water storage.

For cost estimating purposes, it was assumed that 30 second-feet of water spreading and infiltration capacity would be constructed in the Simi Subunit, and that 50 second-feet of such capacity would be constructed in the East Las Posas Subunit. With a Piru-Las Posas Conduit of 80 second-foot discharge capacity, an average supplemental water supply of about 7,550 acre-feet per season would be made available in the Simi Subunit, and about 12,550 acre-feet per season in the East Las Posas Subunit, which amounts would be sufficient to eliminate present ground water overdrafts in Simi and East and West Las Posas Basins and to provide some water for future growth. Regulation of these supplemental supplies would require about 50,000 acre-feet and 90,000 acre-feet of storage capacity, respectively. Assuming that there would be no substantial rise in ground water levels during future wet periods, it appears that sufficient storage capacity for this purpose would be available in Simi Basin. However, whether there is 90,000 acre-feet of dewatered ground water storage capacity available in East and West Las Posas Basins is questionable.

For cost estimating purposes, it was assumed that about 70 acres of land would be acquired for spreading purposes near Dry Canyon, in the north-central portion of Simi Valley. With an infiltration capacity of one foot of depth of water per day, these proposed spreading grounds would be capable of infiltrating a continuous discharge of 30 second-feet. Similarly, about 50 acres of presently undeveloped land would be acquired in Happy Camp Canyon in the East Las Posas Subunit, near the southerly portal of the previously described Happy Camp Canyon tunnel, a feature of the Piru-Las Posas Conduit. It was estimated that these lands would have an infiltration capacity of about two feet of depth of water per day, which would allow spreading and infiltration of a continuous flow of 50 second-feet. The spreading works would consist of a series of ponds, created by earthen dikes and interconnected with culverts. Maximum depth of water in the ponds would be 5 feet, and 2 feet of freeboard would be provided.

The location of the two spreading grounds and of laterals thereto from the Piru-Las Posas Conduit are shown on Plate 42. The costs of the Dry Canyon spreading grounds and of the lateral from the Piru-Las Posas Conduit thereto were estimated to be $266,000 and $1,619,000, respectively, or a total of $1,885,000. The cost of the Happy Camp Canyon spreading grounds was estimated to be $129,400.

Geologic investigation indicated the desirability of spreading and infiltrating water in Simi Valley at a location in the vicinity of Tapo Canyon, further east than the considered spreading grounds. However, lack of head at the southerly portal of the Happy Camp Canyon Tunnel precluded conveyance of the supplemental water to Tapo Canyon, without provision for pumping.

It should be pointed out that prior to construction of spreading works at the considered site in the Simi Subunit, drilling should be undertaken to definitely ascertain its suitability. At the Happy Camp Canyon site, a refraction seismic survey conducted by the Division of Water Resources confirmed sparse geologic evidence that the Grimes Canyon member of the San Pedro formation outcropped in the alluvium, and that the site, therefore, was apparently suitable for spreading grounds from the geologic standpoint. It appears that percolation of water in the Grimes Canyon aquifer would also replenish the overlying Fox Canyon aquifer. Whether or not the rate of movement of ground water in the two aquifers would be sufficient to prevent a mound from building up beneath the Happy Camp spreading grounds, and thereby reducing the estimated spreading capacity could not be determined. If after a period of operation there were such an occurrence, construction of additional spreading grounds in the outcrop of the Fox Canyon aquifer to the west of Happy Camp Canyon would be required to equitably distribute the water throughout East and West Las Posas Basins. A similar condition could arise in the considered spreading grounds near Dry Canyon in the Simi Subunit.

It should be pointed out that artificial replenishment of the Fox anyon aquifer in East and West Las Posas Basins would also benefit Pleasant alley Basin in the Santa Clara River Hydrologic Unit. As was stated in Chapter I, it appears that there is hydraulic continuity in the aquifer between these asins, and that Pleasant Valley Basin presently receives a portion of its eplenishment by underflow from East and West Las Posas Basins through the Fox anyon aquifer.

Plans for Importation by Means of Feather River Project

As previously described, the State-wide Water Resources Investigation, proceeding under authorization of Chapter 1541, Statutes of 1947 and under direction of the State Water Resources Board, has as its objective the formulatic of The California Water Plan. The Feather River Project resulted from these State-wide studies, and was proposed as a feature of The California Water Plan. Under provisions of this project, supplemental water would be made available to meet the probable ultimate water requirements of Ventura County.

Features of the Feather River Project are described in detail in a publication of the State Water Resources Board entitled "Report on Feasibility of Feather River Project and Sacramento-San Joaquin Delta Diversion Projects Proposed as Features of The California Water Plan", dated May, 1951. These projects were authorized and adopted by the 1951 Legislature, in an act which authorized their construction, operation, and maintenance by the Water Project Authority of the State of California. Provision was made in the authorizing act for financing construction of the proposed works through issuance and sale of revenue bonds, and through receipt of contributions from other sources. In May, 1952, the Legislature provided $800,000 by budgetary appropriation to the Divisio of Water Resources for necessary investigations, surveys, and studies, and preparation of plans and specifications for the Feather River and Sacramento-San Joaquin Delta Diversion Projects. A similar appropriation in the amount of $750,000 was made in 1953.

There is presented in this section a summary description of the foregoing projects, the estimated costs thereof based on prices prevailing in 1951, and the provisions made therein for supplying supplemental water to Ventura County. It should be mentioned that continuing studies are being made of alternative designs and locations for project features, and as a result, works finally constructed may differ from those described herein.

The multipurpose Feather River Project contemplates construction of a gravity concrete dam, 710 feet in height above streambed, at a point on the Feather River 1.7 miles below the junction of the North and Middle Forks and 5.5 miles above the City of Oroville. The dam will have an overpour spillway. It will create a reservoir of 3,500,000 acre-foot storage capacity, and will provide a large measure of control of the runoff of the Feather River for purposes of conservation, flood control, hydroelectric power generation, and other beneficial uses. Provision will be made for a hydroelectric power plant located at the dam, of 440,000 kilowatt capacity, and for an afterbay dam, and power plant of 25,000 kilowatt capacity, located four miles downstream from the main dam. The project also includes construction of a power transmission line from the Oroville power plants to Bethany, near Tracy in San Joaquin County, and a switch yard at the terminal. A channel crossing of the Sacramento-San Joaquin Delta will be required to carry Oroville Reservoir releases from the Sacramento River to the San Joaquin River Delta, for subsequent transmission to water-deficient areas in other parts of California.

With Oroville Reservoir operated for flood control, and to supply water for all requirements in the Feather River Service Area and for prior rights in the Sacramento-San Joaquin Delta, sufficient releases could be made to supplement surplus waters in the Delta so as to permit a continuous diversion of about 3,900 second-feet from that area, or approximately 2,845,000 acre-feet per season. Under the plan proposed in the 1951 report for serving areas of deficiency, water would be diverted from the San Joaquin Delta at sea level, the point of diversion being on Old River about five miles northwest of Tracy. The water would be lifted to a canal at an elevation of 225 feet, which would parallel the Delta-Mendota Canal southerly to a point near the south line of Merced County, where a second pumping plant would lift the water to an elevation of 400 feet. The canal would then continue southerly approximately on grade contour along the we side of the San Joaquin Valley to the Buena Vista Hills, where another pumping plant would lift the water to an elevation of 500 feet. Four additional pumpin lifts, and a canal, would deliver the water at Pastoria Creek, three miles east of Grapevine at an elevation of 1,500 feet. At various points in the San Joaqu Valley, diversions would be made from the conduit to serve lands requiring supplemental water. A series of pumping lifts at Pastoria Creek would raise the wat to an elevation of 3,375 feet, and to the portal of the first of two tunnels th would convey the water through the Tehachapi Mountains to a point on the divide between the Santa Clara River Basin and Antelope Valley near Quail Lake. Near this point, releases from the conduit could be conveyed via a short tunnel to a tributary of Piru Creek, and thence to service areas in Ventura County. The mair conduit would continue southerly in a series of canals, tunnels, and siphons to its terminus at a tributary of the Tia Juana River in San Diego County at a distance of about 567 miles from the point of diversion in the San Joaquin Delta. E route it would serve supplemental water to lands in the Lahontan, Colorado Deser and South Coastal Areas. In connection with the delivery of water from the conduit, hydroelectric power could be developed at several points on the Pacific slope of southern California. Plate 39, entitled "Feather River Project," shows the location of Oroville Reservoir, and the general alignment of the San Joaquin Valley-Southern California Diversion conduit.

Detailed estimates of cost of the Feather River Project are included in the feasibility report, but are currently being revised. A summary of estima ed capital costs of the project, as presented in the 1951 report, is given in Table 106. The estimates of capital cost were based on prices prevailing in 1951, and included allowances of 10 per cent for administration and engineering, 15 per cent for contingencies, and 3 per cent for interest during one-half of the estimated construction period.

TABLE 106

SUMMARY OF ESTIMATED CAPITAL COSTS OF FEATHER RIVER PROJECT AND SACRAMENTO-SAN JOAQUIN DELTA DIVERSION PROJECTS

Oroville Dam and Reservoir	$ 342,626,000
Oroville Power Plant	64,509,000
Oroville Afterbay and Power Plant	14,146,000
Oroville Transmission Line and Terminal Switchyard	19,734,000
Delta Cross Channel	3,798,000
Santa Clara-Alamada Diversion	31,065,000
San Joaquin Valley-Southern California Diversion	794,509,000
TOTAL	$1,270,387,000

It was assumed in the cost analyses presented in the feasibility report that the Federal Government would contribute to the Feather River Project the sum of $50,000,000, without reimbursement, in the interest of flood control. Substantial flood control benefits to lands and communities along the Feather River would result from operation of the project. There is a well-established federal policy for such financial participation in projects of this character. It was also assumed that the State of California would contribute the sum of $86,926,000 for the acquisition of lands, easements, and rights of way, and for the relocation of utilities. This contribution would also be non-reimbursable. Such financial participation by the State would be justified under the policy set forth in the State Water Resources Act of 1945, as amended. If these federal and state contributions to the Feather River Project were forthcoming, capital costs shown in Table 106 would be reduced to $1,133,461,000.

Based on this estimated capital cost, it was further estimated with 1951 report that annual costs of the project would be about $108,775,000 with an assumed 2 per cent interest rate, and about $114,539,000 with an assumed 3 per cent interest rate. The annual costs included interest repayment, replacements, operation and maintenance, power charges, insurance, and general expense. In th cost analysis, it was shown that annual costs based upon the 2 per cent interest rate could be met under the schedule of revenues shown in the following tabulation, but that an annual deficit of some $1,898,000 would occur with the 3 per cent interest rate.

Item	Unit Charge	Annual Revenue
311,000 acre-feet of new water delivered to service area along Feather River	$ 1.00	$ 311,000
127,000 acre-feet to Santa Clara-Alameda Diversion	20.00	2,540,000
945,000 acre-feet to San Joaquin Valley	10.00	9,450,000
1,773,000 acre-feet to southern California	50.00	88,650,000
1,670,000,000 kilowatt-hours Terminal Substation	0.007	11,690,000
	Total	$112,641,000

Based on the foregoing assumptions, the estimated cost of water from the Feather River Project available for diversion to Ventura County from the San Joaquin Valley-Southern California Diversion Conduit would be about $50 per acre-foot.

The stated purpose of the Feather River Project is to furnish water as needed to supplement existing supplies. In the cases of both the San Joaquin Valley and southern California, it would provide supplemental rather than substitutional water for otherwise developed water supplies, including California's rights in and to the waters of the Colorado River in the amount of 5,362,000 acre-feet annually. In this connection, studies made as a part of the current State-wide Water Resources Investigation indicate that the probable ultimate supplemental water requirements of the San Joaquin Valley and southern California will be much larger than can be met by the Feather River Project as previously described. For this reason Oroville Reservoir is considered to be only an initial storage unit in The California Water Plan, and additional reservoirs and increased conduit capacities will be provided as the demands of an increasing population dictate.

The plan of utilizing the delta of the Sacramento and San Joaquin River as a point of diversion of surplus waters developed in northern California for export to areas of need has many practical advantages. The diversion point is below all riparian owners and users of water in the basin above the delta, and therefore is not subject to objection by such owners. The delta channels are recipient of all the flood flows and return waters from an area of about 50,000 square miles. The supply to the delta, therefore, is not dependent on the vagaries of a single stream. Water developed in any part of the Sacramento or San Joaquin River basins could find its way by gravity to the delta, and the same is true of surplus water that might be transferred from the North Coastal Area to the Sacramento River Basin.

Advantages of the planned conduit to the San Joaquin Valley and southern California are that it would traverse, in large part, undeveloped terrain, would not interfere with the operation of existing water supply systems, would not involve any exchange of waters, and would be located in a position to furnish by gravity from the conduit additional water supplies to existing systems, and to new areas capable of development and in need of water. It is feasible of construction from both engineering and geological standpoints, capable of development to serve supplemental water to meet the ultimate needs of the west and southern sides of the Upper San Joaquin Valley, the South Coastal Area including Ventura County, and the desert areas in Los Angeles, San Bernardino, and Riverside Counties.

Studies are being continued to select a final alignment and grade for San Joaquin Valley-Southern California Diversion Conduit, and also to determine the most feasible manner in which supplemental water from the project could be diverted for use in Ventura County. From the results of studies described in this bulletin, it was estimated that the probable ultimate requirement for imported water in Ventura County will be in the order of 200,000 acre-feet per season, which amount could be readily supplied from the San Joaquin Valley-Southern California Diversion Conduit when operated at ultimate capacity.

For illustrative purposes, there is shown on Plate 40 a possible profile, resulting from preliminary reconnaissance, for the foregoing diversion to Ventura County. The location of this diversion should be considered as tentative, and subject to considerable modification after studies currently underway have been completed. Commencing at a turn-out from the San Joaquin Valley-Southern California Diversion Conduit, at about an elevation of 3,325 feet in the upper end of the Antelope Valley near Quail Lake, water for diversion to Ventura County would discharge into a small regulating reservoir having a normal water surface elevation of about 3,324 feet. Discharge from the reservoir would be conveyed a distance of about 8,200 feet in a southerly direction in a canal. The canal would discharge into a tunnel about 21,500 feet in length through the Piru Mountains. From the outlet of the tunnel, the conduit would consist of about 2,000 lineal feet of reinforced concrete siphon, followed by a tunnel about 4,600 feet in length, which would discharge into the penstock of Power Plant No. 1, located near Highway 99 at an elevation of about 2,480 feet. About 800 feet of power drop would be available at this plant.

Discharge from Power Plant No. 1 would enter Canada de Los Alamos, a tributary of Piru Creek, and would follow that tributary and Piru Creek to a point about 17,400 feet downstream from their confluence. At this point the flow would be diverted to a tunnel about 11,200 feet in length, from which it would discharge into the penstock of Power Plant No. 2, located on Piru Creek about 2.6 miles upstream from the Ventura-Los Angeles County Line, at an elevation of about 1,885 feet. The power drop available at this plant would be about 370 feet.

Water from the afterbay of Power Plant No. 2 would be diverted to a tunnel about 13,900 feet in length, and thence into the penstock supplying Power Plant No. 3. This plant would be located on Piru Creek some 7.0 miles upstream from the Devil Canyon dam site, at an elevation of about 1,325 feet. Approximately 520 feet of power drop would be available at Power Plant No. 3.

Discharge from Power Plant No. 3 would enter Piru Creek and flow to terminal storage at Devil Canyon Reservoir. As previously described, this reservoir would have a storage capacity of about 150,000 acre-feet. Its normal water surface elevation would be about 1,265 feet. As an alternative to terminal regulation at Devil Canyon Reservoir, consideration was given to utilization of Blue Point Reservoir, constructed to a storage capacity of about 50,000 acre-feet for regulation of imported Feather River Project water.

Although the alignment for the diversion to Ventura County, as described, would be advantageous from the standpoint of developing hydroelectric power, revenue from the sale of which could be used in reducing costs of the imported water supply, further studies may show that construction of the several required tunnels of substantial length is unfeasible. If such should be the case, a gravity diversion to Ventura County, with a minimum of tunnel, could be effected from the foregoing regulating reservoir near Quail Lake. Discharge from the regulating reservoir would then largely follow the natural channels of Piru Creek and its tributaries to Devil Canyon Reservoir.

From Devil Canyon Reservoir, gravity service of the imported water could be provided most areas of need in the Calleguas-Conejo, Malibu, and Santa Clara River Hydrologic Units, and a substantial portion of those in the Ventura Hydrologic Unit. A diversion to the Calleguas-Conejo and Malibu Hydrologic Units could be effected through a conduit from Piru Creek to Happy Camp Canyon, similar to that described previously. It would also be possible to supply supplemental water through this system to that portion of the Malibu Creek drainage area within Los Angeles County, including the community of Malibu and adjacent resort areas. Gravity water service could also be provided to Santa Barbara County in the vicinity of Carpenteria.

Plans for Importation by Means of Metropolitan Water District of Southern California

A source of supplemental water for Ventura County is immediately vailable in the Colorado River through the facilities of the Metropolitan Water istrict of Southern California. Colorado River water is now imported to the outh Coastal Area by the Metropolitan Water District from Lake Havasu, an arti-icial reservoir on the Colorado River created by Parker Dam. The importation s made through an aqueduct about 242 miles in length to terminal storage in ake Mathews, about nine miles southerly of the City of Riverside. From Lake athews the imported water is distributed to many public water service agencies n Los Angeles, San Bernardino, Riverside, Orange, and San Diego Counties.

In lieu of immediate construction of local conservation works in entura County, consideration was given to the annexation of Ventura County to he Metropolitan Water District of Southern California for the purpose of btaining supplemental water to eliminate present water supply deficiencies and o provide for anticipated future water needs.

etropolitan Water District of Southern California

The Metropolitan Water District of Southern California was organized in 1928, after the State Legislature had passed an enabling act in 1927. In 1931, when bonds in the amount of $220,000,000 were voted for financing the Colorado River development, the District comprised 13 member cities, having a total assessed valuation of slightly less than $2,500,000,000. As of August 20, 1953, the assessed valuation was estimated to be $6,015,500,000, and the District comprised 13 member cities, six municipal water districts, and the San Diego County Water Authority. Actual construction on the Colorado River Aqueduct started in January, 1933. The first delivery of softened Colorado River water, from the softening and treatment plant located near La Verne, was made to the City of Pasadena in June, 1941.

The right of the Metropolitan Water District of Southern California to waters of the Colorado River, as determined under provisions of the Colorado River Compact, Boulder Canyon Project Act, and in accordance with the Seven-Party Water Agreement which was executed among interested California parties in August, 1931, is 1,112,000 acre-feet per annum, including the right of the San Diego County Water Authority of 112,000 acre-feet per annum. During 1952-53, about 162,000 acre-feet, or 14.6 per cent of the foregoing entitlement of the District to Colorado River water, were sold by the District.

Section 5-1/2 of the Metropolitan Water District Act provides as follows:

> "Each city, the area of which shall be a part of any district incorporated hereunder, shall have a preferential right to purchase from the district for distribution by such city, or any public utility therein empowered by said city for the purpose, for domestic and municipal uses within such city a portion of the water served by the district which shall, from time to time, bear the same ratio to all of the water supply of the district as the total accumulation of the amounts paid by such city to the district on tax assessments and otherwise, excepting purchase of water, toward the capital cost and operating expense of the district's works shall bear to the total payments received by the district on account of tax assessments and otherwise, excepting purchase of water, toward such capital cost and operating expense."

The preferential right of a member to available water, therefore, is proportional to the ratio of total tax payment actually made by that member to the total tax payments actually made by all members of the District. Thus, a newly annexed area would have an entitlement based only on the taxes actually paid to the District. However, entitlements so determined do not at the present time limit the quantities of water that may be obtained from the District, but would be effective when utilization of water by the District equals the ultimate capacity of Colorado River Aqueduct, if no other water supply is made available in the meantime.

Procedure for annexation of Ventura County to the Metropolitan Water District would include formation of a public district with appropriate powers nd embracing the entire County. If such a district were formed, the assessed valuation of the County would be used in estimating entitlements to water under the preferential right principle, and Ventura County's share in the Colorado River water supply would be determined thereby. In order to estimate the quantity of water to which Ventura County would be entitled, with the Colorado River Aqueduct operating at its ultimate capacity, the entire Colorado River supply in use, and disregarding losses, it was assumed the ratio of Ventura County's assessed valuation to that of the entire Metropolitan Water District, including that of Ventura County over a 40-year period commencing in 1929, would be proportional to the estimated 1953-54 ratio of $306,000,000 to $6,321,500,000. By multiplying the District's entitlement of 1,212,000 acre-feet per season of Colorado River water by this ratio, it was indicated that Ventura County would be entitled to a water supply of about 59,000 acre-feet per season under the stated conditions.

It is apparent that the foregoing supplemental water supply would be inadequate to meet present requirements in Ventura County. However, in this regard, the following statement of policy by the Metropolitan Water District's Board of Directors on December 16, 1952, is considered pertinent:

> "The Metropolitan Water District of Southern California is prepared, with its existing governmental powers and its present and projected distribution facilities, to provide its service area with adequate supplies of water to meet expanding and increasing needs in the years ahead. The district now is providing its service area with a supplemental water supply from the Colorado River. When and as additional water resources are required to meet increasing needs for domestic, industrial, and municipal water, the Metropolitan Water District of Southern California will be prepared to deliver such supplies.
>
> "Taxpayers and water users residing within The Metropolitan Water District of Southern California already have obligated themselves for the construction of an aqueduct supply and distribution system involving a cost in excess of $350,000,000. This system has been designed and constructed in a manner that permits orderly and economic extensions and enlargements to deliver the district's full share of Colorado River water as well as water from other sources as required in the years

ahead. Establishment of overlapping and paralleling governmental authorities and water distribution facilities to service Southern California areas would place a wasteful and unnecessary financial burden upon all the people of California, and particularly the residents of Southern California."

This policy statement may be interpreted in light of recent developments relating to importation of supplemental water to southern California, which have been described hereinbefore under the section entitled "Plans for Importation by Means of Feather River Project".

Untreated Colorado River water, which has been considered for importation to Ventura County, is of acceptable mineral quality for irrigation use. Total mineral solubles in the supply delivered to the Metropolitan Water District's system have averaged between 750 and 800 parts per million during the past five years. The water has a low concentration of boron, and a moderate percentage of sodium ion. However, the concentrations of total mineral solubles are such that some soil types to which the water might be applied would require adequate leaching to prevent excessive accumulation of minerals. For domestic use, Colorado River water would require chlorination, as do practically all raw waters. Softening treatment would enhance its suitability for such use. A typical analysis for constituent characteristics of Colorado River water, related to its domestic use, is presented in the following tabulation:

Total hardness, as parts per million of $CaCO_3$	334
Non-carbonate hardness, as parts per million of $CaCO_3$	215
Alkalinity, as parts per million of $CaCO_3$	119
Magnesium, as parts per million	30
pH	8.3

As a matter of interest, it may be noted that the mineral quality of Colorado River water compares favorably with that of local supplies throughout Ventura County.

onveyance of Imported Water to Ventura County

Discussion with engineers of the Metropolitan Water District has indi-ated that the nearest source of Colorado River water for Ventura County would e a take-off point on a conduit currently being considered for construction rom Lake Mathews to Orange County, designated the "Lower Orange County Feeder". lthough final alignment of this conduit has not been fixed, for cost estimating urposes it was assumed that it would follow the general alignment shown on late 25, and that the take-off for Ventura County would be in Walnut Canyon bout 10 miles southeast of the City of Fullerton.

The assumed elevation of Lower Orange County Feeder at the take-off or Ventura County was taken as 940 feet. From this initial point, preliminary onsideration was given to three possible conduit routes to Ventura County. hese routes were as follows: (1) westerly to the coast, and thence northerly long U. S. Highway 101 Alternate to the coastal plain of the Santa Clara River alley; (2) northwesterly to the vicinity of Glendale, and thence along U. S. ighway 101 to Conejo Valley; and (3) northwesterly to the vicinity of Glendale, nd thence across San Fernando Valley to Chatsworth and to Simi Valley. It was etermined that gravity supply could be obtained at the Oxnard Plain utilizing he first of the foregoing routes. The second and third routes considered would equire pumping. The third route, in addition to the pumping installations, ould require a tunnel through the Santa Susana Mountains into Simi Valley. econnaissance type estimates of cost indicated that to reach a common terminal torage site in Ventura County, which would be required to obtain maximum tility of such a conduit, there would be little difference in cost of the three outes. However, the third route would be the most favorable from the standpoint f distribution of water in the Calleguas-Conejo Hydrologic Unit. This latter oute, therefore, was chosen to illustrate the costs of delivering Colorado River water for use in Ventura County. The conduit for conveying Colorado River water to Ventura County is hereinafter referred to as the Ventura County Aqueduct.

Preliminary estimates of cost were prepared for conduits with capacities of 25, 50, 75, 100, and 150 second-feet, respectively. Commencing at the aforementioned point on the proposed Lower Orange County Feeder, at an elevation of 940 feet, the Ventura County Aqueduct would extend generally in a northwesterly direction, a distance of about 438,800 feet or about 83 miles, to terminal storage at the Conejo reservoir site on Conejo Creek. It would include about 15,200 lineal feet of tunnel through the Santa Susana Mountains at an elevation of 1,077 feet.

From the take-off, the line would extend northwesterly down Walnut Canyon, and would cross beneath the Santa Ana River bed at station mile 3. From the river, it would extend northwesterly through the town of Yorba Linda and pass northeast of the town of Brea, to Whittier Boulevard at station mile 13. From this point the aqueduct would parallel Whittier Boulevard, passing through the City of Whittier, and crossing the San Gabriel River at station mile 24. At station mile 25, it would turn northerly to Beverly Boulevard, and then proceed westerly along that boulevard, crossing the Rio Hondo at station mile 26. At station mile 28 the aqueduct would leave Beverly Boulevard and extend northwesterly through the City of Los Angeles, crossing the Arroyo Seco at station mile 36.

From the Arroyo Seco, it would follow the alignment of San Fernando Road through Glendale to station mile 42, where it would turn westerly, following the left bank of the Los Angeles River to station mile 45. At this point, the aqueduct would turn northwesterly and pass through the City of Burbank, to Burbank Boulevard at station mile 48, and then continue westerly along the alignment of Burbank Boulevard, passing beneath the improved channel of Tujunga Wash at station mile 50, to Fulton Avenue at station mile 52.

From the intersection of Fulton Avenue and Burbank Boulevard, the onduit would extend northerly to station mile 52, where Pumping Plant No. 1 ould be located. From this plant, the aqueduct would continue northerly to oscoe Boulevard at station mile 55. From the intersection of Fulton Avenue and oscoe Boulevard, it would extend westerly along Roscoe Boulevard to station ile 66, where Pumping Plant No. 2 would be located, at a site about one mile outh of Chatsworth Reservoir. From this plant, the conduit would continue esterly along Roscoe Boulevard to station mile 67, where it would turn north-esterly at Dayton Canyon, following the North Fork of Dayton Canyon to the outheasterly portal of the aforementioned Santa Susana Tunnel at station mile 68.

The northwesterly portal of the Santa Susana Tunnel would be on the outherly side of Simi Valley, about 1.5 miles southeast of the town of Santa usana. From this portal, the aqueduct would extend westerly along the south ide of Simi Valley to station mile 77, where a take-off for the Oak Canyon Ter-inal Reservoir would be located. Continuing westerly, the conduit would cross saddle between the Calleguas and Conejo Creek drainage areas at an elevation of bout 980 feet, and would terminate at a tributary of the North Fork of Conejo reek at about station mile 83. From this point, water discharged from the aque-uct would follow the natural watercourse to terminal storage at Conejo Reservoir. he proposed Conejo Dam would be at station mile 86.

For illustrative purposes, there are described herein design features or a Ventura County Aqueduct having a discharge capacity of 150 second-feet. late 41, entitled "Profile of Proposed Ventura County Aqueduct to Connect with ystem of Metropolitan Water District of Southern California - Capacity 150 Second-eet" shows a profile of this conduit from Walnut Canyon to Conejo Reservoir. esign features of the other conduit capacities considered would be similar in ll respects except size. The conduit with discharge capacity of 150 second-feet ould comprise about 414,800 lineal feet of 72-inch diameter, about 5,000 lineal feet of 42-inch diameter, and about 3,800 lineal feet of 36-inch diameter lock joint concrete cylinder pipe. The 72-inch diameter pipe would extend from the take-off at Walnut Canyon to the saddle between the Calleguas and Conejo Creek drainage areas, from which point the smaller size pipes would be installed to dissipate pressure head prior to discharging into the natural watercourse. Velocity in the 72-inch diameter pipe would be about 5.3 feet per second, and the slope of the hydraulic grade line would be about 0.001. Maximum pressure head in the conduit would be about 600 feet at a point near the San Gabriel River crossing.

Releases to the Ventura County Aqueduct from the Lower Orange County Feeder would be effected by a bifurcation structure with gate valve regulation. Throughout its length, the conduit would be buried with a minimum cover of 4 feet. At major unimproved stream crossings, the conduit would have a cover of 20 feet and would be encased in concrete. Automatic air release valves would be installed at all high points, with automatic blowoff valves at low points where release would discharge to a stream channel. The Santa Susana Tunnel would have a horseshoe section, 7 feet in diameter, and would be concrete lined throughout. The slope of the tunnel invert would be 0.0009, and water therein would flow under gravity at a depth of 5.7 feet.

The two pumping plants required on the main conduit would have identical facilities. Inflow to the plants would be from a small regulating reservoir on the line, installed to maintain a constant discharge and head. Each plant would be equipped with five pumping units in parallel connection. Two of the units would have capacities of 25 second-feet, and the remaining three units would have capacities of 50 second-feet. One of the larger pumping units would be used for standby purposes. Each 25 second-foot capacity unit would consist of two pumps connected in series, each equipped with a 450 horsepower motor. Each of the larger units would similarly be equipped with two pumps in series driven by 900 horsepower motors. The pumping lift at each of the plants would be about 225 feet.

The take-off for the Oak Canyon Terminal reservoir at station mile 77 would be effected by a bifurcation structure in the main conduit. The Oak Canyon lateral would be a 42-inch diameter reinforced concrete pipe about 4,000 feet in length, and would have a capacity of 40 second-feet. Pumping Plant No. 3 would be located on the right abutment of Oak Canyon Dam described hereinafter. A maximum lift of 90 feet would be required on the lateral with Oak Canyon Terminal Reservoir full. Pumping Plant No. 3 would be equipped with two 20 second-foot capacity pumps driven by a 300 horsepower motor.

Terminal Storage

In order to obtain the maximum utility from the Ventura County Aqueduct and to provide the peaking capacity within Ventura County, construction of two terminal storage reservoirs was considered. For illustrative purposes, reservoirs that would be required for regulation of the conduit with a capacity of 150 second-feet are described herein.

A dam, and reservoir with capacity of 7,500 acre-feet, would be constructed at the Oak Canyon site to regulate the 40 second-foot diversion from the main conduit. This water surface elevation at the spillway lip would be 1,100 feet. Water from this reservoir would be distributed in the Calleguas-Conejo Hydrologic Unit. The Oak Canyon Dam would be an earthfill structure with an impervious core and upstream and downstream sections of random fill. The dam would be 170 feet in height from stream bed to spillway lip, with upstream and downstream slopes of 2.5:1. The volume of fill would be about 1,587,000 cubic yards. The spillway would be across the right abutment, and would have a discharge capacity of 2,000 second-feet. Releases from the reservoir would be effected by means of a concrete outlet tower. A topographic map of the dam site was prepared at a scale of one inch equals 100 feet, with a contour interval of 10 feet, by the Division of Water Resources in 1953. Areas and capacities of the reservoir for various stages of water surface elevation were determined from available U.S.G.S. quadrangles with a 40-foot contour interval.

Conejo Terminal Reservoir would provide terminal regulation and water service to the Oxnard Plain and Pleasant Valley Subunits and the Ventura Hydrologic Unit. The dam would be located on Conejo Creek near the boundary between the Santa Rosa and Conejo Subunits, and would create a reservoir with storage capacity of 20,000 acre-feet. The water surface elevation at the spillway lip would be 360 feet. The dam would be an earthfill structure with an impervious core and upstream and downstream sections of random fill. The dam would be 130 feet in height from stream bed to spillway lip, with 2.5:1 upstream and downstream slopes. The volume of fill would be about 1,655,000 cubic yards. A spillway would be across the right abutment and would have a discharge capacity of 6,000 second-feet. Releases from the reservoir would be effected by means of a concrete outlet tower. A topographic map of the dam site was prepared at a scale of one inch equals 100 feet, with a contour interval of 10 feet, by the Division of Water Resources in 1953. Areas and capacities of the reservoir for various stages of water surface elevation were determined from U.S.G.S. quadrangles with a 40-foot contour interval.

Distribution of Colorado River Water in Ventura County

From the Conejo Terminal Reservoir, Colorado River water could be delivered by gravity to the Oxnard Plain and Pleasant Valley Subunits, to the City of Ventura, and to the Santa Rosa Subunit. It was assumed that water supplies for the Conejo Subunit and for the Malibu Hydrologic Unit would be met initially from the main aqueduct. Water from the main aqueduct could also be served in the Tierra Rejada Subunit. Estimates were not made of works required for providing such service. The Oak Canyon Terminal Reservoir would be utilized to supply Colorado River water to all of the Calleguas-Conejo Hydrologic Unit except the Santa Rosa, Tierra Rejada, and Conejo Subunits.

As has been stated, the Oak Canyon Terminal Reservoir would regulate a continuous inflow of 40 second-feet of water from the Oak Canyon lateral, equal to a seasonal supply of about 29,000 acre-feet. It was estimated that reservoir evaporation losses would approximate 300 acre-feet per season, leaving about 28,700 acre-feet of water per season for use in the service area of the reservoir. Because of uncertainties attendant upon the development of presently undeveloped lands in the service area, conduits from the reservoir were designed to distribute this seasonal supply to strategic points in each subunit.

Deliveries to the East and West Las Posas and Simi Subunits would be effected through 42-inch diameter centrifugally spun reinforced concrete cylinder pipe, extending northerly from the reservoir to Los Angeles Avenue, where a wye would be located. From the wye, one lateral would extend westerly to the East and West Las Posas Subunits and the other easterly to the Simi Subunit. The Simi lateral would consist of about 27,000 lineal feet of reinforced concrete cylinder pipe, 30 inches in diameter, and would terminate in a regulating reservoir of 25 acre-feet storage capacity near Santa Susana. The Las Posas lateral would consist of 28,600 lineal feet of 42-inch diameter, 33,000 lineal feet of 36-inch diameter, 14,500 lineal feet of 30-inch diameter, 18,700 lineal feet of 18-inch diameter, and 2,400 lineal feet of 12-inch diameter reinforced concrete cylinder pipe. It would terminate in a regulating reservoir with storage capacity of 75 acre-feet. It was estimated that the Simi and Las Posas laterals would deliver seasonal supplies of 7,000 acre-feet and 21,700 acre-feet, respectively. It was assumed that lands lying above the laterals and requiring supplemental water would be served by pumping.

As stated, it was assumed that Colorado River water for the Conejo Subunit and the Malibu Hydrologic Unit would be taken initially from the main Ventura County Aqueduct. To this end a bifurcation structure would be placed in the aqueduct at a point about 9,000 feet from its terminus, and releases would be made into a 30-inch diameter reinforced concrete cylinder pipe, 3,100 feet in length. This line would terminate in a regulatory reservoir of 80 acre-foot storage capacity northeasterly of Newbury Park. From this reservoir, a reinforced concrete cylinder pipe 36 inches in diameter and 14,100 feet in length, would extend southeasterly toward Newbury Park. At this point, a wye would be located, and laterals would extend westerly and easterly, respectively, therefrom. The westerly trending lateral would consist of 27,900 lineal feet of 18-inch diameter and 4,000 lineal feet of 12-inch diameter reinforced concrete cylinder pipe, and would terminate in a regulating reservoir having a storage capacity of 55 acre-feet. The easterly trending lateral would be about 19,400 feet in length, and would terminate in a regulating reservoir of about 35 acre-feet storage capacity, located just below the saddle separating the Malibu drainage area from that of Conejo Creek. Thus, water service could be provided therefrom to lands in the Malibu Hydrologic Unit. The lateral would be a reinforced concrete cylinder pipe including 7,000 lineal feet of 24-inch diameter pipe and 12,400 lineal feet of 18-inch diameter pipe. It was estimated that about 4,300 acre-feet and 2,900 acre-feet of water per season would be delivered from the westerly and easterly laterals, respectively.

Estimates of cost were made for delivery of Colorado River water from the Conejo Terminal Reservoir to Oxnard Reservoir, which water would then be utilized in the Oxnard Plain and Pleasant Valley Subunits as described in connection with plans for local conservation development. The conduit from Conejo Terminal Reservoir to Oxnard Reservoir would be lock joint reinforced concrete cylinder pipe, with a capacity of 150 second-feet. It would consist of about 73,200 lineal feet of 66-inch diameter pipe, and would deliver about 45,000 acre-feet of water per season to the Oxnard Plain and Pleasant Valley Subunits and 10,000 acre-feet per season to the Ventura Hydrologic Unit. It was assumed that water service for the cities of Oxnard and Port Hueneme would be provided from the well fields in Oxnard Forebay Basin as previously described.

This ground water draft could be replenished by Colorado River water if a lateral were provided from the conduit to the Saticoy spreading grounds. Service of Colorado River water to the City of Ventura and the Ventura Hydrologic Unit would be provided by a pipe line about 37,000 feet in length extending from a bifurcation structure in the conduit at Oxnard Reservoir. This line would terminate in a reservoir with storage capacity of 25 acre-feet at an elevation of 140 feet, located in the southeasterly portion of the City of Ventura. The line would consist of lock joint concrete cylinder pipe, 36 inches in diameter, and would have a capacity of 25 second-feet. It was estimated that the line would be capable of delivering about 10,000 acre-feet of water per season to the Ventura Hydrologic Unit. Pumping would be required if Colorado River water were to be utilized in the Upper Ojai, Ojai, or Upper Ventura River Subunits, and also in portions of the City of Ventura. Chlorination, and possible softening would be required for water used for industrial and domestic purposes.

Estimates of Cost

Estimates of capital and annual costs for importation and distribution of Colorado River water in Ventura County are presented in this section. The estimates, while preliminary in nature, include all anticipated expenses in connection with construction and operation of the facilities considered. Scope of the studies, however, was limited to facilities for delivery of the supplemental water supply to a strategic location in each of the four hydrologic units, and the estimates do not include costs of final distribution of water to individual users. However, the system described in connection with plans for local conservation development could be utilized for distributing Colorado River water in the Oxnard Plain Subunit. The estimates do not include costs for any required treatment of the portion of the water that would be used for domestic or municipal uses.

Capital costs for the Ventura County Aqueduct, terminal reservoirs, and distribution system were estimated from quantities determined from preliminary designs, and from unit prices of construction items taken from recent bid data for projects similar to those in question or from manufacturers' cost lists. Allowance was made in the estimates for acquisition of necessary lands, easements, and rights of way. It was assumed that easements would be obtained gratis within existing public right of way. It was estimated that construction of the aqueduct would require four years, and interest on the capital cost of construction items at a rate of 4 per cent over one-half of this construction period, was included in the cost estimates. Allowances in the amount of 10 per cent of construction costs for engineering and administration, and 15 per cent for contingencies were also included. In addition, officials of the Metropolitan Water District estimated that were a conduit with capacity of 100 second-feet to be constructed for Ventura County, an additional cost of $2,000,000 would be required for enlargement of the proposed Lower Orange County Feeder from Lake Matthews to the Walnut Canyon take-off to accommodate the required increased capacity. Allowances in the costs estimates for increasing the size of the Lower Orange County Feeder for capacities of the Ventura County Aqueduct other than the foregoing 100 second-feet were taken as proportional to the ratio of capacities.

The Metropolitan Water District of Southern California currently charges $10 per acre-foot for untreated Colorado River water. Public agencies annexing to the District are also required to pay their share of the capital costs of the Metropolitan Water District system. Annual payments beginning in the fiscal year 1929-30 are assessed for this purpose, based upon the assessed valuation of the area seeking admission. Four per cent simple interest is charged on these back taxes, and the total amount due may be paid by annual amortization payments on a 4 per cent interest basis over a 30-year period. In addition to back payments, current taxes must be paid annually. For purposes of cost analysis, it was assumed that Ventura County would annex to the Metropolitan Water District during the fiscal year 1953-54, and that the first taxes would be assessed during the fiscal year 1954-55. From the current rate of increase in assessed valuation of the County, it was estimated that the assessed valuation therein would be $306,000,000 in the fiscal year 1953-54, and $329,000,000 in the fiscal year 1954-55. It was also assumed that the tax rate of the Metropolitan Water District for 1953-54, of 0.25 per $100 of assessed valuation, would prevail in 1954-55. Based on these assumptions, it was estimated that back taxes, together with interest, payable by Ventura County would be about $15,570,000, which, if amortized over the 30-year period at 4 per cent, would result in annual payments of about $900,000. This includes the tax payment during the first year which would be about $822,000. Presented in Table 107 is a yearly summary of back taxes and interest that would be payable by Ventura County to the Metropolitan Water District of Southern California, if annexation were made during the fiscal year 1953-54.

TABLE 107

ESTIMATED BACK TAXES AND INTEREST PAYABLE
BY VENTURA COUNTY IF ANNEXED TO
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
BETWEEN DECEMBER 1, 1953 AND DECEMBER 1, 1954

Fiscal year	Assessed valuation	Tax rate levied per $100 by Metropolitan Water District	Interest rate	Tax	Interest at 4 per cent	Total payment
1929-30	$106,619,530	$0.04	.9994301	$ 42,650	$ 42,630	$ 85,2[illegible]
1930-31	108,330,350	.03	.9594301	32,500	31,180	63,6[illegible]
1931-32	107,906,370	.03	.9194301	32,370	29,760	62,1[illegible]
1932-33	83,367,180	.04	.8794301	33,350	29,330	62,6[illegible]
1933-34	76,817,450	.04	.8394301	30,730	25,800	56,5[illegible]
1934-35	76,618,310	.10	.7994301	76,620	61,250	137,8[illegible]
1935-36	82,715,200	.20	.7594301	165,430	125,630	291,0[illegible]
1936-37	85,450,010	.37	.7194301	316,170	227,460	543,6[illegible]
1937-38	96,930,330	.40	.6794301	387,720	263,430	651,1[illegible]
1938-39	94,096,290	.40	.6394301	376,390	240,680	617,0[illegible]
1939-40	96,512,720	.42	.5994301	405,350	242,980	648,3[illegible]
1940-41	98,324,780	.49	.5594301	481,790	269,530	751,3[illegible]
1941-42	100,452,480	.48	.5194301	482,170	250,450	732,6[illegible]
1942-43	104,977,410	.48	.4794301	503,890	241,580	745,4[illegible]
1943-44	111,066,070	.48	.4394301	533,120	234,270	767,3[illegible]
1944-45	123,654,720	.48	.3994301	593,540	237,080	830,6[illegible]
1945-46	135,536,120	.50	.3594301	677,680	243,580	921,2[illegible]
1946-47	144,515,160	.48	.3194301	693,670	221,580	915,2[illegible]
1947-48	160,209,280	.35	.2794301	560,730	156,680	717,4[illegible]
1948-49	189,539,050	.34	.2394301	644,430	154,300	798,7[illegible]
1949-50	228,724,090	.34	.1994301	777,660	155,090	932,7[illegible]
1950-51	241,826,230	.31	.1594301	749,660	119,520	869,1[illegible]
1951-52	257,003,000	.30	.1194301	771,010	92,080	863,0[illegible]
1952-53	283,230,490	.29	.0794301	821,370	65,240	886,6[illegible]
1953-54	306,000,000*	.25*	.0394301	765,000	30,160	795,1[illegible]
1954-55	329,000,000*	.25*	.0018411	822,500	1,510	824,0[illegible]
TOTALS				$11,777,500	$3,792,780	$15,570,2[illegible]

Annual amortization payment, 30 years, 4 per cent interest	$900,4[illegible]

* Estimated

Estimates of annual costs also included interest on and amortization (the capital investment, and electrical power charges for pumping. The charges ›r electrical energy were in accordance with schedual PAP-2 of the Southern ılifornia Edison Company, which was effective on September 1, 1946.

Presented in Table 108 is a summary of the estimated costs of the pro- ›sed Ventura County Aqueduct with five alternative discharge capacities. Costs ıown in Table 108 do not include costs of distrubuting Colorado River water rom the terminal reservoirs to strategic points within the county. Such costs ere only estimated for a Ventura County Aqueduct with discharge capacity of 150 econd-feet. Estimates of initial capital and annual distribution costs for this ize of aqueduct are summarized in Table 109.

TABLE 108

SUMMARY OF ESTIMATED COSTS OF VENTURA COUNTY AQUEDUCT
TO CONNECT WITH SYSTEM OF METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Item	Capacity of aqueduct, in second feet, and delivered water supply, in acre-feet per season				
	25	50	75	100	150
	18,000	36,000	54,000	72,000	108,000
CAPITAL COSTS					
Proportionate cost of Lower Orange County Feeder	$ 500,000	$ 1,000,000	$ 1,500,000	$ 2,000,000	$ 3,000,000
Ventura County Aqueduct	16,427,000	26,614,000	30,912,000	35,611,000	46,370,000
Oak Canyon Lateral	---	---	200,000	200,000	200,000
Conejo Regulating Reservoir	2,966,000	2,966,000	2,966,000	2,966,000	2,966,000
Oak Canyon Regulating Reservoir	---	---	1,460,000	1,460,000	1,460,000
TOTALS	$19,893,000	$30,580,000	$37,038,000	$42,237,000	$53,996,000
ANNUAL COSTS					
Payments to Metropolitan Water District					
Cost of water	$ 180,000	$ 360,000	$ 540,000	$ 720,000	$1,080,000
Back taxes and interest	900,000	900,000	900,000	900,000	900,000
Current taxes	823,000	823,000	823,000	823,000	823,000
Interest on capital investment	796,000	1,223,000	1,482,000	1,690,000	2,160,000
Amortization of capital investment	209,000	322,000	390,000	444,000	568,000
Energy charges	114,000	225,000	375,000	463,000	610,000
Operation and maintenance	50,000	77,000	93,000	106,000	135,000
TOTALS	$3,072,000	$3,930,000	$4,603,000	$5,146,000	$6,276,000
AVERAGE ANNUAL COST OF WATER DELIVERED TO VENTURA COUNTY, PER ACRE-FOOT	171	109	85	71	58

TABLE 109

SUMMARY OF ESTIMATED INITIAL COSTS OF DISTRIBUTING COLORADO RIVER WATER WITHIN VENTURA COUNTY, WITH VENTURA COUNTY AQUEDUCT OF 150 SECOND-FOOT CAPACITY

Item	Estimated Costs	
	Capital	Annual
Calleguas-Conejo Distribution System	$ 4,800,000	$ 257,000
Oxnard- City of Ventura Conduit	5,868,000	311,000
Oxnard Plain-Pleasant Valley Distribution System	3,038,000	169,000
TOTALS	$ 13,706,000	$ 737,000

Discussion of Alternative Initial Plans for Water Supply Development

Presented in this section is a discussion of possible alternative initial plans for water supply development in Ventura County, as related to their accomplishments, and to their feasibility for immediate construction, financing, and operation by local interests. It has been shown that immediate sources of supplemental water include local conservation developments, both surface and underground, and the Colorado River through facilities of the Metropolitan Water District of Southern California.

In the future, a water supply sufficient to satisfy the portion of forecast ultimate requirements in excess of the probable maximum supply that could be developed locally in the County, will be available from the Feather River Project. Supplemental water available from this project should not be considered as competitive or substitutional to either potential local conservation developments or to the imported supply that might be obtained from the Metropolitan Water District. The cost of supplemental water from the Feather River Project, which on the basis of preliminary designs and financial analyses was estimated in 1951 to be $50 an acre-foot delivered to southern California, might be used as a guide in establishing the limit to which water resources of Ventura County should be developed. However, this should not be taken as a rigid criterion for limiting local development. Provision for a supplemental water supply for Ventura County is a matter of immediate concern, whereas the timing of financing and constructing the Feather River Project is as yet undetermined.

The selection of an initial plan of water resources development for Ventura County and of the component features thereof was based on consideration of the following factors: (1) Present and forecast future supplemental water requirements of the County; (2) the amount of new water that would be developed under a given plan or feature thereof, relative to that under alternative plans;

3) the capital cost of a given plan relative to that of alternative plans; (4) he annual cost of net safe yield that would be developed under a given plan elative to that under alternative plans; (5) the annual cost of incremental et safe yield that would be developed from various sizes of a given plan or omponent feature thereof; and (6) the limit of bonding capacity of the County or water resources development.

In regard to the latter factor, it has been estimated that the present onding capacity of Ventura County for financing water resources development oes not exceed $50,000,000. From a practical standpoint, it may be that bonds n this amount could not be marketed at reasonable interest rates. This latter onsideration is therefore an important factor in selecting an initial plan for he development of the water resources of the County.

There is presented in Appendix D a discussion of organizational and inancial aspects attendant upon plans for providing supplemental water for entura County. As described in this appendix, it appears that under the existing political structure in the County, the Ventura Hydrologic Unit is the nly unit with the financial capacity to develop supplemental water in an amount ufficient to satisfy its present water supply deficiency. It is believed that nly through the formation of a single county-wide water agency, organized with ppropriate powers, can a sound comprehensive program of water resources development be financed. It is considered that such an agency is necessary not only o undertake the development of local water resources, but also to obtain imported water from either the Colorado River Aqueduct or the Feather River Project.

Were such a county-wide water district to be formed in Ventura County, ts function would be to finance, construct, and operate major projects, and to xecute water service contracts with subordinate districts. The existing Ventura Municipal Water District, and United Water Conservation District, with possible modification of the powers of the latter agency, could convey and distribute water within their respective areas. A similar district would necessarily have to be formed in the Calleguas-Conejo and Malibu Hydrologic Units. In some areas of the County, distribution of water to individual users might be undertaken by improvement districts which would be formed for this purpose.

A direct benefit would inure to all of Ventura County through the formation of a county-wide water district, as a result of broadening of the tax base of the constructing agency, and corresponding enhancement of the financial capacity thereof. With a broader tax base, it would appear that more favorable interest rates could be obtained on bond issues for water resources development. Furthermore, increased flexibility in utilization of developed water supplies would be possible as the needs of the various hydrologic units demanded. In the Ventura Hydrologic Unit, it is indicated that supplemental water in excess of the immediate requirements could feasibly be developed. From an engineering standpoint, it has been demonstrated that it would be possible to divert a portion of this surplus for interim use in the Oxnard Plain Subunit. With construction of a reservoir at the Casitas site by a county-wide agency, this surplus could be temporarily contracted and sold to users in the water deficient coastal plain of the Santa Clara River Valley, thereby relieving tax payers of the Ventura Hydrologic Unit of the burden of paying for water not presently needed.

It has been demonstrated that costs of water available to Ventura County through the construction of potential surface storage developments, or by importation through facilities of the Metropolitan Water District of Southern California are quite expensive, both in capital cost of construction of required works and in unit cost of water made available. It has also been shown that the least expensive source of supplemental water available to Ventura County is extant in presently undeveloped ground water storage, but that development f this source is limited by possible interference with the rights of overlying round water users.

Surface storage developments considered varied in capital cost from bout $4,000,000 to $44,000,000, with developed net safe yields varying from a inimum of about 2,500 acre-feet per season to about 27,000 acre-feet per season. Average annual unit cost of net safe yield varied from a minimum of about 30 per acre-foot to in excess of $150 per acre-foot at the reservoir. The more easible of the developments studied would vary in capital cost from about 8,000,000 to about $15,000,000, with net safe yields varying from about 12,000 o 22,000 acre-feet per season. Average annual unit cost of net safe yield that ould be made available by construction of the more favorable developments ranged rom $30 to $50 per acre-foot.

For comparative purposes, there is presented in Table 110 a recapiulation of yields of water that would be developed by construction of the sevral storage capacities considered at each of the ten dam and reservoir sites tudied in Ventura County. Presented in Table 111 is an economic comparison f potential Ventura County reservoirs. The estimated costs are based on an ssumed 4 per cent interest rate. The estimates do not include costs of disribution facilities, and the unit costs of new water shown are indicative of uch costs at the reservoirs. Certain of the relationships shown in Table 111 re depicted graphically on Plates 35, 36, and 37.

TABLE 110

YIELDS OF POTENTIAL VENTURA COUNTY RESERVOIRS

Reservoir	Storage capacity, in acre-feet		Net safe seasonal yield (in acre-feet)				
				Santa Clara River			
				Uniform release operation		Rapid release operation	
	Gross	Net	Ventura River	Available to Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits, with releases for maintenance of ground water levels	Available to Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits, without releases for maintenance of ground water levels	Available within Santa Clara River Hydrologic Unit	Available to Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits
Coyote Creek							
Casitas (with 200 second-foot diversion)	92,000	90,000	14,000				
	105,000	103,000	15,600				
	130,000	128,000	18,600				
	156,000	154,000	21,900				
Santa Paula Creek							
Ferndale	12,000	10,000		2,500	4,000	2,500	2,000
	24,000	22,000		4,900	6,500	4,900	3,000
	34,000	32,000		6,600	8,500	6,700	4,200
Sespe Creek							
Cold Spring	35,000	32,000		5,000	5,500	5,100	3,500
	43,000	40,000		6,500	7,000	6,600	4,200
	77,000	74,000		10,500	11,800	11,600	6,600
	100,000	97,000		12,000	13,800	12,200	8,800
Topatopa	50,000	42,000		8,000	8,400	8,100	6,000
	75,000	67,000		12,400	12,900	12,500	9,000
	100,000	92,000		16,500	17,000	16,700	12,000
Hammel	25,000	13,000		4,000	5,800	4,100	3,000
	50,000	38,000		9,500	11,300	9,600	8,000
Fillmore	64,000	52,000		12,500	15,000	12,700	10,500
	98,000	86,000		20,000	24,000	20,300	13,500
	148,000	136,000		27,000	32,000	27,500	16,000
Piru Creek							
Upper Blue Point	50,000	38,000		6,500	9,300	6,700	4,500
Blue Point	50,000	38,000		6,500	9,300	6,700	4,500
Devil Canyon	100,000	87,000		15,000	19,000	15,500	10,500
	150,000	137,000		22,000	27,000	22,700	15,000
	150,000*	137,000		33,400	38,100	---	---
Santa Felicia	50,000	36,000		6,600	9,500	6,800	4,600
	75,000	61,000		11,000	14,300	11,300	7,500
	100,000	86,000		15,000	19,000	15,500	10,500

*With 80 second-foot capacity Piru-Las Posas Diversion. Indicated yields include average seasonal export of 20,100 acre-feet to

TABLE III

ECONOMIC COMPARISON OF POTENTIAL VENTURA COUNTY RESERVOIRS

Reservoir	Storage capacity, in acre-feet		Net safe[a] seasonal yield, in acre-feet	Capital cost			Average annual cost		
	Gross	Net		Total	Per acre-foot of gross storage capacity	Per acre-foot of yield	Total	Per acre-foot of net safe yield	Per acre-foot of incremental net safe yield
Coyote Creek									
Casitas (with 200 second-foot diversion)	92,000	90,000	14,000	$10,049,500	$109	$ 718	$ 526,700	$ 38	
	105,000	103,000	15,600	10,789,600	103	692	567,100	36	$ 25
	130,000	128,000	18,600	12,875,200	99	692	675,500	36	36
	156,000	154,000	21,900	20,748,000	133	947	1,077,300	49	121
Santa Paula Creek									
Ferndale	12,000	10,000	2,500	5,374,000	448	2,150	276,500	111	
	24,000	22,000	4,900	7,248,500	302	1,480	372,700	76	40
	34,000	32,000	6,600	9,864,600	290	1,495	505,400	77	78
Sespe Creek									
Cold Spring	35,000	32,000	5,000	3,796,100	108	760	199,200	40	
	43,000	40,000	6,500	5,612,800	131	860	291,500	45	62
	77,000	74,000	10,500	7,282,700	95	690	377,900	36	22
	100,000	97,000	12,000	8,571,000	86	714	445,500	37	45
Topatopa	50,000	42,000	8,000	9,155,000	183	1,144	482,500	60	
	75,000	67,000	12,400	12,521,000	167	1,010	652,500	53	39
	100,000	92,000	16,500	15,544,000	155	942	805,300	49	37
Hammel	25,000	13,000	4,000	12,887,500	516	3,220	666,100	166	
	50,000	38,000	9,500	24,490,900	490	2,580	1,252,200	132	107
Fillmore	64,000	52,000	12,500	18,966,400	296	1,520	968,200	77	
	98,000	86,000	20,000	28,352,200	289	1,420	1,444,900	72	64
	148,000	136,000	27,000	44,679,600	302	1,650	2,272,700	84	118
Piru Creek									
Upper Blue Point	50,000	38,000	6,500	8,529,800	171	1,312	438,400	67	
Blue Point	50,000	38,000	6,500	8,170,900	163	1,257	420,300	65	
Devil Canyon	100,000	87,000	15,000	12,118,700	121	810	624,700	42	
	150,000	137,000	22,000	15,486,500	103	704	798,100	36	25
	150,000[b]	137,000	33,400	15,486,500	103	464	798,100	24	
Santa Felicia	50,000	36,000	6,600	7,127,500	143	1,080	369,100	56	
	75,000	61,000	11,000	8,417,300	112	765	435,200	40	15
	100,000	86,000	15,000	9,028,700	90	602	468,600	31	8

[a] Yields of reservoirs on tributaries of Santa Clara River are from uniform release method of operation, with releases for maintenance of ground water levels.
[b] With 80 second-foot diversion to Calleguas-Conejo Hydrologic Unit.

As shown on Table 110, for reservoirs on tributaries of the Santa Clara River, new water that would be made available to the Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits, if the reservoirs were operated under the uniform release method and the water was conveyed to the three subunits by surface conduit, would substantially exceed new water made available thereto under the rapid release method of operation. Therefore, further consideration was not given the rapid release method of operation, and all yields of water hereinafter referred to in connection with these reservoirs are those that would result with uniform release operation.

Presented previously in this chapter was a discussion of possible annexation of Ventura County to the Metropolitan Water District of Southern California, together with estimates of cost of constructing various capacities of aqueduct to connect with the Metropolitan Water District system, and annual costs that would result from such annexation and construction. It was shown that for the capacities of aqueduct considered, capital costs, including the costs of terminal regulation in Ventura County, varied from about $20,000,000 to about $54,000,000. The average annual unit cost of water delivered to Ventura County varied from about $170 per acre-foot for the smallest capacity aqueduct, to about $58 per acre-foot for the largest capacity considered. These costs may be compared with values presented in Table 111. It may be noted that for the four more favorable local reservoirs in Ventura County, average annual costs per acre-foot of net safe yield are substantially less than similar costs of Colorado River water delivered to Ventura County, for all capacities of aqueduct considered. Although the unit cost of delivered Colorado River water shows a marked decrease with increase in aqueduct capacity, there is also a substantial increase in required capital expenditure.

It is believed that if Ventura County were to annex to the Metropolitan Water District of Southern California, sufficient aqueduct capacity should be constructed initially to eliminate present water resources problems and to provide for future growth of the County. This follows from the fact that the aqueduct does not appear to be susceptible to staged development. To achieve this objective, an aqueduct with capacity of at least 150 second-feet should be constructed. The indicated capital cost of constructing such an aqueduct is about $54,000,000. Aqueducts of lesser capacity would provide insufficient supplemental water at a relatively high capital outlay. Also, as stated, the average annual unit cost of water so delivered does not compare favorably with that of potential local conservation developments.

From examination of Tables 110 and 111, and of Plates 35, 36, and 37, it is indicated that of the potential surface storage developments studied in Ventura County, the Casitas site on Coyote Creek, the Cold Spring and Topatopa sites on Sespe Creek, and the Devil Canyon and Santa Felicia sites on Piru Creek are the most favorable from the standpoint of capital cost, amount of net safe yield developed, and average annual unit cost per acre-foot of net safe yield. The remainder of the sites considered, although favorable in some respects, and possibly worthy of consideration in the future, were not given further consideration for initial development.

Of the four sizes of reservoir considered at the Casitas site, it may be noted that a definite increase in yield persists as reservoir capacity is enlarged, but that the average annual unit cost of the 21,900 acre-feet of net safe yield that would be developed by the 156,000 acre-foot reservoir would be about $49 per acre-foot, or substantially in excess of the comparable costs of yield developed by the smaller sizes of reservoir. Furthermore, the average annual cost per acre-foot of incremental yield between the 130,000 and 156,000 acre-foot reservoirs was estimated to be about $121 per acre-foot. Between the reservoirs of 105,000 and 130,000 acre-foot storage capacity the estimated average annual unit cost of incremental yield was only $36 per acre-foot. For these reasons, it was concluded that the most desirable capacity of reservoir at the Casitas site would be about 130,000 acre-feet.

Estimates of cost of yield for various capacities of Cold Spring Reservoir indicate that this site is suitable for the construction of a dam and reservoir with a storage capacity of 100,000 acre-feet, and that the site is the most favorable of those studied on Sespe Creek. A reservoir of this capacity at the Cold Spring site would be the least expensive to construct, and have the lowest annual cost per acre-foot of net safe yield developed. As was stated in earlier discussion of this reservoir, there are uncertainties regarding runoff at the dam site. Based on available hydrographic data, and upon rough estimates of runoff for the period from 1894-95 through 1950-51, an analysis was made of the probable time required to fill Cold Spring Reservoir after its construction. It was estimated that for the 100,000 acre-foot reservoir, about 16 years on the average would have been required for the reservoir to fill after construction. Thus, it is indicated, on the basis of the sparse hydrographic data available, that 100,000 acre-feet of storage capacity at the Cold Spring site probably approaches the absolute maximum which should be constructed. In order to protect the site against either underdevelopment or construction of excess capacity, it was concluded that construction of a Cold Spring Reservoir should be postponed until such time as adequate hydrographic data become available.

Analysis was made of the Topatopa, Santa Felicia, and Devil Canyon sites, which as stated appear to be favorable for initial construction, to ascertain the most feasible storage capacity at each of the sites under a plan of coordinated operation. In this connection, it should be emphasized that construction of a reservoir at the Santa Felicia site would preclude subsequent construction of a reservoir at the Devil Canyon site. Conversely, if a reservoi were to be constructed at the Devil Canyon site this would eliminate the possibility of building a dam at the Santa Felicia site. In Table 111 it is shown that for a reservoir storage capacity of 100,000 acre-feet, the Santa Felicia site is more favorable than the Devil Canyon site from the standpoints of both capital cost and annual cost per acre-foot of net safe yield, and that in these respects it is also more favorable than a comparable capacity at the Topatopa site on Sespe Creek. As has been stated, construction of reservoir capacity at the Santa Felicia site is limited to a maximum of about 100,000 acre-feet, while at the Devil Canyon site a dam creating storage capacities up to about 150,000 acre-feet is considered feasible. The Topatopa site also is considered limited to a maximum storage capacity of about 100,000 acre-feet.

There is presented in Table 112 an economic comparison of selected combinations of reservoir storage capacities at the Santa Felicia, Topatopa, and Devil Canyon sites. The estimated costs are based on an assumed 4 per cent interest rate. It may be noted that this analysis was made under the assumption that the reservoirs would be operated coordinately under the uniform release method. Values are presented showing the accomplishments of various combinations of reservoir storage capacity at the three sites, operated both with releases for maintenance of ground water levels and without such releases. It will be noted that for any given combination of reservoir capacity, not only would the greatest yields be obtained without releases for maintenance of ground water levels, but also the average annual cost per acre-foot of net safe yield would be substantially less without such releases. It is also shown in Table 112 that the largest yields of water with the lowest annual unit costs are obtained with a Devil Canyon Reservoir of storage capacity of 150,000 acre-feet operated for the joint benefit of the Santa Clara River and Calleguas-Conejo Hydrologic Units.

TABLE 112

ECONOMIC COMPARISON OF SELECTED COMBINATIONS OF POTENTIAL RESERVOIRS ON SESPE AND PIRU CREEKS, WITH UNIFORM RELEASE OPERATION

Gross reservoir storage capacity, in acre-feet				Net safe seasonal yield, in acre-feet		Capital costs				Average annual costs		
								Per acre-foot of yield			Per acre-foot of yield	
Santa Felicia	Topatopa	Devil Canyon	Total	With releases for maintenance of ground water levels	Without releases for maintenance of ground water levels	Total	Per acre-foot of gross storage capacity	With releases for maintenance of ground water levels	Without releases for maintenance of ground water levels	Total	With releases for maintenance of ground water levels	Without releases for maintenance of ground water levels
100,000	100,000		200,000	30,500	35,000	$24,572,700	$123	$ 806	$702	$ 1,273,900	$42	$36
100,000	75,000		175,000	26,500	31,000	21,549,700	123	813	695	1,121,100	42	36
100,000	50,000		150,000	23,000	27,400	18,183,700	121	791	664	951,100	41	35
75,000	100,000		175,000	27,000	30,800	23,961,300	137	887	778	1,240,500	46	40
75,000	75,000		150,000	23,000	26,800	20,938,300	140	910	781	1,087,700	47	41
75,000	50,000		125,000	19,000	22,300	17,572,300	141	925	788	917,700	48	41
50,000	100,000		150,000	23,000	26,400	22,671,500	151	986	859	1,174,400	51	44
50,000	75,000		125,000	18,900	22,300	19,648,500	157	1,040	881	1,021,600	54	46
50,000	50,000		100,000	14,600	17,900	16,282,500	163	1,115	910	851,600	58	48
	100,000	150,000	250,000	37,500	42,500	31,030,500	124	827	730	1,603,400	43	38
	100,000	150,000*	250,000	48,900	54,100	31,030,500	124	635	574	1,603,400	33	30
	75,000	150,000	225,000	34,000	39,500	28,007,500	124	824	709	1,450,600	43	37
	50,000	150,000	200,000	31,000	36,000	24,641,500	123	795	684	1,280,600	41	36
	100,000	100,000	200,000	30,500	35,000	27,662,700	138	907	790	1,430,000	47	41
	75,000	100,000	175,000	26,500	31,500	24,639,700	141	930	782	1,277,200	48	41
	50,000	100,000	150,000	23,000	27,500	21,273,700	142	925	774	1,107,200	48	40

*With 80 second-foot capacity Piru-Las Posas Diversion. Indicated yields include an average seasonal export of 20,100 acre-feet to Calleguas-Conejo Hydrologic Unit during base period.

It is shown in Table 112 that under the indicated plans of coordinated operation for the sole benefit of the Santa Clara River Hydrologic Unit, slightly lower unit costs of developed yield would be obtained with either Devil Canyon or Santa Felicia Reservoirs constructed to the indicated maximum capacity, and with Topatopa Reservoir constructed to a capacity of 50,000 acre-feet. However, there would be but a slight increase in unit cost of net safe yield with maximum storage capacity at Topatopa and with maximum storage capacity at either Santa Felicia or Devil Canyon. Because of the general paucity of feasible dam sites in Ventura County, it is believed that the more favorable sites should be developed to the maximum practicable capacity in consonance with engineering and economic criteria. It was concluded, therefore, that any dam constructed at the Topatopa site should provide a reservoir storage capacity of about 100,000 acre-feet, and that storage capacity constructed at the Santa Felicia or Devil Canyon sites should not be less than about 100,000 or 150,000 acre-feet, respectively, depending upon the site developed.

There follows a discussion of three alternative basic plans considered feasible for initial construction and operation by an appropriate county-wide water agency in Ventura County. There are also presented three additional plans, that would achieve similar accomplishments in terms of water yield, but at a lesser cost through planned operation of ground water storage in the Santa Clara River Hydrologic Unit. The estimated costs of new water cited are based on an assumed 4 per cent interest rate.

Plan I

Under the provisions of this plan relating to the Ventura Hydrologic Unit, Casitas Reservoir would be constructed to a storage capacity of 130,000 acre-feet, together with a distribution system to serve each subunit. The capacity of the distribution system would be about 13,400 acre-feet per season. It was assumed that a seasonal supply of 1,400 acre-feet would be delivered to the Ojai Subunit from Matilija Reservoir through the existing line.

Under Plan I in the Santa Clara River Hydrologic Unit, both Santa Felicia and Topatopa Reservoirs would be constructed, each with a storage capacity of 100,000 acre-feet. The Santa Clara River Conduit would be constructed, and would have a capacity at its terminus at Oxnard Reservoir of 120 second-feet. A distribution system to supply about 30,000 acre-feet of agricultural water per season and about 10,000 acre-feet of municipal water per seas to the Oxnard Plain and Pleasant Valley Subunits would be included in the plan. The Casitas-Oxnard Plain Diversion Conduit would be constructed with a capacity of 25 second-feet, and would deliver a seasonal supply of about 10,000 acre-feet to Oxnard Reservoir.

Under Plan I, initially about 8,600 acre-feet per season of supplementa water would be made available at strategic points in the Ventura Hydrologic Unit, at an estimated average annual cost of $62 per acre-foot. About 40,000 acre-feet of supplemental water per season would be delivered to users in the Oxnard Plain and Pleasant Valley Subunits, at an estimated average annual unit cost of $58 pe acre-foot. The total net safe seasonal yield developed by features of the plan would be about 49,000 acre-feet, with an estimated average annual unit cost of $5 per acre-foot delivered to users in the Oxnard Plain and Pleasant Valley Subunits and to strategic points in the Ventura Hydrologic Unit. The estimated capital cost of Plan I would be about $52,000,000.

Plan IA

Plan IA would include the same component features as Plan I, except that in lieu of 100,000 acre-feet of reservoir storage capacity at the Topatopa site, a well field would be constructed in Fillmore Basin and operated to yield an average supply of new water to the Oxnard Forebay Subunit of about 16,000 acre-feet per season. In addition, Santa Felicia Reservoir would be operated n the uniform release basis without effecting releases to maintain historic ;round water levels in Piru, Fillmore, and Santa Paula Basins. Under provisions f this plan, an average seasonal supplemental supply of about 45,000 acre-feet f water would be delivered to Oxnard Reservoir from developments in the Santa lara River watershed and from Casitas Reservoir. The estimated capital cost of lan IA would be about $36,000,000. The estimated average annual unit cost of ew water delivered to users in the Oxnard Plain and Pleasant Valley Subunits ould be $34 per acre-foot. The total seasonal yield of new water developed by eatures of the plan would be about 54,000 acre-feet. The estimated average nnual unit cost of net safe yield so developed would be about $39 per acre-foot.

lan II

Component features of Plan II would be the same as Plan I, except hat in lieu of 100,000 acre-feet of reservoir storage capacity at the Santa elicia site, Devil Canyon Reservoir would be constructed to a storage capacity f 150,000 acre-feet, and would be operated for the benefit of the Santa Clara iver Hydrologic Unit alone, under the uniform release method of operation nd with releases to maintain historic ground water levels in Piru, Fillmore, nd Santa Paula Basins. The yield of new water in the Ventura Hydrologic Unit nd the average annual unit cost thereof would be the same as in the preceding lternative plans. In the Santa Clara River Hydrologic Unit, about 47,500 cre-feet per season of new water would be made available in the Oxnard Plain nd Pleasant Valley Subunits, at an estimated average annual unit cost of 56 per acre-foot. The total new water supply that would be developed under he provisions of Plan II would be about 56,000 acre-feet per season, having n estimated average annual unit cost of $57 per acre-foot. The estimated apital cost of Plan II would be about $59,000,000.

Plan IIA

Plan IIA includes the same features as Plan II, except that in lieu of a 100,000 acre-foot reservoir at the Topatopa site, new water in the amount of about 16,000 acre-feet per season would be extracted from the well field in Fillmore Basin, and conveyed to the Oxnard Plain and Pleasant Valley Subunits for use therein. In the Ventura Hydrologic Unit the amount of new water developed, and the average annual unit cost thereof would be the same as in the preceding alternative. In the Santa Clara River Hydrologic Unit, about 53,000 acre-feet per season of new water would be made available to the Oxnard Plain and Pleasant Valley Subunits, at an estimated average annual unit cost of $35 per acre-foot. The total new water supply developed by Plan IIA would be about 62,000 acre-feet per season, at an estimated average annual unit cost of $39 per acre-foot. The estimated capital cost of Plan IIA would be about $43,000,000.

Plan III

Plan III includes the same component features as Plan II, except that Devil Canyon Reservoir would be operated for the joint benefit of the Santa Clara River and Calleguas-Conejo Hydrologic Units, and the Piru-Las Posas Conduit would be constructed with a capacity of 80 second-feet and would deliver water from Devil Canyon Reservoir to the Happy Camp Canyon and Dry Canyon spreading grounds in the East Las Posas and Simi Subunits, respectively. Releases from Devil Canyon and Topatopa Reservoirs to the Santa Clara River Conduit would be under the uniform release method of operation, with releases for maintenance of histori ground water levels in Piru, Fillmore, and Santa Paula Basins.

Under the provisions of Plan III, the amount of new water and the average unit cost thereof in the Ventura Hydrologic Unit would be the same as in the preceding alternative. About 39,000 acre-feet per season of new water would be developed for use in the Oxnard Plain and Pleasant Valley Subunits, at an estimated average annual unit cost of $56 per acre-foot. Similarly, an average seasonal new water supply of about 20,000 acre-feet would be delivered to the Calleguas-Conejo Hydrologic Unit at the foregoing spreading grounds, at an estimated average annual unit cost of $48 per acre-foot. The total new water supply developed under the provisions of Plan III would be about 67,000 acre-feet per season, at an estimated average annual unit cost of $54 per acre-foot. The estimated capital cost of Plan IIIwould be about $68,000,000.

Plan IIIA

The features of Plan IIIA would be the same as those in Plan III, except that in lieu of a 100,000 acre-feet reservoir at the Topatopa site, new water in the amount of about 16,000 acre-feet per season would be extracted from the well field in Fillmore Basin and conveyed to the Oxnard Plain and Pleaant Valley Subunits, for use therein. In addition, Devil Canyon Reservoir would be operated under the uniform release method, without releases to maintain historic ground water levels in Piru, Fillmore, and Santa Paula Basins.

In the Ventura Hydrologic Unit, the amount of new water and average annual unit cost thereof would be the same as in the preceding alternative. A new water supply of about 44,000 acre-feet per season would be delivered for use in the Oxnard Plain and Pleasant Valley Subunits, at an estimated average annual unit cost of $33 per acre-foot. As under provisions of Plan III, about 20,000 acre-feet of new water per season would be delivered to the Happy Camp Canyon and Dry Canyon spreading grounds in the Calleguas-Conejo Hydrologic Unit, at an estimated annual unit cost of $45 per acre-foot. The total new water supply that would be developed under the provisions of Plan IIIA would be about 73,000 acre-feet per season, at an estimated average annual unit cost of about $40 per acre-foot. The estimated capital cost of Plan IIIA would be about $52,000,000.

Comparison of Alternative Plans

There is presented in Table 113 a summary comparison of estimated costs and yields of water that would result under alternative Plans I, II, and III. Presented in Table 114 is a summary comparison of cost and yields of water that would result under the provision of Plan IA, IIA, and IIIA. It is apparent from examination of these tables that with planned operation of ground water storage both capital and annual costs of plans with similar accomplishments in water yield would be substantially reduced.

Because of uncertainties regarding interest rates that could be obtaine in financing of the foregoing alternative plans, there is presented in Table 115 a comparison of costs that would result with interest rates of 3 per cent, 4 per cent, and 5 per cent.

TABLE 113

ESTIMATED COSTS AND YIELDS OF WATER OF ALTERNATIVE INITIAL PLANS
FOR WATER SUPPLY DEVELOPMENT, WITHOUT PLANNED OPERATION
OF GROUND WATER STORAGE IN SANTA CLARA RIVER HYDROLOGIC UNIT

Item	Plan I				Plan II				Plan III			
	Capital cost	Net safe seasonal yield, in acre-feet	Average annual cost: Total	Average annual cost: Per acre foot of yield	Capital cost	Net safe seasonal yield, in acre-feet	Average annual cost: Total	Average annual cost: Per acre foot of yield	Capital cost	Net safe seasonal yield, in acre-feet	Average annual cost: Total	Average annual cost: Per acre foot of yield
Ventura Hydrologic Unit												
Casitas Reservoir[a]	$12,875,200	8,600	$ 312,300	--	$12,875,200	8,600	$ 312,300	--	$12,875,200	8,600	$ 312,300	--
Distribution System[b]	2,953,800	---	223,800	--	2,953,800	---	223,800	--	2,953,800	---	223,800	--
Subtotals	$15,829,000	8,600	$ 536,100	$62	$15,529,000	8,600	$ 536,100	$62	$15,829,000	8,600	$ 536,100	$62
Santa Clara River Hydrologic Unit												
Casitas Reservoir[a]	$ ---	10,000	$ 363,200	--	$ ---	10,000	$ 363,200	--	$ ---	10,000	$ 363,200	--
Casitas-Oxnard Plain Diversion Conduit	1,670,500	---	127,100	--	1,670,500	---	127,100	--	1,670,500	---	127,100	--
Santa Felicia Reservoir	9,028,700	30,500	(468,600	--	---	---	---	--	---	---	---	--
Topatopa Reservoir	15,544,000		(805,300	--	15,544,000	37,500	(805,300	--	15,544,000	28,800	(805,300	--
Devil Canyon Reservoir[a]	---	---	---	--	15,486,500		(798,100	--	6,166,800		(317,900	--
Santa Clara River Conduit	5,658,900	---	302,300	--	5,763,500	---	307,800	--	5,763,500	---	307,800	--
Fillmore Well Field	---	---	---	--	---	---	---	--	---	---	---	--
Municipal Distribution System	1,317,500	---	94,300	--	1,317,500	---	94,300	--	1,317,500	---	94,300	--
Agricultural Distribution System	3,037,700	---	168,700	--	3,037,700	---	168,700	--	3,037,700	---	168,700	--
Subtotals	$36,257,300	40,500	$2,329,500	$58	$42,819,700	47,500	$2,664,500	$56	$33,500,000	38,800	$2,184,300	$56
Calleguas-Conejo Hydrologic Unit												
Devil Canyon Reservoir[a]	---	---	---	--	---	---	---	--	$ 9,319,700	20,100	$ 480,200	--
Piru-Las Posas Diversion Conduit	---	---	---	--	---	---	---	--	6,960,500	---	369,000	--
Spreading works in East Las Posas and Simi Basins	---	---	---	--	---	---	---	--	2,014,200	---	106,800	--
Subtotals	---	---	---	--	---	---	---	--	$18,294,400	20,100	$ 956,000	$48
TOTALS	$52,086,300	49,100	$2,865,600	$58	$58,648,700	56,100	$3,200,600	$57	$67,623,400	67,500	$3,676,400	$54

[a]Average annual cost proportioned on basis of yields.
[b]Energy charges presented in Appendix C reduced by $28,200 because of lesser initial delivery.

TABLE 114

ESTIMATED COSTS AND YIELDS OF WATER OF ALTERNATIVE INITIAL PLANS
FOR LATER SUPPLY DEVELOPMENT, WITH PLANNED OPERATION
OF GROUND WATER STORAGE IN SANTA CLARA RIVER HYDROLOGIC UNIT

Item	Plan IA				Plan IIA				Plan IIIA			
	Capital cost	Net safe seasonal yield, in acre-feet	Average annual cost: Total	Average annual cost: Per acre-foot of yield	Capital cost	Net safe seasonal yield, in acre-feet	Average annual cost: Total	Average annual cost: Per acre-foot of yield	Capital cost	Net safe seasonal yield, in acre-feet	Average annual cost: Total	Average annual cost: Per acre-foot of yield
Ventura Hydrologic Unit												
Casitas Reservoir[a]	$12,875,200	8,600	$ 312,300	--	$12,875,200	8,600	$ 312,300	--	$12,875,200	8,600	$ 312,300	--
Distribution System[b]	2,953,800	---	223,800	--	2,953,800	---	223,800	--	2,953,800	---	223,800	--
Subtotals	$15,829,000	8,600	$ 536,100	$62	$15,829,000	8,600	$ 536,100	$62	$15,829,000	8,600	$ 536,100	$62
Santa Clara River Hydrologic Unit												
Casitas Reservoir[a]	$ ---	10,000	$ 363,200	--	$ ---	10,000	$ 363,200	--	$ ---	10,000	$ 363,200	--
Casitas-Oxnard Plain Diversion Conduit	1,670,500	---	127,100	--	1,670,500	---	127,100	--	1,670,500	---	127,100	--
Santa Felicia Reservoir	9,028,700	19,000	468,600	--	---	---	---	--	---	---	---	--
Topatopa Reservoir	---	---	---	--	---	---	---	--	---	---	---	--
Devil Canyon Reservoir[a]	---	---	---	--	15,486,500	27,000	798,100	--	7,316,500	18,000	377,100	--
Santa Clara River Conduit	4,814,900	---	255,400	--	4,919,500	---	260,900	--	4,919,500	---	260,900	--
Fillmore Well Field	338,100	16,000	55,500	--	338,100	16,000	55,500	--	338,100	16,000	55,500	--
Municipal Distribution System	1,317,500	---	94,300	--	1,317,500	---	94,300	--	1,317,500	---	94,300	--
Agricultural Distribution System	3,037,700	---	168,700	--	3,037,700	---	168,700	--	3,037,700	---	168,700	--
Subtotals	$20,207,400	45,000	$1,532,800	$34	$26,769,800	53,000	$1,867,800	$35	$18,599,800	44,000	$1,446,800	$33
Calleguas-Conejo Hydrologic Unit												
Devil Canyon Reservoir[a]	---	---	---	--	---	---	---	--	$ 8,170,000	20,100	$ 421,000	--
Piru-Las Posas Diversion Conduit	---	---	---	--	---	---	---	--	6,960,500	---	369,000	--
Spreading works in East Las Posas and Simi Basins	---	---	---	--	---	---	---	--	2,014,200	---	106,800	--
Subtotals	---	---	---	--	---	---	---	--	$17,144,700	20,100	$ 896,800	$45
TOTALS	$36,036,400	53,600	$2,068,900	$39	$42,598,800	61,600	$2,403,900	$39	$51,573,500	72,700	$2,879,700	$40

[a]Average annual cost proportioned on basis of yields.
[b]Energy charges presented in Appendix C reduced by $28,200 because of lesser initial delivery.

TABLE 115

COMPARISON OF ESTIMATED COSTS OF ALTERNATIVE PLANS
OF WATER SUPPLY DEVELOPMENT, WITH SELECTED INTEREST RATES

Plan	Capital cost	Average annual cost					
		3 per cent basis		4 per cent basis		5 per cent basis	
		Total	Per acre-foot of yield	Total	Per acre-foot of yield	Total	Per acre-foot of yield
I	$52,086,300	$2,472,900	$50	$2,865,600	$58	$3,266,100	$67
IA	36,036,400	1,811,300	34	2,068,900	39	2,344,500	44
II	58,648,700	2,759,900	49	3,200,600	57	3,651,800	65
IIA	42,598,800	2,098,300	34	2,403,900	39	2,730,200	44
III	67,623,400	3,170,500	47	3,676,400	54	4,197,300	62
IIIA	51,573,500	2,508,900	35	2,879,700	40	3,275,700	45

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CHAPTER V. SUMMARY OF CONCLUSIONS, AND RECOMMENDATIONS

As a result of field investigation and analysis of available data on the water resources and water problems of Ventura County, and on the basis of the estimates and assumptions discussed hereinbefore, the following conclusions and recommendations are made:

Summary of Conclusions

1. Water resources problems of Ventura County are manifested in the perennial lowering of ground water levels, sea-water intrusion to pumped aquifers, degradation of ground water quality, and general diminution of surface and ground water supplies during periods of drought to quantities inadequate to satisfy requirements.

2. The initial alleviation of the foregoing problems will involve further regulation of the erratic local water supply, so that waste conserved during wet periods can be made available for beneficial use during periods of drought. Final solution of water problems of Ventura County will lie in the importation of water supplies from outside sources.

3. The present principal sources of water supply of Ventura County are direct precipitation and runoff from tributary drainage areas. Imported water constitutes a minor item of water supply. Mean seasonal depth of precipitation in the County varies from a minimum of about 12 inches near the coast to a maximum of about 32 inches in the northerly mountainous area. Mean seasonal runoff to the ocean from the Ventura and Santa Clara Rivers, with the present pattern of land use and water supply development, is about 230,000 acre-feet.

4. Regulation and re-regulation of the water supplies of Ventura County is accomplished almost entirely through storage in underlying ground water reservoirs. Matilija Reservoir is the only significant surface storage reservoir in the County, and direct use of surface water is limited to a relatively few users along the Ventura and Santa Clara Rivers. A total of 17 major ground water basins have been identified in the County, 16 of which are presently of economic importance. Extensive utilization of ground water storage has enabled Ventura County to achieve its present stage of development. The safe yield of the presently developed water supply is about 107,000 acre-feet per season, distributed as follows: Ventura Hydrologic Unit, 9,400 acre-feet; Santa Clara River Hydrologic Unit, 73,200 acre-feet; Calleguas-Conejo Hydrologic Unit, 23,700 acre-feet; and Malibu Hydrologic Unit, 800 acre-feet.

5. Piezometric levels in confined aquifers of the Mound, Oxnard Plain, and Pleasant Valley Basins, were drawn below sea level during the drought period from 1944-45 through 1950-51, and landward gradients from the ocean prevailed therein. In 1951, sea water invaded a portion of the Oxnard aquifer being actively pumped in the Oxnard Plain Basin.

6. Surface and ground water supplies of Ventura County generally are of good mineral quality and suitable for irrigation and other beneficial purposes.

7. The gross area presently requiring water service in Ventura County comprises about 140,000 acres, distributed as follows: Ventura Hydrologic Unit, 12,000 acres; Santa Clara River Hydrologic Unit, 103,000 acres; Calleguas-Conejo Hydrologic Unit, 25,000 acres; and Malibu Hydrologic Unit 500 acres. There are about 235,000 acres in

the County considered susceptible to concentrated and intensive water-using developments.

8. The present mean seasonal water requirement of Ventura County is about 180,000 acre-feet, distributed as follows: Ventura Hydrologic Unit, 13,000 acre-feet; Santa Clara River Hydrologic Unit, 133,000 acre-feet; Calleguas-Conejo Hydrologic Unit, 33,000 acre-feet; and Malibu Hydrologic Unit, 1,000 acre-feet.

9. The probable ultimate water requirement of Ventura County will be about 389,000 acre-feet, distributed as follows: Ventura Hydrologic Unit, 39,000 acre-feet; Santa Clara River Hydrologic Unit, 227,000 acre-feet; Calleguas-Conejo Hydrologic Unit 104,000 acre-feet; Malibu Hydrologic Unit, 14,000 acre-feet; and remainder of the County, 5,000 acre-feet.

10. The present mean seasonal requirement for supplemental water in Ventura County is about 73,000 acre-feet, distributed as follows: Ventura Hydrologic Unit, 4,000 acre-feet; Santa Clara River Hydrologic Unit, 60,000 acre-feet; and Calleguas-Conejo Hydrologic Unit, 9,000 acre-feet. Supplemental water is presently required in the Ventura Hydrologic Unit to eliminate ground water overdraft in Ojai and Upper Ventura River Basins, and to firm the presently erratic and deficient surface water supplies. Supplemental water is presently required in the Santa Clara River Hydrologic Unit to prevent the intrusion of sea water to pumped aquifers in the Oxnard Plain and Pleasant Valley Basins. There is no present requirement for supplemental water in the Piru, Fillmore, and Santa Paula Subunits of the Santa Clara River Hydrologic Unit. Supplemental water is presently required in the Calleguas-Conejo Hydrologic Unit to prevent perennial and progressive

lowering of ground water levels, with attendant degradation of ground water quality, in Simi, East and West Las Posas, and Tierra Rejada Basins.

11. Under forecast ultimate conditions of development in Ventura County, the mean seasonal requirement for supplemental water will be about 266,000 acre-feet, distributed as follows: Ventura Hydrologic Unit, 30,000 acre-feet; Santa Clara River Hydrologic Unit, 142,000 acre-feet; Calleguas-Conejo Hydrologic Unit, 81,000 acre-feet; and Malibu Hydrologic Unit, 13,000 acre-feet.

12. An immediate source of supplemental water is available locally to Ventura County in the surface waters presently wasting to the ocean, the salvage of which will require the development of equalizing storage capacity either in surface reservoirs or in presently undeveloped ground water storage capacity. An immediate source of imported supplemental water is available to the County in waters of the Colorado River, through facilities of the Metropolitan Water District of Southern California. A future source of supplemental water, sufficient in quantity to satisfy those probable ultimate water requirements of Ventura County in excess of the yield of feasible local water supply developments will be available to the County from the Feather River Project.

13. The capital costs of potential surface storage developments in Ventura County vary from about $4,000,000 to about $40,000,000, and the average annual unit cost of new water made available by these developments vary from about $30 to an excess of $150 per acre-foot. The least expensive development of supplemental water for the County consists of the use of presently undeveloped ground water storage

capacity, which development in the Santa Clara River Hydrologic Unit would involve a capital expenditure of about $338,000, and would yield about 16,000 acre-feet per season of new water at an average annual unit cost of about $3.50 per acre-foot. These costs do not consider possible damages to overlying ground water users.

14. Alleviation of present ground water overdraft in the Oxnard Forebay, Oxnard Plain, and Pleasant Valley Basins can be accomplished only by development of a supplemental water supply, either in upstream surface or ground water storage or through importation, and the distribution of this supply in surface conduits to lands in the Oxnard Plain and Pleasant Valley Subunits presently served with ground water. Initially, a supplemental water supply of from 40,000 to 50,000 acre-feet per season should be made available to the Oxnard Forebay, Oxnard Plain and Pleasant Valley Subunits for this purpose.

15. Any conservation reservoirs constructed in the Santa Clara River watershed would be for the primary purpose of furnishing new water to the Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits of the Santa Clara River Hydrologic Unit. Such reservoirs should be operated with uniform seasonal releases to meet demands for water in the foregoing subunits. To achieve the maximum benefit, water released from the reservoirs should be conveyed to areas of need in a conduit. A substantial increase in the benefit from surface reservoirs in the Santa Clara River watershed will result if releases therefrom are not made to maintain historic ground water levels in Piru, Fillmore, and Santa Paula Basins.

16. The most favorable dam and reservoir sites in Ventura County, from the standpoints of cost and yield of water, are the Casitas

site on Coyote Creek with reservoir inflow implemented by diversion of water from the Ventura River, the Cold Spring and Topatopa sites on Sespe Creek, and the Santa Felicia and Devil Canyon sites on Piru Creek. The most desirable reservoir storage capacity at the Casitas site is about 130,000 acre-feet; at the Topatopa site, about 100,000 acre-feet; at the Santa Felicia site, about 100,000 acre-feet; and at Devil Canyon site, about 150,000 acre-feet. Because of inadequate data relating to runoff, construction of a dam and reservoir at the Cold Spring site should be postponed until such time as reliable hydrographic data become available, which will enable evaluation of the proper reservoir capacity to be constructed.

17. It is feasible from an engineering standpoint temporarily to divert surplus waters from Casitas Reservoir for interim use in the Oxnard Forebay, Oxnard Plain, and Pleasant Valley Subunits of the Santa Clara River Hydrologic Unit.

18. It is feasible from the engineering standpoint to operate a Devil Canyon Reservoir of 150,000 acre-foot storage capacity for the joint benefit of the Santa Clara River and Calleguas-Conejo Hydrologic Units, and to convey water conserved by the reservoir in a pressure conduit to spreading grounds in Las Posas and Simi Basins of the Calleguas-Conejo Hydrologic Unit. When Feather River Project water is made available to Ventura County, via Piru Creek, a portion of the 150,000 acre-foot storage capacity of Devil Canyon Reservoir could be used for terminal regulation of the imported water. In addition, the foregoing conduit could be utilized to deliver Feather River Project water to the Calleguas-Conejo Hydrologic Unit.

19. Colorado River water could be delivered, through extended facilities of the Metropolitan Water District of Southern California, to terminal regulating reservoirs in Ventura County, at capital costs varying from about $20,000,000 to about $54,000,000 for aqueduct capacities of from 25 second-feet to 150 second-feet. The average unit cost of the 18,000 acre-feet per season of Colorado River water delivered by the 25 second-foot capacity aqueduct would be about $171 per acre-foot. The average annual cost of the 108,000 acre-feet of water per season delivered by the 150 second-foot capacity aqueduct would be about $58 per acre-foot. These estimates do not include costs of distributing Colorado River water within the County. Average annual unit costs of the water at the terminal reservoirs compare unfavorably with like costs from potential local conservation developments. Furthermore, the works for importation of Colorado River water are not susceptible to staged development. A firm water supply, in an amount sufficient to satisfy present deficiencies in Ventura County and to provide some capacity to meet increased future requirements, could be obtained from the Colorado River, but only at a relatively large initial capital expenditure. This capital cost, under the presently required financial arrangements with the Metropolitan Water District, may be in excess of the present financial capacity of Ventura County.

20. Of the six plans considered for county-wide development of local water resources, the most favorable from the standpoints of yield of new water and capital and unit costs are Plans IA, IIA, and IIIA, which include planned operation of ground water storage capacity in the Santa Clara River Hydrologic Unit. From the standpoint of

service of water to areas of need, Plan IIIA is the most desirable. From the standpoint of watershed development, both Plans IIA and IIIA are superior to Plan IA. Capital cost of Plan IIIA, estimated to be about $52,000,000 which includes provision of supplemental water for the Calleguas-Conejo Hydrologic Unit, may be beyond the present financial capacity of Ventura County. For this reason, Plan IIIA should be adopted as a staged development, with the features of Plan IIA to be constructed initially, and with the objective of constructing the Piru-Las Posas Diversion as soon as future financial capacity will permit.

Plan IIIA includes a 130,000 acre-foot Casitas Reservoir, the Casitas Distribution System, and the Casitas-Oxnard Plain Diversion. Devil Canyon Reservoir, with 150,000 acre-feet of storage capacity is operated under the uniform release method and without releases to maintain historic ground water levels, for the joint benefit of the Santa Clara River and Calleguas-Conejo Hydrologic Units. The plan also includes the Piru-Las Posas Diversion, spreading grounds in the Calleguas-Conejo Hydrologic Unit, the Santa Clara River Conduit, the Fillmore Well Field for planned operation of undeveloped ground water storage capacity, and the Oxnard Plain-Pleasant Valley Distribution System. Plan IIA differs from Plan IIIA in that Devil Canyon Reservoir is operated solely for the benefit of the Santa Clara River Hydrologic Unit, and the Piru-Las Posas Diversion and spreading grounds in the Calleguas-Conejo Hydrologic Unit are not included. The estimated capital cost of Plan IIA is about $43,000,000.

21. Should Plans IA, IIA, and IIIA prove to be infeasible because of legal limitations relating to water rights of overlying ground water users, Plan III would be the most desirable from the

standpoints of yield of new water and service to areas of need. However, the capital cost of this plan estimated to be about $68,000,000, is believed to be considerably greater than the probable present capacity of Ventura County to finance. For this reason, and under the foregoing legal circumstance, staged development of Plan III should be undertaken. A desirable initial development to this end would include all features of Plan III except for Topatopa Reservoir and the works to provide supplemental water to the Calleguas-Conejo Hydrologic Unit. The capital cost of these initial works would be about $43,000,000.

Plan III includes a 130,000 acre-foot Casitas Reservoir, the Casitas Distribution System, and the Casitas-Oxnard Plain Diversion. Devil Canyon Reservoir, with 150,000 acre-feet of storage capacity, is operated for the joint benefit of the Santa Clara River and Calleguas-Conejo Hydrologic Units. The plan includes the Piru-Las Posas Diversion and spreading grounds in the Calleguas-Conejo Hydrologic Unit. Topatopa Reservoir, with 100,000 acre-feet of storage capacity, and Devil Canyon Reservoir, are operated under the uniform release method with releases to maintain historic ground water levels. Plan III also includes the Santa Clara River Conduit and the Oxnard Plain-Pleasant Valley Distribution System.

22. Only through the formation of a single county-wide water agency, organized with appropriate powers, can a sound, comprehensive program of water resources development be prosecuted in Ventura County. Such an agency is essential, not only to undertake the development of local water resources, but also to obtain imported water for the County as will be necessary to meet the probable ultimate supplemental water requirement.

Recommendations

1. That a county-wide water agency endowed with appropriate powers be created in Ventura County for the purpose of financing, constructing, and operating feasible water supply developments.

2. That plans for solution of the water problems of Ventura County be executed in conformity with the conclusions set forth herein.

3. That a program be initiated for the acquisition of lands, easements, and rights of way necessary for construction of feasible water resource development works in Ventura County.

4. That the program of hydrologic investigation by Ventura County be continued and expanded for the purpose of more definitely evaluating the water problems under continuing growth and development of the County.

5. That continuing support be given to the investigation and study of major multi-purpose water resources developments under The California Water Plan, including those relating to importation of water to southern California under provisions of the Feather River Project.

STATE OF CALIFORNIA
GOODWIN J. KNIGHT
GOVERNOR

PUBLICATION OF
STATE WATER RESOURCES BOARD

Bulletin No. 12

VENTURA COUNTY INVESTIGATION

Volume II

APPENDIXES AND PLATES

October, 1953
Revised April, 1956

TABLE OF CONTENTS

Page

APPENDIXES

. Agreement, and Its Supplement, Between the State Water Resources Board, the County of Ventura, and the Department of Public Works A-1

. Geology and Ground Water of Ventura County, California B-1

. Estimates of Cost C-1

. Some Organizational and Financial Aspects Involved in Implementing Water Plans in Ventura County D-1

PLATES

(Plates 1-42 are bound at end of Volume II)

late No.	
1	Location of Ventura County
2	Major Water Districts, 1953
3	Hydrologic Units, 1953
4	Lines of Equal Mean Seasonal Precipitation in Inches, 1897-98 Through 1946-47
5	Recorded Seasonal Precipitation at Ojai
6	Accumulated Departure From Mean Seasonal Precipitation at Ojai
7	Stream Gaging and Water Sampling Stations, 1952
8	Estimated Seasonal Natural Runoff of Sespe Creek Near Fillmore
9	Accumulated Departure From Mean Seasonal Natural Runoff of Sespe Creek Near Fillmore
10	Areal Geology, 1953
11	Ground Water Basins, 1953
12-A	Geologic Sections
12-B	Geologic Sections
12-C	Geologic Sections
13	Diagrammatic Sketch of Oxnard Plain and Oxnard Forebay Basins

PLATES
(Continued)

Plate No.

14-A Ventura Hydrologic Unit, Lines of Equal Elevation of Ground Water, Fall of 1936

14-B Santa Clara River Hydrologic Unit, Lines of Equal Elevation of Ground Water, Fall of 1936

14-C Calleguas-Conejo and Malibu Hydrologic Units, Lines of Equal Elevation of Ground Water, Fall of 1936

15-A Ventura Hydrologic Unit, Lines of Equal Elevation of Ground Water, Spring of 1944

15-B Santa Clara River Hydrologic Unit, Lines of Equal Elevation of Ground Water, Spring of 1944

15-C Calleguas-Conejo and Malibu Hydrologic Units, Lines of Equal Elevation of Ground Water, Spring of 1944

16-A Ventura Hydrologic Unit, Lines of Equal Elevation of Ground Water, Fall of 1951

16-B Santa Clara River Hydrologic Unit, Lines of Equal Elevation of Ground Water, Fall of 1951

16-C Calleguas-Conejo and Malibu Hydrologic Units, Lines of Equal Elevation of Ground Water, Fall of 1951

17-A Ventura Hydrologic Unit, Lines of Equal Depth to Ground Water, Fall of 1951

17-B Santa Clara River Hydrologic Unit, Lines of Equal Depth to Ground Water, Fall of 1951

17-C Calleguas-Conejo and Malibu Hydrologic Units, Lines of Equal Depth to Ground Water, Fall of 1951

18-A Ventura Hydrologic Unit, Lines of Equal Change in Ground Water Elevation, Fall of 1936 to Fall of 1951

18-B Santa Clara River Hydrologic Unit, Lines of Equal Change in Ground Water Elevation, Fall of 1936 to Fall of 1951

18-C Calleguas-Conejo and Malibu Hydrologic Units, Lines of Equal Change in Ground Water Elevation, Fall of 1936 to Fall of 1951

19-A Ventura Hydrologic Unit, Lines of Equal Change in Ground Water Elevation, Spring of 1944 to Fall of 1951

19-B Santa Clara River Hydrologic Unit, Lines of Equal Change in Ground Water Elevation, Spring of 1944 to Fall of 1951