State of California

THE RESOURCES AGENCY

Department of Water Resources

BULLETIN No. 160-66

IMPLEMENTATION OF THE CALIFORNIA WATER PLAN

MARCH 1966

HUGO FISHER
Administrator
The Resources Agency

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FOREWORD

This bulletin is the first of a series about progress on water resources planning, construction and related activities pertaining to implementation of The California Water Plan. It has been prepared as a function of the Coordinated Statewide Planning Program of the Department of Water Resources.

Of the many agencies engaged in water resource activities in California, the Department of Water Resources alone possesses the authority, interest and responsibility for the conduct of statewide water resources planning activities. This report, authorized by the Legislature, is responsive to this unique charge.

The first chapter presents a review of progress in implementing The California Water Plan from 1956 through 1965. The second chapter gives the Department of Water Resources' present estimates of (1) future water requirements and requirements for other project services, such as flood control and recreation, throughout California; (2) capabilities of existing projects to meet such requirements; (3) the sizing and timing of future federal and state projects which now appear to be needed to meet the growth of demands for water supplies until the year 2020; and (4) a generalized discussion of projects needed to supply other services.

In a number of areas, the estimates presented in this report need to be strengthened. Techniques for predicting the economic demands for project services and for staging projects to meet those demands need to be improved. Subsequent reports of this series will present refinements of the data used, where necessary, to provide more dependable analyses of the needs for future projects. As the times for construction of new facilities approach, the needs for services will become clearer, and it will be possible to assess the required accomplishments of each project with increasing precision.

An appendix to this bulletin will be published later. It will present additional information on the subject matter covered in this report.

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CHAPTER I. 1956-1965: A SIGNIFICANT DECADE IN IMPLEMENTATION OF THE CALIFORNIA WATER PLAN

The California Water Plan was published by the Department of Water Resources in May 1957. The Plan provided a broad and flexible pattern into which future definite projects may be integrated in an orderly fashion. It recognized that allowances would have to be made for additional experience, advances in technology, and other changes in future conditions that could not be foreseen at the time of its publication. The basic concept of the Plan as a master plan to meet the ultimate requirements for water at some unspecified but distant time in the future, when the land and other resources of California have essentially reached a state of complete development, remains unchanged.

During the decade commencing in 1956, when the studies which led to The California Water Plan were completed, many significant events have occurred in water resources planning and development, and in allied fields, either toward implementation of the Plan or related thereto. This chapter briefly describes California's growth from 1956 through 1965; the accomplishments in water development during that period; significant legislation and court decisions that have had a direct bearing on the Plan; and current planning activities of state and federal agencies looking toward further implementation of the Plan.

California's Growth, 1956-1965

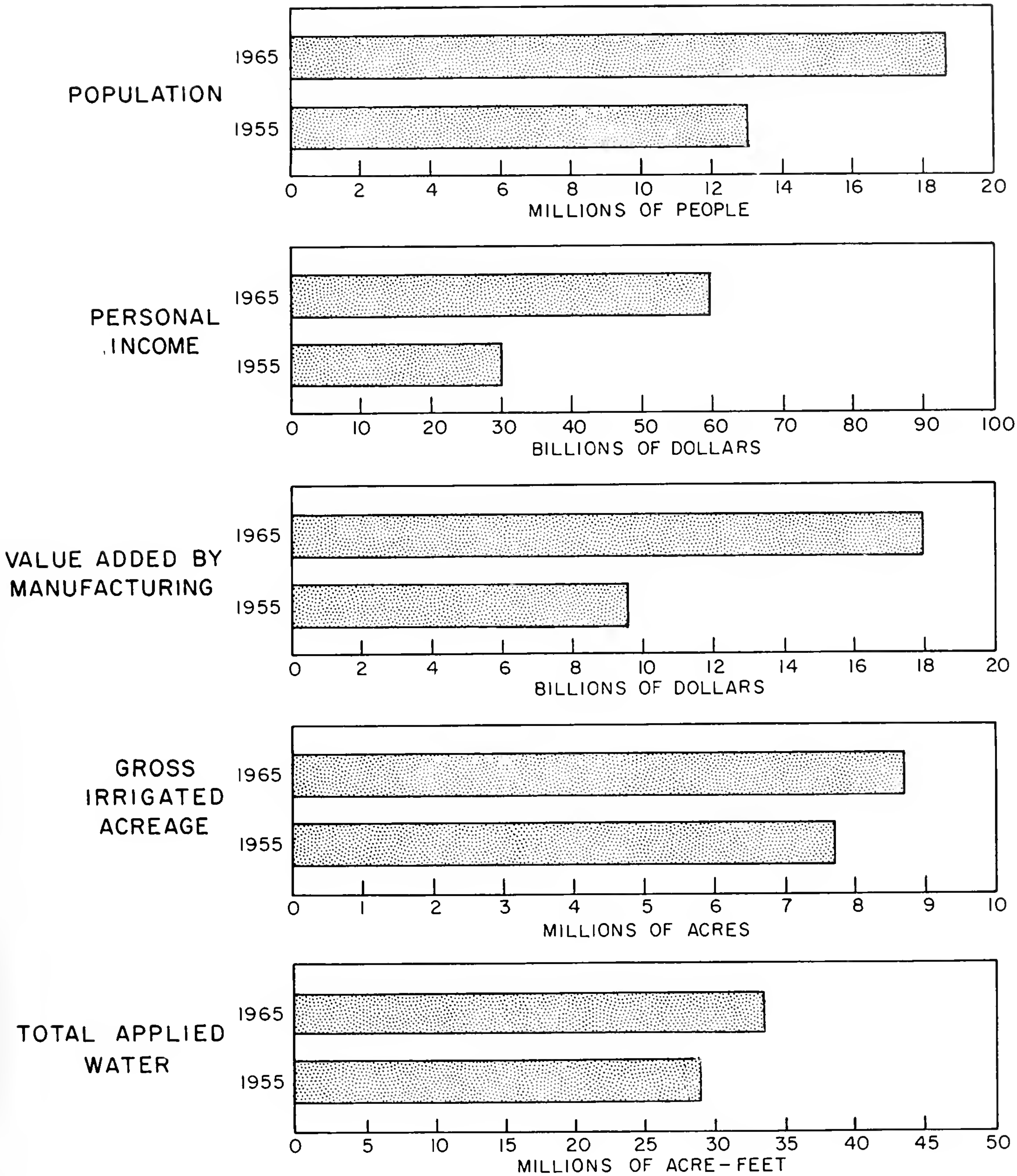
During the last 10 years in California, all areas of activity, including employment, personal income, construction, retail sales, corporate profits and cash farm receipts have advanced to higher levels. California's growth in several of these areas, from 1956 through 1965, and the resulting increase of statewide water requirements, are discussed in the following paragraphs. Figure 1 presents this information graphically.

Population, Personal Income and Manufacturing

Since the Gold Rush, this State has experienced perhaps the greatest mass migration in the history of man. There is no sign of a halt in the trek westward that stops at the Pacific shore. The tempo of the migration of the past decade has, in fact, exceeded that of any other like period.

Net migration into California has averaged about 350,000 persons annually since the end of 1955. This 10-year increase through migration of about 3.5 million persons has been augmented by another 2.25 million as a result of natural increase within the State. The total growth during the past decade, of approximately 5.75 million people, represents an increase of almost 45 percent over the estimated 1955 population of 13 million. California is now the most populous State in the United States with a 1965 total population of 18.75 million.

FIGURE I



CALIFORNIA'S ECONOMIC GROWTH 1955-1965

The growth of population has directly affected the water requirements of urban areas. Through increasing the demands for farm products, it has also contributed to the growth of agricultural water requirements.

The personal income of California residents was reported to be 30.2 billion dollars in 1955. Ten years later it has almost doubled. This has been an important factor in the growth of domestic water requirements and of outdoor recreational activities. The latter has led to increased emphasis on water-oriented recreation at water development projects.

Since the end of World War II, in 1945, California's industrial growth has been continuous. Total value added by manufacturing in California increased from 9.6 billion dollars in 1955 to about 18 billion dollars in 1965. Although many of the industries experiencing this growth have relatively low water requirements, overall industrial expansion produced a substantial increment in total industrial water demands in the State during this period.

Agriculture

Agriculture is one of the principal industries of the State. California farmers have marketed annually more than three billion dollars worth of agricultural products for the past seven years; the value of their production has surpassed that of farmers in any other state for the past 16 years. California has an excellent climate, with soils permitting the growth of a variety of crops, but man himself has been most important in this production achievement. Much of California's finest agricultural land lies in semiarid zones and, during the major growing season, rainfall is insufficient for crop production. Irrigation has made the difference. Approximately 95 percent of the tonnage being harvested in California receives some supplemental water.

During the past 10 years, about one million acres of additional irrigated land has been brought into production, bringing the State's total to over 8.5 million acres. One of the more important aspects of this growth, especially as it affects planning for water development, has been the regional shifts in agricultural expansion. The enormous growth of the metropolitan areas in California (principally Los Angeles and San Francisco Bay) has forced thousands of acres out of agricultural production. To a great extent this loss has been the Central Valley's gain, especially in the San Joaquin and Tulare Basins. The latter area alone has accounted for about one-half the increase in irrigated acreage during the past 10 years.

Besides the development and expansion of irrigated agriculture, the technological revolution that is taking place on the American farm has brought about astonishing gains in crop production. Although this agricultural revolution began only 30 years ago, when mechanical farming became widespread, the past decade has seen farm output rise more than in any decade since the turn of the century. The reason has not been so much the increased inputs of land and labor (the latter has actually been declining for the past several years) as it has been the increase in the efficiency with which the resources have been applied.

In 1900 one farm worker was producing enough for about seven people. Fifty years later the figure was around 15. Since 1950, it has almost doubled again.

The fact that less land and water are now needed for the same quantity of output has directly influenced the need for water resources projects.

Increases in Statewide Water Demands

The increases in water demands during the past decade reflect the growth in population, industry and irrigated agriculture. At the end of 1955, total statewide applied water for all purposes was approximately 28.9 million acre-feet. Since then, water demands have increased by about 470,000 acre-feet annually to a total of 33.6 million acre-feet in 1965.

Municipal and industrial requirements have grown significantly during the decade, increasing from an estimated 2.7 million to 3.9 million acre-feet. About two-thirds of the increase has been caused by growth in population and, to a lesser extent, by a rise in per capita consumption. Industrial development has accounted for the remaining one-third.

From 1955 to 1965, applied agricultural water requirements increased from 26.2 million acre-feet to 29.7 million acre-feet. Although this increase, measured in percentages, is considerably less than that for municipal and industrial demands, agriculture remains the largest user of water at 88 percent of the total.

One of the most significant aspects of the increasing demand for water is the change in character of use occurring in some parts of the State. In the South Coastal area, for example, agricultural water requirements are decreasing while urban needs are rapidly expanding. In 1955 agriculture accounted for approximately one-half of all water requirements in the area. This requirement was only 35 percent in 1965. Similarly, the municipal and industrial use of water has increased substantially in the San Francisco Bay area. Municipal and industrial requirements are now one-half again as large as they were in 1955 and constitute more than 60 percent of the region's total water requirements.

Tulare Basin has had a substantial growth in irrigated agriculture. Annual applied water requirements for this purpose increased approximately 1.5 million acre-feet between 1955 and 1965, to over eight million acre-feet. Urban uses tripled from 1955 to 1965, but are still only four percent of the total use. In the Sacramento and San Joaquin River Basins, annual agricultural water requirements have increased by more than two million acre-feet during the 10-year period. Municipal and industrial usage is approximately 500,000 acre-feet.

Ten-Year Chronology of Water Project Development

Many of the features proposed in The California Water Plan have been built during the past 10 years. Approximately 2.1 billion dollars were spent during the decade for major water development. This included beginning construction of the State Water Project, major extensions to the federal Central Valley Project, other federal reclamation and flood control projects, and continuing development by local water agencies and public and private utilities. Federal agencies spent slightly over one billion dollars and the State spent about 600 million dollars. Table 1 summarizes the estimated total annual state and federal expenditures. In addition, local water agencies and public and private utilities spent about 500 million dollars.

Major reservoirs completed during the last 10 years or now under construction are shown in Table 2. Figure 2 shows the locations of these projects. The capacities of these reservoirs total more than 16 million acre-feet.

Table 3 shows the major water conveyance facilities completed during the 10-year period or now under construction. When all of those facilities are fully operable, the total water delivery capability will be increased by approximately six million acre-feet per year.

Locations of the reservoir and conveyance features shown in Tables 2 and 3 are depicted on the eleven even-numbered figures from Figure 8 through 28 in Chapter II.

TABLE 1

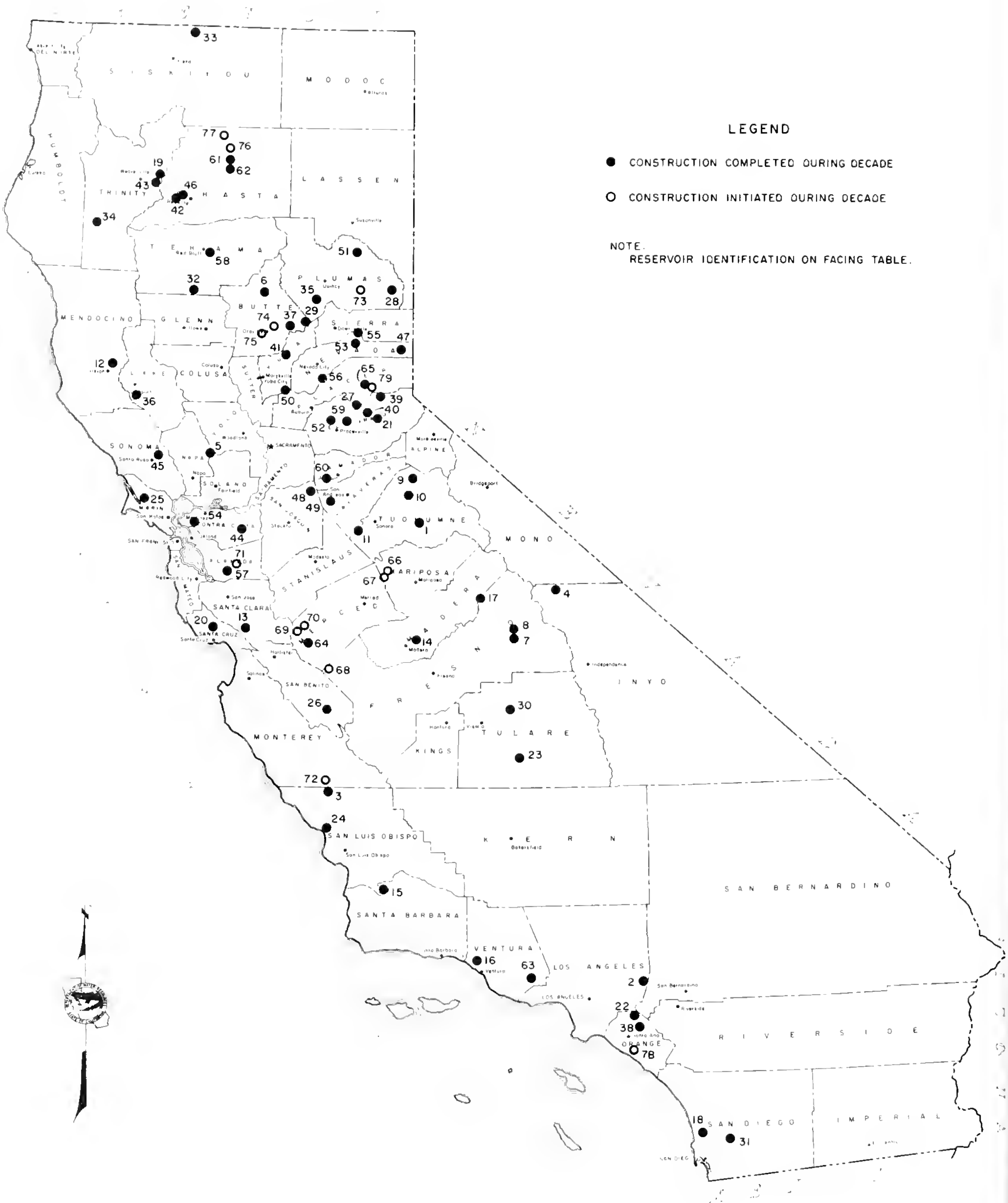
SUMMARY OF EXPENDITURES FOR WATER DEVELOPMENT IN CALIFORNIA
BY PRINCIPAL FEDERAL AND STATE AGENCIES
1956-1965

(for construction and planning only
in thousands of dollars)

Fiscal year	California Department of Water Resources	Bureau of Reclamation U. S. Department of the Interior	U. S. Army Corps of Engineers 1/	Totals
1955-56	2,723	27,352	25,973	56,048
57	4,929	45,000	32,960	82,889
58	7,803	47,000	41,328	96,131
59	16,332	56,027	47,036	119,395
60	35,407	52,196	46,262	133,865
1960-61	48,914	74,037	43,384	166,335
62	36,772	72,360	40,178	149,310
63	56,383	64,144	43,844	164,371
64	146,317	59,280	32,979	238,576
65	246,954 2/	60,100 2/	45,000 2/	352,054 2/
TOTALS	602,534	557,496	398,944	1,558,974

1/ Expenditures for navigation and beach erosion not included.
2/ Estimated.

FIGURE 2



RESERVOIR DEVELOPMENT IN CALIFORNIA
1956 TO 1965

TABLE 2

TEN-YEAR CHRONOLOGY OF MAJOR
RESERVOIR DEVELOPMENT IN CALIFORNIA[1/]
1956-1965

Map key No.	Completion date	Reservoir	Agency[2/]	Gross storage acre-feet	Stream	Use[3/]
1	1956	Cherry Valley	C&CSF	268,000	Cherry Creek	W P R
2		San Antonio	USCE	9,110	San Antonio Creek	F
3	1957	Nacimiento	MCFC&WCD	350,000	Nacimiento River	W F R
4		Pleasant Valley	CLA	3,825	Owens River	W P
5		Lake Berryessa	USBR	1,600,000	Putah Creek	W R
6		Paradise	PID	6,430	Little Butte Creek	W R
7	1958	Wishon	PG&E	128,000	North Fork Kings River	P R
8		Courtright	PG&E	123,300	Helms Creek	P R
9		Donnells	O&SSJID	64,500	Middle Fork Stanislaus River	W P R
10		Beardsley	O&SSJID	97,500	Middle Fork Stanislaus River	W P R
11		Tulloch	O&SSJID	68,400	Stanislaus River	W P R
12		Lake Mendocino	USCE	122,500	East Fork Russian River	W F R
13		Uvas	SSVWCD	10,000	Uvas Creek	W R
14		Madera Lake	SDFG	4,700	Fresno River	R
15		Twitchell	USBR	250,000	Cuyama River	W F R
16	1959	Casitas	USBR	250,000	Coyote Creek	W F R
17	1960	Mammoth Pool	SCE	123,000	San Joaquin River	W P R
18		Miramar	CSD	7,250	Big Surr Creek	W
19		Clair Engle Lake	USBR	2,500,000	Trinity River	W P R
20		Loch Lomond	CSC	8,400	Newell Creek	W R
21		Ice House	SMUD	45,960	South Fork Silver Creek	P R
22		Carbon Canyon	USCE	7,220	Carbon Canyon Creek	F
23	1961	Success	USCE	80,000	Tule River	W F R
24		Whale Rock	DWR	40,000	Old Creek	W

TABLE 2 (Continued)

TEN-YEAR CHRONOLOGY OF MAJOR
RESERVOIR DEVELOPMENT IN CALIFORNIA[1/]
1956-1965

Map key No.	Completion date	Reservoir	Agency[2/]	Gross storage acre-feet	Stream	Use[3/]
25	1961	Nicasio	MMWD	22,500	Nicasio Creek	W R
26		Hernandez	SBFC&WCD	18,000	San Benito River	W R
27		Lake Edson	GDPUD	20,000	Pilot Creek	W R
28		Frenchman	DWR	54,400	Little Last Chance Creek	W R
29		Sly Creek	OWID	65,050	Lost Creek	W P R
30	1962	Terminus	USCE	150,000	Kaweah River	W F R
31		Chet Harritt	HID	10,500	Quail Canyon Creek	W R
32		Black Butte	USCE	160,000	Stony Creek	W F R
33		Iron Gate	PP&LC	58,000	Klamath River	P R
34		Ruth	HBMUD	51,800	Mad River	W R
35		Little Grass Valley	OWID	93,010	South Fork Feather River	W P R
36		Highland Creek	LCFC&WCD	3,500	Highland Creek	W F R
37		Ponderosa Diversion	OWID	4,750	South Fork Feather River	W P
38	1963	Villa Park	OCFC&WCD	15,600	Santiago Creek	F
39		Loon Lake	SMUD	76,500	Gerle Creek	W P R
40		Union Valley	SMUD	271,000	Silver Creek	P R
41		Merle Collins	BVID	57,000	French Dry Creek	W R
42		Whiskeytown	USBR	250,000	Clear Creek	W P R
43		Lewiston	USBR	14,600	Trinity River	W P R
44		Marsh Creek	CCCFC&WCD	4,425	Marsh Creek	F
45		Spring Lake	SCFC&WCD	3,550	Santa Rosa Creek Tributary	F
46		Spring Creek	USBR	5,874	Spring Creek	D
47	1964	Prosser Creek	USBR	30,000	Prosser Creek	W R
48		Camanche	EBMUD	431,500	Mokelumne River	W F R
49		New Hogan	USCE	325,000	Calaveras River	W F R

TABLE 2 (Continued)

TEN-YEAR CHRONOLOGY OF MAJOR
RESERVOIR DEVELOPMENT IN CALIFORNIA[1/]
1956-1965

Map key No.	Completion date	Reservoir	Agency[2/]	Gross storage acre-feet	Stream	Use[3/]
50	1964	Camp Far West	SSWD	150,000	Bear River	W R
51		Antelope	DWR	21,600	Indian Creek	R
52		Chili Bar	SMUD	3,700	South Fork American River	W P R
53		Faucherie	NID	5,000	Canyon Creek	W P R
54	1965	Briones	EBMUD	67,500	Bear Creek	W R
55		Jackson Meadows	NID	68,000	Middle Fork Yuba River	W P R
56		Rollins	NID	66,000	Bear River	W P R
57		James H. Turner	C&CSF	50,500	San Antonio Creek	W
58		Red Bluff Diversion	USBR	1,900	Sacramento River	W R
59		Slab Creek	SMUD	16,600	South Fork American River	P R
60		Jackson Creek	JVID	22,000	Jackson Creek	W
61		Pit No. 6	PG&E	15,700	Pit River	P
62		Pit No. 7	PG&E	34,000	Pit River	P
63		Wood Ranch	CMWD	10,000	Arroyo Simi Tributary	W
64		Los Banos Creek	DWR-USBR	34,500	Los Banos Creek	F
65		French Meadows	PCWA	133,700	Middle Fork American River	W P R
66	Under construction	New Exchequer	MID	1,026,000	Merced River	W P F R
67		McSwain	MID	9,480	Merced River	W P R
68		Little Panoche Creek	DWR-USBR	5,600	Little Panoche Creek	F
69		San Luis	DWR-USBR	2,095,000	San Luis Creek	W P R
70		San Luis Forebay	DWR-USBR	58,000	San Luis Creek	W P R
71		Del Valle	DWR	78,500	Arroyo del Valle	W F R
72		San Antonio	MCFC&WCD	350,000	San Antonio River	W F R
73		Lake Davis	DWR	83,000	Big Grizzly Creek	W R
74		Oroville	DWR	3,484,000	Feather River	W P F R

TABLE 2 (Continued)

TEN-YEAR CHRONOLOGY OF MAJOR
RESERVOIR DEVELOPMENT IN CALIFORNIA1/
1956-1965

Map key No.	Completion date	Reservoir	Agency2/	Gross storage acre-feet	Stream	Use3/
75	Under con-	Thermalito Diversion	DWR	13,400	Feather River	P R
	struc-	Thermalito Forebay	DWR	11,400		P R
	tion	Thermalito Afterbay	DWR	57,500		P R
76		Iron Canyon	PG&E	24,300	Cedar Salt Log Creek	P
77		McCloud	PG&E	35,300	McCloud River	P
78		San Joaquin	IRWD	3,036	Bonita Creek Tributary	W
79		Hell Hole	PCWA	208,400	Middle Fork American River	W P R

1/ Exclusive of reservoirs having capacities less than about 2,000 acre-feet and of those constructed by private individuals.

2/ Abbreviations:

BVID - Browns Valley Irrigation District
CCCFC&WCD - Contra Costa County Flood Control and Water Conservation District
C&CSF - City and County of San Francisco
CLA - City of Los Angeles
CMWD - Calleguas Municipal Water District
CSC - City of Santa Cruz
CSD - City of San Diego
DWR - Department of Water Resources
EBMUD - East Bay Municipal Utility District
GDPUD - Georgetown Divide Public Utility District
HBMWD - Humboldt Bay Municipal Water District
HID - Helix Irrigation District
IRWD - Irvine Ranch Water District
JVID - Jackson Valley Irrigation District
LCFC&WCD - Lake County Flood Control and Water Conservation District
MCFC&WCD - Monterey County Flood Control and Water Conservation District
MID - Modesto Irrigation District

TABLE 2 (Continued)

2/ Abbreviations (Continued)

MMWD - Marin Municipal Water District
NID - Nevada Irrigation District
OCFCD - Orange County Flood Control District
O&SSJID - Oakdale and South San Joaquin Irrigation District
OWID - Oroville-Wyandotte Irrigation District
PCWA - Placer County Water Agency
PG&E - Pacific Gas and Electric Company
PID - Paradise Irrigation District
PP&LC - Pacific Power and Light Company
SBCFC&WCD - San Benito County Flood Control and Water Conservation District
SCE - Southern California Edison Company
SCFC&WCD - Sonoma County Flood Control and Water Conservation District
SDFG - State Department of Fish and Game
SMUD - Sacramento Municipal Utility District
SSCVWCD - South Santa Clara Valley Water Conservation District
SSWD - South Sutter Water District
USBR - U. S. Bureau of Reclamation
USCE - U. S. Army Corps of Engineers

3/ Abbreviations: W-Water Supply, P-Power, F-Flood Control, R-Recreation, D-Debris Control.

TABLE 3

MAJOR CONVEYANCE SYSTEMS COMPLETED OR
UNDER CONSTRUCTION 1956-1965

System	Responsible agency	Length (miles)	Capacity at intake (cfs)	Status[1]
California Aqueduct				
North San Joaquin Division	Department of Water Resources	62.0	10,000	U. C.
San Luis Division	Department of Water Resources and Bureau of Reclamation	101.4	13,100	U. C.
South San Joaquin Division	Department of Water Resources	120.0	8,100	U. C.
Tehachapi Division	Department of Water Resources	11.7	4,100	U. C.
East Branch Division	Department of Water Resources	138.2	1,477	U. C.
West Branch Division	Department of Water Resources	22.2	3,123	U. C.
Coastal Branch Division[2]	Department of Water Resources	14.8	450	U. C.
Colorado River Aqueduct Enlargement	The Metropolitan Water District of Southern California	242.0	1,605[3]	1960
Corning Canal	Bureau of Reclamation	21.0	500	1960
Hetch Hetchy Aqueduct Enlargement	City and County of San Francisco	93.7	455[3]	U. C.
Los Angeles Aqueduct Enlargement	City of Los Angeles	176.0	210[4]	U. C.
Mokelumne Aqueduct No. 3	East Bay Municipal Utility District	80.0	192	1965
Putah South Canal	Bureau of Reclamation	33.3	956	1957

TABLE 3 (Continued)

MAJOR CONVEYANCE SYSTEMS COMPLETED OR UNDER CONSTRUCTION 1956-1965

System	Responsible Agency	Length (miles)	Capacity at intake (cfs)	Status 1/
Second San Diego Aqueduct	The Metropolitan Water District of Southern California	33.7	1,000	1960
Second San Diego Aqueduct	San Diego Water Authority	59.0	250	1960
South Bay Aqueduct	Department of Water Resources	43.7	300	1965
Tehama-Colusa Canal	Bureau of Reclamation	122.0	2,300	U. C.

1/ Legend: U. C. - under construction; 1960 etc. - completion date.
2/ Portion from the main line of the California Aqueduct to the Devil's Den Pumping Plant.
3/ Total capacity after enlargement.
4/ Capacity of enlargement.

The State Water Project

One of the most significant events in the decade was passage by the State Legislature of the California Water Resources Development Bond Act (Stats. 1959, Ch. 1762). This measure, commonly known as the Burns-Porter Act, was approved by the voters in November 1960. It provided the principal financial base for construction of the State Water Project.

Construction under special legislative appropriations began in 1957. Antelope and Frenchman Reservoirs and the South Bay Aqueduct are in operation,and work is completed or in progress in every other major subdivision of the project.

The total capital cost of the project features now authorized for construction is estimated at about 2.5 billion dollars. The project will provide municipal, industrial, and irrigation water supplies; provide flood control; improve recreation and fish and wildlife; and provide water quality control and drainage. It will also produce for sale substantial amounts of hydroelectric power but, considering pumping requirements, will consume more power than it generates. Its primary purpose is to make available 4.23 million acre-feet of water each year, approximately three-quarters of which will be for muncipal and industrial purposes and one-quarter for agriculture. The metropolitan areas to be served by the project contain 66 percent of the population of California. The major agricultural service area includes about 850,000 acres in the San Joaquin and Tulare Basins.

DOS AMIGOS PUMPING PLANT - SAN LUIS CANAL

This portion of the California Aqueduct, designated the San Luis Canal, is a joint-use facility of the State Water Project and federal Central Valley Project. At this location, the aqueduct has a capacity of 13,100 cubic feet per second.

The Central Valley Project

Two major extensions of the federal Central Valley Project have received congressional authorization since 1956. These are the San Luis Unit (authorized in 1960) and the Auburn-Folsom South Unit (authorized in September 1965). Major construction of the Trinity River Division (authorized in August 1955) was completed in 1964. Construction of the Sacramento Canals Unit (authorized in 1951) is under way.

During the decade, water deliveries from the Central Valley Project increased by almost 30 percent to over 2.8 million acre-feet in 1964, the latest year for which complete statistics are available. Power generation nearly doubled and approximately 4.5 billion kilowatt hours of energy was produced in 1964. The addition of the San Luis, Sacramento Canals, and Auburn-Folsom South Units will increase the potential service area of the project to approximately 2.5 million acres.

Other Major Projects

The Corps of Engineers completed Coyote Dam and Lake Mendocino on the Russian River in 1958, Success Reservoir on the Tule River in 1961, Terminus Reservoir on the Kaweah River in 1962, Black Butte Reservoir on Stony Creek in 1963, and New Hogan Reservoir on the Calaveras River in 1964. The Corps also continued work on levee systems, channel work for flood control and navigation and beach erosion projects.

The Bureau of Reclamation completed the Solano Project in Napa, Solano and Yolo Counties, consisting of Lake Berryessa and the Putah-South Canal. It completed Twitchell Reservoir on the Cuyama River near Santa Maria, Cachuma Reservoir on the Santa Ynez River and conveyance facilities to the Santa Barbara area, and Casitas Reservoir for offstream storage of Ventura River water.

Water resource development by local water agencies and public and private utilities during the 10-year period was extensive. Examples of such developments are the Sacramento Municipal Utility District's Upper American River Development; expansion of the Nevada Irrigation District's system on the Yuba and Bear Rivers; completion or expansion of the Pacific Gas and Electric Company's North Fork Kings River, Pit River, Feather River and Stanislaus River systems; the Oakdale and South San Joaquin Irrigation Districts' Tri-Dam Project on the Stanislaus River; additions to the East Bay Municipal Utility District's Mokelumne River Project; and the final stage enlargement of The Metropolitan Water District of Southern California's Colorado River Aqueduct. The features of many other similar projects are listed in Tables 2 and 3.

Local Assistance Programs

During the 1956-1965 decade the State and Federal Governments provided over 200 million dollars of direct financial assistance to local agencies for various types of water projects. This was accomplished through programs existing in 1956 and through new programs started during the decade.

State Programs

California provides direct financial assistance to local agencies under the Administration of Flood Control Funds program and the Davis-Grunsky program.

The Administration of Flood Control Funds program has been very active during the last decade. From 1956 through 1965 approximately 100 million dollars for about 40 different projects was disbursed. Projects eligible for state financial assistance in acquiring lands, easements, and right-of-ways under this program include (1) major flood control projects constructed under specific federal authorization; (2) small flood control projects constructed under the basic authority of PL 80-858, as amended; and (3) watershed protection projects constructed under the provisions of PL 83-566.

The Davis-Grunsky program provides direct financial assistance to local agencies which construct water development projects. The Burns-Porter Act provided that 130 million dollars of the bonds authorized by the Act should be used to finance the Davis-Grunsky program.

Since 1957, the Department of Water Resources has received 102 requests for preliminary determination of eligibility. There have been 39 formal applications resulting from the requests. Thirty, involving funds in excess of 25 million dollars, have been approved. Five formal applications for large grants are being reviewed.

Federal Programs

Several federal programs which provide for direct financial assistance to local agencies in connection with water projects were enacted at the start of the last decade. Two relate to irrigation projects and are administered by the Bureau of Reclamation. A third program concerns watershed protection projects and is administered by the Soil Conservation Service.

Public Law 84-130 provides for financial assistance by the Federal Government to irrigation districts and other public agencies for construction of distribution systems on federal reclamation projects. Since 1957 approximately 35 million dollars has been loaned under this program.

Public Law 84-984 provides financial assistance to local agencies for the construction of small water projects for irrigation and municipal-industrial purposes. Since 1960, approximately 29 million dollars has been loaned under this program.

Under the basic authority of Public Law 83-566, the Soil Conservation Service provides direct financial assistance to local agencies for the construction of small watershed projects. Authorized purposes of the projects may include watershed protection, flood prevention, water conservation, distribution, drainage, wildlife enhancement, and recreation. Approximately 18 million dollars of financial assistance has been provided under this program during the decade.

Ground Water Development

Although less dramatic than surface water development, ground water development has furnished much of the water used in California .

There has been significant growth of ground water use in the past decade. Annual increases in ground water pumpage have averaged 300,000 to 400,000 acre-feet. In 1955, ground water supplied an estimated 12 million acre-feet of the 28.9 million acre-feet used, and, in 1965, it furnished about 16 million of the 33.6 million acre-feet used. Over 10 million acre-feet of the 1965 pumpage came from San Joaquin Valley ground water basins. There were two million acre-feet pumped in the Sacramento Valley and nearly 2.5 million acre-feet pumped in Southern California in 1965.

Accelerated ground water use has intensified many problems, but progress has been made in finding solutions. Water importation to some basins has been increased because of ground water overdraft. Hydraulic barriers to stop sea water intrusion into coastal ground water basins are being installed in Los Angeles, Orange and Ventura Counties. The barriers are lines of recharge wells near the ocean. Proposed statewide standards and local standards for several areas have been formulated to prevent construction of defective wells or inadequate sealing of abandoned wells, which could let poor quality surface or ground water degrade ground water supplies. These standards have not yet been adopted by the responsible agencies.

Conjunctive operation, or the coordinated operation of surface reservoirs with underground storage basins, has been advanced by application of new electronic computer techniques.

RIO HONDO SPREADING GROUNDS

California ground water basins represent invaluable storage reservoirs. Since the early 1900's, spreading grounds have been developed to facilitate recharge of the basins. The water being spread above has been imported from the Colorado River.

This type of operation can minimize ground water problems and enhance the composite yield of available water supplies.

Electric Power Development

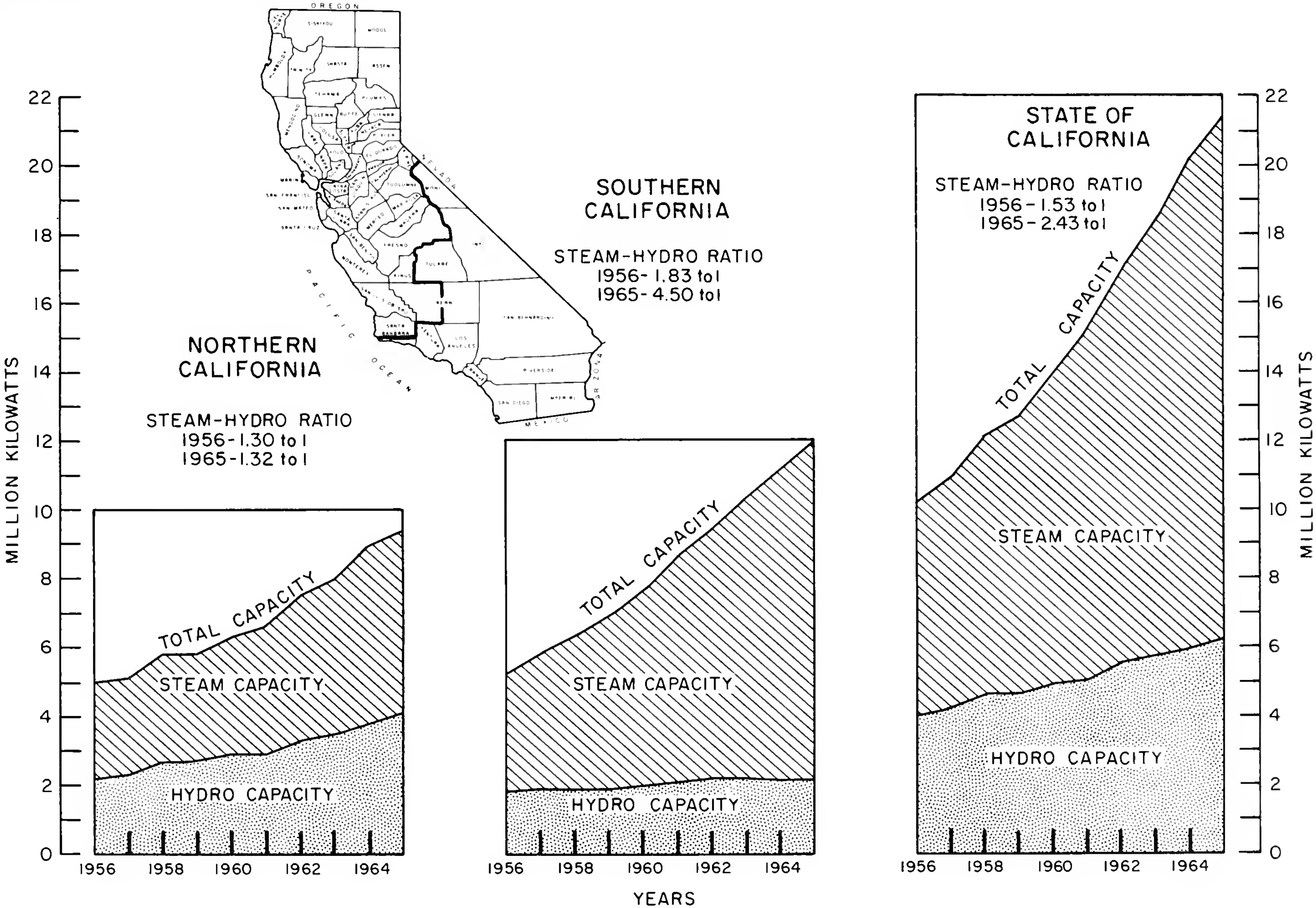
During the last decade, the use of power has grown at a phenomenal rate. There have been a number of important technological changes in power development.

From 1956 to 1965, California's total installed electric generating capacity more than doubled, rising to 21.3 million kilowatts. This rate of expansion was substantially greater than the population growth rate and indicates growing industrialization and increasing uses for electricity.

Figure 3 shows the 10-year increases in installed steam-electric and hydroelectric generating capacity for Northern and Southern California and for the State. New hydroelectric plants accounted for about 20 percent of the State's increase in capacity. About 90 percent of these plants serve Northern California. More than 95 percent of the new capacity for Southern California is in steam-electric plants. This shows that most of the conventional hydroelectric opportunities available to Southern California were developed before 1956.

The technological advances in the generation and transmission of electricity during the decade significantly lowered power costs. The impact upon future planning of water resource development is discussed in Chapter II.

FIGURE 3



INSTALLED GENERATING CAPACITY, STATE OF CALIFORNIA

Important Legislation and Court Decisions

From 1956 through 1965 more important legislative acts and court decisions affecting water development in California were completed than in any previous decade.

Legislation

Important legislation has been enacted on both the state and federal levels to round out authorities of water project planning and construction agencies and to set policy in fields related to water development.

There has been much California legislation in the last 10 years that pertains to implementation of The California Water Plan. The Plan was adopted as a general guide for the orderly and coordinated development and utilization of the water resources of the State (Stats. 1959, Ch. 2053). The Burns-Porter Act (Stats. 1959, Ch. 1762) authorized and made appropriations for the State Water Project. The Davis-Grunsky Act (Stats. 1959, Ch. 1752) presents policies and procedures for state financial assistance to projects of local agencies. Under the Davis-Dolwig Act (Stats. 1961, Ch. 867), the Legislature declared that recreation and enhancement of fish and wildlife are among the purposes of state water projects and are to be supported by appropriations from the General Fund. The Porter-Dolwig Act (Stats. 1961, Ch. 1620) declared that the people of the State have a primary interest in the correction and prevention of damage to ground water basins and appropriated funds for study of projects to protect such basins. Pursuant to the Cobey-Alquist

Flood Plain Management Act (Stats. 1965, Ch. 506), the Legislature encouraged local agencies to regulate land use in floodplains. The Cobey-Porter Saline Water Conversion Act (Stats. 1965, Ch. 993) augmented the Department's basic authority to engage in saline water conversion activities, and granted additional authority to finance, construct, and operate saline water conversion facilities, either independently or in cooperation with public and private agencies, upon specific legislative authorization.

In addition, statutes to expand state participation in federal flood control projects were enacted, further steps were taken to preserve the qualities of both surface and ground waters, provision for state participation in regional water planning activities was made, and state jurisdiction over dams and reservoirs was expanded.

Federal legislation has generally emphasized research and planning and has broadened areas of federal cooperation with state and local agencies. Through the Water Supply Act of 1958 (85-500, 72 Stat. 297), federal agencies were authorized to participate and cooperate in developing local water supplies. Under the Water Resources Research Act of 1964 (88-379, 78 Stat. 329), provision was made for research centers or institutes. The Water Resources Planning Act of 1965 (89-80, 79 Stat. 250) established a Water Resources Council to oversee plans, policies and programs of national and regional character and provided the mechanism for setting up river basin commissions to plan developments in their respective areas. The Water Pollution Control Act of 1956

(84-660, 70 Stat. 498) declared that the states have primary responsibility in preventing and controlling water pollution and provided federal financial assistance or services in related technical research. The Water Quality Act of 1965 (89-234, 79 Stat. 903) provided for the establishment and administration of water quality standards for interstate waters and increased federal grants for sewage treatment plants and studies of waste water disposal. The Federal Water Project Recreation Act of 1965 (89-72, 79 Stat. 213) provides for recreation and fish and wildlife enhancement at federal water resources projects, together with rules and cost-sharing criteria related to those purposes.

Expanded federal programs have also been authorized in desalination, assistance to local projects, and electric power transmission.

An important policy statement of the United States was approved by the President in 1962 and published as Senate Document No. 97, 87th Congress. This document sets forth policies, standards and procedures to govern federal agencies in the formulation, evaluation and review of plans for use and development of water and related land resources. It expands guidelines in such matters as interest rates, period of analysis, benefits to be considered, accounting for conditions of underemployment, price levels and treatment of taxes.

Court Decisions

The decree of the U. S. Supreme Court in Arizona v. California, issued on March 9, 1964, was one of the most important events in the California water picture to occur since The California Water Plan was published.

The decree resulted from a suit brought by Arizona in 1952 to settle differences of interpretation of the Colorado River Compact of 1922, the Boulder Canyon Project Act of 1928, and related documents, as these would affect water supplies for the Central Arizona Project.

The Court ruled that apportionment among the Lower Basin States of Arizona, California and Nevada would apply to water from the main stream of the Colorado River only. The sole use of the Gila River was assigned to Arizona and New Mexico. The Court awarded 4.4 million acre-feet per year to California, 2.8 million acre-feet to Arizona, and 0.3 million acre-feet to Nevada. These awards were contingent upon 7.5 million acre-feet being available to the Lower Basin. In the event of an annual supply of less than 7.5 million acre-feet the decree left the allocation to the Secretary of the Interior or to future Congressional action.

The California Water Plan was developed on the premise that contracts for a total of 5.362 million acre-feet per year from the Colorado River would be honored. The decree has reduced this amount by almost one million acre-feet. About two-thirds of the loss will be replaced with additional importations from Northern California and the Owens Valley. The California Water Plan must be modified to supply the remaining one-third, and to allow for Lower Basin supplies dropping below 7.5 million acre-feet per year.

Studies indicate that the supply available to the Lower Basin will be less than six million acre-feet if the average flow for a period like 1930 to 1965 should be repeated. This recognition that there is not enough water available from the Colorado River to supply the long-range needs of the Colorado River Basin states has led to consideration of ways to augment the supply from that stream.

Several other court decisions will influence water planning. The decision of the California Supreme Court in Warne v. Harkness (1963), 60 Cal. 2d 579; 35 Cal. Reptr. 601; 387 P. 2d 377, held that authority was provided under the water code provisions governing the Central Valley Project to issue revenue bonds for financing the costs of power facilities in the Oroville Division of The State Water Project. In California Water Resources Development Finance Committee v. Betts (1963), 60 Cal. 2d, 595, 387 P 2d 387, a companion case to Warne v. Harkness, supra, the State Supreme Court's decision allows revenues from water and power marketing contracts under the presently authorized State Water Project to be used to support bond issues in addition to Burns-Porter bonds if required to construct additional features of that project or of the State Water Resources Development System to meet growing water requirements in California.

In Dugan v. Rank (1963), 372 U. S. 609, 83 Sup. Ct. 999, 16 L ed 2d 15, the Supreme Court of the United States decided that the Federal Government might seize the water rights of landowners, providing it makes just compensation based on the value of the land before and after seizure. In the United States v. Fallbrook Public Utility District, et al (1965) 347 Fed. 2d 48, the Circuit

Court of Appeals upheld the right of the City of Fallbrook to construct a dam on the Santa Margarita River and indicated that if the Federal Government appropriates water under state law it must comply with that law.

The U. S. Supreme Court considered on appeal the case of Ivanhoe Irrigation District and the State of California v. McCracken, et al (1958), 357 U. S. 275, 78 S. Ct. 1174, 2 L ed 2 d 1313. It held that the 160-acre limitation on federal reclamation projects does apply in California.

Planning Activities

Since 1956, many planning studies have been conducted. Some of the features of The California Water Plan which should be implemented to meet the growth of demand for water project services have been defined by these studies. They have considered a number of physical, economic, budgetary, legal and social factors not fully evaluated in the Plan. These studies which are being made by state and federal agencies are discussed below.

State Agencies

The Department of Water Resources conducts broad planning activities directed toward statewide water development. Locally, demands for water supplies are projected, capabilities of local surface and ground water resources to meet the needs are estimated, and surplus water supplies or importation requirements are determined. Consideration is given to local needs for flood control, recreation, fish and wildlife enhancement, and other project services. Local demands for imported water and other services are integrated at the statewide level to determine large-scale facilities required to conserve and transport the water from basin to basin and to supply associated project services. Finally, investigations of specific conservation and transportation projects are undertaken to evaluate their accomplishments, costs, and feasibilities, and to select and define projects.

These are the only studies being made in California which consider all functions of water projects in all areas of the State to develop optimum plans.

Several other state agencies are concerned with water and land resources and with planning for future development. The Department of Fish and Game, under contract with the Department of Water Resources, evaluates the impact of state water projects on the fish and wildlife of affected areas and recommends water requirements associated with the preservation and enhancement of those resources. The Department of Fish and Game, in cooperation with the State Office of Planning in the Department of Finance, is also developing the "California Fish and Wildlife Plan" for the protection and enhancement of wildlife resources.

The Department of Parks and Recreation, through contracts with the Department of Water Resources, supplies advice and services in preparing recreation plans for features of the State Water Project and estimates future water project recreation needs. The Department of Parks and Recreation is also conducting a study, in cooperation with the State Office of Planning, to evaluate the need for all types of outdoor recreation and to determine how to meet such needs.

The Department of Conservation has responsibilities for development and utilization of the State's primary natural assets in forest, mineral and soil resources, and conducts investigations in all these areas.

The State Office of Planning is responsible for the preparation and periodic review and revision of a comprehensive long-range general plan for the physical growth and development of the State to be known as the "State Development Plan". It conducts this study with its own staff and with assistance from consultants and other departments of the State. The Department of Water Resources, in its statewide planning activities, contributes to the State Development Plan.

Federal Agencies

The Bureau of Reclamation conducts water resources planning, design and construction activities in California. Its planning activities are directed toward multiple-purpose water resource development. They begin with reconnaissance investigations of possible projects to meet estimated demands within selected service areas and culminate in definite project reports which define the feasibility and recommend congressional authorization and appropriation of funds.

The Bureau's major current planning activities in the State are focused mainly on additional local and transbasin diversion projects to extend the Central Valley Project. Proposed extensions would include service to additional areas on the Sacramento and San Joaquin Valley floors; to foothill areas adjoining those valleys; and to portions of Santa Clara, Santa

Cruz and Monterey Counties. The Bureau is also making reconnaissance and feasibility studies of projects in the North Coastal and San Francisco Bay areas. In Southern California it is investigating projects in Santa Barbara and Ventura Counties, and in the desert areas in the southeastern part of the State.

Planning programs of the U. S. Army Corps of Engineers are also oriented toward general multiple-purpose development of water resources. The three principal functions for which the Corps undertakes projects, however, are flood control, navigation and beach erosion control. Only flood control will be considered in this report. The Corps is working on planning investigations related to single-purpose flood control or multiple-purpose projects authorized by the Congress. The Corps also has a number of authorized investigations of such projects. Chapter II identifies the projects being studied.

The Soil Conservation Service is considering financial assistance to 35 projects under Public Law 566. This agency is also considering watershed management in the Eel River Basin and other drainage basins of the North Coastal area.

Interagency Planning Coordination

The widespread water resources planning, design and construction activities of the state and federal agencies in California indicate that coordination is necessary to avoid duplication and competition. To assist in such coordination, the California State-Federal Interagency Group was established in 1958. It is composed of the California Director of Water

Resources, as chairman; the Director of Region 2, Bureau of Reclamation; the Division Engineer, South Pacific Division, U. S. Army Corps of Engineers; and the State Conservationist, Soil Conservation Service.

A task force, composed of the planning chiefs of the respective agencies, is working toward reconciliation of differences among planning criteria and proposed plans of development. The task force has completed a comparison of economic criteria for project formulation and has developed the basis for coordination of reconnaissance level planning activities in the North Coastal area. It is currently working toward coordination of four-year feasibility level Eel River Basin planning investigations which may lead to formulation of one or more joint federal-state projects.

To avoid duplication of basic data, a data pool has been or will be established in each of the following areas: hydrology, geology, designs and cost estimates of alternative physical features, project formulation, in-basin water requirements, recreation potential, fisheries preservation and enhancement measures including flow requirements, and benefit evaluations. Each agency will use this information to make planning evaluations within its prescribed legal policy framework.

CHAPTER II. CALIFORNIA'S WATER REQUIREMENTS AND DEVELOPMENT OUTLOOK

This chapter presents the current projections by the Department of Water Resources of the State's economic growth to the year 2020 and the corresponding requirements for water supplies and other project services. It presents the available information on local and statewide water supplies and on yield capabilities of existing and authorized water development features. Additional projects required to meet water supply needs to the year 2000 are identified, and possible alternative means of supplying the needs thereafter are discussed. Present knowledge about projects needed to supply flood control and other project purposes is presented generally. Finally, the changing role of electric power in water development is described, and an indication of its impact upon projected power costs and power values is given.

With the exception of the projections of the part to be played by electric power, the analyses described were made with respect to the 11 hydrologic study areas of the State shown in Figure 4. These areas were selected because each of them has relatively homogeneous characteristics of streamflow, existing and potential local water development, and import requirements or export potential.

Projected Growth, 1960-2020

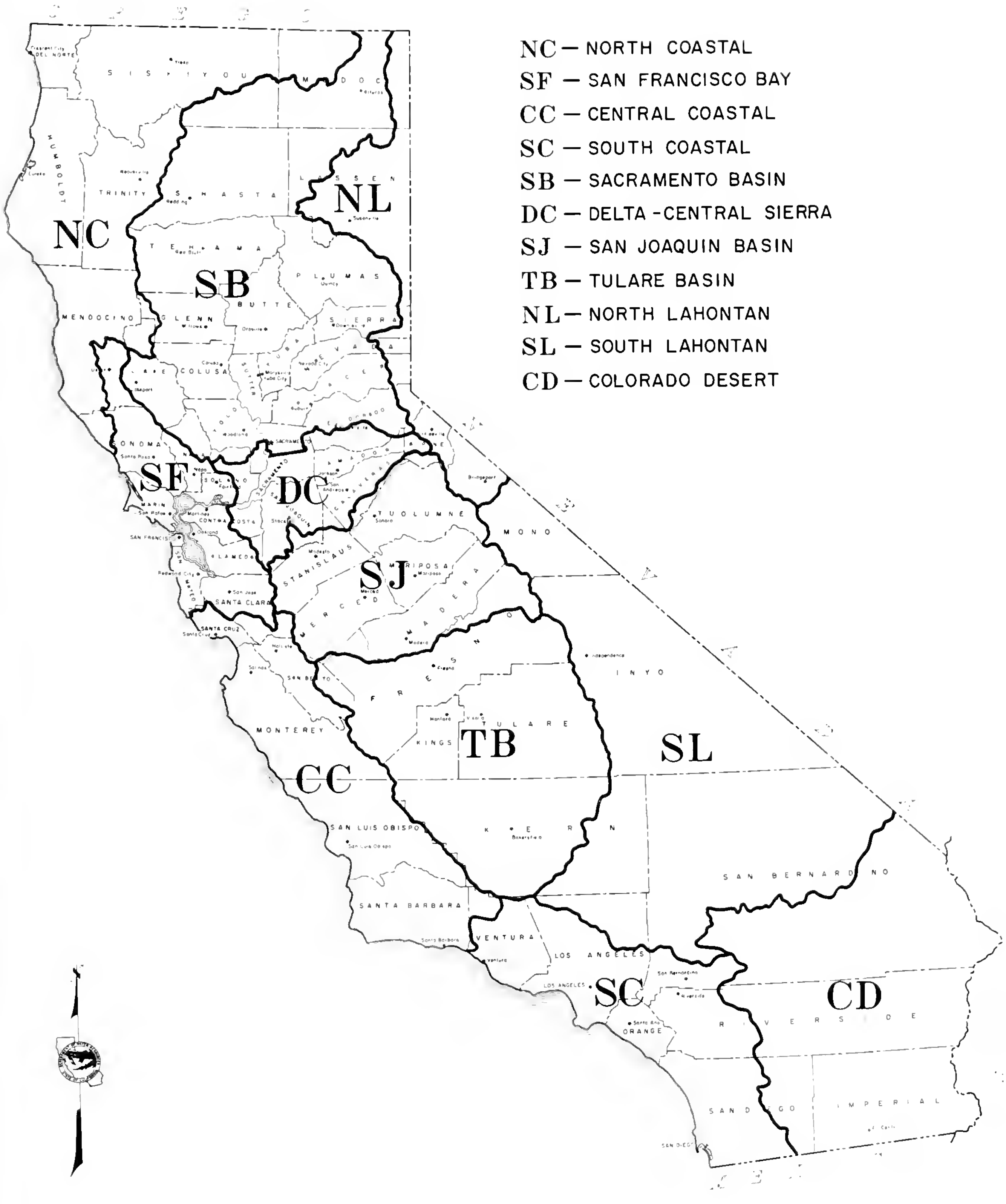
The growth California has experienced during the past 60 years is expected to continue over the next 60. While this further expansion holds great promise for sustaining a strong and vigorous economy, it also represents the State's greatest challenge. Problems associated with housing, education, jobs, transportation, water supply, air and water pollution, and other matters will require foresight and ingenuity in finding and implementing solutions.

The projected growth of the State to the year 2020 was based on historical trends, including the experience of the last 10 years described in Chapter I, and on the resources and growth potential of each hydrologic study area. These projections were used to estimate increases in requirements for water supply and other water project services.

Population and Urban Land Use

The population of California has approximately doubled in every 20-year period since 1860, except between 1880 and 1900. Accompanying this spectacular growth has been a drastic shift in population distribution between rural and urban areas. In 1860 only 20 percent of the population lived in urban areas, but by 1960, the proportion living in such areas had risen to about 86 percent. These changes have strongly influenced the pattern of water utilization in California.

FIGURE 4



HYDROLOGIC STUDY AREAS
OF CALIFORNIA

The long-range population projections made by the Department cover periods of 60 years or more. They have been derived, primarily, from data provided by the U. S. Bureau of the Census. Estimates and 20-year projections of the California Department of Finance, together with analyses of birth, death and migration rates, have also been utilized. Consideration has been given to such economic factors as industrial development and employment.

The population of the State and of the 11 hydrologic study areas for 1960 and the projections for 1990 and 2020 are shown in Table 4. These estimates for the State are also shown on Figure 6 and for the hydrologic study areas on the odd-numbered figures from Figure 7 through 27.

In 2020, California's population is expected to be 54 million. This represents an increase of 38 million over the 1960 figure. Slightly more than 50 percent of this increase will occur in the South Coastal and San Francisco Bay areas, with the remainder in the other, presently less populated, areas of the State. In 2020, the proportion of the State's population residing in these two metropolitan areas is expected to be only 63 percent compared to 77 percent in 1960.

Projections of total population and density of population were the principal factors used to estimate land area required for future urban development. Department estimates shown in Table 4 indicate that by 2020 nearly six million acres will be needed. It is estimated that, between 1960 and 2020, there will be an average annual increase of 65,000 acres. This

TABLE 4

SUMMARY OF 1960 AND PROJECTED POPULATION,
LAND USE AND IRRIGABLE LAND IN
HYDROLOGIC STUDY AREAS

Items	North Coastal	San Francisco Bay	Central Coastal	South Coastal	Sacramento Basin	Delta-Central Sierra	San Joaquin Basin	Tulare Basin	North Lahontan	South Lahontan	Colorado Desert	Totals for State
Population												
1960	187,000	3,560,000	568,000	8,551,000	932,000	357,000	349,000	830,000	27,000	179,000	177,000	15,717,000
1990	410,000	7,690,000	1,900,000	17,480,000	2,470,000	950,000	710,000	1,920,000	80,000	1,160,000	560,000	35,330,000
2020	790,000	11,140,000	4,000,000	22,970,000	4,910,000	1,950,000	1,530,000	3,620,000	170,000	2,100,000	1,120,000	54,300,000
Total Areas 1/ (acres)	11,390,000	3,650,000	7,220,000	7,000,000	16,600,000	3,200,000	6,990,000	11,060,000	3,790,000	17,180,000	12,420,000	100,500,000
Urban Lands (acres)												
1960	44,000	443,000	80,000	998,000	178,000	47,000	64,000	149,000	4,000	25,000	36,000	2,068,000
1990	80,000	970,000	240,000	1,750,000	380,000	120,000	130,000	330,000	10,000	150,000	80,000	4,240,000
2020	130,000	1,130,000	480,000	2,100,000	570,000	220,000	280,000	600,000	20,000	280,000	150,000	5,960,000
Gross Irrigable Lands (acres)												
1960	810,000	1,000,000 2/	1,370,000	1,100,000	4,160,000	1,650,000	2,900,000	5,030,000	610,000	2,490,000	1,430,000	22,550,000
1990	770,000	600,000	1,220,000	600,000	3,940,000	1,580,000	2,830,000	4,850,000	600,000	2,370,000	1,390,000	20,770,000
2020	720,000	400,000	1,000,000	350,000	3,770,000	1,490,000	2,680,000	4,580,000	590,000	2,240,000	1,320,000	19,140,000
Net Irrigated Lands (acres)												
1960	258,000	160,000 2/	370,000	476,000	1,410,000	708,000	1,154,000	2,709,000	125,000	89,000	626,000	8,085,000
1990	310,000	230,000	400,000	350,000	1,800,000	780,000	1,515,000	3,320,000	135,000	74,000	650,000	9,564,000
2020	400,000	160,000	460,000	280,000	2,080,000	860,000	1,880,000	3,790,000	160,000	35,000	670,000	10,775,000
Remaining Irrigable Lands (acres)												
1960	552,000	840,000 2/	1,000,000	624,000	2,750,000	942,000	1,746,000	2,321,000	485,000	2,401,000	804,000	14,465,000
1990	460,000	370,000	820,000	250,000	2,160,000	800,000	1,315,000	1,530,000	465,000	2,296,000	740,000	11,206,000
2020	320,000	240,000	540,000	70,000	1,690,000	630,000	800,000	790,000	430,000	2,205,000	650,000	8,365,000

1/ Total areas within boundaries of hydrologic study areas.
2/ No recent area-wide information on irrigable or irrigated acreage has been collected by the Department of Water Resources for this area. 1960 irrigated acreage approximated from various local sources of agricultural information.

represents an acreage requirement each year comparable to the present area of Sacramento. Most of this requirement will occur in and near the present population centers, including the Los Angeles-Orange Counties metropolitan area, San Diego, Riverside, San Bernardino, Santa Barbara, San Francisco Bay area, Sacramento, Stockton, Fresno and Bakersfield.

Irrigated Agriculture

Agriculture in California is undergoing important changes. These changes are basically caused by economic factors over which the farmer has little or no control. Some of these considerations are: an expanding population that has created a greater demand for farm products; rising personal incomes that have had an influence on the eating habits of people causing them to reduce their intake of starches and to favor a variety of higher value foods such as vegetables, meats, nuts, and fruits; and a price-cost squeeze over the past decade caused by increasing fixed production costs and descending prices received for farm products.

Other factors contributing to the agricultural changes include technological advances such as more efficient, labor-saving farm machinery and the development of more effective fertilizers and weed and pest control chemicals. These have made it possible for the farmer to multiply his productivity several times in recent years. These trends have brought about larger more efficient farms that need less labor per unit of output.

IRRIGATION OF COTTON, SAN JOAQUIN VALLEY

Irrigation accounted for 90 percent of California's water use in 1960. It is projected that agricultural water requirements will continue to grow in California, though less rapidly than urban requirements. In 2020, irrigation will still account for almost 75 percent of California's water use.

Based on these considerations, estimates have been made of California's share of the projected nationwide market for agricultural products for both domestic and export use. These estimates have been based on historical plantings of crops in the State, suitability of soils and climate, competitive position with respect to distance to market, and other factors. Crop projections have included increased percentages of cotton, alfalfa, fruit, nuts, vegetables, and vineyards, and decreased percentages of pasture, hay, grain and rice.

From the projected quantities of crops to be grown, the irrigated land requirements have been estimated on the basis of historical and projected crop yield statistics. In making such projections, predictions of the University of California Agricultural Extension Service, estimates of the U. S. Department of Agriculture and other sources of crop production information have been utilized.

On the bases of climate and of land availability and suitability, the statewide projections were then allocated among the various hydrologic study areas.

With the exception of estimates for the present service areas of the State Water Project, these projections do not reflect full consideration of all of the economic constraints involved. It has been assumed that future market prices will give farmers the ability and willingness to pay the full costs of water and other products and services required for crop production. Future refinements in these estimates to include full consideration of economic factors may result in modification of these projections.

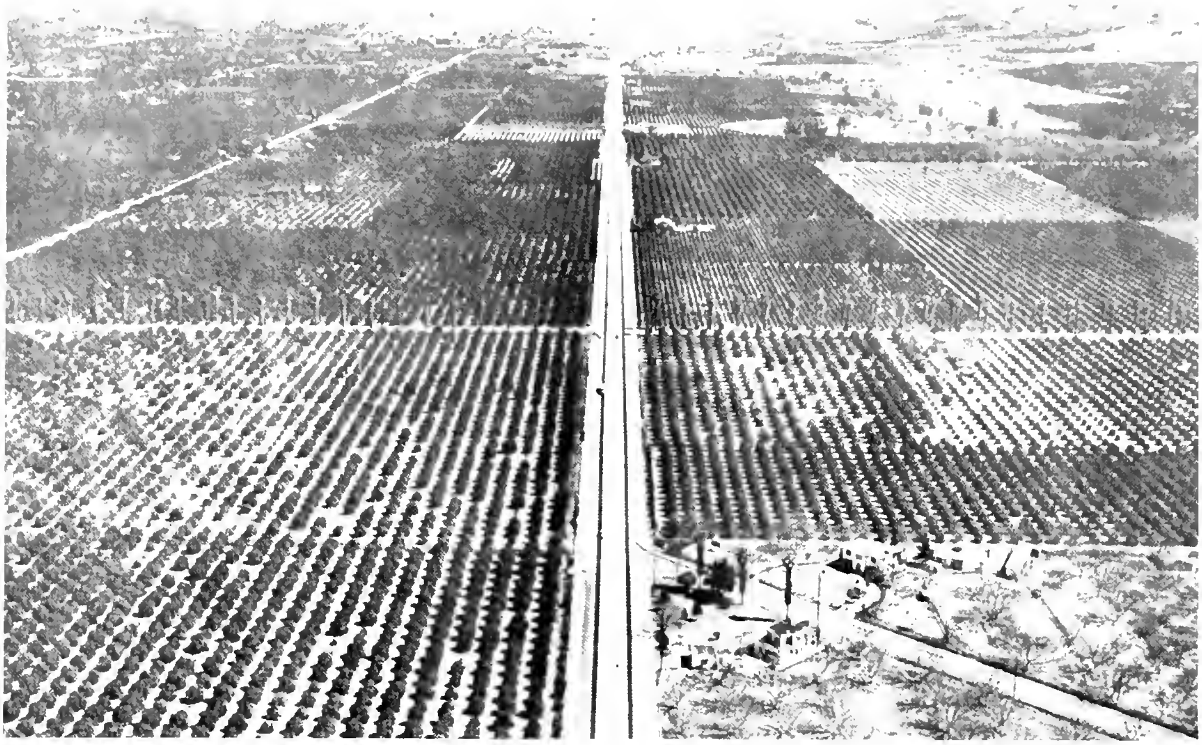
The results of the projections of irrigated land requirements are shown in Table 4. The information is also presented on Figure 6 for the State and on the odd-numbered figures from Figure 7 through 27 for the 11 hydrologic study areas.

Irrigated agriculture in California is expected to occupy 10.8 million acres by the year 2020, an increase of 2.7 million acres over the 1960 total. Urbanization of agricultural lands in the principal metropolitan areas of the San Francisco Bay and South Coastal areas is expected to continue to cause the agricultural acreages to be reduced. The increase in irrigated acreages outside those areas reflects not only the statewide growth in requirements for irrigated agricultural land but also the acreage required to compensate for such land displaced by urban development.

Irrigable Lands

Field surveys to determine the extent of irrigable land have been made by the Department of Water Resources. The fundamental physical characteristics evaluated include soil texture, topography, depth of soil, degree of soil profile development and concentration of salinity. On the basis of these properties, soils have been grouped according to suitability for the production of different crops.

The Department's estimates of irrigable land are summarized in Table 4 and on Figure 6 and the odd-numbered figures from Figure 7 through 27.



MARCH 1940

Looking east along U. S. Highway 99 in the vicinity of West Covina, Los Angeles County. U. S. Highway 33 intersection in right foreground. (Spence Air Photos)

JULY 1963

Exclusive of lands occupied by urban development, it is estimated that the irrigable lands in California in 1960 totaled about 22.6 million acres. Part of the projected urban growth to the year 2020 is expected to occupy irrigable lands. Thus, irrigable lands are expected to be reduced to 19.1 million acres by 2020. Deducting the projected irrigated acreage for that time leaves an estimated eight million acres of irrigable land that will be available for further development. This estimate does not allow for other uses of land such as areas required for freeways, rural park and recreation sites, water development and other purposes. Nevertheless, it is anticipated that there will be undeveloped irrigable lands in the State for many years beyond 2020.

Present and Projected Water Requirements

Estimates of both applied water requirements and net water requirements are presented in this section. Applied water requirements represent the totals of quantities needed annually at all farm headgates and urban distribution system intakes within each hydrologic study area. Net water requirements allow for probable reuses of water within each area. Such reuses may take the form of rediversions from drains or natural stream courses, repumping of ground water which has percolated from previous applications, or reclamation and reuse of sewage and waste water. If there were no opportunity for reuse in an area, net water requirements would equal applied water requirements.

Applied Water Requirements

Quantities of applied water in the various hydrologic study areas of the State have been estimated on the basis of the population and irrigated agricultural acreage information described in the preceding section. The use of water for urban development has been estimated from per capita uses of water in various parts of the State. These values vary from 95 to 330 gallons per day per capita, as shown in Table 5. Projections of the future values, given in Table 5, have been based on historical trends and on anticipated further technological advances, industrialization and changes in habits of the population.

Future studies are planned to refine municipal and industrial water use estimates by accounting separately for domestic and industrial use. Domestic use would be estimated on the basis of per capita values, while industrial use would be derived from projected industrial development and unit use values appropriate for the respective industries or groups of industries.

Agricultural applied water requirements have been estimated from projected acreages of various crops and unit (acre-feet per acre) applied water values. The unit values have been derived on the basis of statistics on the consumptive use of applied water obtained from field measurements by the Department of Water Resources and others. Allowances have been made for the excess applications needed for farm operation. Probable

TABLE 5

ESTIMATED URBAN WATER USE

(gallons per capita per day)

Hydrologic Study Area	1960	2020
North Coastal	95	360[1/]
San Francisco Bay	150	170
Central Coastal	170	180
South Coastal	170	220
Sacramento Basin	240	270
Delta-Central Sierra	250	270
San Joaquin Basin	330	350
Tulare Basin	320	390
North Lahontan	170	190
South Lahontan	230	250
Colorado Desert	310	250[2/]

1/ Reflects projected introduction of pulp and paper industries into the North Coastal area.

2/ Prediction of decrease in unit value based on assumed conditions of high water prices and limited water supplies.

changes in applied water requirements for the various crops with improved agricultural practices have been given weight in the estimates.

The resulting estimates of applied water requirements for urban and irrigated agricultural developments are summarized for the State in Table 6 and Figure 6 and are shown for each hydrologic study area on the odd-numbered figures from Figure 7 through 27.

Several important points are indicated by these estimates. As developments approach 2020 conditions, it is anticipated that there will be a substantial increase in the proportion of water required for urban purposes in comparison with that required for agriculture. Figure 5 demonstrates this graphically. Agriculture will still require the most water in 2020.

One of the most significant aspects of the growth in applied water requirements is shown by the statistics for the individual hydrologic areas. These indicate the relative magnitudes of water requirements for urban and agricultural purposes expected in the various areas of the State. In the Central Valley and particularly in the Tulare Basin, substantial increases in applied agricultural water will occur. This will be in response to the growing demands for irrigated agricultural land described previously. Although applied urban water requirements in the Central Valley will become important (approaching 4.3 million acre-feet by 2020), they will remain far below the agricultural requirements of 28 million acre-feet.

TABLE 6

SUMMARY OF 1960 AND PROJECTED WATER REQUIREMENTS
IN HYDROLOGIC STUDY AREAS

(in acre-feet)

Items	North Coastal	San Francisco Bay	Central Coastal	South Coastal	Sacramento Basin	Delta-Central Sierra	San Joaquin Basin	Tulare Basin	North Lahontan	South Lahontan	Colorado Desert	Totals for State
Applied Water Requirements												
Agricultural												
1960	420,000	330,000	660,000	1,080,000	5,900,000	2,960,000	4,620,000	7,600,000	400,000	409,000	4,103,000	28,482,000
1990	650,000	440,000	780,000	860,000	6,910,000	3,080,000	5,460,000	9,400,000	420,000	360,000	3,960,000	32,320,000
2020	930,000	280,000	950,000	760,000	7,950,000	3,280,000	6,020,000	10,900,000	500,000	175,000	3,960,000	35,705,000
Urban												
1960	20,000	590,000	110,000	1,640,000	250,000	100,000	130,000	300,000	10,000	46,000	61,000	3,257,000
1990	170,000	1,480,000	360,000	3,950,000	740,000	290,000	270,000	730,000	20,000	320,000	150,000	8,480,000
2020	320,000	2,120,000	780,000	5,560,000	1,490,000	590,000	600,000	1,600,000	30,000	600,000	310,000	14,000,000
Totals												
1960	440,000	920,000	770,000	2,720,000	6,150,000	3,060,000	4,750,000	7,900,000	410,000	455,000	4,164,000	31,739,000
1990	820,000	1,920,000	1,140,000	4,810,000	7,650,000	3,370,000	5,730,000	10,130,000	440,000	680,000	4,110,000	40,800,000
2020	1,250,000	2,400,000	1,730,000	6,320,000	9,440,000	3,870,000	6,620,000	12,500,000	530,000	775,000	4,270,000	49,705,000
Net Water Requirements*												
1960	350,000	860,000	670,000	2,180,000	3,630,000	1,810,000	3,060,000	5,930,000	200,000	255,000	4,161,000	23,106,000
1990	660,000	1,820,000	920,000	4,070,000	4,800,000	2,110,000	3,920,000	8,570,000	270,000	295,000	4,035,000	31,470,000
2020	1,000,000	2,260,000	1,580,000	5,730,000	5,780,000	2,370,000	4,570,000	9,840,000	370,000	320,000	4,180,000	38,000,000

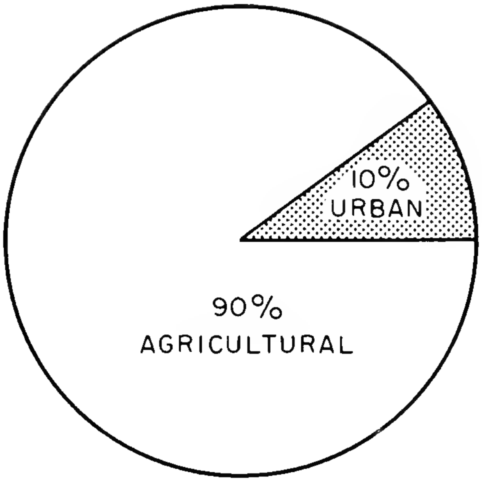
* Applied water requirements less estimated quantities available for reuse.

The situation is somewhat reversed in those areas with the greatest projected population. In the South Coastal and San Francisco Bay areas, urban water requirements will increase by about 5.5 million acre-feet by 2020, but agricultural requirements will decline and will almost disappear in some of the counties of those areas. Urban water requirements in the Central Coastal and South Lahontan areas are expected to increase substantially by that year.

Net Water Requirements

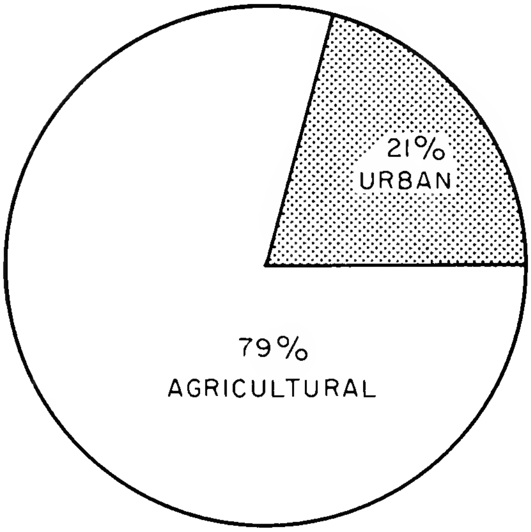
Net water requirements are the quantities of water which must actually be made available in the various hydrologic study areas either through development of local resources or through importation of water from sources outside the area. Net water requirements are the quantities of applied water which remain after consumptive uses and irrecoverable losses. Consumptive uses include disposal by plants through evaporation and transpiration and evaporation from the ground, pavements or water surfaces. Outflow to the ocean and percolation of water to a ground water basin, where depth to water or quality considerations make reuse impracticable, are examples of irrecoverable losses.

Net water requirements have been estimated for each hydrologic study area by applying percentages to the estimated applied water requirements. The percentage values have been based on historical records and on estimates of changing conditions. The estimated percentages vary from 98 percent for the



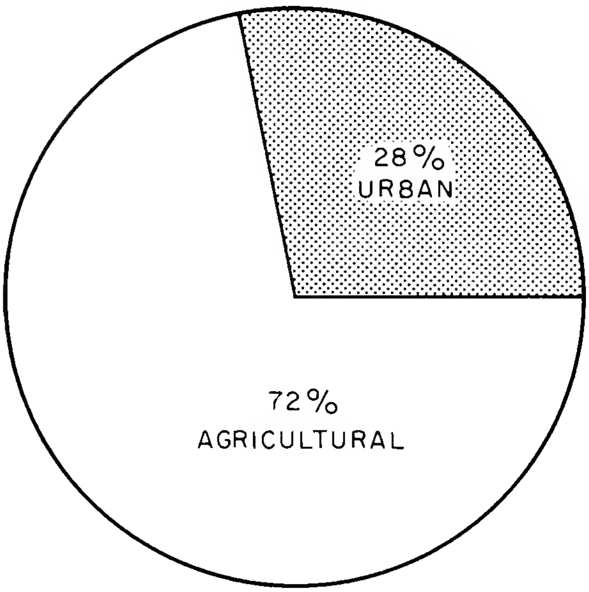
1960

Urban water requirement	3,260,000 AF
Agricultural water requirement	28,480,000 AF
Total water requirement	31,740,000 AF



1990

Urban water requirement	8,480,000 AF
Agricultural water requirement	32,320,000 AF
Total water requirement	40,800,000 AF



2020

Urban water requirement	14,000,000 AF
Agricultural water requirement	35,700,000 AF
Total water requirement	49,700,000 AF

PROJECTED GROWTH OF APPLIED WATER REQUIREMENTS
STATE OF CALIFORNIA

Colorado Desert area, where reuse of the large quantities of water applied for irrigation in the Imperial and Coachella Valleys is impracticable because of water quality considerations, to 41 percent for the South Lahontan area, where water of good quality permits a high degree of reuse.

The net water requirements for the State as a whole and for each of the hydrologic study areas are summarized in Table 6. The lower portion of Figure 6 indicates the estimated growth (from 1960 to 2020) of net water requirements in each hydrologic study area and of the total statewide net water requirements. The growth of net water requirements in each hydrologic study area is also depicted by the heavy line sloping upward to the right on each of the lower diagrams on the odd-numbered figures from Figure 7 through 27. In the discussions of the water supplies for each hydrologic study area (presented subsequently in this chapter), the projected methods by which these net water requirements will be met from local and imported supplies are presented.

Requirements for Other Water Project Services

Traditionally, water resources development has provided for irrigation, municipal and industrial supplies, flood control and hydroelectric power generation. So often in the past, however, a project was undertaken to serve one or the other of these functions on a "one stream - one use" concept. Recently the continued pressures and competition for land and water use has become so acute as to render this concept inadequate. The need to protect the fish and wildlife resources, expand recreational facilities, provide additional flood protection, provide water quality control, and accomplish other possible project purposes has indicated to the responsible policy-making bodies and water agencies the need for a broader approach to water resource development -- both in terms of geographic scope and purposes.

This section presents general discussions of the needs for project services besides water supply and hydroelectric power development. The role of electric power is discussed subsequently in this chapter.

Flood Control

Many agencies have built extensive works in California to provide flood protection. Most active in this field have been the reclamation and flood control districts and the U. S. Army Corps of Engineers. Although much has been accomplished, the Christmas flood of 1964 in Northern California and other recent floods elsewhere in the State have demonstrated that much remains to be done.

Because of the expected growth of California's population and the increasingly intense use of its land resources, solutions to the flood control problems will become more urgent and critical. The State Legislature has declared repeatedly that the people of the State have a vital interest in preventing flood damage.

AMERICAN RIVER AT FLOODSTAGE, DECEMBER 24, 1964

During the flood of December 1964, peak inflow to Folsom Reservoir was 280,000 cubic feet per second. Discharge from the dam was held to 115,000 cubic feet per second, the maximum capacity of the American River levee system. Disastrous flooding in Sacramento and vicinity was thus prevented.

The Department of Water Resources has recently reviewed available information on flood control requirements. Additional study is needed to gain knowledge, at least on a reconnaissance level, of present and future urban and agricultural developments that will be subject to flood damage along with important physical, economic and social factors related to prevention of such damage throughout the State. Studies by the U. S. Army, Corps of Engineers, which are in progress or authorized, are discussed subsequently in this chapter.

The degree to which improvements are exposed to floods varies considerably from area to area of the State. Much of the North Coastal area is subject to staggering periodic flood damage, as evidenced by the Christmas 1964 flood. In the San Francisco Bay area, a number of flood control facilities have been built, but there are still problems to be solved. Examples of the kinds of development needing further protection are urban and agricultural improvements along the Russian and Napa Rivers and urban areas adjacent to restricted natural channels, particularly in the zones of tidal influence near the San Francisco Bay. In parts of the Central Coastal area, provision for channel improvements, bank revetment, flood control reservoirs or levees, or floodplain management will be needed as urbanization proceeds.

Considerable progress has been made by federal and local agencies in developing and implementing comprehensive flood control programs in the South Coastal area. Nevertheless, in certain areas the rate of construction of flood control works is not sufficient to keep up with the growing need. Floodplain management in portions of the area would assist in alleviating flood damage.

In the Central Valley Basin, reservoirs in the mountains and foothills and levees and bypass channels on the valley floor provide a significant level of flood protection. The major streams that will still require reservoir flood control storage, or other protective works, include the Upper Sacramento, Bear, Yuba, American, Cosumnes, Stanislaus, Tuolumne and Merced Rivers and Cache Creek. Bank erosion, which in places threatens the integrity of Sacramento River Flood Control Project levees, calls for continual maintenance and additional bank revetment. Bypass channels and levees in Butte Basin would eliminate the present periodic flood damage of agricultural lands. A number of small streams on the valley floor that pass through urban areas occasionally overflow their banks. There will be a growing need for projects to prevent such damage as the urban areas expand. Problems in the Sacramento-San Joaquin Delta area during major flood periods are caused by poor levee foundation conditions, subsiding land surfaces, high tides and winds during flood periods and the difficulty of fighting floods.

Flood damage in the North Lahontan area occurs chiefly in the vicinity of Lake Tahoe and along the Truckee, Carson and Walker Rivers. Flood control facilities provide a measure of protection to developments along the Truckee River in California but additional facilities are needed to protect the Reno-Sparks area in Nevada. In the South Lahontan area, floods occasionally affect developments along the Mojave River. Infrequent flood damage in the few highly developed portions of the Colorado Desert area results chiefly from intense summer thunderstorms.

Recreation

The publication entitled, "Economic Report of the Governor", dated March 2, 1964, classifies recreation as a major sector of the State's economy. It indicates in part that "with each succeeding year recreation becomes a more important part of California life, its wealth and its economy." No one knows exactly what the magnitude of the recreation industry is in terms of dollars. If tourist expenditures and estimates of average outlays by recreationists are indicative, it is certainly a multibillion dollar business.

As would be expected, the growth of this industry has accompanied the rise of population. But other factors, such as increasing incomes, mobility and leisure time of the people have been significant additional contributors to the trend. Recreational activity in recent years has, in fact, grown three times as fast as population.

The increasing demand for recreation is of special importance to the development of California's water resources. In this State, outdoor recreation is characteristically water oriented. The California Public Outdoor Recreation Plan of 1960 indicated that about 60 percent of all recreation is so oriented. The plan further stated that public access to thousands of acres of potential recreation lands and waters was sorely needed. This

FOLSOM LAKE STATE RECREATION AREA

Recreation use at Folsom Lake State Recreation area during 1965, almost 4,000,000 visitor-days, was greater than any other state or federal park in California.

need will be magnified many times in the future. The magnitude of the demand for all kinds of outdoor recreation is shown by the following Department of Water Resources' estimates of annual statewide recreation use:

Year	Statewide Outdoor Recreation Use (Visitor-Days)
1960	218,100,000
1990	2,586,000,000
2020	4,954,000,000

The portions of these uses that will be water oriented will cause keenly felt if not overwhelming pressures on water resource developments in all areas of the State. Even now, the demand for water recreation is so great in Southern California that expensive water, imported from outside the area, is used to maintain water levels adequate for recreational use at Lake Elsinore, Hansen Reservoir and Puddingstone Reservoir. As additional reservoirs are added in Southern California and in most other areas of the State, recreation use will be limited more by the physical characteristics and capacities of the reservoirs themselves and by the facilities provided than by lack of demand.

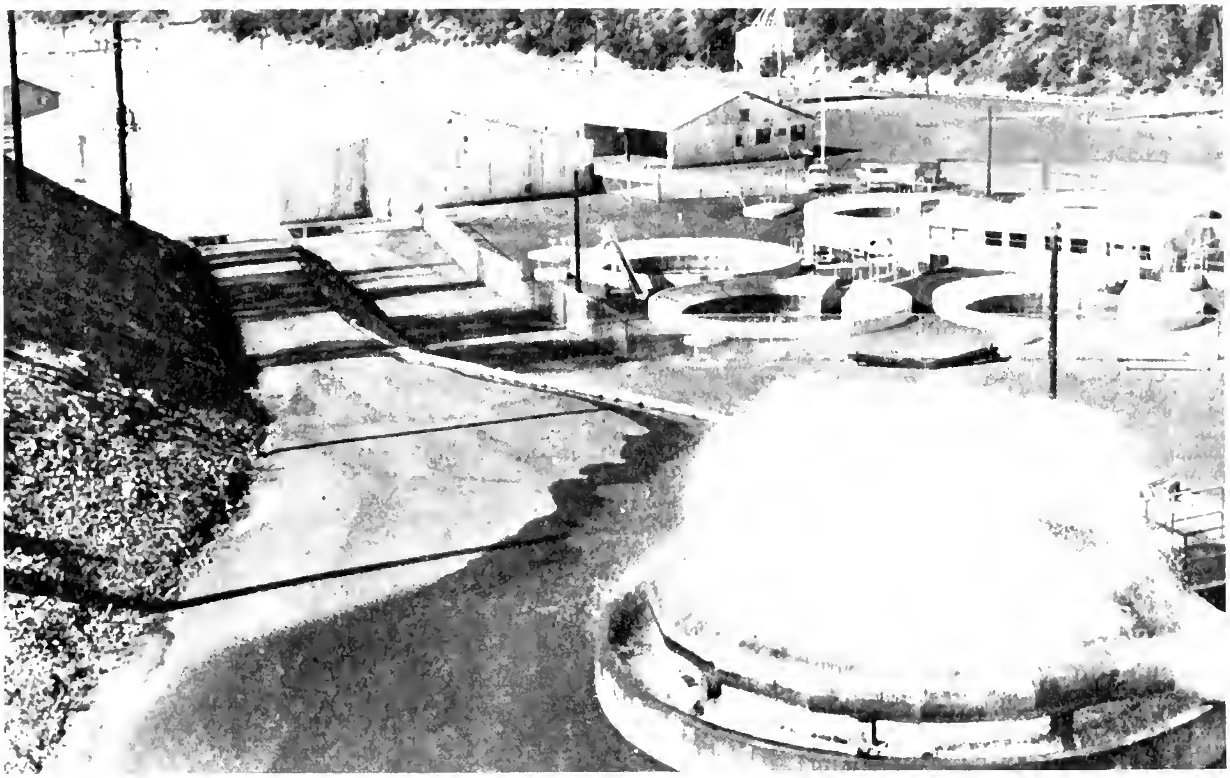
Thus far, estimates of applied and net water requirements in recreational developments has been limited to a few specific investigations where this type of use was an important factor. Consequently, little is known about this aspect of water use on a statewide or even on a regional basis. It has been estimated, however, that recreationists need about 40 gallons of water per user day (applied water) for domestic use. This may be significant in certain recreational areas of the State. It has been estimated that the summer population around Lake Tahoe increases by some 70,000 due to the influx of recreationists and that additional water use amounts to about 2.8 million gallons daily. Because of the tremendous growth expected in recreational activity, this facet of water use will assume increasing importance in the future.

Fish and Wildlife

Hunting and fishing are among the more important recreational activities in California. Commercial fishing for anadromous species is a valuable component of the State's economy. For these reasons, and to leave for future generations as much of the natural heritage of the State as possible, it is important that fish and wildlife resources be preserved and enhanced.

Salmon and steelhead in the North Coastal and Sacramento Basin areas are the objects of both sport and commercial fishing. In the North Coastal area particularly, these resources are most important economically and must be preserved to the maximum practicable extent as water development proceeds.

There are also opportunities for enhancement of anadromous fish resources. One example is the planned use for spawning of part of the Bureau of Reclamation's Tehama-Colusa Canal on the west side of the Sacramento Valley, and the release of water from that canal down tributaries of the Sacramento

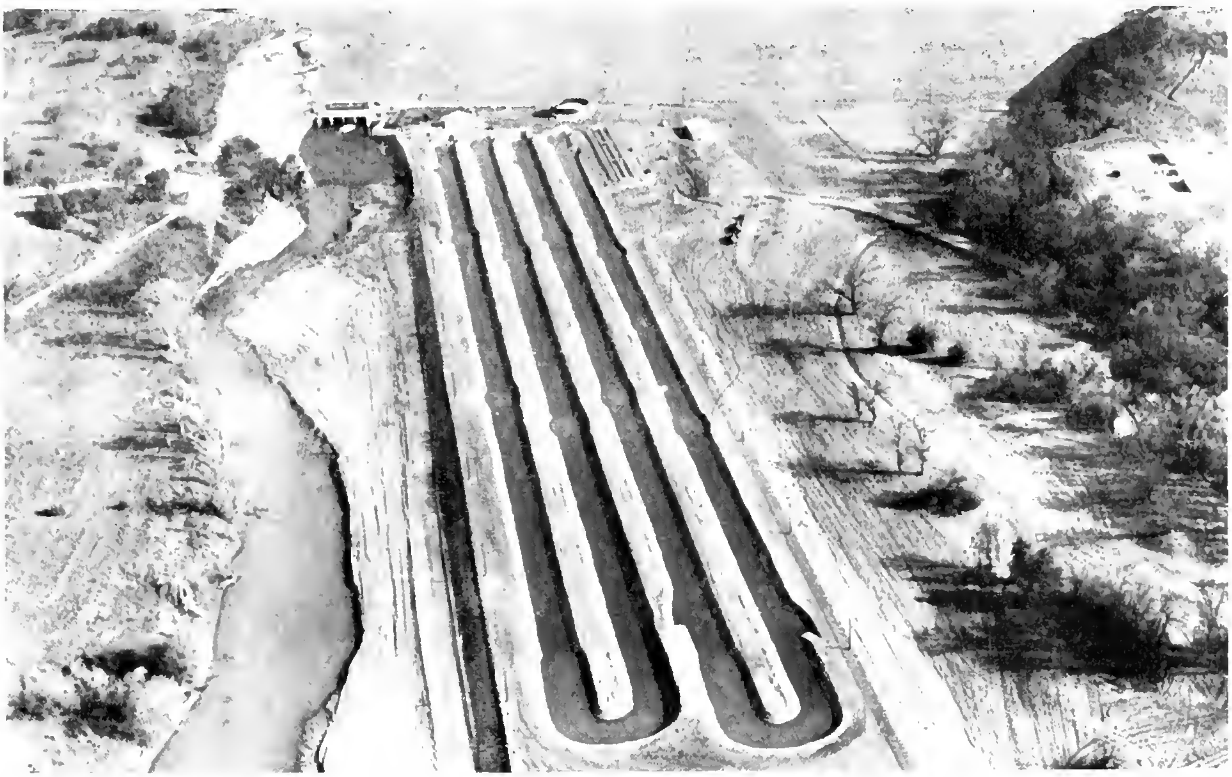


TRINITY FISH HATCHERY

Hatcheries have been used to preserve anadromous fisheries at a number of water projects in California.

This facility is the first installation in California of this particular method of anadromous fisheries preservation. (Photo by Lodi News-Sentinel)

ARTIFICIAL SPAWNING CHANNEL-CAMANCHE DAM



River to increase the available spawning areas. Salmon and steelhead, as well as shad, sturgeon and the extremely important striped bass, which are in or migrating through the Sacramento-San Joaquin Delta, can be protected and possibly enhanced by construction of the Peripheral Canal. There may be an opportunity to rehabilitate and enhance the king salmon run of the San Joaquin River system. Through streamflow augmentation, rejuvenation of stream gravels, removal of vegetation, construction of hatcheries, abatement of damaging water pollution and other measures, it is estimated on a very preliminary basis that salmon runs in the San Joaquin River system, averaging 500,000 fish annually, could be developed by 2020. Additional studies would be required to determine the economic feasibility of such a program.

Reservoirs proposed on mountain trout streams must be capable of releasing sufficient water to sustain existing trout populations below the dams, and possibly to enhance these populations if necessary to compensate for fisheries lost upstream.

California's significant waterfowl populations are found from the northern gateway at Lower Klamath Lake and Tule Lake through the marshes and sloughs of the Central Valley and the Delta to the Salton Sea and the Colorado River marshes in the southern extremity of the State. These populations should be protected and, if possible, enhanced by preservation of marshes, provision of rest areas along fly ways and other means.

Water Quality Control

In California's major water supply areas - the North Coastal area and the Sacramento Basin - water is of excellent mineral quality and suitable for all beneficial uses. In other areas of the State, most of which are water-deficient to some extent, the qualities of natural surface waters vary greatly. Certain waters, such as those originating in the Sierra Nevada and in the higher mountains of the coast ranges, are of excellent quality. Waters in the more southerly areas, particularly in the lower portions of closed drainage basins, are of poorer quality.

In some areas serious water quality degradation has occurred. Sea water intrusion, for example, has adversely affected portions of ground water basins adjacent to the coast or inland bays in the San Francisco Bay, the Central Coastal, and the South Coastal areas. Adverse salt balance conditions have impaired the quality of ground water in parts of the Tulare Basin and elsewhere. There is an increasing need to prevent undesirable effects of pollution caused by the discharge of man-made wastes into fresh water bodies, such as Lake Tahoe and channels of the Sacramento-San Joaquin Delta; into saline water bodies, such as San Francisco Bay; and even into the ocean adjacent to public beaches. The State and Regional Water Quality Control Boards play an important part in preventing pollution and in furthering water quality control.

Existing water development projects have provided control of the quality of water supplies to insure their suitability for intended urban and agricultural uses, and future projects can do the same. In many areas, regulated local supplies or imported water may be blended with poorer quality local water, either in surface reservoirs and conduits or in ground water basins. For example, the Sacramento River not only carries local and export water supplies but also constitutes the means of conveying enormous quantities of municipal, industrial and agricultural wastes out of the Sacramento Valley. In the future, management of the quality of this vital resource, through dilution at times of low streamflow and possibly conveyance of the more objectionable wastes through separate drains, will be required.

In the Sacramento-San Joaquin Delta, potential intrusion of salt water from the San Francisco Bay system, as well as degradation of water quality from agricultural and municipal and industrial waste discharges, may be controlled by dilution and maintenance of salinity control outflows to Suisun Bay. This has been accomplished since 1944 by the Central Valley Project. The proposed Peripheral Canal will improve the present situation by providing a physical separation between Sacramento River waters to be pumped for export and waters in the Delta channels. It will also constitute a positive means of distributing dilution water in the Delta channels.

Water quality control has already become essential in the San Joaquin and Tulare Basins. The San Joaquin Master Drain, to separate wastes from local waters of good quality, has been authorized and is in the process of advance planning. Dilution of water in the drain or in stream channels may be found necessary as a part of the overall water quality management program. The drain will provide the means for controlling salt balance in the San Joaquin and Tulare Basins to prevent the buildup of minerals in the ground water and soils.

In the large ground water basins of the South Coastal area, water quality improvement can be achieved by several means. Good quality water from Northern California can be delivered at higher elevations in each basin. This will dilute local supplies and permit a greater degree of reuse of water at successively lower elevations. In coastal ground water basins, imported and reclaimed water is being injected near the ocean to check sea water intrusion. The present recharge systems in the South Coastal area are being expanded and extended to other basins.

Water Supplies and Water Development by Hydrologic Study Areas

Studies leading to The California Water Plan demonstrated that the State has within its boundaries sufficient water resources to meet ultimate water requirements amounting to an estimated 51.1 million acre-feet per year. This conclusion is still believed to be valid, notwithstanding subsequent reductions of California's rights to the Colorado River as a result of Arizona v. California. Certainly there is sufficient water available physically within the State to meet the currently projected 2020 level of net water requirements, amounting to 38.0 million acre-feet.

This section presents for each hydrologic study area of the State (Figure 4), estimates of water supplies available from local water developments. It gives brief descriptions of conservation features proposed by local agencies and of those proposed under the State Water Resources Development System, which are primarily for local use. For areas having surplus supplies, estimates of quantities being exported and required to be exported in the future are also presented. This section also gives estimates of the capabilities of present facilities for importing water to certain of the areas and derives the additional importations that will be required to overcome local ground water overdrafts and to meet the growing net water requirements described previously. Where specific import projects have been proposed, the effects of these on meeting future water requirements are indicated. The locations of the major water conservation and conveyance facilities that appear to be among the more favorable of those proposed, are shown on the even-numbered figures from Figure 8 through 28. Many features described in The California Water Plan, or proposed after the preparation of that Plan, are not included on these figures. A summary of the estimated water supplies for the various hydrologic study areas, described in this section, is presented in Table 7.

TABLE 7

SUMMARY OF 1960 AND
PROJECTED SOURCES OF WATER TO MEET
NET WATER REQUIREMENTS IN HYDROLOGIC STUDY AREAS

(in acre-feet)

Items	North Coastal	San Francisco Bay	Central Coastal	South Coastal	Sacramento Basin	Delta-Central Sierra	San Joaquin Basin	Tulare Basin	North Lahontan	South Lahontan	Colorado Desert	Totals for State
Net Water Requirements Met by Local Supplies 1/												
1960	350,000	393,000	670,000	980,000	3,630,000	1,777,000	2,090,000	4,980,000	189,000	255,000	167,000	15,481,000
1990	660,000	510,000	762,000	1,000,000	4,400,000	1,677,000	2,840,000	3,180,000	259,000	87,000	105,000	15,480,000
2020	1,000,000	641,000	901,000	1,000,000	5,330,000	1,677,000	2,910,000	3,050,000	359,000	105,000	75,000	17,048,000
Net Water Requirements Met by Imported Supplies 2/												
1960	0	467,000	0	1,200,000	0	33,000	970,000	950,000	11,000	0	3,994,000	7,625,000
1990	0	1,310,000	158,000	3,070,000	400,000	433,000	1,080,000	5,390,000	11,000	208,000	3,930,000	15,990,000
2020	0	1,619,000	189,000	3,190,000	450,000	693,000	1,360,000	6,490,000	11,000	215,000	3,930,000	18,147,000
Remaining Net Water Requirements 3/												
2020	0	0	490,000	1,540,000	0	0	300,000	300,000	0	0	175,000 4/	2,805,000
Total Net Water Requirements												
1960	350,000	860,000	670,000	2,180,000	3,630,000	1,810,000	3,060,000	5,930,000	200,000	255,000	4,161,000	23,106,000
1990	660,000	1,820,000	920,000	4,070,000	4,800,000	2,110,000	3,920,000	8,570,000	270,000	295,000	4,035,000	31,470,000
2020	1,000,000	2,260,000	1,580,000	5,730,000	5,780,000	2,370,000	4,570,000	9,840,000	370,000	320,000	4,180,000	38,000,000

1/ Includes safe yield of surface and ground water plus ground water overdraft.
2/ Includes importations from existing, authorized, and proposed water conveyance facilities.
3/ Includes net water requirements to be met by future conveyance facilities, which have not been identified, and by other sources.
4/ Additional net requirements of about 2.7 million acre-feet could occur if low cost water supplies were available.

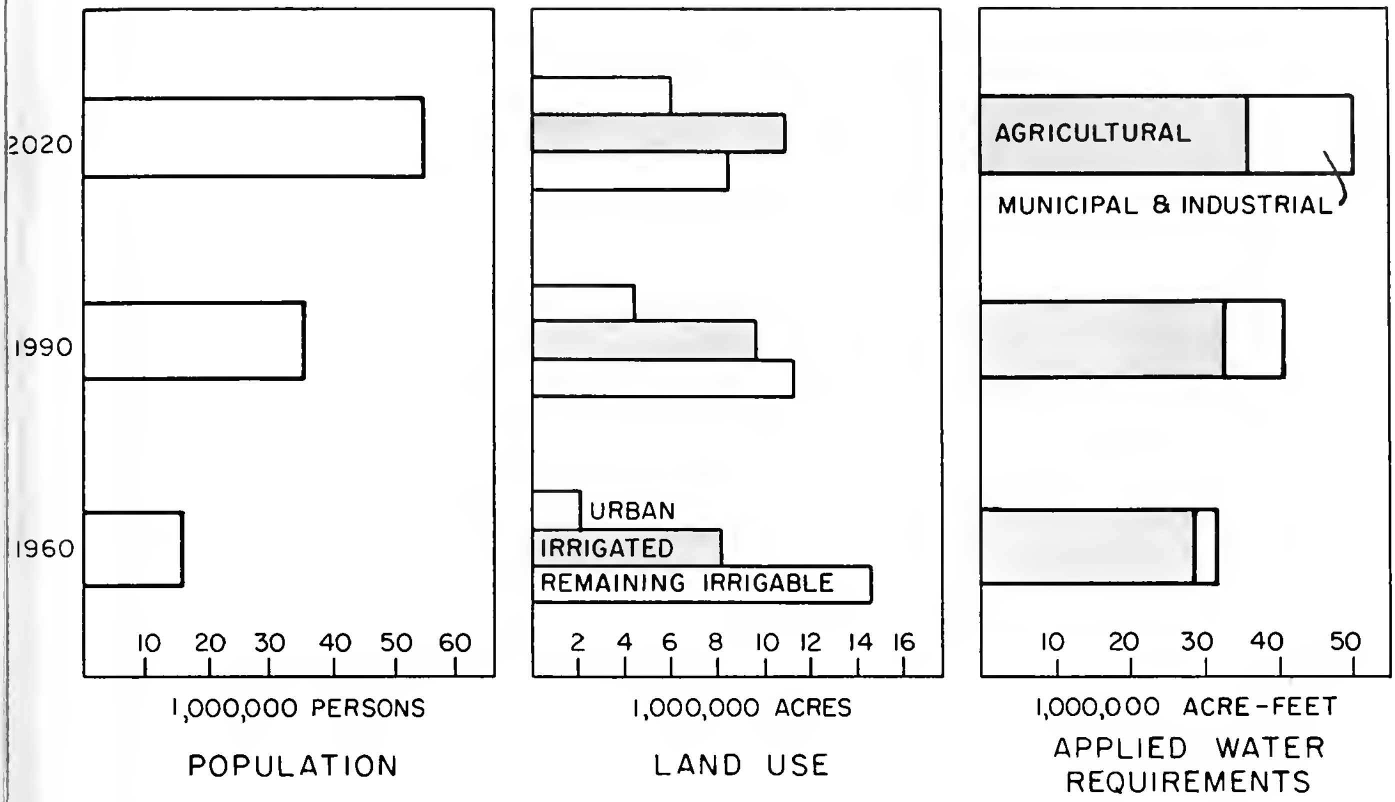
Expansion of waste water reclamation is mentioned as a possible source of future water supply in the South Coastal area. Although this source is not considered in this report for other areas, it is possible that a portion of their net water requirements could also be supplied in this manner.

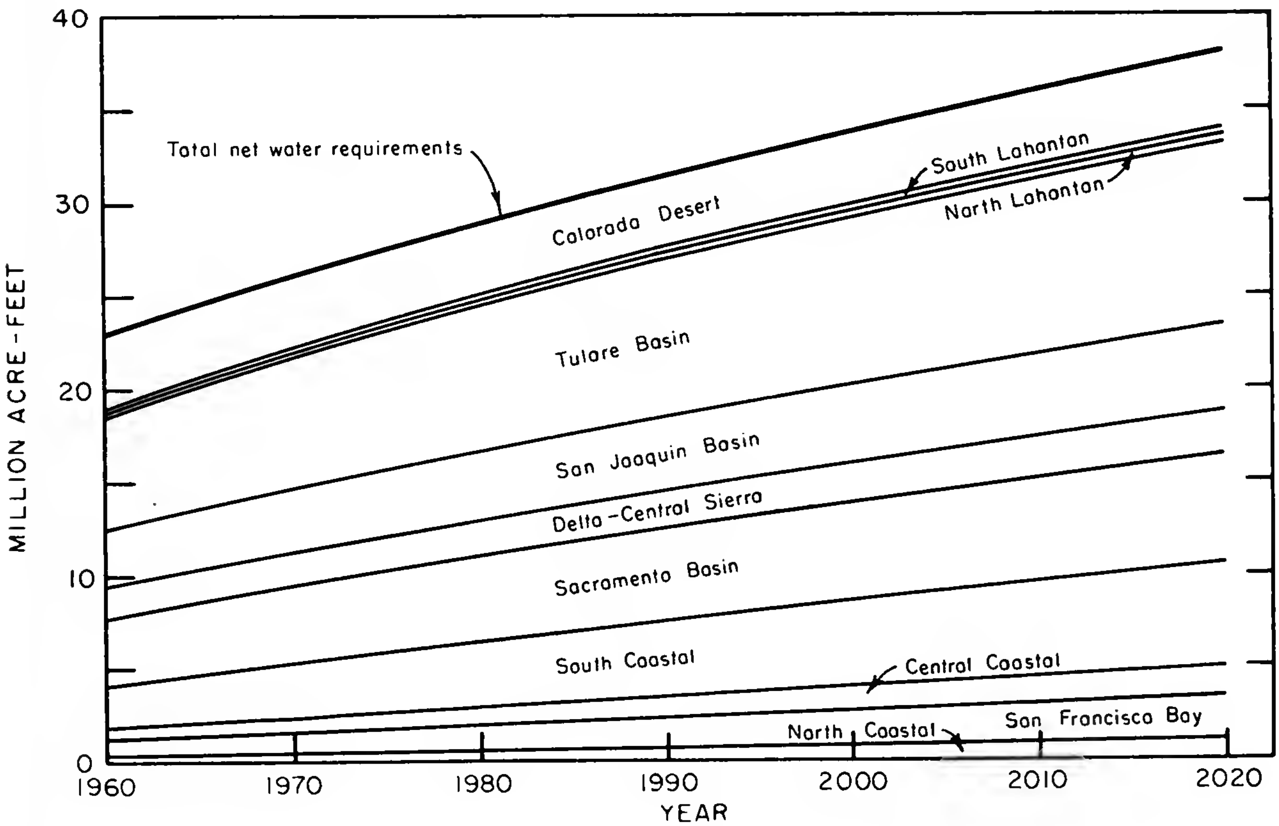
Present estimates of local water supplies in certain of the hydrologic areas have been based on limited information. The needs for further studies in these areas have been identified, where possible.

North Coastal Area

The North Coastal area has the most abundant water supplies of any of the State's hydrologic study areas. The long-term mean annual runoff of all streams in the area totals 29.7 million acre-feet. This is more than 40 percent of the total for the State.

Despite its copious water supplies, the North Coastal area will have to depend on water development facilities for its in-area water requirements because of the maldistribution of runoff within the season. Some of the great rivers which account for much of the area's winter runoff are little more than small creeks during the summer and fall. Ground water resources are limited to widely scattered alluviated valleys and coastal plains.

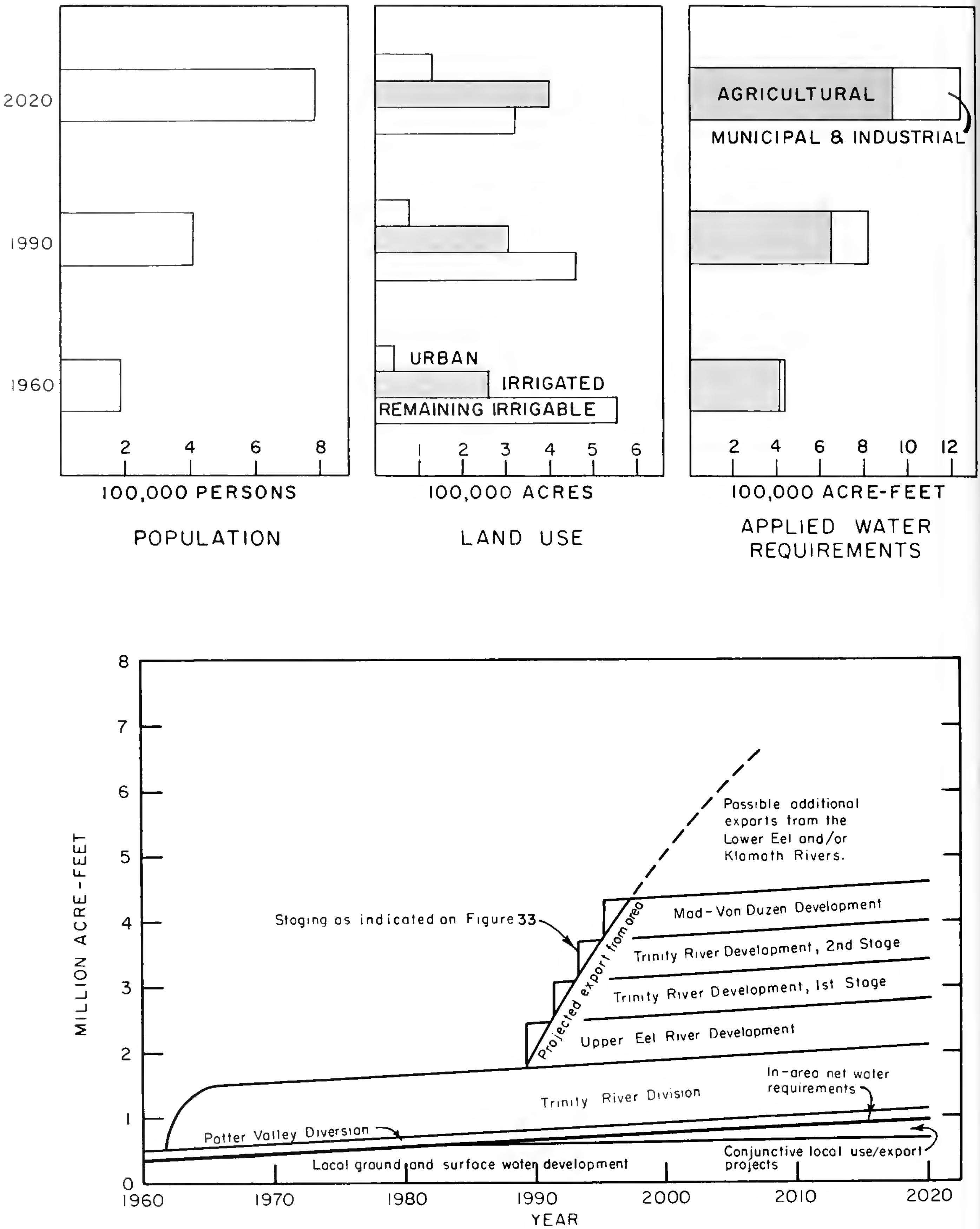




NET WATER REQUIREMENTS

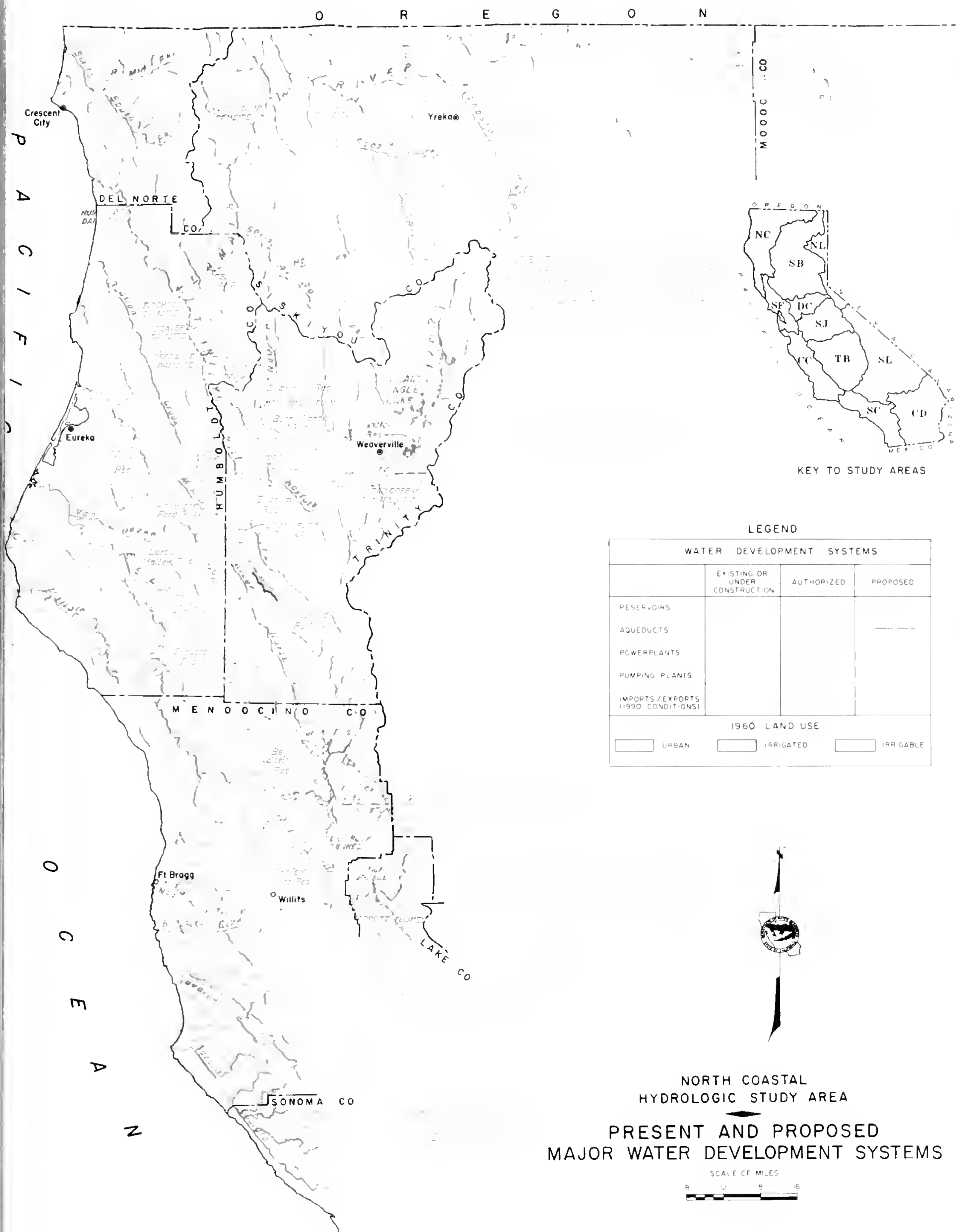
STATEWIDE TOTALS

FIGURE 7



PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS

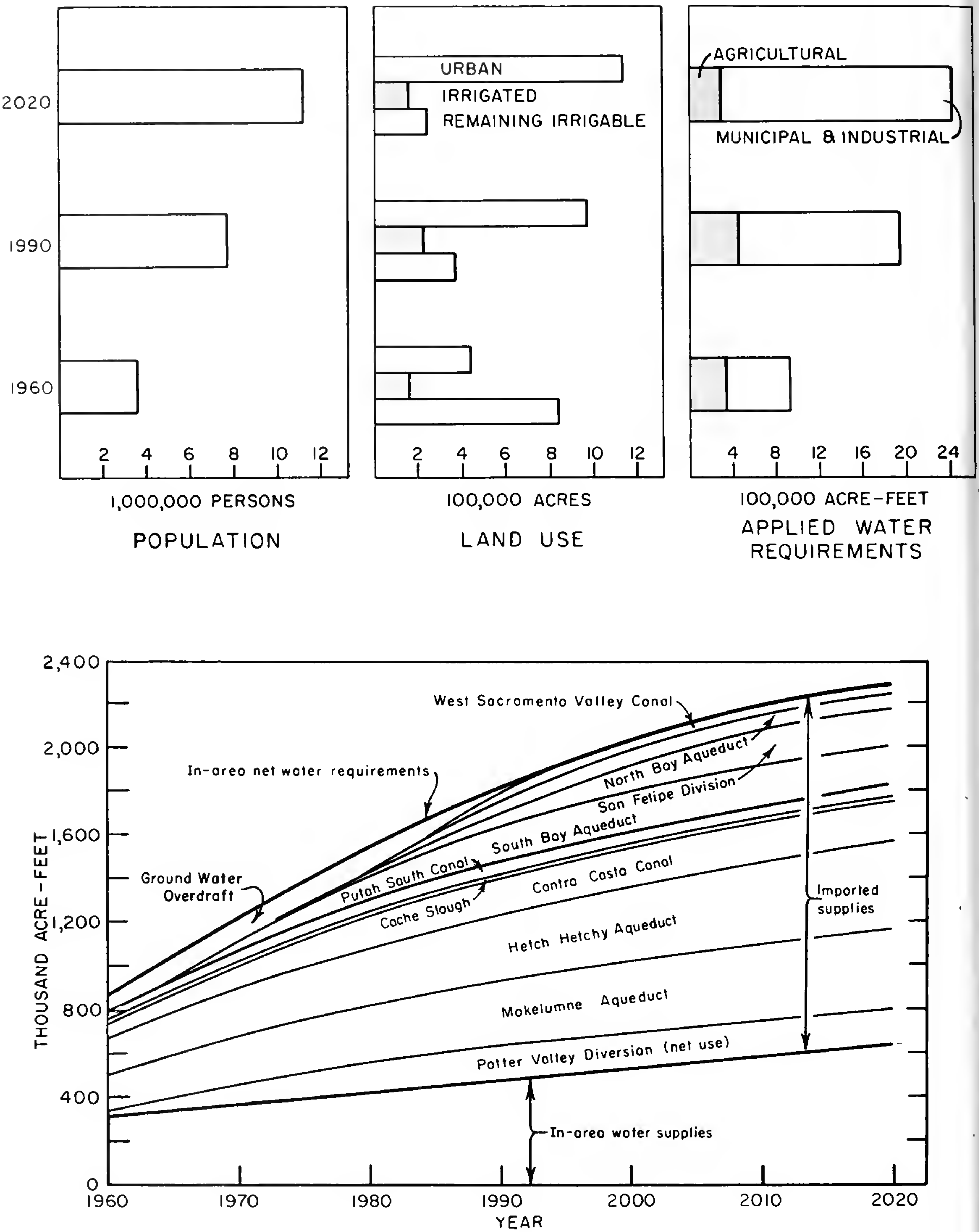
NORTH COASTAL HYDROLOGIC STUDY AREA



NORTH COASTAL
HYDROLOGIC STUDY AREA

PRESENT AND PROPOSED
MAJOR WATER DEVELOPMENT SYSTEMS

FIGURE 9



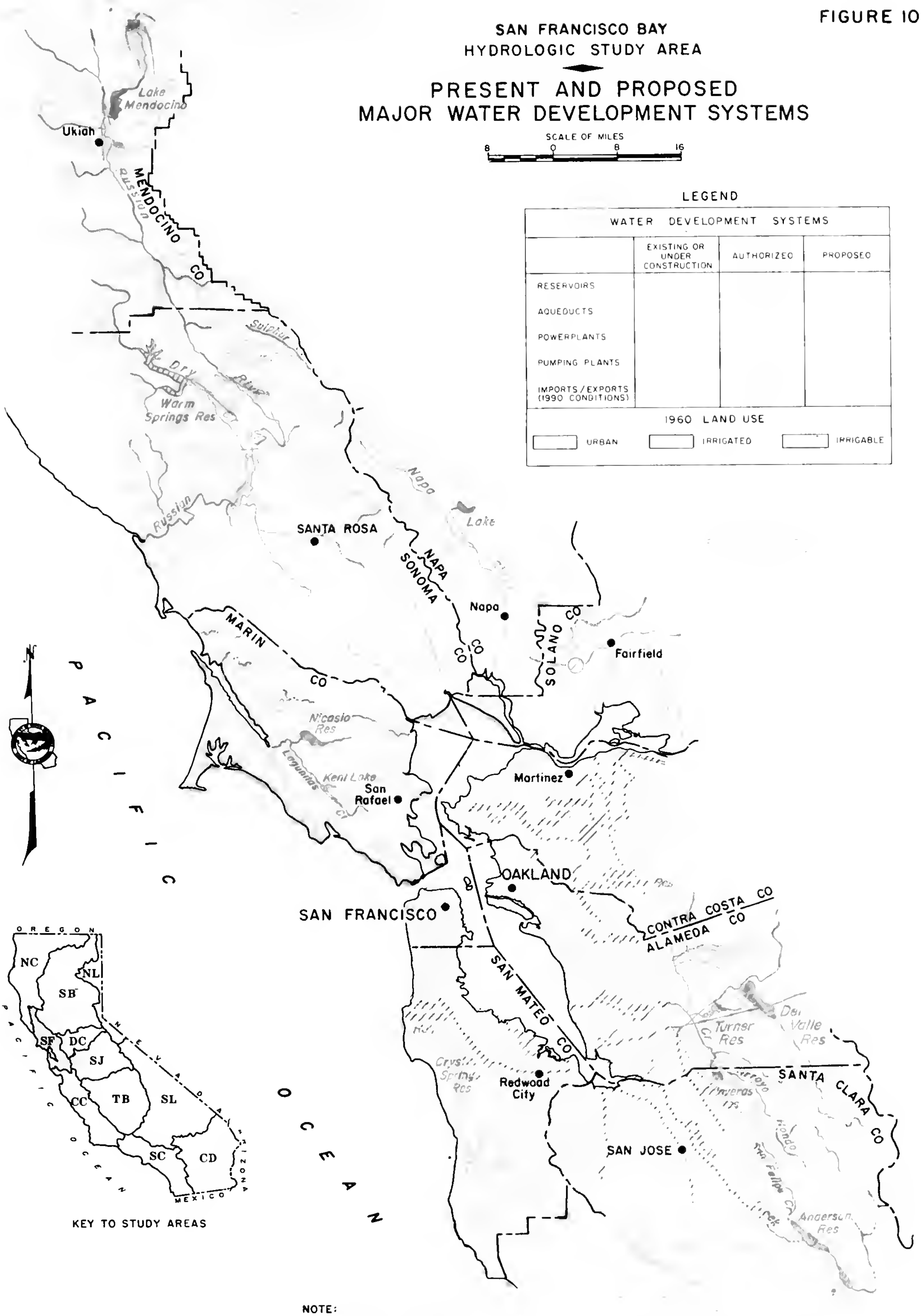
PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS

SAN FRANCISCO BAY HYDROLOGIC STUDY AREA

FIGURE 10

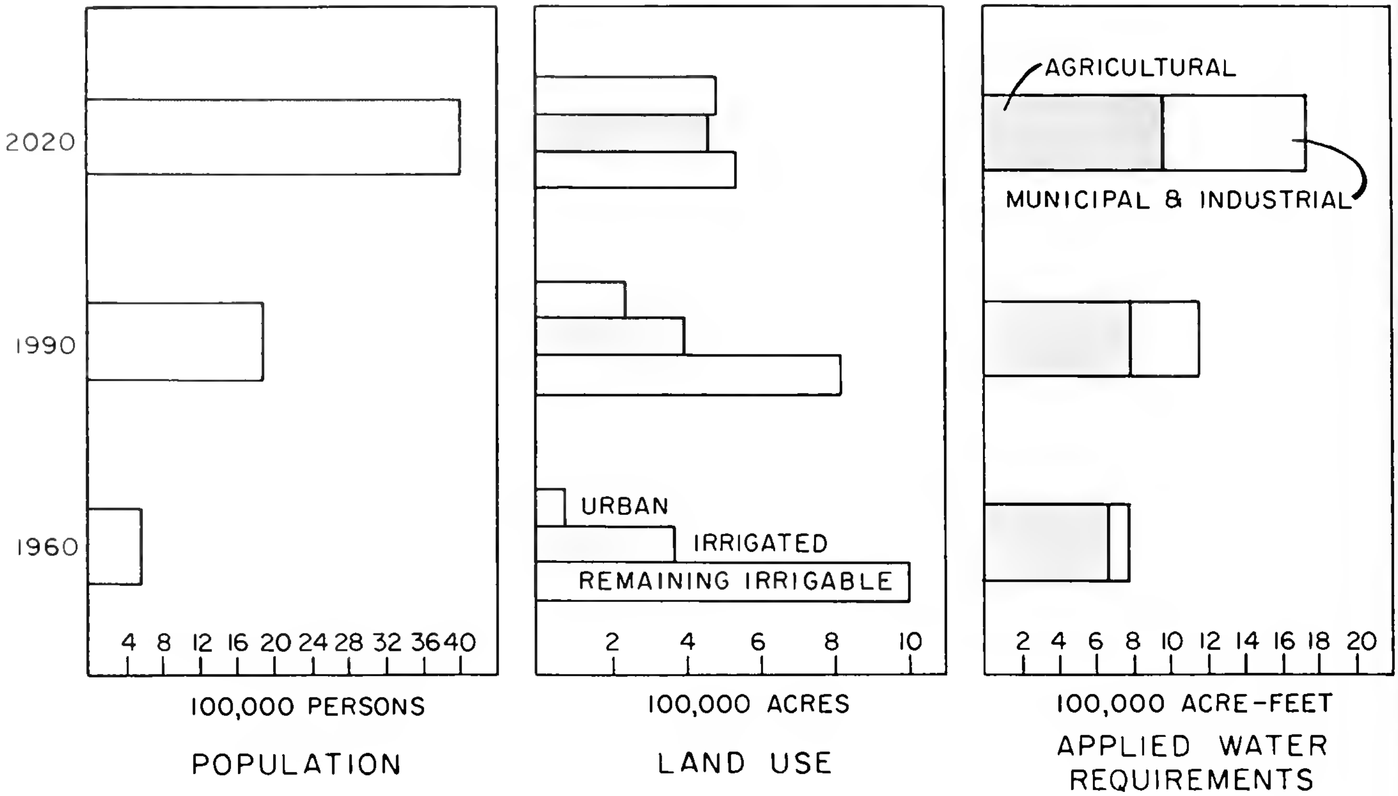
SAN FRANCISCO BAY HYDROLOGIC STUDY AREA

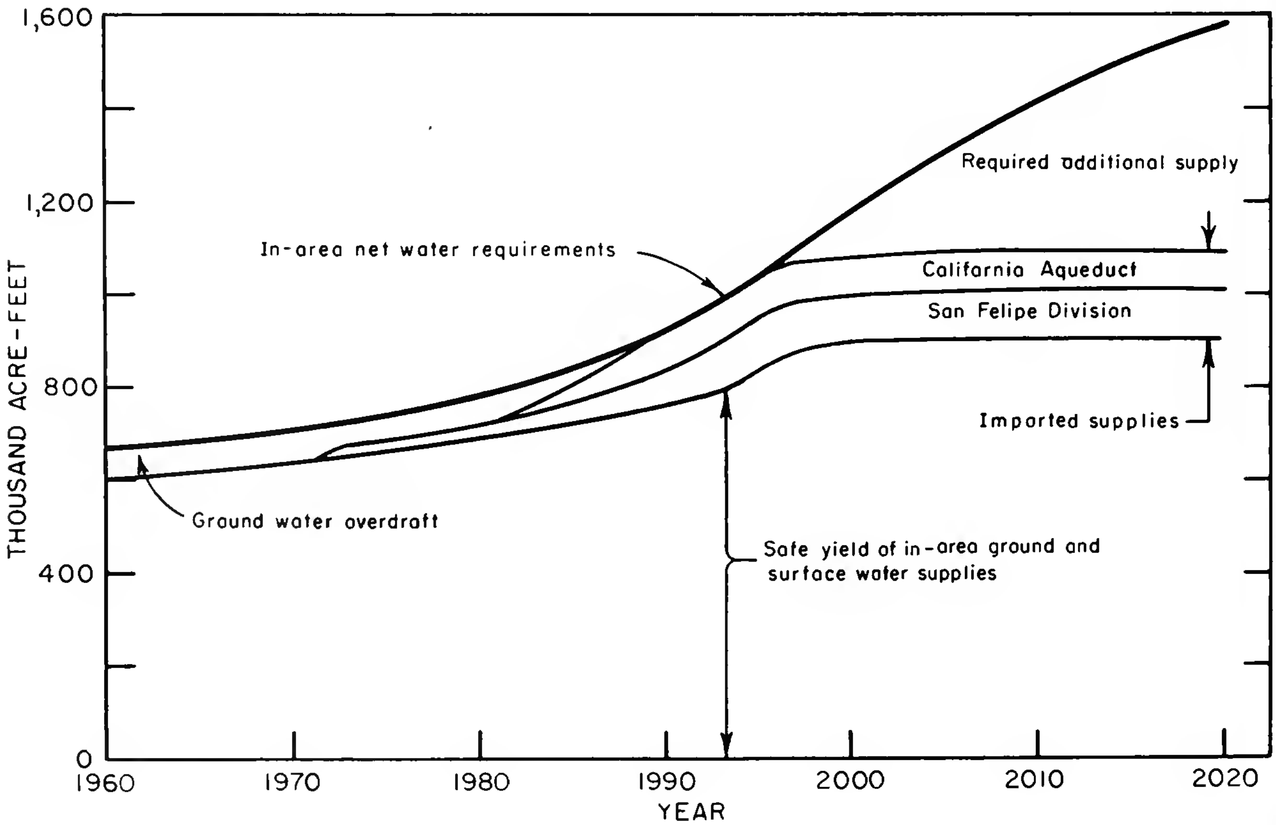
PRESENT AND PROPOSED MAJOR WATER DEVELOPMENT SYSTEMS



NOTE:
Red cross-hatch indicates estimated extent of urban complex.

FIGURE 11





PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS

CENTRAL COASTAL HYDROLOGIC STUDY AREA

FIGURE 12

CENTRAL COASTAL
HYDROLOGIC STUDY AREA

PRESENT AND PROPOSED
MAJOR WATER DEVELOPMENT SYSTEMS

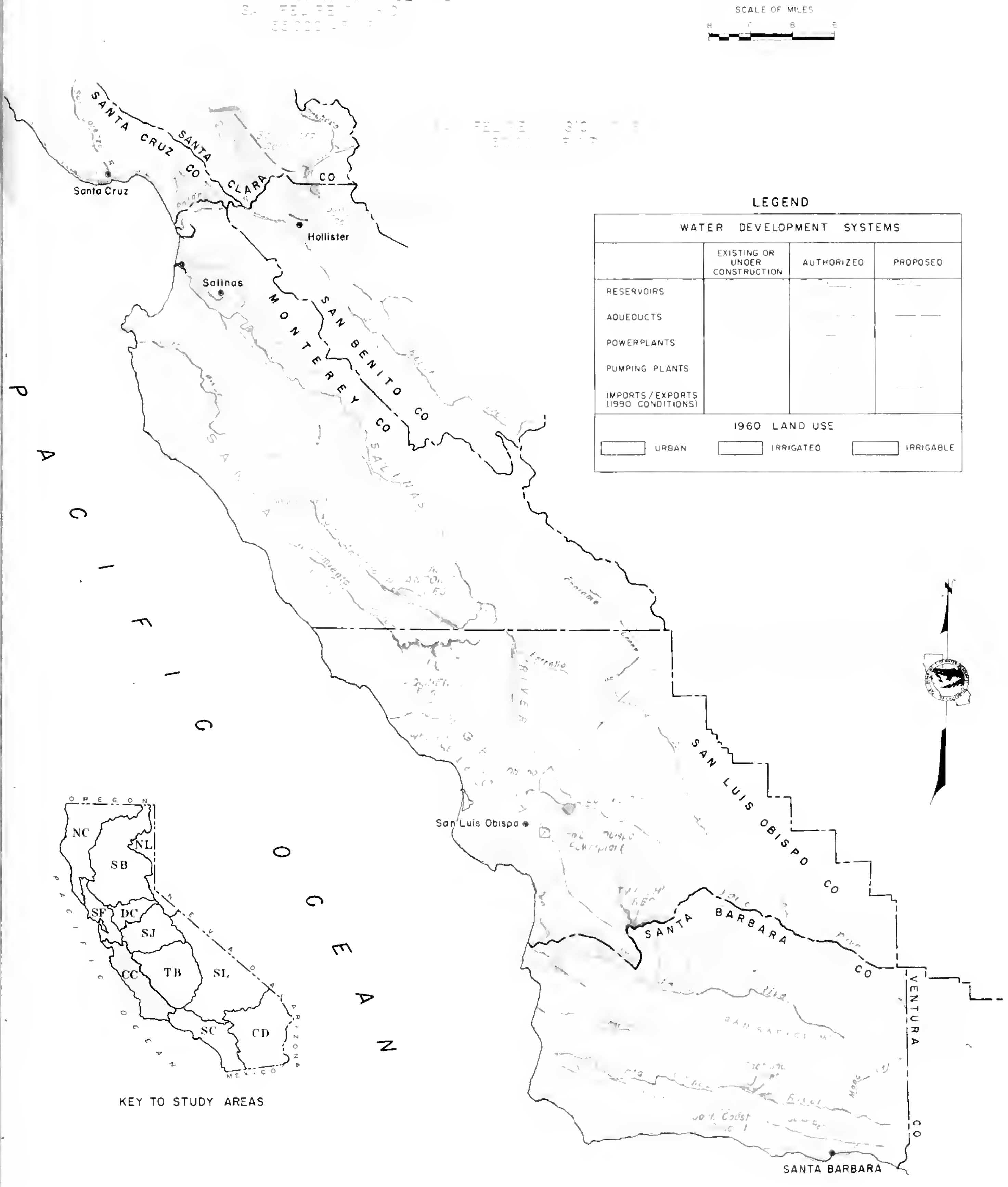
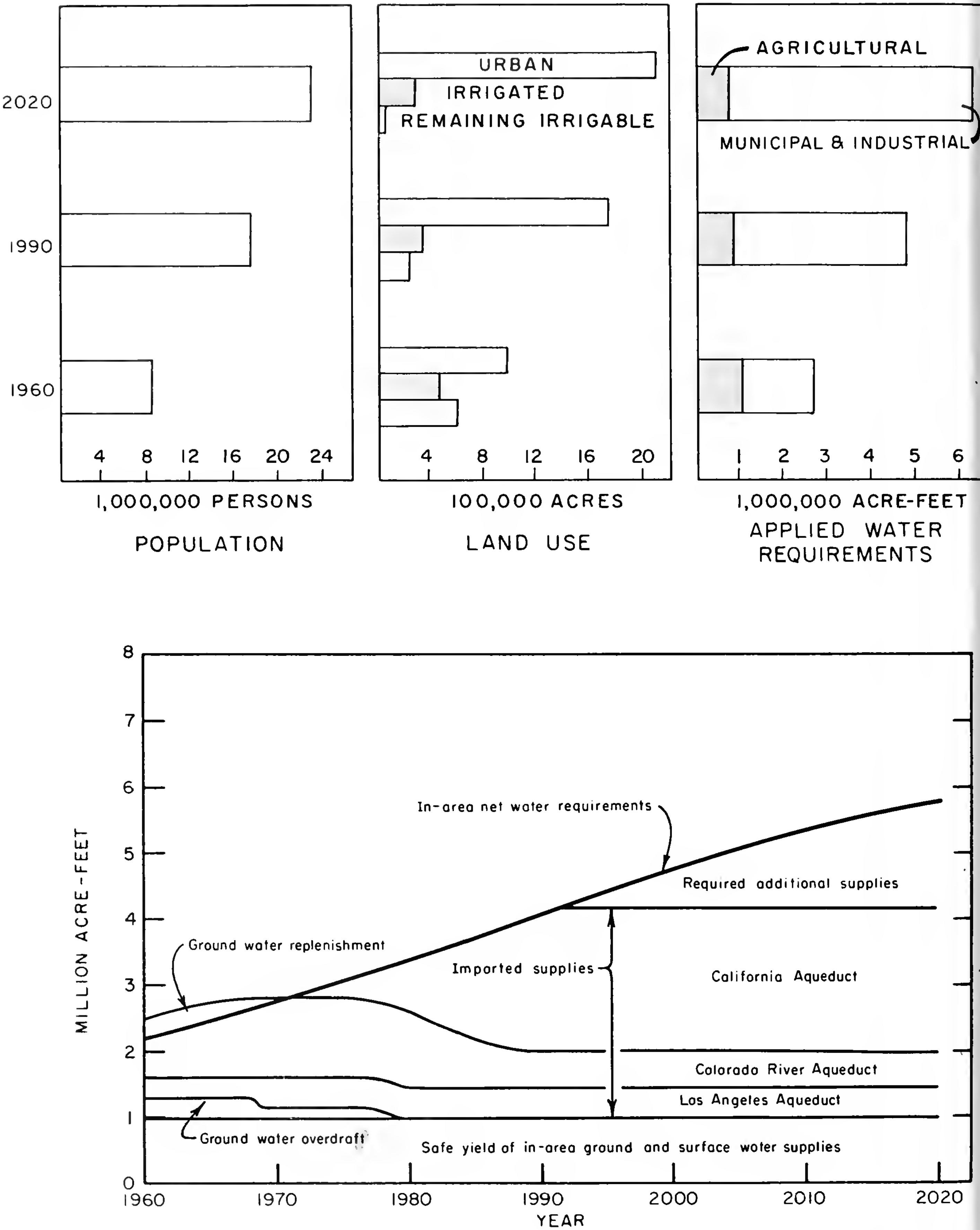


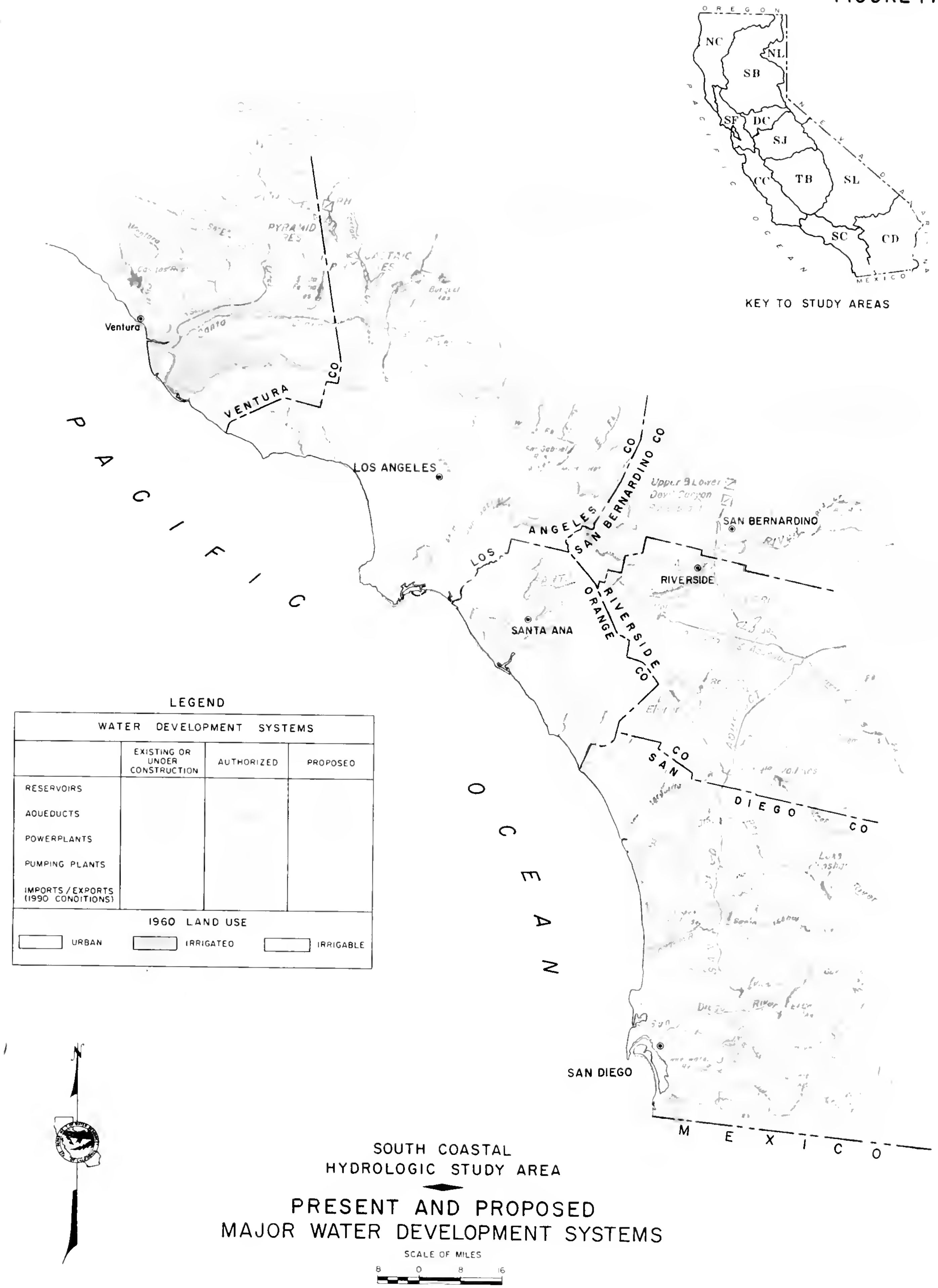
FIGURE 13



PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS

SOUTH COASTAL HYDROLOGIC STUDY AREA

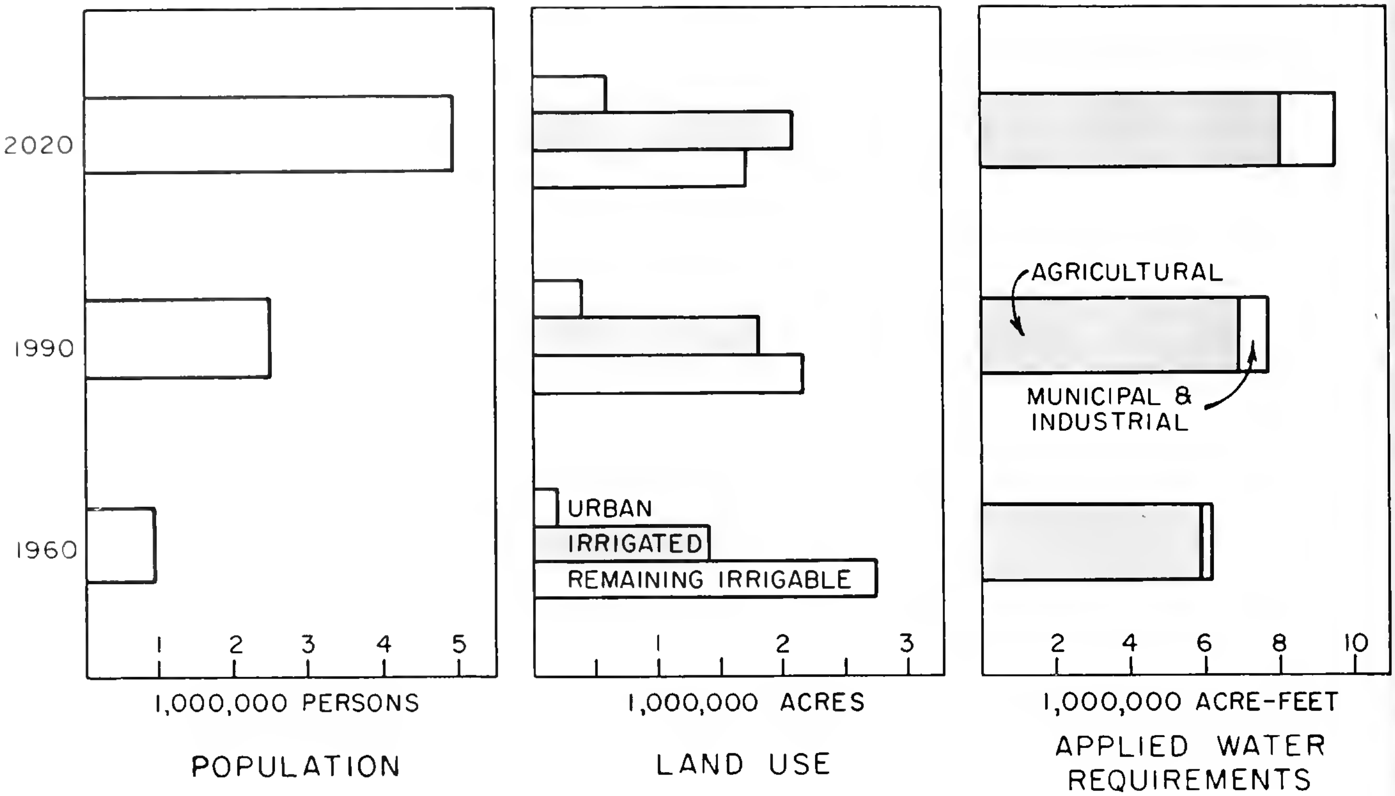
FIGURE 14

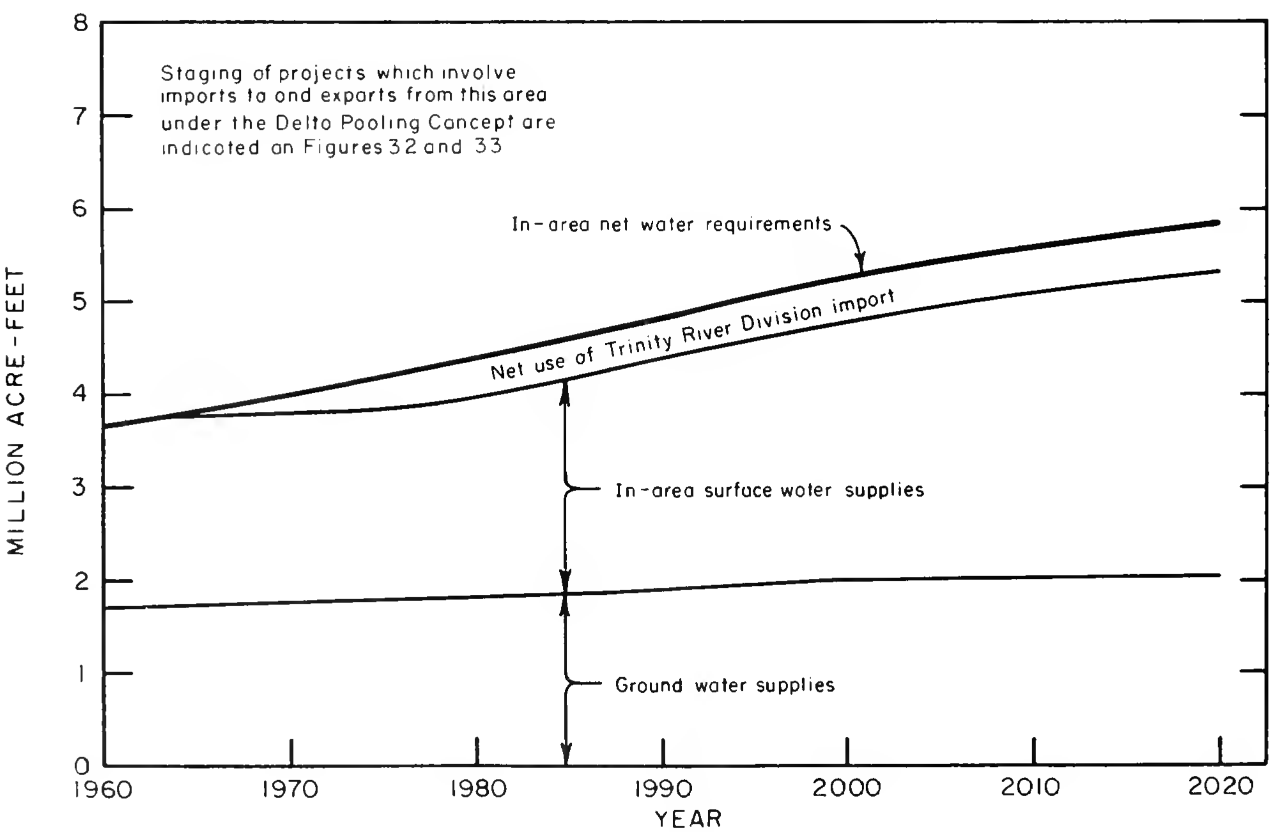


SOUTH COASTAL
HYDROLOGIC STUDY AREA

PRESENT AND PROPOSED
MAJOR WATER DEVELOPMENT SYSTEMS

FIGURE 15





PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS

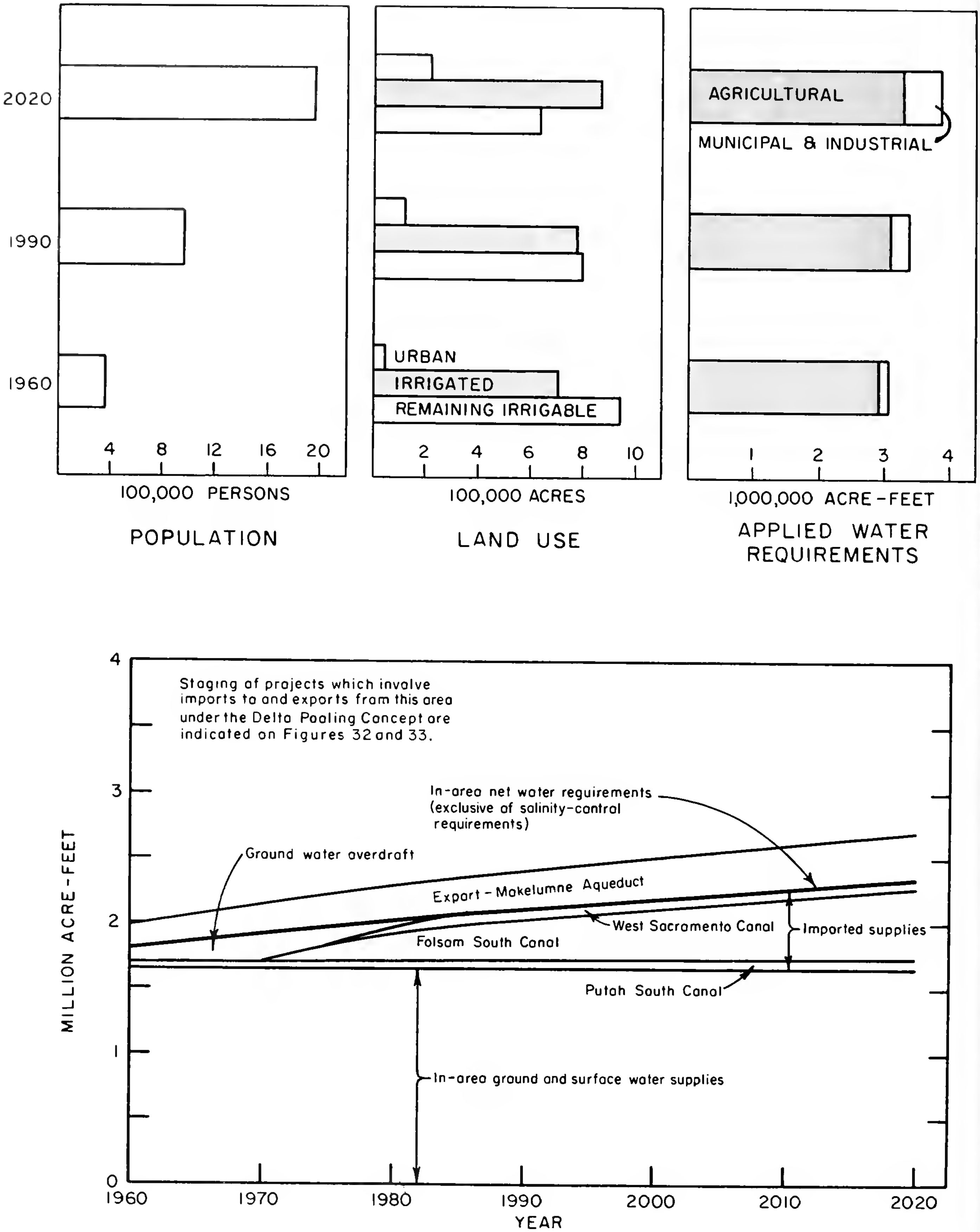
SACRAMENTO BASIN HYDROLOGIC STUDY AREA

FIGURE 16

SACRAMENTO BASIN
HYDROLOGIC STUDY AREA

PRESENT AND PROPOSED
MAJOR WATER DEVELOPMENT SYSTEMS

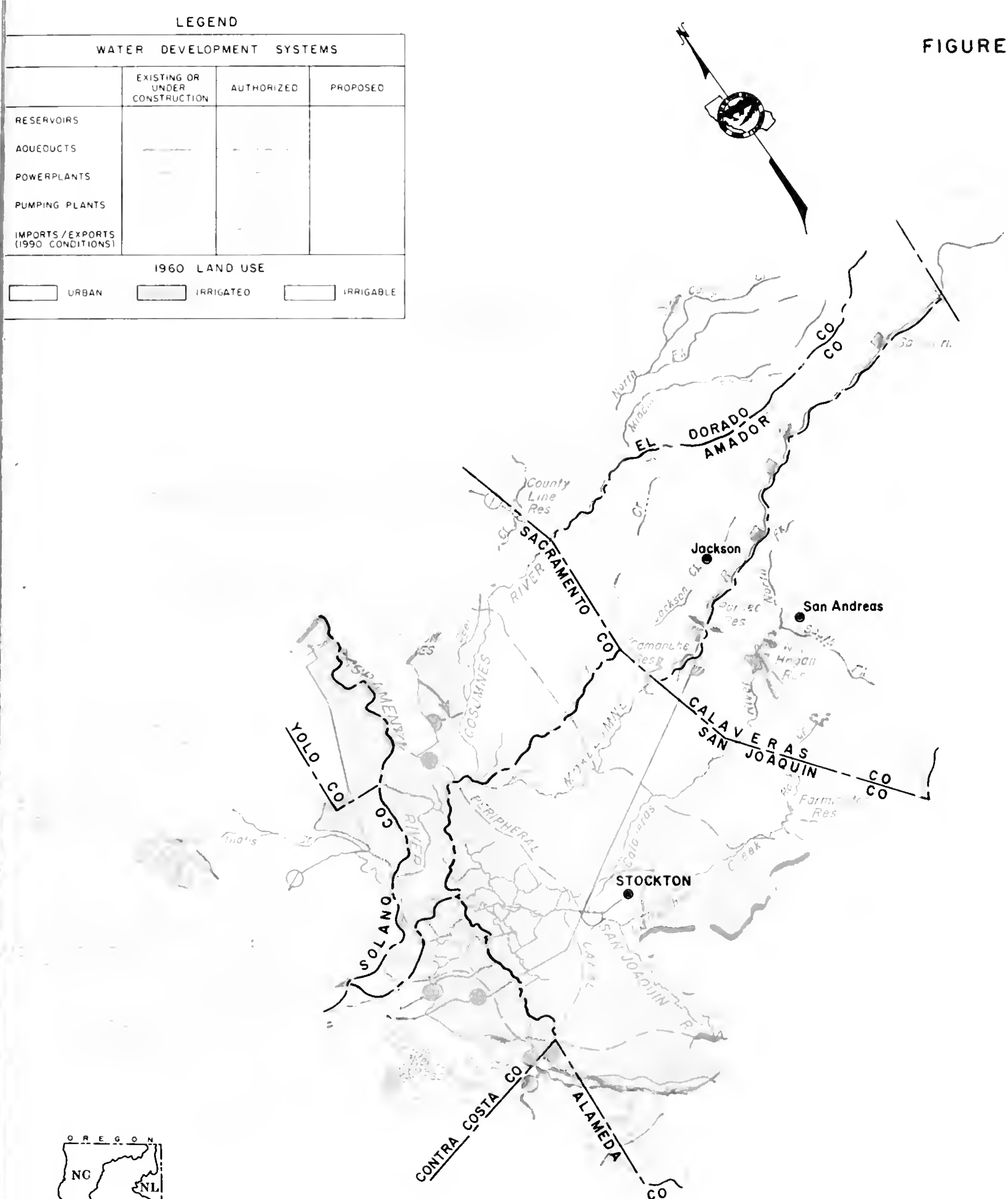
FIGURE 17

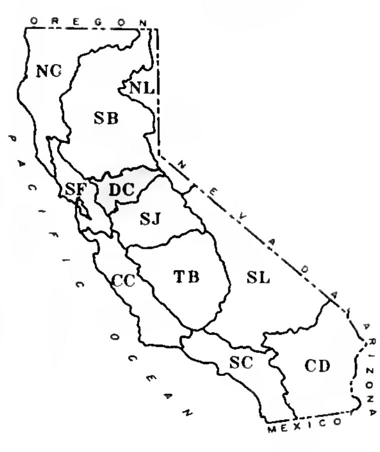


PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS

DELTA-CENTRAL SIERRA HYDROLOGIC STUDY AREA

FIGURE 18





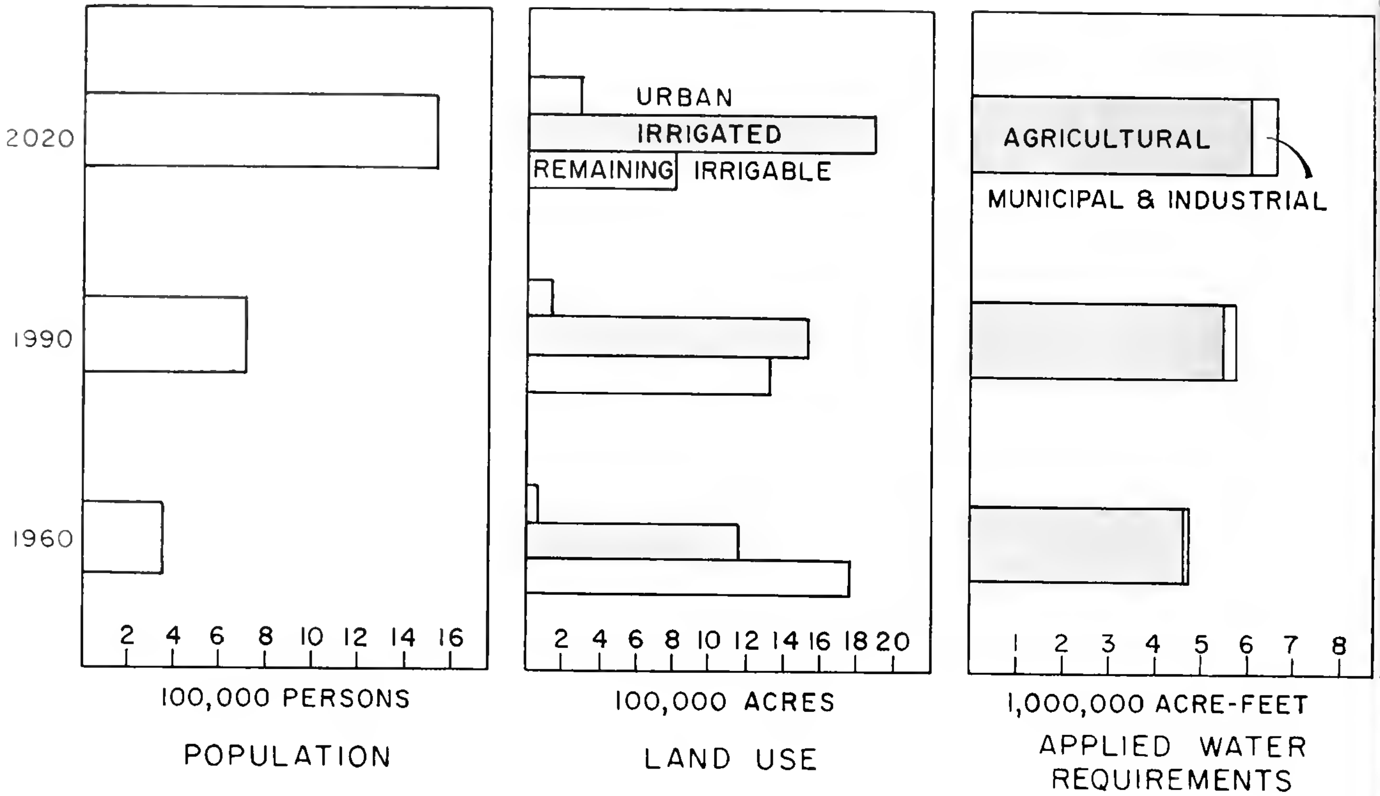
KEY TO STUDY AREAS

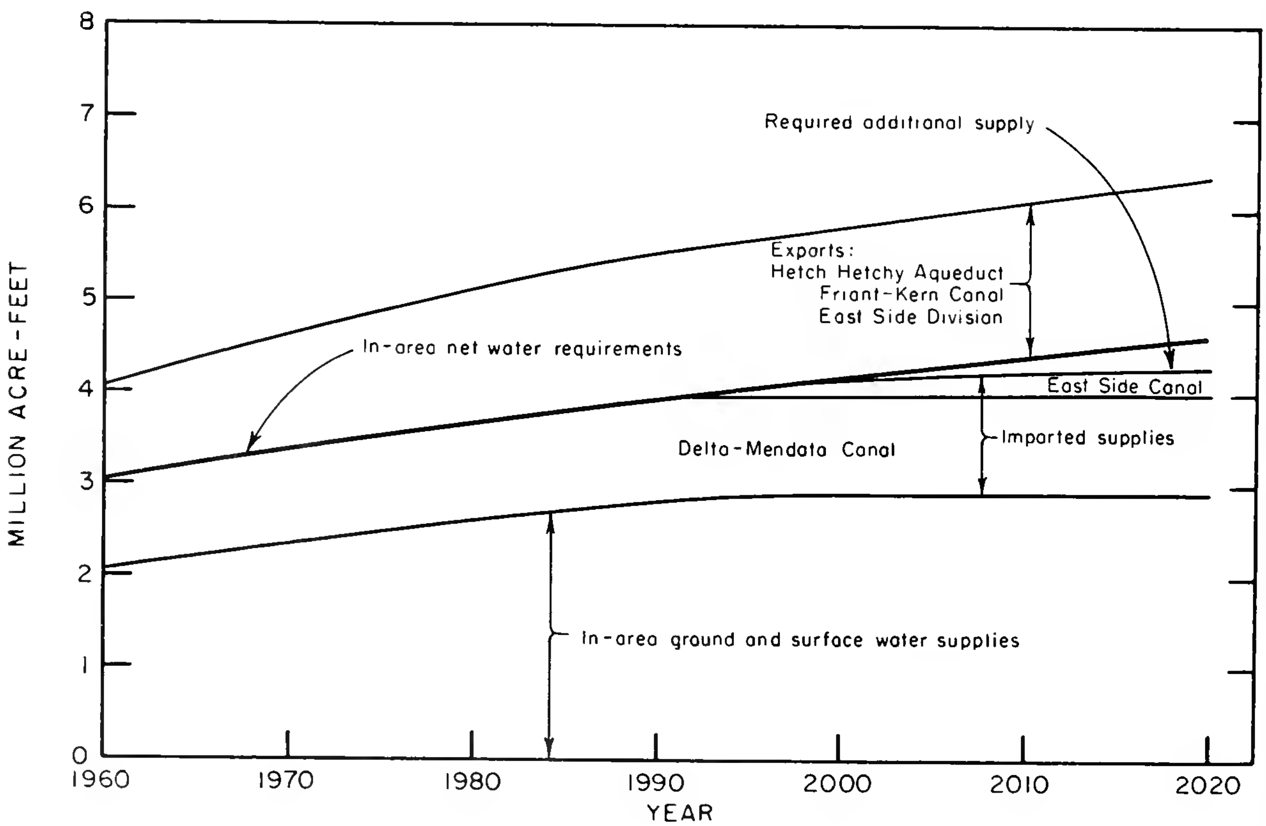
DELTA – CENTRAL SIERRA
HYDROLOGIC STUDY AREA

PRESENT AND PROPOSED
MAJOR WATER DEVELOPMENT SYSTEMS

SCALE OF MILES
8 0 8 16

FIGURE 19

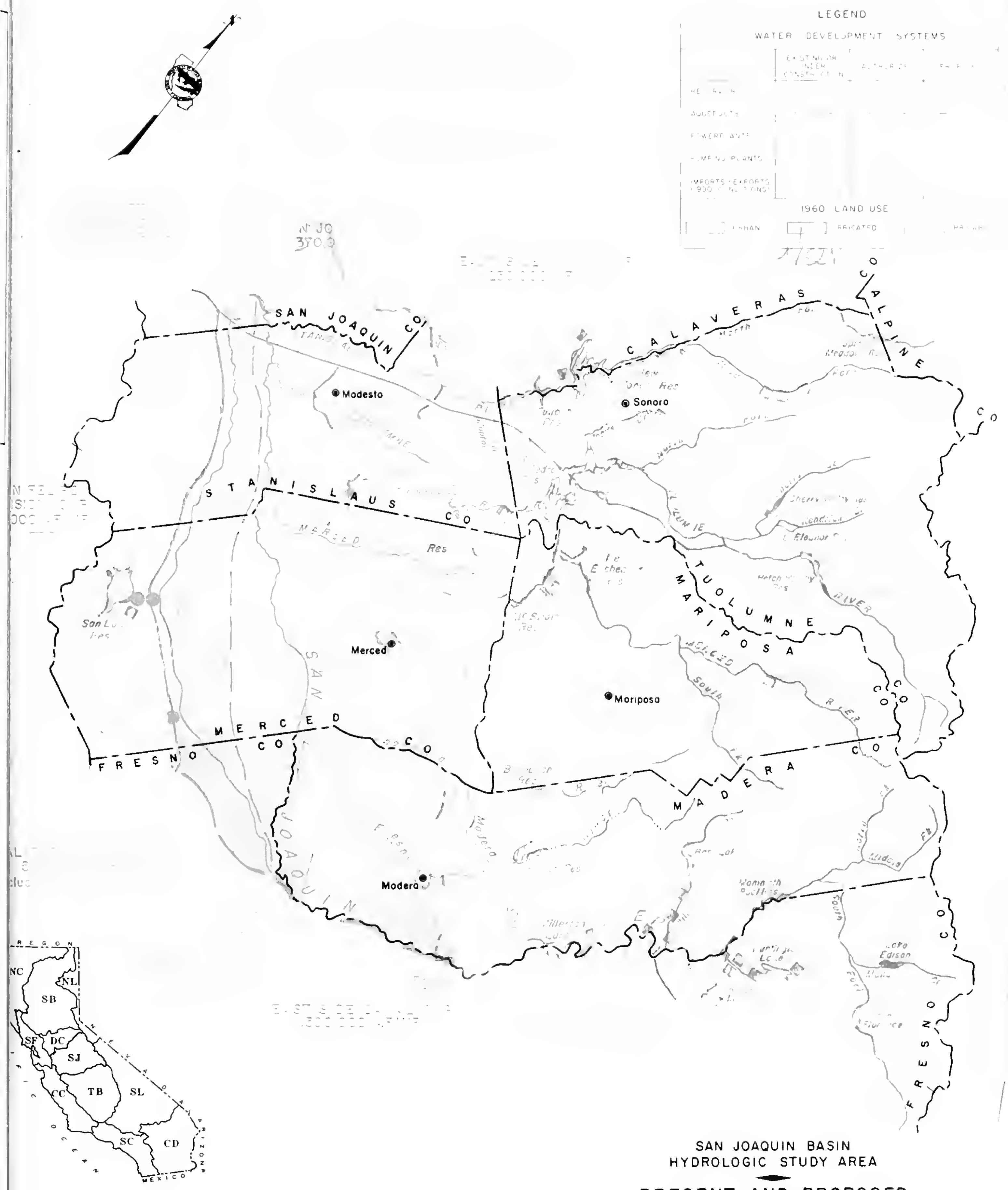




PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS

SAN JOAQUIN BASIN HYDROLOGIC STUDY AREA

FIGURE 20

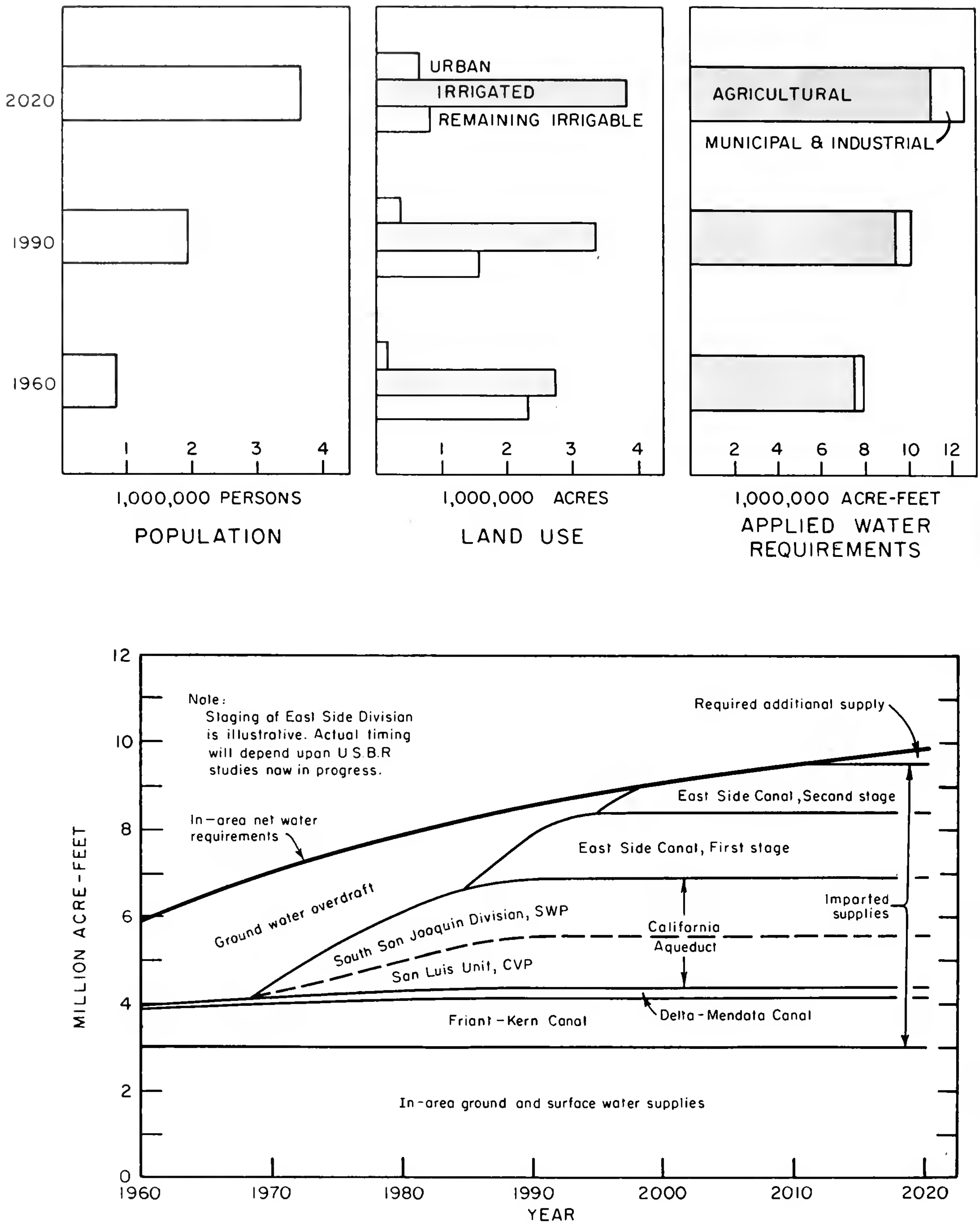


SAN JOAQUIN BASIN
HYDROLOGIC STUDY AREA

PRESENT AND PROPOSED MAJOR WATER DEVELOPMENT SYSTEMS

SCALE OF MILES
8 0 8 16

FIGURE 21



PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS

TULARE BASIN HYDROLOGIC STUDY AREA

FIGURE 22

LEGEND

WATER DEVELOPMENT SYSTEMS			
	EXISTING OR UNDER CONSTRUCTION	AUTHORIZED	PROPOSED
RESERVOIRS			
AQUEDUCTS			
POWERPLANTS			
PUMPING PLANTS			
IMPORTS / EXPORTS (1990 CONDITIONS)			

1960 LAND USE

URBAN | IRRIGATED | IRRIGABLE

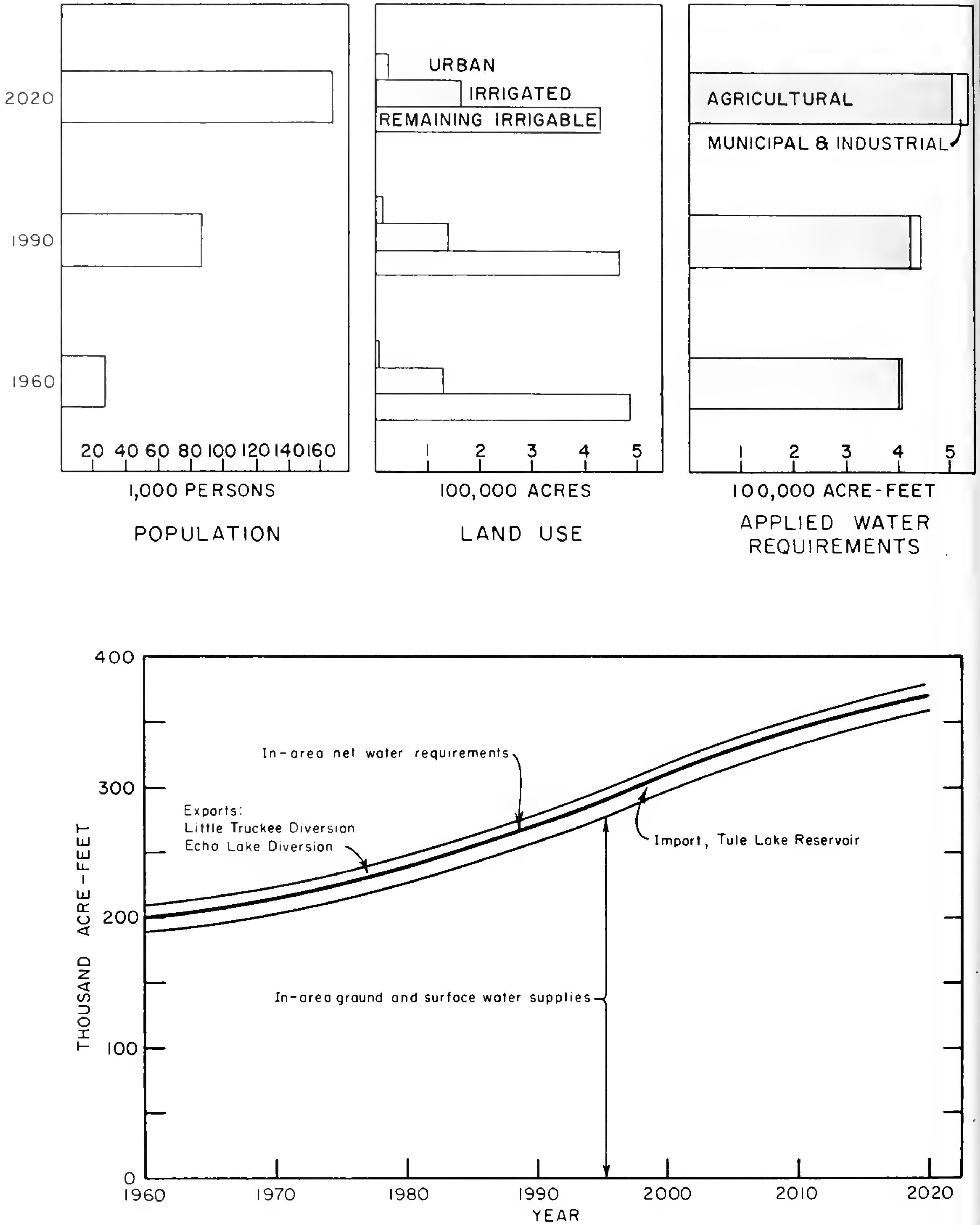
TULARE BASIN
HYDROLOGIC STUDY AREA

PRESENT AND PROPOSED
MAJOR WATER DEVELOPMENT SYSTEMS

SCALE OF MILES

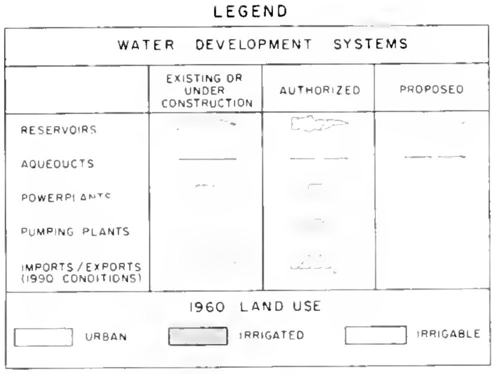
8 0 8 16

FIGURE 23

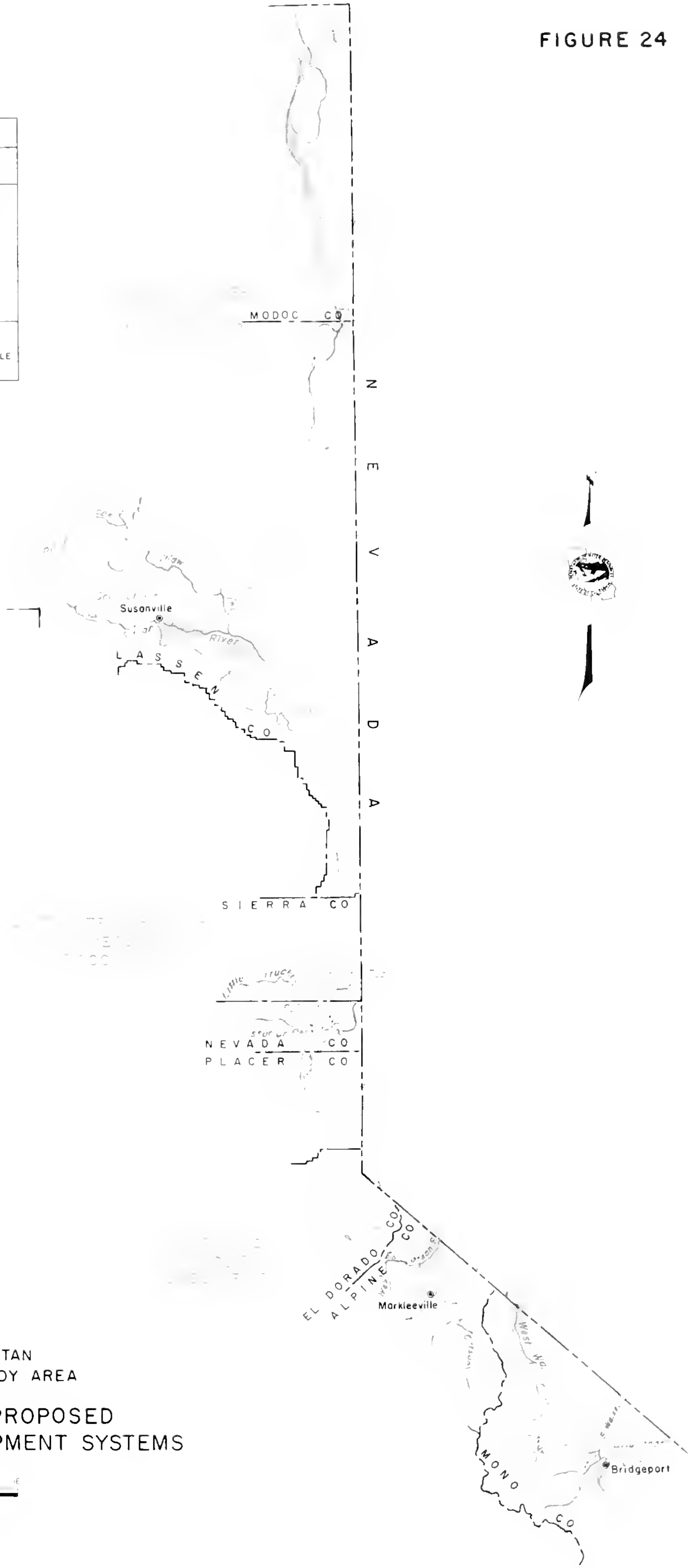


PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS

NORTH LAHONTAN HYDROLOGIC STUDY AREA



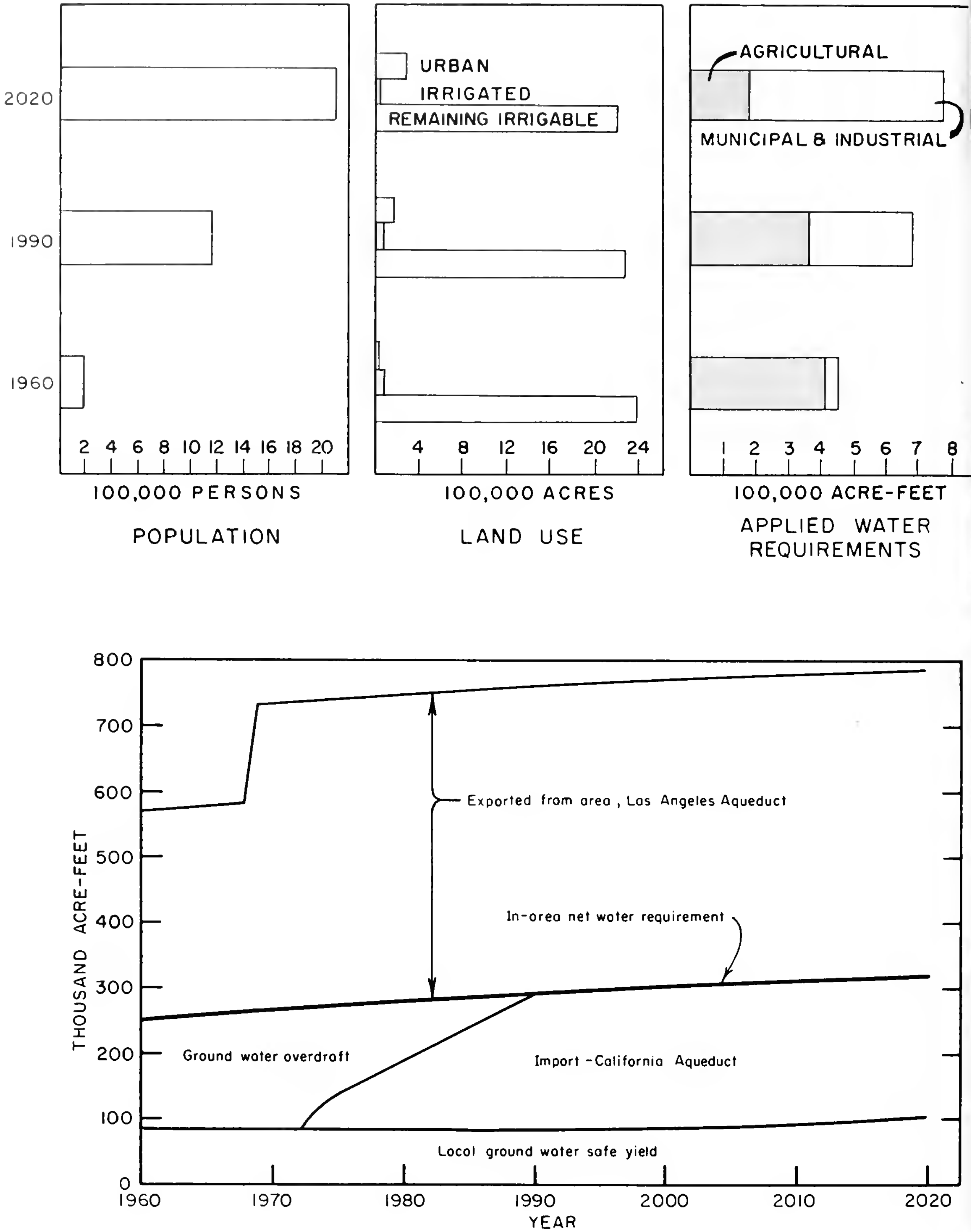
KEY TO STUDY AREAS



NORTH LAHONTAN
HYDROLOGIC STUDY AREA

PRESENT AND PROPOSED
MAJOR WATER DEVELOPMENT SYSTEMS

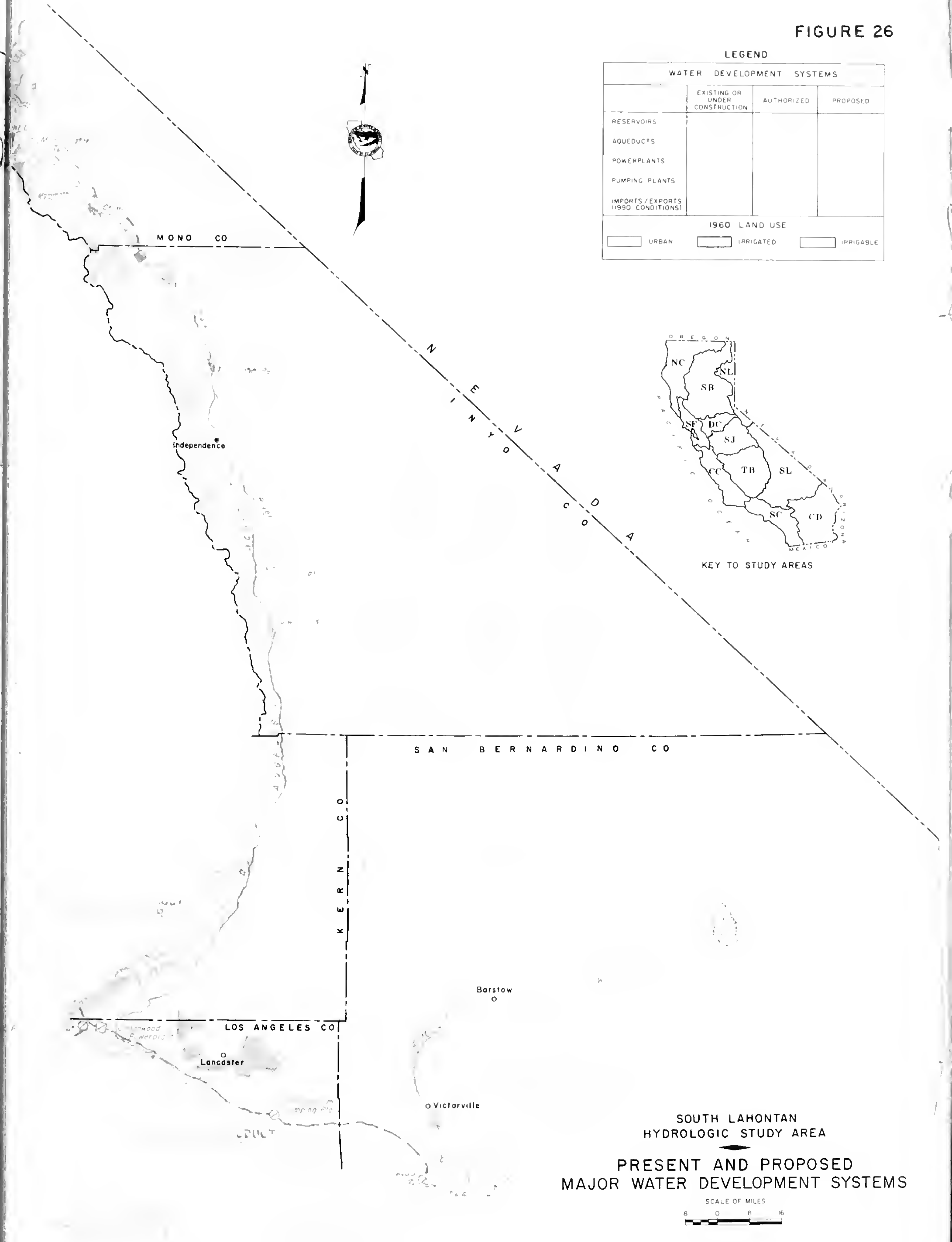
FIGURE 25



PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS

SOUTH LAHONTAN HYDROLOGIC STUDY AREA

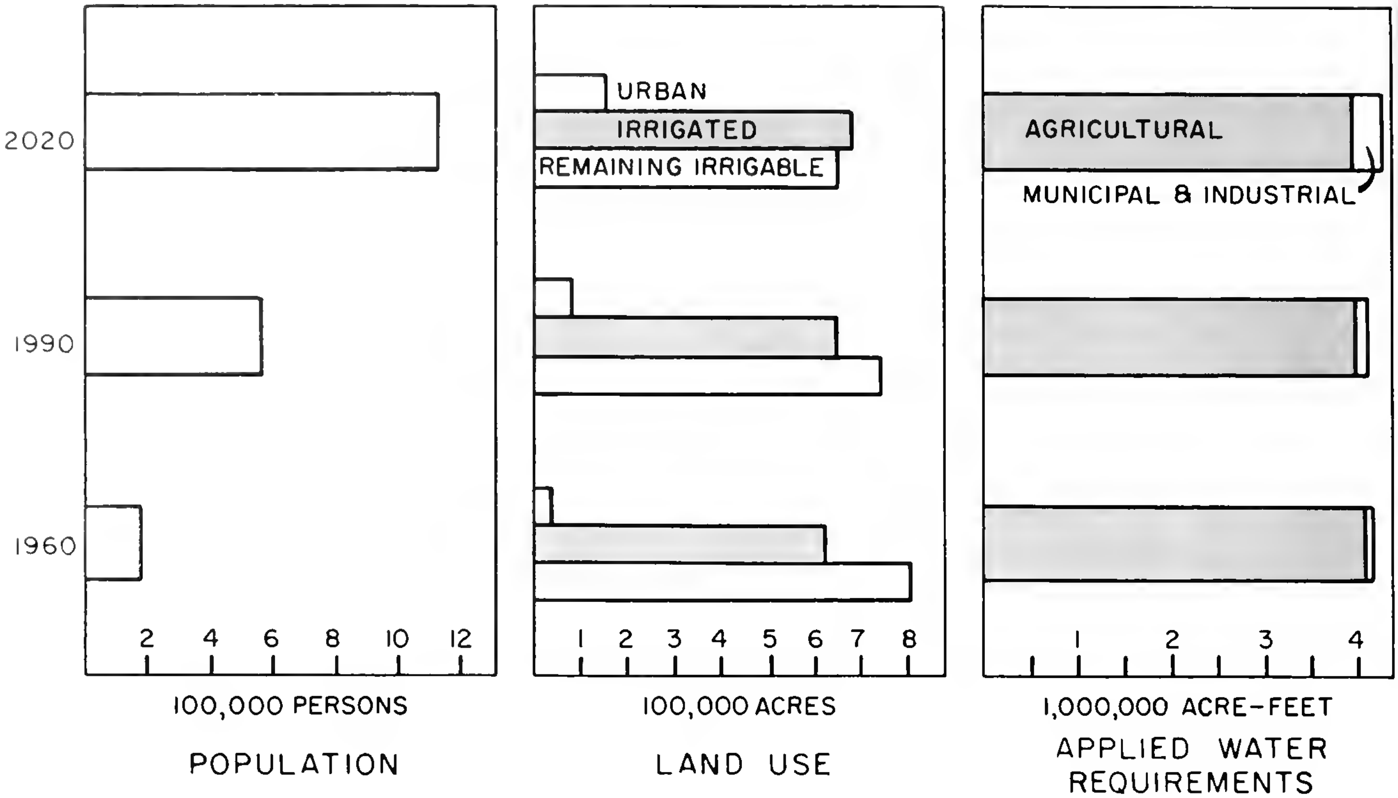
FIGURE 26

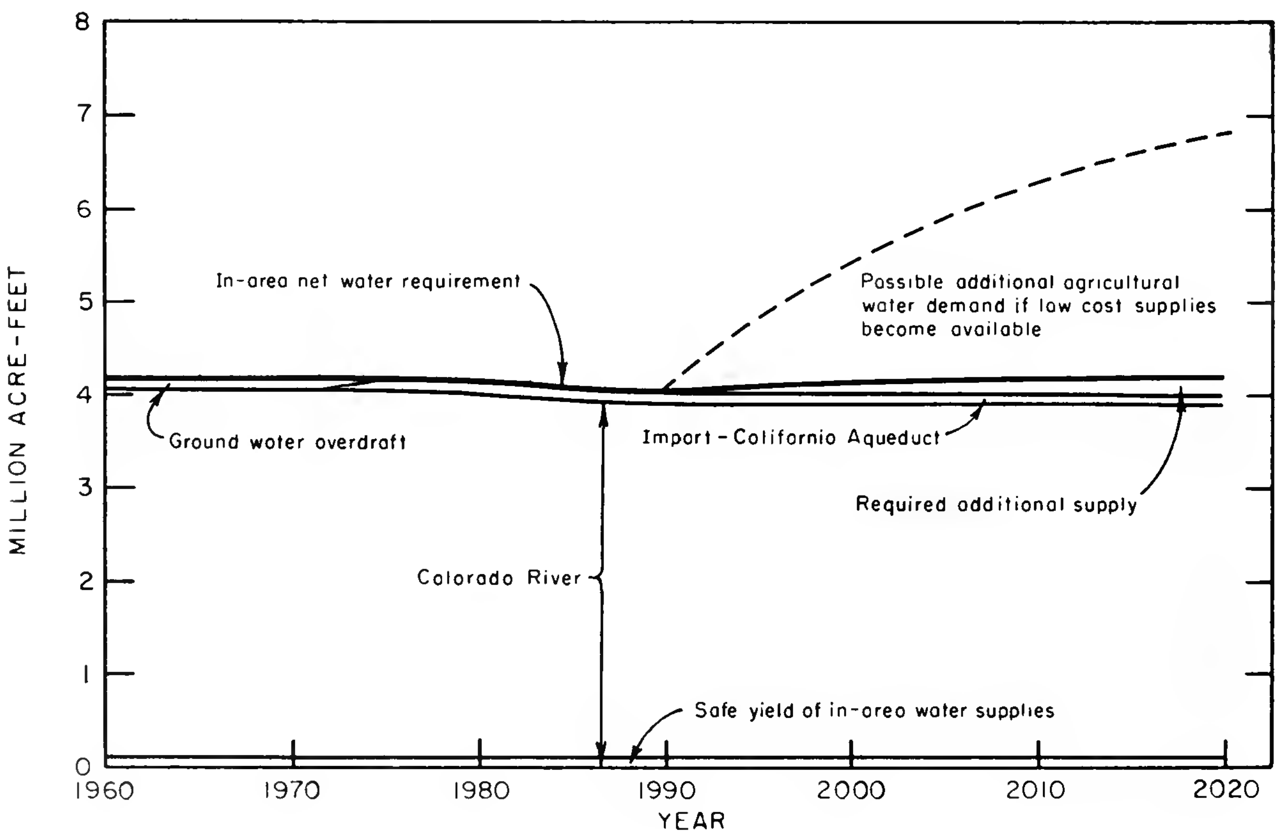


SOUTH LAHONTAN
HYDROLOGIC STUDY AREA

PRESENT AND PROPOSED
MAJOR WATER DEVELOPMENT SYSTEMS

FIGURE 27





PROJECTED WATER SUPPLIES AND NET WATER REQUIREMENTS

COLORADO DESERT HYDROLOGIC STUDY AREA

FIGURE 28

COLORADO DESERT
HYDROLOGIC STUDY AREA

PRESENT AND PROPOSED MAJOR WATER DEVELOPMENT SYSTEMS

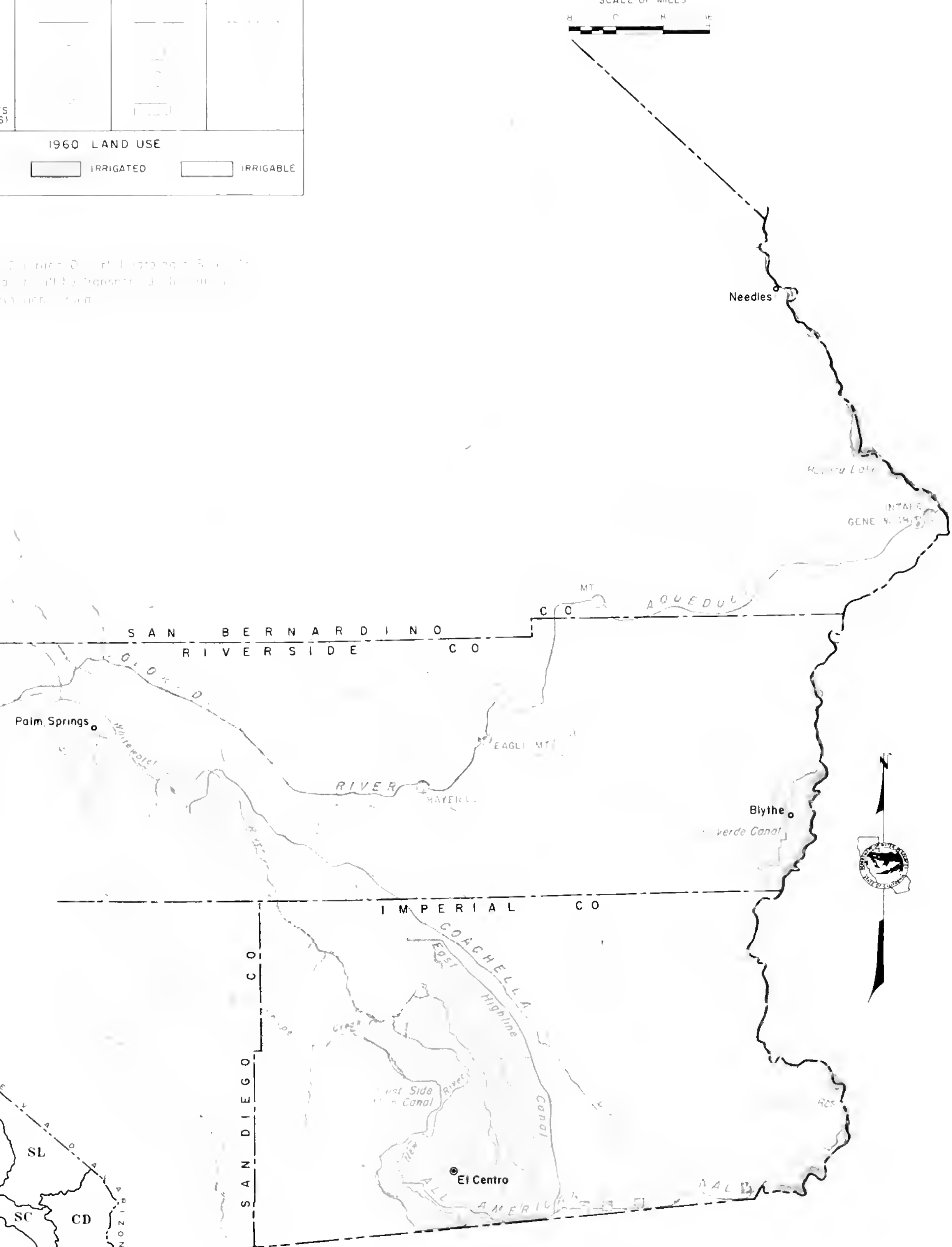
SCALE OF MILES

LEGEND

WATER DEVELOPMENT SYSTEMS	EXISTING OR UNDER CONSTRUCTION	AUTHORIZED	PROPOSED
RESERVOIRS			
AQUEDUCTS			
POWERPLANTS			
PUMPING PLANTS			
IMPORTS / EXPORTS (1990 CONDITIONS)			

1960 LAND USE

URBAN — IRRIGATED — IRRIGABLE



KEY TO STUDY AREAS

There are a number of opportunities for local surface water developments. An example is the proposed Butler Valley Dam and Reservoir on the lower Mad River about 20 miles east of Eureka. Its location is shown on Figure 8. At an estimated cost of 25 million dollars, this reservoir could be constructed with a capacity of 400,000 acre-feet. It would provide an annual water yield of about 220,000 acre-feet, flood protection along the lower Mad River and substantial recreation benefits. Its water yield could satisfy the growth of water requirements in Humboldt County and could replace water supplies of the upper Mad River which in turn could be diverted through the proposed lower Trinity River system into the Sacramento Valley.

The major conservation facilities being planned in the North Coastal area primarily for export purposes will also make water available for in-area use. These are discussed below and in the next section.

The California Water Plan demonstrated the general feasibility of conserving and transporting to water-deficient areas of the State a significant portion of the surplus runoff in the North Coastal area. Studies in the Department's North Coastal Area Investigation, which were reported in Bulletin No. 136, refined this concept and outlined it in more detail. The new estimates indicate that approximately 10 million acre-feet of firm water supply could be developed in the area by the staged construction of a series of major projects. This would be in addition to the yields of existing developments for local and export water supplies and in addition to estimated streamflow maintenance requirements for fisheries preservation.

Current projections, described in the next section, indicate that major increments of water supply from the North Coastal area will be needed for the Central Valley Project and State Water Project beginning in the late 1980's. Figure 7 shows the projected staging of developments in the Upper Eel, Trinity, Mad, and Van Duzen River Basins to meet an estimated combined water demand on the two projects of between 2.5 and 3.0 million acre-feet by the year 2000. This indicated staging is predicated upon the need for new water supplies only. Construction scheduling of these multiple-purpose projects may also be determined by the need for other project services such as flood control and water quality control. Figure 7 further indicates the possibility that supplies from the Lower Eel and Klamath Rivers may also be needed after the year 2000. These potential projects are described in the next section.

San Francisco Bay Area

The San Francisco Bay Hydrologic Study Area, considered as a whole, has sufficient water supplies developed or projected for development to meet its requirements until about 2020 (Figure 9). This area has a complex system of water supply, however, and deficiencies will occur in some local areas after 1990.

For the purposes of estimating water supplies and projecting water development, this study area has been divided into two subareas. The first is the area surrounding San Francisco Bay proper and extending to the east and south of the bay. Local surface and ground water supplies in this subarea have been almost fully developed and there is heavy dependence on imported water. The southern part of the area, particularly Santa Clara Valley, has had a condition of significant ground water overdraft for a number of years, which has caused sea water intrusion near the Bay. Water now imported through the South Bay Aqueduct of the State Water Project and importations by the proposed San Felipe Division of the Central Valley Project should eliminate this condition.

The second subarea lies north of San Francisco Bay and includes the Russian River Basin. Although present and projected imports to this area provide the primary water supplies for certain localities, the subarea as a whole has substantial quantities of developable local supplies. Most of the projected increase in supplies obtained from local developments (Figure 9) will serve this subarea. The largest local sources are the Russian River and its tributaries. Analyses of proposed projects indicate that over 500,000 acre-feet per year of firm water supply can be developed in the Russian River Basin to assist in meeting the growth of net water requirements.

The authorized and proposed projects in the San Francisco Bay area are shown on Figure 10. Warm Springs Reservoir, authorized for construction by the Corps of Engineers, will provide flood control on the Russian River and will contribute 90,000 acre-feet of new water supply for use in Sonoma and Marin Counties.

The largest of the proposed projects would be Knights Valley Reservoir which would be formed by dams on Maacama and Franz Creeks. These creeks are tributaries of the Russian River. The reservoir would regulate natural runoff of the two streams and would store water pumped from the Russian River during periods of excess flow. At a capacity of 1.5 million acre-feet, the reservoir would provide an annual water supply of approximately 350,000 acre-feet for Napa Valley and Sonoma and Marin Counties, would furnish flood control, and would accommodate exceptionally high recreational usage. The cost would be about 200 million dollars.

The remaining two proposals are Big Sulphur Reservoir on Big Sulphur Creek (a tributary of the Russian River) and Walker Reservoir on Walker Creek. Big Sulphur Reservoir would be chiefly for flood control, and Walker Reservoir would provide local water service in Marin County.

Central Coastal Area

In the Central Coastal Hydrologic Study Area, local water supplies will not meet the area's long-range water requirements. To sustain the projected growth of the area, water must be imported from the Central Valley or obtained from other sources. By the year 2020, over one-third of the water requirements are expected to be met from outside sources, as shown on Figure 11.

The Central Coastal area now depends entirely on local water supplies. In portions of San Luis Obispo and Santa Barbara Counties and in the Hollister-Gilroy area, the local supplies are nearing full development. These localities will shortly be turning to imported water from the State Water Project and from the Bureau of Reclamation's proposed San Felipe Division, shown on Figure 12. In other areas more water can be developed from locally available supplies.

A large portion of the local water supply in the Central Coastal area is derived from ground water, and several of the ground water basins are being overdrawn. The aggregate overdraft in the entire area is probably about 70,000 acre-feet per year, but additional study is required to confirm its magnitude. Much of the overdraft is expected to be eliminated by imported water from the California Aqueduct and from the proposed San Felipe Division. Conjunctive operation of ground water basins with existing and future surface water reservoirs would also help to overcome the overdrafts.

Possible local projects have been identified which could provide an additional yield of about 180,000 acre-feet per year. A large portion of this potential supply would come from development of the relatively minor streams along the coast of San Luis Obispo County. When developed, probably after 1990, these supplies would be conveyed by conduit to the San Luis Obispo metropolitan area for municipal and industrial use.

By the year 2020, the annual yield from local development is expected to increase to about 900,000 acre-feet, representing essentially full development of local ground and surface water supplies. Present plans are for annual imports from the State Water Project and the San Felipe Division totaling 189,000 acre-feet by 2020. With a net water requirement of 1.58 million acre-feet in 2020 it is estimated that the area will require an additional annual imported supply of approximately 490,000 acre-feet. This amount is assumed in this report to be met by imports from the Central Valley, through future additions to the State Water Resources Development System.

South Coastal Area

The South Coastal Hydrologic Study Area presently depends on three sources of water, as shown on Figure 13. These are local surface and ground water supplies, which are almost fully developed and in fact are overdrawn in some areas; the Los Angeles Aqueduct, which is presently being enlarged to deliver approximately 472,000 acre-feet per year; and the Colorado River Aqueduct, which is now delivering water at almost its full capacity, after conveyance losses, of about 1.18 million acre-feet per year. Importations to portions of the South Coastal area are expected to exceed water requirements until about 1970. This excess will enable additional interim water replenishment. Beginning in the mid-1970's, net deliveries through the Colorado River Aqueduct are expected to be gradually reduced to about 540,000 acre-feet per year, as a result of the U.S. Supreme Court's decision in Arizona v. California, which was discussed in Chapter I.

The major local surface water supply development which has been proposed in the South Coastal area is the Sespe Creek development in Ventura County. This has been studied by both the United Water Conservation District and the Bureau of Reclamation. The Bureau's proposal would consist of Topatopa and Cold

Springs Reservoirs, with capacities totaling 410,000 acre-feet, and a conveyance conduit. The project would have a total annual yield of about 27,500 acre-feet. The cost of the development would be about 68 million dollars.

Figure 14 shows the locations of the principal existing and proposed local surface storage features and the routes of import works.

Before the impact of the Colorado River loss is felt, deliveries from the State Water Project to The Metropolitan Water District of Southern California and other cities and water agencies in the South Coastal area will begin. Annual deliveries are scheduled to commence in 1971 at 251,000 acre-feet and to increase to a maximum of 2,180,000 acre-feet per year by 1990. This import, together with the supplies described above, should meet the area's water needs until shortly after 1990, when additional supplies will be needed.

It is expected that by 2020, this requirement for additional water will have increased to about 1.5 million acre-feet per year. This will probably be met from several sources. Significant technological advances are being made in saline water conversion. This process and additional waste water reclamation will probably meet a portion of the requirement. It is assumed conservatively for this report that, by 2020, a total of 300,000 acre-feet per year could be produced at favorable costs in parts of the South Coastal area by these two methods. It is assumed that the remaining requirement of approximately 1.2 million acre-feet per year will be met by additional imports from Northern California through the State Water Resources Development System.

Sacramento Basin

With a long-term mean annual runoff totaling slightly more than 20 million acre-feet, the Sacramento Basin Hydrologic Study Area is second only to the North Coastal area in terms of water supply. Water development for a wide range of purposes has been proceeding for many years. At present in the basin, there is a total of about 16 million acre-feet of surface reservoir storage either existing or under construction. In addition, there are many miles of canals for conveyance of surface water supplies. The locations of the major water development facilities are shown on Figure 16.

Ground water is used extensively for agricultural and domestic purposes throughout the Sacramento Basin, particularly on the valley floor portion. The projected increase in ground water usage, indicated on Figure 15, is predicated upon continuation of the present pattern of ground water development in the basin, which is largely independent of surface storage facilities.

The Department has made preliminary estimates that conjunctive operation of ground water basins of the Sacramento Valley with surface storage facilities could develop an additional annual yield of about 1.2 million acre-feet for both local and export use. Additional study of this possibility is required to evaluate its feasibility. The costs of such yield should be compared with costs of water from surface developments in the basin and of water imported from the North Coastal area.

It has been assumed for this report that use of in-area surface water supplies will increase by about 1.2 million acre-feet from the present to 2020 (Figure 15). This growth would be accommodated by storage and transportation facilities existing and under construction and by proposed additional facilities.

Examples of proposed new facilities are shown on Figure 16. The West Sacramento Valley Canal Unit of the Central Valley Project, including Sites Reservoir as an offstream pumped-storage feature, would provide a firm water supply of about 355,000 acre-feet per year at a cost of about 166 million dollars. The proposed New Bullards Bar Reservoir, on the Yuba River, would have a capacity of 930,000 acre-feet and would provide flood control, power, recreation and about 370,000 acre-feet of new water supply yield at a total cost of about 188 million dollars. Other facilities proposed in the Sacramento Basin include the Allen Camp Unit of the Central Valley Project on the Pit River; Millville, Hulen and Dippingvat Reservoirs on upper tributaries of the Sacramento River, and Wilson Valley Reservoir on Cache Creek or Indian Valley Reservoir on the North Fork of Cache Creek.

Delta-Central Sierra Area

The Delta-Central Sierra Hydrologic Study Area is the hub of the major state and federal water development facilities in California. The locations of important features are shown on Figure 18.

The aggregate quantities of water which either originate within, or flow into the Delta-Central Sierra area far exceed the present and projected water requirements of the area itself. The geographic distribution of these water supplies, however, is such that ground water overdraft conditions have developed along the eastern edge of the valley floor portion of the area and northwest of the Delta.

Construction of the authorized Folsom South Canal by the Bureau of Reclamation will enable substantial reduction of the ground water overdrafts, and will provide for most of the anticipated increase in water requirements indicated on Figure 17. The West Sacramento Canal is expected to meet the remaining requirements in the northwestern portion of the area.

The Peripheral Canal, an authorized feature of the State Water Project, will convey state and federal water around the Delta as a link in the system to convey water southward. It is proposed as a joint facility of the federal Central Valley Project and the State Water Project. It will also provide for local water supply, water quality control, fish and wildlife preservation and enhancement, recreation and other purposes within the Delta.

Besides these works, the Bureau of Reclamation has proposed a future development on the Cosumnes River for local water supply in that watershed and to provide flood control, recreation, and fish and wildlife enhancement. The major unit of this development would be Nashville Reservoir with a capacity of 900,000 acre-feet. This reservoir, together with three auxiliary storage units and associated distribution and recreation facilities comprising the initial phase, would cost about 158 million dollars and would provide a firm yield of 150,000 acre-feet annually for portions of the foothills in Amador and Sacramento Counties. A future phase, consisting of two more reservoirs, would cost an additional 25 million dollars and would yield about 25,000 acre-feet annually.

The proposed East Side Canal, shown on Figure 18, would constitute an extension of the Folsom South Canal, but would not provide water service within the Delta-Central Sierra area. It would include a pumped diversion from the Sacramento River near Hood.

San Joaquin Basin

Water resources originating within the San Joaquin Basin Hydrologic Study Area have been largely sufficient to meet in-area requirements and to support a substantial export to the San Francisco Bay area (Figure 19). The major existing import, through the Delta-Mendota Canal, is intended chiefly to exchange water for that which is exported southward into the Tulare Basin through the Friant-Kern Canal. The Delta-Mendota Canal also provides service to lands along the west side of the valley.

Surface water, which serves about two-thirds of the area, has been extensively developed and plans now in progress would augment these works. Ground water serves the remaining needs of the area, and is in abundant supply considering the basin as a whole. There are local areas, however, where ground water levels have been declining and where overdraft conditions are suspected.

By about the year 2020, annual use of in-area water supplies is expected to reach about 2.9 million acre-feet, an increase of about 800,000 acre-feet over 1960 use. This increase will be permitted by facilities under construction, such as New Exchequer Reservoir on the Merced River, and by those authorized, such as New Melones Reservoir on the Stanislaus River and New Don Pedro Reservoir on the Tuolumne River. New Melones Reservoir is authorized for construction by the Corps of Engineers and for operation by the Bureau of Reclamation as part of the Central Valley Project. It will have a capacity of 2.4 million acre-feet and will provide water conservation, flood control, hydroelectric power, fish and wildlife enhancement, and recreation. The total cost will be about 122 million dollars. New Don Pedro Reservoir will be built by the City of San Francisco and the Turlock and Modesto Irrigation Districts to provide flood control and to firm urban water supply exports by the city and local irrigation supplies of the districts. It will probably have a capacity of about two million acre-feet, but this has not been determined finally. The locations of these authorized reservoirs are shown on Figure 20.

Additional water requirements in the foothill areas may also lead to construction of new local facilities. For example, in the Tuolumne River Basin the Bureau of Reclamation is proposing the Sonora-Keystone Unit of the Central Valley

Project. It would provide approximately 46,000 acre-feet of water per year for agricultural, municipal, and industrial use. Tuolumne County Water District No. 2 proposes a smaller project in the same area to provide a water supply of 5,000 acre-feet and to furnish recreation and fisheries enhancement.

Present and proposed imports, including the proposed first stage of the East Side Division, Central Valley Project, when operated in concert with local supplies, should meet the area's water requirements until about the year 2000. Import requirements, in excess of the capabilities of present and proposed projects, are projected to increase to about 300,000 acre-feet by 2020.

Tulare Basin

The highly developed agricultural economy of the Tulare Basin is dependent upon runoff from the Sierra Nevada, imports from the Central Valley Project, and ground water overdraft to supply its vital water needs.

The basin has long had a deficient water supply. The present and projected water supply picture is presented on Figure 21. The mean annual natural runoff available for all purposes on the valley floor, including replenishment of ground waters, is only about 3.1 million acre-feet. The Central Valley Project imports about 950,000 acre-feet, which leaves a present average annual ground water overdraft of about two million acre-feet. It is apparent that any increase in the water-using economy of this area must be supported by additional imported water supplies.

Until waters from the California Aqueduct of the State Water Project and the San Luis Unit of the Central Valley Project become available in 1968, the Basin must increase its overdraft to meet its needs. By that year, the overdraft is expected to be about 2.8 million acre-feet annually.

For this report, it has been assumed that some of the wells in the Basin will be abandoned as all or most of their economic lives terminate and that future imported water supplies will be gradually increased to eliminate the overdraft by about 1995. Yields of the proposed first and second stages of the East Side Division, Central Valley Project, are shown on Figure 21. The locations of the proposed features of that division are indicated on Figure 22.

There is little opportunity to develop additional yield from surface waters in the Tulare Basin. There may be, however, the possibility of optimizing the yields of existing supplies by systematic management of the ground water basins. This possibility should be studied to determine its feasibility.

The state and federal projects currently being constructed or planned are expected to meet the future water needs of the Tulare Basin until about 2010. The area will then require an additional supply which will increase to about 300,000 acre-feet by 2020. The alternative would be to allow ground water overdraft to occur again.

North Lahontan Area

Water supplies for the North Lahontan Hydrologic Study Area originate chiefly in the Warner Mountains and on the eastern slopes of the Cascade Range and the Sierra Nevada. The estimated magnitudes of in-area supplies and imports are depicted on Figure 23. General features of the area, including the locations of water supply developments, are shown on Figure 24.

That portion of the study area north of the Truckee River drainage area receives a regulated import of about 11,000 acre-feet per year from the Pit River. With the exception of this and the releases from minor storage on the Susan River, the surface supplies for irrigation are used during the spring and early summer months essentially in their natural regimen. Present ground water extractions total about 65,000 acre-feet per year, and extensive increased use of this resource is not now considered feasible.

The possibilities for local surface water developments within the northern portion of the area are limited. The California Water Plan included Devils Corral Reservoir on Susan River and Long Valley Dam on Long Valley Creek. It also suggested the Pete's Valley-Eagle Lake development, comprising a confining dike across Eagle Lake and a dam and reservoir on Willow Creek. This development would make about 59,000 acre-feet of water available in the Honey Lake area. About 30,000 acre-feet of this would be considered new yield. The feasibilities of these possible developments have not been determined.

It is believed that the projected increase in net water requirements in the northern portion of the area can be met by increasing irrigation efficiencies and by a combination of the surface developments mentioned above and minor increased use of ground water. Additional study would be required to confirm this conclusion.

The southern portion of the study area consists of the California portions of three interstate streams: the Truckee, Carson and Walker Rivers. All of these rivers have been developed for use within both California and Nevada. Two small exports, one from the Little Truckee into the Feather River drainage and the other from Lake Tahoe drainage into the American River watershed, total about 9,000 acre-feet per year.

Because the potential use of these rivers for irrigation, domestic water supply, recreation and other purposes exceeds the available flows, water rights have long been controversial. Court decrees, under the administration of federal watermasters, control the uses of each stream. Since 1956, the States of California and Nevada have been engaged in the negotiation of a compact concerning present and future uses of the interstate waters of Lake Tahoe and the three rivers. During the Fall of 1965, the California-Nevada Interstate Compact Commission provisionally approved a proposed compact between the States, subject to ratification by them and to consent of the Congress.

The major purposes of the proposed compact are: to provide for the equitable apportionment of water between the two States; to promote interstate comity and to further intergovernmental cooperation; to protect and enhance existing economies; to remove causes of present and future controversies; and to permit the orderly, integrated, and comprehensive development, use, conservation, and control of the waters of the three rivers and Lake Tahoe. This document, when approved, will confirm present uses in California and provide for allocation of unused water between the states.

The Bureau of Reclamation is proposing several projects in the southern portion of the area. These include Stampede Reservoir on the Little Truckee River and Pickle Meadows Reservoir on the West Walker River. These facilities would be operated according to the proposed compact, and would provide service both in California and Nevada.

South Lahontan Area

In the South Lahontan Hydrologic Study Area, water and its cost, rather than land, are the factors that limit future development for both agricultural and municipal purposes.

The principal stream in the area is the Owens River, which has been developed for export to the City of Los Angeles. In recent years, the export of about 320,000 acre-feet per year has been near the capacity of the aqueduct. A parallel aqueduct will be completed by 1968 and will increase the export to a total of about 470,000 acre-feet annually. This yield will be obtained by operation of the Owens Valley ground water basin in conjunction with surface supplies of the Owens River and streams of Mono Basin. Both aqueducts are expected to be operated at full capacity by 1969. These facts are depicted graphically on Figure 25. Figure 26 shows the locations of the facilities.

Water supplies for local use in the area are obtained chiefly by diversion of streams flowing from the Sierra Nevada and by the pumping of ground water. A small import of about 2,000 acre-feet into the Mono Lake drainage basin and Littlerock Reservoir near Palmdale, with a yield of about 2,000 acre-feet per year, are the principal surface water supply developments other than facilities of the City of Los Angeles. In the southern part of the area, the ground water is presently being overdrawn by about 160,000 acre-feet each year.

In 1972, the area will begin importing water from the State Water Project, and deliveries are expected to build up to about 215,000 acre-feet per year by 1991. These imports will offset the present ground water overdraft and allow for a modest expansion of the water-using economy of the area.

Colorado Desert Area

Although the Colorado Desert Hydrologic Study Area is the driest region in the State, its irrigated agricultural development is second only to that of the Central Valley area. This has been accomplished almost entirely by diversion and use of low-cost Colorado River water through facilities shown on Figure 28.

Annual net diversions from the Colorado River are projected to decrease from the present level of about 4.0 million acre-feet to 3.85 million acre-feet, because of the U.S. Supreme Court decision in Arizona v. California. It is estimated that the full reduction will be reached in about 1990 (Figure 27). To achieve the modest increase in level of agricultural activity projected for the basin, it will be necessary to make all feasible savings of water by additional canal lining, phreatophyte eradication, and other improvements.

Because of the costs involved, supplies to be imported to the area from the State Water Project, totaling approximately 80,000 acre-feet annually by 1990, will be used primarily to support the projected population growth within the service areas of the Coachella Valley County Water District and the Desert and San Gorgonio Pass Water Agencies. These service areas are north of the Salton Sea. It is estimated that urban expansion will continue after 1990 and that this will require additional imports, increasing to about 175,000 acre-feet by 2020.

There is a very close relationship between the potential demands for agricultural water in the Colorado Desert area and the availability of low-cost imported water supplies. It has been estimated that about 1.8 million acre-feet of additional water supplies could be used to develop some 250,000 acres of desert lands within the service area of the Imperial Irrigation District alone. There are other large expanses of undeveloped valley and mesa lands within and adjacent to the

Palo Verde Irrigation District and the Coachella Valley County Water District, on which additional agricultural water supplies, totaling perhaps 900,000 acre-feet annually, could be used if low-cost water were available.

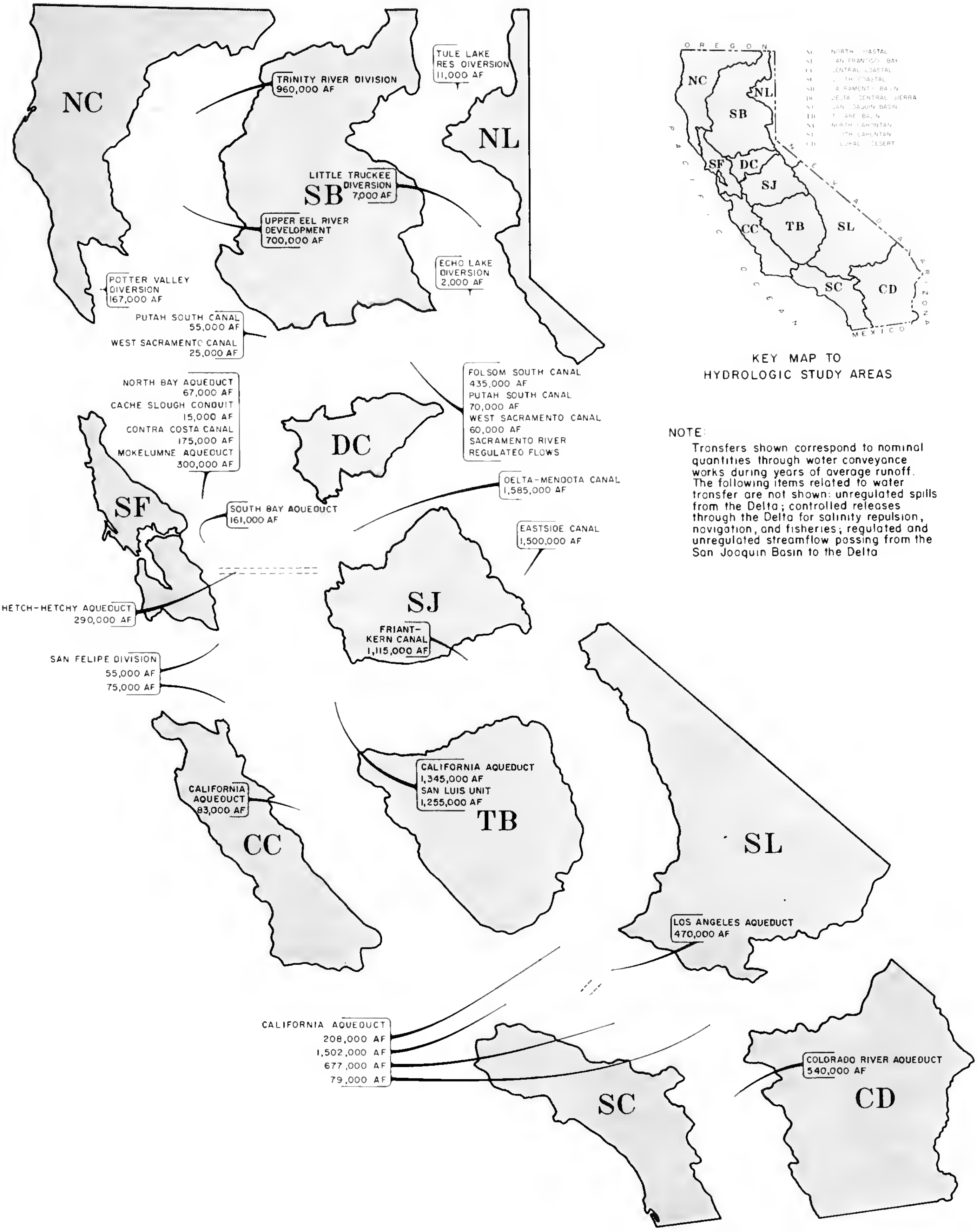
The sum of these contingent additional requirements, amounting to about 2.7 million acre-feet per year by 2020, is shown by the dashed line on Figure 27.

Statewide Water Supplies and Development

The foregoing discussions have described the water supplies and existing and proposed or potential water developments in each of the 11 hydrologic study areas of the State. The purpose of this section is first to summarize those aspects of water supply and development for the various areas that pertain to required interarea transfers of water. This leads to development of a statewide analysis of the capabilities of existing and authorized large-scale water conservation and transportation facilities and to projections of the sizes and timing of required future facilities.

Emphasis in this section is placed on development of an integrated system of multiple-purpose water conservation and conveyance projects, conceived as extensions of the federal Central Valley Project and the State Water Project. As in the past, a number of federal and state agencies will undoubtedly participate in these projects and other facilities will be built by local agencies. Figure 29 illustrates the projected 1990 interbasin transfers of water supplies among the 11 hydrologic study areas of the State.

FIGURE 29



PROJECTED INTRASTATE WATER TRANSFERS FOR
1990 LEVEL OF DEVELOPMENT

Required Water Supply Capability of State and Federal Facilities

The Burns-Porter Act recognizes the need for implementation of a coordinated statewide approach to water development as envisioned and recommended in The California Water Plan. Implicit in the Act is the premise that, as water development in California becomes more complex and costly, larger organizations and greatly increased financial capability will be required. This will make necessary an increasingly active role by the state and federal water agencies.

The principal projects comprising the State Water Resources Development System, as defined in the Act, are the State Water Facilities and the federal Central Valley Project. The term "State Water Project", used in this report, encompasses the State Water Facilities and additional features of the System to be constructed by the State. The projected increasing role of these projects in meeting California's long-range water requirements is discussed in the following paragraphs.

In 1960 the Central Valley Project provided about 23 percent of California's total net water requirements. By 1990 the Central Valley Project and the State Water Project combined will be serving about 15.4 million acre-feet annually or about 50 percent of the State's total projected net water requirements of 31 million acre-feet per year. By 2020, these two projects will be providing 20.4 million acre-feet or 54 percent of the projected total net water requirements of 37.8 million acre-feet.

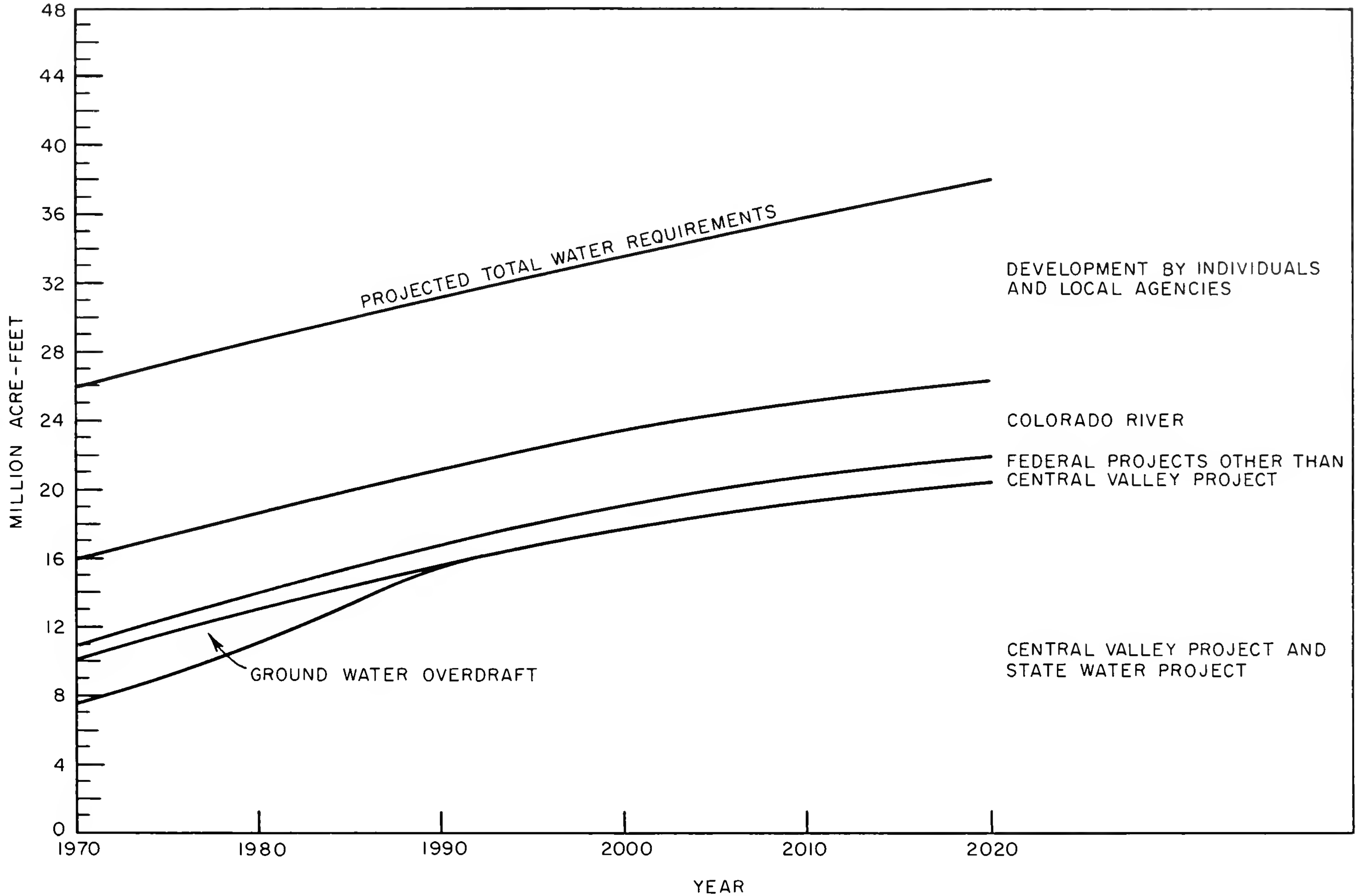
The projected increasing role of these projects in meeting the future water requirements of California after 1970 is shown on Figure 30. This figure also indicates the other sources from which the future total net water requirements of the State are expected to be met and the projected phasing out of ground water overdraft by about 1990. Figure 31 shows the portion of the projected water requirement in each hydrologic study area, which estimates indicate will be met by the State Water Project and the Central Valley Project beginning in 1970. The statewide summation of this information is also included.

The North Lahontan area is the only one of the 11 hydrologic study areas for which water service is not forecast under these two major projects of the State Water Resources Development System. Its requirements will probably be met by development of local water supplies, as previously described.

Capability of State and Federal Conveyance Facilities

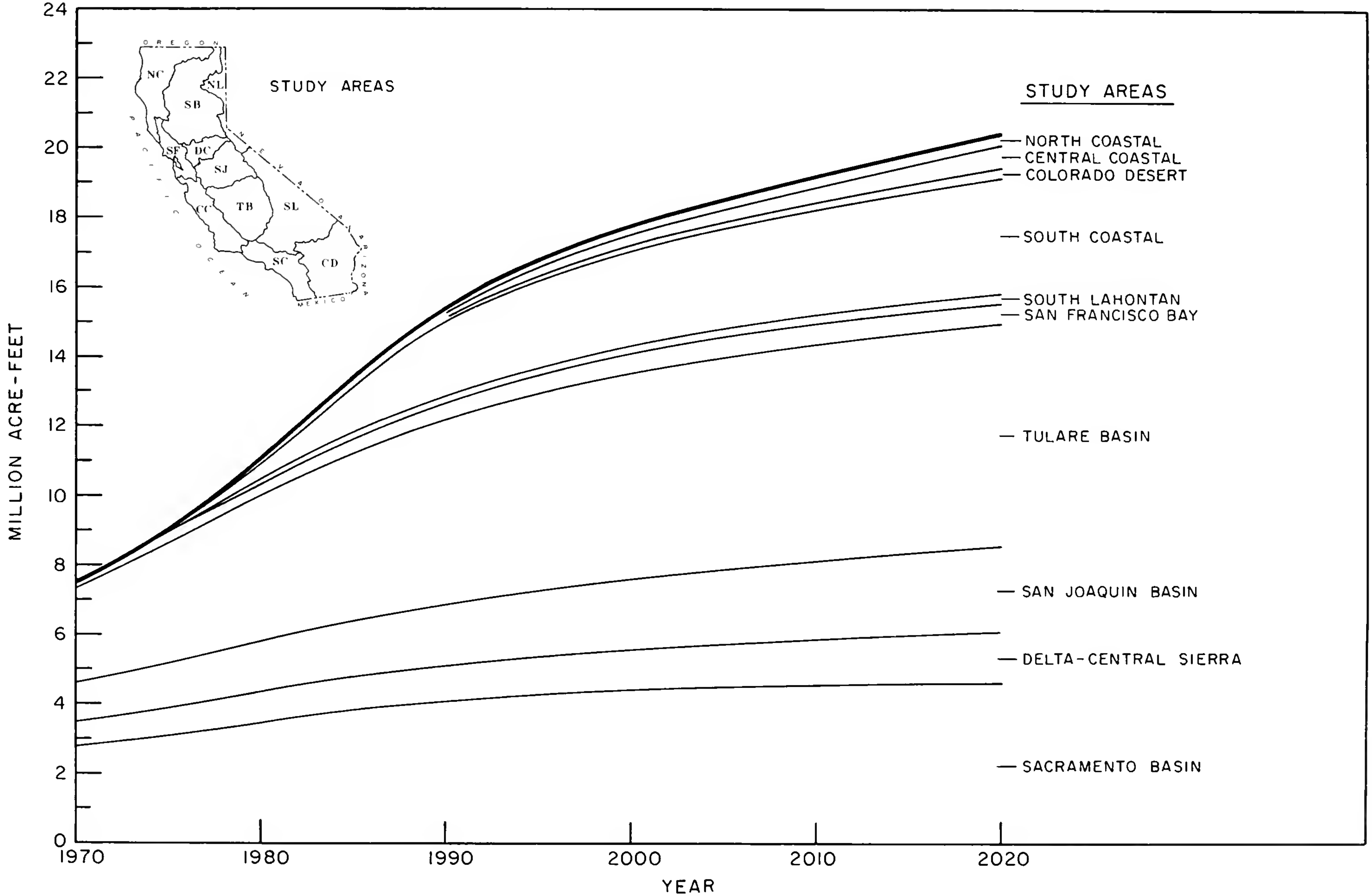
Figure 32 shows the various projected water requirements that can be met by authorized facilities of the Central Valley Project and the State Water Project. These requirements are distinguished by (1) the identified water conveyance features or (2) service areas covered either by water supply contracts or by the May 16, 1960 Agreement between the Department and the Bureau of Reclamation. This figure also indicates the probable additional service from these projects which will require future transportation facilities.

FIGURE 30



SOURCES OF WATER SUPPLY
TO MEET CALIFORNIA'S PROJECTED WATER REQUIREMENTS

FIGURE 31



PROJECTED WATER REQUIREMENTS - STATE WATER PROJECT AND CENTRAL VALLEY PROJECT REFERENCED TO HYDROLOGIC STUDY AREAS

Present annual deliveries of dependable water supplies through existing facilities of the Central Valley Project total about five million acre-feet. Deliveries by state and federal systems will increase to about seven million acre-feet per year by 1968 when the federal San Luis Division and the California Aqueduct commence service in the Tulare Basin. The total annual dependable water supplies to be distributed by the authorized systems will total approximately 13 million acre-feet by the year 1990, and will increase to 14 million by 2020 (Figure 32).

Completion of presently authorized conveyance systems of the Central Valley Project and the State Water Project will still leave a requirement of over 6.5 million acre-feet per year in 2020 to be supplied by expansion of these projects or by some other means. A portion of this additional requirement could be met by proposed transportation facilities of the Central Valley Project as shown on Figure 32. On the basis of the Department's current estimates (discussed in connection with water supplies of the various hydrologic study areas), the San Felipe Division will be required for the Central Coastal area by the early 1970's West Sacramento Canal Unit will be needed by the mid-1970's for the Sacramento Basin, Delta-Central Sierra and San Francisco Bay areas; and the East Side Division should be available for the San Joaquin and Tulare Basins not later than the early 1980's. The estimated capital costs of these conveyance facilities are 90, 155 and 800 million dollars, respectively.

Additional water supplies (to be delivered via conveyance facilities not yet identified) will also be needed in the San Joaquin Valley, Central Coastal, and Southern California areas beginning in the 1990's. Current studies indicate that by 2020, the Central Coastal and South Coastal areas will require some 490,000 and 1.2 million acre-feet per year, respectively. The additional requirement within the San Joaquin Valley might be met most favorably through enlargement of the proposed second phase of the East Side Division of the Central Valley Project. There may also be the need for additional transportation facilities on the west side of the valley.

In general, water service within the North Coastal area from federal or state projects can be provided most economically as an adjunct to future developments which will also serve to export water from that region. It has been assumed for this report that all North Coastal conservation features, which will be needed to increase the firm water supplies of the State Water Project and the Central Valley Project, will also make water supplies available locally, as required to supplement the yields of local facilities. The estimated amounts of such supplemental service, beginning in the late 1980's, are indicated on Figure 32.

Capability of Central Valley Project and State Water Project Conservation Facilities

To determine the timing and sizes of required additional conservation facilities under the State Water Resources Development System, it was necessary to estimate the water yield capability of existing and authorized features of the system. This was accomplished by performing coordinated operation studies of the Central Valley Project and the State Water Project.

In these studies, the Delta was recognized as the central collection point for all surplus water in the Central Valley. The studies also anticipated that depletions of natural surplus flows reaching the Delta, as a result of further water resource development in the tributary area, will reduce the yield of export projects and require additional conservation developments. This principle is manifest in the Area of Origin Statutes contained in Sections 10505 and 11460 through 11463 of the Water Code.

The operation studies were conducted using monthly water supplies during the critical period, 1928 through 1934, and monthly water demands for projected levels of development until 2020. They were based on full operational coordination of the basic Central Valley Project and the State Water Project facilities listed below.

1. Central Valley Project

   a. Trinity River Division

      Clair Engle Lake
      Trinity Powerplant
      Lewiston Reservoir
      Lewiston Powerplant
      Clear Creek Tunnel
      Whiskeytown Reservoir
      Judge Francis Carr Powerplant
      Spring Creek Powerplant

   b. Shasta Division

      Shasta Reservoir
      Shasta Powerplant
      Keswick Reservoir
      Keswick Powerplant

c. American River Division

Folsom Reservoir
Folsom Powerplant
Nimbus Reservoir
Nimbus Powerplant

d. Delta Division

Tracy Pumping Plant
Delta-Mendota Canal

2. State Water Project

a. Oroville Division

Oroville Reservoir
Oroville Powerplant
Thermalito Diversion Dam
Thermalito Powerplant
Thermalito Canal
Thermalito Forebay
Thermalito Afterbay

b. North Bay Aqueduct

c. South Bay Aqueduct

d. North San Joaquin Division

Delta Pumping Plant
Portion of California Aqueduct

3. Joint-Use Facilities

a. Peripheral Canal

b. San Luis Division

San Luis Reservoir
San Luis Pumping-Generating Plant
San Luis Forebay
San Luis Forebay Pumping Plant
San Luis Canal to Mile 18
Dos Amigos Pumping Plant

Other local-agency and federal storage and transportation features within the Central Valley Basin were also considered in the operation studies. These units were operated separately for their respective project purposes, and the net effects on streamflow were reflected in the coordinated operation studies. The authorized Auburn and New Melones Reservoirs were included as units of the Central Valley Project-State Water Project system in this manner.

The operation studies considered the project functions of irrigation, industrial, and municipal water supply; power production; navigation on the Sacramento River; minimum reservoir releases for fish; flood control; recreation; and salinity control in the Sacramento-San Joaquin Delta.

The monthly operation studies were performed on a digital computer. The procedure involved first the estimation of flows at key points along the Sacramento River, on its tributaries, and in the Delta at the particular level of development in the valley chosen for a given study. This initial calculation assumed that all inflows to the Central Valley Project and State Water Project reservoirs during the month would be held in storage. Releases were then made from the reservoirs to meet assumed power requirements and minimum flows for fish life. Further releases were made, if necessary, to meet the mandatory flow requirements at the key downstream points. The machine program selected the reservoirs from which releases were made for power and other purposes so as to minimize demands on storage.

The results of the operation studies included estimates of dependable commercial power production at load center and the firm water yield available for future demands after the projected upstream diversions and present contractual obligations of the

State and Federal Governments were satisfied. The estimated firm water yield of the system is shown by the lowest blue line sloping downward to the right on Figure 33. The downward slope of this line reflects the loss of yield due to increasing use of water in the area tributary to the Delta.

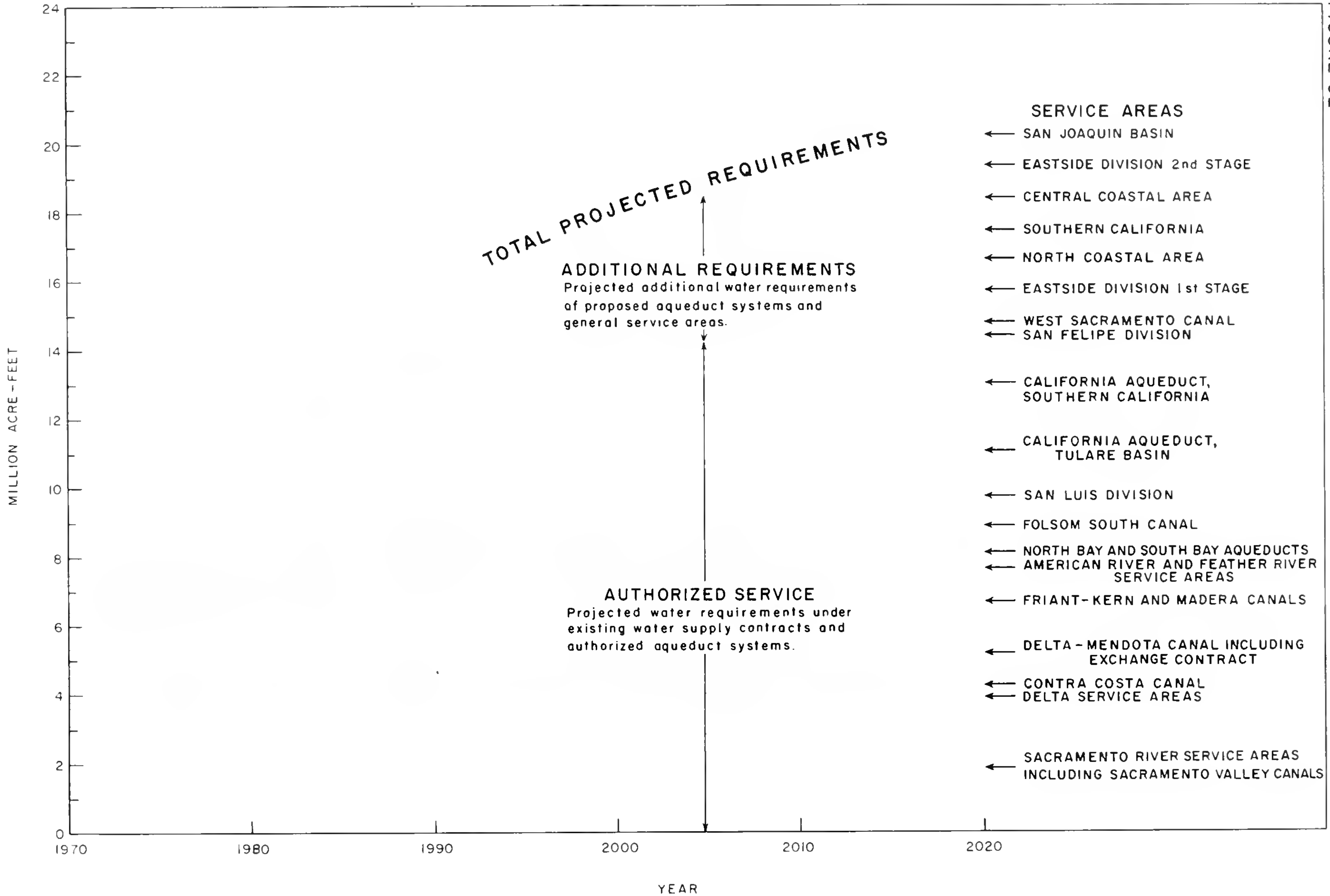
This analysis assumed an idealized, fully coordinated operation of the Central Valley Project and the State Water Project. In this manner the benefits of public development were optimized. The two projects operated separately would provide less power generation and slightly less water yield.

Additional Conservation Facilities Required for Water Supply

Future water conservation projects considered in this section are those required to sustain and increase the water yield capability of the Central Valley Project-State Water Project system. These projects and the more or less independent projects, mentioned previously in connection with individual hydrologic study area water supplies, will provide local water supplies and other services in the areas where they are constructed.

Figure 33 illustrates the required timing and additional water yield capability of future conservation projects within the Central Valley Project-State Water Project system. As previously stated, the lowest blue line on the figure shows the combined dependable water supply capability of existing and authorized features of the system. The red line depicts the combined net

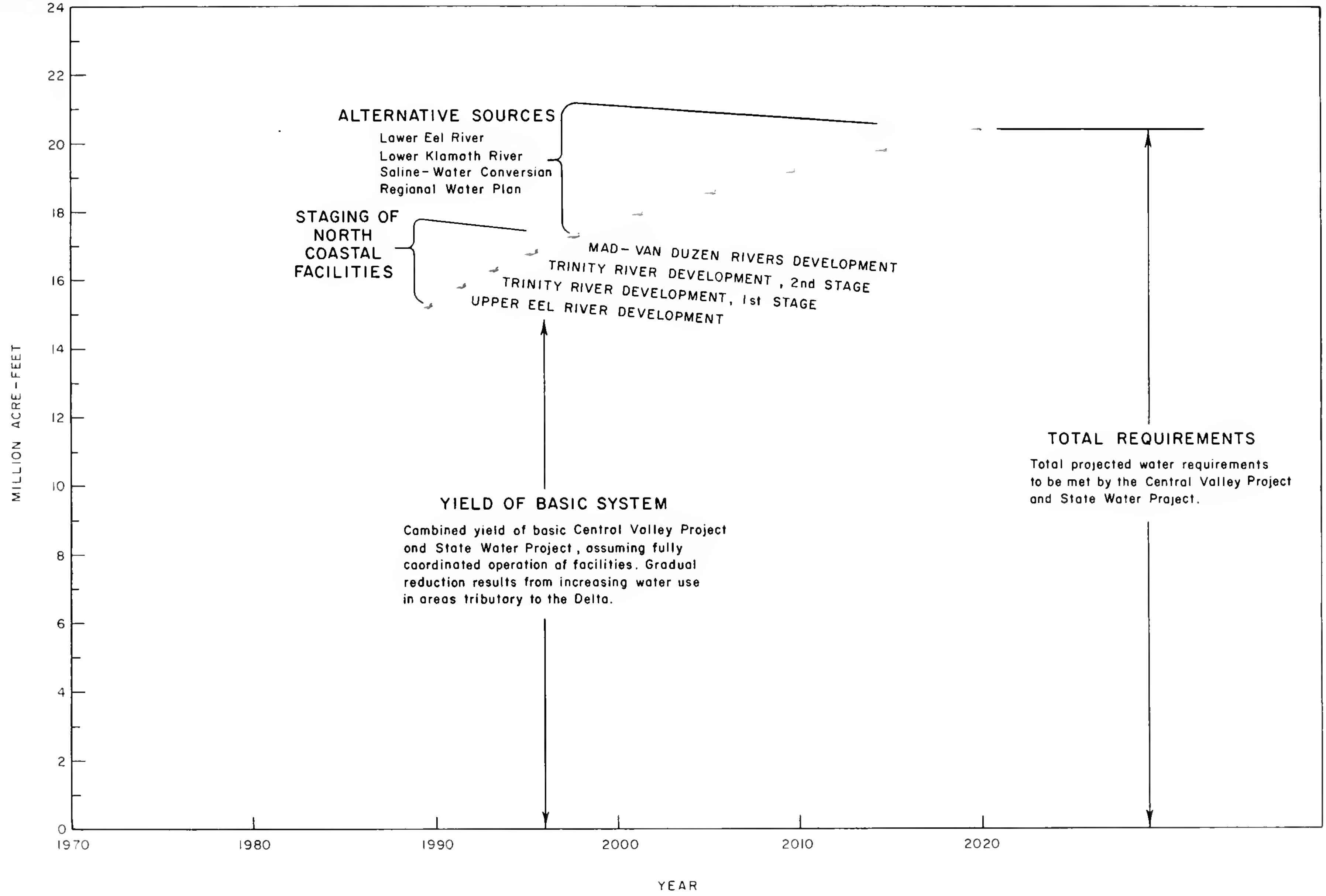
FIGURE 32



PROJECTED WATER REQUIREMENTS

ON THE STATE WATER PROJECT AND CENTRAL VALLEY PROJECT REFERENCED TO PROJECT SERVICE AREAS

FIGURE 33



STAGING OF MAJOR CONSERVATION FACILITIES

TO MEET PROJECTED WATER REQUIREMENTS OF THE STATE WATER PROJECT AND CENTRAL VALLEY PROJECT water requirements which are to be met by these projects. It is the same as the uppermost lines shown on Figures 31 and 32.

The point of interesection of the increasing requirement graph (red line) and the decreasing supply graph (blue line) indicates the timing of need for the first additional water conservation facility. This occurs late in the 1980's.

This derived timing is based on projections of net water requirements and on estimates of water yields of existing and authorized conservation projects. It is entirely conceivable that deviations of actual future values of one or both of these variables from the projections could either advance or delay by several years the date on which the additional facility will be needed. Thus Figure 33 is indicative of the need for the facility in the late 1980's or early 1990's in the event of a drought similar to that of the 1928-34 period.

This indicated timing is predicated upon the need for developing additional water supplies only. It does not reflect the possible earlier scheduling of developments in the interest of flood control, recreation, water quality control, hydroelectric power generation, or other project services, if this should be found feasible. Considerations regarding early construction of multiple-purpose projects for flood control are discussed briefly in the next section.

The stair-stepped series of four bands outlined in blue indicates the staging of conservation developments of the

Central Valley Project-State Water Project system, which is believed at present (1966) to be the most favorable sequence until about the year 2000. These projects will be located on the upper Eel River, the lower Trinity River and the Mad and Van Duzen Rivers, as shown on Figure 8. Feasibility studies for all of these proposed developments are in progress by the Department of Water Resources or the Bureau of Reclamation. The projects are described subsequently in this section.

The dates shown on Figure 33 for the additional conservation facilities indicate when the projects must first become fully operational and capable of producing portions of the indicated dependable water yields (widths of the blue bands) when added to the Central Valley Project-State Water Project system. A certain lag time is required for completion of feasibility studies, design, construction, and, in the case of the larger reservoirs,a period for filling the conservation storage pools to operational levels. Although studies are not completed for this detailed scheduling, past experience has indicated that a period of 10 to 15 years, and sometimes longer, is required from initiation of final design until a major conservation project is fully operational. The need for the present feasibility level planning studies for these facilities is apparent.

There are other projects which might also prove worthy of consideration to meet the growth of net water requirements from the late 1980's to 2000. Nashville Reservoir shown on Figure 18, has been mentioned in connection with the water supplies of the Delta-Central Sierra area. In addition to providing local water supply and flood control, this project could also contribute water for export under the Central Valley Project-State Water Project system. Paskenta-Newville, Marysville and Sites Reservoirs, shown on Figure 16, could increase the Central Valley Project-State Water Project potential for export from the Sacramento Basin as well as provide local water supply and/or flood control. There are also large potential conservation storage units within the Central Valley Basin that would provide long-term carryover storage. Examples are: the Glenn Reservoir Complex, in Glenn and Tehama Counties (Figure 16); Los Meganos Dam and Reservoir, on Kellogg Creek in Contra Costa County; Los Banos Dam and Reservoir, south of San Luis Reservoir in Merced County; and the Greater Berryessa Project on Putah Creek in Napa and Yolo Counties. Further reconnaissance studies will be necessary to determine the probable costs of these reservoirs.

It is possible also that a portion of the future requirements under the Central Valley Project-State Water Project system may be met at favorable costs by the intensive development of the vast Sacramento Valley ground water basin. This development might involve conjunctive operation of the basin with present and anticipated surface storage facilities. Additional studies will be necessary.

After about the year 2000, further alternative sources of supply may become available to meet emerging water requirements. These possibilities include desalination of sea water, a western states regional water plan obtaining surplus waters from the Pacific Northwest, and additional development within Northwestern California in the lower Eel and Klamath River Basins. These longer-range developments are shown on Figure 33 by the lighter stair-stepped blue lines beginning about the year 2000. No attempt has been made in this bulletin to determine the chronology of these possibilities.

The possible alternative developments to meet water requirements from the late 1980's to 2000 and the unscheduled more remote possibilities are described briefly in the ensuing paragraphs.

Upper Eel River Development. The Upper Eel River Development is authorized as an additional conservation facility of the State Water Project. It will include Spencer and Dos Rios Reservoirs, or alternatives, on the Middle Fork of the Eel River. Also included will be facilities to convey the water to the Sacramento Basin either by gravity to Thomes or Stony Creeks or through a pumped diversion to the upper main Eel River and thence by gravity via Clear Lake and Lake Berryessa to the Sacramento-San Joaquin Delta (Figures 8 and 16). It is estimated that the costs of these alternative developments will be between 200 and 300 million dollars.

Spencer and Dos Rios Reservoirs, with a combined gross capacity of approximately 1.4 million acre-feet, will provide a dependable water supply for the Round Valley area of Mendocino County, fisheries preservation flows, and an additional water supply of about 600,000 acre-feet annually at the Sacramento-San Joaquin Delta. Consideration is also being given to inclusion of the functions of flood control and fisheries enhancement. The addition of the Rancheria Compartment of the Glenn Reservoir Complex in the Stony Creek route or of English Ridge Reservoir in the Clear Lake route could increase the firm water yield of this development by about 300,000 acre-feet annually.

Trinity, Mad, and Van Duzen River Developments. Construction of proposed projects in these river basins could add about 1.5 million acre-feet of dependable water supply per year to the Central Valley Project-State Water Project system. Their locations are shown on Figure 8. Although a construction sequence of three stages is presently envisioned, work on these developments would probably be started at close intervals, if not simultaneously, because all of the facilities would be required within three or four years (Figure 33).

The first stage would consist of Helena Dam on the Trinity River about 40 miles downstream from the existing Lewiston Dam of the Central Valley Project. A 590-foot Helena Dam would create a 2.9 million acre-foot reservoir and back water to the toe of the existing Lewiston Dam. Its annual export yield of about 500,000 acre-feet would be conveyed through a second Clear Creek tunnel or a Cottonwood Creek tunnel to the Sacramento Basin. The total cost of Helena Dam and Reservoir including relocations is estimated to be 165 million dollars. The 13-mile tunnel to Clear Creek, designed to convey the 1.5 million-acre-foot yield of the developments on the three rivers, would cost an estimated 60 million dollars.

The second stage of development would include Eltapom Reservoir (South Fork of the Trinity River) and Burnt Ranch Reservoir (main Trinity River). Also included would be a pumping plant and 10-mile tunnel leading to Helena Reservoir. This development would provide an incremental new water yield of 400,000 acre-feet annually at a cost of about 170 million dollars.

Additional water supplies, derived from the Mad and Van Duzen Rivers under a third stage of development, would be diverted via a system of reservoirs and interconnecting tunnels through the earlier staged facilities to the Sacramento River Basin. A new export yield of approximately 600,000 acre-feet annually would be provided by this development. The capital cost is estimated at about 182 million dollars.

Paskenta-Newville Project. This project could act as a regulating reservoir for importations from the Eel and Trinity Rivers or could be built as a separate project. The reservoir would be formed by Paskenta Dam on Thomes Creek and Newville Dam on the North Fork of Stony Creek. The project would constitute the northern two "compartments" of the Glenn Reservoir Complex (Figure 16). The reservoir would have a capacity of approximately 1.6 million acre-feet and would cost about 92 million dollars. It could provide about 200,000 acre-feet per year of new water. About 20 percent of the new supply would be required in local service areas and the remainder would be available for use elsewhere. The project would also provide flood control, fisheries enhancement and recreational opportunities.

Marysville Project. Marysville Dam and Reservoir on the Yuba River (Figure 16) would supplement the New Bullards Bar Project, currently under consideration by the Yuba County Water Agency, by providing the balance of flood control storage necessary to regulate the Yuba River. A one million acre-foot reservoir, including primary flood storage space of 200,000 acre-feet, would yield about 100,000 acre-feet per year at the Sacramento-San Joaquin Delta, and would provide new opportunities for recreation. The cost of the dam, reservoir, recreational facilities, and fish hatchery is estimated at about 100 million dollars.

Sites Reservoir. This facility would be an off-stream storage feature of the West Sacramento Canal Unit (Figure 16). With a gross capacity of about 1.2 million acre-feet, it would regulate surplus winter flows of the Sacramento River conveyed via the Tehama-Colusa Canal. There would be approximately 150,000 acre-feet per year of dependable water supply developed for use within the Sacramento Basin area and for export to the Delta-Central Sierra and San Francisco Bay areas. The cost would be about 42 million dollars.

Lower Eel River and Lower Klamath River Developments. The developments on the lower Eel River would include Sequoia Reservoir, with a capacity of 6.7 million acre-feet, and Bell Springs Reservoir, containing 1.35 million acre-feet. These features together would provide an export yield of approximately one million acre-feet annually. The total capital cost of the reservoirs and pumping facilities for delivering the water supply into Dos Rios Reservoir would be about 460 million dollars. This includes 130 million dollars for the relocation of the Northwestern Pacific Railroad.

The lower Klamath River development would include the 15-million acre-foot Humboldt Reservoir on the lower Klamath River, Ironside Reservoir on the Trinity River, three pumping plants to lift the water up the Trinity River into Helena Reservoir, and a second tunnel between Helena Reservoir and the Sacramento Valley. It could develop an annual yield of approximately six million acre-feet, at a cost of about 1.6 billion dollars. Mitigation of damages to the Klamath River fisheries would be a serious problem in this plan. There are alternative plans with a lesser impact on the fisheries, which would yield smaller quantities of water.

Desalination. Extensive research and development in the desalination of brackish and sea water has been sponsored recently by the Office of Saline Water, United States Department of the Interior, and by colleges and universities. Demonstration plants to study several processes have been built and others are planned. The State of California participated with the Office of Saline Water in the financing and marketing of water from the Point Loma Demonstration Plant at San Diego and will do the same for a new plant soon to be built in that area.

Progress in desalination during the last decade, as a result of this work, has been significant. About four basic methods are now being studied to separate salts from water. These are the evaporation or distillation, membrane, crystallization, and chemical processes. Because of the difference in requirements of plant capacity, relative costs of different forms of energy, salinity of the available water and local conditions, no one process is likely to be the choice for all areas. The methods currently showing the most promise for large-scale operation are the multi-stage flash distillation process for desalting sea water, and the membrane processes of electrodialysis or reverse osmosis for brackish water desalting.

In the mid-1950's the cost of desalting sea water in existing small-capacity plants was estimated at four to five dollars per 1,000 gallons, or more than $1,000 per acre-foot. At that time, projections of costs indicated that sea water might eventually be desalted for about $140 per acre-foot. This figure was for a plant of 50 million gallons per day capacity.

Recent estimates have indicated that with large-capacity dual-purpose plants (electricity generation-desalination) it would be possible to produce fresh water from sea water at a seacoast plant site for about $70 to $100 per acre-foot, depending on the powerplant size. It appears that these estimates have been

DEMONSTRATION DESALINATION PLANT - SAN DIEGO

During the two years of its operation, from 1962 to 1964, water produced by the Point Loma sea water conversion plant was mixed with San Diego's regular sources of water supply. The plant was dismantled in February 1964 and moved to the U. S. Naval Base at Guantanamo Bay, Cuba.

based on the favorable assumption that desalination would be charged only the incremental costs in excess of costs for a single-purpose powerplant. The costs would probably be greater if desalination were allocated its full share of costs on a proportionate-use or similar basis. Development plans for full-sized modules and components of desalination plants, now being proposed, will permit more firm estimates of desalination costs within the next few years.

The costs of conveying water inland from desalination plants must be added for comparison with costs of other supplies, such as those imported from Northern California. Present estimates indicate that water delivered from the State Water Project will cost about $49 per acre-foot to The Metropolitan Water District of Southern California, for delivery from Castaic and Perris Reservoirs at elevations of about 1,500 feet, and about $64 per acre-foot to Santa Barbara County, for delivery near Santa Maria at an elevation of about 400 feet.

Western States Regional Water Planning. Events of the past two years indicate increasing activity in western states regional water planning. The State of California must maintain a leading role in such planning. Current projections indicate that California has sufficient water resources to develop and meet its water requirements until well after the turn of the century. But, regional importations could conceivably prove less costly than some of the sources, such as the lower Eel and lower Klamath Rivers.

Besides these reasons, it has become increasingly apparent that the welfare of California cannot be divorced from the economies of the other western states. California must continue to work with the other states in developing a regional water plan for the benefit of all. The need for comprehensive and systematic regional water planning studies is shown by the many suggestions since publication of the Pacific Southwest Water Plan report by the Secretary of the Interior in 1963. Considerable additional study is necessary.

An important step in this direction in 1965 was the drafting of compromise federal legislation authorizing a Colorado River Basin Project. This legislation was negotiated by representatives of the seven states of the Colorado River Basin. Upon passage, it would authorize the Department of the Interior to investigate all potential sources of supply for the Pacific Southwest, including importation of surplus flows from the Pacific Northwest and would require the submission of possible plans and recommendations by 1971. It would permit the formation of a Pacific Northwest-Southwest Regional Commission, composed of state and federal representatives, to assist the Department of the Interior in the studies.

California has also been working with the other western states to create the Western States Water Council. This council was approved by the eleven governors at the Western States Governors' Conference in June 1965, and is being implemented. Its purpose is to achieve cooperation among the western states and the Federal Government in planning of integrated water resource development. Its functions are: (1) to prepare criteria for use in the formulation of plans for regional development of water resources to protect and further state and local interests; and (2) to undertake continuing review of all large-scale interstate and interbasin plans and projects for development, control, or utilization of water resources in the western states.

Although much work remains to be done in regional water planning, the progress made during the last two years toward a solution to western water problems is encouraging. Further progress during the next few years is expected to be equally encouraging.

Flood Control as a Project Purpose

Flood control requirements have been discussed earlier in this chapter. This section identifies projects which would include flood control as a purpose and indicates the flood control studies which are authorized or in progress. The section ends with a discussion of the desirable scope of future flood control investigations.

Authorized and Proposed Flood Control Projects

The Corps of Engineers has a number of authorized flood control projects in California. These are listed by hydrologic study area in Table 8.

Earlier sections of this report have presented descriptions of multiple-purpose water conservation facilities, proposed either as local projects within hydrologic study areas

TABLE 8

AUTHORIZED FEDERAL FLOOD CONTROL PROJECTS

(Construction and planning status, 1966)

Project	Principal Features	Capital Cost[1/] (thousands of dollars)
North Coastal Area		
Eel River Delta Area	Levees and channel work	14,300
San Francisco Bay Area		
Alameda Creek	Levees and channel improvements	17,900
Corte Madera Creek	Channel improvements	6,100
Napa River	Channel work and possible storage	15,600
Russian River	Bank stabilization and channel work	14,200
Sonoma Creek	Levee and channel work	9,800
Warm Springs Reservoir	Multiple-purpose project	49,000
Walnut Creek	Levees and channel improvements	21,800
South Coastal Area		
Los Angeles Drainage Area	Existing project extensions	318,000
Lytle and Warm Creeks	Existing project extensions	9,800
San Diego River	Existing project extensions	17,400
Santa Paula Creek	Channel lining and improvement	2,300

TABLE 8 (Continued)

AUTHORIZED FEDERAL FLOOD CONTROL PROJECTS

(Construction and planning status, 1966)

Project	Principal Features	Capital Cost[1/] (thousands of dollars)
<u>Sacramento Basin</u>		
Bullards Bar Reservoir	Multiple-purpose reservoir	152,400
Oroville Reservoir	Multiple-purpose reservoir	66,400
Sacramento River	Bank protection	67,000
Scotts Creek Reservoir	Reservoir and channel improvements	10,100
<u>Delta-Central Sierra Area</u>		
Morman Slough	Channel and levee improvements	2,100
<u>San Joaquin Basin</u>		
Buchanan Reservoir	Multiple-purpose reservoir	15,300
Hidden Reservoir	Multiple-purpose reservoir	16,700
Lower San Joaquin River	Levees and channel improvements	12,500
New Don Pedro	Multiple-purpose reservoir	5,900
New Exchequer Reservoir	Multiple-purpose reservoir	9,900
New Melones Reservoir	Multiple-purpose reservoir	122,000

TABLE 8 (Continued)

AUTHORIZED FEDERAL FLOOD CONTROL PROJECTS

(Construction and planning status, 1966)

Project	Principal Features	Capital Cost[1/] (thousands of dollars)
Tulare Basin		
Kings River and Tributaries	Channel improvements	1,200
North Lahontan Area		
Martis Creek	Multiple-purpose reservoir	3,100
South Lahontan Area		
Mojave River	Single-purpose reservoir	13,300
Colorado Desert Area		
Tahquitz Creek	Levees and channel work	3,900
	TOTAL	998,000

1/ Federal cost.

or as components of the Central Valley Project-State Water Project system. Those projects, which would include the purpose of flood control, are listed in Table 9. This table omits the authorized flood control projects shown in Table 8.

The Corps of Engineers is authorized to conduct flood control investigations of several of the projects listed in Table 9 and of many more projects in California. These can be separated into four categories: (1) completed investigations for which formal reviews leading to authorization are under way; (2) active investigations begun in 1965 or continuing which have a tentative completion date assigned; (3) inactive investigations, on which work has been deferred; and (4) indefinite investigations, which are authorized but for which no funds are available. A list of these investigations is given in Table 10.

Desirable Scope of Flood Control Investigations

It is apparent that the broadest practicable approach to flood control must be taken. Flood control studies should be comprehensive and should give balanced consideration to all feasible means of flood control and prevention of flood damage including storage facilities, levee and stream improvements, bypass channels, warning systems, and floodplain and watershed management.

Section 12580 of the Water Code declares that the State should engage in studies of water development, including flood control projects, by all agencies in order that expenditures of public funds will bring the maximum benefits to the people of the State.

TABLE 9

PROPOSED MULTIPLE-PURPOSE RESERVOIRS
WITH FLOOD CONTROL POTENTIAL

Project	River
North Coastal Area	
Butler Valley Reservoir	Mad River
Sequoia Reservoir	Eel River
Upper Eel River Development	Eel River
San Francisco Bay Area	
Big Sulphur Reservoir	Sulphur Creek
Knights Valley Reservoir	Maacama Creek
South Coastal Area	
Topatopa Reservoir	Sespe Creek
Sacramento Basin	
Allen Camp Reservoir	Pit River
Millville Reservoir	Cow Creek
Wilson Valley Reservoir*	Cache Creek
Indian Valley Reservoir*	North Fork Cache Creek
Marysville Reservoir	Yuba River
Paskenta-Newville Reservoir	Thomes Creek
Delta-Central Sierra Area	
Nashville Reservoir	Cosumnes River
North Lahontan Area	
Stampede Reservoir	Little Truckee River
Pickle Meadow Reservoir	West Walker River

*Alternative Projects.

TABLE 10

U. S. ARMY CORPS OF ENGINEERS'
FLOOD CONTROL INVESTIGATIONS

Title	Location*	Estimated Completion Date of Investigation
<u>Category (1) - Completed</u>		
Atherton Creek	SF	
Knights Valley, Russian River Basin	SF	
San Francisquito Creek	SF	
Pajaro River	CC	
Pajaro Valley, Pajaro River Basin	CC	
Tia Juana River	SC	
Jack & Simmerly Slough	SB	
<u>Category (2) - Active</u>		
Eel River	NC	1969
Klamath River	NC	1970
Mad River	NC	1968
Smith River	NC	1969
Alhambra Creek	SF	1965
Fairfield Vicinity Streams	SF	1967
Guadalupe River & Adjacent Streams	SF	1967
Pescadero Creek	SF	1966
Richardson Bay Streams	SF	1965
Russian River	SF	1967
San Gregorio Creek & Tributaries	SF	1968
Walnut Creek Basin	SF	1970
Wildcat & San Pablo Creeks	SF	1966
Soquel Creek	CC	1965
Cucamonga Creek	SC	1966
Deer, Day, Etiwanda, & San Sevaine Creek	SC	1967
San Dieguito River	SC	1969
San Luis Rey River	SC	1966
Santa Ana River Basin & Orange County	SC	1969
Santa Barbara County Streams South of Santa Ynez Mountains	SC	1969
Santa Barbara County Streams (Atascadero Creek)	SC	1966
Santa Clara River	SC	1969
Sweetwater River	SC	1965
University Wash & Spring Brook Drainage	SC	1967
Upper Warm Creek	SC	1967
Bear River Basin	SB	1970
Chester, North Fork Feather River	SB	1966
Coon Creek Stream Group	SB	1969

TABLE 10 (contd.)

Title	Location*	Estimated Completion Date of Investigation
Category (2) - Active (contd.)		
Morrison Creek Basin	SB	1968
Northern California Streams	SB	1969
Sacramento River & Tributaries	SB	1969
Upper Putah Creek	SB	1970
Sacramento-San Joaquin Delta	DC	1966
Sacramento-San Joaquin Delta Recreation	DC	1966
Kern River Basin, Isabella Reservoir	TB	1966
Poso Creek Stream Group	TB	1965
Category (3) - Inactive		
Cache Creek Basin	SB	
Cache Creek Settling Basin	SB	
Red Bank & Fancher Creeks	SB	
Cosumnes River	DC	
Category (4) - Indefinite		
Novato Creek & Tributaries	NC	
Burlingame, Streams in Vicinity of	SF	
Petaluma River	SF	
Redwood Creek, San Mateo County	SF	
South San Francisco, Streams in Vicinity of	SF	
Arroyo Grande Creek	CC	
Carmel River & Tributaries	CC	
Salinas River	CC	
San Lorenzo River & Tributaries	CC	
Laguna Canyon	SC	
Santa Ynez River & Tributaries	SC	
Switzer Creek	SC	
Battle Creek, Sacramento River	SB	
Big Valley, Lassen County	SB	
Shanghai & Starr Bends, Feather River	SB	
Sacramento-San Joaquin Delta (Model)	DC	
Los Banos Creek	SJ	
Caliente Creek Stream Group	TB	
Antelope Valley	SL	

TABLE 10 (contd.)

Title	Location*	Estimated Completion Date of Investigation
Category (4) - Indefinite (contd.)		
Imperial & San Diego Counties, Streams Flowing into Salton Sea	CD	
Whitewater River	CD	

* Symbols for hydrologic study areas shown on Figure 4.

NC - North Coastal
SF - San Francisco Bay
CC - Central Coastal
SC - South Coastal
SB - Sacramento Basin
DC - Delta-Central Sierra
SJ - San Joaquin Basin
TB - Tulare Basin
SL - South Lahontan
CD - Colorado Desert

Projections of requirements should be made to determine the earliest feasible time for construction of flood control projects to achieve these maximum benefits. The need for these studies was further recognized in several resolutions adopted by the 1965 Legislature, including SCR 14 (Petersen), SJR 11 (Collier) and AJR 10 (Belotti). These resolutions requested the Department and the Federal Government to accelerate planning and construction of flood control developments in the North Coastal area and elsewhere.

Justification of flood control projects should be based on both historical and predicted economic factors. Provision should be made for the early construction of multiple-purpose projects involving flood control when the flood control benefits exceed the costs, providing the earlier construction is deemed feasible in view of the considerations discussed below.

When estimates of flood control needs indicate that a multiple-purpose project possibly should be built for flood control before it is needed for other purposes, the added costs of the project, including interest, must be compared with the additional flood control benefits that would occur with early construction to determine overall project feasibility.

The financing and repayment of early construction costs of multiple-purpose projects must also be considered and the availability of capital must be determined. Normally, repayment of reimbursable costs by beneficiaries would begin at or near the completion date of the project. If a multiple-purpose project were completed sooner than necessary for some project purposes, it might be desirable for repayment for those purposes to be deferred. This would be contingent upon the ability of the construction agency to meet its financial obligations. The Water

Supply Act of 1958, mentioned in Chapter I, provides the means of deferring for 10 years the repayment of costs of federal projects allocated to future municipal and industrial water supply.

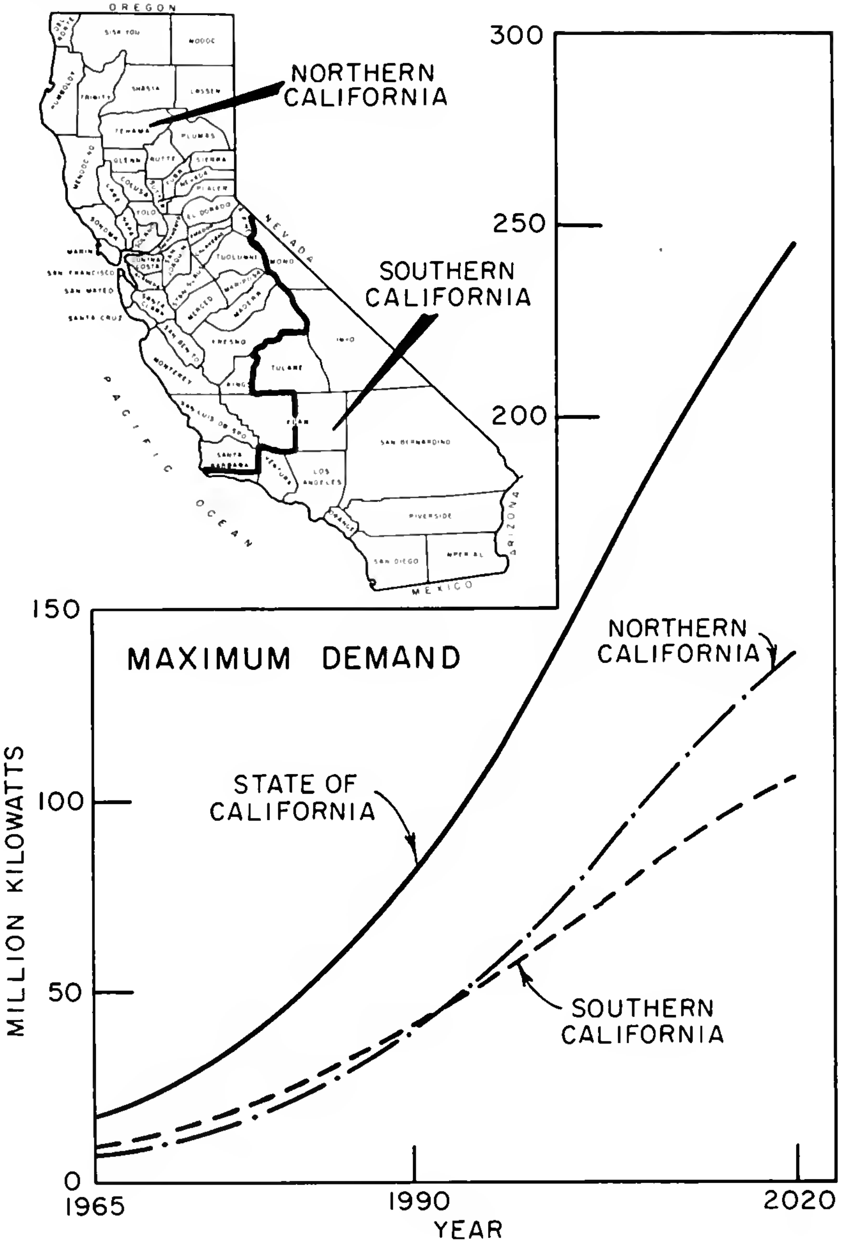
It is probable that analyses will indicate that protection of some areas is not economically justified, however. In many instances the solution may be provided by floodplain management.

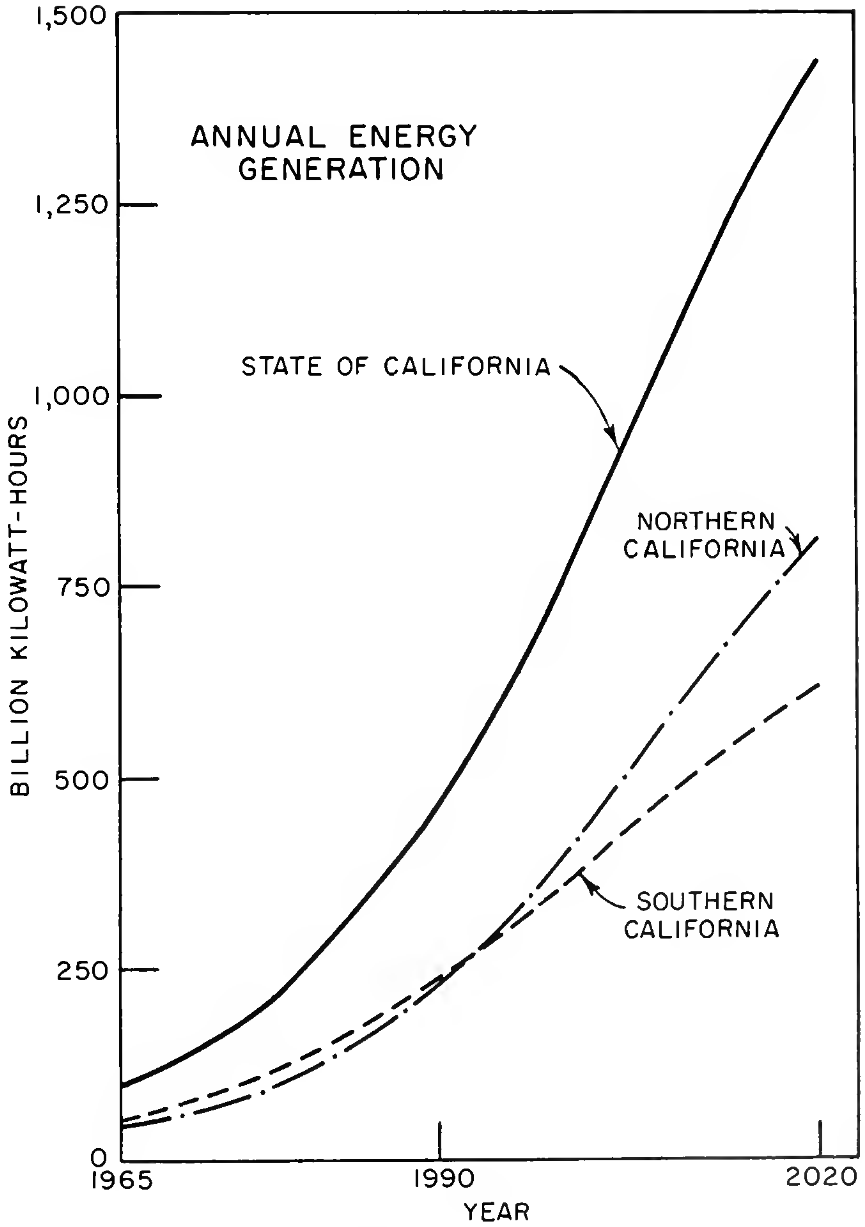
Role of Electric Power

Future water development in California will be tied closely to the development of electric power, as it has been in the past. The market for hydroelectric power will be a factor in determining the economic and financial feasibility of, and costs of water from, many water conservation facilities. Costs of power for pumping will continue to play an important role in determining costs of transporting water over long distances.

Forecasts of Power Requirements and Development

California's projected electric power and energy requirements to the year 2020 are shown on Figure 34. These estimates were derived from population forecasts, anticipated increases in per capita use of electricity, and projections of annual load factors. The State's maximum power demand in 1965 was estimated at about 17.2 million kilowatts. Projected statewide power demands for the years 1990 and 2020 are 80 million kilowatts and 245 million kilowatts, respectively.





PROJECTED GROWTH OF ELECTRIC POWER

The forecasted increases in the per capita use reflect the expanding applications of electricity, such as electric house heating, and the declining cost of power from fossil fuel and nuclear fired thermal plants. This decrease is expected to continue to improve the competitive position of electricity in relation to other forms of energy such as oil and gas.

The per capita use is expected to remain higher in Northern than in Southern California. More industrial plants of the types which require large amounts of power will probably locate in Northern California. A higher proportion of multiple residential dwellings, having a lower per capita use, are anticipated in Southern California.

The industrial power load is predicted to increase at a faster rate in California than in most other parts of the United States. This is expected to occur as the State develops industrial maturity commensurate with its expanding market and labor potentials. It is forecast that residential and commercial power loads will increase more rapidly than other load classes, including industrial. Because of the projected low cost of fuel for coal-fired plants and the even lower cost of nuclear fuel, it is anticipated that relatively low cost off-peak energy will become available. As a result,offpeak loads, such as electric car battery recharging, may increase markedly.

Market for and Value of Hydroelectric Power

With the rapidly expanding power requirements in California, (Figure 34) a potential market should exist for the relatively limited additional hydroelectric power potential in the State. The marketability will depend, however, upon two main interrelated factors.

The first is the extent to which hydroelectric power can be absorbed in the peak portion of the total power load. The degree of peaking supplied from a particular source is expressed in terms of the capacity factor (which is related directly to the percentage of time the plant operates). For a given hydroelectric development possibility, as the capacity factor decreases, the installed plant capacity must be increased.

Current projections of power load and power supply show that the power market will probably be able to absorb hydroelectric production at the following minimum dry-period capacity factors:

	1965-1974	1975-1984	After 1984
Dry Period Capacity Factor (%)	30	25	20

For comparison, estimates of hydroelectric power value for The California Water Plan were based on a dry-period capacity factor of 40 percent, which was assumed to remain constant.

The forecasted utilization of hydroelectric generation in the intermediate dry-period capacity factor range (20 to 30 percent), results from the estimate that California's needs for peaking at capacity factors lower than 20 percent will be supplied by other sources. These will probably include surplus peaking capacity from the Pacific Northwest, additions to existing plants, and special design thermal-electric peaking units. It is anticipated that conventional hydro plants will not be able to compete, from the standpoint of cost, with these other peaking facilities at the very low capacity factors.

The second factor governing the marketability of hydroelectric power is the competitive cost of other potential power sources which might supply the same portion of the power load. This factor is closely related to the first, because it is partly on the basis of cost that the estimates of capacity factor for hydro have been made.

The principal measure of value of hydroelectric power is the cost of producing equivalent power through the alternative thermal-electric unit which would be installed in the absence of the hydroelectric plant. Other factors considered include the greater reliability and operational flexibility of the hydroelectric machinery.

The estimated values of hydroelectric power for future developments are as follows:

	Date of Initial Operation		
	1965-1974	1975-1984	After 1984
Capacity Component at Load Center (dollars per kilowatt-year)	17.90	18.35	19.20
Capacity Component at Plant Sites (dollars per kilowatt-year)	16.65	17.10	17.95
Energy Component at Load Center and Plant Sites (mills per kilowatt-hour)	3.0	2.1	0.7

These estimated values were based on fossil fuel units only for the initial period; fossil fuel and nuclear units, in the proportion of two fossil fuel units to one nuclear unit, for the 1975-1984 period; and nuclear units only after 1984. The capacity components of value at the hydroelectric plant sites were estimated by deducting transmission costs and losses from the values at load center, assuming a transmission distance of about 125 miles. Energy losses in transmission, which would be small at assumed high transmission voltages of 345 and 500 thousand volts, were neglected for these estimates.

The above estimates of values at plant sites compare to the constant values of about $22 per kilowatt-year and 2.8 mills per kilowatt-hour used for The California Water Plan. The decline in the estimated value of the capacity component of hydroelectric power between the time of The California Water Plan studies and the present is due to reductions in the capital costs of fossil fuel generating units. The decrease in the value of the energy component, after the initial period, is the result of the projected use of low-cost nuclear fuel.

The decrease in the components of value of hydroelectric power, discussed above, would be offset by the increase of total unit value, or revenue, due to the lower capacity factor for such power. The total unit value of power at hydroelectric plant sites, given in The California Water Plan, was 7.8 mills per kilowatt-hour. Based on the current estimates of the capacity and energy components of value and the lower capacity factors, the total unit values at plant sites would be 8.1, 8.4 and 8.9 mills per kilowatt-hour for the respective periods named above. Proposed individual hydroelectric power installations will have to be appraised in the light of cost factors and power load conditions prevailing and forecasted when advance planning and design are undertaken.

Sources and Cost of Power for Pumping

Recent technological advances have resulted in several sources of low-cost power for water project pumping. These include developments in nuclear power generation, decreases in the costs of mining and transporting coal, and reductions in the cost of electric power transmission. The Pacific Northwest-Pacific Southwest Interties will provide a source of relatively low-cost power for pumping in California in the near future. This source consists of surpluses anticipated in Pacific Northwest and Canadian Entitlement power, which ultimately will be withdrawn for use closer to the points of generation.

The costs of pumping power are expected to exhibit a continuing decline as nuclear power approaches fulfillment of its promising potential. This reduction in cost is expected to increase the feasibility of higher pumping lifts and aqueduct routes, with the result that associated tunnels will be shortened. The low costs predicted for offpeak power will tend to increase the feasibility of offpeak pumping, which will require, in some instances, greater pumping capacity and larger aqueducts. Low cost offpeak power for pumping would also be conducive to pumped storage development of hydroelectric peaking power.

CHAPTER III. SUMMARY OF CONCLUSIONS

Since publication of The California Water Plan by the Department of Water Resources in May 1957, many events have occurred that pertain to implementation of the Plan. Population, manufacturing and agricultural producation have advanced to higher levels, thus causing substantial increases in requirements for applied water. Federal, state and local agencies have spent over two billion dollars on water project construction. The use of power has grown at a phenomenal rate, and there have been important technological changes affecting the cost of power production and the cost of power for water project pumping. Fundamental policies in the field of water development have been affected by many legislative acts and court decisions. Substantial progress has been made in planning features of The California Water Plan and in coordination of the activities of federal, state and local agencies engaged in planning, design and construction of water resource development.

On the basis of events of the last decade and other available information, analyses have been made of the probable course of development of the State's water resources until the year 2020. The conclusions resulting from these studies are as follows:

1. Projections of growth of the State indicate that between 1960 and 2020 the population will increase by nearly four times to more than 54 million persons, urban land use will roughly triple to nearly six million acres, irrigated lands will increase by more than 25 percent to almost 11 million acres, and undeveloped irrigable lands will be reduced by nearly 50 percent to a little more than eight million acres.
2. From 1960 to 2020, annual applied water requirements for agricultural purposes are expected to increase about 25 percent to almost 36 million acre-feet, applied water requirements for urban purposes will more than quadruple to over 14 million acre-feet, and total applied water requirements will rise nearly 60 percent to about 50 million acre-feet. Applied urban water requirements are expected to increase from 10 percent of the total in 1960 to 28 percent in 2020.
3. Between 1960 and 2020, net water requirements, which allow for probable reuses of water in each hydrologic study area, are expected to increase more than 60 percent to 38 million acre-feet.

4. With the projected growth of California's population and its industrial and agricultural activity, the need for water project services in the fields of flood control, recreation, fish and wildlife enhancement, and water quality control will increase substantially.

5. Between 1960 and 2020, water developed and used locally in each of the 11 hydrologic study areas will increase to a total of about 17 million acre-feet statewide (a 13 percent increase). Imported water (water moved from one hydrologic area to another) must be increased three times above present levels to 21 million acre-feet. Only in the North Coastal, North Lahontan and Sacramento Basin hydrologic areas will imported water needs not increase.

6. The Central Valley Project and the State Water Project will play an expanding role in providing for California's water needs. Between 1960 and 2020, the portion of the State's net water requirements to be met by these projects is expected to increase from approximately 23 to 54 percent. The North Lahontan area is the only area for which service from the State Water Project-Central Valley Project system is not forecast.

7. Completion of the presently authorized conveyance features of the Central Valley Project-State Water Project system will leave a remaining net water requirement of over 6.5 million acre-feet by the year 2020 to be supplied either by expansion of these projects or by other water resources developments. Additional conveyance facilities of the Central Valley Project should be authorized and completed approximately as follows: the San Felipe Division by the early 1970's, the West Sacramento Canal Unit by the mid-1970's, and the East Side Division by not later than the early 1980's. The capital costs of these features will be over one billion dollars. Between 1990 and 2000, additional conveyance facilities not yet identified will be required to serve the San Joaquin Basin, Central Coastal, South Coastal and Colorado Desert areas.
8. The conservation facilities of the State Water Project-Central Valley Project system, which are under construction or authorized, should develop sufficient water supplies to meet the projected net water requirements to be served by these projects until the late 1980's. Water supply needs of the State Water Project and Central Valley Project between the late 1980's

and 2000 can be met from water conservation projects in the upper Eel, Trinity, Mad and Van Duzen River Basins. The projected cost of these conservation developments is between 800 and 900 million dollars. There are alternative means of meeting the needs for new water supplies after about the year 2000. These include reservoirs on the lower Eel and Klamath Rivers, desalination and a regional water plan. Additional surface reservoirs and ground water development in the Sacramento and Delta-Central Sierra areas may also contribute toward satisfying the system yield between the late 1980's and 2020. The schedule for construction of multiple-purpose reservoirs may be determined by the need for flood control and water quality control, rather than for water conservation purposes alone.

9. Construction of the proposed federal portion of the water conveyance and conservation facilities of the Central Valley Project-State Water Project system, together with the completion of facilities already authorized for state or federal construction, and other necessary federal water conservation, conveyance and flood control projects, will

require average annual federal appropriations between 1966 and 1990 considerably higher than the average for the last 10 years. Construction scheduling would undoubtedly cause the maximum annual expenditure to exceed this necessary 1966-1990 average. Because of the competition for obtaining federal appropriations, it is in California's best interest to ensure that each project proposed for construction in the Central Valley Project-State Water Project system and those features not a part of this system conform to an orderly and timely staging to meet statewide needs for water, flood control and other project functions.

10. Flood control should be included as a project purpose in many of the multiple-purpose reservoirs to be constructed. Single-purpose flood control projects will also be required. The U. S. Army Corps of Engineers has a number of authorized flood control projects in the planning or construction phase, and it is authorized to conduct investigations of additional flood control possibilities.

11. Flood control investigations by federal, state and local agencies should give balanced consideration to all feasible methods of flood control and prevention of flood damage. These

methods should include storage facilities, levee and stream improvements, bypass channels, warning systems and floodplain and watershed management. Projections of flood control needs may indicate that it might be desirable to construct a multiple-purpose project for flood control before it is required for its other purposes. Such early scheduling is possible, if it is sound from the standpoint of economics. The solutions to many flood control problems that cannot be solved economically by project construction, may have to depend on floodplain management.

12. Power requirements in California are projected to increase by over 10 times to a maximum power demand of nearly 250 million kilowatts by the year 2020. The cost of generation of thermal-electric power, which determines the value of hydroelectric power, is predicted to be substantially less than estimated for The California Water Plan. However, the projected lower capacity factors at which hydroelectric power is predicted to be used will increase the total value of hydroelectric power to slightly over that estimated for the Plan. Lowered costs of power for pumping, as a result of technological advances, are expected to affect the selection of pumping lifts and aqueduct routes, and could increase the use of power for offpeak pumping.