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Department of Water Resources

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WATER FOR CALIFORNIA
THE CALIFORNIA WATER PLAN
OUTLOOK IN 1970

Summary Report

DECEMBER 1970

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CONTENTS

I. INTRODUCTION 5
The Outlook in 1970 5
The Need for Water Development and Environmental Protection 9
State Responsibility for Water Development . . . 9
Water Resources Management and the Environment 10
State and Federal Environmental Legislation . . 10
Progress in Water Resources Development 11
Local Water Development 11
Federal Water Projects 11
State Water Project 11

II. THE GROWTH OF WATER DEMANDS 12
Population and Economic Growth 12
Population Changes 12
Industrial Growth 13
Irrigated Agriculture 14
Land Use 14
Water Demands 15
Cities and Industry 16
Agriculture 18
Recreation, Fish, and Wildlife 18
Prevention of Flood Damage 19
Water Quality 19
State Water Resources Control Board 19
Porter-Cologne Water Quality Control Act 20

III. POTENTIAL WATER SUPPLY SOURCES 20
Surface Water Development 20
Ground Water Development 21
Availability of Ground Water 21
Ground Water Management 24
Desalting 24
Department of Water Resources Program 24
Current Status and Costs 26
The Future of Desalting 26
Water Reclamation 26
Other Sources of Water 27
Weather Modification 28
Watershed Management 28
Geothermal Water Resources 28
Western States Water Development 29
Undersea Aqueduct 29

IV. REGIONAL WATER DEMAND—WATER SUPPLY RELATIONSHIPS 29
North Coastal Area 31
San Francisco Bay Area 31
Central Coastal Area 32
South Coastal Area 32
Sacramento Basin 32
Delta-Central Sierra Area 33
San Joaquin Basin 33
Tulare Basin 33
North Lahontan Area 34
South Lahontan Area 34
Colorado Desert Area 34

V. MEETING WATER DEMANDS THROUGH STATE AND FEDERAL FACILITIES 35
Central Valley Project 35
State Water Project 35
The Peripheral Canal 35
Projected Water Demands on the Federal and State Systems 37
Possible Additions to the Central Valley Project 37
Possible Additions to the State Water Project 38

VI. POPULATION DISPERSAL AND ITS EFFECT ON RESOURCES DEVELOPMENT 39
Three Model Urban Areas 39
Model A 39
Model B 40
Model C 40
Effects of Population Dispersal 40
Water Development 40
Disposal of Wastes 41
Electric Power 42
Air Pollution 42
Transportation 42
Summary 42

FOREWORD

Over the past 30 years, California has undergone one of the most rapid growth cycles ever experienced by a civilization. From less than 7 million in 1940, the State's population has climbed to almost 20 million in 1970. Today, California is still growing, although at a reduced pace. Recent growth trends suggest a population of 29 million in 1990 and 45 million in 2020.

As California continues to grow, so will the demand for water — for homes, for industry, for agriculture, for recreation and for a quality environment for future generations. Moreover, with increasing population will come equally increasing potential for water pollution. As we face the water problems of the future, we must respond to emerging concepts of environmental enhancement. Many of our past ideas must be modified to accommodate changing environmental conditions.

Bulletin No. 160-70 provides a summary of our current planning — a look at what California is doing, within the framework of the California Water Plan, about the need for water and protection of the environment. The California Water Plan has demonstrated that California has sufficient water supplies to meet future needs. However, we cannot take nature's abundance for granted. As we face the challenges of the 1970s and beyond, we must continue to assess, plan, and use our water resources in an intelligent and thoughtful manner.

Fortunately, the projected slower growth of statewide population, together with the additional water supplies being made available by projects under construction or authorized, will provide a "breathing spell" in the development of California's water resources. This will afford additional time to consider alternative resources of water supply and develop policies for the maximum protection of the environment.

WRGianelli

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December 1, 1970

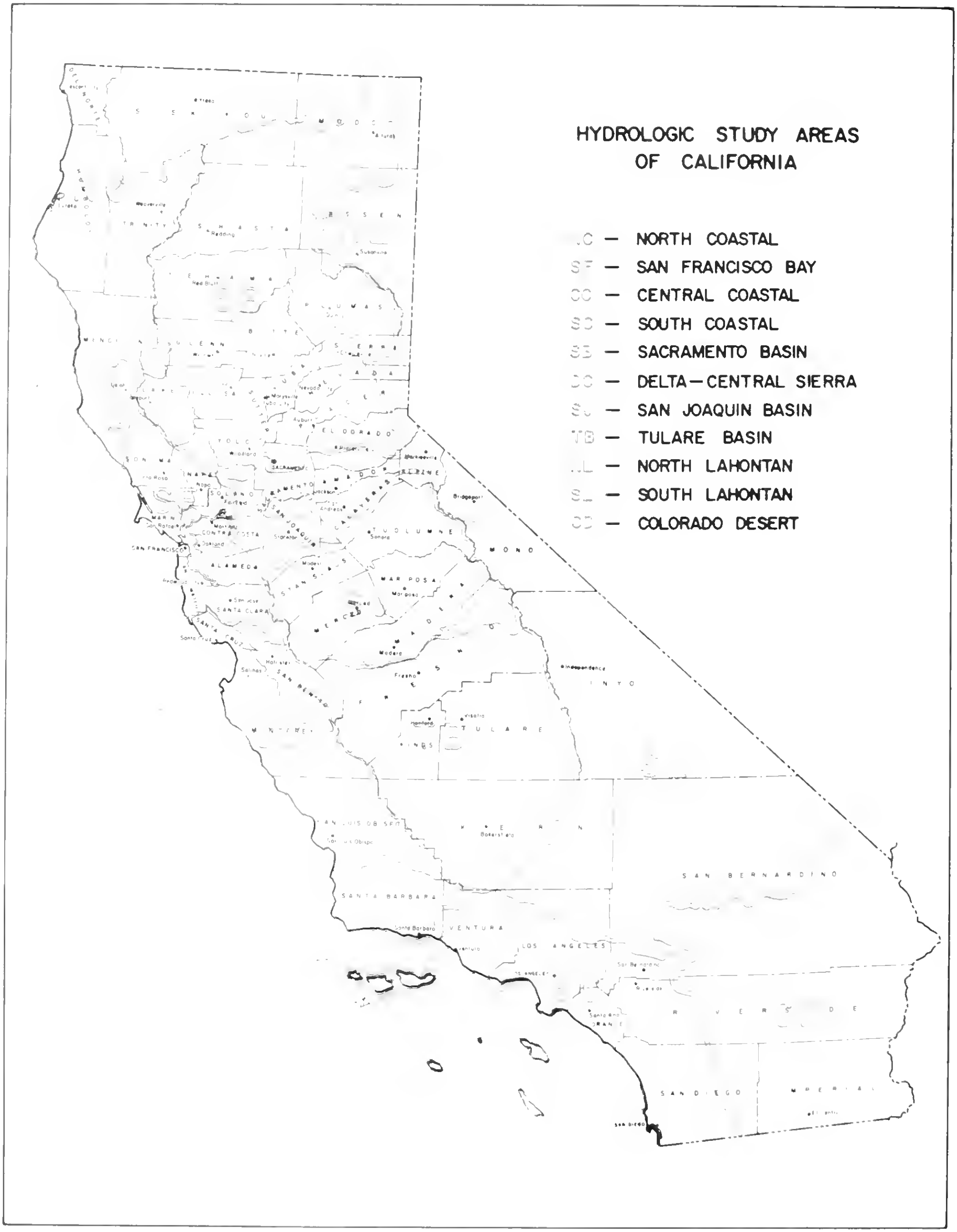


Figure 1 Hydrologic Study Areas of California.

INTRODUCTION

This report summarizes Bulletin No. 160-70, which (1) presents up-to-date projections of statewide water demands in 1990 and 2020, and (2) discusses possible sources of water to supply those demands. Bulletin No. 160-70 reports accomplishments in both planning and water development since the publication of Bulletin No. 160-66*, the first of the Bulletin No. 160 series, which reported earlier progress in implementation of the California Water Plan.

The projections and estimates presented in this report represent the outlook for the future as it appears in 1970 and will be periodically revised as dictated by changes that cannot be foreseen today. The extent of such revisions will of course depend on actual future changes.

Following publication of Bulletin No. 160-66, the California Department of Water Resources began new studies of the long-term demand for water in each of the hydrologic areas of the State (Figure 1). Analyses of statewide water demands, along with the sufficiency of supplies to meet those demands, have revealed the following:

The Outlook in 1970

In General —

- Sufficient water is developed by completed water projects, or will be developed by those under construction, to satisfy most urban and irrigation needs for about two decades. However, additional conveyance facilities are needed to deliver developed supplies to certain service areas.
- The favorable status of developed water supplies affords time to evaluate potential alternative sources of water and devote more attention to the emerging environmental problems associated with water conservation projects and the evolvement of definite public policies on such problems.
- Whereas major storage projects are not immediately needed for water conservation, flood problems are increasing, and the control of floods may warrant construction of storage reservoirs, which should include conservation storage when justified.
- The quality of water supplies is generally satisfactory throughout most of the State, with the principal exception of supplies from the Colorado River, and care must be expressed to maintain the good quality.

On Growth —

- The rapid growth of California's population that followed World War II decreased sharply by the mid-1960s because of reductions in births and migration.
- Recent trends indicate that the present population of 20 million in California will increase to about 29 million in 1990 and 45 million in 2020, instead of 35 million and 54 million as projected four years ago on the basis of the higher growth rates following World War II.
- Urban land use is expected to nearly double from 2.3 million acres in 1967 to about 4.5 million acres in 2020 to accommodate the projected population of 45 million.

* California Department of Water Resources Bulletin No. 160-66. "Implementation of the California Water Plan". March 1966.

- Irrigated acreage is expected to increase about 10 percent from 8.9 million acres in 1967 to 9.8 million acres in 1990, and to increase only an additional 4 percent to 10.2 million acres in 2020. This projected growth in acreage is less than proportional to the projected growth of state and national requirements for food and fiber because improved agricultural methods are expected to produce greater yields per acre.
- Projected increases in both leisure time and extra income suggest a rapid growth in the per capita demand for water-associated recreation, especially near urban areas. The annual demand for recreation is projected to increase from the current 218 million visitor-days to 2.5 billion visitor-days by 2020.
- Consumption of electrical energy has generally doubled about every 10 years. This trend is expected to continue for about 20 years and then decline slightly after 1990. Electrical-generation requirements are expected to increase from 32,000 megawatts in 1970 to 110,000 megawatts in 1990 and 412,000 megawatts in 2020. As more steam-electric powerplants are constructed, demands for cooling water will increase substantially.

On Needs –

- Statewide urban water demands are expected to increase from about 3.7 million acre-feet in 1967 to 6.4 million acre-feet in 1990 and to 10.3 million acre-feet in 2020. Overall per capita water demands are expected to increase some 20 percent by 2020; however, the growth of per capita demands in large metropolitan areas is expected to be somewhat lower because of the projected increase in high-rise multiple dwellings and a consequent reduction in demands for water to irrigate lawns and gardens.
- Demands for agricultural water will generally increase in proportion to the growth of irrigated acreage, i.e., from 24.4 million acre-feet in 1967 to 27.4 million acre-feet in 1990, and 28.7 million acre-feet in 2020.
- More than 80 percent of the additional electrical-generating capacity in 1990 and 2020 is expected to be derived from fossil- or nuclear-fueled steam plants, which require very large amounts of cooling water. If 50 percent of the projected increase in generating capacity between now and 2020 is located at inland sites, due to limited acceptability of coastal sites, about 3 million acre-feet of cooling water will be required each year. The possible water demands for cooling inland plants are not included in the projected demands in this report. They could comprise one of the largest increases in future water demands.
- Intensification of land use, resulting from the increasing population, will require a vigorous flood control program. Local agencies should carefully consider floodplain management in addition to the construction of flood control facilities.
- The increasing demand for water-associated recreation will require the development of additional water surface and shoreline, particularly near major urban areas.
- Studies of hypothetical patterns of distribution of California's future population indicate that, regardless of where population centers may be located, total statewide water demands will be essentially unchanged. Whereas the requirements for water conservation will remain the same, new population centers would require different patterns of water transportation facilities.

On Present Water Supplies —

- All major urban areas have adequate water supplies from existing projects or facilities authorized or under construction to meet water demands for the next 20 or more years.
- Adequate quantities of water are generally available for irrigation, but in some areas, particularly in the San Joaquin Valley, ground water is being overdrafted and in other areas, such as the Imperial and Coachella Valleys, significant water quality problems are emerging.
- During the past four years, a number of major water supply projects have been completed. Other major projects are under construction.
  - The U. S. Bureau of Reclamation has completed federal-state facilities for the federal San Luis service area and begun construction of facilities for service in the Sacramento Valley and in the Folsom-South service areas.
  - The U. S. Army Corps of Engineers has begun construction of six important multipurpose projects.
  - The initial facilities of the State Water Project are more than 95 percent complete or under construction.
  - Local agencies have completed or begun construction of 35 reservoir projects.

On Future Water Supplies —

- The alternative sources of water considered available for meeting future demands include surface water development by federal, state, and local agencies; increased use of ground water in conjunction with surface supplies; desalination; reclaimed waste water; weather modification; and geothermal resources.
- Ground water will continue to be an important source of water. The primary value of ground water basins lies in their use for water storage and distribution in coordination with local and imported surface supplies as integrated systems.
- Desalination offers promise of a supplemental source of fresh water, particularly in California's coastal areas. However, the future of desalted water as a major source of supply cannot be fully evaluated until the economics of desalination have been tested with a large-scale prototype development. The Department of Water Resources and the U. S. Office of Saline Water are cooperating in a program to lead to such a development by the late 1970s.
- Reclamation of waste water presents a potential source for partial fulfillment of increasing water demands in major coastal metropolitan areas, particularly for environmental enhancement projects such as irrigation of recreational and agricultural greenbelts.
- Desalination of geothermal water may eventually produce significant quantities of fresh water and electrical energy. The Department of Water Resources is participating in studies to determine the feasibility of development of geothermal resources in the Imperial Valley.

- Modification of the weather may eventually become a feasible method for augmenting natural water supplies. The Department of Water Resources has been participating in experiments with weather modification since 1951.
- As a result of the projected slower growth of statewide population as compared with projections made four years ago, future water demands are also expected to increase slowly. This slower projected growth of water demands, particularly in the South Coastal area, is expected to delay the time of need for an additional conservation facility for the State Water Project about 10 years until the mid-1990s. However, the time of need for an additional facility could be advanced by (1) greater-than-planned outflows of fresh water from the Sacramento-San Joaquin Delta, as might be required by the State Water Resources Control Board; (2) the needs of additional service areas; or (3) increased water use in areas tributary to the Delta.
- About 1 million acre-feet of imported supplemental water will be needed annually for the east side of the San Joaquin Valley to offset existing large overdrafts of local ground water. The proposed East Side Division of the Central Valley Project is a sound engineering proposal to eliminate existing deficiencies and to permit expansion of agricultural development. Through provisions for stream maintenance releases, the East Side Canal has the potential for environmentally enhancing the Sierra Nevada streams between Dry Creek in Sacramento County and the Kern River in Kern County. Specific plans for such releases should be developed.
- The joint federal-state Peripheral Canal should be authorized by Congress and constructed to enhance the environment of the Sacramento-San Joaquin Delta and to provide good-quality water in the Delta and for other areas of California.
- Local water agencies will continue to play an important role in the development of California's water resources. Local agencies are expected to develop about 20 percent of the new water supplies required between now and 2020. They will also predominate in the construction of distribution facilities for water delivered from state and federal projects.

On Special Environmental Issues –

- The rivers of California should be classified to identify their potential for various future uses, such as scenic and wild rivers, fisheries management, water conservation (including flood control), or hydroelectric power. The Department of Water Resources has a program for characterizing the State's rivers; and the Resources Agency is conducting a study of outstanding scenic and recreational waterways under the California Protected Waterways Act.
- Studies of the protection and enhancement of fisheries and wildlife habitat should be expanded to include more complete consideration within the perspective of total resources planning and decision processes.
- Acceptable water quality is of paramount importance in the conservation, use, and disposal of water. The maintenance of acceptable water quality requires an intensive effort by all levels of government.

The Need for Water Development and Environmental Protection

California's natural water supplies are derived from an average annual precipitation of 200 million acre-feet. About 65 percent of this precipitation is consumed through evaporation and transpiration. The remaining 35 percent comprises the State's annual average runoff of 70 million acre-feet. The average runoff available in the 11 hydrologic areas of California is shown in Figure 2.

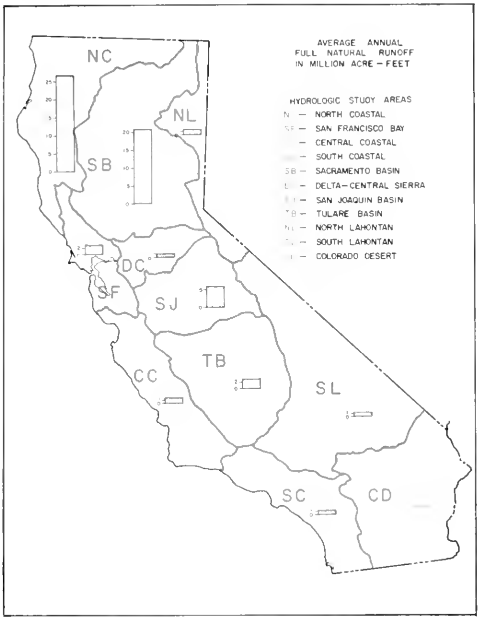


Figure 2. Average Annual Runoff in California.

The wide disparity in available runoff, both from year to year and between hydrologic areas, creates the need for the storage and conveyance of surface water and the extensive use of ground water. As shown in Figure 2, the greatest amounts of runoff are available in areas with the fewest people, i.e., the North Coastal area and the Sacramento Basin. As California has grown, its surface water systems have been expanded to large-scale transfer systems, involving the storage and transportation of water almost the entire length of the State.

A major water problem today is the maintenance of a proper balance between the use of the State's water resources and protection and enhancement of the environment. In the past, such environmental benefits as scenic and cultural resources and the preservation of aesthetic areas, including open and green space, wild rivers, lakes, beaches, fish and wildlife, mountains and wilderness regions, have not always been included in water projects. Equally important is the protection of areas of archaeological, historical, or scientific value. Many such benefits are difficult to measure because they cannot be assigned a monetary value, and the present technique of cost and benefit analysis is, in this respect, inadequate. Accordingly, future water development planning must be broadened to include more thoughtful consideration and evaluation of environmental and ecological effects.

State Responsibility for Water Development

The State's responsibility for the development and use of California's water resources is set forth in various sections of the California Water Code. Section 10005 of the Water Code establishes the California Water Plan as a flexible pattern for the development of the State's water resources — not as a restrictive or all-inclusive plan, but one into which new ideas and new technologies may be incorporated as changing conditions dictate.

Section 10005 of the Water Code also assigns the Department of Water Resources the responsibility for updating and supplementing the California Water Plan as required by changing circumstances. To carry out this responsibility, the Department of Water Resources maintains a statewide planning program, which guides the selection of the most favorable pattern for the use of the State's water resources, considering all reasonable alternative courses of action. Such alternatives are evaluated on the basis of both technical feasibility and economic, social, and institutional factors.

COORDINATED STATEWIDE PLANNING

- Periodic reassessment of existing and future demands for water and the need for flood control, hydroelectric power, recreation, benefits for fish and wildlife.
- Periodic reassessment of local water resources and the magnitude and timing of the need for additional water supplies that cannot be provided locally.
- Determination of various alternative sources of water — dams and reservoirs, ground water, desalting, reclaimed water, weather modification — to meet future demands in areas of water deficiency.
- Determination of the need for protection and preservation of water resources in keeping with the protection and enhancement of the environment.
- Evaluation of water development plans.

Water Resources Management and the Environment

Today, the State's concern includes assurance that its citizens may enjoy the beauty of California's environment and that the quality of the environment may be protected and enhanced as the State continues to grow. Planning for water development is a critical element in environmental protection because of the direct effect of large-scale water projects on the environment. Water development relates not only to the physical and natural ecosystem but also to the social, cultural, and economic aspects of environment, and it must be considered in terms of these effects, both beneficial and adverse, on the total environment.

Recent events have shown that social objectives considered desirable by society are changing. Obviously, certain objectives desired by the public may not be consistent with the most economical use of resources. The public interest in environmental quality, healthful ecology, and aesthetics implies a willingness to spend money in a way that may not necessarily be the most economically efficient. However, the extent of the public commitment to an improved environment has not been clearly defined.

Nevertheless, planners are confronted with the need to develop new philosophies, new concepts, new methodologies, and new techniques. The rapid advance of technology has opened up the possibilities of new alternative approaches to water development, and the increasing public concern with the environment demands the development of new and more refined methods of evaluating the environmental benefits and detriments of specific plans.

The Department of Water Resources is broadening its own planning processes through the increased use of systems analysis to include a wider range of development alternatives. Simply stated, systems analysis is a method for evaluating a large number of alternatives, from the standpoint of both monetary and nonmonetary values, and deciding among them. In cooperation with federal agencies, universities, and other groups, the Department of Water Resources is continuously seeking better methods of evaluation. However, the development of improved methods presents many other problems involving new and highly complex concepts — perhaps even technologies yet to be discovered.

State and Federal Environmental Legislation

Both the California Legislature and the National Congress have declared the 1970s to be "the decade of the environment". In California, this has resulted in the reorientation of legislative committees to provide a closer look at environmental issues and in a substantial number of legislative proposals. At the federal level a number of important acts requiring state cooperation have emerged. Two of the most important new federal laws affecting California are the National Environmental Policy Act of 1969 and the Wild and Scenic Rivers Act of 1968.

The National Environmental Policy Act declares a national policy that will encourage productive harmony between man and his environment; to promote efforts that will prevent or eliminate damage to the environment and biosphere, and stimulate the health and welfare of man; and to enrich the understanding of the ecological systems and natural resources important to the Nation.

The Wild and Scenic Rivers Act sets forth the basic principle that certain rivers of the Nation which, "with their immediate environments, possess outstanding, remarkable, scenic, recreation, geologic, fish and wild-life, historic, cultural and other similar values", are to be preserved in a free-flowing condition and protected for the enjoyment of present and future generations. The Act establishes the Wild and Scenic Rivers System consisting of eight initial rivers, including the Middle Fork of the Feather River in California, and identifies 27 other rivers that may be added to the system.

Several bills concerning the environment have been passed recently by the California Legislature. In addition, in January of 1970, the Legislature appointed the Assembly Select Committee on Environmental Quality to study environmental issues.

The California Protected Waterways Act of 1968 declares it a state policy to conserve those waterways "possessed of extraordinary scenic, fishery, wildlife, or outdoors recreation values." The Act requires the State Resources Agency to prepare a plan to this effect and to report to the Legislature in January of 1971. The Act defines waterways as "the waters and adjacent lands of streams, channels, lakes, reservoirs, bays, estuaries, marshes, wetlands, and lagoons".

The Environmental Quality Act of 1970 (A.B. 2045) requires state, federal, and local agencies to include detailed statements of environmental information in all reports on proposed projects. In addition, the bill requires state agencies to include funds to protect the environment in all budgetry requests.

Assembly Bill 2070, enacted as Chapter 1534, Statutes of 1970, established a new Office of Planning and Research in the Governor's office to help the Governor develop and achieve environmental goals. The new office will evaluate the plans of all state agencies and recommend new policies, programs, and actions that will resolve conflicts and advance statewide environmental goals.

Progress in Water Resources Development

Over the past 30 years, local water agencies have invested some $4 billion in surface and ground water projects. Although the State Water Project and the federal Central Valley Project, both of which involve large interbasin transfers of water, are more widely known, the efforts of local agencies have long predominated water development in California. Plate 1 (page 22) shows features of the State Water Project and federal and local projects that have been completed or are under construction.

Since 1966, local agencies have invested more than $1 billion in water development and distribution systems. California has invested $1.4 billion in the State Water Project, and the Federal Government has expended some $400 million on the Central Valley Project and on conservation and flood-control facilities developed by the U.S. Army Corps of Engineers. The development of California's water resources in an orderly, progressive manner will require the continuous effort of all levels of government. However, State projects, and those of federal agencies, will continue to supplement local water developments, fulfilling only the needs that local governments cannot provide for.

Local Water Development

During the past four years, local agencies have completed, or begun construction of, 35 projects. Major projects completed since 1966 are listed in the following table:

Project	Stream System	Agency
New Bullards Bar	North Yuba River	Yuba County Water Agency
New Exchequer (Lake McClure)	Merced River	Merced Irrigation District
Hell Hole	Rubicon River	Placer County Water Agency
Lopez	Arroyo Grande Creek	San Luis Obispo County Flood Control and Water Conservation District
New Don Pedro	Tuolumne River	City and County of San Francisco; and Turlock and Modesto Irrigation Districts

In addition, several major aqueduct and distribution systems have been completed or are under construction. The City of Los Angeles has completed a second pipeline of the Los Angeles Aqueduct, which transports water some 250 miles to the city from the Owens River. The Metropolitan Water District of Southern California is constructing a major distribution system to deliver water from the State Water Project to member agencies. In addition, several water districts in the San Joaquin Valley have completed, or are constructing, distribution systems to deliver imported water to individual users. In eastern Kern County, the Arvin-Edison Water Storage District has completed a major system for distribution of water from the Central Valley Project. Agencies on the west side of the San Joaquin Valley are constructing similar facilities for distribution of water from the State Water Project.

Federal Water Projects

Since 1966, the United States Bureau of Reclamation has completed the joint federal-state San Luis Dam and Pumping Plant and has begun construction of several other additions to the Central Valley Project. These include (1) the Tehama-Colusa Canal, (2) the San Felipe Division, (3) the Auburn-Folsom South Unit, and (4) the San Luis Drain. The Central Valley Project is now delivering some six million acre-feet of water to local agencies. Hydroelectric capacity exceeds 1,500,000 kilowatts, almost 85 percent of the presently authorized capacity. The Bureau of Reclamation has also completed Stampede Reservoir on the Little Truckee River.

The U. S. Army Corps of Engineers has begun construction of six important projects. These are:

Reservoir	Stream System
New Melones	Stanislaus River
Warm Springs (Lake Sonoma)	Russian River (Dry Creek)
Martis	Truckee River (Martis Creek)
Mojave	Mojave River
Hidden	Fresno River
Buchanan	Chowchilla River

Projects authorized by the federal Flood Controls Acts of 1966 and 1968 include Marysville Reservoir on the Yuba River, Knights Valley Reservoir in the Russian River Basin, and Butler Valley Reservoir on the Mad River in Humboldt County.

State Water Project

The State Water Project — designated in the California Water Plan as the initial unit for State construction — is now delivering water to public agencies in nine counties in Central and Northern California. When in full operation, the Project will supply water to 31 water service agencies in the Feather River area, San Joaquin Valley, San Francisco Bay area, Central Coastal area, and Southern California.

Construction of the State Water Project is on schedule. More than 95 percent of the initial facilities required for deliveries to water-deficient areas of California have been completed or are under contract. Project water is now being delivered in the Sacramento Valley, the San Francisco Bay area, and the San Joaquin Valley. The first delivery to Southern California is scheduled for 1971.

In December of 1970, the California Aqueduct was operational from Clifton Court Forebay, at the southern edge of the Sacramento-San Joaquin Delta, to Wind Gap Pumping Plant some 280 miles further south. Project water will begin crossing the Tehachapi Mountains in 1971. The contract for construction of Perris Dam and reservoir in Riverside County has been awarded, and the Perris facilities are scheduled for completion in 1973.

In 1966, the Department of Water Resources began a four-year study and analysis of the long-term demand for water in each of the 11 hydrologic study areas shown in Figure 1. As a basis for long-range planning to satisfy future water requirements, these demands have been projected to 1990 and 2020. This projected increase in the demand for water is directly related to the growth of California's population, industry, and irrigated agriculture.

Population and Economic Growth

Population Changes

The size and distribution of population is a major factor in estimating requirements for future water service. Between 1940 and 1970, California's population grew from less than 7 million to almost 20 million. Continued growth at a similar rate would result in a state population of 40 million by 1990 and more than 60 million by the turn of the century. However, reductions in both birth rates and migration into California during the last ten years suggest a lower rate of increase.

In 1967, the U. S. Bureau of Census, published new population projections for the entire Nation. In Table 1 the 1967 figures are shown as Series A (highest rate of increase) through Series D (lowest rate). In 1970, the Census Bureau revised its estimates, dropping Series A as unrealistically high and adding Series E, the lowest reasonable rate of increase, representing an almost stable rate of growth. Series D appears to be a reasonable rate of growth and was used by the State Department of Finance for its recent projections of California's future growth through 2000. For Bulletin 160-70, the Department of Water Resources has extended these Series D projections through 2020.

Table 1. United States and California Population Projections, 1980 through 2020

	U. S. Population (millions)				California Population (millions)			
Series	1980	1990	2000	2020	1980	1990	2000	2020
A	240	286	337	488	25.6	32.8	41.0	65.8
B	237	277	321	440	25.2	31.8	38.9	59.1
C	232	266	301	386	24.7	30.4	36.4	51.5
D	228	255	281	336	24.2	29.0	33.9	44.7
E	226	248	266	299	23.9	28.3	32.1	39.6

The projections of California's future growth shown in Table 1 reflect the progressive drop in annual net migration rates. In 1957, the year of maximum net migration, 388,000 moved into the Golden State. By 1969, the number of migrants had declined to some 105,000. However, for the recent long-range forecasts in Table 1, the State Department of Finance assumed an annual net migration rate of 200,000.

On the basis of these lowered rates of birth and net migration, the State's population would increase from the 1970 total of about 20 million to about 29 million in 1990 and 45 million in 2020. Figure 3 shows the growth of statewide population from 1940 through 1970 and the projected growth through 2020. The projections indicate an average statewide growth rate of about 1.75 percent per year as compared with an average annual increase of 3.5 percent between 1940 and 1970.

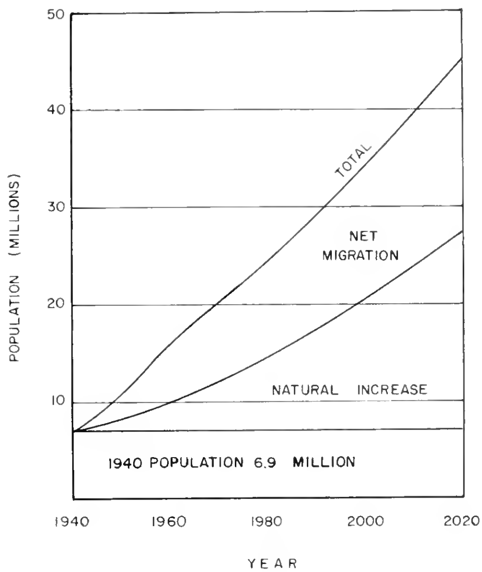


Figure 3. Historical and Projected Population Growth, 1940-2020.

The Department of Water Resources has also distributed the projected population growth among the 11 hydrologic study areas, as shown in Table 2. These projections show further increases in the population of each hydrologic area. Areas with large populations, which have experienced the largest growth during the past 30 years, are expected to record the largest growth in the future.

Table 2. Projected California Population by Hydrologic Study Area, 1967-2020 (in thousands)

Study Area	1967	1990	2020
North Coastal	180	210	300
San Francisco Bay	4,320	6,500	10,100
Central Coastal	750	1,200	2,200
South Coastal	10,510	16,000	23,900
Sacramento Basin	1,140	1,600	2,300
Delta-Central Sierra	400	650	1,100
San Joaquin Basin	410	610	1,000
Tulare Basin	910	1,200	1.800
North Lahontan	40	70	100
South Lahontan	220	590	1,300
Colorado Desert	220	370	600
Total	19,100	29,000	44,700

Population trends have also reflected the migration from rural to urban areas over the past 30 years. If present trends continue, most of the future population growth will occur in California's expanding cities. This concentration of urban population has already led to various problems; two of the most pressing are congestion and pollution — of water and the atmosphere. California is studying these problems associated with population concentration, and future state policies might result in a redistribution of people. In the final section of this bulletin ("Population Dispersal and its Effect on Resources Development"), this concept is explored in more detail.

Industrial Growth

Employment in California is expected to grow at much the same rate as population, resulting in about four million more workers by 1990. At the same time, categories of employment will continue to change. Technological changes will bring a decline in on-farm employment, while other resource-based industries, such as mining, forestry, and fisheries, may gain slightly. Manufacturing jobs will increase by some 700,000 over the next 25 years, but in response to the demands of an expanding and affluent society, the largest gains are expected in the service and government categories.

Industries requiring large quantities of water will reflect this general growth. One such industry is the electric power industry. Estimates of future demands for electric power, based on growing household and industrial needs, indicate that generating requirements will grow from 32,100 megawatts in 1970 to 110,000 megawatts in 1990 and 412,000 megawatts in 2020.

Until recently, almost all the electric power used in California was produced by hydroelectric plants, where the energy of falling water is converted into electrical energy. Since about 1950, however, other sources of electrical energy have become increasingly important.

During the next 50 years, most additional hydroelectric power will be generated by pumped-storage plants. In a pumped-storage plant, low-cost energy is used during periods of minimum demand to pump water from a lower to an upper reservoir. When additional power is required during periods of peak demand, the water is returned from the upper to the lower reservoir through a pumping-generating plant, thus producing high-value electrical energy.

As the demands for power continue to grow between now and 2020, increasing amounts of electrical energy will be produced by steam-electric plants, most of which will be fueled by thermal energy. Whereas the use of fossil fuels predominates at the present time, thermonuclear plants are expected to supply almost 80 percent, or more

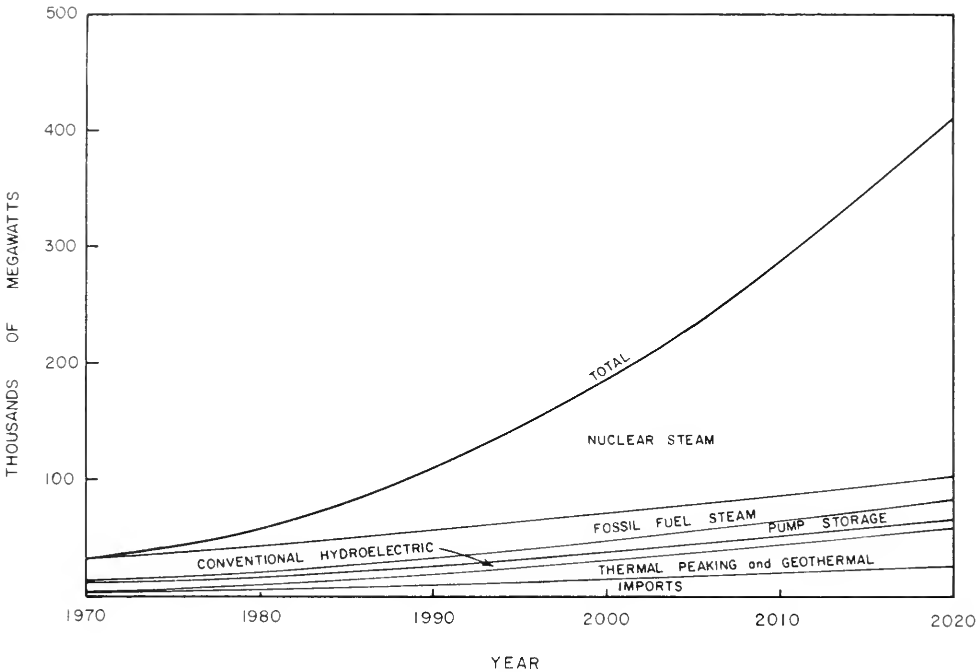


Figure 4. Projected Growth of Electrical Energy by Primary Source.

than 300,000 megawatts, of the total power requirements in 2020. Figure 4 shows the present output and projected growth of primary sources of electrical energy over the next 50 years.

Irrigated Agriculture

Future demands for food and fibre are directly related to the growth of national population, per capita consumption, and export markets. Because most of California's cash crops receive nationwide distribution, national population trends were used for estimates of future farm production.

The value of agricultural products in California is expected to increase from slightly over \$4 billion in 1969 to \$5½ billion by 1980. At the same time, agriculture will face a number of problems during the 1970's, including a squeeze on prices caused by over production of some commodities, rising production costs, increasing taxes, and a highly competitive market for credit. And, as the cities continue to expand, urban encroachment on agricultural land will also continue. All in all, a trend toward more efficient farms will undoubtedly prevail.

As shown in Figure 5, the estimated increase in irrigated acreage over the next 50 years is considerably lower than the actual increase between 1930 and 1970. The Department of Water Resources has projected this decline in the growth of irrigated lands on the basis of (1) continued improvements in crop yield, enabling increased production on less acreage, and (2) the lowered projections of population growth.

Land Use

Land use is related to water requirements in a number of important ways. The use and management of land affects both the quantity and quality of runoff and the location and magnitude of water uses. In California, a large percentage of water is used for agriculture. Meanwhile, the rapid growth of cities requires increasing amounts of water for homes and industry and for the disposal of wastes. Thus, as the uses of land change, so do the requirements for water.

Since 1950, an average of 30 to 40 thousand acres has been required each year for the growth of cities. New agricultural lands must be developed to

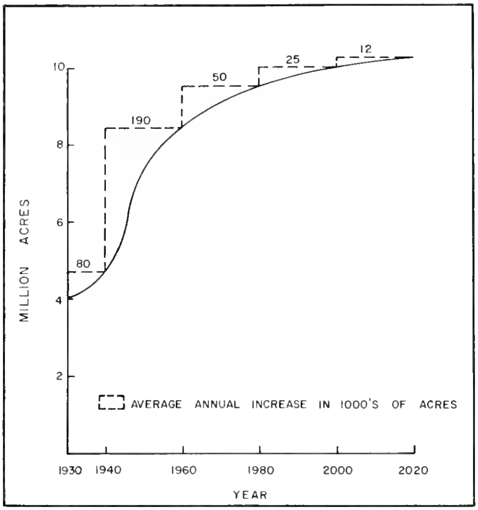


Figure 5. Historical and Projected Growth of Net Irrigated Acreage, 1930-2020.

replace those taken over by this continuous urban expansion. At present, California has some 22.5 million acres of irrigable land.* About 8.5 million acres are currently under irrigation, and 2.3 million acres are occupied by cities. Figure 6 shows the projected changes in land use in California between 1967 and 2020.

* Irrigated acreage and land that could be developed for irrigated agriculture.

Although nearly 11 million acres of irrigable, but nonirrigated, land will still be available in 2020, in certain areas, such as the Central Valley, most of the best agricultural land will have been put under cultivation. In the Tulare and San Joaquin Basins, an estimated 72 percent of the total irrigable land will have been developed. The percentage is lower in the Sacramento Basin and Central Sierra regions. In prime agricultural areas in Yolo, Butte, and Sutter Counties, irrigated acreage is expected to peak about 1990 and then decline somewhat due to urban expansion.

In some parts of the State, the development of irrigable lands would not be feasible. For example, cultivation of South Lahontan desert lands would be highly unlikely due to the scarcity of low-cost water in that area. In certain other areas, soil and climate limit the capacity to produce crops that would justify the expense of the required water supply.

Water Demands

Projected requirements for water are derived from estimated demands for the products and services available through the use of water. The accuracy of such projections depends on such factors as technological change, relative costs of water, population growth and shifts, and other varying factors. The projected statewide demands in this report were derived as the products of

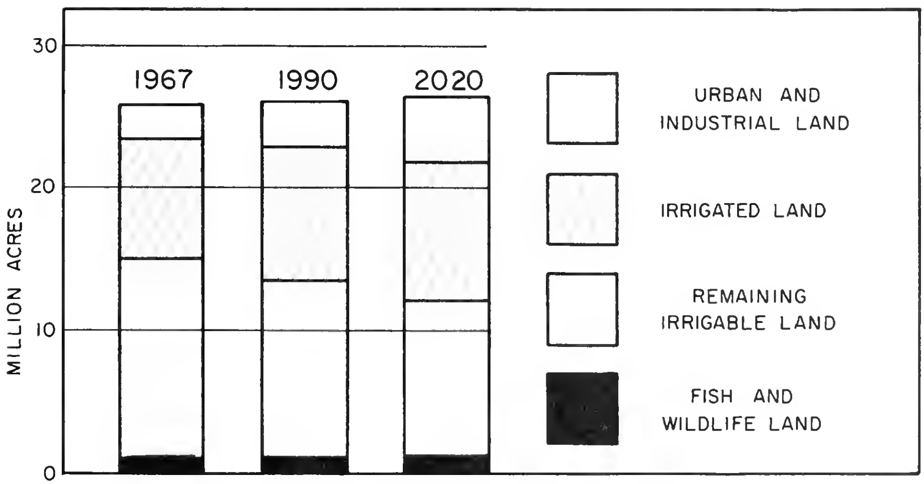


Figure 6. Projected Changes in Land Use, 1967-2020.

estimated population and economic growth and appropriate water use factors. The results of the four-year study of water use in each hydrologic area indicate that by 2020, the statewide net demand for water will increase by more than 11 million acre-feet from the present estimated 28.6 million acre-feet. The projected growth in statewide water demands is shown in Figure 7. The water uses contributing to this projected increase are briefly discussed in the paragraphs that follow.

In this summary, water requirements are generally discussed as *net* demands, as opposed to *applied* demands. Applied water demands are the quantities of water that must be made available at individual places of use, e.g., to a farmer's headgate for irrigation or to a meter for domestic or industrial use. The net water demand is the total amount that must actually be delivered to satisfy the need in a given area. Because some water may be reused, the net demand for a given area is generally lower than individual applied demands.

Cities and Industry

Urban demands include water for household use, industry, fire protection, and the irrigation of lawns, gardens, and parks. On the basis of recent population projections, statewide net urban water demands are expected to increase from 3.7 million acre-feet in 1967 to 6.4 million acre-feet in 1990, and to 10.3 million acre-feet in 2020.

In most areas of California, per capita use, or average water used per person, is expected to increase slightly; past trends indicate that individual use tends to increase with a rising standard of living. However, other factors point to only a modest increase in per capita use. For one thing, as population densities increase, lawn and garden areas will decrease, thus reducing water use outside of homes.

Urban water use will continue to vary considerably from city to city and region to region. As shown in Table 3, per capita use values are similar

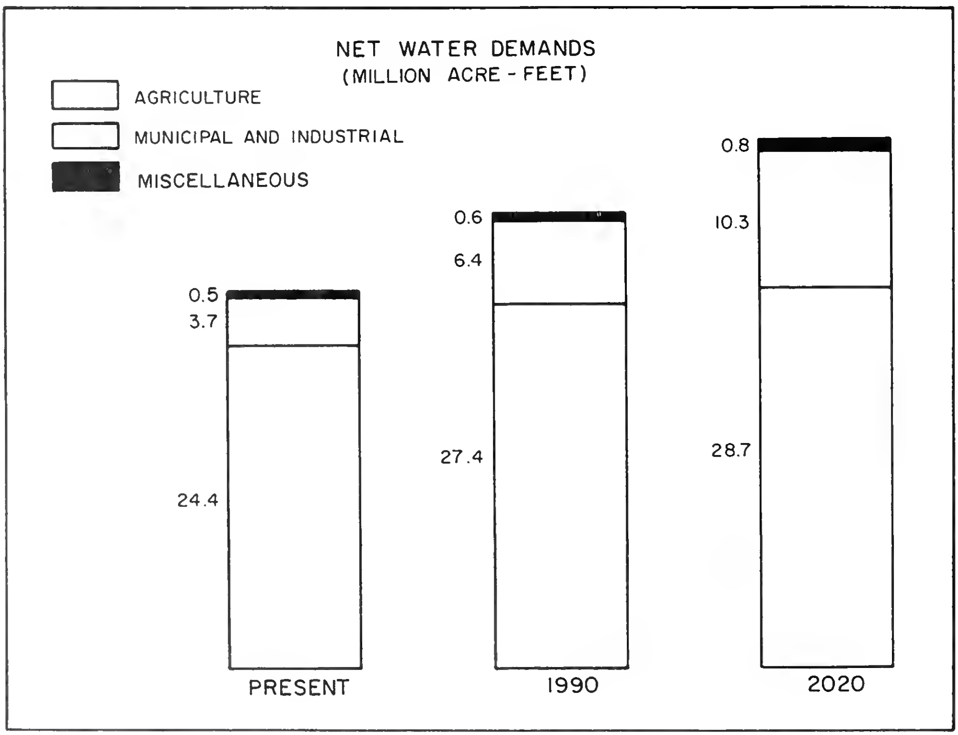


Figure 7. Projected Growth of Net Water Demands, 1967-2020.

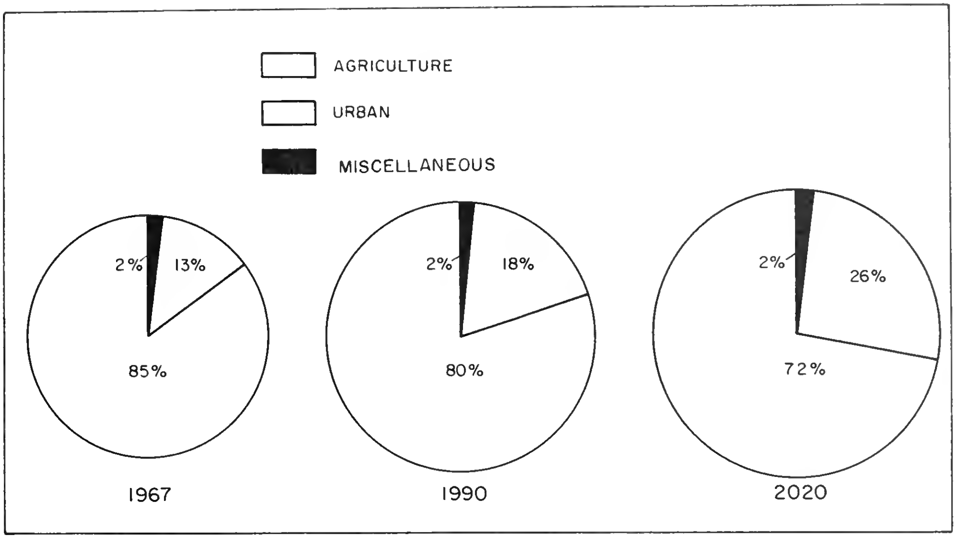


Figure 8. Proportionate Growth of Net Water Demands, 1967-2020.

in areas with similar climates (e.g., the San Francisco Bay and Central Coastal areas). The values also show that individual water use tends to increase in arid and semiarid areas.

Table 3. Projected Urban Per Capita Water Use by Hydrologic Study Area, 1967-2020 (gallons per day)

Study Area	1967	1990	2020
North Coastal[1]	160	140	130
San Francisco Bay	170	200	220
Central Coastal	200	210	210
South Coastal	180	190	200
Sacramento Basin[1]	350	350	350
Delta-Central Sierra[2]	320	280	260
San Joaquin Basin	370	390	420
Tulare Basin	370	350	350
North Lahontan	Per capita values not available		
South Lahontan	280	320	320
Colorado Desert	380	400	400

[1] Water demands for pulp and paper industry not included.

[2] Values are for valley floor only. Recreational and second-home use in Sierra foothills not included.

Increases in industrial water use may be affected by increased pollution controls and rising water costs. As local governments effect more stringent regulations for the disposal of effluents, industries may tend to reduce their water intake. Increasing water costs and improved reclamation techniques will encourage economy and the reuse of waste water.

Large quantities of water will be required for cooling steam-electric power plants. A 1,000-megawatt nuclear steam-electric plant, which will produce sufficient power to meet demands in a metropolitan area of about 600,000 persons, requires a flow of cooling water of about 1,500 cubic feet per second.

Once-through cooling, in which water is run through the plant condensers and returned to its source, is the most economical cooling process. However, the once-through process requires a large source of water and is practical only at coastal sites, where sea water is available. At inland locations, where fresh water is recirculated through cooling towers, a 1,000-megawatt nuclear steam-electric plant in continuous operation would consume about 20,000 acre-feet of water annually.

Current plans of the electric power industry indicate that most steam-electric plants will be located along the coast. However, if coastal sites are unavailable and inland plants are constructed, requirements for cooling water would substantially increase future water demands.

The significance of the projected growth in urban water demands is shown in Figure 8. Comprising only 13 percent of total statewide demands in 1967, urban demands will account for 18 percent in 1990 and 26 percent in 2020. Of the projected 11-million acre-foot rise in total net water demands between 1967 and 2020, about 60 percent may be attributed to population and related growth.

Agriculture

Despite the rapid growth of urban areas in California, water for agriculture accounted for 85 percent of the statewide total demands in 1967 (Figure 8). Although that proportion will decline to 72 percent by 2020, water for agricultural uses will continue to predominate. Net water demands for agricultural water are expected to rise from 24.4 million acre-feet in 1967 to 27.4 million acre-feet in 1990 and to 28.7 million acre-feet in 2020.

Net water demands for irrigated agriculture are derived as the product of the estimated acreage required for various crops and appropriate unit water use values. As is true of urban demands, agricultural demands vary from area to area, depending on climate, soil, and length of irrigation season. Little change in unit water use values is expected between now and 2020. Those that do occur will result largely from changes in cropping pattern rather than from changes in water use by individual crops.

Recreation, Fish, and Wildlife

Possibly 60 percent of all outdoor recreation in California is dependent on water. Swimming, fishing, boating, water skiing, along with camping, picnicking and hiking, accounted for some 218 million visitor days at state facilities in 1960. The use of such facilities is expected to increase to some 1.5 billion visitor days by 1990 and to a possible 2.5 billion by 2020.

Both the State and Federal Governments regard recreation, along with the protection of fish and wildlife, as important features of water development projects. In California, the Davis-Dolwig Act declares recreation, and the enhancement of fisheries and wildlife habitat, to be one of the purposes of state water projects. The Act states that reasonable action to preserve fish and wildlife must be taken.

Recreation Financing. In November of 1970, the California electorate approved an amendment to the Davis-Dolwig Act. The new amendment provides for $60 million in general obligation bonds to finance the design and construction of features for the enhancement of recreation, fisheries, and wildlife habitat at facilities of the State Water Project. The amendment also creates a "Recreation Fish and Wildlife Enhancement Committee" consisting of the Governor, the State Controller, the Director of Finance, the State Treasurer, and the Secretary for Resources.

The new legislation allocates $54 million to the Department of Parks and Recreation, who will design and construct new recreation facilities, and $6 million to the Department of Fish and Game for fish and wildlife features. The Department of Water Resources estimates that new recreation facilities constructed during the next 5 to 7 years will accommodate an additional 16 million visitors. The funds allocated to the Department of Fish and Game are specifically intended for the expansion of trout hatcheries and warm water fisheries, along with the provision of access to fishing sites.

The new facilities are to be constructed at 17 State Water Project reservoirs and at sites along some 500 miles of streams and canals. The tentative schedule of expenditures for the next five years includes $8 million for facilities in Northern California, $4.5 million in Central California, and $42 million in Southern California.

Lack of financing has long been a major obstacle to California's objective of providing the maximum possible recreational opportunites. The Davis-Dolwig Act declares that the costs of features that will enhance fisheries, wildlife habitat, and recreation areas at state water projects must be non-reimbursable; other water project costs, except for those allocated to flood control, must be repaid by water and power users.

Fish and Wildlife Planning. Section 233 of the California Water Code and the Davis Dolwig Act prescribe that fish and wildlife be given equal consideration with other purposes of proposed water projects. Projected planning by the Department of Water Resources includes (1) assessments of the effects of proposed projects on fish and wildlife, and (2) recommendations of measures required for the preservation and enhancement of fisheries and wildlife habitats.

In most parts of California, various public and private agencies have signed agreements with the State Department of Fish and Game to ensure that streamflows and reservoir levels will protect and improve fisheries and wildlife preserves. These agreements are summarized in Table 4. Although these streamflows are shown as specifically required for fish, wildlife, and recreation use, the water is not consumed and is available for other downstream uses.

Table 4. Streamflow Maintenance Agreements by Hydrologic Study Area (acre-feet)

Study Area	Annual Allocation[1]
Sacramento Basin	3,900,000
Delta-Central Sierra	14,000
San Joaquin	258,000
Tulare Basin	114,000
North Coastal	677,000
San Francisco	115,000
Central Coastal	22,000
North Lahontan	54,000
South Lahontan	54,000

[1] Based on normal year runoff. Releases may be substantially lower where agreements provide for the alternative release of natural flows in lieu of a stipulated flow.

Prevention of Flood Damage

Despite the extensive construction of flood-control works over many years in California, flood damage occurs almost every year as a result of the State's continuous growth and occupation of floodplains. All levels of government are responsible to some degree for prevention of flood damage. However, since passage of the federal Flood Control Act of 1936, the U. S. Army Corps of Engineers has dominated the planning and construction of flood-control structures, with state financial aid for the costs of land, easements, and rights-of-way. The mitigation of urban flood drainage problems is the responsibility of local agencies.

A recent state-federal cooperative study of regional water problems* indicates that flood damage in California, which averages about $100 million annually, may increase to an annual average of $160 million by 1980 unless additional control measures are taken. This suggests the need for a vigorous flood control program and a more balanced approach to the mitigation of future flood damage by all levels of government. Such a program should include both structural and nonstructural measures and remain sufficiently flexible to reflect changing land use programs and concepts of environmental control. In this direction, the Cobey-Alquist Flood Plain Management Act of 1965 directs local governments to regulate floodplains prior to the construction of projects as a condition to receiving state financial aid.

The planning of future flood control measures should include increased attention to the desires of beneficiaries for environmental enhancement. This suggest a responsibility on the part of local beneficiaries to become more involved in the planning and selection of such measures and in financial participation where costs are involved.

Water Quality

Water quality is a critical element in all plans for future water needs. The increasing emphasis on quality and the growing concern with the rapidly mounting pollution problem have stimulated heightened efforts to preserve existing good water quality and, in some cases, to restore or enhance polluted water. The abstract term *quality* takes on specific meaning when associated with a specific water use, e.g., drinking, industry, agriculture, recreation, fish and wildlife protection, etc.

Standards for drinking water, as established by the U. S. Public Health Service, specify the limits for bacteriological, physical, radiological, and chemical constituents in a given water supply. Quality standards for industrial use vary with the type of process. In general, however, water suitable for drinking would be suitable for most industrial processes.

Quality standards for irrigation water vary with the type of crop, soil and drainage conditions, climate, and the method of irrigation. The content of dissolved minerals in agricultural water significantly affects the amount of water needed for proper drainage. As irrigation water evaporates and is consumed by plants, the salts left behind must be leached from the soil and carried off in drainage water. In general, the lower the dissolved mineral content, the lower the requirements for leaching water and the greater the possibility of reusing the drainage return water.

In recreation areas, the clarity, color, temperature, and bacterial content of water are especially important, particularly where there is swimming. The water must be free from oil, foam, debris, and unpleasant odors. Suitable environments for fish and wildlife require control of dissolved oxygen, temperature, turbidity, and toxic materials. Successful propagation of fish requires the absence of bottom deposits and a careful selection of temperature levels for optimum spawning conditions.

In some instances, water of good quality may be blended with highly mineralized water to improve its quality. Many areas in California contain poor-quality or brackish ground water, some of which has been abandoned and is virtually unused. Two examples of such areas are the lower San Dieguito and lower San Diego River Valleys. Possibly, the poor-quality water found there could be blended with high-quality water from Northern California to produce acceptable domestic supplies at a reasonable cost.

A function of the State Water Project is to provide high-quality water in the Sacramento-San Joaquin Delta and to protect the western Delta channels against the intrusion of salt water from San Francisco Bay. Releases of good-quality water from Lake Oroville, which reach the Delta via the Sacramento River, help with this important control feature.

State Water Resources Control Board

A growing concern with the deterioration of water quality in California's lakes and rivers has resulted in several recent legislative actions to strengthen the state water quality programs. In 1967, the Legislature established the State Water Resources Control Board, whose responsibilities include the control and prevention of water pollution and the preservation of water quality.

The State Board guides nine Regional Water Quality Control Boards. This enables water quality control to be administered locally but within a

* California Region Federal-State Comprehensive Framework Study. A report on these studies will be published in June of 1971.

framework of statewide coordination and policy. Each of the regional boards, with boundaries generally corresponding to the nine watersheds of the State, is a local regulatory agency and may plan and administer water quality regulations geared to the specific problems of a single region.

Porter-Cologne Water Quality Control Act

The authority of the State Water Resources Control Board and the regional boards was substantially increased when the Porter-Cologne Water Quality Control Act became law on January 1, 1970. This act not only completely revises California's water pollution and water quality control laws but also enables the State Board to Carry out water quality objectives through its water rights function.

The new law expands the term *beneficial uses** of California's water to include aesthetic enjoyment along with the preservation of fish and wildlife and the enhancement of their habitats. The addition of these water uses, permitting more stringent regulation of water and waste disposal, recognizes the new environmental awareness and the increasing concern with California's aquatic resources.

The Porter-Cologne Water Quality Control Act provides that all activities affecting the waters of California shall be so regulated to attain the highest reasonable water quality — considering all demands on those waters and the total values involved. Thus, the Act provides a stronger basis to ensure that California's water resources will serve the needs of California's citizens.

For many years, California water needs have been met by the development of conventional water resources, i.e., the storage and diversion of surface water and the extraction of ground water. In addition, with the advancing technologies of the present era, other sources have begun to emerge as potential sources of water supply. The most promising of these are:

- Desalination, and
- Reuse of waste water.

The anticipated growth of California's water requirements indicates that eventually both of these, and possibly other, alternative sources of water may be needed. Future surface and ground water developments, along with the possible development of unconventional sources of water, are discussed in the following paragraphs.

Surface Water Development

The potential for additional development of major surface water supplies in California is largely confined to the Sacramento Basin and the North Coastal region. In the other hydrologic regions, available surface supplies from the principal river systems have been developed mainly by existing reservoirs, or will be developed by those under construction. A number of local surface water developments in the smaller streams throughout the State are possible, particularly in the North San Francisco Bay area and in the Central Coastal region.

The major remaining potential for the storage of local and exportable supplies in the Sacramento Basin lies within the watersheds of Thomes-Stony Creeks and Cottonwood Creek. The latter is the largest unregulated tributary of the Sacramento River. The U. S. Army Corps of Engineers is presently completing investigation of two multipurpose reservoirs on the middle and south forks of Cottonwood Creek. These storage facilities could provide some 260,000 annual acre-feet for both local service and export. The two reservoirs could also provide flood protection enhancement of the spawning areas in the Cottonwood Creek Basin.

The U. S. Bureau of Reclamation is studying a reservoir at the Paskenta-Newville site on Thomes and Stony Creeks. This potential facility, operated in coordination with the Central Valley Project and the State Water Project, could develop up to 300,000 annual acre-feet for local service and export. The Department of Water Resources has studied Rancheria Reservoir on Stony Creek, which could provide additional storage, either as an independent project or with a diversion from the Middle Fork Eel River.

The flows of the North Coastal Rivers are largely unconserved; studies by the Department of Water

* Division 7, Section 13050, of the California Water Code states that beneficial uses of water "... include, but are not necessarily limited to, domestic, municipal, agricultural and industrial supply, power generation, recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves".

Resources indicate that some 10 to 12 million acre-feet per year could be developed within the North Coastal area. However, the studies have also shown that serious hazards to fisheries and wildlife resources could be created by such developments, particularly by the construction of large storage facilities in the lower Klamath River Basin.

In 1968, the U. S. Army Corps of Engineers proposed Dos Rios Dam and Reservoir on the Eel River in Mendocino County as the best solution for local flood control and for the conveyance of surplus water from the Middle Fork Eel River to the Sacramento-San Joaquin Delta. However, construction of the dam would have flooded Round Valley, including the town of Covelo and an Indian reservation. In response to the wishes of local residents and other concerned groups, Governor Reagan requested that the Department of Water Resources study alternative proposals for a project to conserve Eel River water. These alternatives were subsequently presented in Department of Water Resources Bulletin No. 172 in December 1969.

The Bureau of Reclamation has also studied direct diversion of water from the Klamath River Basin. Because direct diversion would not require reservoirs on the main stem of the Klamath, it probably would be the least disruptive to fisheries and the wildlife environment in the Basin. Similar studies of direct diversion from the Trinity River to hold-over storage in the Sacramento Valley are also being studied by the Bureau of Reclamation. Although direct diversion through large tunnels would probably be more costly than on-stream storage, it may enable the export of nonbeneficial flood flows with the least disruption of the natural environment of both the Trinity and Klamath River Basins.

In addition to on-stream developments, offstream storage facilities could be developed in the Central Valley. Offstream storage consists of a diversion from a stream and conveyance to a site where adequate storage is available. Such offstream reservoirs have been proposed for both the Sacramento Canal and the East Side Division of the Central Valley Project. Additional off-stream storage sites, to complement that provided at San Luis Reservoir, have been investigated along the California Aqueduct of the State Water Project.

Ground Water Development

Ground water, which today supplies about 40 percent of California's water needs, has been used increasingly throughout the State for some 100 years. This continuous use has affected the natural balance in many ground water basins. The most obvious effects are increased pump lifts and the drying up of some surface streams, ponds, and swampy areas. Less apparent effects found in some parts of the State include the intrusion of sea water into coastal aquifers, migration of poor-quality water to wells, and the subsidence of land surfaces.

Assessments of ground water, and of the aquifers through which it moves, cannot be obtained by direct study and must be deduced from measurements of wells and from other hydrologic and geologic information. This is a long and costly process; in some instances, investigators have recommended decreases in ground water pumping or imports of surface supplies, or both, to stabilize pumping lifts. The successful results of such experiments have demonstrated that ground water is subject to planned management.

Availability of Ground Water

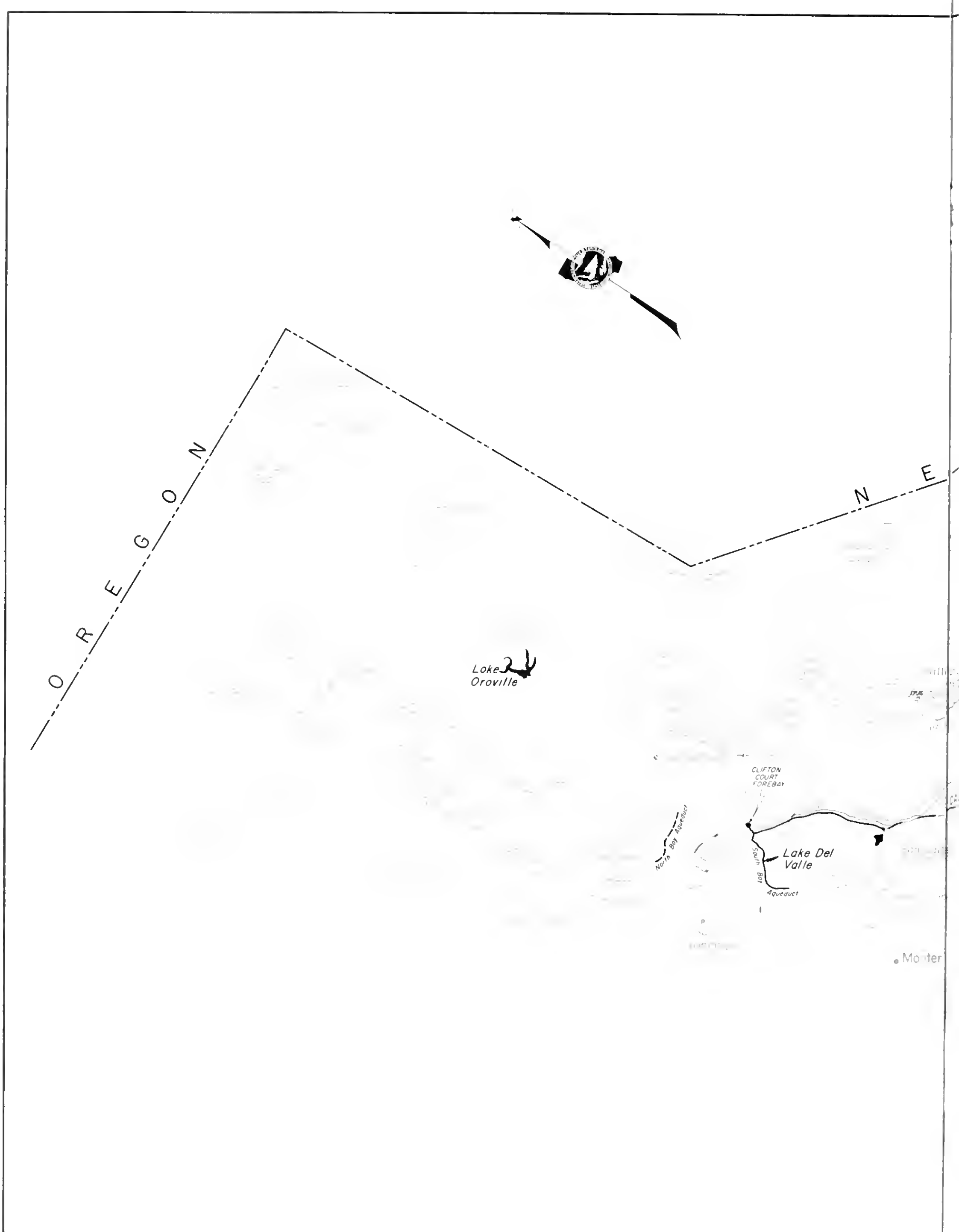
Ground water can be obtained almost anywhere in California. Production rates vary from a few gallons per day to several thousand gallons per minute, depending on underground characteristics. The areas of occurrence of ground water in California are shown in Figure 9.

Measures of availability of ground water in known ground water basins, i.e., basins that have been studied, are summarized in Table 5. These availabilities are presented in terms of (1) usable storage capacity, which denotes the portion of total storage capacity usable in conjunction with surface water sources to develop additional yield; and (2) annual primary recharge, which is a measure of the annual natural replenishment and the recharge accomplished by operation of local reservoirs for detention and gradual release of water to augment natural stream channel percolation.

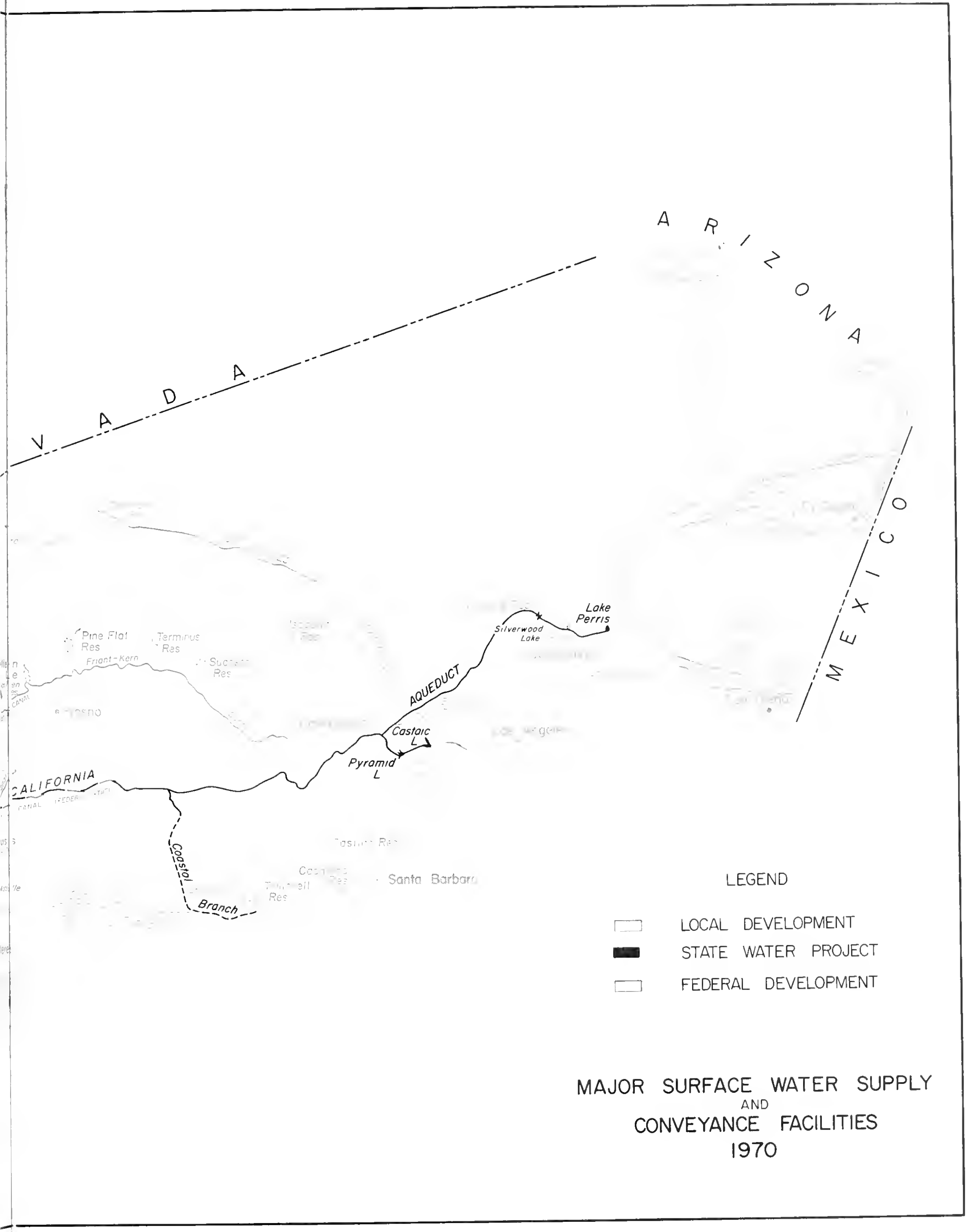
Table 5. Ground water In California
(1000's of acre-feet)

Region	Known Ground Water Areas	
	Usable Storage Capacity	Annual Primary Recharge
North Coastal Area	700	150
San Francisco Bay Area	1,100	310
Central Coastal Area	7,600	730
South Coastal Area	7,000	900
Central Valley Area*	102,000	2,760
Lahontan Area	700	190
Colorado Desert	3,600	60
TOTALS	122,700	5,100

* Combined areas of Sacramento Basin, Delta-Central Sierra area, San Joaquin Basin, and Tulare Basin.



OREGON
Loke Oroville
CLIFTON COURT FOREBAY
North Bay Aqueduct
South Bay Aqueduct
Lake Del Valle



MAJOR SURFACE WATER SUPPLY AND CONVEYANCE FACILITIES 1970

Table 5 shows an estimated usable storage capacity of about 123 million acre-feet, which is a measure of the operational storage capacity of the ground water basins. If more fully managed in coordination with surface water supplies, California's ground water basins offer promise of additional yield. In addition to the present primary recharge, the state's ground water basins are receiving additional water (1) incidental to the development and use of surface water, and (2) through operation of artificial recharge facilities. Thus, the availability of usable storage capacity may develop additional yield in conjunction with surface water sources.

Ground Water Management

Water can be regulated, conserved , and distributed in underground aquifer systems. Just as streamflow is stored in a surface reservoir, underground storage space can be used to capture and store surplus runoff for future use. In water-deficient areas, such as Southern California and the San Francisco Bay area, ground water storage capacity may be used to provide terminal regulation for imported water supplies. Here, ground water storage capacity provides regulation of uniform deliveries to varying monthly demand schedules. In other water-deficient areas, e.g., the Tulare Basin, available ground water storage capacity could be used to regulate surplus water imported during years of surplus runoff for later local use and possible export during subsequent drier periods, thus complementing off-stream storage in surface reservoirs.

In areas of adequate water supply served largely by surface diversions, ground water could be used during drier years to meet local needs, and the surface supplies could be used in other areas. This would require (1) adequate ground water pumping facilities for operation during drier years, and (2) a coordinated operation with surface storage facilities so that ground water could be replenished during subsequent wet years. Such a plan could be mutually advantageous to water users overlying ground water basins and those in more distant areas. However, such an arrangment would entail significant management and fiscal problems.

Management of a ground water basin requires that a local agency be able to (1) use underground storage capacity to regulate local and imported surface water, (2) control sea water intrusion, (3) regulate extraction patterns, (4) finance needed facilities, and (5) distribute benefits equitably. All of these requirements involve substantial problems.

Some local agencies have the power to create hydraulic barriers to sea water intrusion, but no local agency has the power to control extraction patterns, except through the possible economic incentive of a pump tax. A variety of financing measures, ranging from direct taxation to a tax on pumped water, is available.

Unfortunately, California's laws pertaining to the ownership of, or rights to, ground water storage capacity are unclear. A constitutional amendment may be needed to define these rights and, more particularly, to define the right to withdraw water that has been conserved underground.

A number of local agencies are striving for complete management of ground water basins through the construction of artificial recharge facilities, control of sea water intrusion, participation in management studies, and the exploration of needed legal changes.

Desalting

Desalted sea water offers promise of becoming a supplemental source of fresh water in certain areas of California, particularly in the Central and South Coastal areas, where alternative sources of supply are costly. Desalination could eventually reduce the need for additional imports of fresh water and could also be used to desalt mineralized waste water. As desalting techniques are improved and the costs are lowered, the feasibility of using desalted water in California will increase.

The Federal Government has been developing desalting technology since 1952, when the U. S. Congress passed the Saline Water Act. This Act provides for the development of a low-cost method for producing fresh water from sea water, or other saline water, on a scale sufficient to determine the feasibility of desalting as a source of water for the Nation. The term *saline water* includes sea water, brackish water, and other mineralized or chemically charged water.

Department of Water Resources Programs

The Department of Water Resources began desalting research in 1957. The following year, the Department began a program of close cooperation with the federal Office of Saline Water. In 1960, the California Legislature authorized funds for one-half the capital costs of a demonstration plant constructed by the Office of Saline Water at Point Loma near San Diego. In 1964, when the Point Loma plant was moved to the U. S. Naval Base near Guantanamo Bay, Cuba, California agreed to transfer its interest in the Point Loma Plant to the federal San Diego Test Facility, also constructed by the Office of Saline Water. As authorized by the Porter-Cobey Saline Water Conversion Act of 1965, the Department of Water Resource constructed the pipeline for delivery of water from the San Diego Test Facility to the city of San Diego. As of July 1970, the Department had delivered some 2,000 acre-feet, or about 650 million gallons, of fresh water for use in that city.

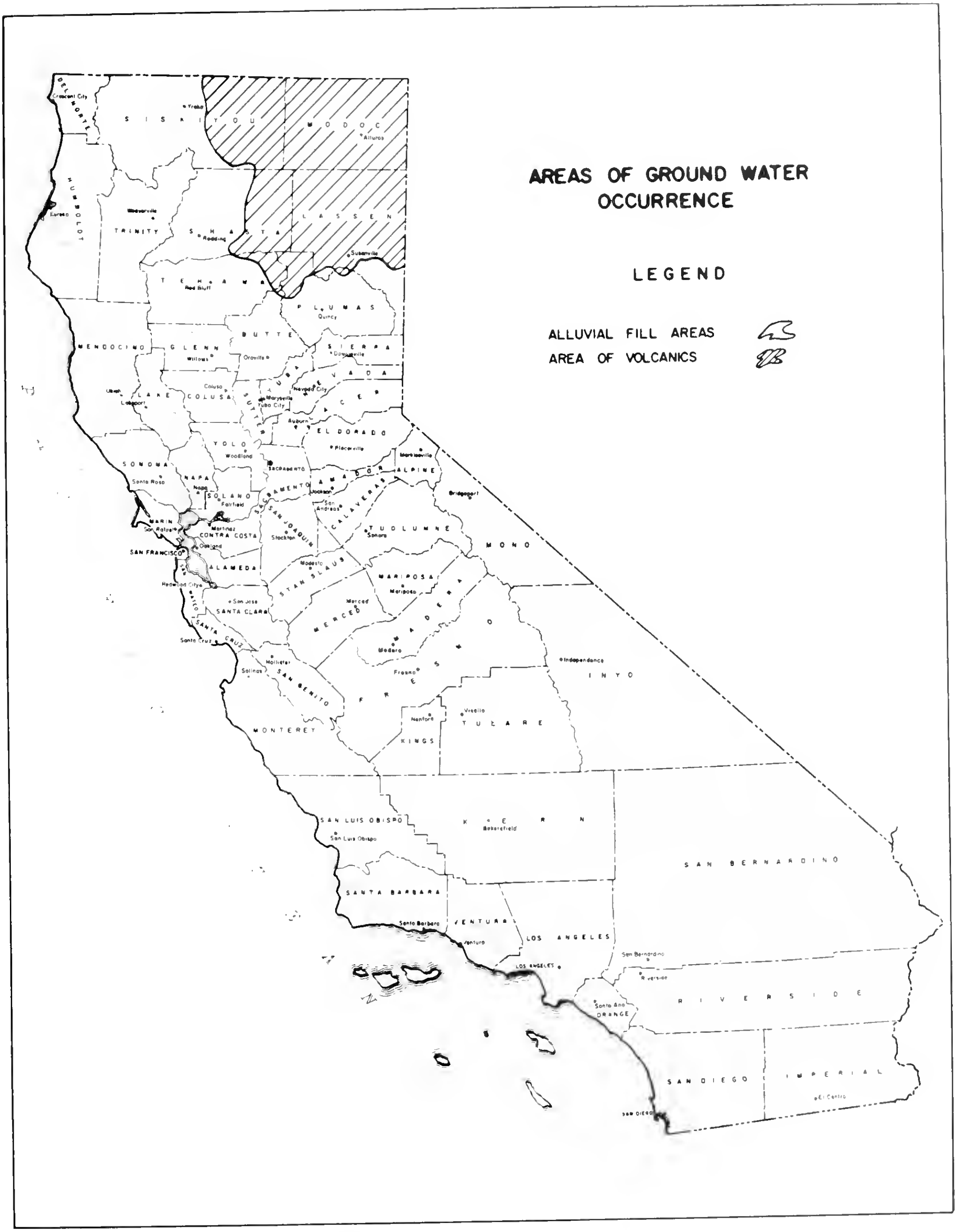


Figure 9. Areas of Ground Water Occurrence.

California is also cooperating with the Federal Government in the development of a large-capacity prototype desalting plant with a unit capable of producing up to 50 million gallons of fresh water per day, or about 50,000 acre-feet per year. In May 1970, the Department of Water Resources and the Office of Saline Water signed an agreement to begin studies of an appropriate site for the proposed plant. The Department estimates that about eight years will be required to select a water service area, to obtain the necessary legislative authorization, and to design and construct the plant.

Participation in this prototype desalter program will provide the Department, and the public, valuable information on (1) construction and operating costs of a large-scale desalting plant, (2) operation of a prototype desalter in conjunction with an electric generation unit, (3) the best means of integrating desalted water with other water supplies, and (4) possible environmental problems resulting from the return of warm sea water and brine to the ocean.

Current Status and Costs of Desalting

At the beginning of 1970, worldwide desalting capacity had increased from 60 million gallons per day in 1961 to about 310 million gallons per day. The projected capacity for 1975 is some 1,250 million gallons per day.

Prior to 1967, the capacity of the largest single-unit desalter was about 1.7 million gallons per day. That year, a plant at Key West Florida with a daily capacity of about 2.6 million gallons, or 2,600 acre-feet per year, began operation. Production costs at this plant are about 85 cents per thousand gallons, or $280 per acre-foot. Costs at a plant in Roserita Beach, Mexico, with an output of 7.5 million gallons per day, are about 67 to 75 cents per thousand gallons, or $210 to $245 per acre-foot.

In 1969, Kuwait purchased five desalting units, each with a capacity of 6 million gallons per day. Estimated production costs for the plant which is expected to be operational in 1971, is about $100 per acre-foot. However, in Kuwait, the cost of fuel is only about one-tenth that in California. When in operation, the Kuwait desalting plant will be the largest in the world.

The Future of Desalting

At the present time, most desalting plants obtain the required energy from fossil fuels. The costs of desalted water may be reduced when large-capacity nuclear desalting plants are constructed. However, the construction of large nuclear plants will involve a number of problems.

To preclude the need for long-distance transportation of the fresh water produced, the site must be close to the potential market for water. At the same time, operation of the plant must not adversely affect the environment of the surrounding air, land, or water. Finally, there is the need to dispose of the large amounts of brine produced by the desalting process.

In a recent report on nuclear powerplants*, the California Resources Agency estimates that at least eight years will elapse between the initial planning of a nuclear powerplant and the actual completion of construction. Construction of a nuclear desalting plant would involve about the same length of time. The same report states that the location and operation of nuclear plants must

> ". . . enhance the public benefits and protect against or minimize adverse effects on the public, on the ecology of the land and its wildlife, and on the ecology of the State's waters and their aquatic life."†

Perhaps another 20 to 30 years will be required before desalting technology is sufficiently improved to include desalination as a significant source of water supply. Furthermore, the problems briefly discussed in the preceding paragraphs will not be easily solved. However, the prospects for large-scale desalting as an alternative source of water in California are sufficiently promising to warrant additional research and development.

Water Reclamation

Section 230 of the California Water Code authorizes the Department of Water Resources to investigate the feasibility of reclaiming water from domestic and industrial wastes. The reclamation and reuse of waste water presents a potential source of additional water supply in coastal metropolitan areas and is therefore a significant feature of the California Water Plan. In addition to providing a supplementary source of fresh water, reclamation reduces the amount of water that must be discharged, thus lowering the total costs of waste disposal. However, the increased use of reclaimed water would not eliminate the need for additional supplies of fresh water. About 50 percent of the total water supply in a given community is consumed and is therefore unavailable for reclamation. Figure 10 shows the quantities of municipal waste water discharged in coastal counties during 1968.

Only a portion of the total waste water discharged can be reclaimed. In general, the percentage that can be reclaimed is limited by (1) the quality of the waste water, (2) the cost of treatment, and (3) the cost of conveyance and distribution in the area where the reclaimed water will be

* California Resources Agency, "Siting Thermal Powerplants in California", February 1970, pp VII-17 ff.

† Ibid, Appendix 2, p. 1.

used. During 1970, about 8 percent of the 2 million acre-feet of municipal waste water discharged in California was reclaimed and used for such purposes as irrigation, industrial cooling, recharge of ground water basins, and creation of artificial lakes.

The concentration of dissolved minerals in waste water generally determines its suitablity for reuse. For most municipal, industrial, and irrigation uses, total dissolved solids must be less than 1,000 parts per million. In addition, water containing excessive chemicals, such as mercury, arsenic, cyanide, boron, phenols, nitrate, and other toxic materials, is usually unsuitable for reclamation.

The direct use of reclaimed water for domestic needs is limited by reservations concerning the certainty of detecting and eliminating virus and other disease agents from waste water. Nitrogen content is another limiting factor. A high nitrate content in drinking water can produce illness, and even death, in infants. The U. S. Public Health Service has set the limits on nitrates in drinking water at 45 parts per million. For the present, therefore, the use of reclaimed water will probably continue to be restricted to irrigation, artificial lakes, and recharge.

Four examples of the use of reclaimed water in California are briefly described in the table that follows:

Location	Capacity per Day	Use
Golden Gate Park, San Francisco	1 million gallons	irrigation and artificial lakes
Whittier Narrows, Los Angeles County	14 million gallons	ground water recharge
Santee Project, San Diego County	4 million gallons	irrigation and artificial lakes
Indian Creek Project, South Lake Tahoe	7.5 million gallons	irrigation and recreation

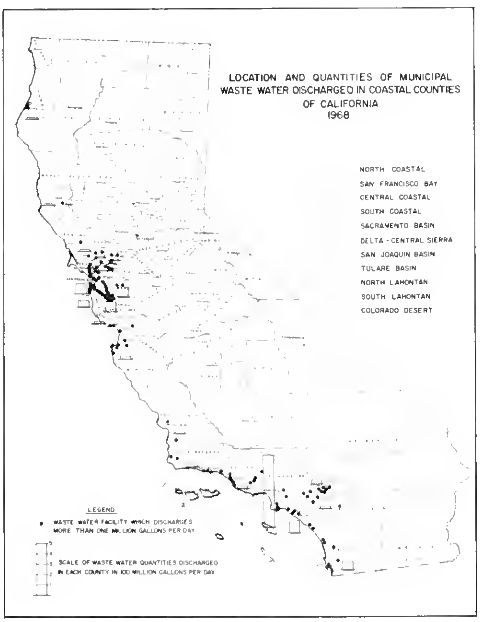


Figure 10. Discharge of Municipal Waste Water in Coastal Counties during 1968.

In San Francisco, about 25 percent of the water needed for irrigation of the 1,017-acre Golden Gate Park is supplied by reclamation. The Whittier Narrows reclamation plant, which was constructed in 1962 primarily to reduce the costs of waste disposal, reclaims about 15,000 acre-feet of domestic sewage annually for replenishment of downstream ground water. Water from the recharged aquifer is used for irrigation, for homes, and for industry.

At the Santee Project in San Diego County, reclaimed water is used in six artificial lakes, four of which provide fishing and boating. Some of the lake water receives additional treatment and is used in a nearby swimming pool. A portion of the reclaimed water is also used to irrigate a golf course. The Indian Creek Project was constructed by the South Tahoe Public Utility District for the disposal of domestic wastes from the Lake Tahoe area. Effluent from local wastes is transported through a 29-mile pipeline to Indian Creek Reservoir in Alpine County. Treated water from the reservoir, which has a capacity of 35,000 acre feet and a surface area of 163 acres, is used for recreation and irrigation in the Carson River Basin.

During 1969, 172 reclamation plants were either in operation or under construction in California, and some 135,000 acre feet of water was reclaimed, most of which was used for irrigation. Current studies by local agencies indicates that by 1990, about 300,000 acre-feet of water may be reclaimed in the South Coastal area, where 90 percent of the potential for water reclamation is located. By 2020, 600,000 acre-feet may be reclaimed in the South Coastal area.

The most economical use of waste water as a supplemental supply will be in areas where imported water is costly and where large amounts of waste water are discharged. These conditions are especially prevalent in the South Coastal area and, to a lesser extent, in the San Francisco Bay area.

Other Sources of Water

New techniques and methodologies are being developed in California for other unconventional sources of water. These include modification of the weather, watershed management, and the use of geothermal energy for the desalination of saline ground water. The interstate transfer of surplus water from the Pacific Northwest has been suggested, and a new concept for long-distance transporation of water from the North Coastal area is embodied in a proposed undersea aqueduct.

Weather Modification

During the past 20 years, the possibility of artificially creating or increasing precipitation has been the subject of considerable research and development. In 1951, the California Legislature appropriated $50,000 for the first state-sponsored program.

So far, experiments in California have primarily consisted of efforts to increase precipitation from individual clouds or storms, and attempts to clear fog at airports and to suppress lightning or hail storms. The most common methods is the seeding of clouds with silver iodide, sulfer trioxide, or combinations of both, from either aircraft or ground-based generators. During the 1968-69 season, eleven such experiments were carried out in California by various public and private licensees. The results thus far have revealed that although the amount and pattern of precipitation can be changed, the amount of rainfall in a particular area cannot yet be directly controlled.

At the moment a number of legal and technical questions remain unresolved. An important legal question relates to the responsibility of operators for increasing flood flows and for the possible decrease in precipitation in areas downwind from target areas. Further experiments are needed to determine what atmospheric conditions are best for cloud seeding and the best method of seeding under various conditions.

The effectiveness of weather modification experiments is difficult to evaluate because of the great variety of natural weather and rainfall patterns. Frequently, similar experiments produce conflicting evaluations. However, recent experiments in California have indicated that cloud seeding may produce an average increase in precipitation of about 5 percent in certain areas of the State.

Of course, a mere increase in precipitation would not directly increase water supplies. The amount of usable water realized from increased precipitation would depend on the availability of storage facilities. Furthermore, additional rain or snowfall during years of normal or above-normal precipitation would be of little value, unless surplus runoff could be controlled and stored for use during dry years.

The role of the Department of Water Resources in weather modification research is a varied one. The Department is cooperating with Fresno State College in studies of a possible increase in precipitation in the Sierra Nevada. The Department is also responsible for licensing public and private operators of weather modification projects and for reviewing performance reports on completed experiments.

Watershed Management

Of the 200 million annual acre-feet of precipitation in California, only about 70 million is available as runoff. The difference of 130 million acre-feet is consumed by trees, shrubs and grass in mountain and foothill watersheds. Watershed management is defined as the control or manipulation of vegetation in such watersheds to increase runoff. The usual practice is to remove perennial trees and shrubs and replace them with grass cover. Past experiments with vegetative manipulation have produced conflicting results. However, removal of vegetation in areas where annual rainfall exceeds 15 inches will usually result in increased runoff.

Since large amounts of water are consumed by trees and shrubs, their removal would appear to present a source of considerable additional water. However, many of the mountain watersheds are either occupied by national forests or privately owned. Furthermore, the removal of trees can lessen the scenic value of a forested area, increase the potential for erosion and landslides, and destroy cover needed by wildlife. The cost of clearing and preventing regrowth is another negative factor.

Watershed management is also complicated by the legal problem of ownership of the additional water made available. Other legal questions involve the status of the developer of additional water with respect to riparian owners or prior appropriators.

Two areas in California offer possibilities for watershed management. These are the foothill brushlands in northern and central California, and snow fields in commercial timber zones. However, limitations and problems connected with the manipulation of vegetation preclude its consideration as a substantial source of additional water in California, at least at the present time.

Geothermal Water Resources

Geothermal energy is literally defined as the natural heat generated beneath the surface of the earth. In certain areas of California, subsurface temperatures rise sharply with depth; in such areas, superheated ground water comes to the surface as hot springs and geysers. The production of fresh water from saline ground water in such geothermal areas offers another possible source of water supply.

The hot mineralized water could be distilled with its own heat or the heat could be used to distill other mineralized water or for the generation of electric energy. The distillation process would also produce large quantities of waste brines; a satisfactory method for their disposal would be essential.

Although some 180 thermal springs have been discovered in California, most of them in Sonoma and Mono Counties and in the Imperial Valley near the Salton Sea, only the latter area offers promise of sufficient geothermal energy and brine to enable large-scale distallation. Preliminary estimates by the University of California indicate that vast quantities of heated brine are stored in sedimentary formations in the Salton Sea area. This offers a potential large source of waste that could be distilled with its own natural heat.

These estimates are only preliminary, and a great deal of research will be required to establish the feasibility of large-scale geothermal distillation. At the present time, the Department of Water Resources, in cooperation with the University of California, is studying the geothermal potential of the Salton Sea area.

If geothermal distillation should become practical, it could provide a new source of water in the Imperial Valley. New water supplies in the Colorado Desert area might help resolve the quality problems in areas served with Colorado River water. Fresh water could be (1) blended with Colorado River water to improve its quality, or (2) used locally or diverted to the South Coastal area in place of water from the Colorado.

Western States Water Development

Among the possible alternative sources of additional water is a suggested plan for imports from the Pacific Northwest, or even as far away as Canada or Alaska. Development on such a scale would be extremely expensive and would certainly entail many political and legal problems. An interstate project would require either large markets for the expensive water transported or financial grants or subsidies. Although the idea of interstate and even international transfer of water is worthy of study, many years will probably be required to initiate a project.

Undersea Aqueduct

An undersea aqueduct to convey surplus water from the North Coastal area to Central and Southern California has been proposed as an alternative for overland aqueducts. A preliminary report published by the U.S. Bureau of Reclamation in 1969 suggests a 30-foot-diameter pipeline anchored on the continental shelf about 300 feet below the surface of the Pacific Ocean. The aqueduct would extend from the mouth of the Klamath or Eel River about 700 miles to Southern California.

A number of materials, including heavy-duty plastic, flexible rubber, fibre glass, concrete, steel, and aluminum, have been suggested for construction of the aqueduct. A great deal of research will be required to (1) evaluate the various materials, (2) determine cost estimates for construction, placement, and maintenance of the aqueduct, and (3) determine how such an aqueduct would affect the marine environment.

An undersea aqueduct is not an alternative source of water but rather an alternative conveyance system. Its use would require onshore facilities similar to those required for an overland aqueduct. Because of the variable amounts of runoff in Northern California, large storage reservoirs would be required to regulate supplies and assure uniform deliveries. In addition, a diversion structure near the mouth of the river that provides the export supplies would be needed to prevent fish from being carried into the aqueduct.

The report by the Bureau of Reclamation outlines the additional research and study required and indicates that about six years will be needed to complete preliminary studies. The U.S. Congress has appropriated funds for the first year of these studies, which are now in progress.

The four-year study of California's long-term water requirements, which was conducted by the Department of Water Resources following publication of Bulletin No. 160-66, was based on analyses of the economic demand for water in each of the eleven hydrologic study areas and the extent to which those demands could be satisfied by the development of local supplies, by imports, or by other sources. The results of these analyses are shown in Table 6 and summarized in the para-

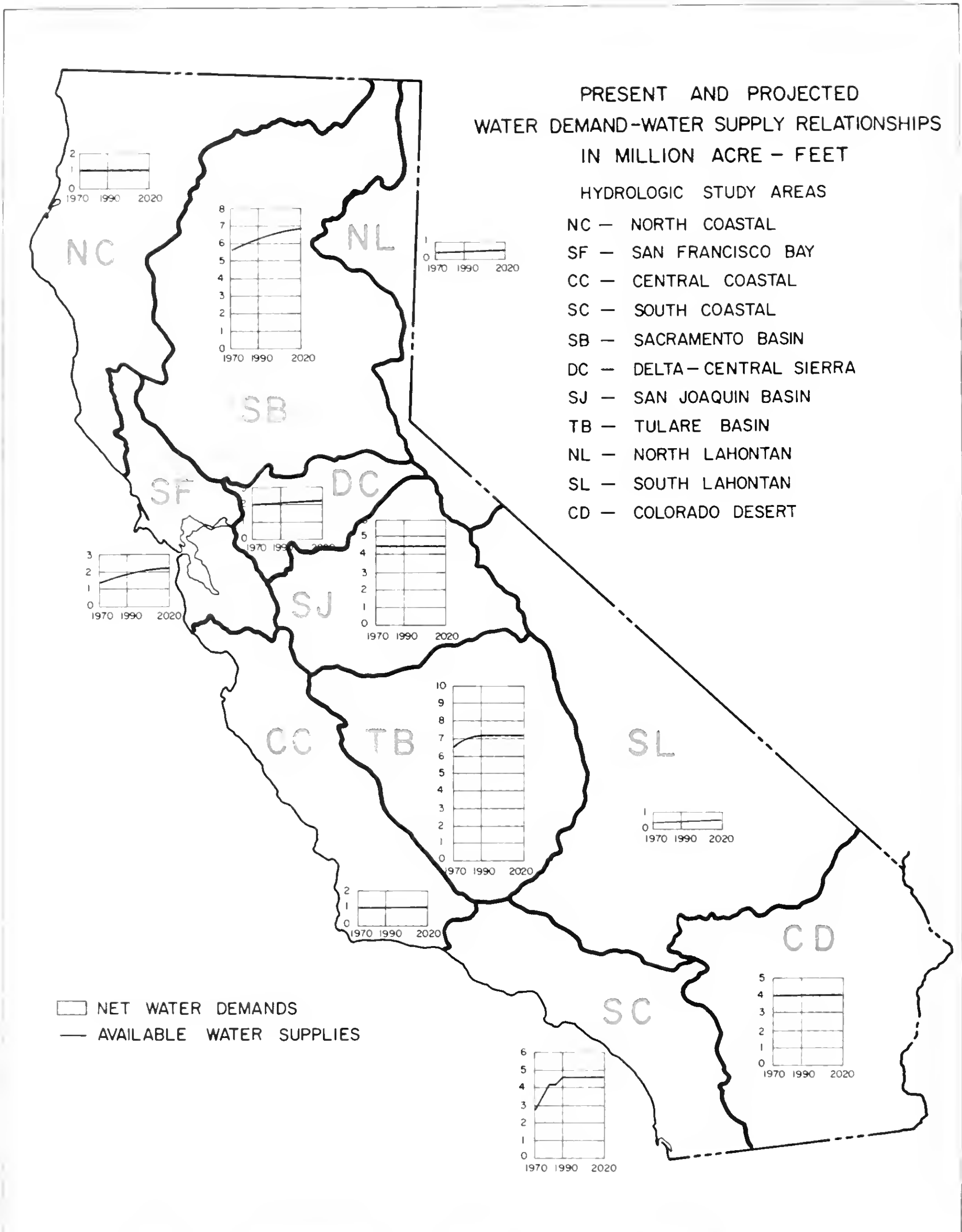


Figure 11. Present and Projected Water Demand Water Supply Relationships.

graphs that follow. The relationship between supply and demand in each hydrologic area is shown in Figure 11.

In Table 6, net water demands represent the requirements for developed water from all sources. Net water supplies represent the sum of all sources of water, both local and imported. In several areas, ground water overdraft has been included as a source of supply. In all areas except the Central Coastal, South Lahontan, and Colorado Desert, where there are no foreseeable economical alternative water-supply sources, this overdraft of ground water is expected to be only temporary.

Table 6. Net Water Demands and Water Supplies
By Hydrologic Study Area, 1967-2020
(in 1,000's of acre-feet)

Hydrologic Area	Net Water Demands			Dependable Water Supplies			Ground Water Overdraft			Total Net Water Supplies			Projected Shortage Or (+) Reserve Supply		
	1967	1990	2020	1967	1990	2020	1967	1990	2020	1967	1990	2020	1967	1990	2020
North Coastal	960	1,100	1,150	950	1,020	1,050	0	0	0	950	1,020	1,050	10	80	100
San Francisco Bay	1,140	1,740	2,740	1,090	1,860	2,270	50	0	0	1,140	1,860	2,270	0	+120*	470
Central Coast	940	1,160	1,420	820	1,015	1,045	120	15	15	940	1,030	1,060	0	130	360
South Coastal	2,490	3,620	5,280	2,490	4,630	4,630	0	0	0	2,490	4,630	4,630	0	+1,010*	650
Sacramento Basin	5,560	6,580	7,270	5,360	6,280	6,860	140	0	0	5,500	6,280	6,860	60	300	410
Delta-Central Sierra	1,930	2,200	2,350	1,830	2,110	2,170	100	0	0	1,930	2,110	2,170	0	90	180
San Joaquin	4,370	4,740	5,050	4,200	4,430	4,440	170	0	0	4,370	4,430	4,440	0	310	610
Tulare Basin	6,390	8,340	9,260	4,590	7,170	7,170	1,800	0	0	6,390	7,170	7,170	0	1,170	2,090
North Lahontan	410	480	600	350	450	480	0	0	0	350	450	480	60	30	120
South Lahontan	420	490	500	180	430	445	240	30	45	420	460	490	0	30	10
Colorado Desert	3,980	4,070	4,140	3,890	3,990	3,990	90	20	60	3,980	4,010	4,050	0	60	90
Total	28,590	34,520	39,760	25,750	33,385	34,550	2,710	65	120	28,460	33,450	34,670	130	1,070	5,090

*Represents contractual or conveyance capability, or both, but not firm water supplies in the hydrologic area

North Coastal Area. The North Coast, by far the most water-abundant area in California, contributes about 27 million annual acre-feet, or some 40 percent of the State's runoff. The 1967 population stood at 180,000. By 1990, the population will approach 210,000; the projected 2020 population is 300,000. The primary water requirement in the North Coastal area is for irrigated agriculture, with a net (1967) demand of 660,000 acre-feet per year. More than 80 percent of the irrigated acreage lies in the upper Klamath River Basin, including Shasta and Scott Valleys. Irrigated lands are expected to expand by about 30,000 acres by 2020.

A large percentage of the urban demand is for the paper and pulp industry, which will probably account for at least half of the total increase in net water demand by 2020. The total net water demand in the North Coastal area is expected to increase by almost 200,000 acre-feet by 2020. About 25 percent of this will be met by an extension of service from existing developed surface water, another 25 percent by additional extractions of ground water, and about one-half will be dependent on new surface-water developments.

Streamflow in the North Coast is also needed to support spawning runs of salmon and steelhead cut off from their spawning grounds by the construction of dams. The California Department of Fish and Game has signed agreements with local and federal agencies for some 680,000 acre-feet of releases on three North Coastal Rivers.

San Francisco Bay Area. The San Francisco Bay Area is the second most populous urban area in California. The 1967 population was 4,320,000. Projected population for 1990 is 6,500,000; for 2020, 10,100,000. As a whole, the region has sufficient water to meet all demands until sometime after 2000. However, in certain areas, deficiencies will probably occur much sooner.

Present water demands in the North Bay area are being met by ground water, several local projects, two federal projects, and the North Bay Aqueduct. Parts of Napa and Sonoma Counties are experiencing an overdraft of ground water supplies. The entire North Bay area will require about 50,000 additional acre-feet within the next 20 years. This anticipated supplemental demand will increase to about 350,000 acre-feet by 2020. The increase will result in part from growth in irrigated agriculture but chiefly from continued urban development. Most of the additional demand can be met by further local development. The Russian River and its tributaries offer the greatest potential, augmented by increased supplies from the North Bay Aqueduct and other local projects.

The South Bay area is highly urbanized — the population is expected to more than double between 1970 and 2020. Local surface and ground water supplies have been almost fully developed and the area is heavily dependent on imports. In 1967, about 500,000 acre-feet were delivered to the South Bay. Reclaimed waste water and desalted sea water are possible future sources of water in the South Bay area, but more data are needed to assess their full potential.

The most urgent water problem in the San Francisco Bay area is pollution resulting from domestic and industrial wastes, irrigation return water, and saline water intrusion. Serious overdrafts of ground water, which are contributing to the seawater intrusion problem, exist in the Santa Clara Valley and in Southern Alameda County, and some provision must be made to correct them. Continuous urban growth is increasing the problem of waste disposal.

The preservation and enhancement of fisheries and wildlife habitat are also important features of the Bay area's future water needs. Striped bass, salmon, and steelhead abound in the various waterways. The area is a major flyway for waterfowl and has a large population of deer. As part of the area's 2020 water demands, some 40,000 annual acre-feet are included specifically for fish and wildlife.

Recreational activity in the San Francisco Bay area, already overtaxed, will continue to be limited by the lack of facilities and will receive heavy use. Consumptive use of water at camping and picnic facilities is not large. However, the water needs of hundreds of thousands of annual visitors to the Bay area are substantial and are included in the projected demand.

Central Coastal Area. The Central Coastal area includes the counties of Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, and portions of Santa Clara and San Benito. The 1967 population of 750,000 is expected to approach 1,200,000 in 1990 and 2,200,000 in 2020. The present net water demand of 940,000 acre-feet is producing an annual ground water overdraft of some 120,000 acre-feet. Despite planned imports from the State Water Project and the authorized San Felipe Division of the Central Valley Project, the projected demand shows deficiencies of some 130,000 acre-feet in 1990 and 360,000 acre-feet in 2020. Optional sources to cover the projected deficiencies include additional surface and ground water developments, additional imports, and desalted water.

South Coastal Area. The largest urban center in California, the South Coastal area had a 1967 population count of 10,510,000. Projected population for 1990 is 16,000,000; for 2020, 23,900,000. The (1967) water demands of almost 2.5 million acre-feet are met by (1) local surface and ground water, which is almost fully developed, (2) the Los Angeles Aqueduct, and (3) The Colorado River Aqueduct.

Deliveries from the State Water Project to the area will begin in 1971. The total maximum entitlement to project water is 2,204,000 acre-feet per year. Imports from the Colorado River will probably be reduced in the mid-1980s, when the Central Arizona Project becomes operational. Nevertheless, the supply in the South Coastal area, including the full entitlement from the State Water Project, should be adequate until about 2010, at which time supplemental water will be needed.

The rapidly increasing salinity of the Colorado River is creating water quality problems in the South Coastal area. Dilution with high-quality water from the State Water Project will afford relief in some water-service areas.

The projected net water demand for 2020 is almost 5.3 million acre-feet per year. The projected supply of 4.63 million acre-feet, including a planned 300,000 acre-feet of reclaimed waste water, shows a deficit of about 650,000 acre-feet that could be supplied from several alternative sources. These include (1) additional early deliveries of State Water Project water to be stored underground for use later, (2) water from supplementary facilities of the State Water Project, (3) desalted water, (4) the interim use of stored ground water and (5) increased waste-water reclamation. A combination of some or all of these alternatives is probable.

Sacramento Basin. Second only to the North Coast in abundance of water resources, the Sacramento Basin produces an estimated 21 million acre-feet of annual runoff, or about 30 percent of the statewide total. Although this average runoff far exceeds the projected 2020 net water demand of seven million acre-feet, regulation is necessary in the Sacramento Basin to (1) conserve winter and wet-year surpluses for irrigation-season and dry-year needs, and (2) protect the basin from floods.

The 1967 population stood at 1,140,000. Projected population for 1900 is 1,600,000; for 2020, 2,300,000. In most of the Sacramento Basin, projected water supplies will equal, or even exceed, projected demands, even in 2020. However, the west side of the Sacramento Valley, the Pit River Basin, and certain foothill and mountain areas, including Lake County, will experience shortages. Supplemental demands on the west side, including Yolo and Solano Counties, could be fulfilled by the proposed Indian Valley Reservoir on Cache Creek and by imports from the Central Valley Project. The authorized Lakeport Project, along with proposed Middletown Reservoir, would fulfill the supplemental need in Lake County.

Portions of the streamflow in the Sacramento Basin are needed to maintain and enhance fisheries and wildlife habitat. The Department of Fish and Game has 26 agreements with 13 agencies for such flows from Clear Creek and the Sacramento, American Feather, Pit, and McCloud Rivers.

Delta-Central Sierra Area. The Delta-Central Sierra area comprises the Delta of the Sacramento and San Joaquin Rivers and the watersheds of the Calaveras, Mokelumne, and Cosumnes Rivers. The 1967 population of 400,000 is expected to increase to 650,000 in 1990 and 1,100,000 in 2020. Irrigated agriculture thrives in both the Delta and valley lands to the east. Irrigated acreage is expected to increase from 760,000 in 1967 to about 900,000 in 2020.

Surface water sources include the Mokelumne and Calaveras Rivers, along with the Putah South, Contra Costa, and Delta Mendota Canals. Ground water fulfills some 30 percent of the present demand, including an annual overdraft of about 100,000 acre-feet in the area east of the Delta. When the Folsom South Canal is operational, most of the ground water overdraft in the area east of Sacramento, Lodi, and Stockton should be alleviated. Additional agricultural water for the northern tip of Stanislaus County could be provided by the New Melones Project.

Projected shortages in Solano County, about 30,000 and 35,000 acre-feet in 1990 and 2020, respectively, could be met from the proposed Sacramento Canal unit of the Central Valley Project, by direct diversion from the Delta, or by interim ground water overdraft. Supplemental demands in Contra Costa and San Joaquin Counties, 10,000 acre-feet in 1990 and 25,000 acre-feet in 2020, could be fulfilled by imports from the Central Valley Project or by additional imports from the State Water Project. Projected shortages of 50,000 acre-feet in 1990 and 120,000 acre-feet in 2020 in the eastern part of the Delta-Central Sierra area could be met by some combination of the Cosumnes River Division of the Central Valley Project, direct diversions from Folsom Lake, and small local projects.

Substantial streamflow is required for maintenance of the large variety of fish and other aquatic life in the Delta's 700 miles of waterways. Freshwater releases are also required for the maintenance of water quality, particularly the repulsion of saline water from San Francisco Bay. Another water quality problem is the increasing discharge of agricultural-drainage and industrial waste water into the Delta waterways.

San Joaquin Basin. The San Joaquin Basin includes the Counties of Madera, Merced, Mariposa, Stanislaus, Tuolumne, and the southerly portion of San Joaquin County. The 1967 population of 410,000 is projected to 610,000 in 1990 and to 1,000,000 in 2020. The 1967 net water demand of some 4.4 million acre-feet was met by local surface and ground water, including an overdraft of about 170,000 acre-feet, and imports from the Central Valley Project.

Most of the demand in the San Joaquin Basin is for agricultural water; smaller amounts are needed for urban use and for recreation, fish, and wildlife in the foothills and mountains to the east. Existing projects and possible additional ground water yield are considered sufficient to meet the needs of the westside valley slopes until 1990 and those of the irrigation districts on the eastern valley floor until 2020. Construction of Hidden and Buchanan Reservoirs on the Fresno and Chowchilla Rivers, respectively, will provide about 50,000 acre-feet annually for water-deficient areas on the valley floor. Projected deficiencies on the Eastern valley floor of 300,000 acre-feet in 1990 and 560,000 acre-feet in 2020 could be met by temporarily continuing to mine stored ground water or by importing supplemental supplies. Additional imports from the Central Valley Project will be necessary.

The California Department of Fish and Game has agreements for streamflow releases to maintain fisheries and wildlife habitat in the San Joaquin Basin. Net water demands for recreation, fish and wildlife are expected to increase from the present 30,000 acre-feet to 70,000 acre-feet in 1990, and to 90,000 acre-feet in 2020.

Tulare Basin. The Tulare Basin comprises the entire drainage area of the San Joaquin Valley south of the San Joaquin River, including Fresno, Kings, and Tulare Counties and those portions of Kern and San Benito Counties lying in the Central Valley. The 1967 population stood at 910,000 and is expected to increase to 1,200,000 in 1990; to 1,800,000 in 2020. The 1967 net water use of 6.4 million acre-feet, primarily for agriculture, included an overdraft of ground water of almost 1.8 million acre-feet.

The primary natural source of water is runoff from the Sierra Nevada into the Kings, Kaweah, Tule, and Kern Rivers. However, water use in the Tulare Basin has long exceeded available supplies, and supplemental water is imported through the Friant-Kern Canal of the Central Valley Project. The need for supplemental supplies is expected to approach 1.2 million acre-feet in 1990 and 2.1 million acre-feet in 2020.

Supplemental water for the area west of the valley trough could be provided by deliveries from the State Water Project and by additional water from the Central Valley Project. Additional water for the eastern part of the valley floor is urgently needed now and could be provided by the proposed East Side Division of the Central Valley Project.

About 25,000 acre-feet per year are required for the maintenance of fish and wildlife in the Tulare Basin. These requirements will increase to some 65,000 acre-feet in 1990 and to 100,000 acre-feet in 2020.

North Lahontan Area. The North Lahontan area occupies the narrow strip east of the Sierra Nevada along the California-Nevada border, extending from Mono County to Oregon. Although the area has the fewest water resources of the 11 hydrologic study areas, projected water requirements are also quite low. The 1967 population of 40,000 is projected to 70,000 in 1990 and to 100,000 in 2020.

Irrigated acreage is not expected to increase, and cattle raising will continue as the chief agricultural activity. However, as regulatory structures are built, and as the additional use of ground water enables irrigation over a longer portion of the growing season, total agricultural water use will increase. A shortage of about 50,000 acre-feet of agricultural water is possible by 2020.

The accelerated growth of recreation in the Lake Tahoe basin will probably continue, and a fourfold increase in summer residents is estimated for 2020. No shortage of water for urban and recreation use is expected before 1990. However, by 2020, the demand for supplementary water for these uses is estimated at 70,000 acre-feet, most of it in the Lake Tahoe-Truckee River basin. Future sources to meet this supplemental need have not been identified.

South Lahontan Area. The South Lahontan area, a part of the Great Basin, is characterized by many enclosed sinks and basins and by the largest extremes in elevation in the coterminous United States, ranging from 282 feet below sea level in Death Valley to 14,495 feet on Mt. Whitney.

The 1967 population stood at 220,000. Estimated population for 1990 is 590,000; for 2020, 1,300,000. The net water demand of 420,000 acre-feet (1967) exceeds the dependable supply by some 240,000 acre-feet, and the annual overdraft is depleting ground water levels. Net water demands are projected to 490,000 acre-feet in 1990 and to 500,000 in 2020.

In 1972, several local agencies will begin receiving imports from the State Water Project. The deliveries will eventually reach the maximum entitlements of 215,000 acre-feet per year. However, these imports will be too costly for any but high-value crops and will only partially stabilize the falling ground water levels. Thus, the demand for supplemental water will continue. Many acres of undeveloped agricultural land could be highly productive if they were provided with adequate water.

The economic development of the South Lahontan area has been accelerated recently by new industry — particularly the new Lockheed Aircraft manufacturing plant near Palmdale — and an increase in vacation and retirement homes. The economy of the area will be further stimulated when the planned Palmdale International airport is completed about 1977. The airport will employ several thousand persons, and additional jobs will be created by the need for related industries and services. This projected increase in employment should result in a substantially increased housing industry.

Colorado Desert Area. The Colorado Desert area is characterized by the driest climate in the State and by very high summer temperatures. Much of the area is frost-free, and crops can be grown throughout the year. Irrigated acreage in the area is second only to that of the Central Valley.

The 1967 population of 220,000 is projected to 370,000 in 1990 and to 600,000 in 2020. The 1967 net water demand of 3,980,000 acre-feet was met chiefly with imports from the Colorado River, a major factor in the development of irrigation in the area. In addition, over 100,000 acre-feet of ground water is used annually, chiefly in the Coachella Valley. Net water demands are projected to 4,070,000 acre-feet in 1990 and to 4,140,000 in 2020.

Additional irrigable land is available, but development of this land is limited by the lack of additional water. Although several local agencies have contracted for annual deliveries of 80,000 acre-feet from the State Water Project, most of this will be used for urban development. The cost of these imports prohibits their use for agriculture, although some benefit will probably result from ground water recharge.

A major problem in the Colorado Desert area is the high salt content of the Colorado River water used for irrigation. Extensive networks of tile drains have been installed, and additional agricultural water is applied to prevent the buildup of salt in the soil. The quality of imported Colorado River water varies with the available flow and the nature of return flows from upstream projects. Predictions of the future quality of Colorado River water, based on the expected development of authorized upstream projects, indicate that, unless corrective measures are taken, the quality may continue to deteriorate until it is usable for irrigation of only the most salt-tolerant crops. The Colorado Desert is one of the few areas in the nation where vegetables, which are relatively sensitive to salt, can be grown during the winter. The elimination of this important winter crop would result in a serious economic loss to the area.

The California Water Plan, and subsequent reports of the Department of Water Resources, were published to provide a basic planning framework for the fulfillment of long-range water demands. Two interbasin developments that will help accomplish this general objective are the federal Central Valley Project and the California State Water Project. These projects exemplify the coordinated systems approach to water resource preservation and management. The coordinated operation of the two projects will enable future extension of water service to areas of California where service could not be provided by local or independently operated projects or by other sources.

Coordinated operation of the Central Valley Project and the State Water Project, including the use of common stream channels and conveyance facilities, enables a high degree of flexibility and efficiency. As water supplies in the Central Valley become more fully used, this coordination will become even more important. At the present time, a proposed joint operating agreement between the Bureau of Reclamation and the Department of Water Resources, covering such features as the transfer or exchange of facilities and criteria for the allocation of water shortages, is being reviewed by the Secretary of the Interior.

Central Valley Project

Construction of the Central Valley Project, which was begun by the U.S. Bureau of Reclamation in 1935, marked the beginning of coordinated interbasin water development in the Central Valley of California. Water service from the Contra Costa Canal, the first unit of the Delta Division, began in 1942. Since that time, the Central Valley Project has been expanded by the addition of the features shown in Plate 1 (page 22), which have either been completed or are under construction. The Central Valley Project is now providing water, flood protection, electrical energy, recreation, salinity control, and an improved environment for fish and wildlife in the Sacramento and San Joaquin Valleys, the Sacramento-San Joaquin Delta, and the San Francisco Bay area. During 1969, deliveries of water totaled almost 6 million acre-feet.

State Water Project

In 1959, the California Legislature enacted the Water Resources Development Bond Act, popularly known as the Burns-Porter Act. The Act, which authorized the sale of bonds for the construction of facilities to develop the water resources of California, was approved by the electorate in 1960. As a result, the California State Water Project, the largest single water development ever carried out in the United States, became a reality. With 95 percent of initial facilities completed or under contract, the State Water Project includes 21 major dams and reservoirs, the 444-mile-long California Aqueduct and other conveyance facilities, 22 pumping plants, and 7 powerplants.

During 1970, some 380,000 acre-feet of project water has been delivered to public agencies in the counties of Butte, Plumas, Napa, Santa Clara, Alameda, Stanislaus, Kings, Kern, and Tulare. When in full operation, the State Water Project will supply 4,230,000 acre-feet per year to 31 water service agencies who have signed contracts with the State of California. Other benefits of the Project include salinity control in the Sacramento-San Joaquin Delta, hydroelectric power, flood control, new recreation areas, and the improvement of fish and wildlife habitats. Major features of the State Water Project, the initial phase of which is now nearing completion, are shown in Plate 1.

The Peripheral Canal

The Peripheral Canal is proposed as an important joint-use facility of the Central Valley Project-State Water Project system. The Canal, an unlined 400-foot-wide channel, would begin at the Sacramento River near Hood and extend about 43 miles along the eastern edge of the Delta to Clifton Court Forebay. Fresh water will be released into the Delta at 12 outlet structures to maintain and improve water quality in the many interior Delta channels.

The importance of the Peripheral Canal is shown by its various functions. Operation of the Canal

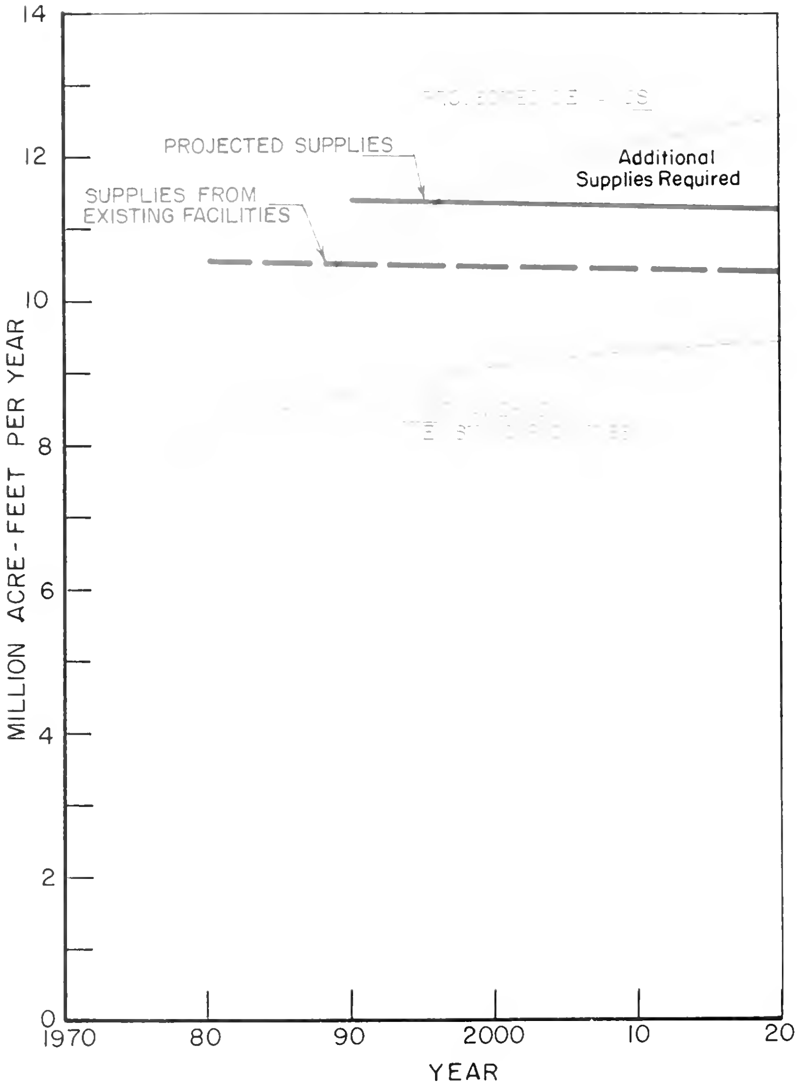


Figure 12. The Central Valley Project -- Projected Net Water Demands and Dependable Water Supplies.

will:

- protect and enhance the Delta fisheries and other aquatic life by eliminating flow reversals and providing freshwater releases in the San Joaquin River and other Delta channels.
- ensure a firm supply of high quality water for farms and homes in the Delta through releases of fresh water during summer months.
- transport high-quality water for the Kellogg Unit of the Central Valley Project or a similar project to provide water to Contra Costa County.
- provide salinity control in the Delta in accordance with criteria to be established by the State Water Resources Control Board and by agreements with local interests.
- fulfill the water-transfer and water quality objectives of the Central Valley Project-State Water Project system without using existing Delta channels for water transfer, thus eliminating possible channel scour, levee erosion, and adverse effects on fisheries.

Although the Peripheral Canal will neither add new service areas nor increase water deliveries from the Central Valley Project-State Water Project system, its operation will enable greatly increased flexibility. Recent operation studies indicate that controlled releases from the canal will alleviate the water shortage and water quality problems in the Delta itself. The studies further indicated that without the canal, water could continue to be diverted directly from the Delta without great risk of shortage until about 1980. However, fish and wildlife interests want the Peripheral Canal constructed as soon as possible to enhance the Delta fisheries and wildlife habitat.

Projected Water Demands on the Federal and State Systems

On completion of the facilities now under construction, the Central Valley Project and the State Water Project will be capable of providing water service in all hydrologic study areas of California except the North Lahontan. However, projected future demands show that additional sources of water supply will be needed beginning in the mid-1990s. These may include various combinations of potential supplies, such as desalination, reclamation of waste water, and other possible sources.*

Possible Additions to the Central Valley Project

Figure 12 shows (1) the increasing demands in CVP service areas and (2) the projected water supplies developed by the project under two conditions. The first condition (represented by the dashed lines) relates to existing features of the project and those under construction. The second condition (represented by the solid lines), shows the effect of the addition of the following proposed features:

The East Side Division could provide new water supplies to potential service areas in Fresno, Kings, Tulare, and Kern Counties. Features would include the East Side Canal, five offstream reservoirs, pumping plants, and a distribution and drainage system. The East Side Canal, which would extend 330 miles from southern Sacramento County to the Kern River, could considerably enhance the environment of streams in the Sierra Nevada foothills, from Dry Creek in Sacramento County to the Kern River in Kern County.

The West Sacramento Valley Canal Unit could provide future water supplies to the Yolo-Sonoma, Lower Cache Creek, and Solano service areas in Yolo and Solano Counties. Principal features would include an enlarged portion of the Tehama-Colusa Canal, which is presently under construction, an extension of that canal, and Sites Reservoir, a 1,200,000-acre-foot pumped-storage reservoir in western Colusa County.

The Cosumnes River Division would comprise three reservoirs and an extensive distribution system to service areas in the foothill regions of Sacramento, Amador, and San Joaquin Counties. The main storage feature would be the 900,000-acre-foot Nashville Reservoir, which would provide recreation, flood protection, and enhancement of the fisheries in the lower Cosumnes River.

The Allen Camp Unit, consisting of Allen Camp Dam and Reservoir on the Pit River, would provide irrigation water, flood control, recreation, and fish and wildlife benefits in the Big Valley area of Lassen and Modoc Counties.

Figure 12 shows that sufficient water supplies are developed by the Central Valley Project to enable substantially increased service with no additional conservation facilities. However, additional conveyance facilities, i.e., the East Side Division and the West Sacramento Valley Canal Unit, are needed to serve areas of present and incipient deficiency in the Tulare and Sacramento Basins.

Figure 12 also shows that additional conservation facilities, beyond those described in the preceding paragraphs, may not be required until about 2000. Figure 12 further shows that by 2020, the projected demand for expanded service could require facilities to develop an additional 1 million acre-feet annually. These additional facilities have not been identified.

* See "POTENTIAL WATER SUPPLY SOURCES", page 20.

Possible Additions to the State Water Project

Figure 13 shows that the initial conservation facilities of the State Water Project will furnish about 3.8 million acre-feet of dependable water supplies annually. Figure 13 also shows projected net water demands in Project service areas to 2020, including (1) present contract entitlements, and (2) anticipated future *supplemental* service in excess of present entitlements. Figure 13 further shows that demands will begin to exceed supplies from the initial conservation facilities in the mid-1990s.

On the basis of current projections of growth in State Water Project service areas, the Department of Water Resources estimates that an additional conservation facility will be needed in the mid-1990s to meet present contract entitlements. Estimates by the Department in 1966 indicated that a new Project facility would be needed in the mid-1980s. However, revised rates of projected growth now indicate that the time of need for an additional facility will be postponed about 10 years. On the other hand, the time of need could be advanced by (1) greater-than-planned outflows from the Sacramento-San Joaquin Delta, as might be required by the State Water Resources Control Board; (2) the needs of additional service areas; or (3) increased water use in areas tributary to the Delta.

By 2020, the fulfillment of present contract entitlements in State Water Project service areas will require about 700,000 acre-feet of additional water annually. Moreover, the projected growth of demands indicates that about 700,000 annual acre-feet of supplemental water service will also be needed by 2020 in four hydrologic study areas as show in the following table:

Hydrologic Area	Supplemental Requirement (acre-feet per year)	Required for
San Francisco Bay	300,000	Municipal and industrial use in Solano, Santa Clara, Alameda, and Contra Costa Counties
Tulare Basin	250,000	Irrigation in Kern County
Colorado Desert	40,000	Municipal and industrial use
South Coastal	130,000	Municipal and industrial use

Thus, by 2020, the total demand for service from the State Water Project could exceed dependable supplies developed by the initial conservation facilities by about 1,400,000 acre-feet per year. Water-supply sources to meet this additional need have not been identified. They may include a combination of the various sources discussed under "POTENTIAL WATER SUPPLY SOURCES" beginning on page 20.

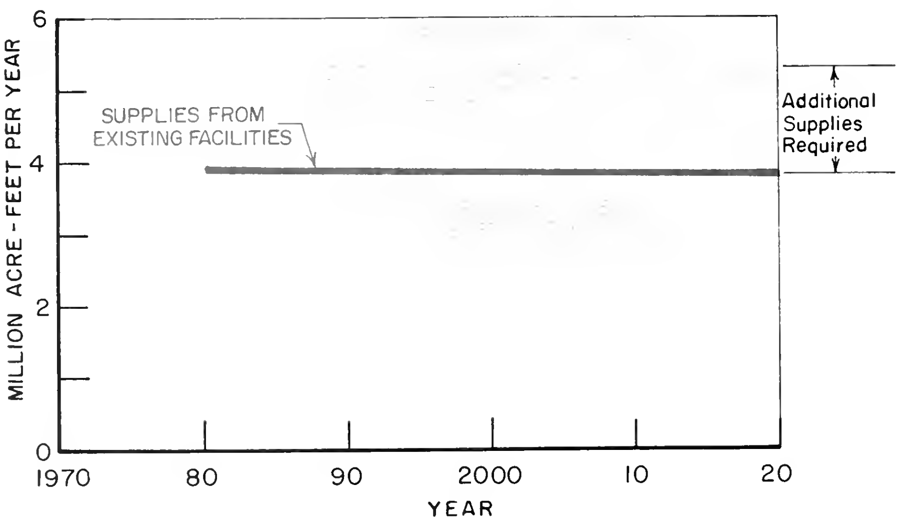


Figure 13. State Water Project — Projected Net Water Demands and Dependable Water Supplies.

Various public groups and individuals have expressed concern that a continuation of present population patterns in California will soon lead to overwhelming environmental problems. Some proponents of ecological improvement argue that the State's large metropolitan areas, particularly the South Coastal area, should no longer be permitted to grow. Suggestions for controlling the future growth of metropolitan areas include (1) ending construction of the State Water Project, thus terminating a source of additional water for Southern California, and (2) encouraging the movement of people to Northern California, the sources of most surplus water in the State.

Recognizing the need for a state land use and population policy, the California State Office of Planning and Research is conducting studies of alternative approaches to future population growth and urbanization. Included in these studies are the possible consequences of future growth in existing metropolitan areas, and assessments of the physical, social, and economic effects of new population centers in areas where urbanization has never been anticipated. The Department of Water Resources is assisting with the studies.

Three Model Urban Areas

The projections of future population presented in this report are based on recent statewide growth trends, which suggest the continued growth of existing large metropolitan areas, particularly the South Coastal and San Francisco Bay areas. In cooperation with the Office of Planning and Research, the Department of Water Resources has put together three alternative patterns of hypothetical population distribution. These alternative patterns, along with their possible effects on the future development, use and disposal of water, are briefly discussed in the following paragraphs. The effects of new population centers on electric power, transportation, and air pollution are also briefly mentioned.

The discussion is based on these criteria:

1. One-half of the estimated population growth of 25.2 million persons between 1970 and 2020 would locate in new urban areas. The remaining 12.6 million would locate in existing population centers.
2. New urban areas would not encroach on agricultural land.
3. The land must not slope more than 30 percent.

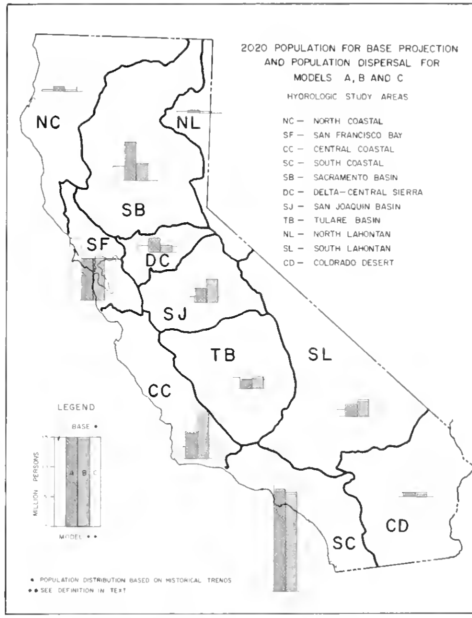


Figure 14. 2020 Population for Base Projection and Population Dispersal for Models A, B, C.

The three model areas are based on a hypothetical allocation of future population to either Northern, Central, or Southern California. Each model allocates a percentage of 12.6 million persons to new metropolitan areas. In each case, the remaining percentage would locate in other parts of the State in much the same pattern as would be expected under recent growth trends.

Figure 14 shows the hypothetical distribution, by hydrologic area, of the total population in 2020. The assumed natural distribution of population, based on recent trends, is shown as a base projection to facilitate a comparison of the effects of the three models. Figure 15 shows the hypothetical distribution of the 12.6 million persons dispersed to new urban areas under each plan.

Model A

Under Model A, about 5.3 million persons would locate in areas between the Sacramento-San

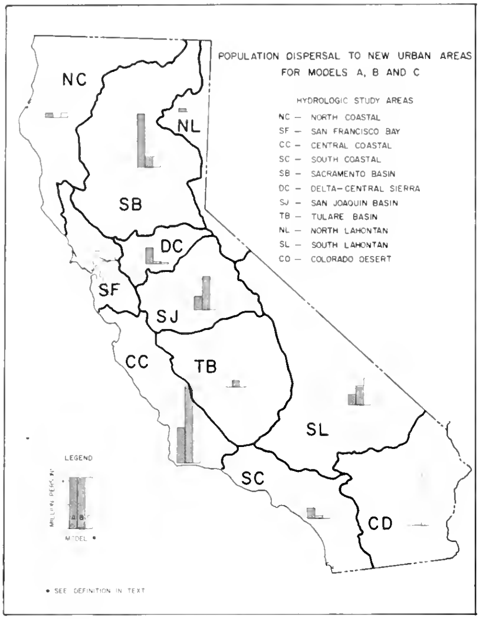


Figure 15. Population Dispersal to New Urban Areas.

Joaquin Delta and the Oregon border, the primary source of California's surplus water. Most of the distribution would be to the upper Sacramento Valley and to adjacent foothill areas of the Coast Range and Sierra Nevada. Distribution to the north coast would be modest because of the limited amount of suitable land. The remaining 6.3 million would locate in Central and Southern California in roughly the same pattern as would be expected by a continuation of present population trends.

Model B

Under Model B, some 10 million persons would locate in new cities between the Delta and the Tehachapi Mountains in Kern County. Most of the population would be distributed along the central coast and in foothill regions of Fresno, Madera, Mariposa, Merced, Stanislaus, and Tuolumne Counties. A smaller number would locate along the eastern slope of the Coast Range on the west side of the San Joaquin Valley.

Model C

Model C largely reflects a continuation of current growth between the Tehachapi Mountains and the Mexican border. However, some 10 million persons would be allocated to desert areas and along the coast between San Diego and San Clemente. A smaller number would locate in the foothills bordering the Antelope Valley.

Effects of Population Dispersal

Water Development

Regardless of how the population might be distributed, the statewide demand for water during the next 50 years will remain essentially the same. Table 7 presents estimated 2020 water demands for the base projection and for each of the three population models. The table indicates that each of the three hypothetical population patterns would tend to decrease future water demands in existing metropolitan centers and increase demands in present-day less crowded areas of the State. A higher statewide demand is projected for Model A because, under this model, more people would locate in inland areas, where per capita water use is generally greatest.

Table 7. Estimated 2020 Net Urban Water Demands for Alternative Patterns of Future Urbanization (1000s of acre-feet)

Hydrologic Study Area	Population Models			
	Base	A	B	C
North Coastal	210	250	210	250
San Francisco Bay	2,480	1,690	1,690	1,690
Central Coastal	470	1,050	1,770	820
South Coastal	4,920	3,480	3,310	3,830
Sacramento Basin	880	2,510	1,080	1,080
Delta-Central Sierra	460	830	430	390
San Joaquin Basin	140	320	560	140
Tulare Basin	250	190	280	190
North Lahontan	130	230	130	130
South Lahontan	200	340	450	550
Colorado Desert	160	160	160	1,350
State Total	10,300	11,050	10,070	10,420

Population centers in previously unoccupied areas of the State would require different patterns of water distribution. Existing water development facilities, as well as those planned for the future, are sufficiently flexible to accommodate a wide range of population patterns. In coastal areas, desalination and water reclamation would enable even greater flexibility. On the other hand, new inland population centers would reduce the feasibility of desalting as an alternative source of water and increase waste-disposal problems.

The transfers of water supplies and additional developments discussed in the following paragraphs are intended only as suggested methods for meeting demands that might develop under different patterns of population distribution.* The discussion is not intended as a proposed solution to future water-development and environmental problems.

Model A. Under Model A, increased demands in the North Coastal area might be met by the development of streams along the Mendocino Coast. However, such developments would be detrimental to local fisheries. Additional demands in the Central Coastal area might be satisfied through local developments or by the transfer of reserves and imports. For example, additional water for the Delta-Central Sierra area might be supplied from local streams and by the transfer of reserves that, under this population pattern, would not be needed in the San Francisco Bay area. Similarly, increased supplies for the South Lahontan area might be obtained from water that would ordinarily be allocated to the South Coastal area under normal growth patterns.

New cities in the Sierra foothills, and other new population centers in the San Joaquin Basin, might be served by both the Friant-Kern Canal and enlargement of the proposed East Side Division of the Central Valley Project. Additional demands in the North Lahontan area might be partially satisfied by the development of local streams but would probably require imports from the Sacramento Basin.

Model B. The distribution of population under Model B would mean increased water demands in Central California, particularly in the Central Coastal area and along the Sierra foothills in the San Joaquin Basin. Large water demands along the Central Coast might be met by local developments and by the transfer of reserve supplies from the San Francisco Bay and South Coastal areas. In addition, desalination and water reclamation might furnish additional supplies in coastal communities.

New cities along the east side of the San Joaquin and Tulare Basins might be served by enlargement of the proposed East Side Division of the Central Valley Project. Demands on the west side of the San Joaquin Valley might be met by diversions from the California Aqueduct. Supplies for new cities in the South Lahontan and Colorado Desert areas might be furnished by diversions from the Los Angeles and Colorado Aqueducts.

Model C. Under Model C, new cities would be located in the South Lahontan and Colorado Desert areas. New population centers in the southeastern desert regions would entail more long-distance imports than might be required under the other two population patterns. Cities in the Mojave area might be served by increased deliveries from the California Aqueduct. The aqueduct might be extended to accommodate increased demands in the Colorado Desert. New population centers in the desert might also be served by diversion of Colorado River water. In other areas of the State, increased demands might be met in much the same manner as suggested for the distribution of population under Models A and B.

In conclusion, any redistribution of future population would not alter two basic facts:

- Regardless of where new population centers might be located, future water demands will remain essentially unchanged.
- An additional 5 million acre-feet of water per year will be required by 2020 to satisfy future statewide demands.

Disposal of Wastes

As the population of California continues to grow, so will the problems connected with the disposal of increasing amounts of liquid and solid wastes. New cities would present an opportunity to use new techniques for waste management. The latest methods for waste disposal could be designed into new urban areas to provide efficient facilities and increased protection for the environment. With proper zoning and other controls, waste-disposal facilities might never become inadequate.

Of course, the mere presence of new cities and new disposal facilities would not in itself solve the growing waste problem. Effective treatment and disposal of wastes could be achieved only if all aspects of new cities were carefully planned. The development of new urban centers without carefully designed growth and zoning controls could result in serious waste-disposal problems, particularly in inland areas.

The brief discussion that follows is presented only to suggest methods that might alleviate the problem in future population centers and is not based on actual studies of procedures and costs. The design of new waste facilities would require a complete systems analysis to evaluate alternative methods and costs of disposal.

The maximum benefits from the disposal of liquid wastes would be obtained through reclamation. With the latest process and control methods, sludges and composts from sewage-treatment plants might be used as fertilizers or as soil conditioners. Reclaimed water could be used for irrigation, for artificial lakes, or for the recharge of ground water basins.

In coastal areas, the better quality wastes could be reclaimed for reuse, with the remainder discharged to the ocean. Deep-ocean disposal of treated waste water should cause little ecological degradation and might be beneficial in areas where

* Transfers of reserve supplies would entail a number of legal and administrative problems, and would, of course, require facilities to carry them out.

nutrient levels do not adequately support desirable biological growth. In the Central Valley, however, disposal to the ocean would involve expensive conveyance facilities. Waste management plans for inland cities should be designed to provide maximum benefits from recycling and reclamation.

In new cities located far from the coast, e.g., the Colorado Desert and South Lahontan areas, the disposal of waste water could present serious problems. Unusable effluents might possibly be transported to disposal lakes, where the water could evaporate or percolate into the ground, leaving the salts to accumulate without further use. However, sites would have to be carefully selected so that highly mineralized waste water would not percolate into usable ground water. The ecological effects of such new sinks would require careful study.

Electric Power

The primary source of additional electric power in California will probably be thermal steam-electric powerplants, most of which will be located near the coast because of the need for large quantities of cooling water. The hypothetical model cities would tend to move the population inland; therefore, power would have to be transmitted from the coast to the new population centers. This would require new high-capacity transmission centers and would entail significant environmental problems.

New cities in Northern California would require the least complex arrangements. Powerplants could be located along the sparsely populated northern coastline; extra power required in Southern California could probably be transmitted via the north-south transmission grid in the Central Valley. New cities in the Sierra foothills of Central California would require the construction of additional transmission facilities from the coast to the new foothill cities.

The most complex arrangement would result from the location of new population centers in the Colorado Desert and South Lahontan areas. The substantial facilities required to transmit power through the densely populated South Coastal area would entail significant environmental problems and would be extremely expensive.

Air Pollution

Land use and population policies could be established to control the quantities of pollutants emitted in a given area. Generally speaking, the greater the population in an area, the greater the source of pollutants. Therefore, prevention of heavy concentrations of pollutants might eventually require control of (1) the total number of people in an area, (2) the population density, and (3) the source of pollution.

The amount of air available to dilute concentrations of pollution is generally determined by atmospheric conditions. Atmospheric conditions that increase dilution would tend to decrease air pollution over a given area. Meteorological conditions favoring dilution are most prevalent along the coast and in Northern California.

The apparent conclusion is that air pollution could be reduced by population centers located along the Northern California coast. However, such conclusions are only speculative, and much more study of the entire problem will be required to determine the overall effect of population dispersal on air pollution. At the present time, the effects of alternative patterns of population distribution on air pollution are being studied by the Office of Planning and Research.

Transportation

All three hypothetical models contain new population centers within the Pacific Coast Mountain Ranges. Primary corridors in this area lie on a north-south axis, with limited east-west connections to the central interior. New urban centers in the coastal area would require expansion of the north-south corridor facilities. Improved connections between the coast and central interior would also be required.

The main highways on the valley floor in the Sierra-Cascade foothills also lie on a north-south axis. New cities in the Sierra foothills would require expanded transportation facilities within the north-south corridors, along with improved east-west connections. The development of new population centers in the Colorado Desert and South Lahontan areas would require new transportation facilities between the desert region and the South Coast. In addition, expanded north-south corridor facilities would probably be needed to accommodate increased traffic between Northern and Southern California.

Summary

This brief discussion of population dispersal was based on a very cursory examination of (1) urban problems that might be more easily solved if new population centers were established, and (2) new problems that might be created. With the exception of the effect on water demands, the discussion is perhaps more significant in the questions raised than in definitive information. It does, however, suggest the need for a complete evaluation of all the possible benefits and detriments that might result from the establishment of new cities in presently unoccupied or sparsely populated areas of California.