STATE OF CALIFORNIA
The Resources Agency

Department of Water Resources

BULLETIN No. 160-70

WATER FOR CALIFORNIA
THE CALIFORNIA WATER PLAN
OUTLOOK IN 1970

DECEMBER 1970

NORMAN B. LIVERMORE, JR.
Secretary for Resources
The Resources Agency

RONALD REAGAN
Governor
State of California

WILLIAM R. GIANELLI
Director
Department of Water Resources

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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 sources of water supply and develop policies for the maximum protection of the environment.

William R. Gianelli, Director
Department of Water Resources
The Resources Agency
State of California
December 1, 1970

TABLE OF CONTENTS

	Page
FOREWORD	iii
ORGANIZATION	xiii
CALIFORNIA WATER COMMISSION	xv
CHAPTER I. SUMMARY AND FINDINGS	1
Outlook in 1970	2
Organization of Report	6
CHAPTER II. AN ERA OF CHANGE	9
Emphasis on Water Quality	9
Environmental Awareness	10
Recent Environmental Legislation	11
Federal Environmental Legislation	11
National Environmental Policy Act of 1969	11
Wild and Scenic Rivers Act (P.L. 90-542)	11
Water Quality Improvement Act of 1970	12
California State Environmental Legislation	12
California Protected Waterways Act	12
Assembly Select Committee on Environmental Quality	12
Progress in Interstate and Federal-State Water Relationships	14
The Water Resources Planning Act (P.L. 89-80)	14
National Water Commission Act (P.L. 90-515)	14
Colorado River Basin Project Act (P.L. 90-537)	15
Federal-State Framework Studies	15
Western United States Water Plan	16
Western States Water Council	16
Progress in Water Resource Development	16
Local Water Development	17
Federal Projects	18
State Water Project	19

Page

CHAPTER III. PLANNING FOR WATER RESOURCE MANAGEMENT 21

Planning Considerations 21

Planning Process 22

Policies, Goals and Plans 23

Water Resource Management Analysis Process. 25

Decision and Implementation Activity 26

CHAPTER IV. WATER DEMANDS 31

Future Economic Development 31

Population 31

Industrial Development 36

Electric Power Development 38

Agricultural Development 41

Water Demand 43

Urban Water Demands 45

Agricultural Water Demands 49

Water Demands for Electric Power Generation 51

Recreation, Fish and Wildlife and Related Water Development 52

Major Policies of Federal and State Water Development Agencies 52

Recreation Financing 52

Fish and Wildlife Planning 53
Streamflow Maintenance for Fish and Wildlife 54
Fish and Wildlife and Recreation Water Demands 55

Flood Damage Prevention 56

Water Quality 56

Water Quality and Water Use 56
Municipal and Industrial Use 57
Agricultural Use 57
Recreation 58
Fish and Aquatic Life 58

Water Quality and Water Reuse 58

Water Quality Control 60

	Page
CHAPTER V. POTENTIAL WATER SUPPLY SOURCES	63
Surface Water Development	63
Sacramento Valley Development Potential	65
North Coastal Area Development Potential	66
Ground Water Development	67
Availability of Ground Water	67
Ground Water Management	70
Future Ground Water Use	72
Desalting	72
Department's Desalting Program	73
Federal Desalting Program	74
Current Status and Cost of Desalting	74
Desalting in the Future	75
Water Reclamation	76
The Department's Role in Water Reclamation	76
Potential Future of Water Reclamation	77
Present Status and Use of Reclaimed Water	78
Water Reclamation Studies	80
Cost of Water Reclamation	82
Legal Requirements and Public Acceptance	82
Other Possible Sources of Water	83
Western States Water Development	83
Weather Modification	84
Watershed Management	86
Undersea Aqueduct	87
Geothermal Water Resources	88
Nonstructural Alternatives	91
Reallocation of Water Supplies	91
Pricing Policies	91
Increased Efficiency of Water Use	92
Mitigation of Colorado River Salinity	92
Summary	93

Page

CHAPTER VI. REGIONAL WATER DEMAND-WATER SUPPLY RELATIONSHIPS 95

North Coastal Area 95

San Francisco Bay Area 98

Central Coastal Area 103

South Coastal Area 107

Sacramento Basin 111

Delta-Central Sierra Area 117

San Joaquin Basin 121

Tulare Basin 125

North Lahontan Area 129

South Lahontan Area 133

Colorado Desert Area 137

Regional Water Demand-Water Supply Summary 142

CHAPTER VII. MEETING WATER DEMANDS THROUGH CENTRAL VALLEY PROJECT AND STATE WATER PROJECT FACILITIES 147

The Central Valley Project 147

The State Water Project 148

Operational Characteristics and Flexibilities 150

Water Supply Capabilities 151

The Role of the Peripheral Canal 153

Projected Water Demands on the Federal and State Systems 154

Possible Central Valley Project Expansion 154

Possible State Water Project Expansion 157
San Francisco Bay Area 157
Tulare Basin 158
Colorado Desert Area 158
South Coastal Area 158

Central Valley Project Water Demand-Supply Relationship 158

State Water Project Water Demand-Supply Relationship 159

Recreational and Environmental Accomplishments 162

Environment and the Central Valley Project 162

	Page
Environment and the State Water Project	163
Summary	166
CHAPTER VIII. POPULATION DISPERSAL--IMPACT ON RESOURCES DEVELOPMENT	169
Study Criteria	170
Impact of Population Dispersal on Water Development and the Environment	174
Water Demand and Supply	174
Northern Model "A"	175
Central Model "B"	175
Southern Model "C"	176
Waste Disposal	176
Electric Power Requirements	178
Other Considerations	178

FIGURES

Number		
1	Relationship of California Water Plan to Other State Environmental and Development Policies and Plans . .	24
2	Planning for Water Resources Management in California	29
3	United States Fertility Series	32
4	Hydrologic Study Areas of California	35
5	California's Historical and Projected Population Growth	36
6	High, Median and Low Population Project, State of California	37
7	Generation of Electric Energy by Prime Source to Meet Future Power Demands	39
8	Present and Projected Land Use	43
9	California's Historical and Projected Net Irrigation Acreage, 1930-2020	44
10	California's Historical and Projected Applied Water Demands, 1930-2020.	44
11	Projected Growth of Applied Water Demands, State of California	48

FIGURES (continued)

Number		Page
12	Average Annual Full Natural Runoff	64
13	Areas of Ground Water Occurrence	68
14	Location and Relative Quantities of Municipal Waste Water Discharged in Coastal Counties of California, 1964. .	79
15	Projected Water Supplies and Net Water Demands, North Coastal Hydrologic Study Area	96
16	North Coastal Hydrologic Study Area	97
17	Projected Water Supplies and Net Water Demands, San Francisco Bay Hydrologic Study Area	100
18	San Francisco Bay Hydrologic Study Area	101
19	Projected Water Supplies and Net Water Demands, Central Coastal Hydrologic Study Area	104
20	Central Coastal Hydrologic Study Area	105
21	Projected Water Supplies and Net Water Demands, South Coastal Hydrologic Study Area	108
22	South Coastal Hydrologic Study Area	109
23	Projected Water Supplies and Net Water Demands, Sacramento Basin Hydrologic Study Area	114
24	Sacramento Basin Hydrologic Study Area	115
25	Projected Water Supplies and Net Water Demands, Delta-Central Sierra Hydrologic Study Area	118
26	Delta-Central Sierra Hydrologic Study Area	119
27	Projected Water Supplies and Net Water Demands, San Joaquin Basin Hydrologic Study Area	122
28	San Joaquin Basin Hydrologic Study Area	123
29	Projected Water Supplies and Net Water Demands, Tulare Basin Hydrologic Study Area	126
30	Tulare Basin Hydrologic Study Area	127
31	Projected Water Supplies and Net Water Demands, North Lahontan Hydrologic Study Area	130
32	North Lahontan Hydrologic Study Area	131
33	Projected Water Supplies and Net Water Demands, South Lahontan Hydrologic Study Area	134
34	South Lahontan Hydrologic Study Area	135

FIGURES (continued)

Number		Page
35	Projected Water Supplies and Net Water Demands, Colorado Desert Hydrologic Study Areas	138
36	Colorado Desert Hydrologic Study Area	139
37	Present and Projected Water Demand-Water Supply Relationships	143
38	Major Authorized Features of the State Water Project and the Central Valley Project	149
39	The Central Valley Project, Projected Net Water Demands and Dependable Water Supplies	160
40	The State Water Project, Projected Net Water Demands and Dependable Water Supplies	161
41	2020 Population for Base Projection and Population Dispersal for Models A, B and C	172
42	Population Dispersal to New Urban Areas for Models A, B and C	173

TABLES

Number		Page
1	Total Population in California by Hydrologic Study Area, 1967, 1990, 2020	34
2	Present (1967) and Projected Land Use and Irrigable Land in California by Hydrologic Study Areas . .	42
3	Estimated Urban Water Use	46
4	Present (1967) and Projected Applied and Net Water Demands in California by Hydrologic Study Areas	47
5	Irrigated Agriculture, Applied Unit Water Use Values . . .	49
6	Streamflow Maintenance Agreements by Hydrologic Area . . .	54
7	Ground Water in California	69
8	Summary of 1967 and Projected Net Water Demands and Water Supplies by Hydrologic Study Areas	144
9	Major Features of Basic Central Valley Project and State Water Project System	152
10	Summary of 1967 and Projected Future Water Demands on Existing Facilities of the Central Valley Project and State Water Project	155

TABLES (continued)

Number		Page
11	Summary of Possible Future Water Demands Anticipated to be Supplied by Future Facilities of the Central Valley Project and State Water Project	156
12	Central Valley Project, Recreation-Use in 1969	165
13	Recreation-Use at State Water Project Facilities	167
14	Net Urban Water Demands in 2020 for Selected Alternative Patterns of Future Urbanization	174

PLATES
(In pocket at back of bulletin)

1 Water Resource Development in California

2 Irrigated, Irrigable and Urban Lands

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The Resources Agency
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CHAPTER I. SUMMARY AND FINDINGS

This bulletin presents an up-to-date appraisal of water demands for various beneficial purposes throughout the State for 1990 and 2020, and the potential sources of water supplies to satisfy those demands. It discusses accomplishments in both planning and water development implementation in the four years since publication of Bulletin 160-66, the first of the Bulletin 160 series. The Bulletin 160 series reports on progress in the implementation of the California Water Plan and updates certain of the concepts embodied in that Plan.

Considerable confusion has been evident concerning the California Water Plan and its relationship to the State Water Project. It is important that the distinction between the two be explained at the outset to facilitate understanding of the information presented in this bulletin.

The California Water Plan is a long-range planning framework for the development of California's water resources. The State Water Project, currently nearing completion by the Department of Water Resources, is a specific system of physical facilities which will satisfy water demands in large areas of the State in the immediate future. The State Water Project, as well as all projects whether local, state or federal, contributes toward achievement of the objectives of the California Water Plan as they become implemented.

This bulletin and supporting studies deal with demands for water and sufficiency or supplies to satisfy those demands to 1990 and 2020, some 20 and 50 years hence, respectively. Such projections are increasingly subject to change with the passage of time due to changing factors and events that cannot be foreseen today. Accordingly, the estimates and projections concerning the future, as presented in this bulletin, represent only the magnitudes or conditions foreseen at the present time. It is fully recognized that periodic revision will be necessary in the light of additional information and experience, and that such revisions may well be substantial--either upward or downward.

Major emphasis is placed on the 1990 projections, as these will have considerable influence on decisions that will be made in the next few years. The major purpose of the 2020 estimates is to provide perspective for those decisions necessary to implement plans for water supply sources to meet demands in the 1990s.

Findings from the studies reported in this bulletin are set forth under the heading "Outlook in 1970". They are a series of concise statements summarizing the information of significant importance for which supporting data and information are presented in detail in the ensuing chapters.

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, shortages in dependable supplies presently exist in certain areas and conveyance facilities are needed to deliver developed supplies to those 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 at present to about 4.5 million acres in 2020 to accommodate the projected population of 45 million.

- Irrigated acreage is expected to increase about 10 percent from 8.9 million acres at present 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 at present 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 at present 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 requre 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.

- Construction has been initiated or completed on a number of major water supply projects during the last four years.

    - The U. S. Bureau of Reclamation has completed the federal-state San Luis Dam, Pumping Plant, and Canal and has initiated construction of the Tehama-Colusa Canal, the San Felipe Division, the San Luis drain, and the Auburn-Folsom South Unit, all features of the Central Valley Project.

    - The U. S. Army Corps of Engineers has initiated construction of New Melones Dam on the Stanislaus River; Warm Springs Dam on Dry Creek, a tributary of the Russian River; Martis Dam on Martis Creek, a tributary to the Truckee River: Mojave Dam on the Mojave River; Hidden Dam on the Chowchilla River; and Buchanan Dam on the Fresno River.

    - The State Water Project is more than 95 percent complete or under construction, with water being delivered to the Sacramento Valley, San Francisco Bay area, and the San Joaquin Valley. Initial water delivery to Southern California is scheduled for 1971.

    - Local agencies contributed to water development by completing or initiating construction on 35 reservoir projects. Major projects completed were New Bullards Bar on the Yuba River (Yuba County Water Agency), New Exchequer on the Merced River (Merced Irrigation District), Hell Hole on the Rubicon River (Placer County Water Agency), Lopez or Arroyo Grande Creek (San Luis Obisop County Flood Control and Water Conservation District), and New Don Pedro on the Tuolumne River (City of San Francisco and Modesto and Turlock Irrigation Districts). In addition, the City of Los Angeles completed the second pipeline of the Owens River Aqueduct, and several agencies in the San Joaquin Valley have completed or are constructing major distribution systems to deliver imported water to individual users.

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 more 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.

Organization of Report

The text of this bulletin is presented in seven chapters. Chapter II, "An Era of Change", discusses changing public values and attitudes toward water development and its impact on the environment. It also describes activities and events since the publication of Bulletin 160-66 that have significant bearing on California's water resources.

Chapter III, "Planning for Water Resource Management", considers environmental and social goals in relation to water resource planning and discusses a broadened planning concept of water resource management planning.

Chpater IV, "Water Demands", summarizes California's water needs on a statewide basis. It discusses the various factors of demand for developed supplies, with particular emphasis on projections of population, industrial development, irrigated agriculture, and land use. It also discusses the water demand-related considerations of water quality, flood control, recreation, fish and wildlife, and other environmental factors.

Chapter V, "Potential Water Supply Sources", describes the various possible sources of water that offer potential for meeting future water needs. However, no conclusion is drawn as to the timing or indicated priority of any particular source.

Chapter VI, "Regional Water Demand-Water Supply Relationships", covers in some detail the derivation of present and projected future demands for water and related services by each of the 11 major hydrologic areas of the State and an inventory of existing and developable water supplies available toward satisfying those demands.

Chapter VII, "Meeting Water Demands Through Central Valley Project and State Water Project Facilities", describes the role of the State Water Project and the Central Valley Project and explains the manner in which they could be expanded and operated to provide continuing water service, if such service is indicated.

Finally, Chapter VIII, "Population Dispersal--Impact on Resources Development", considers the impact of possible future alternative patterns of population distribution on water development, use and disposal, and other environmental considerations such as sources and transmission of electric energy, highway transportation, and air pollution.

It will be noted in the ensuing chapters that the "present" is designated as 1967. This is the base year chosen to reflect as nearly as possible present (1970) conditions, while at the same time representing the actual development status as determined from the most recent land and water use surveys which have been in progress over the past four years. For the most part this information, combined with trend data and the preliminary 1970 census, has been considered representative of present conditions.

CHAPTER II. AN ERA OF CHANGE

Since publication of Bulletin No. 3, "The California Water Plan", in 1957, the Department has been engaged in an intensive statewide planning program to supplement and update the California Water Plan. This program involves: (1) periodic reassessment of existing and future demands for water and the economic and social needs for related services such as flood control, hydroelectric power, and recreational and fish and wildlife opportunities; (2) periodic reevaluation of local water resources available to satisfy estimated demands, and the magnitude and timing of need for additional water supplies that cannot be provided from local sources; (3) evaluation of the various alternative sources of water supplies to meet future demands in areas of deficiency, including dams and reservoirs, desalination, reuse of reclaimed water, weather modification, and other possibilities; (4) evaluation of the need for protection and preservation of the water resource for environmental enhancement; and (5) examination of alternative water resource management plans.

The objective of the statewide planning program is to provide a guide to the selection of the most favorable management plans for California's water resources, considering all reasonable alternative courses of action. Evaluation of these alternatives is premised not only on physical and engineering considerations but also takes into account changing economic, social, technological, political, and cultural factors, as best those factors can be foreseen. The results of the program are documented in the Bulletin 160 series.

Since publication of the Bulletin No. 160-66 in 1966, California has experienced a dynamic era, not only in the area of water project implementation, but also in the evolution of the broad consideration of water resource development within the framework of the overall environment. Certainly, this evolution is desirable and needed, as water is a most valuable natural resource and must be considered in its broadest ramifications. The scope of planning must be broadened to encompass fully the environmental and total resources considerations.

Studies reported in this bulletin indicate that estimates of future water demand are lower than at the time of publication of Bulletin No. 160-66, and that more time is available to develop new water supplies. However, concern for environmental quality and especially emphasis on "clean water" necessitates much more effort on water resource management. The beneficial uses of our water resources must be protected, and increased effort must be made to clean up our rivers, lakes, estuaries, and ocean continental shelf.

Emphasis on Water Quality

Water resource management implies the integration of water supply with water quality. Two major goals in water resource management are: (1) the management and use of the water resources to meet the needs and desires of the people as best those needs can be determined; and (2) the management of the water and related resources of land and air to preserve and enhance the resources for indefinite use and enjoyment.

The importance of maintaining the quality of the waters of California has long been recognized by the State. A major step was taken in 1967 to strengthen the water quality control programs through the establishment of a State Water Resources Control Board. Functions of the five-member State Board are divided into water rights and water quality. The water quality functions include the control and prevention of water pollution.

The State Board guides the nine Regional Water Quality Control Boards, enabling state policy for water quality control to be administered regionally, within a framework of statewide coordination and policy. The Regional Boards, with boundaries generally based on major watershed areas, are regulatory agencies, each gearing its work to the specific problems of its particular region. The Boards formulate water quality control plans for waters of their regions, establish and enforce waste discharge requirements, and implement policies of the State Board.

The authority of the State Water Resources Control Board and the California Regional Water Quality Control Boards was substantially increased on January 1, 1970 when the Porter-Cologne Water Quality Control Act became effective. This Act, considered the most comprehensive water quality control law in the Nation, completely revises the state water pollution and water quality control laws and also enables the State Water Resources Control Board to carry out water quality objectives through its water rights function.

A significant element of the Act is the provision for development by the State Water Resources Control Board of state policy for water quality control and regional water quality control plans. These policies and plans become a part of the California Water Plan upon submission to the Legislature.

Environmental Awareness

The recent emergence of environmental awareness and concern stems from two major considerations: first, the obvious deterioration of our surroundings today--air pollution, water pollution, debris of our industrial society, urban sprawl, loss of our natural fauna and flora, ecological disruption, and many other distressing aspects of contemporary society; and second, the predictions of what may happen in the future as the population pressures increase, and the related impact of our expanding technological society is intensified. That these problems must be solved within a framework of comprehensive environmental and resources policy is becoming increasingly clear.

The real issue is the problem of planning adequately for the use of one resource--water--in a near vacuum of other equally controversial and interrelated problems such as population and land use. Planning for water use is made considerably more difficult by the absence of any firm policies and direction in these other areas which are the focal point of much concern. The need for such policies is particularly manifest in water resource development because of the long time required for planning and implementation.

The Department of Water Resources recognizes the need for a comprehensive policy framework to provide keener perspective with regard to water resource development. Until such policy is articulated by the State, the Department must continue its philosophy and policy of ensuring that the water needs of the people are satisfied, as best those needs can be determined now and in the future. The needs of people include not only the demand for use, but also the need for preservation of those resources. This necessitates an awareness of the need for planning for the maintenance of a proper balance between the preservation and protection of water resources and the development and use of those resources.

While there is much talk about population control, no expectation of some population increase is unrealistic. As population increases, and there is every indication that it will, water demands will increase proportionately. Proper consideration of environmental issues must be premised on the acknowledgment that people and their related activities will continue to need water, no matter how the future pattern of population growth and distribution may occur. Therefore, the question should not be whether further water development should occur, but how such development can best be accomplished, fully taking into account the interrelation with the environment and population and land use policy, as such policy may develop.

Recent Environmental Legislation

With the approach of the 1970s, the environment and environmental problems have become the watchword not only of the public but also of the Governor, the executive departments, and the lawmakers. In fact, both the State Legislature and the Congress have declared the 1970s to be the decade of the environment. This is reflected at the state level in the passage of three significant bills, and at the federal level by enactment or extension of important policy statutes. While this legislation is somewhat broadly based, it will profoundly affect future water resource development.

Federal Environmental Legislation

Many bills concerning the environment are now pending before the Congress, and a number of bills dealing in various degrees with the environment have been passed recently. Three significant policy enactments concerning water resource environment are worthy of particular note and are briefly discussed in the following paragraphs.

National Environmental Policy Act of 1969. This Act declares national policy to encourage productive and enjoyable harmony between man and his environment; to promote efforts which will protect the environment and stimulate the health and welfare of man; and to enrich the understanding of the ecological systems and natural resources important to the Nation. It declares that the continuing policy of the Federal Government in cooperation with the state and local governments and other concerned public and private organizations will be to use all practicable means, including financial and technical assistance, to foster and promote the general welfare.

The Act provides that all federal agencies incorporate environment in planning and decision-making, and include in every recommendation or report a detailed statement on the environmental impact and other considerations involved. It also requires those agencies to include the comments of other agencies affected. The Act also establishes a Council on Environmental Quality in the Executive Office of the President. The Council assists and advises the President and reviews the federal agency programs and attitudes.

Wild and Scenic Rivers Act (P.L. 90-542). The Act, passed in 1968, established the basic principle that certain selected rivers of the Nation which, with their immediate environments, possess outstanding, remarkable, scenic, recreation, geologic, fish and wildlife, historic, cultural, and other similar values, are to be preserved in a free-flowing condition and protected for the benefit and the enjoyment of present and future generations.

The Wild and Scenic Rivers Act established the Wild and Scenic Rivers System, composed of eight initial rivers, including the Middle Ford of the Feather River, and identifies 27 other rivers to be studied for possible inclusion in the national system. In addition, the Act also authorizes the Secretary of the Interior to provide technical assistance, advice, and encouragement to the states, political subdivisions, and private organizations in their efforts to establish state and local wild, scenic, and recreation river areas.

Congress has made clear that the task of preserving and administering outstandingly remarkable, free-flowing streams is not solely the domain of the Federal Government; and that the states should be encouraged to undertake as much of the job as is possible. To date, 12 states, including California, have active scenic river programs to enhance the values of free-flowing rivers.

Water Quality Improvement Act of 1970. The Act is aimed essentially at strengthening federal water pollution control authority, setting up an all-inclusive federal office to give policy guidance to environmental quality improvement programs, and improving effectiveness of the federal construction grant program in combating water pollution.

California State Environmental Legislation

As with the Congress, a number of bills concerning the environment have been passed or are under consideration by the Legislature. Three legislative acts have been recently passed that have direct bearing on water-related environment. Moreover, the California Assembly Select Committee on Environmental Quality was appointed because of growing concern about California's environmental problems.

California Protected Waterways Act. This Act, passed as Chapter 1278, Statutes of 1968, has two major aspects. First, it declares that it is state policy to conserve those waterways of the State possessed of extraordinary scenic, fishery, wildlife, or outdoor recreation values. Second, it requires the Resources Agency to prepare the initial elements of a plan and report thereon to the Legislature by January 1971. The Act defines waterways as "The waters and adjacent lands of streams, channels, lakes, reservoirs, bays, estuaries, marshes, wetlands, and lagoons".

Assembly Select Committee on Environmental Quality. The growing concern about California's environment prompted appointment of the Assembly Select Committee on Environmental Quality in January 1970. This committee reviewed the major environmental problems confronting California and published a report entitled "Environmental Bill of Rights" in March of 1970. The report includes 34 recommendations covering a wide range of recommended state actions. Major conclusions of the report cover population growth and distribution, land use patterns, need for a greatly expanded public investment, formation of regional planning agencies and preparation of regional environmental protection and enhancement plans, abatement of pollution caused by the automobile, and protection of resources of the coastal zone.

Two important bills resulting from the report were passed during the 1970 Legislative Session. They are AB 2045, "The Environmental Quality Act of 1970", and AB 2070, which abolishes the existing State Office of Planning and creates an Office of Planning and Research in the Governor's Office to assist the Governor in developing and achieving environmental goals.

AB 2045 will require state agencies to:

1. Include a detailed statement of specific environmental information in any report on any project they propose to carry out which could significantly affect the environment.

2. Include a detailed environmental statement in the official

California's "Environmental Bill of Rights" is concerned with protection of resources of the coastal zone.

In some areas, land use choice has already been made

DPW – Division of Highways

In other areas, opportunities for alternative uses still exist state review of any proposed federal project which could significantly affect the environment. (This also is consistent with the Federal Environmental Policy Act of 1969 requiring federal agencies to present similar environmental information on their proposed projects.)

3. Request in their budgets, funds necessary to protect the environment from problems caused by its activities.

4. Require from local agencies detailed statements of specific environmental information prior to allocation of state or federal funds for projects which may have a significant effect on the environment.

Under AB 2070 the new Office of Planning and Research will serve the Governor and his Cabinet as staff for long-range planning and research, and constitute the comprehensive state planning agency. It will have authority to assist in the preparation of all environment-related programs of state departments and agencies, including water development, and to assist the Department of Finance in preparing the annual state budget as it relates to environmental goals and objectives.

Progress in Interstate and Federal-State Water Relationships

During the past several years a number of steps have been taken by California in cooperation with other states or with the Federal Government, and by the Federal Government, which will have significant influence on the State's water development. Three of the most important federal laws enacted were: the Water Resources Planning Act (P.L. 89-80), the National Water Commission Act (P.L. 90-515), and the Colorado River Basin Project Act (P.L. 90-537). California and the other 10 western states have moved toward better understanding by their participation in the Western States Water Council and in the recently authorized Western United States Water Plan Study.

The Water Resources Planning Act (P.L. 89-80)

As stated in the preamble, this Act is:

> " ... to provide for the optimum development of the Nation's natural resources through the coordinated planning of water and related land resources, through the establishment of a water resources council and river basins commission, and by providing financial assistance to the states in order to increase state participation in such planning."

Primary responsibility for implementation of this far-reaching law rests with the Water Resources Council, which was created by the Act specifically for that purpose. The Council consists of the Secretaries of the Interior, Agriculture, the Army, and Health, Education, and Welfare, and the Chairman of the Federal Power Commission.

The Water Resources Council is required to prepare national assessments of the adequacy of supplies of water necessary to meet each water resource region in the United States and the national interest therein.

The "First National Assessment" was published by the Council in November 1968.

National Water Commission Act (P.L. 90-515)

This Act, passed by the Congress in 1968, promises to be of importance to western water development. The Act created a seven-member National Water Commission which is responsible for (1) review of present and anticipated national water resource problems; (2) consideration of economic and social consequences of water resource development, including the impact of water resource development on regional economic growth, and on institutional arrangements and esthetic values; and (3) advice on specific water matters. The Commission is also required to consult with the Water Resources Council, and to furnish its reports to that body for review and comment prior to submittal to the President and the Congress.

The responsibilities and authority of the Commission are very general. During 1969 it sought the views of federal and state agencies, private consultants, and the public in an attempt to delineate a scope of effort in which it could produce a report that would give more meaningful direction to the planning and development of the Nation's water resources. The Commission plans to submit its final report to the President and the Congress early in 1973.

Colorado River Basin Project Act (P.L. 90-537)

This law was enacted in 1968 after four years of interstate negotiations and congressional hearings. It authorized the Central Arizona Project and five Upper Colorado River Basin projects, established a development fund, delineated principles and priorities for operation of Colorado River reservoirs, conditionally authorized one project and reauthorized another project in Utah, and provided for assumption of the Mexican Water Treaty burden by the United States when the Colorado River is augmented by 2.5 million acre-feet. The Act gave existing California, Arizona, and Nevada Colorado River water contractors a priority over the Central Arizona Project whenever the annual usable supply is less than 7.5 million acre-feet, with California's priority limited to 4.4 million acre-feet per year.

The Central Arizona Project was authorized with reference to the 1964 U. S. Supreme Court Decree which apportions the waters of the Lower Colorado River Basin among the States of California, Nevada and Arizona. Under that decree, California is apportioned 4.4 million acre-feet per year plus 50 percent of any surplus. California agencies have contracts with the Secretary of the Interior for 5.362 million acre-feet per year. It is anticipated that California's supply in the Colorado will be reduced when the Central Arizona Project becomes operational, which is expected to be sometime during the 1980s. The principal effect of this reduction will be to reduce the annual deliveries to the Metropolitan Water District of Southern California from the present 1,212,000 acre-feet to 550,000 acre-feet. The Imperial, Palo Verde, and Coachella Irrigation Districts will also lose rights to 300,000 acre-feet of second-priority water.

The Act recognizes the shortage of water in the Colorado River Basin and acknowledges the need for augmentation of the natural water resources of the Basin. It directs the Secretary of the Interior to conduct reconnaissance investigations for the purpose of developing a general plan to meet the future water needs of the Western United States. However, the Act imposes a 10-year moratorium on studies of any plan for importation of water into the Basin from any other natural drainage basin lying outside the States of Arizona, California, Colorado, and New Mexico and outside of those portions of Nevada, Utah, and Wyoming which are in the Colorado River Basin, until September 30, 1978. The Secretary has assigned responsibility for this study to the Bureau of Reclamation, which now refers to it as the "Western United States Water Plan Study".

Federal-State Framework Studies

The Federal Government inaugurated the Type I Framework Studies in 1966 under the Water Resources Planning Act, with the objective of providing comprehensive water planning in all regions of the Nation. This is basically a federal interagency program in which the states are encouraged to participate. The responsibility for initiation and overall coordination has been administratively assigned to the Water Resources Council.

Framework Studies in the Pacific Southwest area cover the Great Basin, the Upper and Lower Colorado Basins, and the California Region. The State of California is the lead agency for the California Region Study, which has been in progress since 1967. All Framework Study reports for the Region are scheduled for completion by June 30, 1971.

The Framework Studies are being conducted at the reconnaissance level, with the objective of developing a framework plan to meet the projected needs for water and related land resources through 2020. The state agencies participating in the California Region study are the Departments of Water Resources, Fish and Game, Parks and Recreation, Navigation and Ocean Development, Conservation, and Public Health, and the Reclamation Board, Colorado River Board, and State Water Resources Control Board.

Western United States Water Plan

The Bureau of Reclamation launched this planning study early in 1970. The states have been invited and urged to participate in the investigation. Insofar as possible the study will use information to be provided by the federal Type I Framework Studies and any other relevant studies for the Pacific Northwest and the Pacific Southwest.

Progress reports are to be submitted by the Secretary of the Interior to the President, the National Water Commission (while it is in existence), the Water Resources Council, and the Congress every two years. The first report will be due on or before June 30, 1971. The study is to terminate with a final reconnaissance report not later than June 30, 1977. Interregional transfers of water from the Northwest to the Southwest will not be studied in this investigation because it will conclude before the 10-year moratorium in P.L. 90-537 expires. However, it was envisioned by the Congress, in enacting P.L. 90-537, that such transfers will be considered and a comprehensive water plan for the entire West will be formulated by the Secretary after September 30, 1978.

Western States Water Council

The 33-man Western States Water Council was created in 1965 by the governors of the 11 contiguous states lying wholly or in part west of the Continental Divide. Its purpose is to foster effective cooperation among the Western States in planning for programs leading to integrated development of water resources by state, federal, and other agencies. Its functions are to:

1. Prepare criteria for plans for regional development of water resources to protect and further state and local interests; and

2. Undertake continuing review of all large-scale interstate and interbasin plans and projects, and advise the governors regarding their compatibility with the orderly and optimum development of the water resources of the Western States.

Progress in Water Resource Development

The State Water Project, the federal Central Valley Project and other major federal projects are widely known, because of both the public and governmental process of authorization and the financing and individual project scope and magnitude. However, the extensive efforts of local agencies, largely unhearalded, have provided the backbone of

California's water resource development achievement to date. Estimations have been made that local agencies have invested nearly $5 billion in surface water and ground water projects. This estimate is based on dollars expended over the years, and would be substantially greater based on the value of the dollar today.

It is estimated that local agencies have expended more than $1 billion in water conservation, conveyance, and major distribution systems over the past four years. The State has invested a similar amount on the State Water Project, and the Federal Government has expended about $400 million on the Central Valley Project and other facilities. Although state and federal construction expenditures may exceed local agency investment in the future, because of the increasing scope and magnitude of interbasin projects, state and federal water development will continue to supplement rather than supplant local development, fulfilling only the needs that local agencies are unable to provide for. In this regard, local agencies will play the lead role in developing distribution systems for state and federal water facilities.

This concluding section presents a brief description of the progress in water development project construction during the four years since publication of Bulletin No. 160-66. In this regard a map showing existing and possible future water development and conveyance systems in California is enclosed in the jacket at the back of this bulletin as Plate 1, entitled "Water Resource Development in California".

Local Water Development

During the past four years local agencies completed or initiated construction on 35 reservoir projects. Major projects completed were New Bullards Bar on the North Yuba River by the Yuba County Water Agency; New Exchequer on the Merced

New Bullards Bar Dam – North Yuba River

Yuba County Water Agency

Local projects provide the backbone for California's water resources development

River by the Merced Irrigation District; Hell Hole on the Rubicon River by Placer County Water Agency; Lopez on Arroyo Grande Creek by San Luis Obispo County Flood Control and Water Conservation District: and New Don Pedro Project on the Tuolumne River by the City and County of San Francisco and the Turlock and Modesto Irrigation Districts.

In addition, major aqueduct and distribution systems were completed or are in progress. The City of Los Angeles completed the second barrel of the Los Angeles Aqueduct which conveys water 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. Some $217 million in construction was under contract on June 30, 1969. The completed facilities are expected to cost about $1.4 billion.

Several major water districts in the San Joaquin Valley have completed or are in the process of constructing distribution systems to deliver imported water to individual users. The Arvin-Edison Water Storage District in eastern Kern County has completed a $38 million system for distribution of water from the Central Valley Project. The agencies on the west side of the Valley are constructing similar facilities for distribution of water from the State Water Project, with an aggregate expenditure of about $40 million as of December 1968.

The foregoing projects by no means represent the total local agency construction effort over the past four years. But they do serve to indicate the very important role of the local agencies in fulfilling California's water needs.

Federal Projects

Highlights of progress on the Central Valley Project during the past four years include the completion of the joint federal-state San Luis Dam and Pumping Plant and San Luis Canal, initiation of construction of the Tehama-Colusa Canal, and initiation of construction of the San Felipe Division. Construction of the Auburn-Folsom South Unit (authorized in 1965) and the San Luis drain is also currently in progress.

Central Valley Project deliveries have increased 50 percent over the past four years, reaching 60 percent of the estimated total area contemplated under the presently authorized project. Water deliveries in 1969 totalled 4.9 million acre-feet as compared to 3.6 million acre-feet in 1965. Installed hydroelectric capacity also increased 50 percent, currently exceeding 1,500,000 kilowatts. This represents nearly 85 percent of the presently authorized total capacity.

Other noteworthy construction accomplishments by the Bureau of Reclamation include completion of Stampede Reservoir on Little Truckee River and first power transmission to the Central Valley Project over the Pacific Northwest-Pacific Southwest intertie.

The Corps of Engineers continued its construction program to provide for navigation, beach erosion and flood control projects. The Corps began construction on six reservoir projects: New Melones on the Stanislaus River, Warm Springs in the Russian River Basin, Martis on the Truckee River, Mojave on the Mojave River, Hidden on the Fresno River, and Buchanan on the Chowchilla River.

The Flood Control Act of 1966 authorized Marysville and Knights Valley Reservoir Projects on the Yuba River and in the Russian River Basin, respectively, and the Flood Control Act of 1968 authorized Butler Valley Reservoir Project on the Mad River in Humboldt County.

State Water Project

Notable progress has been made since 1966 toward completion of the State Water Project. Oroville Dam has been in operation for over three years and has performed very successfully its multi-purpose duties of flood control, conservation, power generation, and recreation. In fact, Oroville Reservoir not only completely filled during its first year of full operation, but also performed admirably in controlling the substantial floodflows during January and February of 1969 and January of 1970.

The first phase of the North Bay Aqueduct was completed early in 1968. Del Valle Dam on the South Bay Aqueduct was completed in 1968 and Lake Del Valle was full by the spring of 1969.

The favorable water conditions during the spring of 1969 enabled the complete filling of San Luis Reservoir, the key facility of the San Luis features which were completed in 1968.

Deliveries of project water to contracting agencies in the San Joaquin Valley began in 1968, and a total of nearly 200,000 acre-feet of water was delivered to nine water service agencies along the west side of the Valley in Kings and Kern Counties in both 1968 and 1969. An estimated 300,000 acre-feet was delivered in 1970. Of the 75,000 acres currently irrigated from project deliveries, only 12,000 acres had previously been irrigated.

As of December 1970 the California Aqueduct was operational from Clifton Court Forebay at the southerly edge of the Delta to Wind Gap Pumping Plant, some 280 miles to the south. Included in that reach are five of the nine major pumping plants on the aqueduct.

The Tehachapi Crossing facilities (Tunnels Nos. 1, 2, and 3, and the 4.7-mile-long Carley V. Porter Tunnel) were completed during 1970. The lengths of these tunnels total nearly 8 miles. Water will begin flowing through the Tehachapis in June 1971. The West Branch facilities needed for initial water delivery will be completed in the fall of 1971, and water deliveries are expected to be initiated from Castaic Dam in October of that year.

A contract for construction of Perris Dam at the terminus of the aqueduct was awarded in October 1970. The project is on schedule, and the prospects of meeting the target date for delivery of project water to the West Branch contractors in 1971 and the East Branch contractors in 1972 and 1973 seem excellent indeed.

CHAPTER III. PLANNING FOR WATER RESOURCE MANAGEMENT

The State of California has long recognized that the growth and well-being of its economy require adequate water supplies. The State has traditionally assumed responsibility for providing guidance and leadership in planning for the orderly use and development of its water resources, as enunciated in Section 105 of the California Water Code, which states:

> "It is hereby declared that the protection of the public interest in the development of the water resources of the State is of vital concern to the people of the State and that the State shall determine in what way the water of the State, both surface and underground, should be developed for the greatest public benefit."

This policy has been elaborated and detailed in many subsequent provisions of the Water Code and forms the basic and primary objective of the planning program of the Department of Water Resources.

Planning Considerations

Planning for resources in general is influenced by public goals and values as reflected in laws, rules, regulations and accepted practices. In the case of water resource planning, the Flood Control Act of 1936, which declared that benefits of federal projects should at least equal costs, provided a legal basis for an era of planning which emphasized "benefit-cost" in the analysis of river basin projects. This concept was progressively developed over the years and today, as defined in Senate Document 97 (adopted by the Eighty-seventh Congress in 1962) represents what might be considered the "traditional" approach to water development planning. This traditional approach encompasses both the established concepts and techniques of economic and financial analysis, some consideration of recreational and social benefits, and specific informational and technical criteria which underlie the project formulation process.

Recent events reveal that social objectives considered desirable by society have been significantly expanded and that certain of these may not be consistent with the most economically efficient use of resources. The public interest in recreation, quality of environment, healthful ecology, and esthetics implies a willingness to forego opportunity or to spend money in a way that does not necessarily yield the highest economic efficiency as it is now computed. The extent of public commitment to some of the emerging environmental demands has not been defined. Trade-offs of benefits and/or new financial obligations will be involved.

Most resources planning and development have been initiated from essentially a single-purpose viewpoint for a primary resource, even though particular developments may have multiple uses and benefits, affecting other resources. Water resource projects have brought into sharp focus the interrelationships of resources and resource management problems with the environment and economic development. They have emphasized the need to begin to consider how to carry out coordinated comprehensive resource management planning in the total context of the environment. This indicates the need for a statewide land use policy as a prerequisite to the management of California's resources.

Planners are confronted with the need to develop new philosophies, new concepts, new methodology and new techniques. The rapid development of technology has opened possibilities for new alternative approaches to water development; and the increasing concern of the people regarding environment demands the development of new and more refined methods of evaluating the environmental benefits and detriments of water development.

The Department of Water Resources is broadening its planning and evaluation processes and techniques to cover a wider range of water development alternatives and the increased application of techniques and concepts of systems analysis. Systems analysis in the broader sense is the process of explicitly identifying the fundamental problems requiring solution and analyzing a wide scope of alternatives from the standpoint of both monetary and nonmonetary values for the purpose of aiding the decision-makers in making decisions. A systems approach might be described as a sensitive, analytical process which helps in formulating and acting upon required decisions.

The systems analysis methodology has been widely applied in both business and government. However, full use of its techniques in water resource planning must be further explored and developed. Successful application of this technique holds promise of broadening the range of alternatives for meeting water development and other resource needs of the State, and in incorporating a wider range of considerations into the evaluation process.

Decisions regarding management and utilization of water resources should be based on a thorough comparison of the need for action with the virtues of retaining options for the future. Benefits foregone are real and every effort should be made to evaluate such benefits before final decisions are made. All effort should be made to ensure that decisions made now will minimize deleterious effects that might have been avoided had decisions been made in such a way as to retain flexibility for future action.

Water quality assumes increasing importance as greater pressures develop on the resources and as the environmental objectives considered desirable by society are broadened. The Department of Water Resources is charged with broad and continuing responsibilities toward water quality management as a part of its role in water resource management. In order to exercise this role, new methods and techniques must be developed for evaluating the relationship of water quality to the environment and defining benefits and equating consequences of water resource management.

Increased communication with a more environmentally conscious public is also important to focus their attention on water quality management alternatives and the consequences of management strategy. There must be an expanded range of alternatives available to meet this demand.

Planning Process

The planning process covers the full range of activities in which objectives are identified and evaluated, information is analyzed and integrated, plans are formulated and updated, alternative approaches are developed, and decisions are made. The identified objectives are, of course, a function of the complex and interrelated social, environmental, ecological, and physical factors, constituting both forces and constraints, which must be considered in developing alternative management approaches. In reference to water resources, the planning process includes not only the physical needs for urban and agricultural uses, but the emerging environmental needs as well. Problems of environmental quality, however, have made necessary the development of better methods of identifying and evaluating water-related environmental objectives, which requires a wider range of coordination and an expansion of evaluation procedures.

Finally, the planning process provides a procedure for the rational selection of specific plans and programs which leads to the end product of planning--the implementation of specific courses of action to meet the needs of the people. Public review and comment is an important aspect of the planning process.

Development of an overall planning concept is important to the refinement of the planning process. In this regard, Figure 1 illustrates the relationship of the California Water Plan within the governmental organization, including policies and plans; and Figure 2 at the end of this chapter illustrates the planning concepts and process for water resource management in California. Together, these figures indicate the relationship of water resource management to overall statewide planning, and present the basic concept of integrated water resource management planning. These charts represent both established relationships and processes and areas where developmental efforts are being made.

Figure 2 represents the idealized planning process which generally guides the Department. The beginning point and foundation of the planning process is the California Water Plan, as updated and supplemented by Bulletin No. 160-66 and Bulletin No. 160-70. The studies and analyses which provide the basis for supplementing the California Water Plan are largely represented by the process described in this schematic chart. However, several significant areas of the planning concepts and techniques shown in the schematic are being improved and refined.

The overall water resource management planning process as illustrated in Figure 2 consists of three major sections. These are described in the following sections.

Policies, Goals and Plans

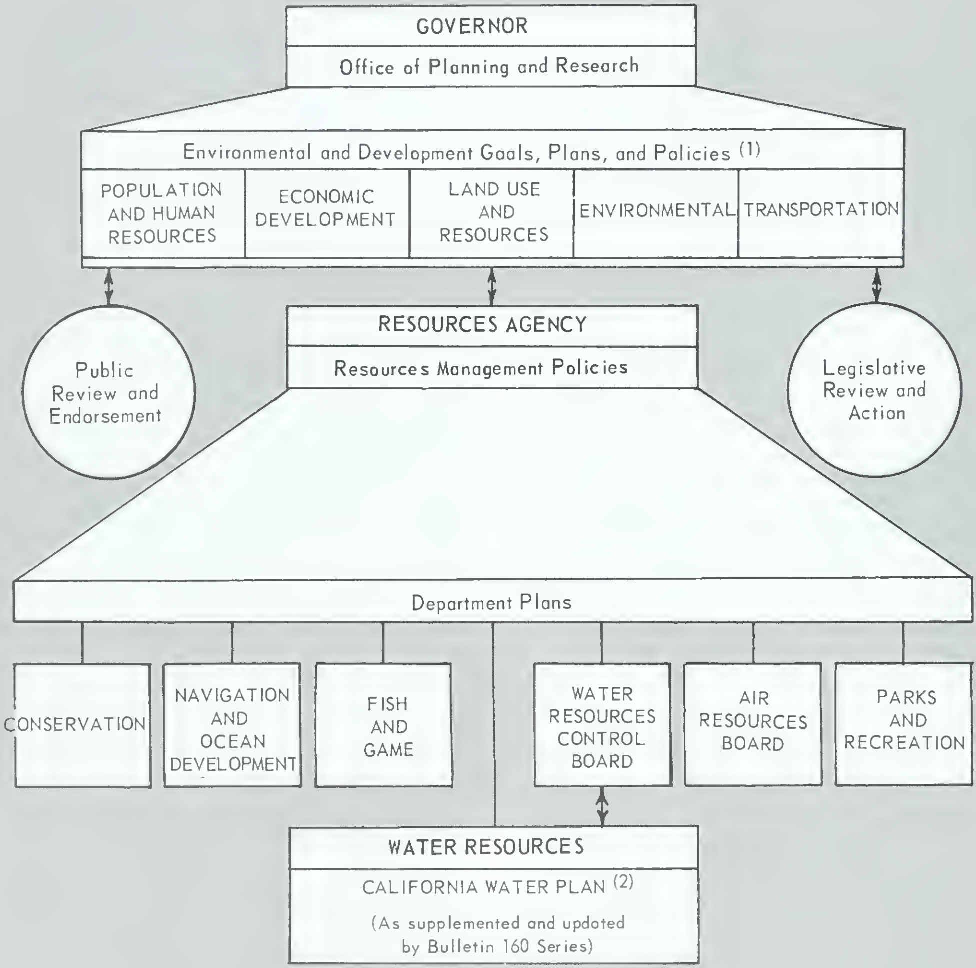
Although planning is a continuous process with feedback and readjustment of earlier phases, this portion of the diagram in Figure 2 is the beginning point. It is represented by the California Water Plan as supplemented and updated by the Bulletin 160 series; and the various policies, goals and statewide plans which have impacts upon water resource management.

The policies and plans of the State of California as a whole and the specific state development policies, shown in Figure 1, provide the basic framework within which the state water resource management planning process may be conducted in proper perspective. The state development policies embrace five major areas: population and human resources; economic development; land use and resources; environment; transportation. These policies provide the foundation for the development of the various state agency management plans. Other departments in the Resources Agency are in the process of developing their specific department plans. The California Water Plan, as updated by Bulletin No. 160 of the Department of Water Resources and supplemented by the water quality control policies and water quality control plans of the State Water Resources Control Board, represents the master plan for water resource management in California.

Although the state planning process and the State Development Plan Program have not been completed, developments in this direction will substantially improve the total planning process of the State, and will have important influences upon water resource management. It is through the further integration of these policies and plans that the State of California will be able to consider the problems of resources management and environment as a totality, and to develop plans and programs which are more capable of

FIGURE 1

RELATIONSHIP OF CALIFORNIA WATER PLAN TO OTHER STATE ENVIRONMENTAL AND DEVELOPMENT POLICIES AND PLANS



(1) The California State Development Plan Program Report discusses these environmental and development policies in terms of a comprehensive state planning process.

(2) California Water Plan takes into account the impact of the plans of other resources agencies and other State Departments. Sec. 13141 of the Water Code states that state policy for water quality control and regional water quality control plans shall become a part of the California Water Plan. Secs. 13145 and 13225 require consideration of effect of water quality actions on the California Water Plan.

meeting the interrelated and complex problems of an expanding technological society. The refinement of the water resource planning process and the integration of this process into the total state planning process is a major step in this direction.

Water Resource Management Analysis Process

This process constitutes the formulation of alternative water resource management plans and programs and is diagramed in the central part of Figure 2. The central analysis is carried as a central coordinated statewide planning activity. At this point in the process all pertinent information relating to water management in California is collected, integrated and analyzed. This analytical process results in changes in the California Water Plan based upon existing conditions, and provides the necessary information for the specific alternative plans and programs to meet the present and emerging water management needs of the State. It takes into account water resource management activities at all levels--federal, state, local and private. Through the analytical process, existing conditions, the emerging problems, environmental and technological factors and constraints, and public policies are brought together and analyzed from the standpoint of their impacts upon water resource management needs and possible solutions.

The process is carried out simultaneously at two levels of planning studies. First, on a statewide basis, overall systems analysis is provided, incorporating those factors affecting water availability, use, and disposal, and the economic and environmental-ecological consequences of changes in availability, quality, use, and disposal of water. The second level is concentrated on a more detailed analysis, focused on the local regions, service areas, and individual streams. This detailed information is required as input and parameters necessary for statewide systems analysis of water management.

The specific factors which go into the water resource management analysis are shown in Figure 2 by the type of studies which are carried out. The analysis takes into account all relevant water resource management alternatives and the estimated consequences of their implementation.

Formulation of water resource management plans and programs through continuous coordinated statewide planning analysis (broad white central arrow) is the process in which all of the information is integrated and synthesized in a systems analysis approach. Through various analytical techniques, including simulation, input-output, and other models, it brings together projections of future economic development, analysis of present land use patterns and projections of future trends, water supply-demand relationships, projection of demand for water-associated services, integration of water supply disposal considerations, and other relevant factors for identification of those specific alternative plans and programs to be considered in meeting the water management needs of the State. At many points in the process, information and opinion from the public will be sought.

The major areas of expansion and refinement of the evaluation process are in the analysis of environmental, ecological, social, economic, water quality, beneficial use, and institutional factors that are pertinent to water management plans. Advanced techniques, utilizing computer technology and associated modeling techniques, will facilitate consideration of these interrelated factors. Further, expanded use of the systems analysis approach will provide additional input for the analysis of alternative plans and programs and the selection of specific plans and programs for implementation.

Other Resources Agency studies of water resources (upper left arrow) cover the monitoring, coordination where appropriate, and interpretation of the studies and plans of federal, state, and local agencies that have an impact on the Department's water resource management planning responsibilities.

Definition of future services (lower left box) is the activity defining the requirements and objectives for water management plans. Included in this activity are studies of the magnitude and timing of future water demand and water management needs. Consideration of water-associated recreation plans, water quality control plans, flood control, and floodplain management are all important aspects of this phase of planning process.

Capability of major water development options (lower right box) includes studies to determine the yield, physical configuration, and potential accomplishments of those options that can physically provide significant additional water supplies. Options available include surface water impoundment and related conveyance systems, ground water basin operational schemes, interstate water development (Department participation in the U. S. Department of the Interior's Western United States Water Plan Study) which might lead to an out-of-state supply of supplemental water to California, desalting, and any other technological development that might make available a large supply of fresh water.

Effect of major changes in social, economic, environmental, technological, and governmental factors on water demand (upper center box) is basically the study of "nonstructural" alternatives to water development. Studies cover investigation of the extent to which major changes in present institutional arrangements would reduce or postpone the need for additional water development in California, the economic and environmental consequences of such changes, and the political and legal practicality of attempting to implement them. Studies would include consideration of: (1) reallocation of existing water supplies and water rights; (2) planned location of industries, educational facilities and other public services; (3) technological research and development; (4) reduction in water use, demand, and waste water disposal through pricing policies; and (5) land use policies.

Effects of water reuse and conservation on water supply, demand, and environmental quality (upper right box) is an evaluation of the roles of water reclamation, watershed management, evaporation and seepage suppression, and phreatophyte eradication or control in water resource management plans. Most of these options would have economic benefits of extending the use of an existing developed water supply. However, they also have the potential of greatly affecting the environment.

Water reclamation may offer the opportunity to reduce overall water supply and waste treatment costs or to realize significant environmental benefits by irrigating recreational areas and agricultural greenbelts adjacent to metropolitan areas. Other options, such as phreatophyte eradication or watershed management, can have detrimental ecological consequences by eliminating or reducing wildlife habitat. Comprehensive evaluation of each of these options is important to ensure that all benefits and detriments are identified and evaluated, including all environmental and ecological consequences.

Decision and Implementation Activity

This is an objective of the planning process, resulting in specific plans and programs to meet the water resource management needs of the State. It is in this phase that the planning process enters into the area of decision-making. Also it is at this point that the traditional planning process encounters a major criticism--the criticism that a broader range of technically feasible alternatives for meeting water development objectives should be made available to the public for consideration, along with both tangible and intangible costs and benefits for each alternative.

Through the use of advanced analytical techniques it is possible to analyze alternative approaches, particularly those based upon developing technology, and to provide a more intensive analysis of the environmental, social and economic impact of these alternatives for public review. Thus, an essential product of the analytical process is to provide a broad range of alternatives which may be considered by the public and the Legislature. These alternatives or options would be presented in terms of economic, social, and physical consequences. An important consideration at this point of the process is that the final decisions should provide a wide degree of flexibility for the future, and foreclose as few choices as practicable.

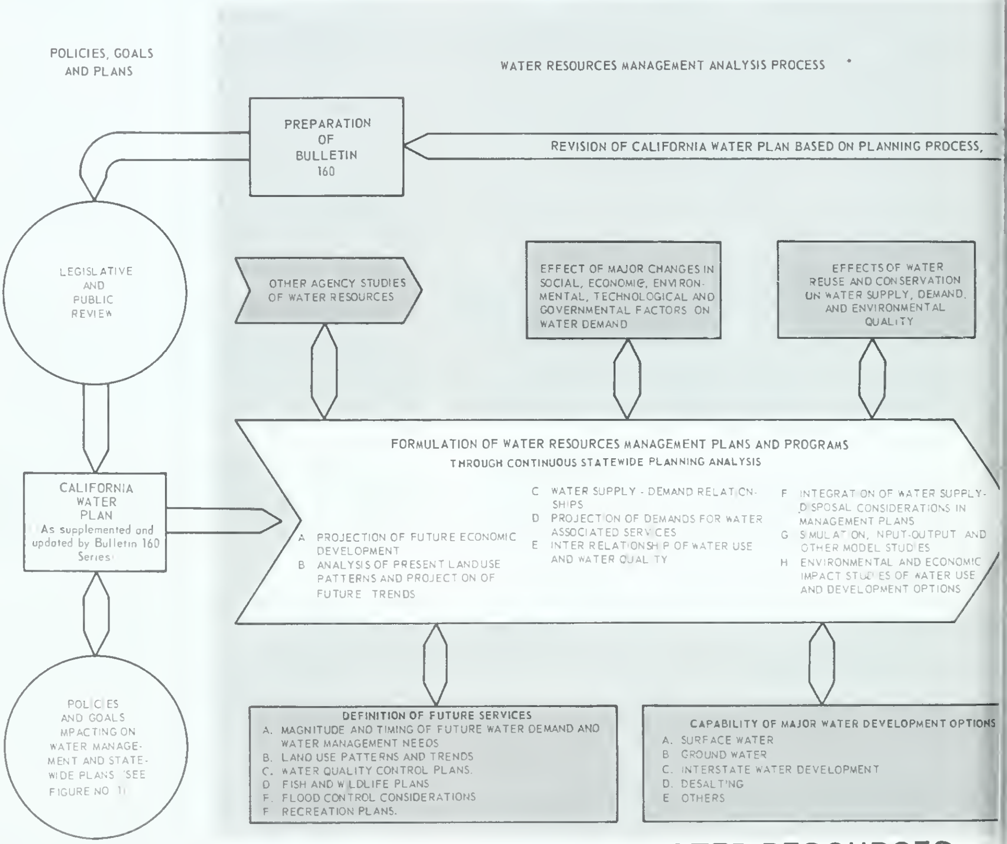
The identification of alternative plans and programs lays the foundation for the necessary public and legislative reviews which lead to the selection of specific water resources proposals and plans. Selected plans and programs would be implemented to meet the water resource management needs of the State after review and comment by the public.

At each step of the process--whether it be in the analytical process where information is fed into the system, the identification of alternative plans or programs, the selection of specific water resources plans and programs, or the actual implementation of such plans and programs--and at whatever governmental level this may take place, the resulting information, decisions and actions influence the developing California Water Plan. Periodically in the Bulletin 160 series, the Department of Water Resources analyzes and evaluates all of the changes, present and projected, and supplements the California Water Plan as best it can be foreseen at the time of publication.

In Summary, as we enter the decade of the '70s the planning program of the Department must be and will be further broadened to reflect adequately the increasing concern for environmental and ecological considerations. Many of the traditional concepts and techniques that were both relevant and sufficient for water development planning in the past must be scrutinized and reevaluated to reflect both changing technology and changing values.

The Department must provide for the water needs of the State in such a way as to minimize the adverse effects of project construction on the natural environment and, at the same time, to enhance the environment. This approach necessitates the broadening of choice among alternatives to consider parameters other than maximization of net economic benefits and least cost only. It also requires flexibility in the planning process so as not to foreclose the available options by premature selection of a course of action. The concepts of reduction of damage to the environment and enhancement of the environment will loom large in the decision-making process in the future.

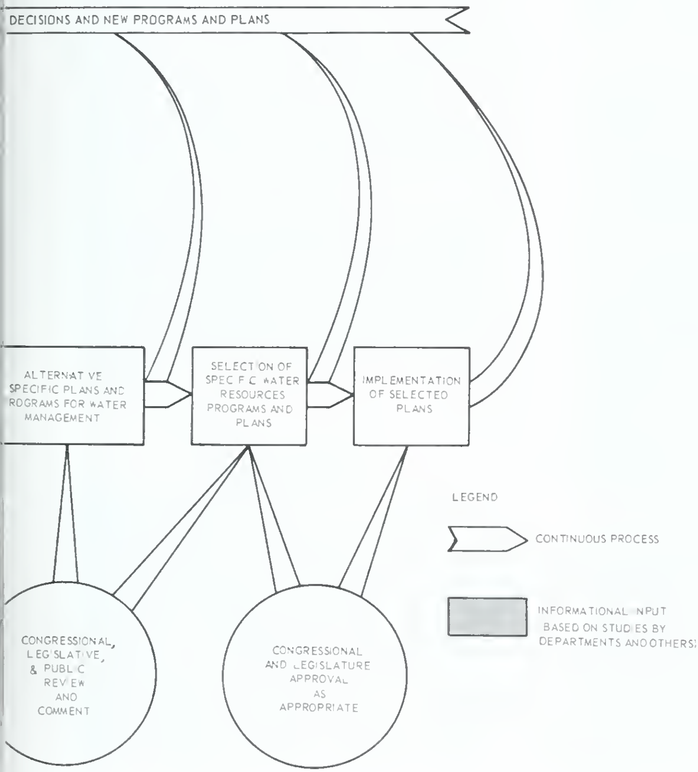
FIGURE 2



* INPUT FROM PUBLIC ENTERS THIS PROCESS AT A NUMBER OF POINTS

PLANNING FOR WATER RESOURCES MANAGEMENT IN CALIFORNIA

DECISION AND IMPLEMENTATION
OF WATER MANAGEMENT PROGRAMS AND PLANS



CHAPTER IV. WATER DEMANDS

Following publication of Bulletin No. 160-66 the Department undertook a four-year study and analysis of demands for water service throughout the State. These demands were projected to years 1990 and 2020 to provide an analytical framework for long-range planning necessary for the most effective development and use of additional water supplies from the various potential sources.

This chapter summarizes the demands for water on a statewide basis. Some of the principal determinants of future demands such as population and irrigated agriculture are discussed, as are the important aspects of recreation, fish and wildlife, flood control, and water quality.

Future Economic Development

Urban and agricultural uses of water account for nearly all of the water presently consumed in California. Estimates of population and related industrial and commercial development provide the basis for determining urban water demands. Agricultural water needs are dependent upon food and fiber requirements and irrigated acreages considered necessary to meet those requirements. This section discusses these aspects of water use.

Population

Projection of population is basic to water planning studies. In many respects it is the key to other water development needs such as agricultural production, flood control, electric power, recreation, fisheries, wildlife and water quality. Population growth has become the focal point for many environmental and ecological considerations which are becoming of increasing concern. For these reasons it is important to understand the direction and general level of present and anticipated future population trends.

Between 1940 and 1970 the State's population more than tripled, growing from about 6 million people to slightly under 20 million. Generally California's population has doubled every 20 years since 1860. A continuation of such rates would suggest a state population of 40 million in 1990 and about 60 million by the turn of the century. Two factors have occurred in the past decade which indicate that such levels of population growth in California are unlikely. The first relates to a national phenomenon--people's attitudes toward population and family size in particular. The second relates to a particularly important component of California's growth--namely, massive in-migration.

As to the first, the rapid decline in fertility rates during the past decade is one of the most striking of recent demographic trends. As recently as 1967 the U. S. Bureau of the Census published a series of population projections for the Country as a whole, corresponding to four birthrate series. These are depicted in Figure 3 as A through D. Each has been experienced at some time in the past. In August 1970 the Bureau revised its estimates, dropping series A as unrealistic and adding series E which would result in a more or less stable population The magnitude of the difference in total population may be seen in the tabulation at the top of the following page.

A constant net migration of 200,000 was used to depict the impact of the change in birthrates on the population projections for the State. The 200,000 figure is quite significant in that it reflects a reduction

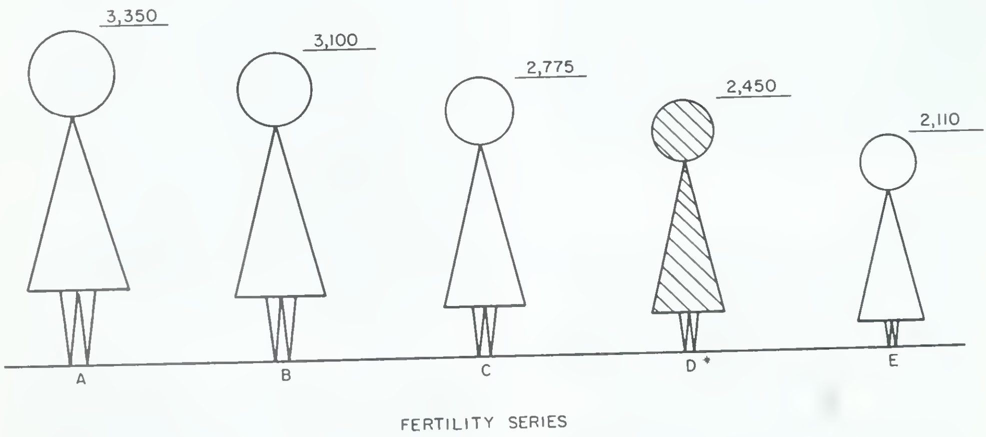
Series	U. S. Population (millions)				Corresponding California Population (millions)			
	1980	1990	2000	2020	1980	1990	2000	2020
A	240	286	337	488	25.6	32.8	41.0	65.8
B	237	277	321	440	25.2	31.8	38.9	59.1
C	232	266	301	386	24.7	30.4	36.4	51.5
D	228	255	281	336	24.2	29.0	33.9	44.7
E	226	248	266	299	23.9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

from 300,000 which for so many years was typical in California. However, in the period since 1964 there has been a progressive and substantial drop in annual net migration to California, leading to the choice of the lower level as the basis for the Department's presently adopted projections, as indicated in the following paragraph.

In view of the changes occurring in fertility rates and migration levels, the California Department of Finance made extensive revisions of population estimates for California in January 1970. Projections were made for five-year intervals to year 2000. Series D birthrates and an average annual net migration of 200,000 were assumed throughout the period. These estimates were adopted by the Department as representing the "official" projections of the State and are so reported in this bulletin. They are the basis upon which the water demands for the State have been determined.

Figure 3

UNITED STATES FERTILITY SERIES
THOUSANDS OF CHILDREN PER 1000 CHILDBEARING WOMEN



*SERIES D USED FOR MAKING CALIFORNIA POPULATION PROJECTIONS

Wildlife — — an important water demand consideration U.S. Bureau of Reclamation

Since the Department of Water Resources' planning period extends to 2020, it was necessary to extrapolate the Department of Finance population estimates to that date. It was also necessary for the Department to distribute the state totals among the 11 hydrologic areas adopted for the studies reported on in this bulletin and depicted in Figure 4. Allocations to the study areas were based on an analysis of trends, including natural increase and net migration for individual counties within the appropriate hydrologic areas. The projections of population for California and the 11 hydrologic study areas are summarized in Table 1 and Figure 5.

In general, the projections reflect a continuation of historic growth patterns. Those areas with large present populations that have undergone the largest growth in the past are expected to record the largest gains in the future. The coastal area of California, extending from San Francisco Bay southward to the Mexican border, is the prime growth area, accounting for all but 5 million of the expected 25 million increase in population between 1970 and 2020.

TABLE 1

TOTAL POPULATION IN CALIFORNIA
BY HYDROLOGIC STUDY AREA
1967, 1990, 2020

(in 1,000s)

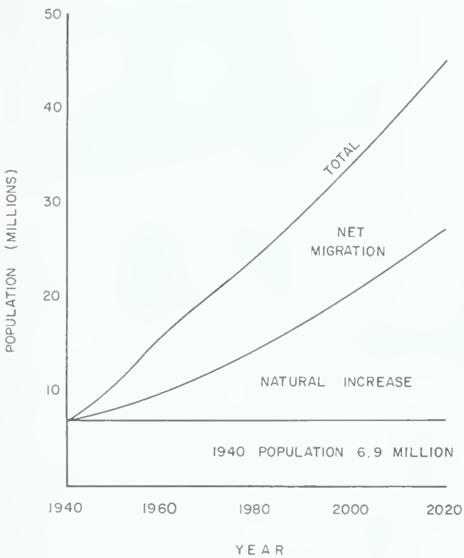
Hydrologic Study Area	1967	1990	2020
North Coastal	180	210	300
San Francisco Bay	4,320	6,500	10,100
Central Coastal	750	1,200	2,200
South Coastal	10,510	16,000	23,900
Sacramento Basin	1,140	1,600	2,300
Delta-Central Sierra	400	650	1,100
San Joaquin Basin	410	610	1,000
Tulare Basin	910	1,200	1,800
North Lahontan	40	70	100
South Lahontan	220	590	1,300
Colorado Desert	220	370	600
TOTAL	19,100	29,000	44,700

Figure 4


STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
HYDROLOGIC STUDY AREAS OF CALIFORNIA
NC — NORTH COASTAL
SF — SAN FRANCISCO BAY
CC — CENTRAL COASTAL
SC — SOUTH COASTAL
SB — SACRAMENTO BASIN
DC — DELTA—CENTRAL SIERRA
SJ — SAN JOAQUIN BASIN
TB — TULARE BASIN
NL — NORTH LAHONTAN
SL — SOUTH LAHONTAN
CD — COLORADO DESERT
NC
NL
SB
SF
DC
SJ
CC
TB
SL
SC
CD

Figure 5

CALIFORNIA'S HISTORICAL and PROJECTED POPULATION GROWTH



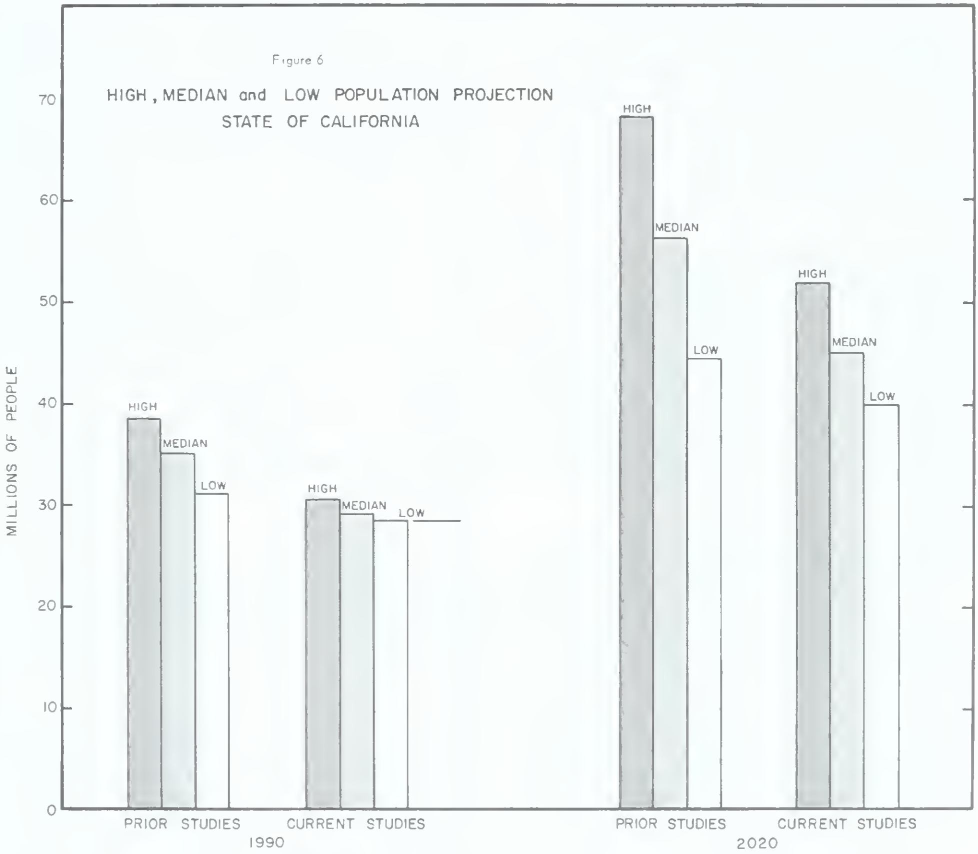
The projections shown in Table 1 represent the Department's best judgment at this time. Although the listed projections reflect recent downward trends in birthrates and net migration to California, they should not be considered either the possible high or possible low, but a median projection. As shown in Figure 6, the general range of possibilities has shifted downward. The median projection now approximates very closely the low projection made by the Department some 12 years ago.

The impact of future population levels on the timing of need for future water supplies can be quite significant. The difference between earlier estimates published in Bulletin No. 160-66 and those in this bulletin suggest a stretch-out of some 10 years before an additional source of water is needed to augment the initial facilities of the State Water Project. This will be discussed in Chapter VII. The impact involves not only the reduction of urban water demands, but also a lower agricultural water demand. On the other hand, if there is a resurgence in California's growth, as there has so often been in the past, an additional water supply could be needed at an earlier date.

Other aspects of future population growth should be recognized. There are many pressures, problems, and concerns growing out of the congestion and pollution associated with large urban areas. It is possible that changing federal, state, and local planning policies would significantly affect future urban development. One approach might be a redistribution of people. This possibility is explored in some detail in Chapter VIII with emphasis on its impact on water development needs, use, waste disposal, and other possible impacts such as air pollution. It also serves to illustrate the possible impact on water demands in highly urbanized areas as a result of a drastic change in population growth.

Industrial Development

Employment is expected to grow at about the same rate as population, resulting in approximately 4 million new jobs by 1990. At the same time shifts in employment are expected to continue between major industrial categories. On-farm employment, reflecting further technological advances, will show declines while other natural resource-based industries such as mining, forestry, and fisheries, may reflect modest gains. Manufacturing employment will have increased by about 700,000 over the next 25 years, but the largest increases are expected to occur in the service and governmental categories in response to the demands of an expanding and affluent society.



Industries requiring large quantities of water will reflect the general growth trends. For the most part the most significant water-using industries are directly related to California's population and its growth in the demands for goods and services. Ten industries are either related to agricultural or timber production.

In preparing estimates of urban water demands, the general practice is to include industrial water needs with the other components of urban use, making judgments concerning overall per capita water use in each area. However, in certain areas, analysis indicated that specific high-water-using industries, independent of the size of the local population, would account for large proportions of the total urban water use. In these cases growth and needs of such industries were evaluated separately. The resulting industrial water demands were added to the water needs related directly to population to determine total urban water demands.

Electric Power Development

Increases in population per capita consumption, and industrial-commercial uses of electricity have resulted in a phenomenal rate of growth in electric power demands, especially in recent years. These same factors will contribute to the very substantial growth in generating requirements shown in the tabulation at the bottom of this page.

Until the 1950s, the chief source of electrical power in California was hydroelectric generation. However, as hydroelectric sites have become more scarce and costly, other sources of power have become increasingly important in meeting the growing power demands. While it is anticipated that some additional capacity will be realized through enlargement of existing facilities, the major sources of additional hydroelectric power during the next 50 years will probably come from the installation of pumped storage plants.

A pumped-storage plant uses lower-cost energy available from other generating sources during periods of low power demand to pump water from a lower to an upper reservoir. When additional generating capacity is required, the water is allowed to flow from the upper to the lower reservoir through a pumping-generating unit and thus generate higher-value electric power.

The quick response and generally superior operating flexibility and reliability of hydroelectric equipment make the pumped-storage unit ideal for peaking operation and for system reserve service.

Steam electric plants will be relied upon to supply a greater portion of total power requirements in the future. Of the estimated 412,000 megawatts of the power resources required in 2020, more than 300,000 megawatts or over 80 percent may have to be provided by additional thermal plants. In 1970 fossil fuel plants were the primary source of energy with a generating capability of about 20,000 megawatts. Nuclear-fueled plants had a capacity of about 493 megawatts. In all probability nuclear-fueled plants will be emphasized in the coming decades for environmental and economic reasons.

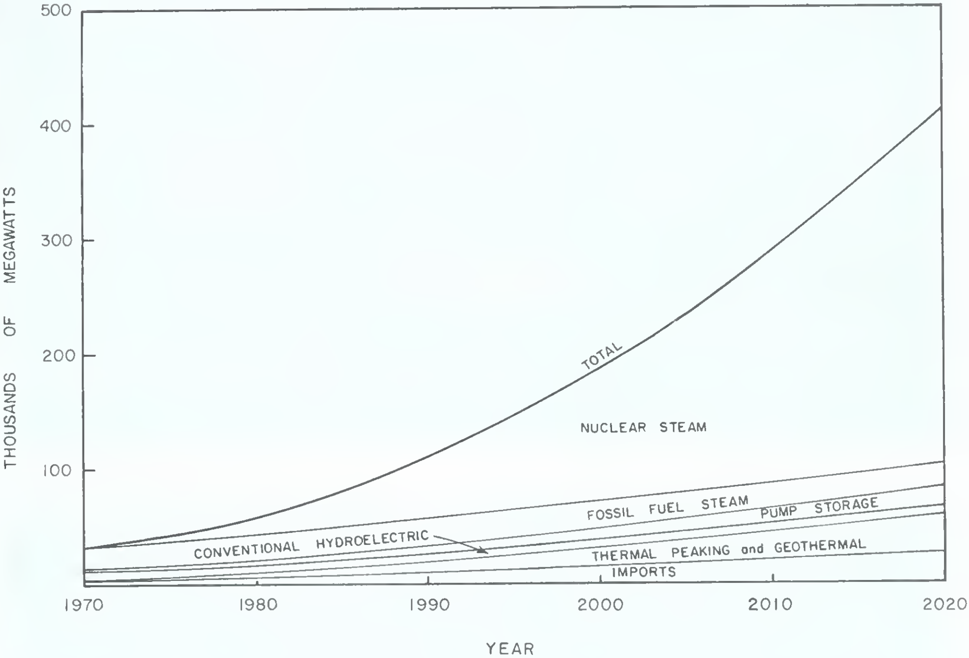
The projected emphasis on nuclear-fueled plants will enhance the desirability of pumped storage. Nuclear plants are relatively high capital cost and low energy cost. To obtain their full economic potential, nuclear plants must be kept operating at or near maximum plant capability to the extent possible. Pumped-storage plants require low-cost pumping energy for economical operation. Thus, when a power system includes both nuclear and pumped-storage units the nuclear units can be kept operating at or near full capability during periods of low power demand, and furnish energy for operation of the pumped-storage plants. Also, the nuclear units provide the low-cost energy necessary to make the pumped-storage operation economical.

The projections of electricity generated by primary sources of power is illustrated in Figure 7.

	1970	1990	2020
Generating requirements (megawatts)	32,100	110,000	412,000
Peak Demand (megawatts)	25,000	92,000	340,000
Population (millions)	20	29	45
Per Capita Energy Requirement (megawatt-hours)	7	18	46

Figure 7

GENERATION OF ELECTRIC ENERGY BY PRIME SOURCE TO MEET FUTURE POWER DEMANDS



Careful consideration will be necessary in siting future plants. Until recently, utilities have been able to find suitable locations for steam plants. However, serious problems exist at this time for a number of reasons: land area requirements; waste heat discharges; air pollution from fossil-fuel-fired plants; seismic design requirements; and required distances from population centers for nuclear plants. Because of the many and varied siting problems involved, a State of California Powerplant Siting Committee has been established. The Committee is charged with evaluating all proposed steam electric powerplant sites.

The availability of land will be an important consideration. The tabulation below indicates the land requirements for three types of thermal powerplants of 6,000 megawatts using various cooling arrangements.

Cooling System	Plant Type (acreage requirements)		
	Nuclear	Gas and Oil	Coal
Once-through	400-800	200	800-1,000
Cooling Towers	500-1,000	400	1,000-1,200
Cooling Pond	6,000-12,000	4,000-6,000	5,000-9,000

Spence Air Photos

1954

Spence Air Photos

1960

"In Los Angeles, Orange, Riverside . . . Counties over 90 percent of urban expansion . . . has taken place on agricultural lands."

Agricultural Development

California has been the Nation's leading agricultural state for more than 20 years. In 1970 the value of production approximated $4 billion. While California is expected to retain its prominence in agriculture during the '70s and beyond, the industry will undoubtedly experience substantial problems, including: a dampening of prices caused by overproduction of some commodities; rising production costs; a highly competitive market for credit; and continued pressure on land resources with attendant rises in land values and taxes. In fact, urban pressures are one of the foremost problems facing the industry.

During the past two decades 30,000 to 40,000 acres a year have been required to accommodate California's growth in population and commercial developments. Generally, about half of this growth has occurred on highly productive agricultural lands. In Los Angeles, Orange, Riverside, and Santa Clara Counties over 90 percent of the urban expansion, or 14,000 acres annually, has taken place on agricultural lands. In some counties during the past few years all additional urban development took place on crop-land.

Anticipated reductions in the future rate of population growth, coupled with higher densities, will reduce the absorption rate somewhat. But the value of land will remain high and there will be increasing pressures from an assortment of uses including recreation, wildlife habitat and preserves. Figure 8 illustrates the decrease in remaining irrigable lands (lands suitable for crop production) over the next 50 years.

It will be noted in Figure 8 that in 2020 California will still have a significant supply of lands available for agricultural development. However, in the major agricultural regions of the State much of the best agricultural land will have been put to some use by 2020 if present trends continue. In the San Joaquin and Tulare Basins an estimated 72 percent of total irrigable lands will be developed by that date. In prime agricultural areas such as Yolo and Sutter Counties and in Salinas Valley there probably will be practically no remaining undeveloped agricultural areas. In the highly urbanized regions of the San Francisco Bay and South Coast, agriculture will be virtually eliminated by urban encroachment.

Because of the many and varied pressures on agriculture, it is anticipated that California farming will continue to evolve into larger more efficient operations. Crop patterns will become even more intensive with an emphasis on high-value crops. Generally, the trend is expected to be toward the vegetables, fruit, and nuts categories in which California has a proven competitive advantage.

The present (1967) and projected irrigated acreage in California is shown by hydrologic study areas in Table 2. The location of presently irrigated and potentially irrigable lands is shown on Plate 2 entitled "Irrigated, Irrigable, and Urban Lands".

The specter of overproduction mentioned at the beginning of this section will be a matter of periodic market adjustments as it has been in the past. The next few years are expected to be particularly difficult for the producers of commodities such as fruit, nuts, cotton, and perhaps others. Adjustments are expected to take place either in the form of price reductions, reduced acreages, changing crop patterns, or an increase in California's share of market.

The longer-range projections of irrigated acreage appearing in this bulletin presume that the adjustments will have been made and that there will be a need for the additional irrigated acreages shown in Table 2. This has been accomplished by relating the supply of food and fiber to demand. The latter has been determined from increases in the projected

TABLE 2: PRESENT (1967) AND PROJECTED LAND USE AND IRRIGABLE LAND IN CALIFORNIA BY HYDROLOGIC STUDY AREAS

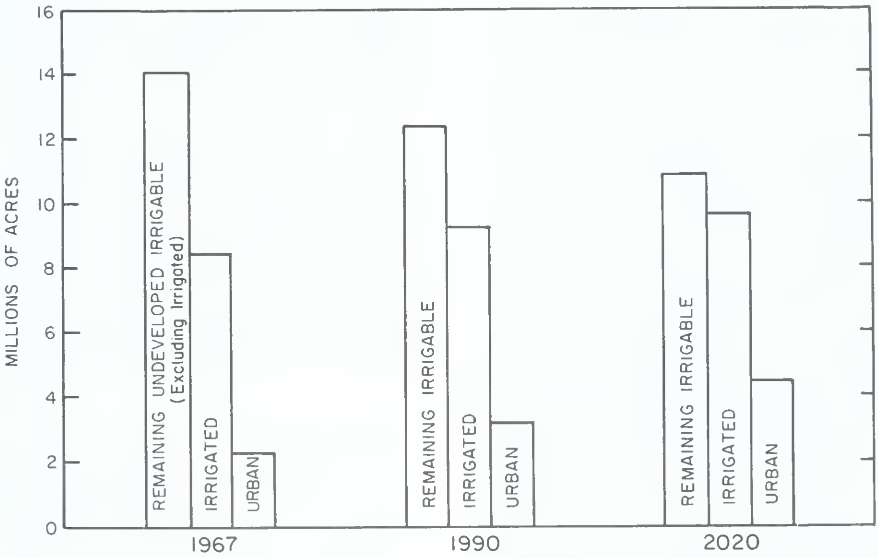
(1,000 Acres)

ITEMS	NORTH COASTAL	SAN FRANCISCO BAY	CENTRAL COASTAL	SOUTH COASTAL	SACRAMENTO BASIN	DELTA-CENTRAL SIERRA	SAN JOAQUIN BASIN	TULARE BASIN	NORTH LAHONTAN	SOUTH LAHONTAN	COLORADO DESERT	TOTALS
URBAN LANDS												
1967	50	450	130	1,050	220	60	50	150	20	60	60	2,300
1990	60	660	200	1,470	280	100	80	180	60	100	70	3,260
2020	70	980	310	1,940	360	160	120	240	130	140	90	4,540
IRRIGATED LAND AREA 1/												
1967	260	130	350	480	1,540	730	1,200	2,940	140	100	610	8,480
1990	280	120	380	290	1,770	810	1,400	3,430	140	100	620	9,340
2020	290	110	390	210	1,920	840	1,520	3,520	140	80	620	9,640
IRRIGATED CROP ACREAGE 2/												
1967	260	130	440	550	1,550	760	1,230	3,040	140	100	690	8,890
1990	280	120	490	350	1,780	850	1,440	3,580	140	100	720	9,850
2020	290	110	520	240	1,940	900	1,580	3,720	140	80	720	10,240
REMAINING IRRIGABLE LANDS 3/												
1967	560	590	1,140	1,020	2,700	920	1,310	2,080	470	2,400	820	14,010
1990	540	430	1,070	820	2,420	810	1,090	1,560	460	2,370	800	12,370
2020	520	220	980	350	2,200	730	940	1,410	450	2,340	730	10,920
FISH AND WILDLIFE AREAS												
1967	150	10	230	150	90	10	10	80	20	150	50	950
1990	180	10	240	180	120	20	30	90	20	150	60	1,100
2020	180	10	250	230	130	20	40	100	20	160	60	1,200
TOTAL AREAS	11,330	3,910	7,330	7,030	16,960	3,170	7,080	11,130	3,890	17,310	12,420	101,560

1/ Land area actually farmed and irrigated.
2/ Includes irrigated land area plus double-cropped acreage.
3/ Remaining lands suitable for irrigation after other nonagricultural uses of land have been accounted for.

Figure 8

PRESENT AND PROJECTED LAND USE



population, changes in per capita consumption, and export requirements. Taken together, these factors result in a total production requirement for food and fiber. Based upon work of the University of California Agricultural Extension Service an allowance was made for increasing future crop yields. Acreages necessary to meet anticipated food consumption were derived by dividing production requirements by the yields per acre.

In summary, the projected increase in irrigated acreage over the next 50 years will show a marked decrease from projections based on earlier trends. Historical increases from 1940 to the present and projected increases to 2020 are shown in Figure 9.

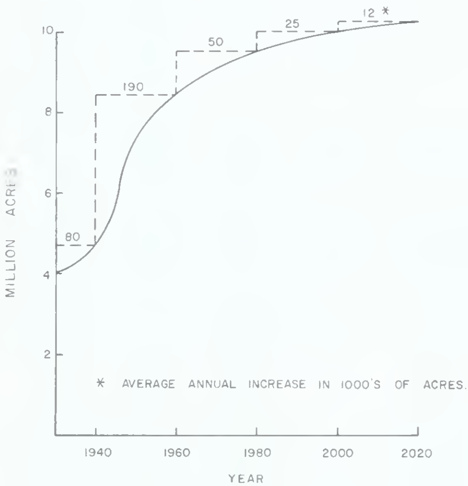
The lower projections result from continued improvements in crop yields, enabling increased production on less acreage, and lower trends in the State's and the Nation's population.

Water Demand

Future urban and agricultural water demands for 1990 and 2020 were derived as the product of economic growth, as discussed in the previous section, and appropriate water use factors. Needs for other uses such as recreation, fish and wildlife are

Figure 9

CALIFORNIA'S HISTORICAL and PROJECTED NET IRRIGATED ACREAGE 1930 — 2020



also included. The statewide summary of water demands presented in this section is actually a composite of regional studies conducted by the Department and presented in Chapter VI. The possible ways and means of meeting the projected water demands are discussed in Chapters V and VI. The resulting impact on the need for future facilities in the State Water Project and Central Valley Project is presented in Chapter VII.

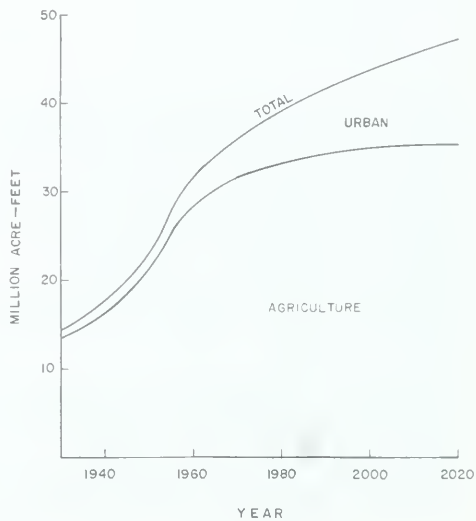
In total, the Department's findings indicate that water demands in the State are expected to increase between 11 and 12 million acre-feet from 1967 to 2020. The historical and projected growth pattern of applied water demands for urban and agricultural purposes is shown in Figure 10.

The remainder of this chapter discusses the principal uses contributing to increased water demand, namely for urban and irrigated agricultural uses. It also covers other uses of water including recreation, fish and wildlife, and flood control. The chapter concludes with a discussion of water quality considerations.

It will be noted in the discussion that water demands have been referred to as either applied or net. In water resource planning it is necessary to know and understand both. Applied water is an expression of the quantity of water that must be made available at the actual place of use. Net water demand is the quantity of water that must be delivered to a service area as a whole, including conveyance losses within the area that are not recovered for reuse. As a general rule, net demand is less than applied demand due to the possibilities of reuse within the service area. An exception to this definition occurs

Figure 10

CALIFORNIA'S HISTORICAL and PROJECTED APPLIED WATER DEMANDS 1930 — 2020



in the Colorado Desert where very little reuse is possible because of water quality considerations. In this case net demands at the actual place of use are essentially the same as applied demands. However, conveyance losses, amounting to about one-half million acre-feet, do not reach the place of use, thereby constituting an increment of net demand. This results in the net diversion demand being greater than the applied demand.

Urban Water Demands

California is a highly urbanized and industrialized state. The need for water to meet requirements for household uses, fire protection, irrigation of lawns and gardens, parks, golf courses, and industry and commerce has generally increased with the population and growth of the economy.

Over the years the Department has collected urban use values for cities throughout the State and from a large number of water agencies and manufacturing establishments. Per capita water use, or average water used per person, has been determined by relating total water deliveries for all urban purposes to the population served. Historical data identify trends in water use; when combined with the many factors influencing use, such as climate, urban densities, and industrialization, they serve as a basis for projecting per capita use.

Generally, the historical trend in per capita water use has been upward. The evidence seems to indicate that use increases with a rising standard of living. The projections, however, have been tempered by several considerations. Anticipated pressures on land and attendant development costs will tend to increase densities and decrease average lawn and garden areas, thereby decreasing outside water use. There is also some likelihood of reduced water use in the industrial sector. The growing concern over pollution and stronger effluent controls may result in less water intake. Increasing water costs and waste water treatment will encourage technological changes and economies in water use.

On a more localized basis, water use varies considerably from city to city, region to region. The per capita projections shown in Table 3 are weighted average values derived from historical data and judgments regarding a number of factors influencing water use in each region. These factors include the nature of the urban complex, whether heavily industrialized or primarily residential; densities as related to average lot size; climate; and others. A more complete discussion on this subject is published in Department of Water Resources Bulletin No. 166-1, "Municipal and Industrial Water Use".

The combination of changes in per capita use, increases in population, and expansion of the economy results in an applied urban water demand of nearly 12 million acre-feet by 2020. This compares to 4.4 million acre-feet in 1967 and 7.4 million acre-feet in 1990. Applied and corresponding net water demands are summarized in Table 4. Unless there are drastic reductions in California's future growth or a dramatic shift in population distribution as suggested in Chapter VIII, most of the increased water demands will occur in regions that are already importing water. Even if population shifts occur, the findings in Chapter VIII indicate that further water developments will be necessary. However, the date at which additional water must be made available for urban use has been affected by the general reduction in population increase.

In the South Coastal area, a very important water import area, the combination of a slower buildup in urban growth and less per capita water use has contributed greatly to lower net water demands than presented in Bulletin No. 160-66. As stated earlier, these considerations

TABLE 3

ESTIMATED URBAN WATER USE

(gallons per capita[1/] per day)

Hydrologic Study Area	1967	1990	2020
North Coastal[2/]	160	140	130
San Francisco Bay	170	200	220
Central Coastal	200	210	210
South Coastal	180	190	200
Sacramento Basin[2/]	350	350	350
Delta-Central Sierra[3/]	320	280	260
San Joaquin Basin	370	390	420
Tulare Basin	370	350	350
North Lahontan	4/	4/	4/
South Lahontan	280	320	320
Colorado Desert	380	400	400

1/ Average number of gallons of water used per person, per day. Based on projected urban water demands and urban population served.
2/ Water demands for pulp and paper production not included in per capita values.
3/ Based on urban use in valley floor portion only. Recreational and "second home" use in Sierra foothills not included.
4/ Total urban water demands for this area, as shown in Table 4, were determined by means other than per capita water use values.

Note: The above figures are weighted averages and reflect a considerable range of per capita values for communities within the study areas. The Department's Bulletin No. 166-1 should be referred to for a more detailed breakdown of urban water values and discussion regarding the various factors affecting urban water use.

will delay the timing of need for an additional water supply in relation to the timing estimated in Bulletin No. 160-66.

The significance of the projected growth in urban demands may be seen in Figure 11. Comprising only 13 percent of total water demands in the State in 1967, urban needs will account for 25 percent by 2020. On an incremented basis, total applied water demands are expected to increase about 12 million acre-feet during the 1967-2020 period. Of this amount, 7.5 million

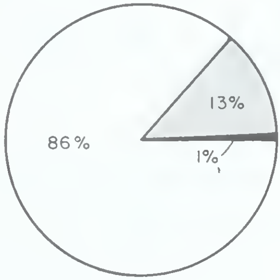
TABLE 4: PRESENT (1967) AND PROJECTED APPLIED AND NET WATER DEMANDS IN CALIFORNIA BY HYDROLOGIC STUDY AREAS

(1,000 Acre-Feet)

ITEMS	NORTH COASTAL	SAN FRANCISCO BAY	CENTRAL COASTAL	SOUTH COASTAL	SACRAMENTO BASIN	DELTA-CENTRAL SIERRA	SAN JOAQUIN BASIN	TULARE BASIN	NORTH LAHONTAN	SOUTH LAHONTAN	COLORADO DESERT	TOTALS
APPLIED WATER DEMANDS												
Urban												
1967	100	810	170	2,060	450	120	150	340	20	70	90	4,380
1990	190	1,460	290	3,450	620	270	240	440	40	210	160	7,370
2020	210	2,490	510	5,380	880	400	440	670	120	480	260	11,840
Agricultural												
1967	710	340	1,030	1,110	6,240	2,300	5,550	9,530	400	550	3,410	31,170
1990	760	280	1,180	820	7,110	2,510	5,760	11,180	440	560	3,480	34,080
2020	790	240	1,260	560	7,540	2,580	6,000	11,890	470	400	3,480	35,210
Fish, Wildlife and Recreation*												
1967	220	20	5	5	110	5	40	35	10	5	20	475
1990	220	30	5	10	200	30	90	95	20	10	35	745
2020	225	40	10	15	240	40	115	145	30	15	50	925
TOTALS (Rounded)												
1967	1,030	1,170	1,200	3,180	6,800	2,420	5,740	9,910	430	620	3,520	36,020
1990	1,170	1,770	1,480	4,280	7,930	2,810	6,090	11,710	500	780	3,680	42,200
2020	1,220	2,770	1,780	5,960	8,660	3,020	6,560	12,700	620	900	3,790	47,980
NET WATER DEMANDS												
Urban												
1967	100	800	150	1,820	450	130	50	120	20	30	60	3,730
1990	190	1,450	260	3,100	620	300	80	160	40	90	110	6,400
2020	210	2,480	470	4,920	880	460	140	250	130	200	160	10,300
Agricultural												
1967	660	320	790	660	5,000	1,800	4,290	6,240	380	390	3,900	24,430
1990	710	260	890	510	5,780	1,870	4,590	8,110	420	390	3,930	27,460
2020	740	220	940	340	6,180	1,860	4,820	8,910	440	280	3,930	28,660
Fish, Wildlife and Recreation*												
1967	200	20	5	5	110	5	30	25	10	5	20	435
1990	200	30	5	10	180	25	70	65	20	10	35	650
2020	205	40	10	15	210	35	90	100	30	15	50	800
TOTALS (Rounded)												
1967	960	1,140	940	2,490	5,560	1,930	4,370	6,390	410	420	3,980	28,590
1990	1,100	1,740	1,160	3,620	6,580	2,200	4,740	8,340	480	490	4,070	34,520
2020	1,150	2,740	1,420	5,280	7,270	2,350	5,050	9,260	600	500	4,140	39,760

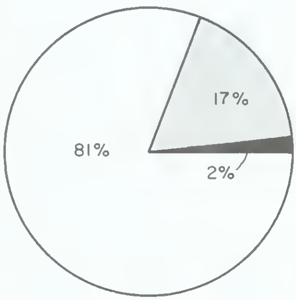
* Outdoor recreation such as hunting, fishing, hiking, camping, etc., outside of metropolitan areas.

FIGURE 11



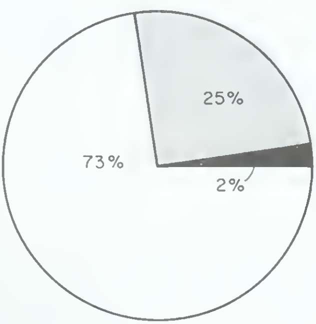
1967

URBAN WATER DEMAND	4,370,000 A.F.
AGRICULTURAL WATER DEMAND	31,080,000 A.F.
MISCELLANEOUS	475,000 A.F.
TOTAL WATER DEMAND	35,925,000 A.F.



1990

URBAN WATER DEMAND	7,370,000 A.F.
AGRICULTURAL WATER DEMAND	34,060,000 A.F.
MISCELLANEOUS	745,000 A.F.
TOTAL WATER DEMAND	42,175,000 A.F.



2020

URBAN WATER DEMAND	11,850,000 A.F.
AGRICULTURAL WATER DEMAND	35,260,000 A.F.
MISCELLANEOUS	925,000 A.F.
TOTAL WATER DEMAND	48,035,000 A.F.

PROJECTED GROWTH OF APPLIED WATER DEMANDS
STATE OF CALIFORNIA

acre-feet, or more than 60 percent, will be due to population and related urban growth.

Agricultural Water Demands

Agriculture remains far and away the largest water user in California and is expected to remain so throughout the period of analysis. Total applied water demands for irrigated agriculture amounted to 31 million acre-feet in 1967 and is projected to increase to 34 million acre-feet in 1990 and to more than 35 million acre-feet in 2020. Although this increase is only about half that expected for urban purposes, irrigated crops will still account for 73 percent of total applied water demands in 2020 (Figure 11).

Applied water requirements for irrigated agriculture are determined by multiplying the estimates of irrigated acreage for specific crops by appropriate unit water use values. Like urban per capita water use values, crop requirements vary from area to area depending on climate, farming practices, and soil conditions. Weighted averages reflect the crop pattern in each region and are summarized in Table 5.

In general, comparatively little change in unit water use values is expected during the study period. Change that does occur will result, to a large extent, from changes in cropping patterns and increases in irrigation efficiencies, especially in areas having high water costs.

TABLE 5

IRRIGATED AGRICULTURE
APPLIED UNIT WATER USE VALUES*

(acre-feet per acre)

Hydrologic Study Area	1967	2020
North Coastal	2.7	2.7
San Francisco Bay	2.6	2.2
Central Coastal	2.3	2.4
South Coastal	2.0	2.3
Sacramento Basin	4.0	4.0
Delta-Central Sierra	3.0	2.9
San Joaquin Basin	4.4	3.8
Tulare Basin	3.1	3.2
North Lahontan	2.9	3.4
South Lahontan	6.1	5.4
Colorado Desert	4.9	4.8

*Weighted average for all present and probable future crops.

March 1968

DWR NO. 3532-10

October 1970

DWR NO. 4064-15

Impact of water on agricultural development – – State Water Project serving western Kern County

Total applied agricultural water demands summarized in Table 4 exceed those in Bulletin No. 160-66 by more than one and a half million acre-feet in 1990. This occurs in spite of a reduction in projected irrigated acreage. Field studies conducted over the past four years indicate that the consumptive use of water of some crops is significantly greater than earlier estimated values. By 2020 the reduction in projected irrigated acreage is significant enough to more than offset the increase in unit use values and applied water demands are less than previously estimated.

Bulletin No. 160-66 did not report net values for individual purposes. Therefore, a comparison of net agricultural water demands cannot be made. With a few exceptions, however, agricultural water demands are far and away the most significant element of a region's total demand, and changes in total net demands largely reflect changes in that sector. For the most part, the implication is that net agricultural water demands are greater than reported in Bulletin No. 160-66.

The reason for this increase is that the Department's studies since publication of that Bulletin have provided much new and additional information regarding return flows in areas throughout the State. This information, in combination with additional knowledge of consumptive use of water and on-farm irrigation efficiencies, served as a basis for making significant changes in some areas.

Since the need for additionally developed water supplies is contingent upon the needs of a service area (represented by net water demands), the determination of the latter carries great importance. Chapter VI describes the relationship of net water demands and supplies in each hydrologic region, and Chapter VII discusses the impact of the projections in relation to water supplies on the timing of future facilities to the State Water Project and the Central Valley Project.

Water Demands for Electric Power Generation

All large thermal powerplants contain condensers requiring large quantities of water for cooling purposes. Once-through cooling, the most economical cooling process, requires a large body of water from which the water is withdrawn and returned. To reduce costs it is desirable that such plants be located close to a water supply.

Today, the cooling water required for a 1,000 megawatt unit is roughly 1,500 cubic feet per second. The amount of water actually consumed in the cooling process is considerably less. A modern 1,000 megawatt unit operating essentially continuously will use between 15,000 and 20,000 acre-feet of water per year.

The unit amount of water required for cooling will undoubtedly decrease with more efficient plants in the future. While waste water can provide a limited supply, the limited supply of fresh water and the availability of sea water coupled with the expected growth in population along California's coast will influence the siting of a significant portion of future thermal plants.

The amount of fresh water to be used for cooling in thermal powerplants will be dependent on a large number of factors, such as siting consideration, cost and availability of water. However, it is presently estimated that only about 100,000 acre-feet of fresh water will be used annually for powerplant cooling by 2020, on the premise that powerplants will be located near the ocean.

Recreation, Fish and Wildlife and Related Water Development

It is the policy of the State of California to provide its citizens with the fullest possible opportunity for recreation. This involves a variety of facilities throughout the State. The task required to meet this obligation will be formidable. Estimates place outdoor use at 1.5 billion recreation-days a year by 1990 and 2.5 billion in 2020. This compares to 218 million in 1960. The increase in demand for recreational facilities comes at a time when the competition among land and monetary resources is very keen. Government at all levels, the private sector and a general willingness of people to spend additional dollars for recreation will be required to meet the growing demand.

Since about 60 percent of all outdoor recreation involves water-associated activities, water developments have a major role to play. This section discusses some of the more important policy and financial considerations affecting this role.

Major Policies of Federal and State Water Development Agencies

Both the Federal Government and the State of California have had long-standing policies with regard to the incorporation of recreation services into water development projects. At the federal level, the most recent policy statement having far-reaching implications is P.L. 89-72. Very briefly, the document states that outdoor recreation and fish and wildlife development will receive full consideration as purposes in project formulation and evaluation, and provides for federal financial participation in the development and operation of recreation and fisheries and wildlife enhancement features, if there is major financial participation by nonfederal activities.

In California, the Davis-Dolwig Act of 1961 serves as the primary source of state policy concerning recreation and fish and wildlife at state-constructed water projects. The Act declares recreation and fish and wildlife enhancement to be among the purposes of state water projects, and requires that all reasonable actions be taken to preserve fish and wildlife. It makes clear the legislative intent of substantial action to promote recreation development. A more complete discussion of the Act and the implementation of its provisions may be found in Department of Water Resources Bulletin No. 117, "Recreation and Fish and Wildlife Program for the State Water Project", 1968.

Recreation Financing

Lack of money poses the major obstacle to recreation development and the fulfillment of the State's objective to provide its people with the fullest possible recreational opportunities. The seriousness of the situation has been recognized by the State Legislature which is attempting to find ways and means of meeting the problem. It is generally recognized that it will require the cooperative efforts of governmental and nongovernmental agencies alike. In spite of large expenditures of funds by the government and private sectors in the past, the need for recreational facilities remains larger than the supply.

This "dollar shortage" has necessitated a critical review of the state program for the planning and development of recreation and fish and wildlife enhancement facilities in connection with the State Water Project. A task force was appointed by the Secretary for Resources of California's Resources Agency to study this problem, and its findings and recommendations have been published in the "Report of the Recreation Task Force on the State Water Project", August 1967. Further discussion on this matter appears in Department of Water Resources Bulletin No. 117.

The State Electorate on November 3, 1970 approved an amendment to the Davis-Dolwig Act which provides for a total of $60 million in general obligation bonds to finance the design and construction of recreation, fish and wildlife enhancement features for the State Water Project--$54 million to be allocated to the Department of Parks and Recreation and $6 million to be allocated to the Department of Fish and Game and the Wildlife Conservation Board. To carry out this program, the legislation created a Recreation and Fish and Wildlife Enhancement Committee consisting of the Governor or his designee, the State Controller, the Director of Finance, the State Treasurer, and the Secretary for Resources.

Design and construction of recreation facilities at the State Water Projects will be implemented by the Department of Parks and Recreation. It is estimated that these water-oriented recreation facilities built in the next 5 to 7 years will provide for an additional 16 million recreation visitors. Activities to be provided for include boating, fishing, water skiing, camping, picnicking, riding, hiking, sightseeing, and swimming.

The $6 million specifically allocated to fish and wildlife enhancement includes the expansion of fish hatcheries for production of trout and warmwater fisheries, and the provision of angler access to fishing waters which has a potential of realizing millions of recreation days.

Some 17 reservoirs and more than 500 miles of canals and streams will benefit from the "Recreation and Fish and Wildlife Enhancement Bond Act Program". The tentative schedule for development in the next 5 years is to expend $8 million on facilities in Northern California, $4.5 million in Central California, and $42 million in Southern California.

The Legislature has declared that state costs for enhancement of fish and wildlife and recreation should be nonreimbursable as distinguished from other water project purposes which must be repaid by the water and power users. Furthermore, planning, land acquisition, and the joint project costs allocated to recreation are repaid to the extent available from tidelands oil revenues. Such repayment is limited to $5 million per year.

Because of the magnitude of recreation expenditures and allocations, the Department expects the full $5 million of reimbursements to be required each year for the foreseeable future. In the long run, the Department's expenditure of funds for recreation will be repaid in full. But there is a delay between actual outlay and repayment. When funds are in short supply, as they have been in recent years, such a delay puts a tight squeeze on the availability of project funds, intensifying the financing problem.

Solution of the financing problem will not come easy or without cost to the user. The implications of the projected demands for recreation suggest that annual expenditures over the next 20 years should increase sevenfold over present levels. This allows for just the increase in demand and does not include making up deficiencies that now exist.

Fish and Wildlife Planning

Prevailing state and federal law and policy (Water Code 233, Davis-Dolwig Act, and P.L. 85-624, P.L. 89-72) prescribe that fish and wildlife be given full and equal consideration with other project purposes in the planning and design of water development projects. These laws and policies have evolved in realization that the past role of fish and wildlife interests in earlier water development planning, was largely ineffective in implementing project modifications in the interest of protecting or enhancing fish and wildlife resources.

Current planning efforts are directed toward assessment of the impact of proposed water development projects on fish and wildlife, and the recommendation of measures necessary for preservation and enhancement of these resources. Special attention is being directed toward future water needs for fisheries, and measures necessary for the preservation of wildlife habitat.

Streamflow Maintenance for Fish and Wildlife. In addition to the water reserved for wildlife management areas shown in Table 4, various governmental, public, and private water and utility agencies have entered into agreements with the California Department of Fish and Game to ensure adequate streamflows and reservoir water levels to protect and improve fishery, wildlife, and recreational values. Agreements currently in force cover virtually all the major developed watersheds in California. It is most desirable that these agreements be developed early in the planning process so that adequate steps may be taken to ensure maintenance of water quality in the project area and downstream during project construction. Likewise, periodic review and revision of flow schedules can improve project operations and optimize flow regimens in the interests of fishery, wildlife and recreation. Table 6 lists current streamflow amounts by hydrologic area to indicate the extent of this important phase of water project operations.

Existing agreements are as varied as the watersheds they cover. Minimum flows may be for a stipulated amount for a specified time period, or adjusted flows may be called for to raise existing flows to desirable levels. Some stipulate the level of water withdrawal from a reservoir to bring downstream water temperatures to optimum levels for spawning. A few provide for hatchery water supplies or spawning channels or for

TABLE 6

STREAMFLOW MAINTENANCE AGREEMENTS
BY HYDROLOGIC AREA

Hydrologic Area	Annual Water Allocations for Streamflow Maintenance* (acre-feet)
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

*Water allocations shown are based on "normal year" runoff. Actual releases may be considerably less where agreements provide for the alternative release of the "natural flow" in lieu of a stipulated flow.

Sprinklers are becoming increasingly popular as a method for improving irrigation efficiency

waterfowl management areas. Where possible and desirable, certain flows over and above those stipulated are released to optimize spawning flows for salmon and steelhead.

While streamflow maintenance agreements have obviously alleviated critical water shortages that would have otherwise occurred in many streams, water allocated for these purposes, in some instances, has not been sufficient to maintain fisheries resources at satisfactory levels. Turbidity, sediment, and temperature problems have arisen under conditions of controlled flows. Corrective measures are being sought by the State where such problems exist.

Fish and Wildlife and Recreation Water Demands. The present and projected applied and net water demands for recreation and fish and wildlife, shown in Table 4, are for water used in fish and wildlife management areas and refuges, and that used consumptively by recreationists. In total, the consumptive uses of water for these purposes are comparatively small, amounting to only 2 percent of the 2020 state total water requirements. However, in individual areas, they can be very important and create serious water problems. Another very important demand for water not reflected in the projections is the demand for water for various environmental purposes, such as water quality, fishery or recreational enhancement, and instream requirements for fish, wildlife, and recreation.

The explosive growth in recreational homesites throughout much of the State is illustrative of impact of man's activities on the resources of an area, and the need for new local water supplies. In the Tahoe Basin, for example, the nonresident population accounts for about three-quarters of the area's water requirements. In Nevada County, a popular mountain recreation area, it is estimated that 36,000 new lots covering 48,000 acres have been formed through subdivision since 1964. When all of the existing lots are occupied, the treated effluent discharge is expected to exceed the normal minimum streamflows in the area. Major new water supplies will have to be developed, not only to meet domestic needs, but also to maintain suitable water quality standards in streams and rivers where such development occurs.

Flood Damage Prevention

Despite extensive planning and construction of flood control works over a period of many years in California, considerable flood damage continues to occur as a consequence of the State's continued growth and occupation of active floodplains.

All levels of government in the State have assumed some degree of responsibility in an effort to prevent flood damage. Since the passage of the federal Flood Control Act of 1936, however, the U. S. Army Corps of Engineers has taken the lead in planning and constructing flood control measures for major basins with financial aid from the State for the cost of lands, easements, and rights-of-way. Means of mitigating urban flood drainage problems have been left to the resources of local agencies.

Examination of future flood control needs in California conducted under the Comprehensive Framework Study, California Region, mentioned briefly in Chapter II, indicates the 1965 average annual flood damage of around $100 million will increase to about $160 million by 1980 if no additional flood control measures are implemented. This means that a vigorous flood control program will be needed to reduce these potential future flood damages.

Despite a continued project-oriented flood control program, the historical increase in flood damages suggests a need to adopt a more balanced approach to mitigating future flood damage. This approach should incorporate more nonstructural measures either as alternatives to, where circumstances permit, or in conjunction with structural measures.

In this regard, the Cobey-Alquist Flood Plain Management Act of 1965 mandates local government to regulate floodplain use within designated floodways prior to construction of economically justified projects as a prerequisite to state financial assistance in the cost of lands, easements and rights-of-way.

When considering future flood control measures, greater attention should be directed to desires of the beneficiaries for environmental enhancement. This suggests 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 an essential and critical element of water resource planning and management in California. Water of suitable quality must be available in adequate quantity at the times and places needed for all intended beneficial uses which may include domestic, industrial, agricultural, recreational, fish and wildlife, and other requirements.

Water Quality and Water Use

The term "water quality" has practical meaning only when associated with specific beneficial water uses. A suitable water supply is one which satisfies water quality criteria for the intended uses. Quality, therefore, is inseparable from quantity and must be evaluated along with the purposes and uses for which water supplies are developed.

Adequate planning for maximum use and preservation and enhancement takes into consideration the complex interrelations of water quantity and quality, of supply, use, and disposal. Water systems are dynamic. Changes in one part of a water system may materially affect other parts, whether those changes are in the water or on the surrounding land.

Water management and development implies quality changes. The dams on a river which are essential for reliable water supplies also result in a changed water environment, such as different water temperatures, alteration of turbidity, and changes in aquatic habitat. Changes in land use under different water use conditions may alter the runoff patterns and erosion characteristics.

Water use is closely related to waste disposal. The wastes often contain not only the constituents of the original supply in concentrated form, but also materials added or properties changed during the use. Moreover, wastes from an area may influence the quality of water supply to a downstream area.

The effects of water use and waste disposal on the water resources may be reflected in depletion of dissolved oxygen in streams and estuaries, toxic effects on aquatic life, mineralization which renders the supply unfit for further use, and the more subtle changes of eutrophication. They can include increased nitrates in ground water, sea water intrusion, or compaction of ground water aquifers by lowering water levels.

Environmental changes may not be detrimental. In fact, any water resource management program is designed to change the environment for the benefit of mankind. The major concern is to predict and control changes which will occur.

<u>Municipal and Industrial Use</u>. Water for municipal supplies is used for drinking, bathing, washing cars, irrigating lawns, flowers and trees, waste disposal, manufacturing processes, and other purposes, some of which may require special treatment to meet particular needs. Drinking water should be clear, colorless, odorless, and pleasant tasting. It must be free from disease-causing organisms and other impurities which endanger public health and should not contain excessive amounts of dissolved minerals. The most widely-used guide, or criterion, for determining the suitability of water for municipal use is the U. S. Public Health Service Drinking Water Standards. These standards specify limits for bacteriological, physical, radiological, and chemical constituents in a water supply.

Industrial water supplies vary widely in water quality requirements, depending upon the types of industrial processes involved. In general, water suitable for drinking is also suitable for most industrial uses. Cost of treatment is an important factor. Treatment costs to soften hard water to desirable levels may range from $4 to more than $20 per acre-foot, depending upon the use of water and the method of softening.

<u>Agricultural Use</u>. Quality requirements for agriculture (irrigation) depend upon many factors such as crop types, soil and drainage conditions, climate, and irrigation practices. Some crops are particularly sensitive to certain constituents, especially boron.

Drainage of irrigated lands is of major importance for continuing successful irrigation. In irrigation use relatively insignificant amounts of dissolved minerals are consumed in processes of evaporation and plant growth, and salts are left behind. Excess salts must be leached from the soil and carried off in drainage water. The content of dissolved minerals in applied irrigation water can have a significant influence on the amounts of irrigation water required for leaching. In general, the lower the total dissolved mineral concentration in the water supply, the lower the leaching water requirements. Also, the possibilities for reuse of the return water are enhanced.

Recreation. For recreational purposes, clarity, color, temperature, and bacterial quality are especially important. The best quality of water is needed for swimming and other water contact sports. Bacteriological safety is of primary importance for those activities.

General esthetics at water recreation sites also may be affected by water quality conditions. The water must be protected from obnoxious sights such as floating oil, grease, foam and debris, and from unpleasant odors. Levels of turbidity, alkalinity and dissolved oxygen must be held within desirable limits.

Fish and Aquatic Life. Water quality considerations for maintaining suitable environments for fish and aquatic life include control of dissolved oxygen, temperature, turbidity, pH, and prohibition of toxic materials or lethal concentrations of trace constituents. Spawning or propagation of fish also requires consideration of bottom deposits and careful selection of temperature levels which maintain optimum spawning conditions.

The aquatic environment has received increased attention in recent years because of the recognition that accelerated changes in the environment to meet population needs can radically change the habitat upon which fish, wildlife, and the aquatic community are dependent for their continued survival. Habitat is the collective conditions in an area contributing to the particular needs of an animal for food, cover, space, and reproduction. Each species has its own highly restricted habitat needs. Often the disruption of one small but key element in the environment can result in complete elimination of desirable species.

Isolated occurrences of accidental pollution such as oil spills or the discharge of toxic materials into receiving waters get most of the publicity; and, of course, they are cause for concern. However, chronic pollution can occur without the realization that harmful alterations are taking place; and this in the long run could cause more lasting detriments to the aquatic environment. Changes caused by chronic pollution may result in a "domino effect" where the elimination or change of one critical factor may trigger a whole series of reactions leading to the eventual destruction of a healthy aquatic community.

Water Quality and Water Reuse

The quality of a water supply is directly related to its reuse capability. A single cycle of domestic use generally results in an increase of 100 to 300 parts per million of dissolved mineral content. As previously noted irrigation return water also becomes more saline than the supply water. Therefore, in terms of total mineral content, water containing 100 to 200 ppm dissolved salts could successfully be used and reused two, three, or even four times, as compared to water which initially contains 700 to 800 ppm of dissolved salts, which may not be used feasibly more than once. Of course, reuse could also be limited by the accumulation of toxic materials or the presence of individual mineral constituents even though the total mineral concentration might be relatively low.

In the southern part of the State, the Departmentof Water Resources is engaged in a number of programs to protect and conserve the quality of

DWR NO. 3776-45

Oroville Reservoir — —

High quality water is essential for water contact sports local water supplies and to encourage reclamation and reuse of waste water for the ultimate purpose of reducing the quantities of supplemental fresh water. These programs range from monitoring and surveillance of surface and ground water and waste discharges, to working with local water entities in the formulation of plans and criteria for conserving and improving ground water quality, and developing plans for ground water basin operation and use.

Some areas in California contain ground water that is virtually unused because of its marginal or brackish quality. Such is the case in the Lower San Dieguito and Lower San Diego River Valleys of San Diego County. It may be possible to blend this poor quality water with Northern California or other water sources to produce an acceptable water supply at reasonable cost. By judicious operation of these ground water basins it is also possible that water quality might eventually be so improved that the basins themselves could be used as storage reservoirs.

Water Quality Control

The State Water Resources Control Board and the nine Regional Water Quality Control Boards are the principal state agencies with primary responsibility for the coordination and control of water quality (Water Code Section 13001). The Department of Water Resources is also mutually involved with the water quality control agencies but in a separate area of responsibility. While the control agencies are responsible for regulation of water resources in a quasi-judicial sense, the Department provides for development and utilization of the resource through planning and implementation of physical works or management techniques.

The new Porter-Cologne Water Quality Control Act protects water quality from both a practical and a philosophical standpoint by expanding the term "beneficial uses" of California's waters to include esthetic enjoyment and the preservation and enhancement of fish, wildlife and other aquatic resources or preserves. Practically, the addition of these beneficial uses will enable more stringent regulation of water use and waste disposal to protect and enhance water quality. Philosophically, the inclusion of esthetic enjoyment and enhancement of fish and wildlife is a major departure from most existing regulatory statutes. It recognizes a new environmental awareness and the growing public concern over the water resources of California.

A most significant element of the Water Quality Control Act provides for development by the State Water Resources Control Board of state policy for water quality control and regional water quality control plans. "State policy" includes:

1. Water quality principles and guidelines for long-range water resource planning, including ground water and surface water management programs and control and use of reclaimed water.

2. Water quality objectives at key locations for planning and operation of water resource development projects and for water quality control activities.

3. Water quality control plans adopted by the State Board for interstate or coastal waters or other waters of interregional or statewide interest.

4. Other principles and guidelines deemed essential by the State Board for water quality control.

The regional water quality control plans for each hydrographic area of the State encompass (1) the beneficial uses to be protected, (2) water quality objectives necessary to ensure the reasonable protection of beneficial uses and the prevention of nuisance, and (3) a program of implementation and enforcement.

These policies and plans become a part of the California Water Plan upon submission to the Legislature.

The Act also provides for regulation of wastes which could affect the waters of the State. Any person proposing such a discharge, including disposal of solid waste, must file a report of discharge with the appropriate regional board. That board establishes, in accordance with state policy and water quality control plans, requirements under which a waste discharge may be made. The requirements may prescribe the quality of the discharge, the effect upon the receiving water, or both. They may include a monitoring system and a time schedule. The Board may specify conditions on areas where no discharge is permitted. Violation of requirements may be abated through board and court actions. The violator may be subject to a fine up to $6,000 for each day of violation, or in the case of a public sewage facility, may be prevented from adding services to the system until the discharge is in compliance with requirements.

Waste discharges into waters of the State are privileges and not rights.

Thus, in addition to combining the water rights and water quality policy and regulatory functions into a single board, the Water Quality Control Act strengthens and broadens the integration of quantity-quality planning relations. It provides a focal point through the California Water Plan to ensure, in accordance with the original precept of the Plan, that the waters of the State will serve the needs of the people. As basic policy it provides that activities which may affect the waters of the State shall be so regulated to attain the highest reasonable water quality levels, the various needs to be met, and related economic, social and other considerations.

CHAPTER V. POTENTIAL WATER SUPPLY SOURCES

California's water demands generally have been met from traditional water developments by storage and/or diversion and transportation of surface supplies, and extraction of underground supplies. As the State's economy has expanded, surface water supply systems have expanded from local developments to large-scale systems involving storage and long-distance conveyance of water from intrastate and interstate streams.

However, rapidly advancing technology has focused considerable attention on other possible sources of water which are being studied seriously as potential economic water supplies. Most notable of these are desalting of the inexhaustible supply of sea water bordering California's 1,200 miles of coastline, and reuse of reclaimed waters instead of sewering them to the ocean after a single use.

This chapter discusses various possible water supply sources which could provide for increasing needs for beneficial uses and purposes. It covers development and transportation of additional surface water supplies, the significance of ground water and its relation to local and imported surface water supplies, desalting, water reclamation, weather modification, geothermal water, watershed management, Western States water development, and possible nonstructural alternatives.

The potential water supply sources described in this chapter are not presented in the sense of one alternative to be developed at the exclusion of another. The anticipated rate of growth in California's demand for water and water-related services in relation to the various potential sources of supply indicates that a combination of the water supply sources discussed may well be required; and the selection of that combination will be based on the determination of how best to schedule the development and use of the various sources to effect the optimal overall long-range satisfaction of demands.

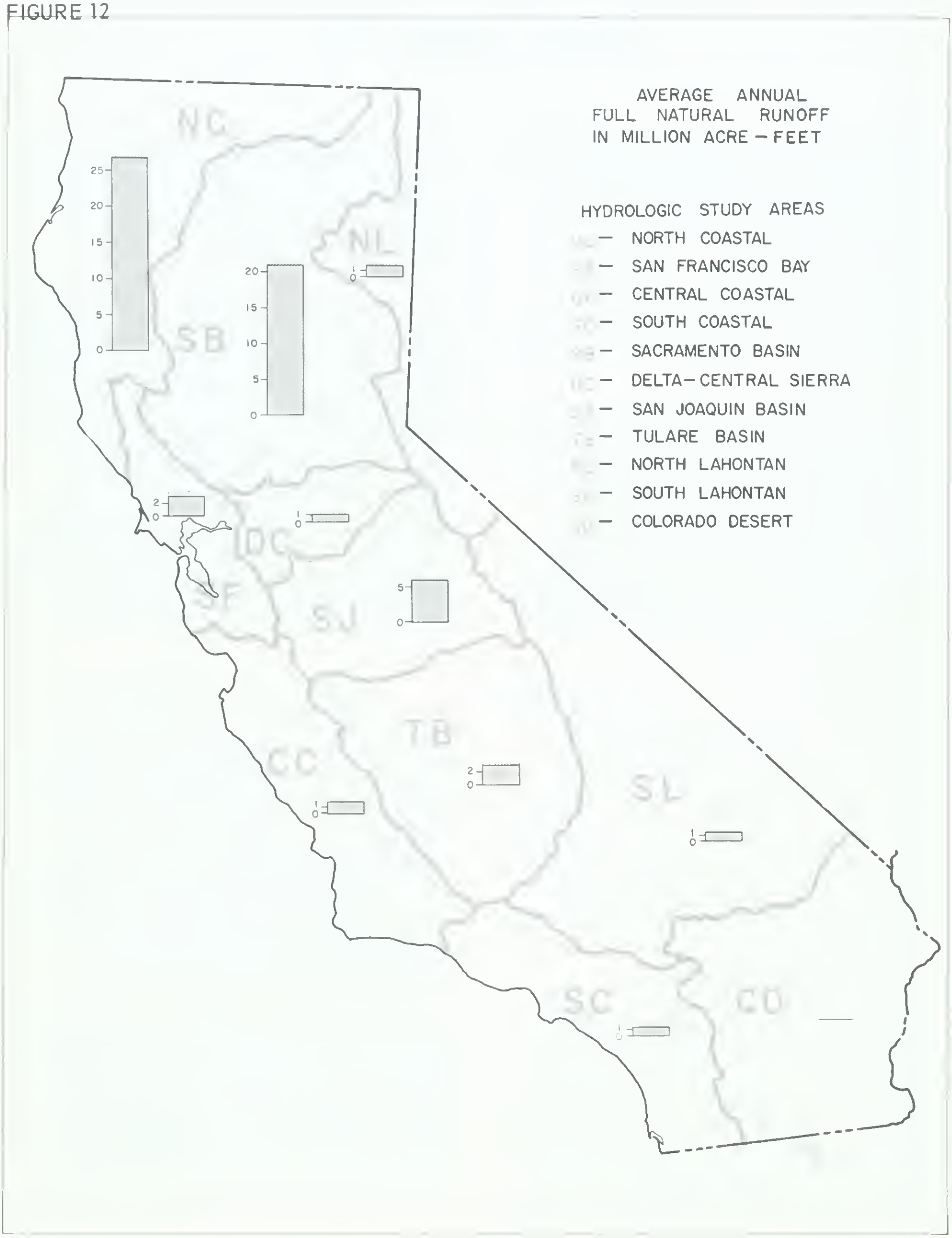
As we begin the 1970s, the accent on environmental considerations requires that a careful balance be maintained between the preservation and protection of the water resource and the development and use of that resource. Moreover, as indicated in Chapter IV, the slowdown in growth of future water demands in comparison with earlier projections suggests that more time is available for making decisions regarding further conservation projects. These considerations emphasize the need for maintaining flexibility in the analysis and choice of future options from among the various alternatives.

Surface Water Development

While surface water resources are ample to meet foreseeable statewide needs on an overall basis, they are maldistributed geographically with respect to the areas of need. For example, about 75 percent of the water resources occur north of the Sacramento-San Joaquin Delta, while some 75 percent of the requirements occur south of the Delta. The geographical distribution of runoff originating within the State is illustrated in Figure 12.

About 60 percent of the total present statewide applied water demands is supplied from surface water sources, comprised primarily of local agency surface water development, local agency imports, the federal Central Valley Project and other federal water developments.

FIGURE 12


AVERAGE ANNUAL
FULL NATURAL RUNOFF
IN MILLION ACRE – FEET
HYDROLOGIC STUDY AREAS
— NORTH COASTAL
— SAN FRANCISCO BAY
— CENTRAL COASTAL
— SOUTH COASTAL
— SACRAMENTO BASIN
— DELTA–CENTRAL SIERRA
— SAN JOAQUIN BASIN
— TULARE BASIN
— NORTH LAHONTAN
— SOUTH LAHONTAN
— COLORADO DESERT
NC
NL
SB
DC
SF
SJ
TB
CC
SL
SC
CD

Imports by local agencies include the Hetch Hetchy, Mokelumne, Los Angeles and Colorado Aqueducts. The "other federal water developments" category includes imports from the Colorado River for irrigation in the Imperial and Coachella Valleys. The local surface water developments will be specifically identified in Chapter VI which will present a comparison of demands and supplies on a regional basis. A number of existing and possible local and major projects are shown on Plate 1.

The potential for major additional development of water supplies in California is for the most part limited to the Sacramento Basin and the North Coastal regions. In the other regions the available surface supplies from the principal river systems will have been largely developed by existing reservoirs or by those presently under construction.

The potential remains for many localized surface water developments on the smaller streams. However, as with major developments, opportunities for such developments occur primarily in the North Coast and Sacramento Valley, with limited potential in the North San Francisco Bay area and the Central Coastal area.

In addition to on-stream development, a further conservation of surface water resources could be provided through the development of off-stream storage facilities within the Central Valley Basin. Off-stream storage consists of a diversion from a stream and conveyance to a storage site where adequate capacity is available. San Luis Reservoir on the west side of the San Joaquin Valley is an excellent example of an off-stream storage facility. Such reservoirs have been proposed in connection with the West Sacramento Canals Unit (Sites Reservoir); the East Side Division (Montgomery and Hungry Hollow Reservoirs); and the Delta Division (Kellogg Reservoir) of the Central Valley Project. Investigations have already been made of the possibility of constructing additional off-stream storage sites at locations along the alignment of the California Aqueduct to complement that presently provided at San Luis Reservoir. Potential storage facilities could be located at the Los Banos site in western Merced County or the Sunflower site in Kings County.

Sacramento Valley Development Potential

Two major streams with potential for storage remain in the Sacramento Valley. These are Cottonwood Creek, the largest remaining unregulated tributary of the Sacramento River, and the Thomes-Stony Creek system.

The Corps of Engineers has proposed two reservoirs within the Cottonwood Creek Basin at the Dutch Gulch and Tehama sites. These storage facilities could provide a high degree of flood protection and a new water supply of some 260,000 acre-feet annually for local and statewide service. The two reservoirs could also provide fisheries enhancement through control of the flows in the principal spawning areas of the Cottonwood Creek Basin located downstream from the damsites.

The Bureau of Reclamation has investigated a reservoir development at the Paskenta-Newville site on Thomes and North Fork Stony Creeks. This potential facility could develop a new water supply of as much as 300,000 acre-feet annually if coordinated with existing features of the Central Valley Project and the State Water Project.

Additional large storage could also be provided on Stony Creek at the Rancheria site. Rancheria Reservoir has been studied by the Department of Water Resources both as an independent project and as a part of a Middle Fork Eel River development. Rancheria Reservoir also has potential for development of an economical additional water supply by a pump-storage operation, with a diversion of Sacramento River floodflows. Studies of the

DWR NO. 3594-9

San Luis Reservoir – – *an example of off-stream storage*

latter possibility are in progress.

North Coastal Area
Development Potential

The long-term mean annual runoff from the large river basins in northwestern California is approximately 27 million acre-feet, most of which is unregulated. Prior Department studies have indicated that a physical potential exists for the development of a total dependable water yield within the North Coastal region of up to 10-12 million acre-feet annually. Those studies have also indicated that such development could be adverse to fisheries and wildlife resources, particularly in relation to the construction of large storage facilities within the lower Klamath River Basin.

Other problems of an environmental and ecological nature may also be created by traditional surface water development through reservoirs within the Klamath River Basin and elsewhere in the North Coast. The Department and the federal water agencies are well aware of these problems and of the need for more sensitive analysis of the consequences on the ecology and environment of future surface water development within the North Coastal area.

Within the upper Eel River Basin two major developments have received considerable study since 1965. These are the English Ridge Project on the upper main Eel River, investigated by the U. S. Bureau of Reclamation, and the Dos Rios Project on the Middle Fork Eel River which was proposed for authorization in 1968 by the U. S. Army Corps of Engineers. The Dos Rios Reservoir proposal generated considerable controversy, particularly because of the inundation of Round Valley in Mendocino County, and the necessity of relocating the community of Covelo and the local Indian population.

In 1969 Governor Reagan expressed his concern for these displacements and directed the Department of Water Resources to work with the Corps of Engineers to develop further information on alternatives to the proposed large Dos Rios Reservoir. These alternatives to the Dos Rios Project, involving 16 project configurations, are presented in the Department's Bulletin No. 172 entitled "Eel River Development Alternatives", December 1969.

The U. S. Bureau of Reclamation is engaged in a reconnaissance-level study of possible project configurations within the lower Trinity River Basin. The study also includes consideration of possible diversions from the Mad and Van Duzen Rivers to the Trinity River system. The work to date has been concentrated on three reservoirs--Eltapom Reservoir on South Fork Trinity and Helena and Schneiders Bar Reservoirs on the main stem of the Trinity River.

Very preliminary studies are also being made by the Bureau of Reclamation of plans for direct diversion from the Klamath and Trinity Basins. Such plans would avoid the need for main-stem reservoirs on the Klamath and Trinity Rivers and would appear to be the least disruptive to the fisheries and wildlife environment. Holdover storage would be provided in the Sacramento Valley. These direct diversion possibilities would involve extremely large tunnels and would be more costly than the previously examined on-stream storage plans. However, they could possess certain advantages from the standpoint of maintaining the Trinity-Klamath River systems more nearly in their natural environment, while at the same time conserving the floodflows for consumptive use purposes in other regions of California.

Ground Water Development

Use of ground water in California began about 1870 in the South Coastal area where, by 1900, approximately 10,000 wells had been drilled. Since the turn of the century, use of underground water resources has spread throughout the State and now provides about 40 percent of the total water needs of the State.

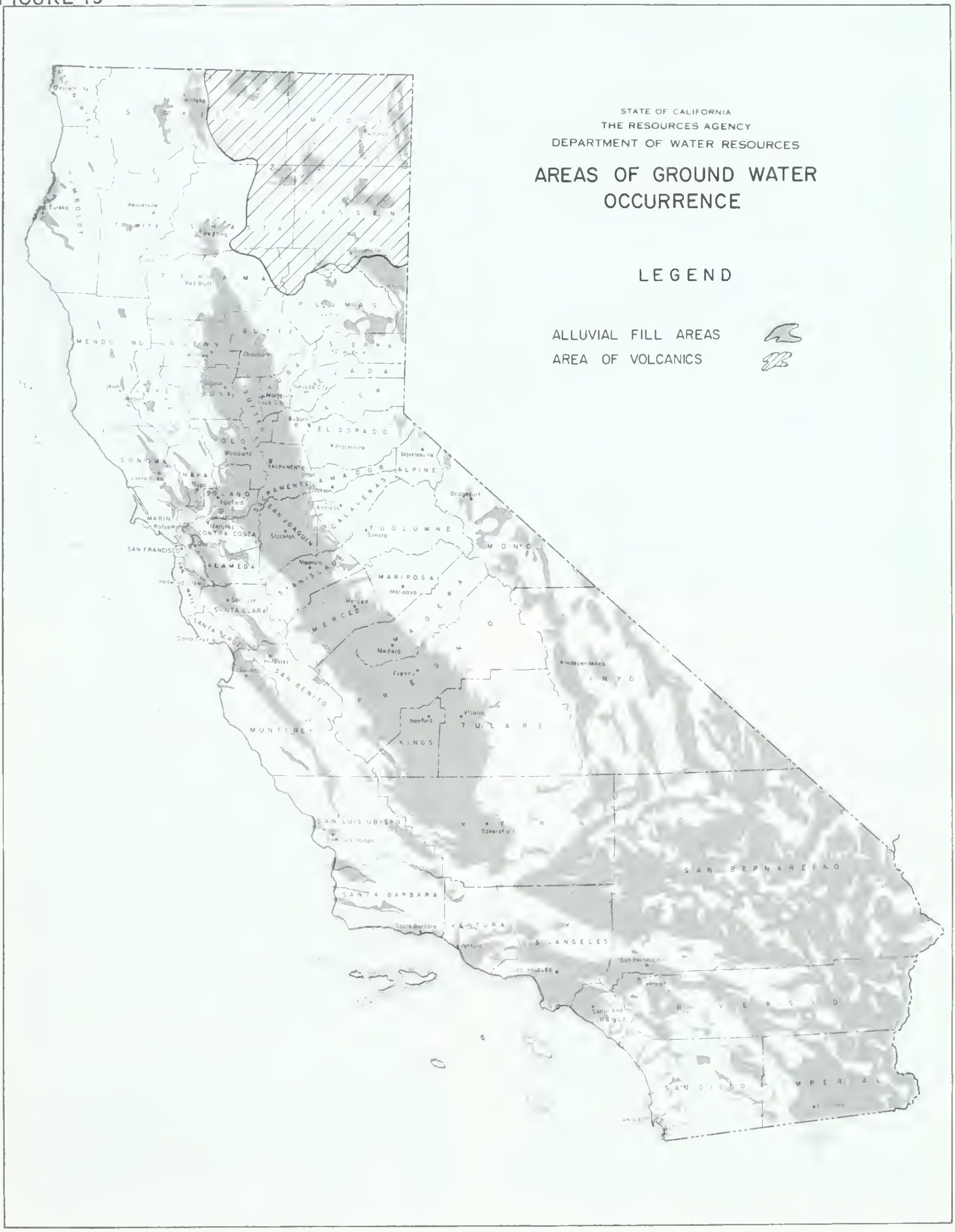
Continued and extensive use of this vast resource has not been without effects, the most apparent of which are increased pump lifts and the "drying up" of some surface streams and ponds and swampy areas. Less obvious are sea water intrusion into coastal aquifers, migration to wells of sea water entrapped inland from earlier geologic periods, and local subsidence of some land surfaces. In addition, legal actions associated with ground water use have occurred.

The characteristics of a ground water basin must be deduced from well water level measurements, well logs, and other hydrologic and geologic data. This is a lengthy and costly process which frequently has led investigators to recommend a decrease in ground water pumping to stabilize pumping lifts--or to import supplemental surface water supplies, without fully understanding the storage and transmissive potential of underground aquifers. However, the successes realized from such actions have demonstrated that ground water resources are, indeed, subject to deliberate planned management to achieve a set of established goals.

Availability of Ground Water

Ground water can be obtained in many areas in California. Production varies from a few gallons per day to several thousand gallons per minute. Interest of the Department of Water Resources has been directed

FIGURE 13


STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
AREAS OF GROUND WATER OCCURRENCE
LEGEND
ALLUVIAL FILL AREAS
AREA OF VOLCANICS
SAN FRANCISCO
SAN BERNARDINO
SANTA BARBARA
MONTEREY
SAN LUIS OBISPO
TUOLUMNE
MARIPOSA
ALAMEDA
CONTRA COSTA
SAN JOAQUIN
SACRAMENTO
SONOMA
MARIN
SOLANO
SANTA CLARA
SAN BENITO
Stockton
Sacramento
Bakersfield
Fresno
Madera
Merced
Visalia
Hanford
Independence
Bridgeport
Placerville
Jackson
Woodland
Oroville
Red Bluff
Redding
Susanville
Eureka
Weaverville
San Bernardino
Santa Barbara
Ventura

to those areas in which ground water is a significant water supply source.

Recent alluvial material (the valley fill areas of the State) provides the most prolific areas of occurrence of ground water. Alluvial fill areas and other areas of occurrence of ground water are shown in Figure 13. Most ground water studies have been made in these areas. Older alluvial materials which frequently underlie and are adjacent to the recent alluvium have also been studied where they are significant producers of ground water.

Measures of the availability of ground water include (1) annual natural replenishment or recharge (a measure of the annual yield), which is generally about half the permissible sustained pumpage; (2) total storage capacity, a relatively small portion of which is used to develop the annual yield; (3) total water in storage, which measures the magnitude of possible extraction of ground water in excess of annual yield; and (4) usable storage capacity, which indicates the portion of total storage capacity usable in conjunction with surface storage to develop a reliable system yield.

The measures of availability of ground water in known ground water basins are summarized by regions in Table 7 .

TABLE 7

GROUND WATER IN CALIFORNIA

(1,000 Acre-Feet)

Region	Known Ground Water Areas			
	Storage Capacity			
	Total	Usable	Water in Storage	Annual Primary Recharge 1/
North Coastal Area	2,000	700	2,000	150
San Francisco Bay Area	3,000	1,100	1,000	310
Central Coastal Area	20,000	7,600	18,000	730
South Coastal Area	100,000	7,000	95,000	900
Central Valley Area 2/	608,000	102,000	540,000	2,760
Lahontan Area	157,000	700	100,000	190
Colorado Desert	158,000	3,600	100,000	60
Total	1,048,000	122,700	856,000	5,100

1/ Includes natural recharge plus recharge from local reservoirs operated to augment natural stream channel percolation.

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

The table indicates a total statewide ground water storage capacity of more than 1 billion acre-feet. This estimate is compiled from published data based on varying depth criteria, ranging from 200 feet in the Sacramento Valley to 1,000 feet in other areas, except where limited by the occurrence of saline water or by non-water-bearing materials. The table also indicates that more than 800 million acre-feet of ground water is in storage. These large values are in a sense academic, as they do not represent a measure of availability of the ground water resource. Substantial withdrawal from the 800 million acre-feet of ground water in storage is analagous to the mining of oil or natural gas reserves, as it would not be replenished.

The two items of most significance in Table 7 are the usable ground water storage capacity and the annual primary recharge. Usable capacity, totaling about 123 million acre-feet, is only a fraction of total storage capacity. This estimate has been developed from studies of varying intensity. Limitations of usable storage capacity reflect economic, legal, quality (such as sea water intrusion into coastal basins), and other constraints. Further, more detailed studies are needed for refinement of estimates of usable ground water storage capacity in the individual major ground water basins, taking into account the various constraints.

The annual primary recharge shown in Table 7 includes natural ground water replenishment under present conditions and the recharge accomplished by operation of local reservoirs for detention and gradual release of water to augment natural stream channel percolation. It does not include the incidental recharge resulting from the distribution and application of surface water supplies, which is considered reuse. Such incidental recharge is substantial, and will become more significant in the future as greater amounts of surface water supplies are used. In addition, recharge from deliberate spreading of local and imported water will increase.

Ground Water Management

Management of a ground water basin involves the planned use of ground water storage in conjunction with local and imported surface water supplies to effect the most economical use of total available storage in meeting overall water demands. Such management requires deliberate augmentation of recharge to place necessary quantities of water underground, which necessitates planned extraction patterns and facilities to control internal transmission. It also will necessitate measures for protection of the ground water resource from degradation from accumulation of salts, sea water intrusion into coastal aquifers, or from pollution.

Increased ground water basin recharge often will require the use of additional storage capacity. Thus, while ground water replenishment is a most important resource, the availability of usable storage capacity, which can provide regulation to both local and imported water supplies to develop additional yield, is an equally valuable resource.

The use of ground water storage capacity can be divided into three general categories which relate to certain areas of the State.

In water-deficient areas, such as Southern California and the San Francisco Bay area, ground water storage capacity may be required to provide terminal regulation to imported water supplies. In this case ground water storage capacity provides regulation of uniform deliveries to varying monthly demand schedules.

In the San Joaquin Valley, ground water storage can be used to provide regulation of surplus water imported from Northern California during wet years for later local and possible export use during subsequent drier periods, thus complementing off-stream surface reservoir storage. In the Sacramento Valley, ground water storage capacity similarly could be operated in conjunction with surface storage facilities. This would allow some additional storage of flood waters with an increased firm water yield to meet local and statewide needs.

With regard to augmentation of recharge, planned ground water replenishment has been practiced on a substantial scale for a number of years. The spreading of water by the Los Angeles County Flood Control District in the Montibello Forebay in coastal Los Angeles County is a notable example of such operation. The principal areas of deliberate recharge on a large scale are the South Coastal area, San Joaquin Valley, and the Santa Clara Valley south of San Francisco Bay. Spreading basins, pits, and modified channels are the principal methods of placing water underground.

Prevention of sea water intrusion is an essential management element in coastal ground water basins. This involves the operation of a hydraulic barrier to create a seaward gradient along the coast. This gradient can be established by injection of fresh water into the aquifer, such as is being accomplished in the Los Angeles Coastal Plain by the Los Angeles County Flood Control District; a combined injection-pumping extraction system, such as is being employed at the Alamitos Gap by the Orange County Water District and the Los Angeles County Flood Control District; and a ground water extraction barrier, such as constructed on an experimental basis in the Oxnard Plain near Ventura by the Department of Water Resources.

During the early 1960s the Department of Water Resources developed a ground water model which permitted studies of the integrated use of surface and ground water facilities by providing information enabling an economic comparison of a range of alternative plans. The computerized model has been and is being used in a number of cooperative ground water basin management studies jointly funded by the Department and local agencies. The purpose of the studies is to provide a basis for local agency selection and implementation of the most advantageous plan.

Such studies are being used by local agencies to determine questions of zones of benefit (Kern County), benefits of possible modification of classic court decrees for ground water operation (Raymond Basin), optimization of a water distribution system (San Bernardino Valley Municipal Water District), and selection of a ground water storage system rather than a dam and reservoir for regulation of imported water (San Diego County).

The delivery of water from the State Water Project aqueduct will provide an opportunity for an additional application of ground water management practices. It involves the use of excess aqueduct capacity during the earlier years to deliver surplus water for recharge and storage underground as a reserve to meet future increased needs. Examples of such practices are indicated in the operations presently being conducted in Santa Clara and Alameda Counties in the San Francisco Bay area, in the San Joaquin Valley, and in San Bernardino County and the San Gabriel Valley in the South Coastal area. Such an operation could enable the deferral of capital investment for a subsequent water supply facility.

The foregoing ground water management possibility is the opposite of practices of the past, wherein vigorous economies have developed by continued ground water overdraft, thereby developing a financial base for construction of an importation project. Carefully planned overdraft of a ground water basin could be practiced until a supplemental water supply could be made available. However, this could be only an interim measure, as an additional water supply would be necessary to sustain the economy and provide for future growth.

Future Ground Water Use

The widespread availability of ground water in California and the increasing cost of the development of surface sources suggest a larger role of ground water in the future. However, a number of physical, economic, legal, legislative, and political factors must be identified and resolved before broad-scale planned management can be realized.

Management of ground water resources within the framework of an adopted management plan requires that the local agency be able to: (1) use ground water basin storage capacity to regulate local or imported surface waters; (2) take steps to control sea water intrusion in coastal areas; (3) regulate extraction patterns; (4) finance needed facilities; and (5) distribute benefits equitably. Procedures are already available for distribution of the annual yield of the ground water basin.

Some local agencies have powers to create hydraulic barriers to sea water intrusion, but no local agency has the power to control extraction patterns, except as accomplished through the economic pressures of a pump tax. A variety of financing measures, from direct taxation to a tax or assessment on water pumped, are available to local districts. In the future, financing methods and a method of distributing benefits could evolve into a single financial system accomplishing both purposes.

Finally, California's statutes are not clear regarding ownership of, or rights to, the use of ground water storage capacity. The only laws and regulations in this regard are those established by the courts as problems have arisen and suits have been filed by the aggrieved. A constitutional amendment might be necessary to define the right to withdraw water that has been conserved through use of this storage.

Agencies that are operating artificial recharge projects at this time record the amounts of water placed in storage as a basis for later withdrawal, but no legal basis exists for such withdrawal. Little has been done to determine the losses connected with use of underground storage, or the apportionment of losses among those agencies using storage capacity. There have been a number of proposals for a permit or license system to use underground storage, but no proposal is universally supported.

In summary, ground water in storage and ground water storage capacity constitute an extremely valuable resource at present and will continue to be in the future. The value of ground water resources lies in the use of ground water in storage and underground storage capacity (1) to provide regulation of natural replenishment, and (2) operated coordinatedly with both local and imported surface supplies, to effect the most economical use of total available storage, both surface and underground, as an integrated system. Full realization of such integrated surface water-ground water system operations in areas where the ground water resource is available will require legal and legislative action and social and political acceptance.

Desalting

Desalting is undoubtedly the most talked-about potential source of water supply to meet future needs not only in California but also in other areas of the Nation and the world. The prospects for desalting depend considerably on one's point of view. In some arid regions of the world adjacent to the ocean, literally the only alternative to desalting is water delivered by barge. In such areas the art of desalting has been practiced for many years. Many of these installations have very small capacities, and relatively large-capacity plants were ordered only recently, during the 1960s.

In California, with an abundant water supply from surface and ground water, desalting has played essentially no part to date in water development. From the standpoint of economics it is not considered that desalting will play a significant role in supplying substantial quantities of water in California much before the turn of the century. Large-capacity desalting is expected to be by that time a technical alternative and, possibly, an economical alternative to other water supply sources, particularly in coastal areas. Already, however, existing or planned coastal cities with a population of up to 50,000 and isolated inland communities could be provided with a supply of high quality desalted water from commercially available apparatus at costs acceptable for municipal and industrial uses. The subject of desalting has been reported on in depth in the Department's Bulletin No. 134-69, "Desalting--State of the Art".

Department's Desalting Program

The Department of Water Resources has had a program in desalting since 1957. Close cooperation has been maintained with the federal Office of Saline Water in an attempt to develop and expand desalting technology. The Department was authorized to cooperate with the Office of Saline Water, and the California Legislature appropriated funds for a 50-50 sharing of capital costs for the federal Office of Saline Water Demonstration Plant at Point Loma in San Diego. The State of California contributed about $820,000 to the project during its construction. After the United States moved the plant to Guantanamo Bay in Cuba, California, by mutual agreement, transferred its interest in the Point Loma plant to the Office of Saline Water test facility in San Diego.

Under provision of the Cobey-Porter Saline Water Conversion Law desalted water from this test facility is delivered to the City of San Diego through a pipeline constructed by the Department of Water Resources. The desalted water is used in the San Diego area. By the end of fiscal year 1969-70 the Department had delivered over 650 million gallons (2,000 acre-feet) of desalted water. In addition to gaining experience from handling the desalted water, the Department is gaining experience regarding the effect of desalted water on various materials and coatings from the study of 10 different test sections in the pipeline.

In furtherance of its cooperative efforts in areas of mutual interest with the Office of Saline Water, the Department of Water Resources updated on November 17, 1969 its 1958 cooperative agreement for mutual assistance in the development and application of desalting. Under the current agreement the Department will intensify its cooperative efforts in the development of potential desalting applications and sites, and in the development of a large-capacity prototype desalter. One of the early efforts will be to explore thoroughly the possibilities for the construction and operation of a prototype desalter in California. Toward that end the Department signed an agreement with the Office of Saline Water on May 1, 1970 to undertake a siting study for a prototype desalting plant.

The prototype desalter program is intended to develop a desalting plant with a nominal capacity of up to 50 million gallons per day (equivalent to 50,000 acre-feet per year). The exact capacity will be a balance between the need for technology and the market for the desalted water. Several years will be required in the selection of a water service area and a site; in obtaining authorization; and in the design and construction of the plant.

This program is needed in the 1970s to develop large-capacity desalting technology so that operating and cost information can be available for decision-making purposes in the 1980s concerning the role desalting may play in meeting some of California's future water requirements. Specifically, the program is intended to accomplish:

1. Determination of technical and operating information from a prototype desalter needed for the design and cost estimate of large-capacity desalters;

2. Operation of a prototype desalter in conjunction with an electric generation unit to evaluate interface problems between water and power production;

3. Utilization of the water in a water service area in order to gain experience in the best means of integrating a supply of desalted water with other water supplies;

4. Establishing means of environmentally acceptable operation, especially in connection with the discharge of warm sea water and brine back into the ocean.

Federal Desalting Program

Since congressional enactment of the Saline Water Act in 1952, the Federal Government has been actively developing desalting technology. The Act provides for the development of practicable low-cost means of producing water of a quality suitable for various beneficial uses on a scale sufficient to determine the feasibility of production and distribution on a large-scale basis. The term saline water includes sea water, brackish water, and other mineralized or chemically charged water.

Federal expenditures for desalination were modest until the mid-1960s when a large expansion was made in the program. Expenditures during fiscal year 1969-70 were about $26 million. The larger budget has permitted the federal Office of Saline Water to substantially expand the reserach and development work it can support.

Current Status and Cost of Desalting

The aggregate capacity of desalters on a worldwide basis has increased from 60 million gallons per day in 1961 to about 310 million gallons per day at the start of 1970, for an annual growth rate of 18 percent. The total desalting capacity by 1975 is projected to increase to 1,250 million gallons per day.

Prior to 1967 the largest single-unit sea water desalter had a capability of producing about 1.7 million gallons per day (1,700 acre-feet per year). In 1967 a desalter was placed in operation in Key West, Florida, with a capability of producing 2.6 million gallons per day (2,600 acre-feet per year) in a single-unit plant. The Key West plant desalts sea water for about 85 cents per 1,000 gallons, or $280 per acre-foot. It was the largest in the world until late 1968 when a plant was completed at Rosarito Beach, Mexico. It has a capability of 7.5 million gallons per day (7,500 acre-feet per year) from twin-unit desalters, each with a capacity of 3.75 million gallons per day. Desalted water from the Rosarito Beach plant has been estimated to cost in the 65-to-75-cents-per-thousand-gallon range ($210-245 per acre-foot).

In 1969 Kuwait purchased five desalting units, each with a capacity of 6 million gallons per day for a total capacity of 30 million gallons per day. These plants are expected to be placed on the line starting in 1971. The projected cost of desalted water from the 6-million-gpd plants is expected to be about $100 per acre-foot. However, in Kuwait the cost of fuel is only about one-tenth the cost in California.

Studies and plans are under way in many countries for much larger desalting plants, usually in combination with power production. A nuclear reactor is the most likely energy source for these very large plants.

One of the most complete studies for determining the probable cost of desalted water in large-capacity plants was the Bolsa Island Project, a dual-purpose nuclear power and desalting plant, studied by the Metropolitan Water District of Southern California, local power utilities, the U. S. Office of Saline Water, and the U. S. Atomic Energy Commission.

The desalted water from the Bolsa Project delivered to the Diemer filtration plant for distribution was estimated in 1965 to cost $88 per acre-foot ($0.27 per thousand gallons), and estimated in 1968 to cost $143 per acre-foot ($0.44 per thousand gallons). This project did not proceed largely because of escalation and the cost and uncertainties associated with licensing of the nuclear reactors.

Desalting in the Future

As the technology of removing dissolved solids from water is developed and the cost of such processes is lowered, the economic feasibility of supplying desalted water to more areas of the State will increase. It is anticipated that developments in desalting will provide new and promising means to assist in the future development of California's water resources and must be considered as an option in the development of future water supply sources.

Reduction in the cost of desalted water from large-capacity plants of the future can be achieved through the application of nuclear energy, most likely in dual-purpose plants. However, nuclear desalters will encounter the same licensing and safety problems as will nuclear power-only plants. A satisfactory solution to siting on the California coast will not be easy. Failure to achieve resolution of the siting problems may add materially to the cost of desalting as an alternative source of supply to meet future needs in California.

At the present time the distillation methods (the use of heat to boil water) of desalting show the most promise for large-capacity sea water desalting. Developments have been substantial with the reverse osmosis process (the separation of water from the salt solution by passage through an organic membrane). It seems entirely possible that continued developments in this technology could substantially widen desalting options in the future in terms of sea water, brackish water, and waste water desalting and in the flexibility of plant locations.

The distillation method of desalting produces almost salt-free water. This high-quality water would have a value in "stretching" existing supplies and in water quality management in general. This potential exists in several areas of California where the water supplies presently available are slightly brackish but could be made more usable through a blending process.

Looking into the future, the expectation is that the technology needed to build dual-purpose nuclear systems could be developed so that construction of large-capacity sea water desalters might be initiated in the mid-1980s for operation in the 1990s. Also in the 1990 time frame the reverse osmosis process utilizing electro-energy may be developed so that such desalters for sea water and other salt waters, including waste waters, can be located close to the point of water demand and at the same time at a considerable distance from the necessary power source. As larger capacity facilities are built, brine disposal problems will become more formidable.

Many factors that will influence the cost of desalted water in the future cannot be determined with certainty. Expectations, however, appear to be sufficiently attractive to warrant continued consideration of desalting as an alternative for future augmentation or supplementation of water supply.

Water Reclamation

The 2 million acre-feet of municipal waste water discharged annually in California represents a significant flow of water to be considered in planning for future water supplies. At the present time less than 8 percent of this waste water is reclaimed for beneficial uses. Although certain technical, economic and other factors would preclude renovation and reuse of all waste water generated, there would still be an important residual that could be put to beneficial use, thereby stretching the use of a primary water supply to meet increasing water demands in a region. Water reclamation also can reduce overall waste disposal costs and translate potential water quality control problems into environmental enhancement.

Conditions are becoming increasingly more favorable for water reclamation. Current emphasis on "clean water", for example, necessitates higher levels of treatment solely for the purpose of waste water disposal. Also the public is becoming more receptive to the idea of water reclamation and reuse. In considering the feasibility of water reclamation as a potential source of additional water supply, all benefits, costs, constraints, and other factors must be evaluated, as is done with any other potential water supply source.

This section discusses the role of the Department of Water Resources and the potential and present status of water reclamation in California.

The Department's Role in Water Reclamation

In planning for water supplies to meet future needs the Department of Water Resources considers water reclamation of significant potential. Since 1952 the Department has collected information on waste treatment facilities, quality and quantity of major waste discharges, and waste water reclamation projects in California. At the present time an inventory is maintained on the quantity of significant waste discharges in the metropolitan areas of the South Coastal and the San Francisco Bay areas.

This inventory serves as a basis for more detailed studies of the feasibility of waste water reclamation to meet a part of the demand for additional water supplies. Data are obtained on the quantity of reclaimable water, beneficial uses, and costs of producing reclaimed water. The objectives of such studies are to evaluate the practicality of reclaiming water from waste flows and to encourage and stimulate the planned reuse of waste waters of suitable quality, where warranted.

The Department considers three general ways in which waste water is recovered for beneficial use: (1) by discharging effluent into a natural water course such as a river or ground water basin, without deliberately intending to reclaim the water, (2) by constructing and operating facilities for the express purpose of reclaiming water from wastes, and (3) by directly putting to beneficial use effluent from a treatment facility intended primarily for sewage disposal.

Water reclamation as defined under item (1) occurs incidentally in normal water use and waste water disposal practices in inland areas and is not included in any estimates of quantity or cost in this section. Items (2) and (3), but primarily item (2), deliberate renovation of water, are of concern in this discussion. The major factors of concern in deliberate renovation and reuse of waste water are protection of public health, concentration of dissolved minerals, costs, and public acceptance.

Most existing water reclamation projects employ conventional sewage treatment processes to remove objectionable materials from the waste water. For example, the secondary sewage treatment process, if properly designed and operated, can produce a clear, odorless effluent, almost completely free of organic and bacterial content. Additional treatment, such as filtration and disinfection, can ensure destruction of most disease agents; however, these processes produce very little change in the mineral content of the water. Reclaimed water is not used directly to meet domestic water demands because of problems of detection, identification, and removal of virus and other disease agents.

Potential Future of Water Reclamation

The most favorable opportunity for economical direct reclamation of waste water appears to be in those locations in the State where imported primary water supplies are expensive, and where large quantities of water with low mineral content are discharged to the ocean after only one use. These conditions prevail largely in California's South Coastal and San Francisco Bay areas. Moreover, the present national, state and general public interest in high levels of water quality impose increasingly stringent waste discharge requirements. Compliance with these high standards will necessitate expensive and more advance treatment facilities whether or not water reclamation is intended. Any additional costs for reclamation should be relatively small and this should encourage a trend for more waste water reuse.

In the Central Valley and other inland regions of California almost all waste water is reused incidentally. Quantities are taken into account in planning for future water supplies to serve these regions, but are not identified specifically as water reclamation. Also, agricultural return flows are not considered as waste water in the context of this discussion, as flows, for the most part, are retained in the water supply system and are available for reuse. Accordingly, they are regarded as part of the available supply in the Department's planning studies.

In the North Coastal region, water supplies are basically plentiful; therefore, the necessity for reclamation and reuse of waste water is not considered of immediate importance. As in the Central Valley, water is indirectly reclaimed where waste water is returned to streams and becomes a part of the downstream water supply.

In evaluating the potential of water reclamation a determination must be made of the quantities of water that can be feasibly reclaimed from waste discharges in each area. Feasible water reclamation may be defined as the amount of water produced by the waste water treatment process that can be reclaimed and directly used in an area to meet the economic demand for water without causing physical, economic, and public health detriments. Feasible water reclamation quantities are considered in the Department's water supply projections and are based on project feasibility studies. These studies include consideration of costs, demands for reclaimed water, and physical constraints such as ground water recharge capacity.

Quantities of waste water generated in an area are directly proportional to quantities of water supply. Consumptive uses and system losses reduce the total quantity of municipal waste water to about 50 percent of the total municipal water supply. The quantity of waste water that can be feasibly reclaimed may be limited by the quality of waste water, cost of treatment, prospective uses, and location of prospective use sites. Also a certain amount of water would still be needed to transport residual wastes to the ultimate disposal site such as the ocean. In general, not more than about 20 percent of the total municipal water supply in coastal communities should be considered available for reclamation on a practical basis.

Waste water containing total dissolved solids in excess of 1,000 parts per million generally is unsuitable for most beneficial uses and is not considered potentially reclaimable at this time. Also, the presence of specific chemicals, such as mercury, arsenic, cyanide, fluoride, boron, phenols, nitrate, and sulfate, as well as other toxic materials, could cause waste water to be unsuitable for reclamation. Additional research is needed on detection, removal, and effects of toxic materials in the water environment.

Although there are certain restrictions on its use, reclamation of waste water is increasing in the South Coastal area and other areas where it can be put to beneficial use locally. At the present time the City of Los Angeles and the Los Angeles County Sanitation Districts dispose of approximately 700 million gallons of waste water per day (780,000 acre-feet per year), mostly through ocean outfalls into Santa Monica Bay. However, there is a trend toward constructing the new waste water treatment plants farther inland. This is more economical than constructing long trunk sewers and ocean outfalls. Also, relatively inexpensive water supplies become available to downstream areas of use with little or no pumping required.

The potential amount of water which may be reclaimed from wastes in the South Coastal area, where about 90 percent of the State's potential lies, is estimated to increase from 110,000 to 1.1 million acre-feet per year between 1970 and 2020. This is shown in the tabulation at the bottom of this page which also indicates that feasible reclamation in that area could range from about 60,000 acre-feet per year at the present time to 600,000 acre-feet per year by 2020. The difference between potential water reclamation and feasible water reclamation, as shown in the tabulation, could be considered as a possible additional supply to satisfy uses not included in the projected water demands discussed in Chapters IV and VI.

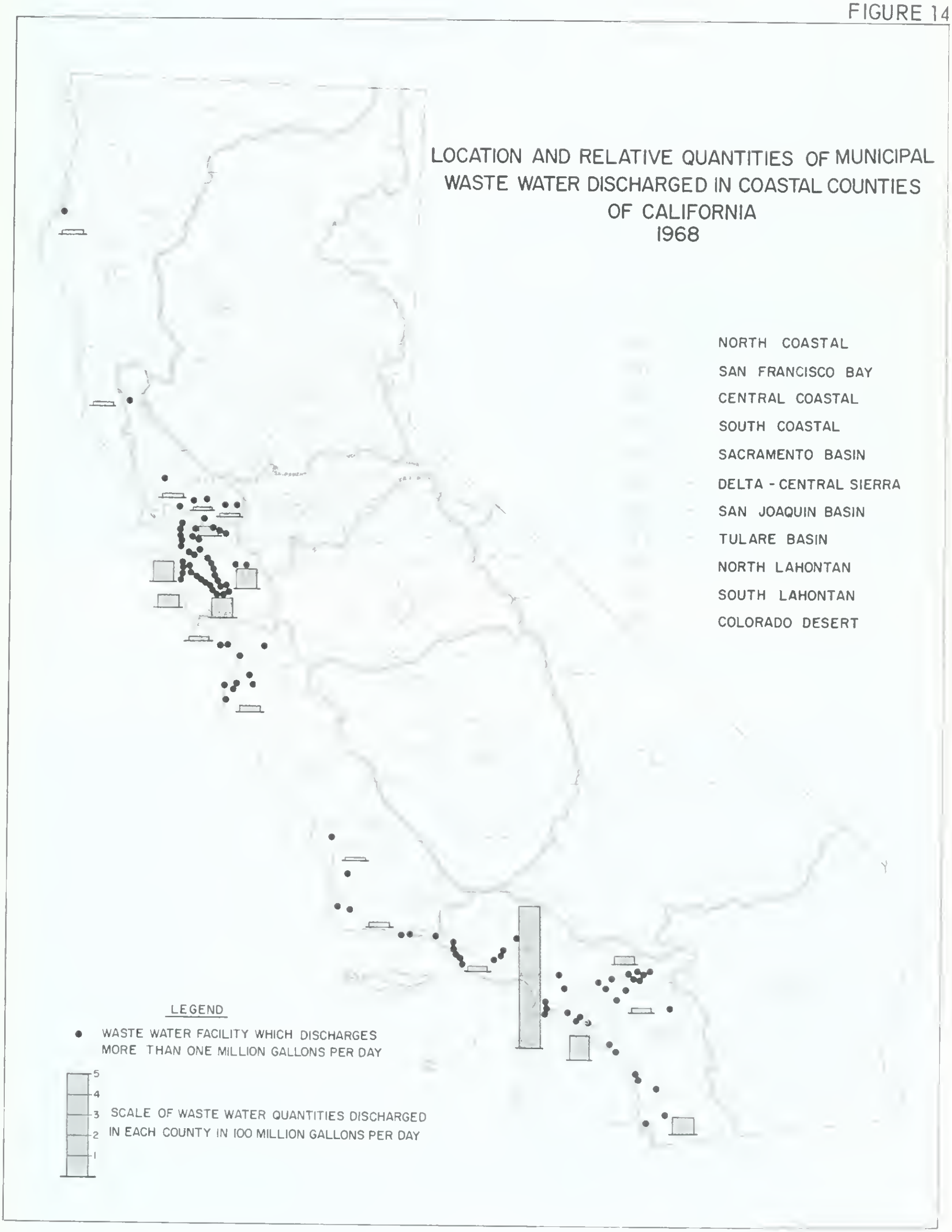
In the future, uses for reclaimed waste water undoubtedly will expand, including uses for landscaping, greenbelts, fire suppression, and recreational lakes. In brushy areas waste water could be used to reduce fire hazards. On an integrated system basis, digested sludge from the waste treatment plant could be used as a soil conditioner and fertilizer. Also, nutrients in waste water are major fertilizer ingredients and could be beneficial in an irrigation water supply.

Present Status and Use of Reclaimed Water

Figure 14 shows locations of all coastal municipal waste water

	1,000 Acre-Feet		
	1970	1990	2020
Waste Water Production	1,225	1,960	2,700
Potential Water Reclamation	110	760	1,100
Feasible Water Reclamation	60	300	600

FIGURE 14


LOCATION AND RELATIVE QUANTITIES OF MUNICIPAL WASTE WATER DISCHARGED IN COASTAL COUNTIES OF CALIFORNIA
1968
NORTH COASTAL
SAN FRANCISCO BAY
CENTRAL COASTAL
SOUTH COASTAL
SACRAMENTO BASIN
DELTA - CENTRAL SIERRA
SAN JOAQUIN BASIN
TULARE BASIN
NORTH LAHONTAN
SOUTH LAHONTAN
COLORADO DESERT
LEGEND
WASTE WATER FACILITY WHICH DISCHARGES MORE THAN ONE MILLION GALLONS PER DAY
5
4
3
2
1
SCALE OF WASTE WATER QUANTITIES DISCHARGED IN EACH COUNTY IN 100 MILLION GALLONS PER DAY

facilities which discharged more than 1 million gallons of effluent per day in 1968. Also shown, graphically, are total quantities in 100 million gallons per day of municipal waste water discharged in each coastal county. The figure illustrates the greater concentrations of individual waste water facilities as well as the greater quantities of municipal waste water discharged in the San Francisco Bay and South Coastal areas.

A directory compiled by the California Department of Public Health in 1969 listed 172 water reclamation projects either under construction or in operation in California. The directory included the use or uses to be made of the reclaimed water. Irrigation of agricultural crops, principally fodder and pasture, was carried out in 138 projects.

Present water reclamation in California aggregates about 135,000 acre-feet per year with irrigation as the major application. In 1967 about 95,000 acre-feet of reclaimed water was used to irrigate nearly 23,000 acres of land at various locations. The following examples cover some of the major types of use.

At Golden Gate Park in San Francisco reclaimed water supplies about 1 million gallons of water per day (1,100 acre-feet per year) from the middle of January through November for use in the park's ornamental lakes and irrigation system. This source supplies about 25 percent of the 1,017-acre park's water needs for horticultural purposes.

The Whittier Narrows Water Reclamation Plant of the Los Angeles County Sanitation District has established the practicality of large-scale planned ground water replenishment operations using reclaimed domestic waste water. The facility reclaims 14 million gallons per day (15,000 acre-feet per year) of domestic sewage for downstream ground water replenishment.

At Santee in San Diego County the Santee County Water District operates a planned water reclamation system of small lakes for recreation. About 4 million gallons per day of domestic sewage, after secondary treatment and pond oxidation, is pumped upstream to Sycamore Canyon where effluent percolates through the alluvium to collection galleries for use in the recreational lakes. Six lakes have been created, four of which are used for fishing and boating. Some of the lake water is further treated and used in a nearby swimming pool. A park adjoins the lakes with picnicking and playground facilities. Some of the reclaimed water is used to irrigate a nearby golf course.

The Indian Creek Project of the South Tahoe Public Utility District was also implemented because of a need to dispose of waste water. There were indications that nutrients from waste water discharged into Lake Tahoe were stimulating the growth of algae which could eventually destroy the alpine-blue color of the lake. As a partial solution to the problem waste water generated on about one-half of the land surrounding the lake is now given advanced tertiary treatment in a plant designed for 7.5 million gallons per day and pumped out of the basin into Indian Creek Reservoir in Alpine County. The water is used for irrigation in the downstream Carson River drainage. Indian Creek Reservoir also has developed an abundance of aquatic life and the beginning of what may turn out to be one of the best fisheries in Northern California.

Water Reclamation Studies. It was mentioned earlier that the Department has conducted studies of the feasibility of waste water reclamation in meeting a part of the demand for additional water supplies. Studies have been completed for the San Francisco-San Jose area, Watsonville area, Los Angeles metropolitan area, coastal San Diego County, Coachella Valley, and Ventura County. A study is now

DWR No. ... 86-4

Santee – – *One of four lakes used for fishing and boating*

South Tahoe Public Utility District

Indian Creek – – *Reclaimed water supply to lake exceeds U.S. Public Health Service drinking water standards* under way in San Luis Obispo County. Bulletins which have been published to present the findings of the completed studies are listed below. Unpublished reports or data on additional studies are available in the Department's files.

1. Bulletin No. 67, "Reclamation of Water from Sewage and Industrial Wastes, Watsonville Area, Santa Cruz and Monterey Counties", 1959.

2. Bulletin No. 80, "Feasibility of Reclamation of Water from Wastes in Los Angeles Metropolitan Area", 1961.

3. Bulletin No. 80-2, "Reclamation of Water from Wastes: Coastal San Diego County", 1968.

4. Bulletin No. 80-3, "Reclamation of Water from Wastes: Coachella Valley", 1966.

Evidence exists that these programs and reports have stimulated interest in the reclamation of water from wastes, particularly in Southern California.

Cost of Water Reclamation. Costs assignable to water reclamation are a function of costs of water supply and waste disposal and depend to a large extent on pricing policies of the agencies involved. In general, the cost assignable to the reclamation of waste water is the cost over and above the cost of treatment for disposal plus the cost of delivery. In evaluating the cost of water reclamation a major consideration is that any costs for primary and secondary treatment should be allocated to waste water disposal because this level of treatment is required for disposal whether or not reclamation occurs. For most uses waste water receiving secondary treatment is generally satisfactory, and the cost of the reclaimed water is the cost of delivery.

Water receiving no more than secondary treatment can generally be used for ground water replenishment and controlled irrigation. The delivered cost of this water depends on the capital cost of the transmission facilities, the amount of pumping required, and the quantity of reclaimed water involved. For existing reclamation projects, estimated costs range from $5 to $20 per acre-foot. Reclaimed water injected into wells for sea water intrusion barriers must receive tertiary treatment, including possibly coagulation and sedimentation. This increases the cost of the water by $15 to $20 per acre-foot. Estimated costs of reclaiming waste water ranged up to about $50 per acre-foot in several feasibility reports prepared by local agencies and to more than $100 per acre-foot for a small reclamation project producing less than 1,000 acre-feet per year.

Legal Requirements and Public Acceptance. Regulations and requirements for quality of water from all sources that can be used by the public have been set by state and local authorities. To ensure protection of the public health, and other social benefits, state and local authorities impose stringent regulations and requirements upon reclamation of water from wastes. These authorities include the State Department of Public Health, the State Water Resources Control Board, the California Regional Water Quality Control Boards, the State Department of Fish and Game, and county and city agencies.

Pursuant to the Water Reclamation Law (Division 7, Chapter 7 of the Water Code), the Department of Public Health has promulgated a set of standards for safe reuse of waste water for specified purposes. The regional water quality control boards are empowered by this law to apply these standards in setting requirements for the reuse of reclaimed waste water.

The renovation of waste water in the past has generally met requirements for the uses intended. In the future, as the technology of reclaiming waste water improves, water of even better quality may be produced.

Reclaimed water has been used in California for many years and the public now appears to be more fully accepting its use. As the costs of new water supplies and waste water disposal continue to rise, it may be anticipated that the public will react favorably to any project that will reduce the cost of either or both of these necessary services. These factors, along with advances in technology on reclamation, indicate that planned reuse of reclaimed water will become an increasingly significant portion of the total water supply in the South Coastal area.

Other Possible Sources of Water

The possibilities offered by new or nontraditional sources of water are intriguing. In general, the public seems to be keyed to the potential rather than the limitations of new, economically unproved methods for developing water supplies. This is a proper public attitude, for such an attitude is a necessary climate for advancement in technology; but it is also necessary that enthusiasm for the potential be tempered by knowledge of the physical, economic, and social constraints so as to enable valid comparison with other alternative available sources.

This section discusses several possible sources of water which could assist in meeting California's future water demands. Among the possible new sources are weather modification, watershed management, and geothermal energy for desalting of saline ground water. New or expanded concepts of long-distance transportation of water are represented in an interstate transfer of surplus water within the Western States, and in a proposed undersea aqueduct. Finally, the possibility of stretching available water supplies through reassignment of uses, pricing policy, and greater efficiency in water management is discussed.

Western States Water Development

Among the alternative sources of water that should be considered in planning to meet California's future water needs is importation through western states or international water development. Such a development might deliver water (1) near California's northern border for distribution via natural streams and existing or new aqueduct systems in the Central Valley and adjacent areas; (2) near the eastern boundary to serve portions of the area east of the Sierra Nevada; or (3) to the Colorado Desert and South Coastal areas probably, at least in part, through augmentation of and rediversion from the Colorado River.

Developments of this scale, involving importation from the Northwestern States or even from Canada or Alaska, would be of such magnitude that they would probably be practical only in conjunction with a general plan to augment the waters of the Colorado River stream system. The cost of such a development would be very large and necessary political arrangements would be complex. Thus, it could be considered only a possibility for meeting the long-term needs of the State sometime after the turn of the century.

It is widely recognized that the Colorado River stream system is overcommitted by existing and authorized projects and water uses under the Mexican Water Treaty, the Colorado River Compact, and related legal documents. The insufficiency of the Colorado River became well-known during the lengthy U. S. Supreme Court litigation in Arizona v. California. The decree in that case provided that California's annual apportionment is 4,400,000 acre-feet when 7,500,000 acre-feet of mainstream water is available to the lower basin states. California is entitled to 50 percent of any surplus water above 7,500,000 acre-feet. In the event of shortage, the decree provides that the Secretary of the Interior may apportion the remaining available supply. The Colorado

River Basin Project Act of 1968 directed the Secretary to follow certain specific priorities in the event of shortage.

Soon after the Supreme Court opinion in 1963, the Bureau of Reclamation published a report describing its "Pacific Southwest Water Plan". The chief proposal of this plan was to import water to the Colorado River from Northwestern California. In presenting this report, the Secretary made it clear that this plan was only a proposal, and he invited alternative suggestions. In response to that invitation, and on the basis of other motivations, a total of about 22 proposals were made according to a report by the Western States Water Council entitled "A Review of Inter-Regional and International Water Transfer Proposals", dated June 1969. These include not only possible diversions from the Columbia and Missouri Rivers systems to augment waters of the Colorado River and other water supply sources in the Southwest, but also proposals to divert water from Canada or from Alaska to meet needs not only of the Southwest, but also of the Great Plains area, portions of Central Canada, and the Great Lakes area.

While these proposals identified possible future sources of water and demonstrated various physical means by which large quantities of water could be moved, they were based on very cursory information. Little attention was given to the highly significant political, legal, institutional, and social factors. Moreover, potential economic demands for water in the areas to be served were not given real consideration, and hydrologic and cost data were only very rough approximations.

Information is now being accumulated through state water planning studies, federal Type I Framework Studies, other studies under the aegis of the federal Water Resources Council, and by boards and agencies within California, which hopefully will provide a foundation for more detailed studies in the future, possibly involving such large-scale plans.

The first westwide investigation was authorized in Public Law 90-537, the "Colorado River Basin Project Act" of 1968 (discussed in Chapter II). This act directed the Secretary of the Interior (1) to determine the water supplies available and the long-range water requirements in each water resource region of the Western United States; (2) to develop a reconnaissance general plan to meet the future water needs of each region, but within the limitations of the 10-year moratorium (see page page 15); (3) to continue to develop a regional water plan to guide the coordination and construction of water projects in the Colorado River Basin; and (4) to recognize the Mexican Water Treaty as a national obligation when the Colorado River is augmented (see page 15).

This investigation is to culminate with a final report by July 1, 1977. Following September 30, 1978, the Secretary, under other authorizations, can proceed with examining sources of supplemental water outside the area just described, including the Pacific Northwest.

Beyond the need for augmentation of Colorado River supply is the problem of increasing salinity in the Lower Colorado River, which impairs the usefulness of the water for agricultural and other purposes, both in the United States and in Mexico. Thus, to both increase its quantity and improve its quality, augmentation of the Colorado River will probably eventually come to pass and provide a potential means of meeting part of California's future water demands.

Weather Modification

For centuries man has sought means of making rain to end drought periods. However, it has been only in the last two decades that serious research and experimentation have been undertaken toward inducing rainfall through cloud seeding. Research and experimentation activities have also been directed to clearing of fog from airports and to suppression of hail or lightning storms.

Considerable progress has been made during the past several years in advancing the state of the art of weather modification; and it has been demonstrated that, under favorable conditions, precipitation can be increased on the order of 5 to 10 percent. The most common method of seeding clouds is by the dispersal of silver iodide either from airplanes or from ground generators.

During the 1968-69 season, 11 weather modification projects were conducted in California, mainly to increase surface storage in reservoirs for municipal and irrigation use and for electric power generation. Additional purposes were for augmentation of ground water storage, fog dispersal, and for applied research. Silver iodide and dry ice were the agents dispersed, except for a project in San Diego County which employed an electrical discharge method.

Direct measurement of results of weather modification activities so far is impossible because of the great variety in natural weather and rainfall patterns, and the sometimes conflicting evaluations; but certain conclusions are becoming apparent. It is evident that there are certain conditions under which precipitation can be increased by cloud seeding. Evaluations, by the operators, of results of cloud seeding in the Kings River (by Atmospherics Incorporated) and San Joaquin River (by North American Weather Consultants) watersheds indicate a relatively high degree of confidence in average increases of runoff of 6 and 8 percent, respectively. Estimated annual precipitation increases of 5 percent have been reported by Pacific Gas and Electric Company for the Lake Almanor watershed in the Feather River Basin.

A weather modification project in Santa Clara County has increased average precipitation over the watershed by an estimated 10 to 15 percent, as reported by the Santa Clara County Flood Control and Water District. A continuing weather modification program in the drainage basins above the reservoirs of the Los Angeles County Flood Control District indicated, according to consultants, overall increases ranging from near zero to 20 inches during the eight-year period from 1960-61 through 1967-68. These increases, averaged over the entire basin, have been estimated to be in the neighborhood of 5 percent of the mean annual precipitation.

The Office of Atmospheric Water Resources, U. S. Bureau of Reclamation, has stated that results of Project Skywater and other programs in the United States and abroad indicate that precipitation can be increased by an average of 10 to 20 percent. This average includes cases of large increases, small increases, no increases, and some decreases. The foregoing reference also reported that costs for indicated increases in runoff will range from $0.50 to $1.50 per acre-foot when the program becomes operational rather than experimental. Reported costs of programs in California have generally been within this range.

It should be recognized that these costs have been estimated for "successful" projects. The cost per acre-foot is a function not only of the procedure used but also of the water yield from the project. Project yield, in turn, is dependent on both the meteorological and hydrological characteristics of the particular area being seeded and the prior availability of facilities for controlling and storing the water developed.

Success of increase in precipitation also depends on the dryness or wetness of the particular year. In this regard the favorable chances for cloud seeding are minimal during the dry years when water is most needed, resulting in somewhat smaller increases in runoff than those expected during normal or wet years. This means that while a weather modification project would be effective where normal and wet-year increases could be stored either in surface or underground reservoirs for use in ensuing drier years, the value of this increased supply would be minimal compared to an increase during drier years.

The yield of the Central Valley Project, the State Water Project, and major local projects cannot be materially enhanced by increases during the wet years, because surplus water is already available in those years. An augmentation of water supplies would have the greatest economic benefit during the dry and average years.

There are many unresolved technical and legal problems in weather modification. More experience is required to determine which conditions are favorable for seeding and the best methods of seeding for given conditions. Not much is yet known about possible downwind effects of cloud seeding. Indications so far include possible decrease, no effect, or increase in precipitation downwind from seeding project areas. Pertinent legal questions relate to the responsibility of cloud seeding operators for any downwind effects and the effect of cloud seeding in increasing floodflows. In California, seeding with silver iodide seems to be most effective on the colder storms; and operations are carried out to enhance snowpack in critical flood regions, thereby reducing the direct flood hazard.

The Department of Water Resources is participating with Fresno State College Foundation in studies concerning weather modification for increase in precipitation in the Sierra Nevada. The work, scheduled for completion in 1973-74, consists of development of planning guidelines for evaluating potential water yield estimates and costs of weather modification in California.

It is anticipated that experience gained from increasing experimental and operational activity in weather modification will lead to resolution of many problems, greater physical control, and an increase in potential for future weather modification activities. On the more exotic side, decreasing an overabundant water supply on the windward side of some mountain ranges and increasing that precipitation on the water-deficient lee-side may sometime be possible. In a program sponsored under the Bureau of Reclamation program, the State of Washington is investigating this possibility.

The day of much more extensive efforts to change the weather or climate by altering worldwide wind circulation or by steering entire storms from ocean areas onto nearby lands in need of rain is, as yet, only in the visionary stage. Many problems must be solved before this can be accomplished or even shown to be desirable. The solution of problems will be based in large degree on knowledge gained from research on programs of current interest with more modest objectives.

Watershed Management

Watershed management embraces a broad spectrum of land treatment and related measures to optimize overall productivity, considering food, forage, timber, wildlife, minerals, recreation, and water. For purposes of this bulletin, however, watershed management will be discussed from the standpoint of possible means of modifying vegetation to improve runoff characteristics, including quantity, quality, and timing.

The physical potential for increasing water yield production through manipulation of the vegetative cover has been demonstrated through experimental research conducted by the U. S. Forest Service, University of California at Davis, and other organizations. The Department of Water Resources has cooperated in this work and has contributed funds on the order of $900,000 over the past decade. The research has generally concluded that runoff can be increased within certain areas by a reduction in consumptive water use associated with the growth of native vegetation. It has also shown that the duration of flow is extended later into the summer, but that the magnitude of the increase and the change in timing of flow is difficult to predict.

The three categories of vegetative manipulation which are applicable to certain areas in California are: selective timber cutting within the snowfield portion of the commercial timber zone; clearing of deeper-rooted vegetation within the foothill and brushlands regions and a replanting to grasses; and eradication of riparian phreatophytic (water-loving) vegetation which is most prolific along the lower elevation reaches of California water courses.

Within the commercial timber zone, selective strip cutting of timber at widths of about one tree-height has been demonstrated as a means of reducing snowpack evaporation and increasing runoff without hastening snowmelt. The clearing of larger blocks of forest appears to increase both runoff and rate of snowmelt.

For brushland areas where the annual rainfall exceeds about 15 inches, the clearing of deep-rooted plants and conversion to grass can result in an increased water yield on the order of 2 to 3 inches annually on the treated areas. It is estimated that up to 800,000 acres of brushland in the Sacramento Basin may be suitable for such conversion. A 3-inch reduction of consumptive use could provide an increase in total basin runoff of perhaps 200,000 acre-feet annually.

Eradication of streamside and lakeside vegetation can reflect a salvage of water of up to 0.5 acre-feet annually per acre eradicated. Although the eradication of phreatophytes is important in localized situations, the area of plant growth is small and the amount of water which may be salvaged is not of great consequence in consideration of California's total statewide water needs. Also, this streamside vegetation often has scenic value and provides food and shelter for wildlife. Extreme care must therefore be exercised in determining those areas where plants may be removed without detrimental effect on the environment.

While each of the foregoing measures has merit in certain areas, there would be many difficult problems with respect to a large-scale vegetation modification practice throughout the State required to significantly increase California's usable water supplies. These problems include: legal rights to alter native vegetation on private and public lands, the compatibility of such modification with scenic and ecological values, and the rights to the water supply which may be salvaged. Moreover, as a large portion of the lands are under private ownership, any modification of cultural practices would have to be demonstrated to be economically advantageous to the individual owners.

From the present state of knowledge and in view of the limitations, watershed management practices involving modification of native vegetation do not appear to be an attractive option for providing significant water supply quantities to meet increasing statewide needs.

Undersea Aqueduct

A concept for conveying water supplies from California's North Coastal rivers to Central and South Coastal regions via an undersea aqueduct has been proposed for study over the past decade by private and public water planners.

This is not a new source of water, but is discussed in this chapter because it is a subject of interest to those who are concerned with water development alternatives. The plan most commonly envisioned would consist of a large offshore pipeline, possibly on the order of 30 feet in diameter, anchored on the continental shelf at a depth of about 300 feet. The pipeline would extend a total distance of some 700 miles from the mouth of the Klamath or Eel Rivers to delivery points in the Central and South Coastal areas.

Various materials have been suggested for the aqueduct. These include heavy-duty plastic, flexible rubber, fiber glass, concrete, steel, and aluminum. Considerable additional research and testing is required to determine the engineering feasibility and to provide reliable estimates of costs associated with the fabrication, placement, and maintenance of a large-diameter undersea pipeline. Additional study is also required to determine the effects of the pipeline upon the marine environment.

An undersea aqueduct is principally an alternative method of conveying water supplies for the coastal areas. Its utilization would require the development of dependable water supplies by onshore facilities in much the same manner as required for an overland aqueduct system. Because of the highly variable runoff characteristics of Northern California rivers, major storage reservoirs would be needed in conjunction with either an undersea or overland aqueduct system to provide regulation of the water supplies to the more uniform conveyance schedules required.

An undersea aqueduct would also necessitate location of a diversion structure near the mouth of the river which provides the water supply source. The diversion structure would require facilities for passage of fish over the structure and screening facilities to protect fish from being carried into the aqueduct.

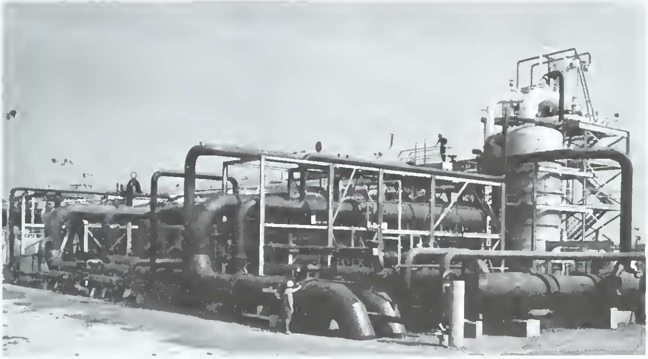
In December 1969 the U. S. Bureau of Reclamation published a report entitled "California Under Sea Aqueduct Prereconnaissance Study". The report outlined the considerable additional research needs and recommended an initial six-year reconnaissance study program. The recommended program was adopted by the Congress and funds were appropriated for the first-year studies now in progress.

Geothermal Water Resources

The term geothermal literally means earth heat, and it refers to the natural heat that is generated beneath the earth's surface. While rock temperature generally increases slowly with depth, the rise (or geothermal gradient) is markedly steep in certain localities. These regions are called geothermal provinces.

Recently attention has focused on the intriguing possibility of utilizing geothermal heat to distill fresh water from sea water or from the saline ground waters that sometime occur in geothermal regions. Since the initial temperatures of geothermal waters are much higher than sea water, little or no heating may be required for their distillation. In this respect, geothermal brines are preferable to ocean water for conversion to fresh water.

The necessary conditions for a geothermal distillation facility include a geothermal heat source, an adequate supply of brine, and a favorable market for fresh water and such by-products as surplus energy and residual minerals. A feasible means for disposal of waste products which will neither pollute the environment nor endanger wildlife is also essential. Although more than 182 thermal springs have been found throughout California to date, only 3 areas have attracted interest from the standpoint of commercial production of geothermal energy. These are: The Geysers, near Cloverdale in Sonoma County; Casa Diablo, northwest of Bishop in Mono County; and southern Imperial Valley. At The Geysers, two steam powerplants with a combined rated capacity of 82 megawatts are operated by the Pacific Gas and Electric Company and an increase to 411 megawatts is contemplated within the next few years.



DWR NO. 3812-6

Clair Engle Plant

– – Sea water conversion

Atmospheric Water Resources Research

Weather modification studies continue

DWR NO. 4072-11

Mexico's development of same geothermal province found in California

The Casa Diablo region has been prospected and tested but does not at this time appear worthy of exploitation. Neither The Geysers nor Casa Diablo is endowed with large quantities of brine from which fresh water could be produced by distillation. The southern part of the Imperial Valley, on the other hand, appears to possess the physical conditions required for a geothermal distillation facility. It is the only place known at present in California where geothermal energy and heated brines are available in abundance.

Serious attempts to develop a natural steam source in Imperial Valley began with the drilling of an unsuccessful steam well in 1927. Since that date approximately 30 wells have been completed which have established Imperial Valley as a major geothermal province. The area considered likely for possible desalination extends generally from the southern end of the Salton Sea to the Gulf of Mexico. It covers an area of about 2 million acres.

Production of steam has commenced in the Mexican sector of Imperial Valley at the Cerro Prieto field which lies about 15 miles south of the border town of Mexicali. Present arrangements call for the installation of a 75-megawatt steam electric powerplant at Cerro Prieto which is expected to be ready for service in 1971. The plant will be operated solely for power production. The brines produced during the process will be conveyed through an open ditch for disposal in the Gulf of California.

A preliminary evaluation of the geothermal potential of the Imperial Valley, California, has been covered by Dr. Robert W. Rex of the University of California at Riverside in two reports entitled "Investigation of the Geothermal Potential of the Lower Colorado River Basin, Phase I" and "Investigation of Geothermal Resources in the Imperial Valley and Their Potential Value for Desalination of Water and Electricity Production, June 1, 1970". Dr. Rex's geologic, geophysical and geochemical studies have established that six and possibly as many as nine geothermal hot spots exist in the region lying between the Salton Sea and the Mexican border and that 1 to 3 billion acre-feet of heated brine may be stored in the sedimentary formations between depths of 5,000 and 20,000 feet. Chemically these waters appear to be no more saline than many oil field brines. Their temperatures range from 500 to 700 degrees Fahrenheit, as measured in the formations at depth.

According to the University report, brine reserves may be sufficient to support 1,000 to 3,000 geothermal wells at an average yield per well of 1,200,000 pounds per hour of steam. This is equivalent to 10.6 acre-feet of fresh water per day for each well. The total projected production rate for full operation therefore would range between 3.6 and 10 million acre-feet per year. At this rate, it would take from 100 to 850 years to exhaust the available brines. A suggestion has been made that the productive life could be extended and possibly doubled by recharging the geothermal aquifers with sea water imported from the Gulf of California.

If the geothermal water resource in the Imperial Valley should prove to be a practicable water supply, it would be strategically located to be of assistance in solution of the water quantity and quality problems relating to the Colorado River. It could be a potential substitute for Colorado River water diverted to the Imperial and Coachella Valleys and to the Coastal Plain of Southern California, thus making those supplies available for diversion to other areas within California, and to other states or Mexico. It might also be used to dilute diversions from the Lower Colorado River to improve their qualities. If electrical energy from geothermal resources could be produced at a favorable cost, desalination of a portion of the drainage waters from Imperial and Coachella Valleys and their reuse might be feasible. Conceivably problems of the increasing salinity of the Salton Sea might also be solved, at least in part, by the use of such waters.

Further investigation of the Imperial Valley province is required before the feasibility of a large-scale geothermal operation can be reasonably examined. In particular, more knowledge is needed of geologic factors (1) to permit refining the estimates of available geothermal heat and ground water brines, (2) to explore procedures for recharging brine aquifers and for the return of saline residual fluids by reinjection into deep formations, and (3) to develop more definitive cost information.

Study of the region is continuing by the University of California, Imperial Irrigation District, U. S. Bureau of Reclamation, and the Department of Water Resources.

Nonstructural Alternatives

In planning to meet future water resource needs, alternatives should be considered that could result in reduction or redirection of those needs. These are referred to as "nonstructural" as they do not involve the physical construction of projects; rather, they consist of major changes in social, economic, environmental, technological, and governmental factors that may affect water demand. Examples of such alternatives are direct reallocations of water supplies to more valuable uses, reductions in water use and waste water disposal through pricing policies, technical improvements that increase efficiency of water use, improvements in water quality management, land use policies (including floodplain management), and planned location of industries. Reallocation of water supplies, pricing policies, and increased technical efficiency in water use are discussed in this section. Other nonstructural alternatives concerning environmental impacts on water needs are discussed in Chapter VIII.

Reallocation of Water Supplies. This would be a direct means of bringing about the transfer of water use from lower-return to higher-return purposes, such as from irrigation to urban use. Reallocation of water supplies from an agricultural to an urban economy was, in effect, accomplished by the City of Los Angeles in the purchase of water rights in the Owens Valley for export to Los Angeles via the Owens River Aqueduct. The practicability and advisability of such a course of action in the future remains to be seen and involves many considerations. Possible economic and social disruption, both present and future, in one area must be weighed against the benefits accruing to another. Gradual reallocation of water involving relatively small reductions through increased efficiency of water use could minimize the problem. Serious, practical difficulties remain, however. Perhaps the most notable involves legal and institutional constraints related to California's complex water rights structure. Any transfer of such rights could entail lengthy negotiations or condemnation procedures, involving, among other things, appropriate compensation for all interests directly or indirectly affected by the transfer, such as users of return flow, ground water, etc.

Pricing Policies. Appropriate pricing policies, combined with increased marketability of water and/or water rights, could ultimately accomplish the same end as would a direct reallocation of water between uses. Water use generally is influenced by prices charged by retail water agencies, such as irrigation districts and city water departments. These prices, in turn, are partially affected by the pricing policies of local wholesale agencies, and those of the federal and state agencies. The pricing policies of the latter are determined by provisions of reclamation law and by the provisions of the State's contracts with the wholesale agencies.

Local agencies can and do influence the types and quantities of water use through pricing policies which can be adjusted to meet changing situations. For example, water use per capita can be reduced by shifting from a flat rate (water charges per month not affected by use) to metering (water charges affected by use). In metered systems, water use per capita can be reduced by shifting from a utility to an inverted utility rate structure, in which the unit price of water increases as the quantity of water increases; or by increasing water charges and decreasing taxes on assessed valuation. Such shifts in pricing policies may appear increasingly attractive to local agencies as the costs of new supplies increase. The development of new water pricing policies would require detailed study of their social, environmental and economic consequences. The actual impact of a price change on the quantity of water used would have to be determined more accurately before pricing policies could be properly included in the water planning process. Preliminary studies by the Department indicate that for the urban South Coastal area a 10 percent increase in price would reduce per capita use by 3 percent. The impact upon certain industries and some agricultural crops would be greater, however. In addition, any increase in the price of water sufficient to curtail water use would have to be weighed against the possible impact on industrial expansions and employment or the possible increase in prices paid by consumers for the products of the affected industries. Consideration also must be given to the impact upon lower income groups--those who could least afford a price increase. The economically disadvantaged may be forced to use less water on lawns, shrubs and trees causing a blighted local environment.

Increased Efficiency of Water Use. Price increases can encourage farmers to invest in more efficient techniques of irrigation and encourage recycling in industry. Household uses could be reduced by non-water-using toilets, underground sprinkler systems, etc. Efficiency of water use can also be encouraged through information, education, and social and cultural pressures that increase awareness of conservation. In particular, increased corporate social responsibility for water quality will encourage reuse of water to avoid social costs associated with waste discharges.

Mitigation of Colorado River Salinity

This chapter has mentioned earlier that the problem of increasing salinity in the Colorado River may eventually be solved, at least in part, by the importation of good-quality water from outside the Colorado River Basin. However, it is unlikely that this solution, if found to be desirable, would be available before 2000.

In the meantime, estimates in a report of the Colorado River Board of California, entitled "Need for Controlling Salinity of the Colorado River", August 1970, are that projected developments in the Upper and Lower Divisions of the Colorado River Basin will cause the salinity of the River to increase. For example, the report predicts that salinity of the River at Imperial Dam, the diversion point for the Imperial and Coachella Valleys, will increase from an average of 850 parts per million between 1963 and 1967, to an average of 1,340 parts per million by 2000, if no preventative measures are taken.

The report describes possible programs to control salinity of the River. In addition to augmentation with water supplies of low salinity, it mentions removal of salts from the River or its tributaries and reduction of water losses by phreatophyte control and water salvage projects. It also lists a number of sources of salinity in both the Upper and Lower Divisions of the Basin which it states could be controlled by individual projects. The report estimates that, with these projects in operation by 2000, the projected concentration of salinity at Imperial Dam would be reduced from 1,340 parts per million to 1,010 parts per million.

In addition to the projects described in the report, there may be other ways of preventing increases in the River's salinity or of mitigating their effects in the various service areas. The possible uses of geothermal water resources and desalination have been mentioned earlier in this chapter. In the South Coastal area, Colorado River water could be diluted with water of low salinity from the State Water Project. Alternative ways of utilizing water resources of the Basin may also result in different salt loads and different economic returns to the respective areas. A possible range of the magnitudes of future salinity problems and all reasonable alternative solutions should be examined first on a reconnaissance basis. Then a program should be initiated to implement those solutions that are found to be most desirable and are proven to be economically sound through feasibility studies.

Summary

This chapter has discussed the array of possible future water supply sources and management measures for augmenting California's dependable water supplies. It has pointed out that to the present time water demands have been met primarily through traditional development approaches involving the regulation and conveyance of surface water from natural sources and the extraction of underground supplies.

In addition to the discussion of traditional approaches, information has been summarized regarding the potential for several other possible measures which the Department of Water Resources believes will become more significant in the future and, therefore, warrant serious further study. These potential sources include: greater reuse of present water supplies through water reclamation practices; more effective management of ground water resources in coordination with surface supplies; desalting of sea water and brackish water; weather modification; watershed management; and the potential which may exist for obtaining usable water supplies at economically competitive costs from geothermal sources.

Chapter V contains brief discussions on the status of investigative activity concerning a Western States water program and on the research in progress regarding the possible future role of an undersea aqueduct. It has also mentioned certain institutional measures concerning supply reallocations, pricing policy modifications, and increased efficiency of use, which could be implemented to stretch the existing supplies and to discourage wasteful practices.

The Department of Water Resources considers the various measures discussed in Chapter V to be complementary. Although many of them are not presently considered to be acceptable for either technological or social reasons, additional research and investigation may very well indicate that each of the options discussed will have a role in the management of California's water resources to meet future demands.

Eureka Newspaper, Inc.

Most of the water is produced during the winter storms, frequently causing devastating floods

DPW - Division of Highways

Regulation is needed to reduce flood flows and make the water available during the summer months

CHAPTER VI. REGIONAL WATER DEMAND-WATER SUPPLY RELATIONSHIPS

Chapter IV discussed statewide water demands and summarized pertinent water demand information by the 11 hydrologic study areas. This chapter discusses the derivation of present and projected demands for water to 1990 and 2020 by individual hydrologic study area, and the outlook for satisfaction of those demands from additional local sources and other possible potential sources described in Chapter V. It indicates for the areas of water deficiency the timing and magnitude of need for additional water supplies in excess of the local development potential that may have to be made available from other sources.

The water demand-water supply relationships for the individual study areas are depicted graphically in Figures 15 through 36. The locations, boundaries and designations of the hydrologic study areas are shown on Figure 4.

North Coastal Area

The North Coastal area is by far the most water-abundant area in California, producing about 40 percent of the State's total surface water runoff. The area sustains lumbering, recreation, and fishing industries which are the mainstays of the economy. Although only 13 percent of the area consists of valley land, agriculture also is important and accounts for the primary applied consumptive water demand. In 1967 total agricultural demand approximated 660,000 acre-feet per year. More than 80 percent of 1967 irrigated acreage was located in the upper Klamath River Basin (including Shasta and Scott Valleys). The Klamath River Project of the U. S. Bureau of Reclamation provided about half of the upper Klamath water supply and the remainder came from local stream diversion and ground water. The remaining irrigated agriculture is scattered throughout the area and is served by stream diversions and ground water development.

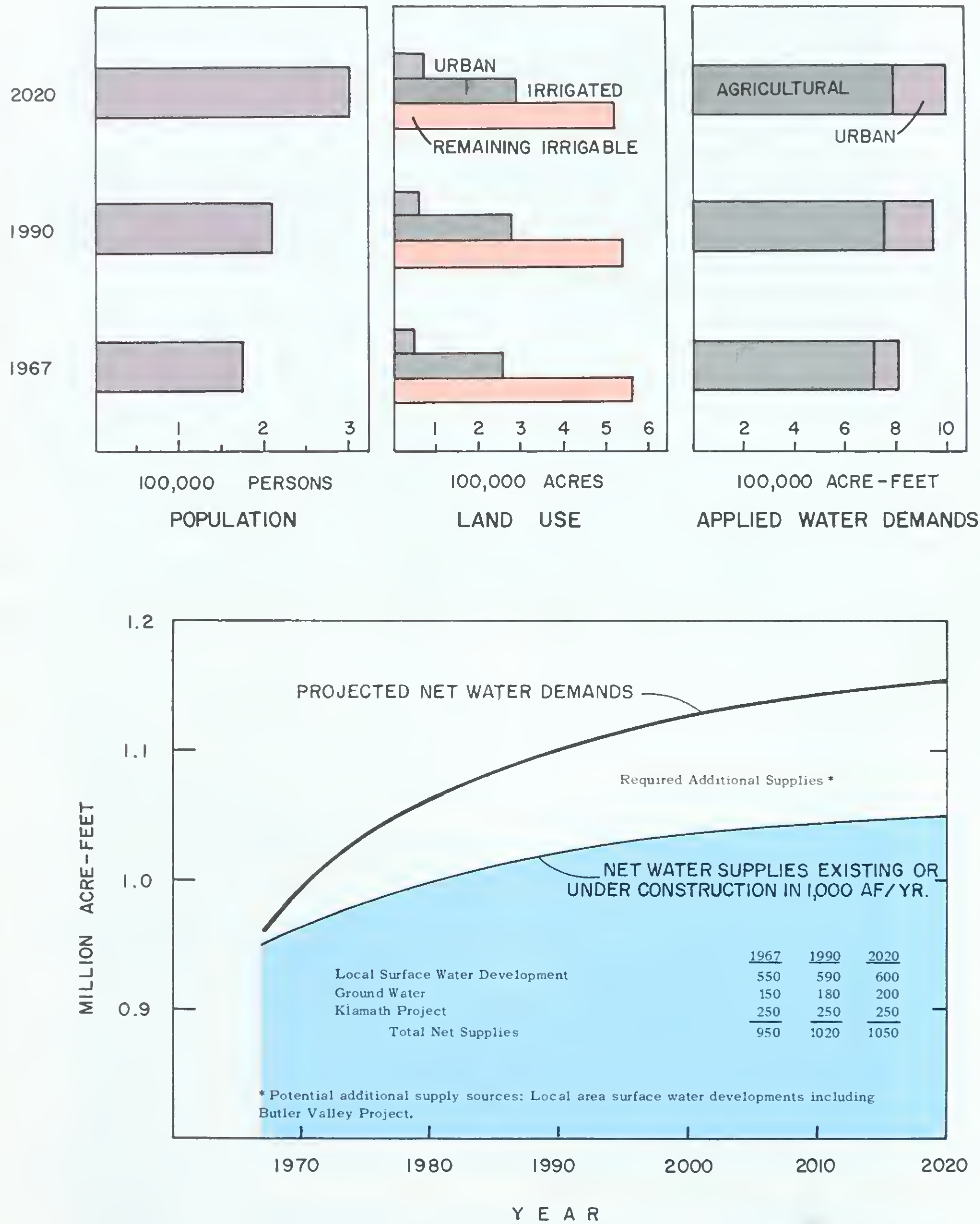
Irrigated acreage is not expected to expand greatly in the future (30,000-acre increase by 2020) because of the constraints of climate and marketing; however, changing crop patterns and increased use of sprinklers will be significant in raising the economic level of agriculture. The greatest increase in irrigation is expected to be in the Scott-Shasta Valleys area.

In 1967 total urban water use in the North Coastal area approximated 100,000 acre-feet per year. Of this, about 70 percent or 70,000 acre-feet was attributable to lumbering and related wood products industries. Although technological advances in the industry are expected to stabilize employment at about present levels, output of the industry is projected to increase with fuller utilization of available raw materials. As a result, the lumbering and wood products industries will account for at least half of the projected increase in the area's total net water demands. An increase in population and related domestic and other uses will account for the remainder.

The present (1967) and projected 1990 and 2020 population, land use, and water demands in the North Coastal area are shown in Figure 15.

The North Coastal streams support annual runs of 350,000 to 400,000 king salmon, 125,000 silver salmon and perhaps a million steelhead. The magnitude of these resources for sport fishing and commercial catch is comparable to those of the Columbia River.

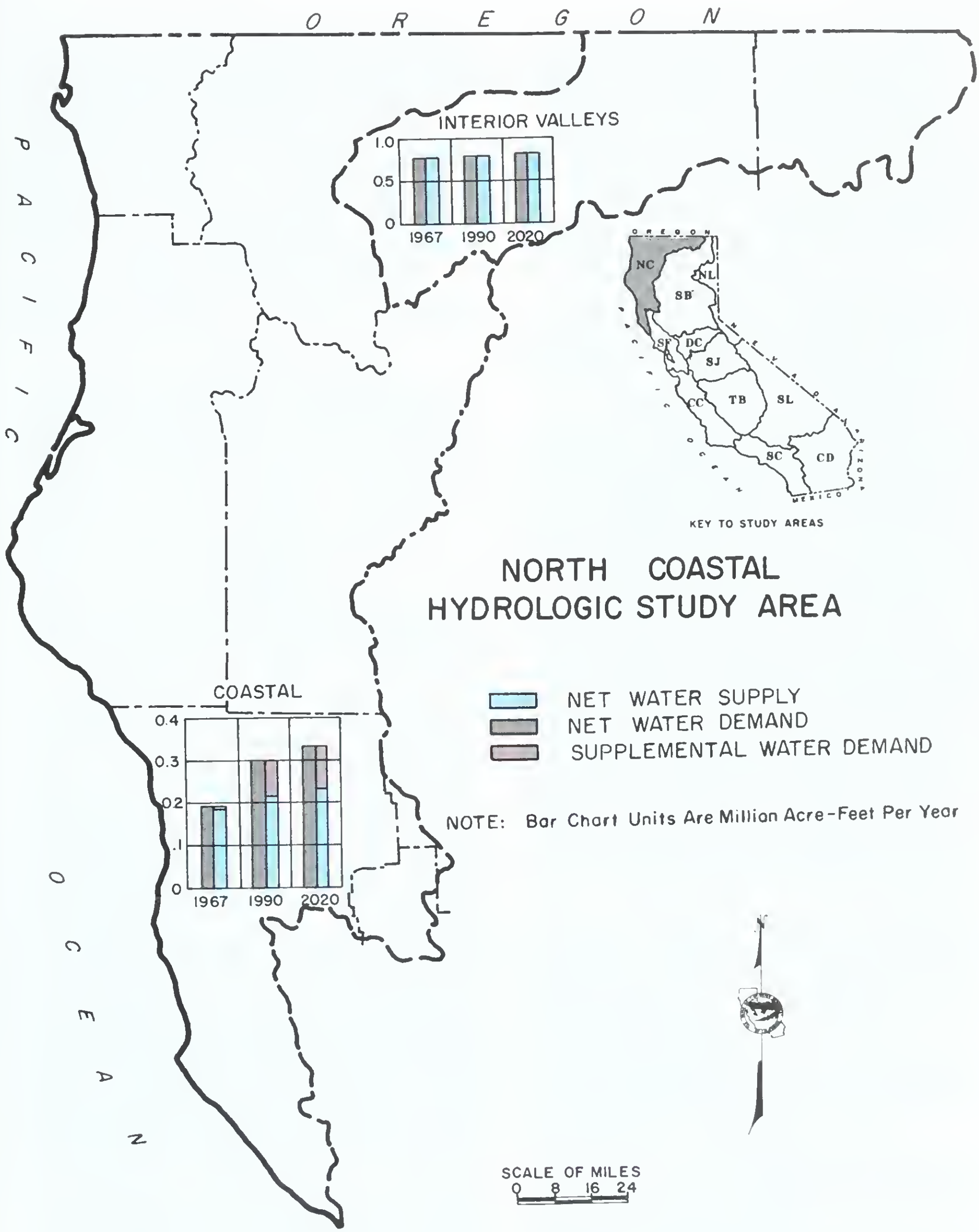
FIGURE 15



PROJECTED WATER SUPPLIES AND NET WATER DEMANDS

NORTH COASTAL HYDROLOGIC STUDY AREA

FIGURE 16


OREGON
PACIFIC OCEAN
INTERIOR VALLEYS
1.0
0.5
0
1967 1990 2020
COASTAL
0.4
0.3
0.2
.1
0
1967 1990 2020
KEY TO STUDY AREAS
NC
NL
SB
SF
DC
SJ
TB
SL
CC
SC
CD
NORTH COASTAL
HYDROLOGIC STUDY AREA
NET WATER SUPPLY
NET WATER DEMAND
SUPPLEMENTAL WATER DEMAND
NOTE: Bar Chart Units Are Million Acre-Feet Per Year
SCALE OF MILES
0 8 16 24

These streams make a major contribution to the commercial salmon catch in California and to a lesser extent in Oregon and Washington. Commerical salmon catch in 1967 at Northern California ports totaled 5.3 million pounds with a value of $2.8 million. Large volumes of water are required not only for transportation of adult and young fish to complete their life cycle, but also to "flush out" sediment accumulations in spawning and nursery areas, keep water quality at a level compatible to fish, and prevent the encroachment streamside vegetation.

At the present time contracts between local and federal agencies and the Department of Fish and Game are in effect on three North Coastal rivers for releases aggregating 680,000 acre-feet per year to maintain salmon and steelhead population.

The North Coastal area is interlaced with a variety of scenic flowing streams and rivers. Increasing each year are the numbers of sightseeing, rafting, canoeing and swimming enthusiasts who place high value on the environmental aspects of flowing streams, proper forest practices and clean air. Maintenance of flowing streams for recreational purposes is important and the North Coastal area with appropriate water projects has an opportunity to preserve and improve streams for these activities.

The expected future demands for water in the North Coastal area is small in comparison to the amount of water available. However, most of the water is produced during the winter storms, frequently causing devastating floods. Regulation is needed to reduce the floodflows and to make the water available during the dry months when it is needed.

In summary, total net water demand in the North Coastal area, excluding fish environmental needs, is forecast to increase by about 200,000 acre-feet by 2020, one-half of which will be for pulp and paper industry. It is expected that nearly 25 percent of the total increased demand will be met from extension of service from existing developed surface sources, another 25 percent from additional ground water extraction, and about half, or 100,000 acre-feet, will have to be provided from new sources. Based on the assumption that the future pulp and paper plants would be located in the Humboldt Bay area, water could be provided by the authorized Butler Valley Project on the Mad River, with a water supply capability of 160,000 acre-feet per year.

North Coastal water supply-demand relationships are depicted graphically in Figure 15; and the area's location and a geographical comparison of water supplies and demands are shown in Figure 16.

San Francisco Bay Area

When considered as a whole the San Francisco Bay area has sufficient water supplies to meet its needs until sometime after 2000. Like so many other areas of the State, however, such broad treatment neglects localized conditions which may indicate water deficiencies in certain areas at a much earlier date. The Bay area has a complex system of water supply and can logically be treated in two parts--the area north of and the area south of San Francisco Bay. In the ensuing discussion these parts will be referred to as the North Bay area and the South Bay area.

The North Bay area is both agricultural and urban in character, with irrigated agriculture accounting for about 60 percent of the total present water demands. However, the area is experiencing rapid urbanization which is expected to continue, particularly in Marin and southern Sonoma Counties. While irrigated agriculture is expected to show some increase, urban demands are anticipated to account for about 70 percent of the total water demand by 2020.

At present, water needs in the North Bay area are being met from ground water, several local projects, two important federal projects (Lake Mendocino on the East Fork of the Russian River in Mendocino County and Lake Berryessa, a feature of the Solano Project, on Putah Creek in Napa County) and the North Bay Aqueduct of the State Water Project. Not to be overlooked is the aqueduct system serving Sonoma and Marin Counties, constructed by local water agencies.

Some areas in Napa and Sonoma Counties, however, are currently in a state of ground water overdraft which will continue unless additional facilities are built to meet the projected increase in water demands. In fact the North Bay area will have an aggregate annual supplemental demand for water of about 50,000 acre-feet within the next 20 years, increasing to approximately 350,000 acre-feet by 2020. This increase will result primarily from expansion of urban development.

An analysis of proposed projects indicates that most of the additional water needs can be met by further development of local supplies. The Russian River and its tributaries offer the greatest potential, although additional supplies will be necessary from various other local projects and the North Bay Aqueduct.

The South Bay area ranks second only to the South Coastal area in urban growth. It is highly urbanized at the present time and is expected to become more so in the future. Population is forecast to more than double between 1970 and 2020. Irrigated agriculture, with a net demand of 166,000 acre-feet at present (1967) is expected to be virtually eliminated by urban encroachment by 2020.

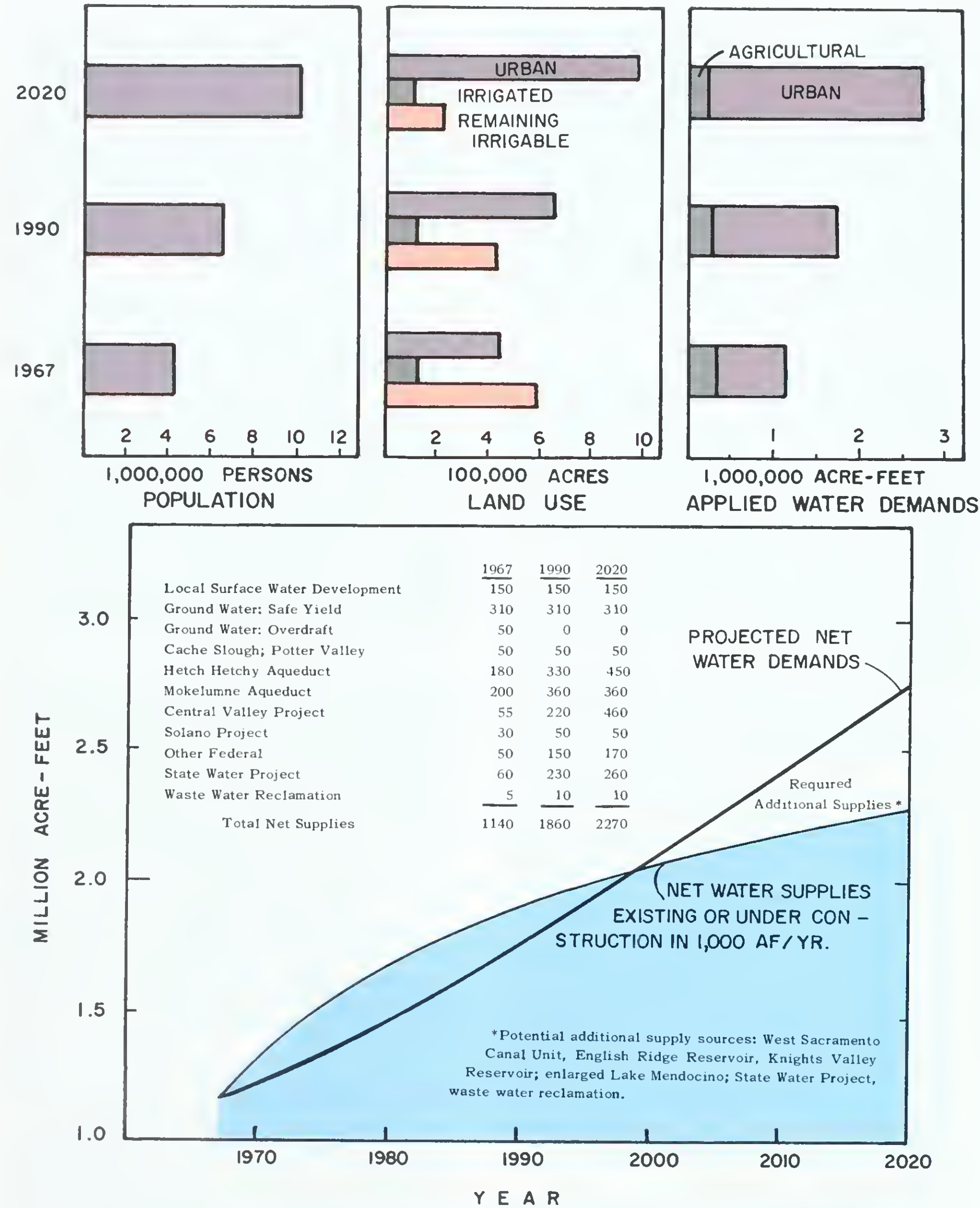
The generally excellent water supply situation in the South Bay area is due largely to the forward-looking planning and development of both local and importation systems by the major local agencies. Local surface and ground water supplies have been almost fully developed and the area depends heavily upon four major import projects: the Hetch Hetchy Water System of the City of San Francisco; the Mokelumne Aqueduct of East Bay Municipal Utility District; the Contra Costa Canal of the Central Valley Project; and the South Bay Aqueduct of the State Water Project.

The total amount of water delivered in 1967 by the four systems was nearly 500,000 acre-feet. Planned expansions would bring the total import capacity of these systems to an estimated 1,150,000 acre-feet per year. In addition a new pending contract between the East Bay Municipal Utility District and the U. S. Bureau of Reclamation will provide for 150,000 acre-feet of water annually in 2020. This additional water has been included in the Central Valley Project water supply for the areas as shown in Figure 17.

In addition, provision must be made to correct a serious ground water overdraft situation in Santa Clara Valley which has contributed to salt water intrusion near the Bay. Possible solutions include advancing planned delivery schedules of water from the South Bay Aqueduct, and the federal San Felipe Division of the Central Valley Project. Waste water reclamation may become a more important factor in balancing the area's water supplies and needs. A small allowance has been made for this possibility. Desalting may also provide a water supply at such future time as costs become competitive.

The principal sources of impairment to the quality of water in the San Francisco Bay area include domestic and industrial wastes, irrigation return water, and saline water intrusion into ground water aquifers. Saline water has seriously degraded once usable ground water supplies in basins adjacent to the Bay. This condition has been caused by prolonged periods

FIGURE 17

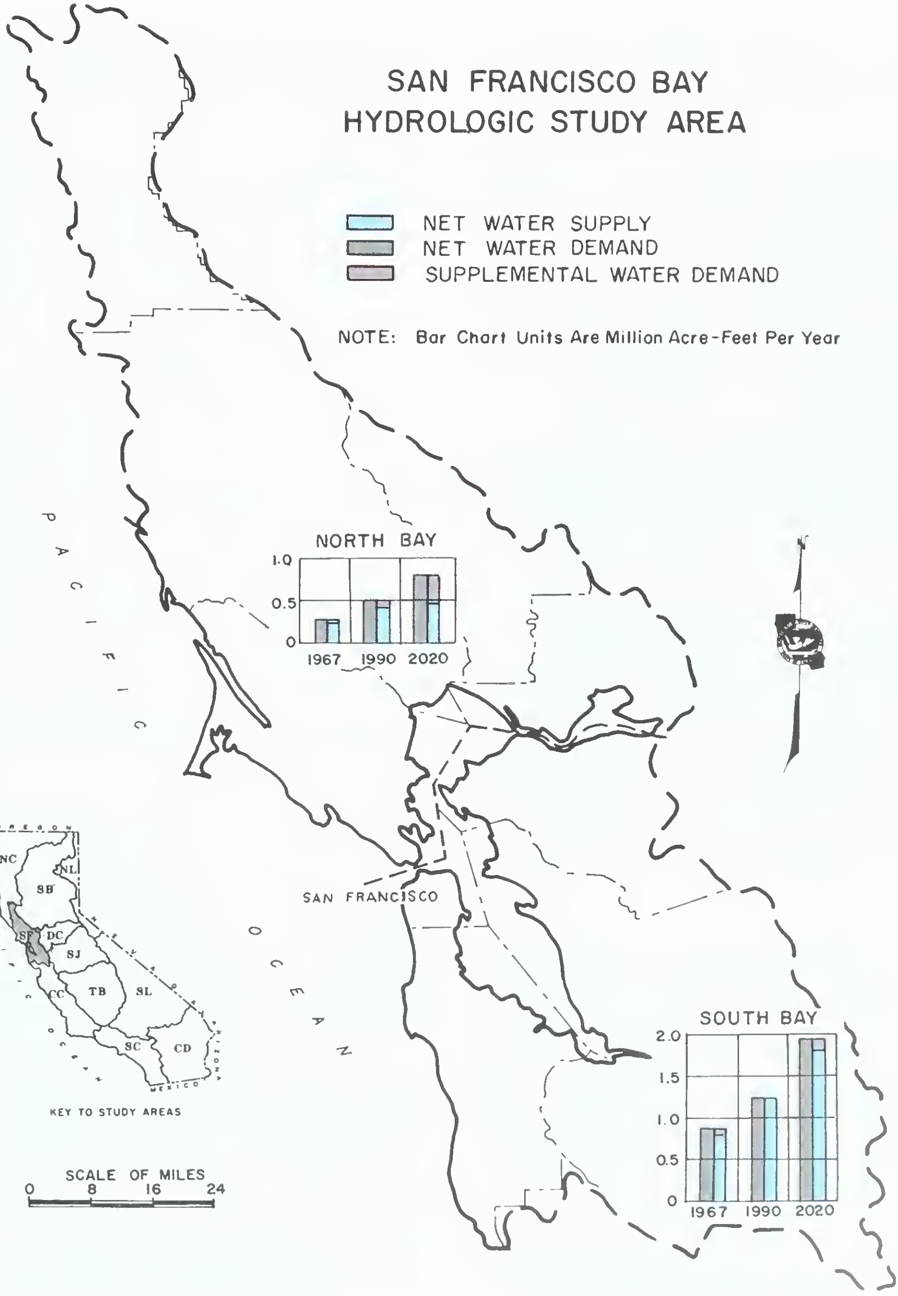


	1967	1990	2020
Local Surface Water Development	150	150	150
Ground Water: Safe Yield	310	310	310
Ground Water: Overdraft	50	0	0
Cache Slough; Potter Valley	50	50	50
Hetch Hetchy Aqueduct	180	330	450
Mokelumne Aqueduct	200	360	360
Central Valley Project	55	220	460
Solano Project	30	50	50
Other Federal	50	150	170
State Water Project	60	230	260
Waste Water Reclamation	5	10	10
Total Net Supplies	1140	1860	2270

PROJECTED WATER SUPPLIES AND NET WATER DEMANDS

SAN FRANCISCO BAY HYDROLOGIC STUDY AREA

FIGURE 18


SAN FRANCISCO BAY
HYDROLOGIC STUDY AREA
NET WATER SUPPLY
NET WATER DEMAND
SUPPLEMENTAL WATER DEMAND
NOTE: Bar Chart Units Are Million Acre-Feet Per Year
NORTH BAY
1.0
0.5
0
1967
1990
2020
PACIFIC OCEAN
SAN FRANCISCO
SOUTH BAY
2.0
1.5
1.0
0.5
0
1967
1990
2020
OREGON
NEVADA
ARIZONA
MEXICO
NC
NL
SB
SF
DC
SJ
CC
TB
SL
SC
CD
KEY TO STUDY AREAS
SCALE OF MILES
0
8
16
24

of overdraft and progressive lowering of the water table below sea level. Continued urban growth is intensifying the problems of domestic and industrial waste disposal.

The recently completed study by the State Water Resources Control Board of water quality of the San Francisco Bay-Delta estuary showed that toxicants and biological growth stimulants from industrial, municipal and agricultural waste waters pose the largest water quality control problem for those waters. With a continuation of existing methods of disposal, the present waste water inflows of 600,000 acre-feet a year would increase to 2,100,000 acre-feet by 2020 at the projected level of urban development. The biochemical oxygen demand (BOD) and nitrogen loads generated (before treatment) would increase about fourfold.

To reduce the potentially adverse effects of these increased waste discharges the study proposed a regional system for waste water collection and disposal that would, by 2020, reduce inland discharges in favor of ocean outfalls located off San Mateo and/or Marin Counties. An additional recommendation covered reclamation plants at inland sites where waste water from residential areas could be diverted and renovated for uses such as Delta outflow, ground water recharge, and irrigation.

The State Water Resources Control Board is following up the Bay-Delta study by sponsoring and financing an 18-month supplementary investigation by the Departments of Water Resources and Fish and Game that will cover sources, effects, and control of toxicity and growth stimulants in Bay-Delta waters. The studies conducted so far have indicated that area-wide planning for water quality management using a systems approach is necessary, as change in water quantity or quality within any portion of the Bay-Delta system can have an impact on the entire environment. Progressive damage to the aquatic environment will result unless an adequate system of facilities for treatment and disposal of these waste waters is developed, or other preventive action is taken.

Demands for recreation in the San Francisco Bay area, the State's second largest population center, are not being met and will probably not be met in the foreseeable future due to the lack of facilities caused by lack of funds, increasing population, decreased work-week time and increased spending power per capita. An attempt to keep up with these demands will be made, and many new facilities will be developed utilizing available urban and natural park settings, the available shoreline and man-made features. The State estimates that outdoor recreation demand in this area will approximately double in 1980 over 1960 levels. The California Outdoor Recreation Plan (1960) indicates 60 percent of all recreation is oriented around water-associated areas, and that the majority of recreation needs are within 1 hour travel time from urban areas. The San Francisco Bay area has the physical attributes for meeting these recreation needs, and the area can expect heavy future recreation use.

Major fish and wildlife resources exist in the San Francisco Bay area. An important segment of the State's 8 million striped bass inhabits San Francisco, San Pablo, and Suisun Bays. It is an important flyway for waterfowl, in addition to having a sizable deer population. Approximately 80,000 steelhead and salmon spawn in the area, 50,000 in the Russian River drainage alone.

The preservation and, where possible, enhancement of recreational, fish and wildlife resources of the San Francisco Bay area are major considerations in planning for the area's water needs. Of particular importance are the compensatory measures required when dams and reservoirs are constructed on anadromous fish streams and the provision for replacing wildlife habitat due to project development or other competing land uses. In this regard, streamflow releases aggregating some 120,000 acre-feet are made under agreement between project-operating agencies and the Department of Fish and Game. Moreover, joint studies are currently under way by the Departments of Fish and Game and Water Resources to define the amount and quality of water required to maintain the Suisun Marsh under future salinity conditions.

The consumptive use of water by recreationists at outdoor camping and picnic facilities is not large. However, the water needs of the hundreds of thousands of annual visitors to the Bay area is substantial and have been included as part of the urban water demand.

In summary, the total net water demands in the San Francisco Bay area are projected to include from 1,150,000 acre-feet per year at present (1967) to an estimated 2,740,000 acre-feet in 2020.

Prospects in general appear to be good for satisfying water demands in the San Francisco Bay area until about 2000 through local projects, ground water supplies, and existing local, state, and federal import systems. Although the total South Bay area overall water supply appears adequate beyond 1990, individual communities and service areas may have problems either as to supplies or in distribution system capacity and reliability. One example is the Contra Costa County Water District where new or enlarged conveyance and storage works will be needed in the mid-1970s to enable the District to meet peak water demands and to give protection against interruption of the water supply. The District is actively promoting the modified Kellogg Project as the solution to their immediate water supply problem.

Water demands and existing and potential supplies are equated graphically in Figure 17. A geographical comparison of water supplies and demands within the area is shown on Figure 18.

Central Coastal Area

The Central Coastal area essentially spans the coastal interval between the metropolitan centers of the San Francisco Bay and the South Coastal area. Mountain ranges that follow the coast extend through the area with many fertile valleys between them. The major drainage basins are the Pajaro, Salinas, Santa Maria, and Santa Ynez Rivers and their tributaries.

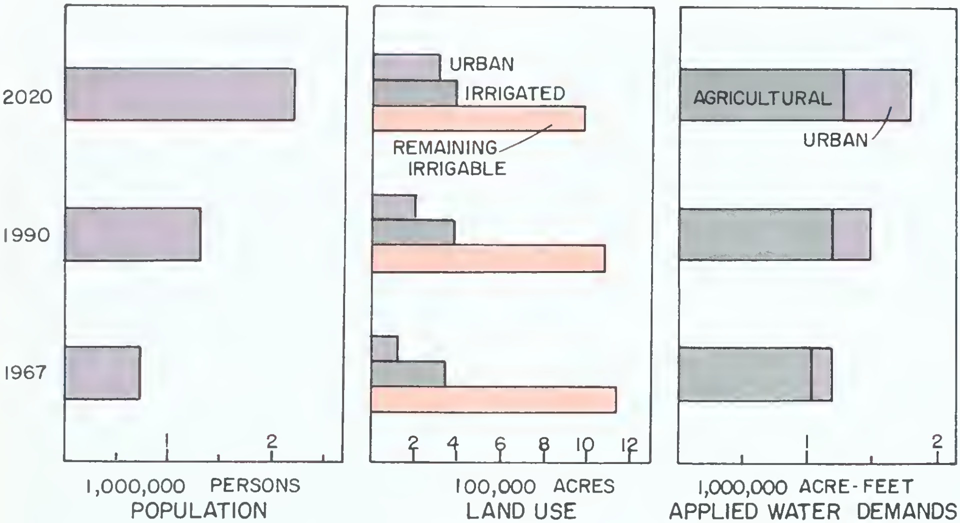
The economy is based primarily on agriculture and related activities; but the extraction and refining of petroleum, mining, commercial fishing and lumbering are also important. A number of military establishments also contribute significantly to the economy of the area.

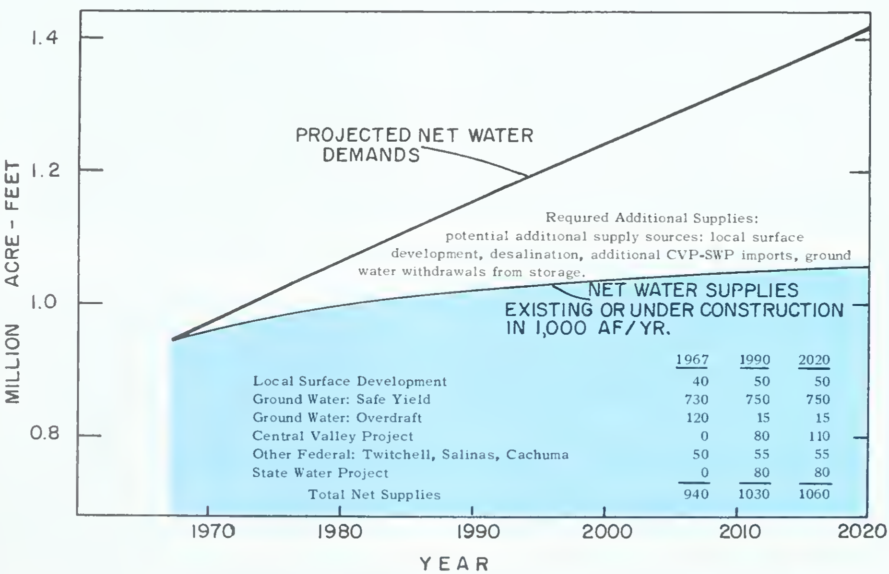
In 1967 about 25 percent of the truck crops produced in California were grown in the intensely developed valleys of the area. That year, about 800,000 acre-feet of water from local ground and surface water supplies were used to irrigate approximately 350,000 acres. Irrigated acreage is not expected to expand greatly in the future (390,000 acres by 2020) because of scattered parcels that would be difficult to farm economically, considering water costs.

The major urban centers of the Central Coastal area are situated in the Monterey Bay urban complex and the cities of San Luis Obispo, Santa Maria and Santa Barbara. Present urban net water demands amount to about 150,000 acre-feet per year. A rapidly increasing population is expected to increase these demands to 470,000 acre-feet by 2020. Also, the present water requirement of 5,000 acre-feet per year for fish, wildlife and recreation is expected to double by 2020.

The present (1967) and projected 1990 and 2020 population, land use and water demands in the Central

FIGURE 19



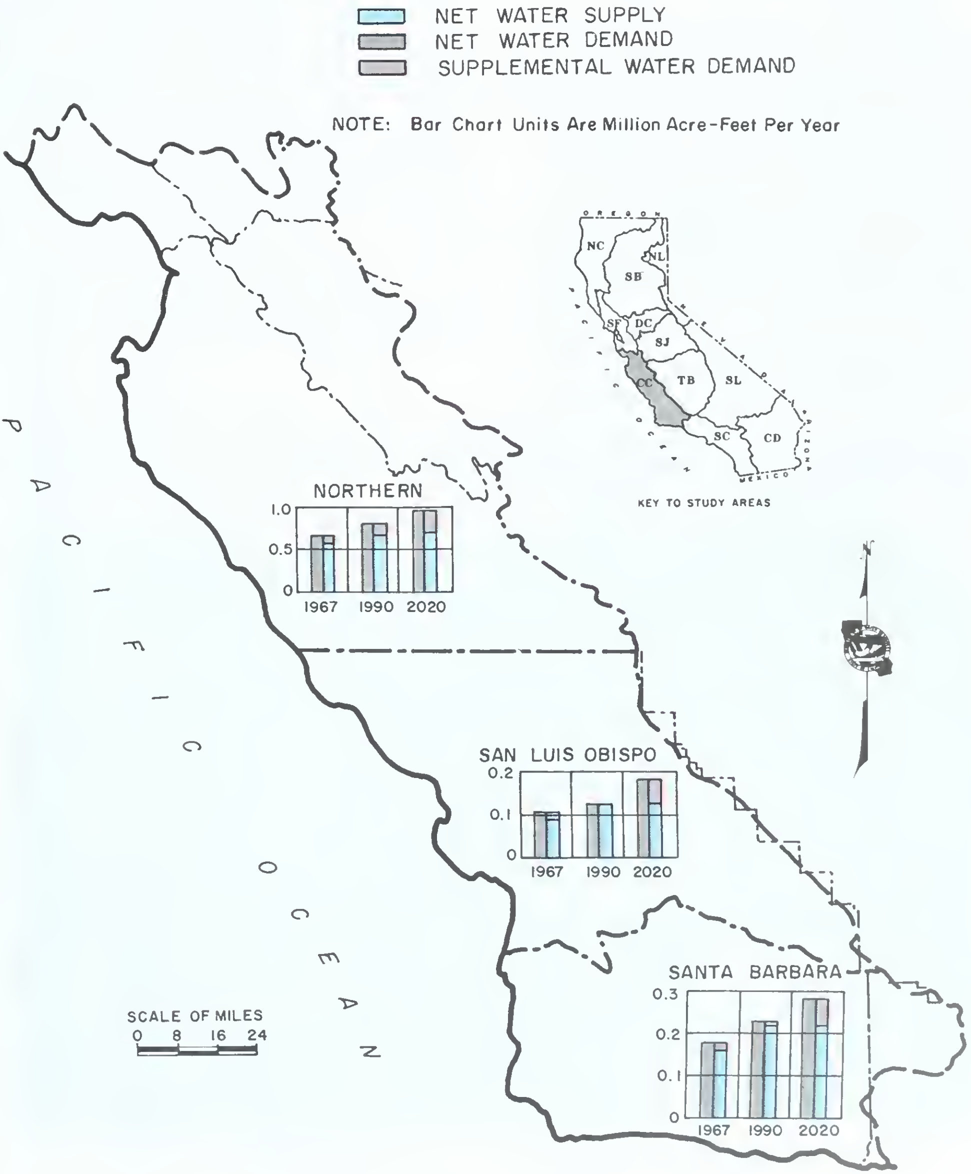


	1967	1990	2020
Local Surface Development	40	50	50
Ground Water: Safe Yield	730	750	750
Ground Water: Overdraft	120	15	15
Central Valley Project	0	80	110
Other Federal: Twitchell, Salinas, Cachuma	50	55	55
State Water Project	0	80	80
Total Net Supplies	940	1030	1060

PROJECTED WATER SUPPLIES AND NET WATER DEMANDS

CENTRAL COASTAL HYDROLOGIC STUDY AREA

CENTRAL COASTAL HYDROLOGIC STUDY AREA



Coastal area are shown in Figure 19. Water demand and supply relationships are also depicted on Figure 19 and the geographical distribution in Figure 20.

Ground water is the main source of supply in the Central Coastal area. However, agricultural growth and urban expansion has caused water levels to fall in many areas such as the Salinas Valley. A complex of dams, canals and percolating basins has been constructed to conserve runoff from the principal streams and to place the water in underground basins. San Antonio, Nacimiento and Twitchell Reservoirs--three of the largest in the area--conserve more than 100,000 acre-feet annually for ground water replenishment, but water levels continue to decline in some areas.

The present annual net water demand of 940,000 acre-feet exceeds the firm water supply by 120,000 acre-feet as shown in Figure 19. The difference is obtained from extraction of ground water in storage (overdraft). The future ground water overdraft shown is primarily in Cuyama Valley in inland Santa Barbara County, where no reasonable alternative supply exists. Studies indicate that there are large volumes of water in some ground water basins of the Central Coastal area; and, it is likely that well owners will continue to pump in excess of the safe yield of certain basins. Pumping will probably continue until limited by economics, quality problems, legal restrictions, or organizational controls.

DWR NO. [illegible]71-6

Central Coastal Area lettuce bowl produces one-half of California's and one-third of Nation's lettuce

Local water districts in San Luis Obispo and Santa Barbara Counties have executed contracts with the State for delivery of more than 80,000 acre-feet annually from the State Water Project by 1990. Also the authorized San Felipe Division of the Central Valley Project is scheduled for annual deliveries of 80,000 acre-feet by 1990 and 110,000 acre-feet by 2020. When these projects are in full operation the Central Coastal area will still be deficient by about 130,000 acre-feet in 1990 and 360,000 acre-feet by 2020.

Almost all of the 1990 estimated demand for supplemental water is in the northern portion of the Central Coastal area, mostly in the lower Salinas Valley and to a lesser extent in Santa Cruz County and the coastal Monterey Coast-Carmel Valley vicinity.

About half of the projected 360,000 acre-feet annual deficit in 2020 is estimated to occur in the lower Salinas Valley. The balance is forecast to be about equally divided between Santa Cruz County, Monterey Coast-Carmel region, and Santa Barbara and San Luis Obispo Counties. Importation of water from the San Felipe Project is expected to provide for the foreseeable demands of the South Santa Clara and Hollister areas.

The question of identifying the sources of water which could most beneficially meet these deficiencies should be considered in terms of the relative economics of alternative water supply possibilities physically available to satisfy the specific deficiencies within the area. They include the options of additional local surface and ground water development, although this potential is small in Santa Barbara County; and the possibilities of additional imported water supplies, and desalting for urban purposes. In addition, the reuse of reclaimed urban waste water should be seriously considered for ground water recharge and/or irrigation use.

South Coastal Area

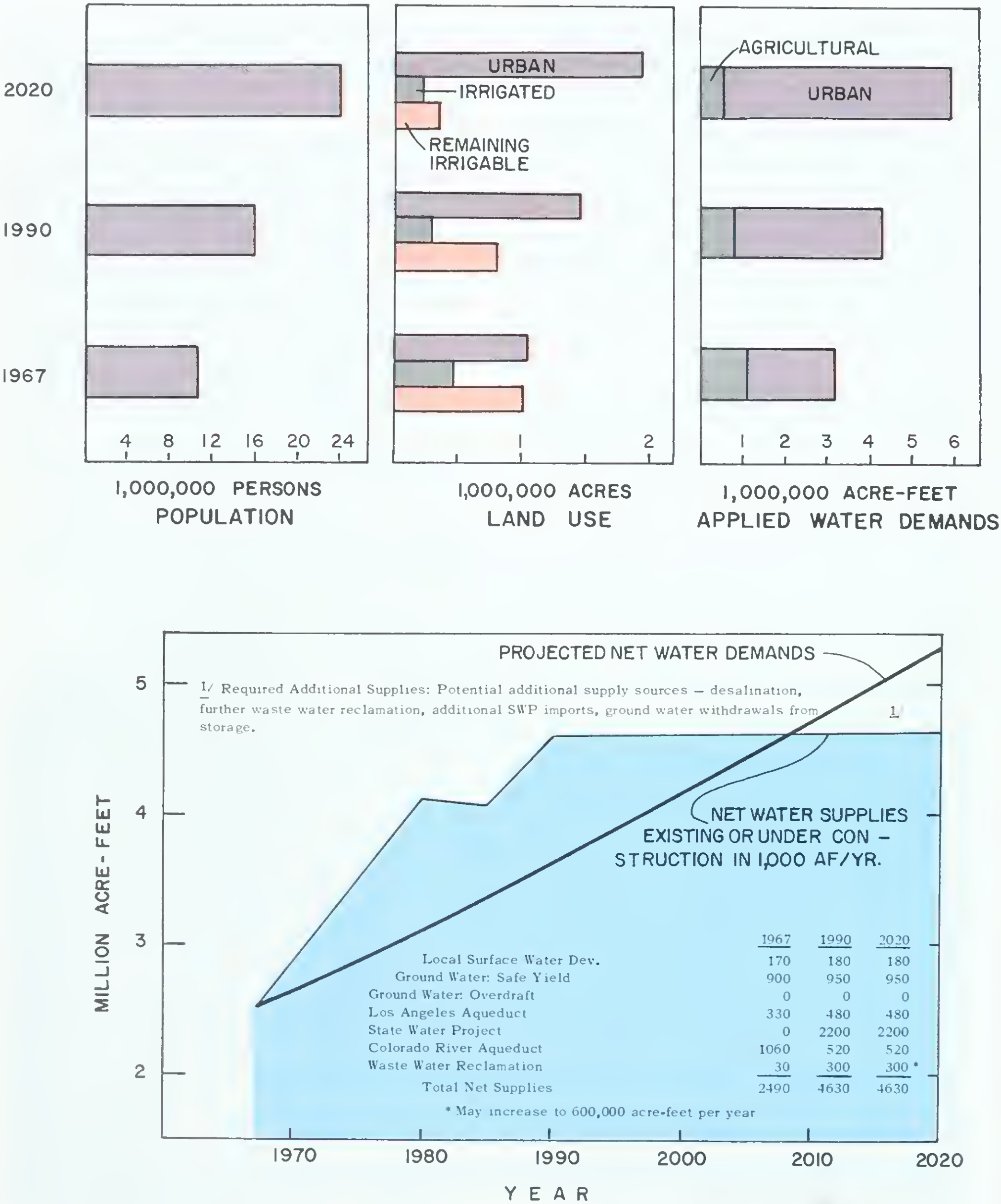
The South Coastal area is the most populous and the leading industrial and commercial center in the State. It is one of the fastest growing areas in the entire Country, and this growth is likely to continue. There has been a shift from an almost entirely agriculturally based economy to one of industry and commerce. The resultant economic diversification and prosperity can be attributed to the discovery of oil and the development of the petroleum industries and its favorable climatic conditions, which attracted the aircraft and national defense-oriented industries.

Reflecting the increasing urbanization, the total water demands of the South Coastal area, including agricultural demand, are projected to grow from about 2.5 million acre-feet per year at present to 5.3 million acre-feet in 2020, more than twice the present demand.

To meet present water demands, the South Coastal area presently depends on: (1) local surface and ground water supplies, which are almost fully developed if the use of water is based on the average annual natural replenishment; (2) the Los Angeles Aqueduct, which was enlarged in 1970 to deliver approximately 480,000 acre-feet annually to the City of Los Angeles; and (3) the Colorado River Aqueduct, now delivering water at almost full capacity of about 1.18 million acre-feet per year to the Metropolitan Water District of Southern California. Currently, the total water supply available to the area is approximately equal to its water demand (2.5 million acre-feet in 1967).

Potential future local surface water supply projects in the South Coastal area are limited, and water available from them will not offer a long-term solution to the area's needs. Fallbrook and DeLuz Reservoirs on the Santa Margarita River, as well as additional surface water

FIGURE 21

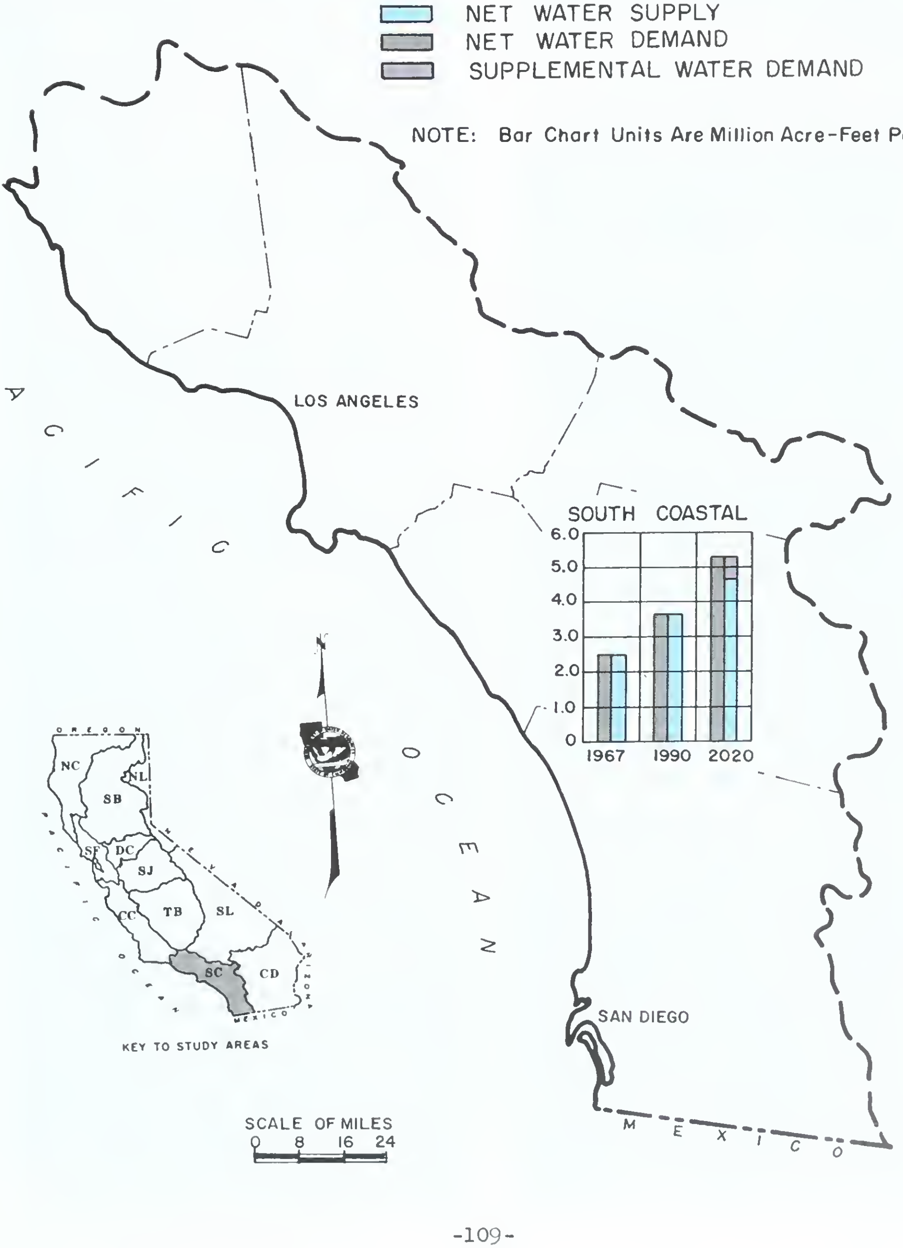


PROJECTED WATER SUPPLIES AND NET WATER DEMANDS

SOUTH COASTAL HYDROLOGIC STUDY AREA

FIGURE 22

SOUTH COASTAL HYDROLOGIC STUDY AREA



development in the San Dieguito River watershed in San Diego County, are currently being studied. Projects were proposed for Sespe Creek in Ventura County, but their near future construction is not considered likely.

In 1971 deliveries will begin from the State Water Project to the service areas of the Metropolitan Water District of Southern California and other water agencies in the South Coastal area. The total maximum entitlement to Project water amounts to 2,204,000 acre-feet per year.

The water supply from the Colorado River will be reduced to about 550,000 acre-feet per year when the Central Arizona Project becomes operational. It is expected that this reduction will occur in the mid-1980s. Nevertheless, the total supply available to the South Coastal area, including the full State Water Project entitlements, should be adequate to meet water demands until beyond 2000, when a demand for supplemental water is anticipated to begin. Delivery of full State Water Project entitlements will require additional conservation developments, as the presently developed firm Project water supply is somewhat less than the contract entitlements. The water supply capabilities of the State Water Project will be discussed in Chapter VII.

A substantial amount of water may be made available from waste water reclamation. By 2020, reclamation of about 600,000 acre-feet annually is believed feasible, even though definite plans have been made only for 300,000 acre-feet. However, additional information and experience must be gained before the full potential can be realized as a long-term source of water supply. For example, more definitive knowledge must be gained regarding the adequacy of underground recharge capacity to accept (percolate) large amounts of reclaimed water on a continuous basis. Also, further evaluation must be made concerning the physical and economic requirements to maintain adequate quality of the replenishing and receiving waters to meet water quality criteria specified by the Regional Water Quality Control Boards.

Converted sea water probably will satisfy a portion of the demand for supplemental water in the South Coastal area. While current costs preclude its consideration as a major source for the near future, it may well become economical on a large scale as technology in desalting processes continues to develop and costs are reduced.

The quality of ground water, a significant source of water to the South Coastal area, ranges from excellent to extremely poor. The quality of water from San Gabriel Valley, Upper Santa Ana River watershed, and San Fernando Valley is generally excellent and the concentration of dissolved minerals is generally below 400 parts per million (ppm), reflecting the quality of the runoff from mountain ranges. The quality of ground water in the Coastal Plain of Los Angeles County and the Coastal Plain of Orange County reflects substantial influence of man and the mineral concentration reaches about 500 ppm. Some isolated areas, however, have concentrations exceeding 1,000 ppm, reflecting the quality degradation from sea water intrusion. The quality of ground water in much of San Diego County is generally poor--700 to 1,400 ppm. Ground water in portions of Ventura County has poor quality--above 700 ppm.

The quality of water imported to the South Coastal area varies with the source. Water from Mono-Owens Valley has a dissolved mineral concentration of about 250 ppm. Colorado River water at Parker Dam, above which the Colorado River Aqueduct originates, has a concentration of about 750 ppm. A recent report by the Colorado River Board of California ("Need for Controlling Salinity of the Colorado River", published by the Colorado River Board of California, August 1970) presents estimates that salinity of Colorado River water at Parker Dam will increase to 860 ppm by 1980 and 1,110 ppm by 2000, in the absence of salinity control measures. If certain salinity control projects identified in the report are implemented and if they reduce salt loadings as estimated, the respective salinity values would be 820 and 830 ppm. Without such projects or other measures, costs of treatment would be increased substantially and usefulness of the water for some purposes would be impaired. To the extent such water could be diluted with water from the State Water Project, its adverse effects could be eliminated or reduced. Water to be delivered by the State Water Project will reflect the quality objective of 220 ppm, which is incorporated in the water supply contracts.

The water demand-supply relationships in the South Coastal area are depicted graphically in Figure 21, and the geographical locations of water demands and available supplies are shown in Figure 22.

It can be seen from an inspection of Figure 21 that the assumed level of reuse of reclaimed water has a considerable effect on the timing of need for supplemental water. The line on that figure depicting available supplies is based on the definitely planned reclamation of waste water in the amount of 300,000 acre-feet per year. If this value were increased to 600,000 acre-feet per year, as future experience may well prove to be the case, the effect would be to delay the need for supplemental water.

In addition to the further use of reclaimed water, the total demand for supplemental water in the South Coastal area in 2020 could be met from several alternative sources: surplus deliveries of Project water during the earlier years, to be stored underground for later use; water from supplementary facilities to State Water Project; converted sea water; and possible interim use of ground water in storage. It is probable that a combination of some or all of these alternatives will be employed to meet the area's water demands.

Sacramento Basin

The Sacramento Basin is the second largest water-producing area in the State. On the average, about 21 million acre-feet of natural runoff annually originates in the basin, amounting to about 30 percent of California's total natural runoff. The Sacramento River is the largest stream in the State. It provides for year-round navigation for shallow-draft craft upstream as far as Colusa. This is made possible by releases from Shasta Reservoir, the largest regulatory reservoir in the Basin.

Like the North Coastal area, the Sacramento Basin is subject to periodic devastating floods. An extensive system of flood control works has been constructed over the years by various agencies including the U. S. Army Corps of Engineers and reclamation and flood control districts. The system includes hundreds of miles of levees along the Sacramento River and tributaries and Shasta and Folsom Dams. The recently completed Oroville Dam on the Feather River and New Bullards Bar Dam on the Yuba River are substantial additions to the flood control system.

In all, the flood control works within the Sacramento Basin have functioned well in recent years to minimize the disastrous flooding which has been part of the history of the Basin. Damages during the extended periods of high runoff in 1969 and 1970 were light in comparison with damages which would have occurred without satisfactory operation of the system.

Completion of Auburn Dam, now under construction and construction of the authorized Marysville Dam will significantly increase protection from major flooding in some of the more urban areas of the Sacramento Basin. The Corps of Engineers has recently proposed construction of two reservoirs on Cottonwood Creek, a major west side tributary of the Sacramento River near Redding. Other possible projects are under study on a number of streams. In addition, proposals for channel improvements and levees are under consideration. Floodplain management programs are also being initiated by local interests.

More than 90 percent of the water used today in the Sacramento Basin is for farming. Agricultural water use is expected to increase moderately in the future with an annual applied water demand in 2020 of about 7.5 million acre-feet, an increase of approximately 20 percent over present (1967) levels.

Agricultural demands are expected to rise at a more rapid rate prior to 1990; after that date the increase is expected to slow, partly because of urban encroachment and partly because most of the best land with convenient water supplies will be under irrigation by 1990.

Urban demands are expected to approximately double by 2020. Most of the urban growth is expected to continue near present cities. Included in the future urban demand is an allotment of about 60,000 acre-feet for the paper and wood products industry in the northern Sacramento Valley.

The Sacramento Basin accounts for a substantial portion of the statewide fish, wildlife, and recreation water requirements. This is due primarily to several existing wildlife refuges.

Rice Growers Association of California

Sacramento Valley – – " . . . *the area is well suited to rice culture.*"

In addition, many private organizations flood farmlands in the fall to provide waterfowl hunting opportunities.

The present (1967) and projected 1990 and 2020 population, land use, water demand, and usable water supplies in the Sacramento Basin are shown in Figure 23. The geographic distribution of water supplies and demands is shown on Figure 24.

Total basin-wide developed water supplies exceed total foreseeable water demands in the Sacramento Basin. Some water agencies in favorable locations have more developed water available than the indicated demand in 2020, particularly in the southeastern portion of the Basin. Other areas do not have sufficient supplies to fully meet expected future needs.

Areas of indicated water shortages are (1) the west side of the Sacramento Valley, mainly in Yolo and Solano Counties; (2) the Pit River Basin, mainly in Big Valley; and (3) scattered foothill and mountain areas both on the east side and west side, including Lake County. Future supplemental demands in Yolo and Solano Counties can be met by the Indian Valley Reservoir on Cache Creek to be constructed by the Yolo County Flood Control and Water Conservation District, and the West Sacramento Canals Unit of the Central Valley Project. The proposed Allen Camp Unit would meet the projected deficits in the Pit River Basin and would make possible development of a new wildlife refuge in Big Valley. The authorized Lakeport Project by the U. S. Army Corps of Engineers could take care of a significant part of Lake County needs, while the proposed Middletown Reservoir in the upper Putah Creek drainage (part of the proposed West Sacramento Canals Unit) would permit agricultural development in that portion of Lake County. Other possibilities are the proposed English Ridge import from the Eel River and additional Cache Creek storage.

Other areas of water shortage are projected to occur in scattered mountain and foothill areas on the western slopes of the Sierra Nevada-Cascade Range, as a result of the influx of people taking advantage of the pleasant environment.

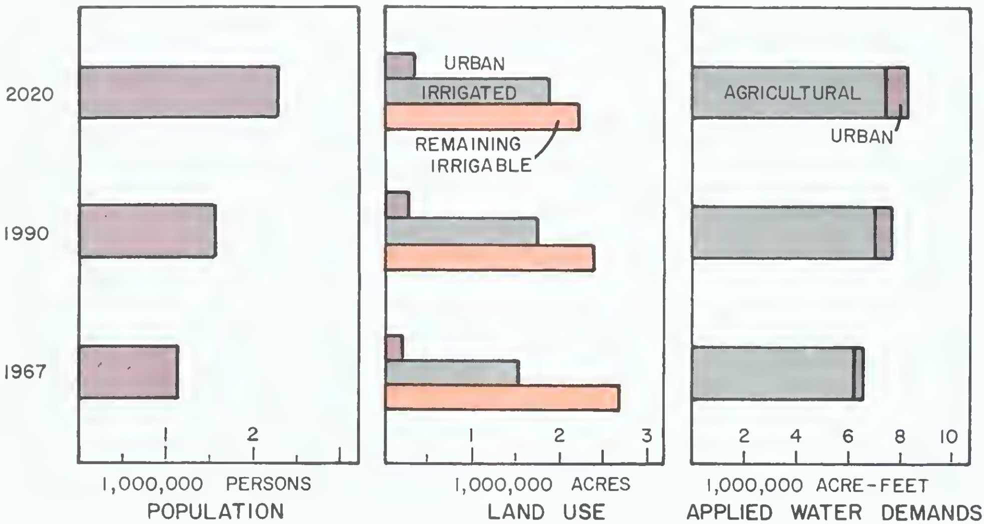
There is a substantial amount of additional land suitable for many irrigated crops in the Sacramento Basin. Water costs for new development generally will be less than in other areas of the State. Climatic conditions for agriculture are almost as favorable as in the San Joaquin and Tulare Basins; therefore, a shift in new land development to the north is possible with corresponding effects on the projections shown here.

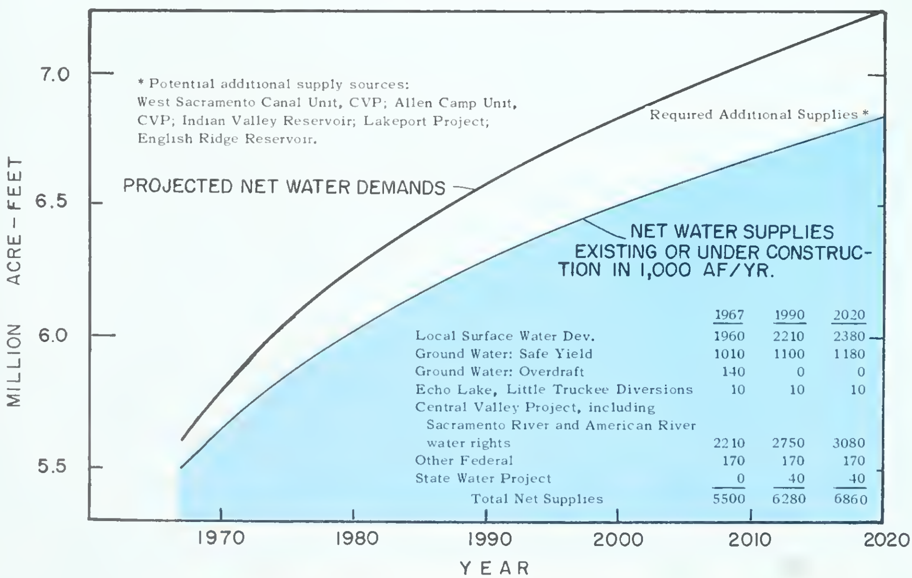
Because of its high water requirement, the future of rice acreage is an important factor in projecting future water demands in the Sacramento Valley. With many acres of fine-textured clay soils, inexpensive water and high yield potential, the area is well-suited to rice culture. Projection of future rice acreage is particularly uncertain, as it is subject to governmental controls and foreign markets. Reported rice plantings in 1967 in the Sacramento Valley were about 320,000 acres; rice acreages for the 1990 to 2020 period were assumed in this bulletin to remain essentially constant, approximating the 1967 level.

Preservation of the present high quality of water in the Sacramento River is of paramount importance. It concerns local water uses, fish and wildlife, and uses dependent upon water exported from the river by the Central Valley and State Water Projects. Quality of the river has been under surveillance and investigation for a number of years.

In January 1969, the California Regional Water Quality Control Board, Central Valley Region, proposed water quality control policy for the

FIGURE 23



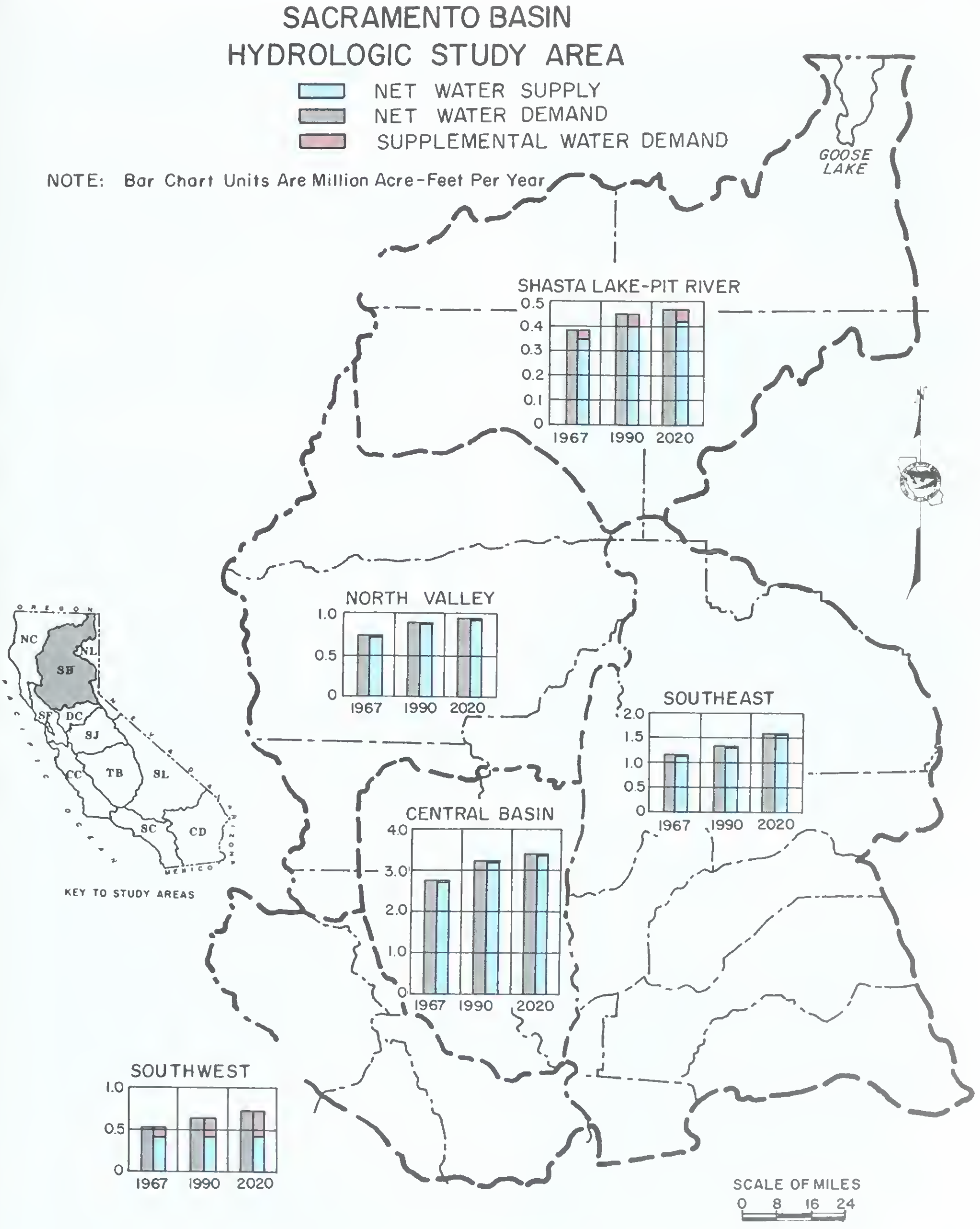


	1967	1990	2020
Local Surface Water Dev.	1960	2210	2380
Ground Water: Safe Yield	1010	1100	1180
Ground Water: Overdraft	140	0	0
Echo Lake, Little Truckee Diversions	10	10	10
Central Valley Project, including Sacramento River and American River water rights	2210	2750	3080
Other Federal	170	170	170
State Water Project	0	40	40
Total Net Supplies	5500	6280	6860

PROJECTED WATER SUPPLIES AND NET WATER DEMANDS

SACRAMENTO BASIN HYDROLOGIC STUDY AREA

FIGURE 24


SACRAMENTO BASIN
HYDROLOGIC STUDY AREA
NET WATER SUPPLY
NET WATER DEMAND
SUPPLEMENTAL WATER DEMAND
NOTE: Bar Chart Units Are Million Acre-Feet Per Year
GOOSE LAKE
SHASTA LAKE-PIT RIVER
0.5
0.4
0.3
0.2
0.1
0
1967 1990 2020
NORTH VALLEY
1.0
0.5
0
1967 1990 2020
SOUTHEAST
2.0
1.5
1.0
0.5
0
1967 1990 2020
CENTRAL BASIN
4.0
3.0
2.0
1.0
0
1967 1990 2020
SOUTHWEST
1.0
0.5
0
1967 1990 2020
OREGON
NC
SB
NL
SF
DC
SJ
CC
TB
SL
SC
CD
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
KEY TO STUDY AREAS
SCALE OF MILES
0 8 16 24

Sacramento River to apply from Sacramento to Keswick Dam. Local interests became concerned about the possible consequences of the proposed policy with respect to future irrigated agriculture, and in May 1969 requested the Department to assist them in a one-year study of the impact of anticipated future expansion of irrigated agriculture on the quality of water in the river.

Preliminary results of the study showed that, although the 1990 annual average mineral concentration (as measured by electical conductivity) would be higher (30 to 58 percent at Freeport) than historic values, the overall mineral quality would not approach the historic monthly extremes. No serious quality problems with respect to total dissolved mineral concentrations were indicated for the hydrologic conditions studied.

A similar cooperative study was initiated in January 1970 for the Feather River. Continuing water quality studies of the Sacramento Basin are necessary to keep abreast with changes in water development and project operations, as well as changes in land use and industrial development.

Water releases from reservoir projects serve the multiple purposes not only of maintaining fish habitat and the riparian, or streamside habitat, upon which many birds and mammals depend, but also of providing for beneficial consumptive uses and purposes. Considerable success has been achieved in effecting downstream releases in the Sacramento Basin. This has been accomplished by agreements usually negotiated between the construction agency and the Department of Fish and Game. At the present time 26 such agreements representing 13 different agencies are in effect. The streams and quantities are shown in the tabulation at the bottom of this page.

In summary, the overall outlook for sufficiency of water supplies to meet future demands in the Sacramento Basin is excellent. Although much of the Basin will have surplus water, such surpluses generally are not transferable because of location, topography, or other factors, and certain areas are expected to have a future deficiency. By and large, however, proposed local and federal projects could satisfy these deficiencies. In addition to the water demands of an expanding agricultural economy, the Basin will remain an

Stream	Streamflow Releases (Acre-Feet Per Year)
Upper Sacramento	60,000
Pit-McCloud	150,000
Sacramento at Keswick Dam	2,000,000
Clear Creek at Whiskeytown Dam	20,000
Feather River at Oroville	970,000
Feather River Tributaries, including New Bullards Bar Dam	290,000
American River and Tributaries	390,000
TOTAL	3,880,000

attractive and desirable area for fish and wildlife and other recreational pursuits.

Delta-Central Sierra Area

The Delta-Central Sierra area contains the Delta of the Sacramento and San Joaquin Rivers and the watersheds of the Calaveras, Mokelumne, and Cosumnes Rivers. The Delta consists of many islands, often below sea level, among a maze of meandering channels. Behind protective levees, irrigated agriculture has flourished for many years on the rich peaty soils, which are especially suited for asparagus growing. East of the Delta, valley lands rise gradually for quite a distance before reaching foothills which blend into the rugged mountains of the Sierra Nevada.

The flat valley lands are similar in appearance and potential use to lands of the Sacramento Valley to the north and the San Joaquin Valley on the south. However, there is more marine influence due to prevailing summer winds coming in through the gap in the Coast Range to the west. This more moderate climate makes possible the culture of the famous Tokay variety of table grape near Lodi and also the pear orchards along the Sacramento River in the Delta.

Estimated 1967 agricultural water demand was 2.3 million acre-feet per year, of which a little over half was in the Sacramento-San Joaquin Delta. Some increase in irrigated land is expected in the future, mostly in valley areas surrounding the Delta. As a result, on-farm water demands are projected to increase to 2.5 million acre-feet in 1990 and 2.6 million acre-feet in 2020.

Water demands for urban purposes are expected to approximately triple by 2020. Included in the future urban demand is an allotment of 75,000 acre-feet of cooling water to be imported from the American River for the Rancho Seco nuclear powerplant now under construction by the Sacramento Municipal Utility District.

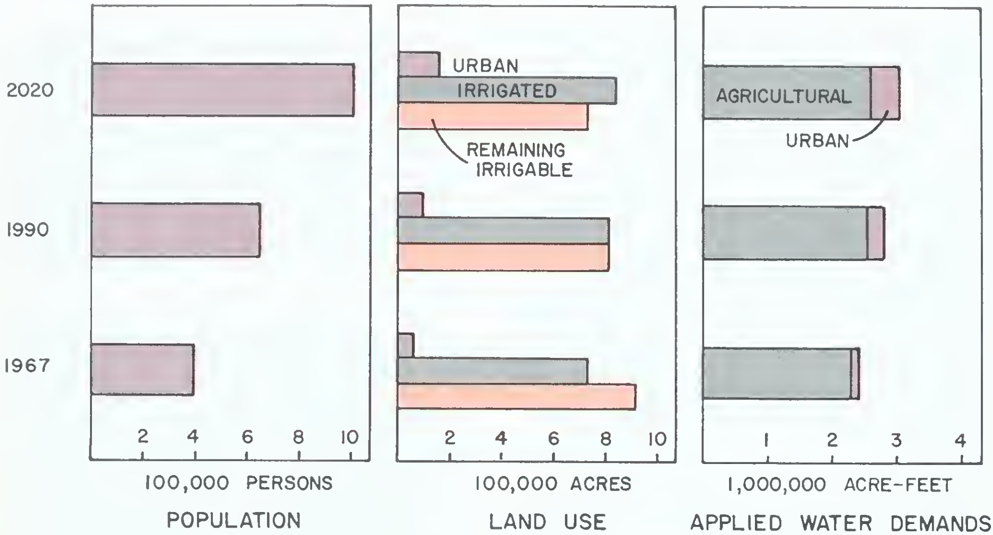
The present (1967) and projected 1990 and 2020 population, land use, water demands, and estimated water supplies in the Delta-Central Sierra area are shown in Figure 25. Figure 26 illustrates the geographical distribution of water demands and supplies.

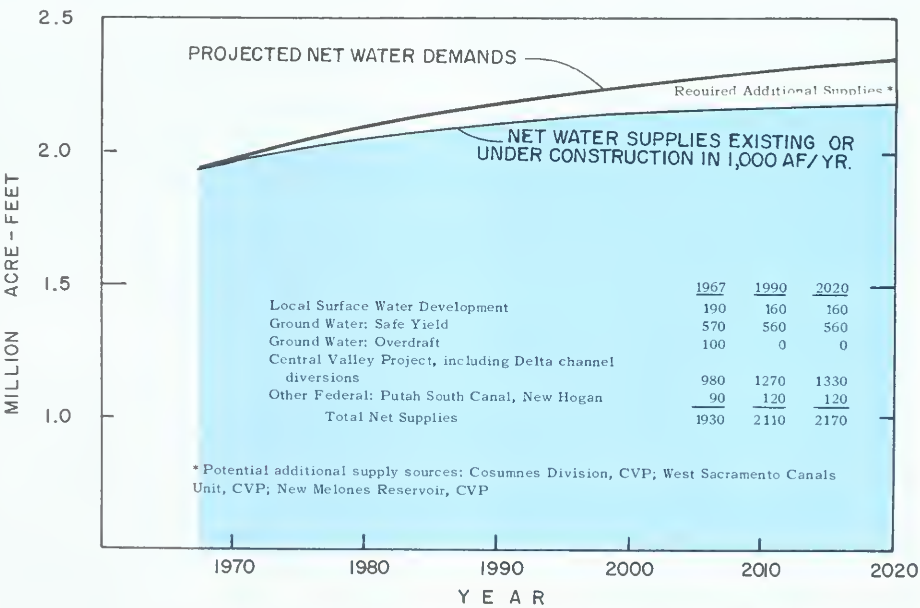
Major existing surface sources of water are the Mokelumne River, which also serves as a supply for the East Bay Municipal Utility District in the San Francisco Bay area; the Calaveras River; and the channels of the Delta. The amount of water available from the Mokelumne River is anticipated to decline somewhat in the future when full East Bay Municipal Utility District exports are made; hence, the reduction in local surface supply on Figure 25.

In addition, water is served in areas west of the Delta from the Putah South, Contra Costa, and Delta-Mendota Canals. Ground water comprises an important source, meeting over 30 percent of the demand today, partially at the expense of ground water overdrafts which aggregate slightly more than 100,000 acre-feet in the area east of the Delta. A major new facility just beginning construction is the Folsom South Canal, which would serve a large area of the valley east of Sacramento, Lodi, and Stockton.

After allowing for the capabilities of existing water sources and those under construction, a deficiency, or supplemental demand, of about 90,000 acre-feet in 1990 and 180,000 acre-feet in 2020 is forecast for the Delta-Central Sierra area. These additional demands would be located in three areas: (1) Solano County to the northwest of the Delta; (2) Contra Costa and San Joaquin Counties to the southwest of the Delta; and (3) higher valley, foothill, and mountain regions east of the Folsom South Canal service area.

FIGURE 25





	1967	1990	2020
Local Surface Water Development	190	160	160
Ground Water: Safe Yield	570	560	560
Ground Water: Overdraft	100	0	0
Central Valley Project, including Delta channel diversions	980	1270	1330
Other Federal: Putah South Canal, New Hogan	90	120	120
Total Net Supplies	1930	2110	2170

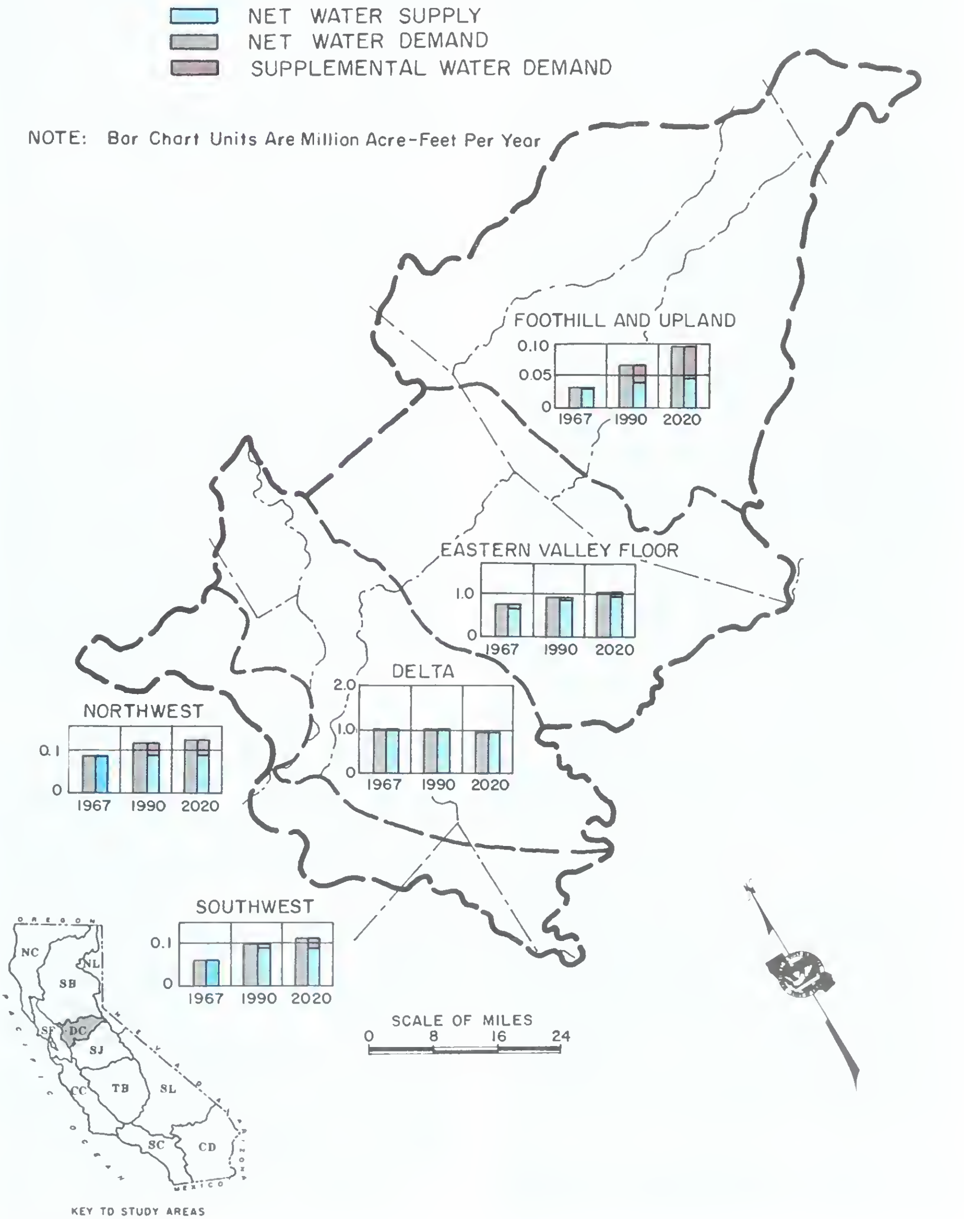
* Potential additional supply sources: Cosumnes Division, CVP; West Sacramento Canals Unit, CVP; New Melones Reservoir, CVP

PROJECTED WATER SUPPLIES AND NET WATER DEMANDS

DELTA - CENTRAL SIERRA HYDROLOGIC STUDY AREA

FIGURE 26

DELTA - CENTRAL SIERRA HYDROLOGIC STUDY AREA



Eastern Solano County shortages could be met from the proposed West Sacramento Canals Unit of the Central Valley Project, by possible direct diversion from one of the Delta channels, or by interim ground water overdraft pending the construction of an import project.

The supplemental demands of the strip of valley and foothill lands southwest of the Delta could be partly supplied from the proposed Kellogg Unit of the Central Valley Project. Those in San Joaquin County, which are expected to be almost entirely for farm purposes, could possibly be met from the Central Valley Project or from expanded State Water Project sources via the California Aqueduct.

In the remaining area future deficiency, east of Folsom South Canal service area, supplemental water demands are forecast to be about 50,000 acre-feet in 1990 and 120,000 acre-feet in 2020. A significant portion of this demand is for agriculture and may not materialize unless a relatively low-priced supply, such as the proposed Cosumnes River Division of the Central Valley Project, is available. A large share of the forecast shortage could be provided from the proposed Cosumnes River Division. It would appear that one upper reservoir plus Nashville Reservoir would be adequate for meeting most local future demands on the Cosumnes River drainage area.

Additional water demands in the northern tip of Stanislaus County could probably be best provided from the New Melones Project, possibly via Oakdale Irrigation District. Supplemental water could also be made available from El Dorado County's Central Valley Project reservation in Folsom Lake, the Malby diversion from Folsom Lake, the proposed Swiss Ranch development in Calaveras County, and other mountain area small projects.

The Sacramento-San Joaquin Delta's 700 miles of waterways form a unique aquatic environment for the greatest variety of fish and other aquatic life found anywhere in California. Substantial populations of striped bass, salmon, steelhead, shad, catfish, and sturgeon are dependent on this area during all or part of their lives. About 80 percent of California's commercial salmon fishing depends upon the Delta estuary in one way or another.

In addition to its local agricultural, industrial, recreational, and esthetic values, the Delta is the common point of collection and diversion of waters southward to meet the growing water needs of the San Joaquin Valley and Central and Southern California.

Water quality has been a problem in the Delta from the time that low-lying lands were originally reclaimed and farming began. In the past the problems have been caused primarily by the intrusion of ocean salinity from the tidal movement, especially during periods of very low outflow of fresh water, such as occurred in 1924 and 1931. During such low-flow conditions much of the Delta could not be irrigated because of the intolerable salinity in the channels and sloughs which served as a water supply source.

Summer releases of stored water from Shasta Reservoir, together with Folsom and Oroville in more recent years, have vastly reduced the salinity intrusion problem. In fact, no significant intrusion of salt water has occurred since 1944 when Shasta Dam was completed.

Water quality problems in the Delta have been intensified with the increasing discharge of agricultural drainage and industrial wastes into Delta channels, expanded use in the Central Valley, and increasing export of Central Valley water to the Bay area. It has been recognized that these problems will become more aggravated in the future unless steps are taken to protect and preserve the Delta environment.

In studies leading to the State Water Project, it became apparent that facilities in the Delta would be needed to transfer project water across the Delta without undue loss or deterioration in quality; to assure an adequate supply of good-quality water and protection of Delta lands from the effects of salinity intrusion; to protect the valuable fishery resources of the Delta, and where possible, provide for their enhancement. Consequently, an interagency committee, composed of representatives of the Bureau of Reclamation, the Corps of Engineers, and the Department of Water Resources, examined all previous plans for a multi-purpose Delta water facility. The objective was to recommend a mutually acceptable plan that would provide for the various needs of the Delta and satisfy the needs of the Central Valley Project and State Water Project for water transfer. The committee recommended the Peripheral Canal plan as the only acceptable plan of the several alternatives that could meet the various criteria considered essential to provide a suitable environment in the Delta while simultaneously meeting water delivery requirements elsewhere.

San Joaquin Basin

The San Joaquin Basin consists of the entire drainage area of the San Joaquin River and its tributaries upstream from the San Joaquin River gage near Vernalis, at the southerly edge of the Delta.

The average annual runoff of the Basin is about 6 million acre-feet. The major streams are the San Joaquin River and its three major east side tributaries--the Stanislaus, Tuolumne, and Merced Rivers. In addition, large amounts of water are imported via the Delta-Mendota Canal, partly as water exchange, permitting diversion of San Joaquin River water at Friant Dam.

As in other parts of the Central Valley a wide variety of crops can be grown in the San Joaquin Basin. The area is noted for its truck, tomato, fruit, and nut production. Dairying is also prominent. Irrigation development began in the 1870s with diversions of water from major rivers. Expansion of irrigated acreage has continued at a rate of about 10 to 15 percent per decade.

Total water applied for all uses in the Basin in 1967 amounted to about 5.7 million acre-feet, of which 5.5 million was for agricultural purposes. Corresponding total net water use (consumptive uses plus irrecoverable losses) was about 4.4 million acre-feet, which was provided by firm local and imported surface and ground water developments, including depletion of ground water storage by nearly 200,000 acre-feet.

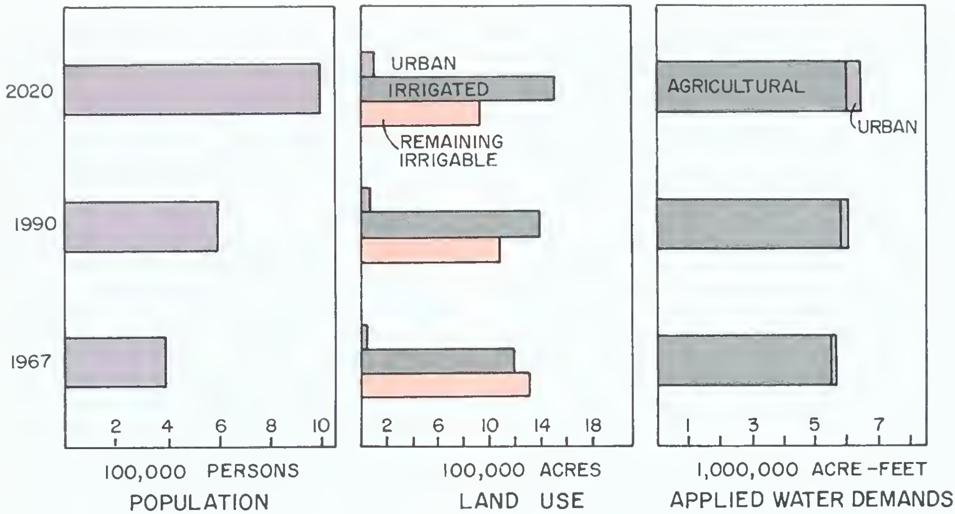
The rate of irrigated land expansion, as forecast in this bulletin, is expected to diminish appreciably, increasing about 25 percent over present levels by 2020. Due to a predicted change in crop patterns, the need for applied water for farming is forecast to increase at a much slower rate from an estimated 5.5 million acre-feet at present to 6 million acre-feet in 2020.

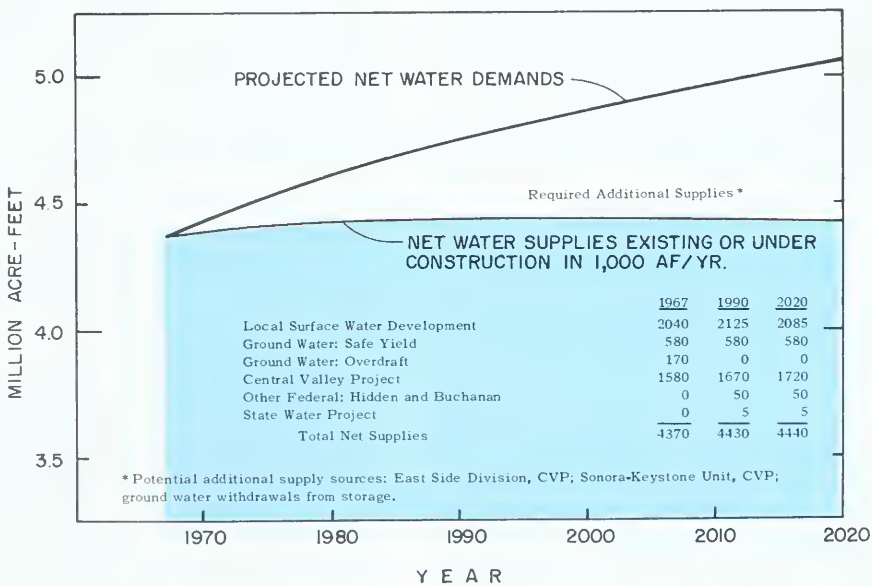
Urban applied water demands, currently about 150,000 acre-feet, are expected to nearly triple by 2020. Even so, urban water use will be only about 7 percent of the total water demand.

Fish, wildlife, and recreation demands were taken from preliminary federal-state Framework Study work. These are primarily for waterfowl refuges. The San Joaquin Basin affords important winter waterfowl habitat, especially in the grasslands region near Los Banos. The projected increase envisions substantial expansion of federal and state waterfowl management areas.

The present (1967) and projected 1990 and 2020 population, land use, water demands, and water supplies in the San Joaquin Basin

FIGURE 27





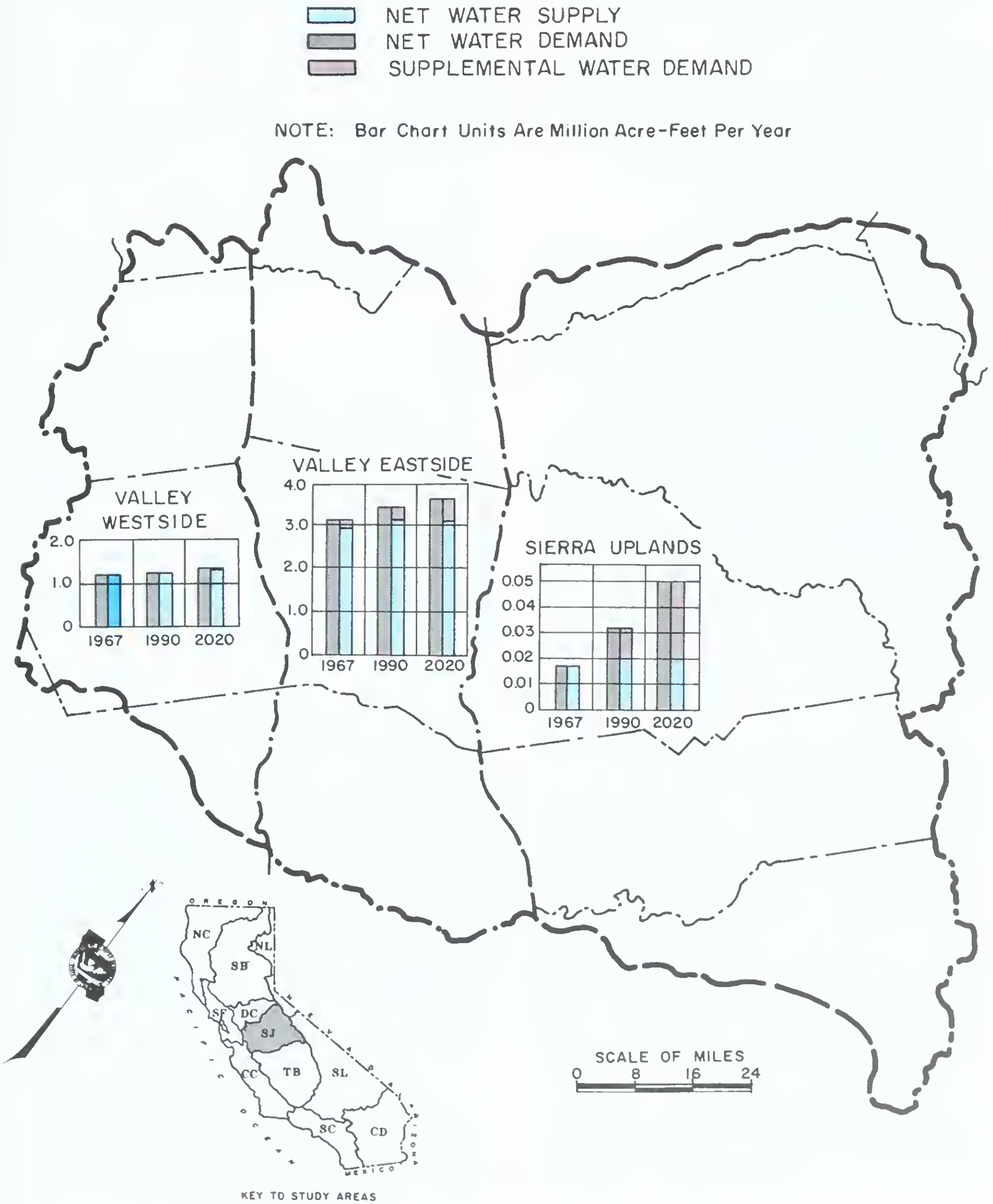
	1967	1990	2020
Local Surface Water Development	2040	2125	2085
Ground Water: Safe Yield	580	580	580
Ground Water: Overdraft	170	0	0
Central Valley Project	1580	1670	1720
Other Federal: Hidden and Buchanan	0	50	50
State Water Project	0	5	5
Total Net Supplies	4370	4430	4440

* Potential additional supply sources: East Side Division, CVP; Sonora-Keystone Unit, CVP; ground water withdrawals from storage.

PROJECTED WATER SUPPLIES AND NET WATER DEMANDS

SAN JOAQUIN BASIN HYDROLOGIC STUDY AREA

SAN JOAQUIN BASIN HYDROLOGIC STUDY AREA



are shown in Figure 27. The geographical distribution of water demands and supplies is indicated on Figure 28. The major share of the increase in water use is expected to occur on the southeastern portion of the valley floor and along the foothills of the Sierra Nevada. The slight decrease in the local surface supply between 1990 and 2020 on Figure 27 is due to slightly decreased net demand in major irrigation districts as a result of projected urban encroachment.

Existing projects and possibly some localized additional ground water pumping are considered adequate to meet the future needs of the Oakdale, South San Joaquin, Waterford, Modesto, Turlock, and Merced Irrigation Districts until 2020. West side supplies appear adequate until sometime after 1990.

Construction of Hidden and Buchanan Reservoirs on the Fresno and Chowchilla Rivers will provide about 50,000 acre-feet of average yield annually, and at the same time give badly needed flood protection to the Madera and Chowchilla areas. The water yields from these two projects will be needed in the water-short valley floor areas before 1990.

New Melones Reservoir, now under construction on the Stanislaus River, will develop nearly 300,000 acre-feet of yield. Its water supply will be incorporated into the Central Valley Project and could be made available to areas of need within the Basin if yet unauthorized conveyance works are built. In addition to the water supply aspect, planned fishery and water quality releases from New Melones Dam will help to alleviate existing water quality problems in the lower San Joaquin River.

Water supplies, mostly small and widely distributed throughout the Sierra Nevada, must be developed to meet the expected additional upland area needs in 1990 and 2020.

The projected east side valley floor deficiencies of 300,000 acre-feet in 1990 and 560,000 acre-feet in 2020 can be met either by temporarily continuing to mine water from underground storage or by importing supplemental water into the Basin. Considering the magnitude and location of the deficiencies in both the San Joaquin and Tulare Basins, and the probable alignment of the proposed East Side Canal of the Central Valley Project, it appears that importation is the most practical long-range solution--most likely via the proposed East Side Division.

It is possible that the East Side Canal may permit development of surface supplies in those Sierra upland areas where development has been inhibited because downstream water users hold all the water rights. Perhaps exchanges could be negotiated in which the downstream users would be furnished East Side Canal water in exchange for upstream development for local purposes. The proposed East Side Canal also has the potential for improving downstream fishery flows in all the significant streams of the San Joaquin Basin.

Streamflow maintenance agreements in the San Joaquin Basin provide water for diverse fish and wildlife needs. In the San Joaquin and Stanislaus Rivers, the flows provide for trout stream habitat that would be otherwise depeleted through diversion for power development, irrigation, and domestic use. The Merced River flows are utilized for salmon and steelhead spawning. The purpose of the agreements with the U. S. Bureau of Reclamation is to mitigate the loss of waterfowl habitat inundated by the San Luis and Los Banos Reservoirs.

Several local agencies and the U. S. Bureau of Reclamation have signed agreements with the California Department of Fish and Game for streamflow releases as shown in the tabulation at the top of the next page.

Stream	Agency	Streamflow Releases (Acre-Feet Per Year)
San Joaquin	Southern California Edison Company	43,000
Merced	Merced Irrigation District	43,000
Stanislaus	Tuolumne County Water District No. 2 Oakdale and South San Joaquin Irrigation District Calaveras County Water District	168,000
Los Banos-San Luis	U. S. Bureau of Reclamation	4,000

The Corps of Engineers is studying flood problems throughout the San Joaquin Basin. Current studies include the Merced Stream Group.

Tulare Basin

The Tulare Basin comprises the entire drainage area of the San Joaquin Valley south of the San Joaquin River. It is grossly deficient in natural water resources; yet, in contrast, it is the largest agricultural producer in the State. Satisfaction of water demands in the Basin, which are the greatest of the 11 hydrologic study areas, relies to a considerable extent on imported supplies and ground water overdraft.

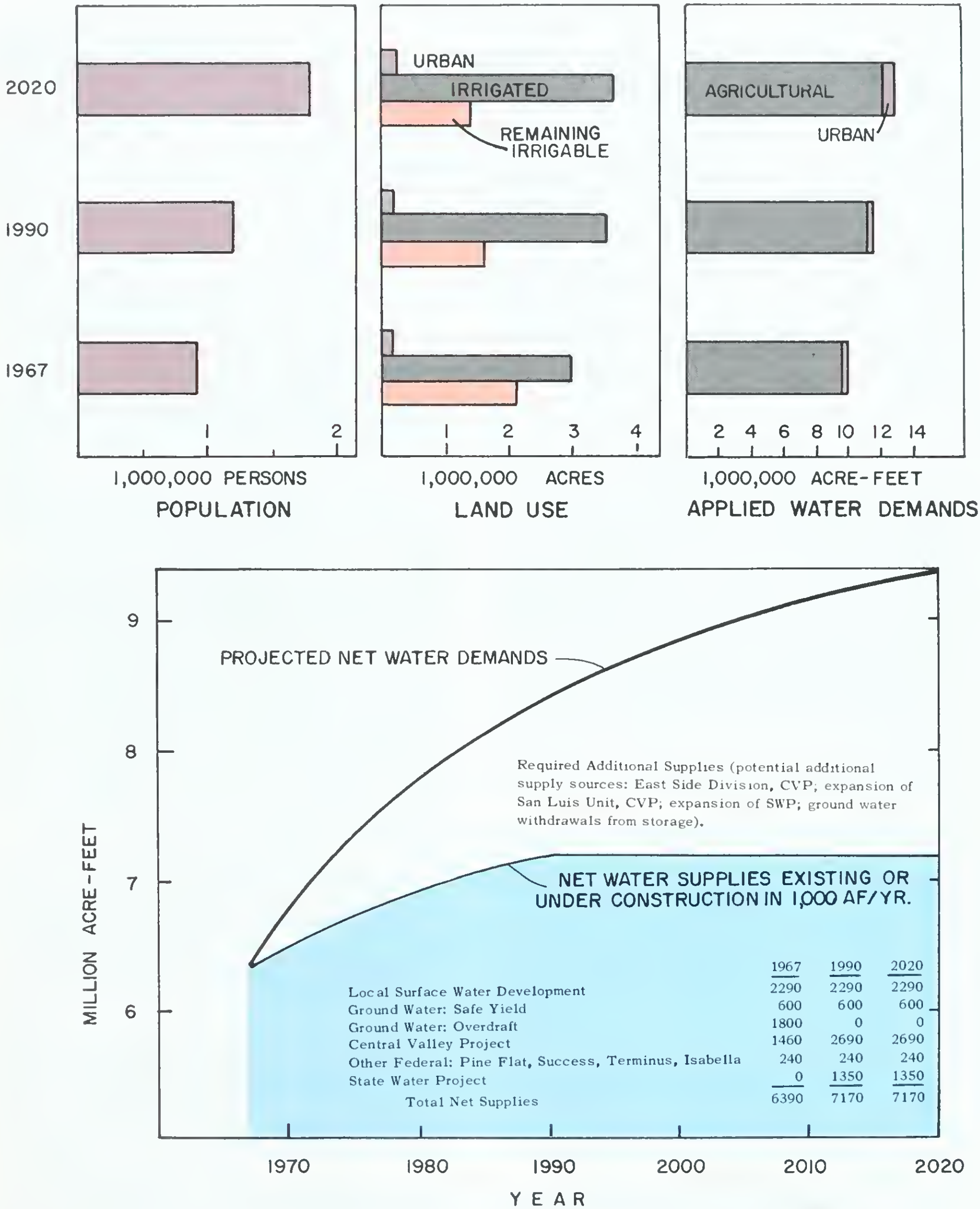
Natural water supplies of the Basin are derived primarily from Sierra Nevada runoff in the Kings, Kaweah, Tule and Kern Rivers. These streams provide a source for direct diversion for agricultural and urban uses and also replenish the underlying ground water basin by direct percolation from channels and from the unconsumed portion of applied waters.

Use of water in the Tulare Basin has long exceeded the natural water supplies, and supplemental supplies have been imported via the Friant-Kern and Delta-Mendota Canals of the federal Central Valley Project. In 1967 the total amount of all water available for firm and sustained use in the Basin averaged about 4.6 million acre-feet, while the net use of water amounted to about 6.4 million acre-feet. The excess of use over available firm supplies is met by a long-term average annual net depletion of ground water of about 1.8 million acre-feet.

Currently, the State Water Project and the San Luis Unit of the Central Valley Project are delivering water to the Basin. Under full delivery those two projects will provide a total of about 2.6 million acre-feet annually. However, even with local developments and these large import projects operating at full contractual cpacity, the Basin's economy is expected to grow to such an extent that the annual water demand in excess of its existing combined yield will be about 1.2 million acre-feet by 1990 and about 2.1 million acre-feet by 2020. This growth in economy is projected on the basis of the extremely favorable combination of soils and climate and advantageous market location for a thriving agricultural industry.

The geographical distribution of present and projected supplemental water demands is important in the consideration of likely water sources to meet the total water needs of the Tulare Basin. Supplemental water needs west of the valley trough could be served by additional deliveries from the San Luis Unit of the Central Valley

FIGURE 29

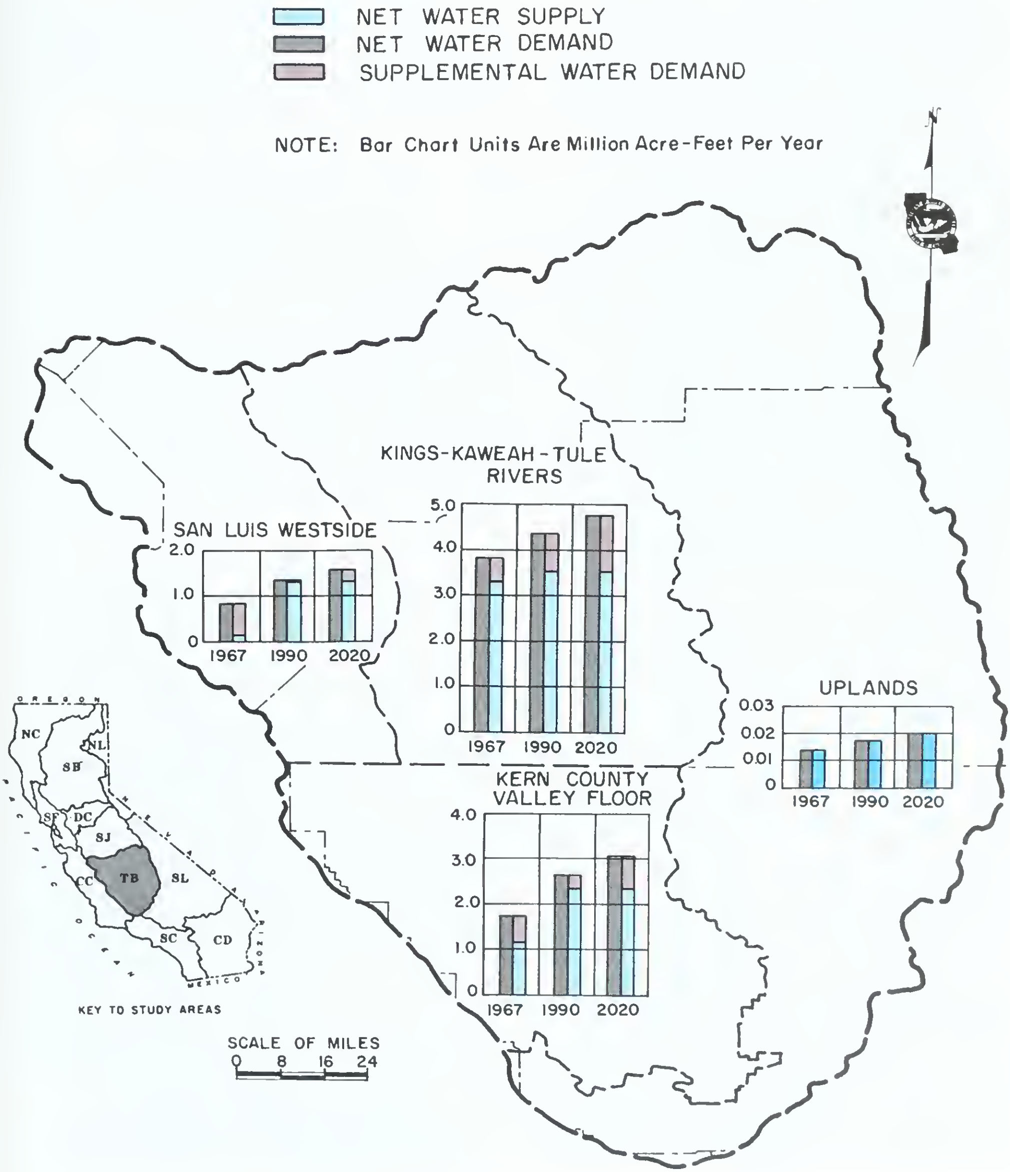


	1967	1990	2020
Local Surface Water Development	2290	2290	2290
Ground Water: Safe Yield	600	600	600
Ground Water: Overdraft	1800	0	0
Central Valley Project	1460	2690	2690
Other Federal: Pine Flat, Success, Terminus, Isabella	240	240	240
State Water Project	0	1350	1350
Total Net Supplies	6390	7170	7170

PROJECTED WATER SUPPLIES AND NET WATER DEMANDS

TULARE BASIN HYDROLOGIC STUDY AREA

TULARE BASIN HYDROLOGIC STUDY AREA



Project and the State Water Project. These deliveries would initially be needed around 1990 and are estimated to increase to about 500,000 acre-feet annually by 2020. While the California Aqueduct could transport the additional water with relatively inexpensive augmentation of capacity, this water service is not included in present contracts.

Supplemental water service for the eastern slope of the valley floor could be provided by a project such as the proposed East Side Division of the federal Central Valley Project. East Side delivery requirements are projected to be about 1.2 million acre-feet in 1990 and about 1.6 million in 2020.

Whereas presently contracted supplies from the federal San Luis Unit and the State Water Project appear sufficient to serve the west side of the valley floor until about 1990, the easterly slopes of the valley floor are in need of supplemental water now, and a rapid buildup in use of imported supplies is anticipated when they become available from the East Side Division.

Preliminary economic studies indicate that at the proposed canalside prices the water users could realize significant savings in their total water cost if the full delivery capacity of the East Side Project were utilized at an early date. This would enable the ground water basins to refill, thereby decreasing the unit pumping costs for the remaining large amount of ground water which still must be pumped to meet the total applied water demand within the area.

Further examination should be made of the possible economic and operational advantages of fully coordinated operation of the existing and future surface and ground water resources of the Tulare Basin. This should include the effects of continuing to draw upon the ground water basin and the operational flexibility which could be obtained for the major aqueduct systems if the east and west side projects were joined either physically or by exchange agreements.

Full realization of the economic potential of the Basin would also require future construction of the San Joaquin Valley master drain to avoid crop losses and serious degradation of the ground water.

With regard to fish and wildlife, streamflow maintenance agreements in the Kern River drainage cover flow releases below various power diversions of the Southern California Edison Company system. The stipulated flows include about 14,000 acre-feet annually for a water supply to the Kern River Fish Hatchery at Kernville. Kings River water releases maintain flows below Pine Flat Dam. Stabilized flows in the Kings have permitted development of a popular year-round trout fishery, including a special fly-fishing season during the winter.

While the principal tributary Sierra Nevada streams have major reservoirs that provide downstream flood protection in most years, intense rainfall (such as occurred over the Kaweah River watershed in the winter of 1968-69) or the combination of warm weather or an extremely deep snowpack, which resulted in severe flooding in the Tulare Lake bed in January 1969 still poses a serious flood threat. The U. S. Army Corps of Engineers is conducting a basin-wide study on water resources development and flood problems in the entire San Joaquin Valley. The Corps is also assisting local agencies in floodplain management through the preparation of floodplain information reports.

In summary, it appears that because of the location of the Tulare Basin with respect to potential water supply sources, future increases in water demand could most logically be served by federal and state project facilities which already have the capacity to deliver some 4 million acre-feet annually to the area.

The supply-demand relationships for the Tulare Basin from the present (1967) to 2020 are illustrated graphically in Figure 29 and geographically in Figure 30.

North Lahontan Area

The North Lahontan area is the narrow strip of State lying east of the Sierra Nevada along the California-Nevada border. It extends approximately 270 miles from the vicinity of Bridgeport in Mono County to the Oregon border.

The economy is dependent upon agriculture, recreation, lumbering and mining. The principal agricultural activities are livestock production and forage crops. Lake Tahoe and vicinity provides the stimulus for year-round recreation important to the area's economy.

While the total annual runoff exceeds present water demands, lack of streamflow regulation and carryover storage contribute to water shortages during part of the full irrigation season. With possible minor exceptions, paucity of economical reservoir sites preclude surface water development from serious consideration in the future. In recent years, increased use of ground water has partially alleviated seasonal irrigation shortages. The trend is expected to continue, prompting concern from local interests regarding the lack of adequate knowledge of the safe yield of the various ground water basins.

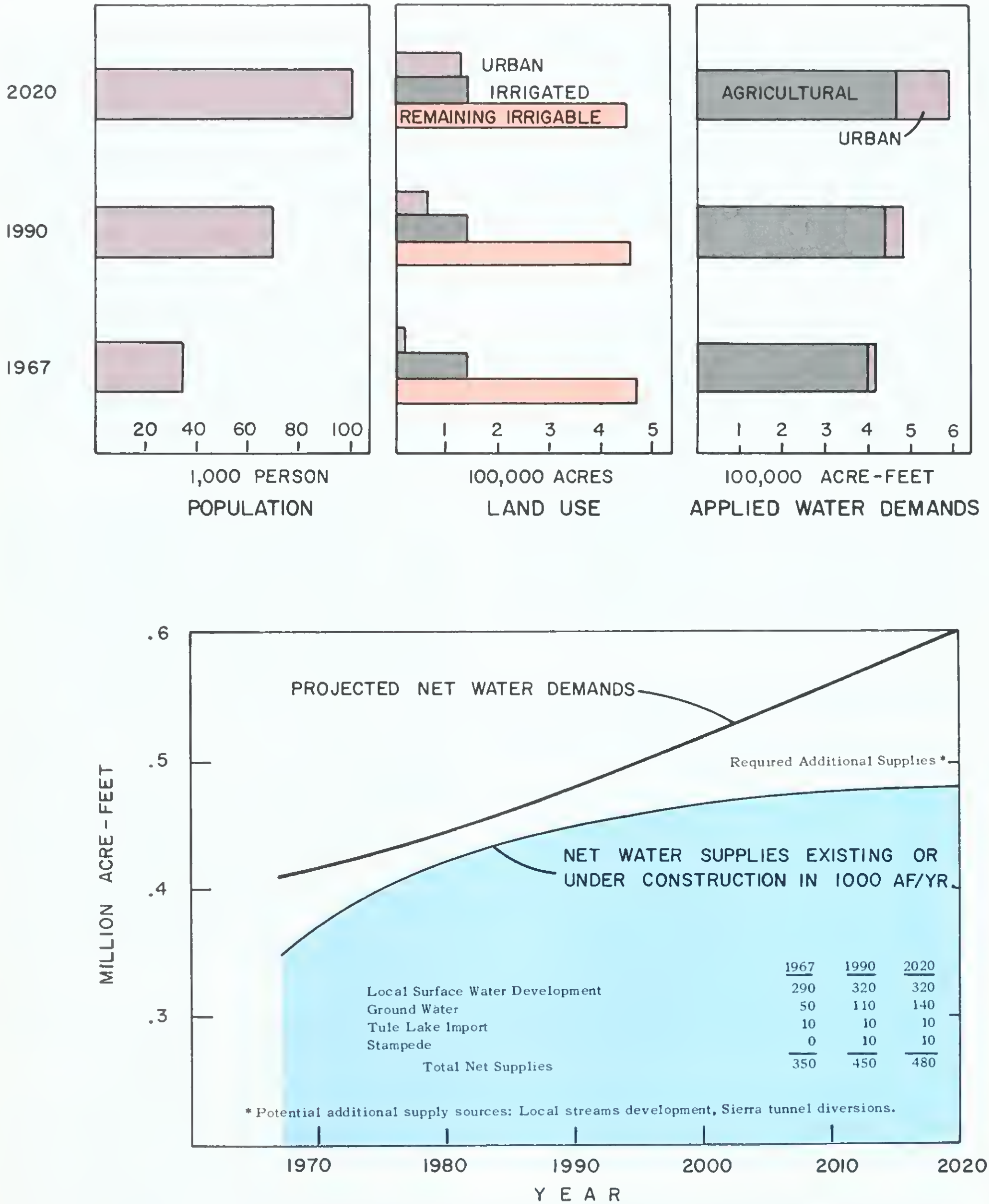
Total irrigated acreage in the North Lahontan area is not expected to increase in the future; but an anticipated change in crop patterns is expected to increase the total agricultural water demand, creating shortages in water supplies amounting to 30,000 acre-feet by 1990 and 50,000 acre-feet by 2020. The water demand-water supply relationship is illustrated in Figure 31 and geographically in Figure 32.

The tremendous recent growth in recreation development within and adjacent to the Lake Tahoe Basin is expected to continue. It is estimated that there will be a fourfold increase in total summer population by 2020. This assumes no restrictions other than land availability. In this regard, the Lake Tahoe Regional Planning Agency was recently created to control land use in that Basin. The land development policies that may emanate from this agency could result in a different mode and level of development than was projected in this study.

Water demands propagated from urban recreation development can be met by supplies until sometime after 1990. By 2020 the supplemental water demand would be about 70,000 acre-feet, of which 60,000 acre-feet would be in the Lake Tahoe-Truckee River Basin. Water use by the permanent population is, and will continue to be, only a small portion of the total urban-recreational water demand. Possible means of meeting this future supplemental demand have not been identified. Estimates of available future supplies were based largely on U. S. Bureau of Reclamation feasibility reports and the proposed California-Nevada Interstate Compact. The authorized Stampede Unit of the Washoe Project was considered a part of the available supply.

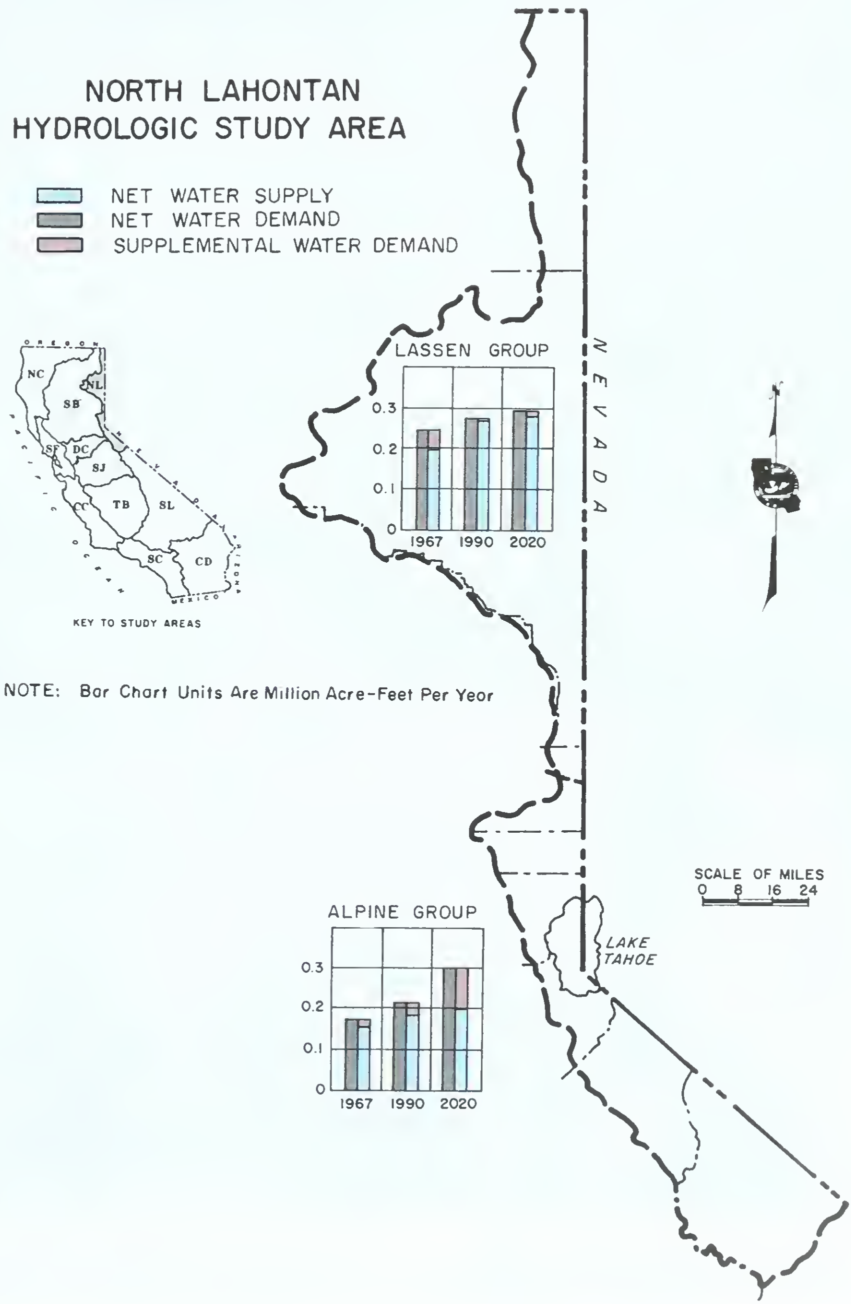
The California-Nevada Interstate Compact divides the waters of Lake Tahoe and Truckee, Carson, and Walker River Basins. The proposed compact was ratified by the California Legislature in amended form at the 1970 session. It is hoped that the amended contract will be ratified by the Nevada Legislature in 1971 so that it may be submitted to the Congress for approval during the next session.

FIGURE 31



PROJECTED WATER SUPPLIES AND NET WATER DEMANDS

NORTH LAHONTAN HYDROLOGIC STUDY AREA


NORTH LAHONTAN
HYDROLOGIC STUDY AREA
NET WATER SUPPLY
NET WATER DEMAND
SUPPLEMENTAL WATER DEMAND
NC
NL
SB
SF
DC
SJ
CC
TB
SL
SC
CD
KEY TO STUDY AREAS
NOTE: Bar Chart Units Are Million Acre-Feet Per Year
LASSEN GROUP
0.3
0.2
0.1
0
1967 1990 2020
NEVADA
ALPINE GROUP
0.3
0.2
0.1
0
1967 1990 2020
LAKE TAHOE
SCALE OF MILES
0 8 16 24

DWR employee

North Lahontan Area – – *nature provides ample water resources, but insufficient carryover storage to meet full summer demands*

Briefly, the allocation of water to California consists of (1) the right to divert 23,000 acre-feet per year for use in the Lake Tahoe Basin; (2) recognition of existing exports from the Lake Tahoe, Truckee River, and Walker River Basins; (3) the right to divert 10,000 acre-feet per year for use within the Truckee River Basin, the right to deplete the 6,000 acre-feet of the annual yield of Stampede Reservoir, and the right to develop and deplete an additional yield of 10,000 acre-feet from the Truckee River and Lake Tahoe Basins, if available; (4) the right to divert water to irrigate approximately 5,600 acres along the West Fork of the Carson River and 3,820 acres along the East Fork of the Carson River, to develop by storage 2,000 acre-feet of water per annum in Alpine County, and to develop for use in California 20 percent of the remaining water after the foregoing California users and existing users in Nevada have been supplied; and (5) recognition of existing rights and uses in the Walker River Basin plus the right to develop 35 percent of the remaining water after Nevada's existing rights and uses are satisfied. In addition, ground water and springs may be used in the Truckee, Carson, and Walker River Basins provided such use does not reduce the amount of water which Nevada would otherwise receive under the allocation.

In addition to water supply-water demand inequalitites, the North Lahontan area has other problems related to its areal growth and development, namely flood control and water quality.

The whole area is periodically subjected to widespread storms and subsequent flooding. Aside from the normal November to April season for rain floods, snowmelt in late spring can cause damage during exceptional snowpack years. Damage areas occur principally along the Truckee and Walker Rivers, the Susan River in Surprise Valley and in the community of Susanville, and communities along the shore of Lake Tahoe. Only 5 percent of the area subject to flooding now has protection by structural measures. Scattered damage centers for the most part will preclude project justification in the future. The most logical means to mitigate flood damages would be through regulation of floodplain use to limit encroachments in active floodways and an improved flood warning system.

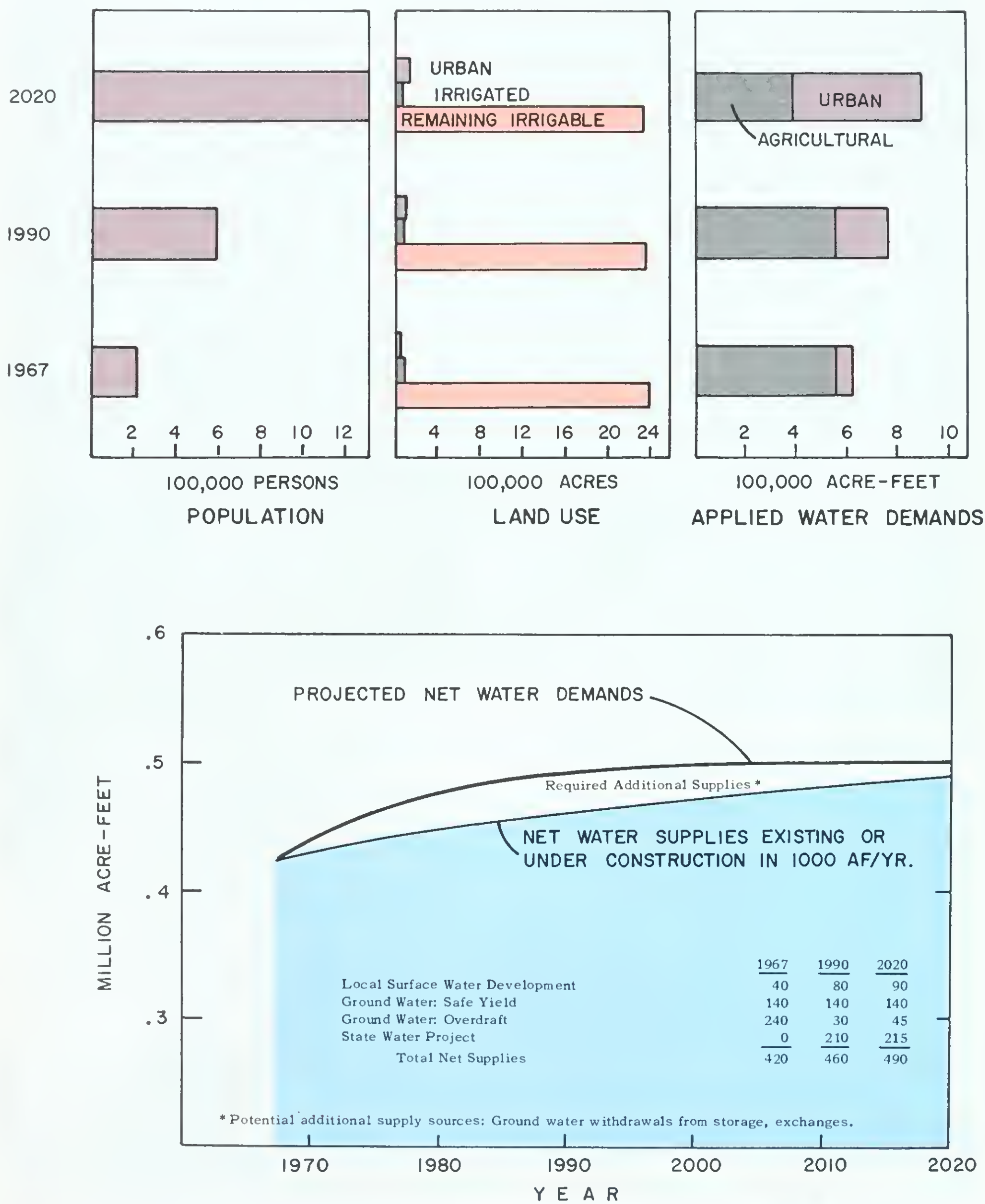
Water quality problems have arisen in recent years due to waste discharges into Lake Tahoe. This problem has been partially solved by exporting treated sewage out of the Tahoe Basin into Indian Creek Reservoir near the town of Woodfords in the Carson River Basin. Studies are now under way to find a solution to the problem of waste discharges in the North Tahoe Basin. Any solution to this problem will be complex because of the implication of water rights, as well as the physical plan of waste disposal.

South Lahontan Area

The South Lahontan area encompasses the portion of Lahontan Hydrologic Drainage Province from Mono Lake south and is characterized by a large number of enclosed basins and sinks. It has the greatest extremes in elevation within the contiguous United States, ranging from 282 feet below sea level in Death Valley to 14,495 feet above sea level on Mount Whitney, only 80 miles distant.

The economic development of the area as a whole was slow in the 1960s but has begun to quicken recently in the Antelope Valley and south of Victorville in San Bernardino County. Lockheed Aircraft Corporation provided the recent stimulus by building a plant just northeast of Palmdale and began the manufacturing of air buses in 1969. The planned Palmdale

FIGURE 33

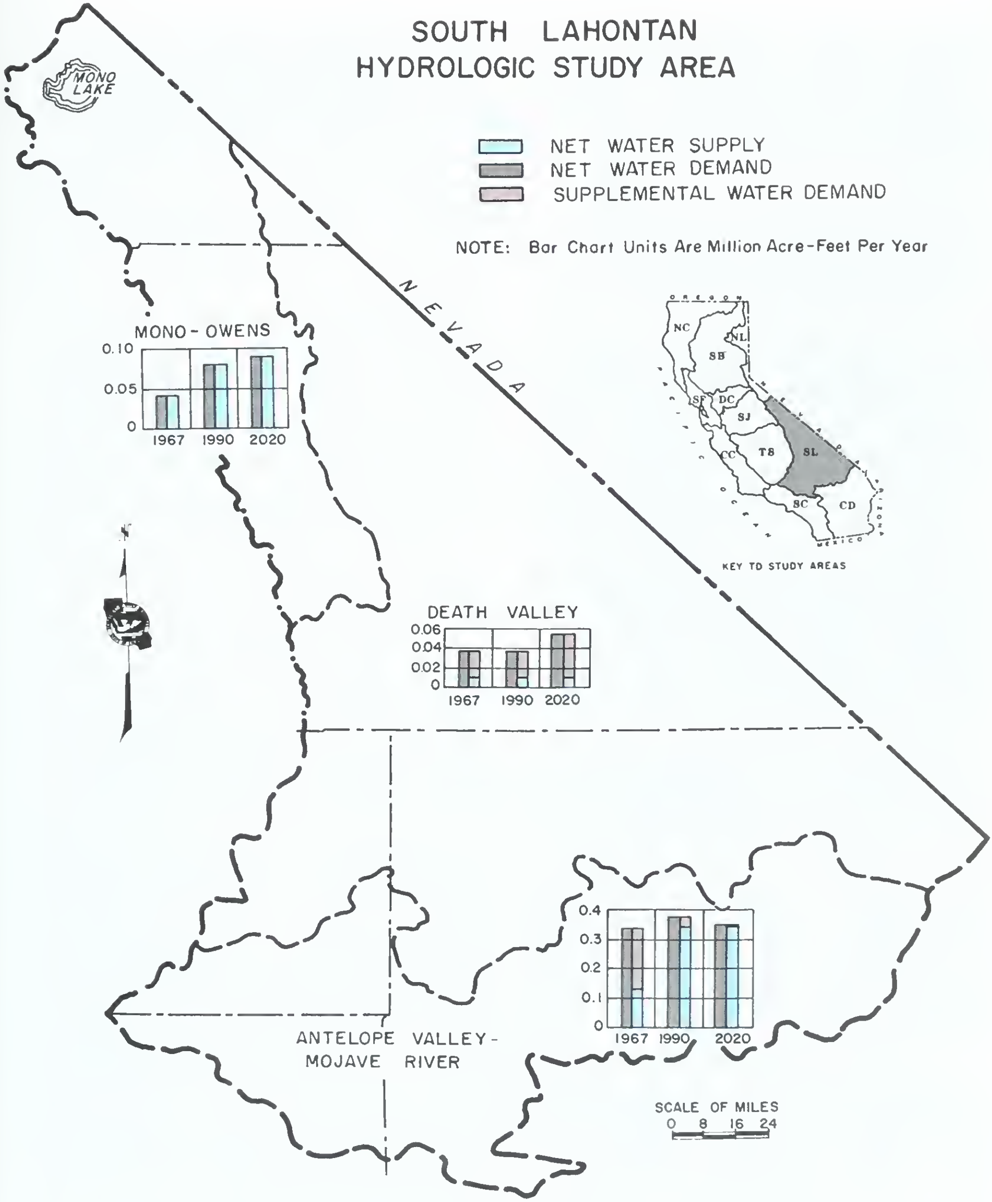


	1967	1990	2020
Local Surface Water Development	40	80	90
Ground Water: Safe Yield	140	140	140
Ground Water: Overdraft	240	30	45
State Water Project	0	210	215
Total Net Supplies	420	460	490

PROJECTED WATER SUPPLIES AND NET WATER DEMANDS

SOUTH LAHONTAN HYDROLOGIC STUDY AREA

SOUTH LAHONTAN HYDROLOGIC STUDY AREA



Intercontinental Airport will provide another stimulus. The impact of this airport will be considerable reaching into Kern County to the north and into San Bernardino County to the east. Construction of the first runway is expected to begin in 1973 and to be ready for the first flight scheduled in 1977. The number of passengers to be handled is projected to grow from 1 million in 1980 to 50 million by 2000.

Plans for an additional freeway and a mass rapid transit system connecting the Antelope Valley with Los Angeles have been discussed by various agencies. The airport will employ several thousand people directly and create many jobs indirectly through related industries and services, which will result in a greatly increased population of the Antelope Valley. Consequently, some irrigated agriculture may move from Los Angeles County to Kern County in the South Lahontan area. Economic development of the southern part of Kern County around the community of Mojave also will be generally enhanced.

The western strip of Victor Valley bordering Los Angeles County will also undergo development; but the recently started subdivision activity in western San Bernardino County in the vicinity of Victorville is largely independent from the planned Palmdale Intercontinental Airport. Two large real estate developments at Spring Valley Lake and at the southern outskirts of Victorville are geared, at least in part, toward providing second homes and retirement homes.

Agricultural water demand of the area is anticipated to remain approximately the same until 1990 and to diminish slightly thereafter, due to the anticipated urbanization centered around Palmdale. The total net water demands are estimated at about 420,000 acre-feet per year in 1967 and 500,000 acre-feet in 2020.

The South Lahontan area is divided for discussion purposes into the Mono-Owens Valley, the Death Valley area, encompassing the huge desert area from Indian Wells Valley to Nevada, and the Antelope Valley-Mojave River area. Relative magnitude and geographical distribution of water demand and supply in the area are illustrated in Figures 33 and 34.

In the Owens Valley, the City of Los Angeles estimates that there will be a sufficient water supply available in the Mono-Owens Valley to meet urban and recreational demands and also to provide a firm irrigation supply for approximately 18,000 acres of agriculture without endangering the integrity of supplies to the City, even during a critically dry period.

In recent years, the City exported over 340,000 acre-feet per year--the full capacity of the first aqueduct. A parallel aqueduct completed in June 1970 increased the total export from the area to about 510,000 acre-feet annually. This yield and the firm local water supply will be obtained from operation of the Owens Valley ground water basin in conjunction with surface supplies from the Owens River and the streams of Mono Basin.

Water supplies for local use in the area outside the Mono-Owens Valley will come from local ground water basins. However, there are limited amounts of water available from surface diversions. Currently, the use of ground water exceeds the annual replenishment of the basins by an estimated 240,000 acre-feet, resulting in falling ground water levels.

The estimated water demands for the Antelope Valley-Mojave River area also include those of Lucerne Valley which is included in the Mojave Water Agency even though physically located in the Colorado Desert area. In 1972 Antelope Valley-East Kern, Crestline-Lake

Arrowhead and Mojave Water Agencies and Palmdale and Littlerock Irrigation Districts (in the Antelope Valley-Mojave River area) will begin receiving water from the State Water Project; their maximum entitlement is 215,000 acre-feet per year.

The water supply estimates on Figure 33 assume a 10,000-acre-foot per year safe supply in the Death Valley area. The safe yield has not been determined for this large desert region, so that figure must be regarded as approximate. The continuing overdraft shown in Figure 34 in 1990 and 2020 represents the amount that the Death Valley area demands will exceed the assumed 10,000-acre-foot safe yield supply. No reasonable alternative to the use of ground water in storage seems apparent for this area.

There are possible alternatives for meeting future demand for water in the Antelope Valley-Mojave River area. These are (1) continuation of the depletion of ground water in storage; (2) purchase of additional farm supplies from an expanded State Water Project; and (3) interim use of available capacity in the California Aqueduct to augment ground water in storage for withdrawal at a later time. The first and third alternatives, however, can be considered only as interim measures.

In summary, the Mono-Owens Valley has adequate water supplies to meet its urban and recreational demands and also to provide a firm irrigation supply for about 18,000 acres of agriculture. The Death Valley area and the Antelope Valley-Mojave River area will continue to be water deficient. Demands in the Death Valley area in excess of the estimated annual safe ground water yield of 10,000 acre-feet are expected to be met from continued extraction of ground water from storage. Importation of State Water Project contractual supplies will not completely stabilize falling ground water levels in the Antelope Valley-Mojave River area, particularly in 1990, and a demand for supplemental water will continue. The water demand-water supply relationships in these areas are depicted in Figure 34.

Colorado Desert Area

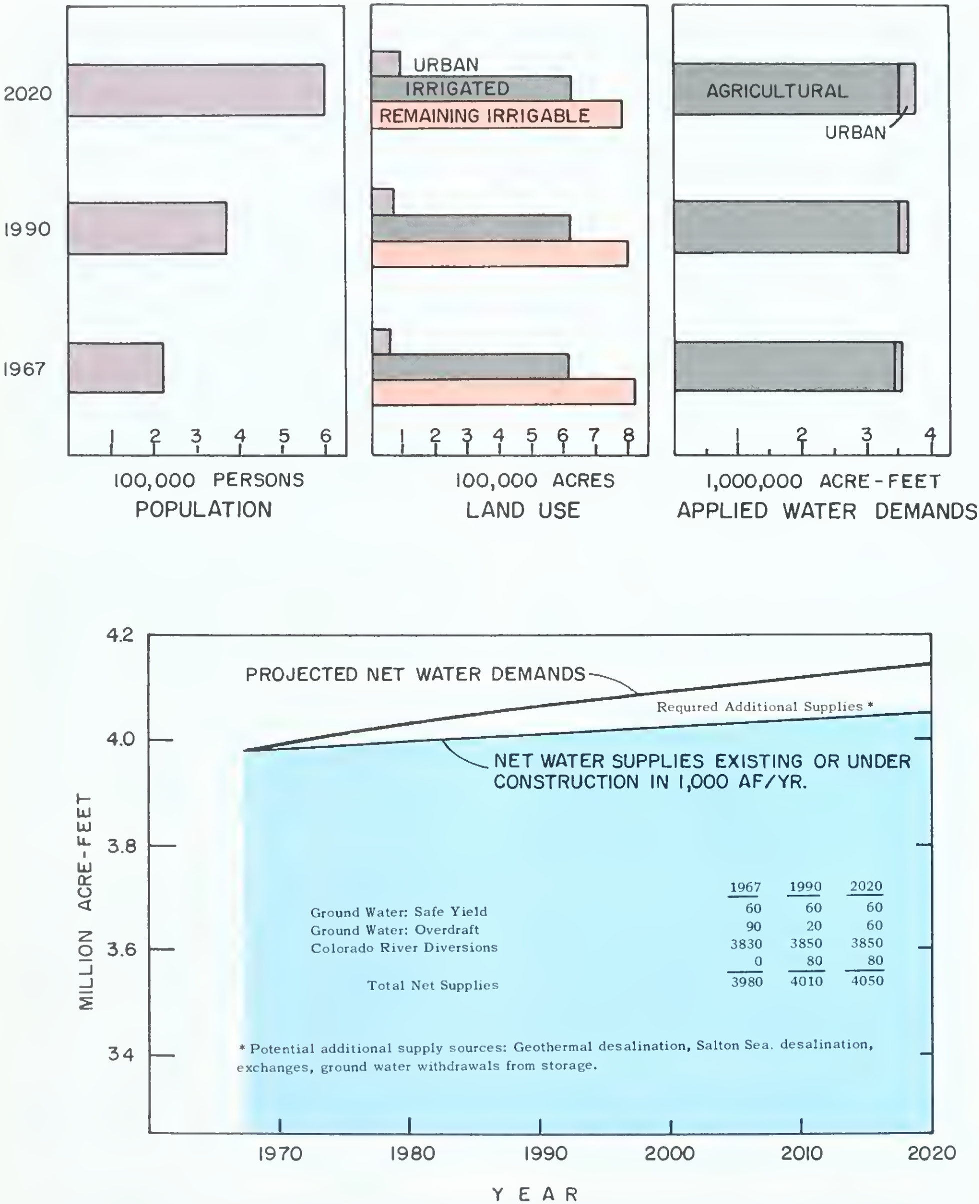
The Colorado Desert area occupies the extreme southeastern portion of California, encompassing Imperial County and portions of San Diego, Riverside, and San Bernardino Counties. The main geographic features are the Colorado River and Salton trough containing the Salton Sea and Imperial and Coachella Valleys. The area drains into the Colorado River and into the Salton Sea, the lowest part of a closed basin.

The Colorado Desert area is characterized by the driest climate in the State along with generally mild winter and very high summer temperatures. This area has not enjoyed a rapid urbanization because of its extreme summer temperatures and its distance from metropolitan centers. The lack of higher-paying employment opportunities also has contributed to the slowness of its growth. However, the area has become popular as a retirement and recreational center.

Much of the area in the Salton trough is below sea level and virtually frost free which permits the growing of agricultural crops throughout the entire year. This, along with availability of low-cost water, has enabled the development of an irrigated agricultural economy second only to the vast Central Valley area. Because of the substantial remaining amount of land that could be developed, urbanization is not likely to curtail irrigated acreage.

Although the quantities of water used for recreation are small, water-related recreational activities have increased in the Colorado Desert area in recent years. Salton Sea has become an increasingly

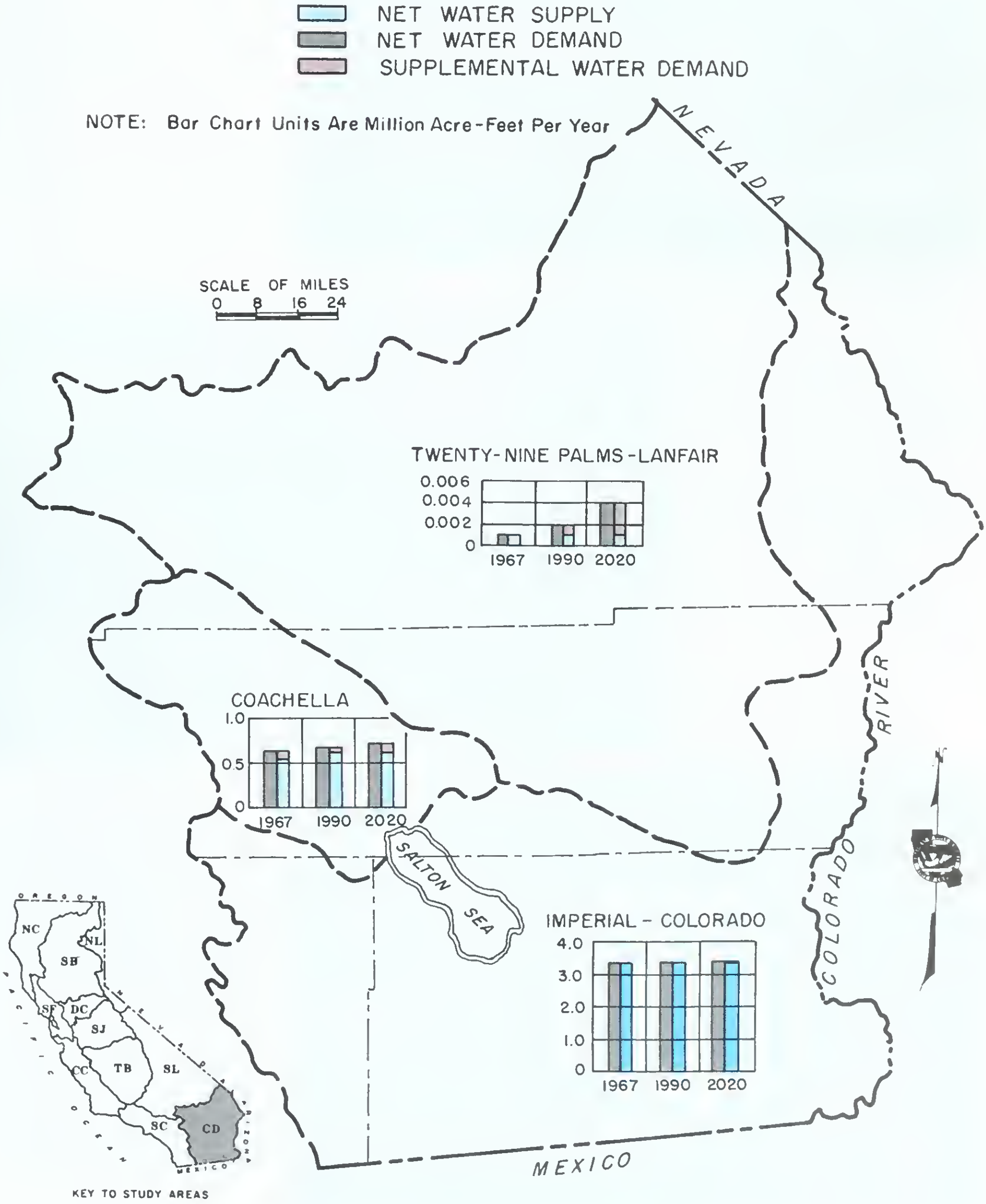
FIGURE 35



PROJECTED WATER SUPPLIES AND NET WATER DEMANDS

COLORADO DESERT HYDROLOGIC STUDY AREAS

COLORADO DESERT HYDROLOGIC STUDY AREA



Much of the Colorado Desert's Valley floor looked like this to the "old-timer".

Now, agriculture is important to the area – –

grapes with date garden in background

And, of course – –

urbanites find fun in the sun, too

popular recreational area for the populous Southern California coastal cities. A federal-state reconnaissance report of October 1969, "Salton Sea Project, California", stated that the Sea presently has a use rate of 1.5 million recreation-days annually. The report also stated that related public and private investments total more than $900 million. However, the recreational value and its attendant investment value will diminish considerably unless measures are taken to control the increasing salinity of the Sea.

The Colorado River also provides excellent recreational opportunities to Southern Californians and others because of warm winters, picturesque settings, and ample opportunities for boating, water skiing, and fishing. Growth of recreational activities along the river is expected to be consistent with the general population and economic growth in Southern California.

The total water demands of the area are projected to increase from 3,980,000 acre-feet per year in 1970 to 4,140,000 acre-feet in 2020.

Four agencies in the area--the Palo Verde and Imperial Irrigation Districts, Yuma Project Reservation Division, and Coachella Valley County Water District--have usable annual diversion rights to 3,850,000 acre-feet of Colorado River water, according to the Seven-Party Agreement of August 18, 1931. The decision of the U. S. Supreme Court in Arizona vs. California and the Colorado River Basin Project Act will make it possible for diversions to continue at that level. In addition to Colorado River water, more than 100,000 acre-feet of ground water is used, mostly in Coachella Valley.

Colorado River water available to California historically has had a relatively high salt content. From 1963 to 1967 it averaged 740 ppm of dissolved minerals at Parker Dam and 850 ppm at Imperial Dam, where diversions to the irrigation districts are made. This has required the installation of extensive networks of tile drains and the application of quantities of water considerably in excess of the actual requirements for plant growth to prevent salt buildup and ensure continued successful farming operations.

The quality of the river water varies from season to season, depending chiefly on its flow and the effects of various upstream uses. Projections of the future quality of Colorado River water were made recently by the Colorado River Board of California. These projections were based on estimated effects of the presently authorized and planned projects in the Basin. They indicate that unless corrective measures are taken the average salinity of river water at Imperial Dam will increase to 1,340 ppm by 2000. Under these circumstances some crops, which are marginal with today's salinity, could no longer be grown. If salinity control projects mentioned in the report were implemented, it was estimated that average salinity at Imperial Dam could be held to about 1,000 ppm.

Salinity at Imperial Dam also varies substantially from month to month, with the greatest concentrations occurring during the winter. In some recent years the peak salinity has exceeded 1,000 ppm. This has had an adverse effect on the germination of seeds for winter-planted crops.

The quality of ground water in the Coachella Valley is surprisingly good. Dissolved minerals in the area are generally less than 200 ppm. Small amounts of ground water used in the Palo Verde Irrigation District have dissolved minerals in excess of 800 ppm, reflecting the quality of Colorado River water used for irrigation in the area.

The quality of ground water in the Imperial Valley is considered to be unsuitable for domestic and irrigation purposes except for a few isolated areas. This has limited the use of ground water in the area to extremely small amounts.

The Coachella Valley County Water District, the Desert Water Agency, and the San Gorgonio Pass Water Agency have contracted with the State for a maximum annual entitlement of 80,000 acre-feet of State Water Project water. These agencies are all located in the Coachella Valley vicinity. However, even with the addition of this water the demand for supplemental water is expected to continue and may be met by the use of ground water in storage, as has been done in the past; by supplemental supplies from the State Water Project; or by water from other potential sources. For other areas where a demand for supplemental water is expected to exist and there are no proposed plans for imported water, it is anticipated that this demand will be met by ground water storage depletion.

The water demand and supply relationships in the Colorado Desert area are illustrated in Figures 35 and 36.

Regional Water Demand-Water Supply Summary

Present (1967) and future (1990 and 2020) water demand and supply relationships for each of the 11 hydrologic study areas and the state total are summarized in Table 8. The total net water demands shown as the first item represent the requirement for developed water, whether from local, imported, or other sources. The total net water supplies represent the sums of all sources of water, both local and imported (including facilities under construction), available toward satisfying net demands.

Note in Table 8 that safe ground water yield is included within the dependable water supplies, but that ground water overdraft is also included as a source of supply at the present (1967) time for several areas. In most cases such overdraft is considered to be only an interim source and is assumed to be phased out by 1990. However, there are exceptions in the Central Coastal area and for localized situations in the South Lahontan and Colorado Desert areas where ground water is the only source of water supply. In these cases, ground water overdraft was assumed to continue indefinitely.

It is anticipated that local agencies will provide 20 to 25 percent of the increased dependable water supplies between the present time and 2020. This includes additional surface developments, increased ground water use, and reclamation of waste water and represents essentially full development of the available local water supplies. In addition, local agencies will play a key role in the construction of distribution systems to deliver water from state and federal, as well as, local water projects.

The indicated shortages shown in Table 8 represent the quantities of water that must be made available over and above the net water supplies to fully satisfy the indicated net demands. Finally, the table lists potential supply sources that might prove feasible for development in the future.

The water demand-water supply relationships for each of the 11 hydrologic study areas are summarized graphically in Figure 37.

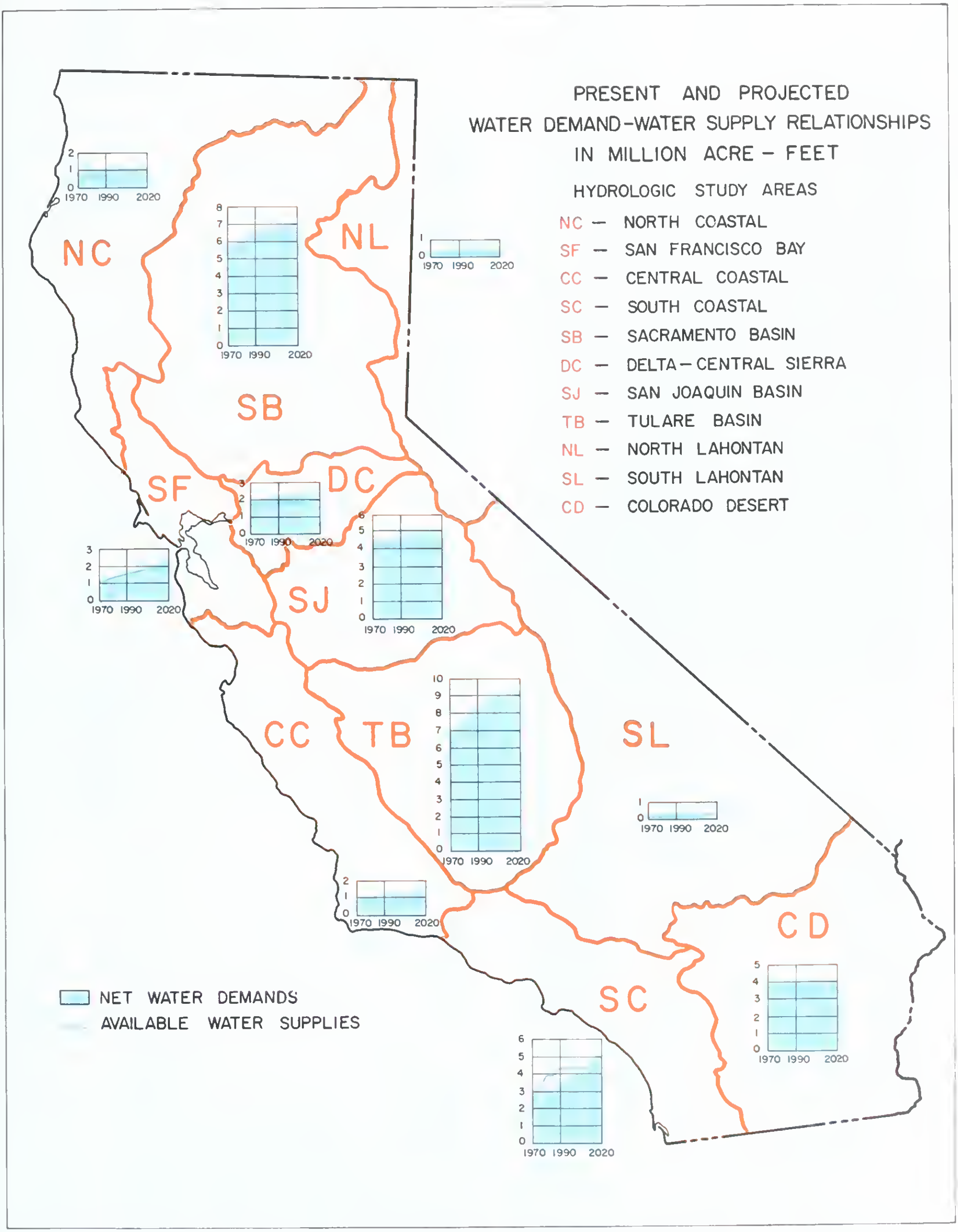

PRESENT AND PROJECTED
WATER DEMAND-WATER SUPPLY RELATIONSHIPS
IN MILLION ACRE - FEET
HYDROLOGIC STUDY AREAS
NC — NORTH COASTAL
SF — SAN FRANCISCO BAY
CC — CENTRAL COASTAL
SC — SOUTH COASTAL
SB — SACRAMENTO BASIN
DC — DELTA-CENTRAL SIERRA
SJ — SAN JOAQUIN BASIN
TB — TULARE BASIN
NL — NORTH LAHONTAN
SL — SOUTH LAHONTAN
CD — COLORADO DESERT
NC
NL
SB
SF
DC
SJ
CC
TB
SL
SC
CD
1970 1990 2020
NET WATER DEMANDS
AVAILABLE WATER SUPPLIES

TABLE 8: SUMMARY OF 1967 AND PROJECTED NET WATER DEMANDS AND WATER SUPPLIES BY HYDROLOGIC STUDY AREAS

(Unit is 1,000 Acre-Feet per Year)

ITEMS	NORTH COASTAL			SAN FRANCISCO BAY			CENTRAL COASTAL			SOUTH COASTAL			SACRAMENTO			DELTA-CENTRAL SIERRA		
	1967	1990	2020	1967	1990	2020	1967	1990	2020	1967	1990	2020	1967	1990	2020	1967	1990	2020
TOTAL NET WATER DEMANDS	960	1,100	1,150	1,140	1,740	2,740	940	1,160	1,420	2,490	3,620	5,280	5,560	6,580	7,270	1,930	2,200	2,350
DEPENDABLE WATER SUPPLIES																		
LOCAL SURFACE WATER DEVELOPMENTS	550	590	600	150	150	150	40	50	50	170	180	180	1,960	2,210	2,380	190	160	160
GROUND WATER SAFE YIELD	150	180	200	310	310	310	730	750	750	900	950	950	1,010	1,100	1,180	570	560	560
IMPORTS BY LOCAL WATER AGENCIES	-	-	-	430	740	860	-	-	-	1,390	1,000	1,000	10	10	10	-	-	-
CENTRAL VALLEY PROJECT 1/	-	-	-	55	220	460	0	80	110	-	-	-	2,210 4/	2,750	3,080	980 4/	1,270	1,330
OTHER FEDERAL WATER DEVELOPMENTS 1/	250	250	250	80	200	220	50	55	55	-	-	-	170	170	170	90	120	120
STATE WATER PROJECT 1/	-	-	-	60	230	260	0	80	80	0	2,200	2,200	0	40	40	-	-	-
WASTE WATER RECLAMATION 2/	-	-	-	5	10	10	-	-	-	30	300	300 6/	-	-	-	-		
TOTAL DEPENDABLE WATER SUPPLIES	950	1,020	1,050	1,090	1,860	2,270	820	1,015	1,045	2,490	4,630	4,630	5,360	6,280	6,860	1,830	2,110	2,170
GROUND WATER OVERDRAFT 3/	0	0	0	50	0	0	120	15	15	0	0	0	140	0	0	100	0	0
TOTAL NET WATER SUPPLIES	950	1,020	1,050	1,140	1,860	2,270	940	1,030	1,060	2,490	4,630	4,630	5,500	6,280	6,860	1,930	2,110	2,170
INDICATED SHORTAGES (OR RESERVE SUPPLIES)	10	80	100	0	(120)	470	0	130	360	0	(1,010)	650	60	300	410	0	90	180
POTENTIAL ADDITIONAL SUPPLY MEASURES 5/	Butler Valley Reservoir Local Streams Development			West Sacto Canals Unit English Ridge Reservoir Waste Water Reclamation Knights Valley Reservoir Enlarged Lake Mendocino Additional SWP Imports Modified Kellogg Project			Desalination Local Streams Development Additional CVP-SWP Imports			Waste Water Reclamation Desalination Additional SWP Imports			West Sacto Canals Unit Allen Camp Unit Indian Valley Reservoir Lakeport Project English Ridge Reservoir Local Streams Development			Cosumnes Division West Sacto Canals Unit New Melones Reservoir (Under Construction) Local Streams Development Additional CVP-SWP Imports		

1/ Facilities Existing or Under Construction
2/ Facilities Definitely Planned for Construction
3/ Assumed to be Phased Out by 1990 in All Areas Except Central Coastal, South Lahontan, and Colorado Desert Due to Possible Harmful Effect to Ground Water Basins and Increasing Cost of Pumpage
4/ Includes Conveyance of Exchange Supplies by Project Facilities under Water Rights Agreements
5/ Indicated Shortages Can be Met by a Combination of the Listed Measures
6/ This May Increase to About 600,000 Acre-Feet Per Year

ITEMS	SAN JOAQUIN 1967	1990	2020	TULARE BASIN 1967	1990	2020	NORTH LAHONTAN 1967	1990	2020	SOUTH LAHONTAN 1967	1990	2020	COLORADO DESERT 1967	1990	2020	STATE TOTALS 1967	1990	2020
TOTAL NET WATER DEMANDS	4,370	4,740	5,050	6,390	8,340	9,260	410	480	600	420	490	500	3,980	4,070	4,140	28,590	34,520	39,760
DEPENDABLE WATER SUPPLIES																		
LOCAL SURFACE WATER DEVELOPMENTS	2,040	2,125	2,085	2,290	2,290	2,290	290	320	320	40	80	90	-	-	-	7,720	8,155	8,305
GROUND WATER SAFE YIELD	580	580	580	600	600	600	50	110	140	140	140	140	60	60	60	5,100	5,340	5,470
IMPORTS BY LOCAL WATER AGENCIES	-	-	-	-	-	-	10	10	10	-	-	-	-	-	-	1,840	1,760	1,880
CENTRAL VALLEY PROJECT 1/	1,580	1,670	1,720	1,460	2,690	2,690	-	-	-	-	-	-	-	-	-	6,285	8,680	9,390
OTHER FEDERAL WATER DEVELOPMENTS 1/	0	50	50	240	240	240	0	10	10	-	-	-	3,830	3,850	3,850	4,710	4,945	4,965
STATE WATER PROJECT 1/	0	5	5	0	1,350	1,350	-	-	-	0	210	215	0	80	80	60	4,195	4,230
WASTE WATER RECLAMATION 2/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35	310	310
TOTAL DEPENDABLE WATER SUPPLIES	4,200	4,430	4,440	4,590	7,170	7,170	350	450	480	180	430	445	3,890	3,990	3,990	25,750	33,385	34,550
GROUND WATER OVERDRAFT 3/	170	0	0	1,800	0	0	0	0	0	240	30	45	90	20	60	2,710	65	120
TOTAL NET WATER SUPPLIES	4,370	4,430	4,440	6,390	7,170	7,170	350	450	480	420	460	490	3,980	4,010	4,050	28,460	33,450	34,670
INDICATED SHORTAGES (OR RESERVE SUPPLIES)	0	310	610	0	1,170	2,090	60	30	120	-	30	10	-	60	90	130	1,070	5,090
POTENTIAL ADDITIONAL SUPPLY MEASURES 5/	East Side Division Sonora-Keystone Unit			East Side Division Additional SWP Imports			Local Streams Development Sierra Tunnel Diversions			Interim Exchanges Additional SWP Imports			Geothermal Desalination Additional SWP Imports Interim Exchanges					

1/ Facilities Existing or Under Construction
2/ Facilities Definitely Planned for Construction
3/ Assumed to be Phased Out by 1990 in All Areas Except South Lahontan and Colorado Desert Due to Possible Harmful Effect to Ground Water Basins and Increasing Cost of Pumpage
4/ Includes Conveyance of Exchange Supplies via Project Facilities in Consideration of Water Rights
5/ Indicated Shortages Can be Met by a Combination of the Listed Measures

CHAPTER VII. MEETING WATER DEMANDS THROUGH CENTRAL VALLEY PROJECT AND STATE WATER PROJECT FACILITIES

The California Water Plan and subsequent reports of the Department of Water Resources were published to provide a basic planning framework for ensuring that the State's long-range water demands are met. Two major multi-purpose projects systems which are presently fulfilling this general objective and which possess the potential for continuing to do so to an increasing extent in the future are the Central Valley Project of the U. S. Bureau of Reclamation and the California State Water Project, currently nearing completion by the Department of Water Resources.

These two developments are unique in their utilization of the coordinated systems approach to interbasin water resource preservation and management. In essence this operational principle, including the utility and pooling concepts employed by the State Water Project, makes possible the future extension of water services to areas of California which could neither physically nor economically be provided by smaller local or independently operated developments alone, or from other alternative sources.

This chapter presents information concerning the present and potential future water supply, recreation, flood control, and water quality control accomplishments of the State Water Project and the Central Valley Project and the advantages of their coordinated operation. With regard to the future, it is recognized that water demands over and above those to be satisfied by existing or authorized facilities of the Central Valley Project or State Water Project may not be met exclusively or even principally by future additions to those projects. Other potential alternative sources described in Chapter V may well play a substantial role in meeting future demands in areas that could be served by these projects. The means of satisfaction of future water demands remains to be determined; but because of the indicated slower rate of buildup in demand discussed in Chapters IV and VI, there is time to make such determination.

However, the assumption is made for purposes of this chapter that future water demands in areas that could logically be served by state and federal projects will be met by expansion of those projects. This procedure serves to illustrate the operational characteristics and flexibility of the Central Valley Project and State Water Project, including exchange potentials and the forecasted timing of need for additional conservation and transportation facilities.

The Central Valley Project

The Central Valley Project was federally authorized for construction in 1935 under provisions of the Emergency Relief Act and as a federal reclamation project in 1937. In 1967 the project celebrated its twenty-fifth anniversary of providing water service via the Contra Costa Canal, an initial unit of the Delta Division. This project marked the beginning of a new phase of water development in the Central Valley, as development in various parts of the Valley had been largely independent of each other prior to its initiation. However, use of water had reached a stage where any additional facility in one part of the Valley affected existing and possible future development elsewhere. Hence the need for a truly comprehensive and fully coordinated interbasin development program was recognized and undertaken through construction of the federal Central Valley Project.

Major reservoirs of the Central Valley Project completed or under construction include Lake Shasta on the Sacramento River, Folsom Lake and Auburn Reservoir on the American River, Millerton Lake on the San Joaquin River, and New Melones Reservoir on the Stanislaus River. Major aqueduct systems serving agriculture and industry in the Valley are the Delta-Mendota Canal, Friant-Kern Canal, Madera Canal, Contra Costa Canal, Folsom South Canal, Tehama-Colusa Canal and the Corning Canal. Other key features of the Central Valley Project are the San Felipe Division, Trinity Division, and the San Luis Division. The latter consists of San Luis Reservoir in western Merced County and the San Luis Canal, which are joint features with the California State Water Project. The total cost of the Central Valley Project to date, including constructed and authorized features, is on the order of $2.6 billion. These major facilities are shown on Figure 38.

Current annual water deliveries under the Central Valley Project total some 6 million acre-feet. By about 1990 project water deliveries are anticipated to be some 10.7 million acre-feet to meet the increasing demands for new and supplemental water supplies within the service areas of the Central Valley Project. These annual demands are projected to grow by an additional 2 million acre-feet between 1990 and 2020. Authorization and construction of additional Central Valley Project facilities, principally the East Side Division and the West Sacramento Canals Unit, would be needed to provide this increase in water deliveries.

While the initial features of the Central Valley Project have been virtually completed and other facilities have been authorized and are under construction, the project is nevertheless anticipated to continue to evolve over the next quarter century to meet the demands within its service areas on an orderly and timely schedule. Priority additions include extension of the project's transportation systems--namely, the East Side Division Aqueduct System and the West Sacramento Canals, and the joint federal-state Peripheral Canal. These and other proposed additions to the Central Valley Project will be discussed in subsequent sections of this chapter.

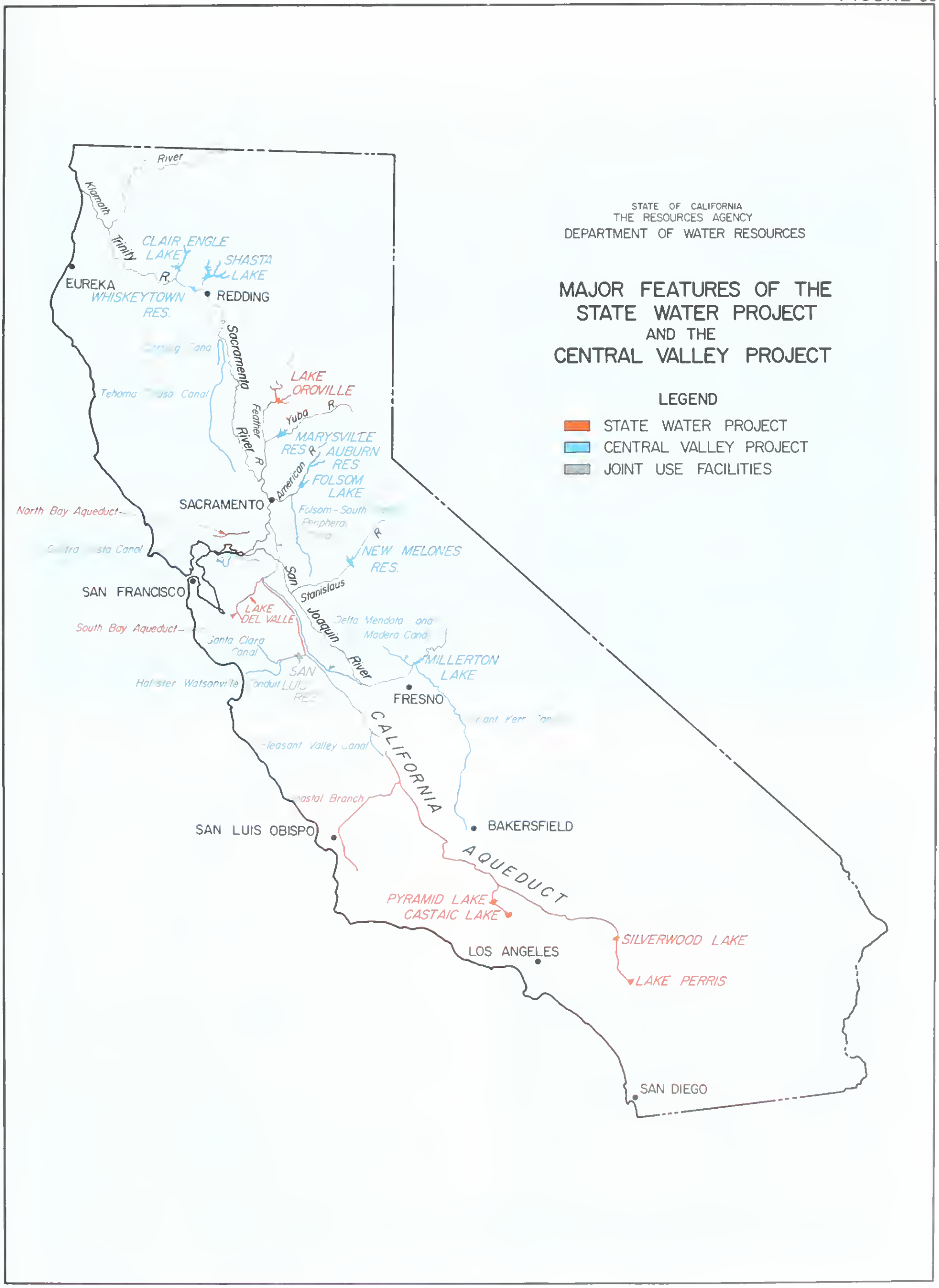
The State Water Project

In 1951 the California Legislature authorized the Department of Water Resources to construct the Feather River Project, later designated the State Water Project, to conserve surplus water supplies in the northern portion of the State in excess of local needs and to convey those supplies to areas of deficiency in Central and Southern California. The Project was designed to provide other water services in the categories of flood control, hydroelectric power generation, water-oriented recreation, salinity control in the Delta in coordination with the federal Central Valley Project, and the enhancement of fisheries and wildlife habitat.

Construction was initiated in 1957 through special legislative appropriations following the disastrous December 1955 flood, but the principal financial base for the Project's implementation was provided in 1960 by the citizens of California through their approval of the California Water Resources Development Bond Act, commonly referred to as the Burns-Porter Act.

Features of the State Water Project are shown on Figure 38. The Project is described in detail in Department of Water Resources Bulletin No. 132-70, "The State Water Project in 1970", and is described and illustrated in digest form in Appendix C to that bulletin. Upon completion, the major physical facilities of the State Water Project will include 21 dams, 6 hydroelectic powerplants

FIGURE 38


STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
MAJOR FEATURES OF THE STATE WATER PROJECT AND THE CENTRAL VALLEY PROJECT
LEGEND
STATE WATER PROJECT
CENTRAL VALLEY PROJECT
JOINT USE FACILITIES
River
Klamath
Trinity
R.
CLAIR ENGLE LAKE
SHASTA LAKE
EUREKA
WHISKEYTOWN RES.
REDDING
Sacramento
Tehama
Canal
LAKE OROVILLE
Feather
River
R.
Yuba
R.
MARYSVILLE RES
R.
AUBURN RES
American
FOLSOM LAKE
SACRAMENTO
North Bay Aqueduct
Folsom - South
Peripheral
R.
NEW MELONES RES.
San
Stanislaus
SAN FRANCISCO
LAKE DEL VALLE
Joaquin
South Bay Aqueduct
Delta Mendota and Madera Canal
Santa Clara Canal
River
MILLERTON LAKE
SAN LUIS RES
Watsonville
FRESNO
CALIFORNIA
Pleasant Valley Canal
Coastal Branch
SAN LUIS OBISPO
BAKERSFIELD
AQUEDUCT
PYRAMID LAKE
CASTAIC LAKE
SILVERWOOD LAKE
LOS ANGELES
LAKE PERRIS
SAN DIEGO

and 22 pumping plants. The total length of the conveyance systems including canals, tunnels and pipelines will be about 700 miles. Current estimates indicate that the total cost of the State Water Project will be some $2.8 billion.

Upon full project deliveries the State Water Project will supply 4,230,000 acre-feet annually to a total of 31 water service agencies which presently hold contracts with the Department of Water Resources. These agencies are located within 8 of the 11 hydrologic study areas of California. These contracts for project water by hydrologic areas are as shown in the tabulation at the bottom of this page.

In addition to the delivery of maximum annual entitlements under full project operation, the State Water Project will also make deliveries of water supplies for specific recreational use on a nonreimbursable basis of approximately 45,000 acre-feet per year. This latter supply plus diversions of approximately 250,000 acre-feet per year to offset operational losses, such as seepage and evaporation, bring the total present maximum State Water Project diversion requirements to 4,525,000 acre-feet per year.

Operational Characteristics and Flexibilities

As the Central Valley Project and State Water Project use common stream channels and conveyance facilities, and the water supplies conserved and distributed become physically indistinguishable, there is a need for close coordination. Such coordination also enables a high degree of very desirable operational flexibility among the facilities of the two-project systems. Coordination of the operation of the two projects will become even more important in the future as the Central Valley Basin supplies become more fully utilized.

In recognition of this need, an important operating agreement has recently been negotiated between the U. S. Bureau of Reclamation and the California Department of Water Resources. It is presently under

Hydrologic Area	Contractors (Number)	Maximum Annual Entitlement (Acre-Feet Per Year)
Sacramento Basin	3	39,800
San Francisco Bay	5	255,000
Central Coastal	2	82,700
San Joaquin Basin	1	5,700
Tulare Basin	7	1,349,300
South Coastal	5 1/	2,204,400
South Lahontan	5 2/	214,600
Colorado Desert	3	78,500
TOTAL	31	4,230,000

1/ One agency in both South Coastal and Colorado Desert areas.
2/ One agency in both South Lahontan and Colorado Desert areas.

Portion of San Luis Joint-Use-Facilities U.S. Bureau of Reclamation

Federal-State use involves close coordination

review by the Secretary of the Interior. The agreement provides the operators of the two projects with the procedures necessary to achieve the objectives set forth in the various laws, orders, policies, and other instruments under which the Central Valley Project and State Water Project are authorized to operate. These procedures include preparation of forecasts for proposed operations, language for the transfer or exchange of facilities use, criteria for the allocation of shortages, and procedures for assigning the responsibility for maintaining the objectives of the operating agencies. While accomplishing the objectives of the agreement, the separate identity of facilities, resources, and contributions of each project is maintained.

Water Supply Capabilities

Current estimates by the Department of Water Resources indicate that the combined dependable water yield for the "basic facilities" of the Central Valley Project and the State Water Project is on the order of 14.4 million acre-feet annually. "Basic facilities" are defined as those facilities which are either existing or under construction for the federal Central Valley Project and the "Initial facilities" of the State Water Project as defined in the Burns-Porter Act. The principal basic facilities of the two projects are listed in Table 9.

The indicated yield capacity of the Central Valley Project-State Water Project basic facilities is referenced to the 1990 time frame for

TABLE 9

MAJOR FEATURES OF BASIC
CENTRAL VALLEY PROJECT AND
STATE WATER PROJECT SYSTEM

Central Valley Project	State Water Project
Major Reservoirs	
Shasta	Oroville
Clair Engle (Trinity)	San Luis*
Whiskeytown	Pyramid
Auburn	Castaic
Folsom	Silverwood (Cedar Springs)
San Luis*	Perris
New Melones	
Millerton (Friant)	
Major Canals	
Corning	North Bay Aqueduct
Tehama-Colusa	Peripheral Canal*
Folsom South	South Bay Aqueduct
Peripheral Canal*	California Aqueduct, including joint San Luis Canal, Coastal Branch and West Branch.
Contra Costa	
Delta Mendota	
San Luis*	
San Felipe Division	
Friant-Kern	
Friant-Madera	

* Central Valley Project-State Water Project joint-use facilities.

local upstream depletions within the Sacramento River Basin. Projections are that by 2020 the continuing development in these upstream areas by local agencies will reduce the 1990 level annual yield of the combined federal-state project system by about 200,000 acre feet.

The State considers its share of this reduction as a commitment in accordance with the "Delta Pooling Concept". That concept, which is premised on the counties of origin and watershed protection statutes of the California Water Code, provides, in effect, that no water shall be exported from an area in which it originates, or from areas immediately adjacent that can be conveniently served by such water, which is needed for the development of those areas. Water supplies may be depleted for upstream uses in the counties of origin, and local agencies in the area in and above the Delta have a prior right to contract for water service from the State Water Project. These principles are incorporated in the contracts between the State and the 31 water service contractors for water deliveries from the State Water Project.

Of the 14.4 million acre-foot nominal yield for the 1990 time period, approximately 3.9 million acre-feet can be provided by the initial conservation facilities of the State Water Project and 10.5 million acre-feet by the Central Valley Project. Corresponding estimates taking into account the 2020 level of upstream local development are approximately 3.8 and 10.4 million acre-feet per year, respectively.

These estimates of water supply capability for the Central Valley Project and State Water Project are premised on a minimum Delta outflow of 1,800 cubic feet per second. This minimum outflow should not be construed as representing the average outflow which can be expected in a normal or above-normal year. For example, estimates are that under full 2020 development, normal-year outflow would frequently exceed 1,800 cubic feet per second. As a comparison, 1,800 cubic feet per second continuous outflow would amount to 1.3 million acre-feet per year, whereas normal outflow to the Bay under 2020 development would average 7 million acre-feet per year, or about five times the minimum outflow.

The Role of the Peripheral Canal

The Peripheral Canal is an important feature of the Central Valley Project-State Water Project system. The State has authority to construct the Canal alone or by joint venture under the 1959 Burns-Porter Act. However, congressional authority is needed for the Bureau of Reclamation to participate in the Canal as part of the federal Central Valley Project.

The Peripheral Canal will not add any new service areas to the state or federal projects nor will it increase the authorized amount of water slated for delivery by these projects. The Canal simply solves the water conveyance, water quality, and fishery problems in the Delta related to carrying water across the Delta to the existing state and federal conveyance facilities and, at the same time, makes possible the redistribution of water within the Delta itself.

Specifically the Canal would: (1) protect and enhance the commercial and sport fisheries and other aquatic life that are dependent upon the Delta by eliminating flow reversals and making releases from the Canal; (2) avoid using existing Delta channels as conduits for conveyance of Project water, thereby eliminating possible channel scour and levee erosion problems; (3) provide a firm supply and improve water quality in the interior Delta by redistributing water through release facilities; (4) provide salinity control in the Delta in accordance with conditions established by the State Water Resources Control Board and agreements with local interests; and (5) fulfill the water transfer and water quality requirements of the State Water Project and the federal Central Valley Project, including the proposed Kellogg Unit, or some similar project, to provide water to the Contra Costa County area.

The Peripheral Canal will consist of a 43-mile-long unlined channel that will skirt the easterly edge of the Delta region. It will originate at a diversion structure on the Sacramento River near Hood, and will terminate in the Clifton Court Forebay at the southwesterly portion of the Delta. Twelve outlet structures will provide freshwater releases at the crossings of Delta channels in amounts necessary to best control and improve water quality in many interior waterways.

The release works and the isolation of water transfer from the existing Delta channels will eliminate the reverse flow problem during the migration season for salmon, shad, steelhead and striped bass. This, in conjunction with adequate waste discharge treatment, is expected to assist in a restoration of San Joaquin River migratory fish runs and enhance the Delta fishery, particularly the striped bass. The separate transfer channel will also eliminate the possibility of scour and levee erosion in certain Delta channels, and water level drawdown in southern Delta channels. Salt water intrusion from San Francisco Bay can be better controlled by canal releases.

Operation of the Peripheral Canal will enable a very high degree of flexibility. With its many release gates and with control of pumping rates, coordinated with upstream reservoir releases, a wide variety of flow and water quality patterns could be provided within the Delta.

Recent operation studies conducted by the Department indicate that for water transportation purposes, completion of the Peripheral Canal should be scheduled notlater than 1980. However, fish and game interests want the Peripheral Canal constructed as soon as possible to prevent the further deterioration of the Delta environment and its fishery and to provide for enhancement.

Projected Water Demands on the Federal and State Systems

Upon completion of those facilities of the Central Valley Project and the State Water Project now under construction, this federal-state water resource development system will be capable of providing water services to all hydrologic areas of California except the North Lahontan area. Although no direct deliveries for use within the North Coastal area are anticipated from existing facilities, the Trinity Division of the Central Valley Project possesses the potential to make such deliveries if and when a demand may occur.

Table 10 indicates the water service anticipated to be supplied from facilities of the two projects now being completed and Table 11 shows the additional service which could be provided from future expansion of these projects.

Possible Central Valley Project Expansion

An expansion of service under the Central Valley Project by addition of the planned major conveyance facilities, namely the initial East Side Division and the West Sacramento Canals Unit, appears to be the most favorable option for meeting the bulk of the supplemental water demands anticipated to occur within the Central Valley Basin. Other areas of projected deficiencies in dependable water supplies in the Central Valley could be served through addition of the Cosumnes River Division and the Allen Camp Unit, plus an extention of service under the existing San Luis Unit. These possible future additions to the Central Valley Project are illustrated on Plate 1.

The East Side Division could provide new and supplemental water service to potential service areas along the east side of the San Joaquin Valley from the vicinity of Stockton to Bakersfield. This proposed extension could also provide beneficial services in the categories of water quality control, flood control, recreation, and fishery and wildlife habitat enhancement. It is envisioned that the Initial Phase would serve 1,500,000 acre-feet annually to Fresno, Kings, Tulare and Kern Counties. The water supply would be derived from operation of existing storage facilities, Auburn and New Melones Reservoirs which

TABLE 10

SUMMARY OF 1967 AND PROJECTED FUTURE WATER DEMANDS ON EXISTING FACILITIES OF THE CENTRAL VALLEY PROJECT AND STATE WATER PROJECT[1/]

(1,000 Acre-Feet)

Hydrologic Study Area	Central Valley Project[2/]			State Water Project		
	1967	1990	2020	1967	1990	2020
San Francisco Bay	60	220	460	60	230	260
Central Coastal	0	80	110	0	80	80
South Coastal	--	--	--	0	1,190	2,200
Sacramento Basin	2,210	2,750	3,080	0	40	40
Delta-Central Sierra	980	1,270	1,330	--	--	--
San Joaquin	1,580	1,670	1,720	0	10	10
Tulare Basin	1,460	2,690	2,690	0	1,350	1,350
South Lahontan	--	--	--	0	210	210
Colorado Desert	--	--	--	0	80	80
Recreation Deliveries & Conveyance Losses	--	50[3/]	50[3/]	--	290	290
Total Demands on CVP and SWP	6,290	8,730	9,440	60	3,480	4,520

1/ Includes facilities under construction.

2/ Includes conveyance via project facilities of exchange supplies in consideration of water rights.

3/ Additional recreational deliveries and conveyance losses for Central Valley Project are included in the study area values.

TABLE 11

SUMMARY OF POSSIBLE FUTURE WATER DEMANDS ANTICIPATED TO BE SUPPLIED BY FUTURE FACILITIES OF THE CENTRAL VALLEY PROJECT AND STATE WATER PROJECT

(1,000 Acre-Feet)

Hydrologic Study Area	Central Valley Project 1/		State Water Project 2/	
	1990	2020	1990	2020
San Francisco Bay	--	--	30	300
South Coastal	--	--	0	130
Sacramento Basin	210	310	--	--
Delta-Central Sierra	90	160	--	--
San Joaquin Basin	300	590	--	--
Tulare Basin	1,170	1,840	0	250
Colorado Desert	--	--	0	40
Conveyance Losses	200	200	--	40
Total Supplemental Demands on CVP and SWP	1,970	3,100	30	760

1/ Supplemental CVP facilities required to meet these demands include: East Side Division, West Sacramento Canals Unit, Cosumnes River Unit, Allen Camp Unit, and service extension within the existing San Luis Unit, plus future conservation facilities yet unidentified.

2/ Supplemental SWP facilities required include parallel North Bay and South Bay Aqueduct facilities, California Aqueduct modifications, plus future conservation facilities yet unidentified.

are presently under construction, and the offstream storage features to be associated with the East Side Division. This surface water supply could offset the present annual ground water overdraft (in excess of 1,000,000 acre-feet) and the projected future increase in demand.

Physical features of the Initial Phase include the East Side Canal, five reservoirs, associated pumping plants, and a distribution and drainage system. The East Side Canal, with source connections to the Sacramento River by means of the Hood-Clay connection, and to the American River by means of the authorized Folsom South Canal, would extend 330 miles to its terminus at the Kern River. Two of the five reservoirs, Montgomery and

Hungry Hollow, would serve as major offstream storage facilities with 986,000 acre-feet of combined active storage.

Through provisions for stream maintenance releases for fisheries, recreation and water quality improvement purposes the East Side Division would have the potential for considerable environmental enhancement of the Sierra-Nevada streams from Dry Creek in Sacramento County to the Kern River in Kern County.

The West Sacramento Valley Canals Unit could provide future water service from the Central Valley Project to the Yolo-Zamora, Lower Cache Creek, and Solano service areas in Yolo and Solano Counties. Principal features would include an enlarged portion of the Tehama-Colusa Canal, presently under construction; an extension of that canal; and Sites Reservoir, a 1,200,000 acre-foot pumped-storage reservoir. This new lake would be located in western Colusa County on lands which do not appear to have significant recreational value or high development potential. The West Sacramento Canal could provide for an annual water conveyance of 360,000 acre-feet, a portion of which is developed by existing Central Valley Project conservation facilities, with the remainder to be supplied through operation of the Sites pumped-storage facility.

The Cosumnes River Division could develop and convey 120,000 acre-feet of water per year for irrigation and an additional 25,000 acre-feet annually for municipal and industrial use, by means of three reservoirs and an extensive distribution system to service areas in the foothill regions of Sacramento, El Dorado, Amador and San Joaquin Counties. The main storage feature of the Cosumnes River Division would be the 900,000-acre-foot Nashville Reservoir. Recreation facilities would be provided at the reservoirs, and flood protection would be provided for floodplain lands now subject to overflow. The meager fishery resources of the lower Cosumnes River system would be enhanced by reservoir releases, and a new reservoir fishery would be established.

The proposed Allen Camp Unit would provide benefits to the Big Valley area of Lassen and Modoc Counties through irrigation, flood control, fish and wildlife enhancement, and recreation. Flows of the Pit River would be controlled and conserved by the proposed 190,000-acre-foot Allen Camp Reservoir which could provide a dependable annual yield of 50,000 acre-feet. Diversions would be made to irrigate 22,000 acres.

Possible State Water Project Expansion

Current water demand studies by the Department indicate that supplemental water service from the State Water Project may be desired within four hydrologic study areas commencing sometime after 1990. These are the San Francisco Bay area, Tulare Basin, and the Colorado Desert and South Coastal areas. The term "supplemental water service", as used here, refers to the delivery of water over and above the present contract entitlements. The quantities of potential supplemental water service presently projected to 2020 for these areas are listed in Table 11.

San Francisco Bay Area. Within the San Francisco Bay area possible supplemental water demands from the State Water Project could be on the order of 30,000 acre-feet annually by 1990 and 300,000 acre-feet annually by 2020. Of this amount the 30,000 acre-feet in 1990 and 170,000 acre-feet in 2020 would be contingent upon location of an industrial complex in the Collinsville area of southern Solano County. The additional 130,000 acre-feet of anticipated supplemental demand by 2020 would develop in Santa Clara County and the inland portions of Alameda and Contra Costa Counties, if recent growth trends continue.

Tulare Basin. Most of the forecasted supplemental water demands within the Tulare Basin would be located on the east side or within areas contiguous to the present federal San Luis Unit service area. However, an additional 250,000 acre-feet of annual supplemental water service is estimated to be required in western Kern County by 2020, mostly in the Antelope Plain area adjacent to present service areas of the California Aqueduct. It is assumed that the supplemental demand in this area would be met by the State Water Project.

Colorado Desert Area. A sizable amount of urban growth is projected for the Colorado Desert region because of its proximity to Southern California urban centers. Water available from the State Water Project could make possible the location of new urban developments in areas that are without water today. Other urban areas may desire State Project water because of its better quality than from other available sources.

Expanded State Water Project deliveries to the Colorado Desert areas would primarily serve increasing municipal and industrial demands, especially in Coachella Valley and the uplands to the west and north of that valley. Possible supplemental water service to accommodate urban growth within the Colorado Desert areas is assumed here to be 40,000 acre-feet annually by 2020.

South Coastal Area. The combined dependable water supplies available to the South Coastal area from existing sources, from facilities under construction, and from waste water reclamation projects now definitely planned appear adequate to meet water demands in this area until after the turn of the century. Projections are that by 2020 continued growth will require supplemental supplies on the order of 650,000 acre-feet per year. The shortage in supply is indicated to begin by about 2010 (refer to Figure 21 on page 108).

Table 8 and the discussion in Chapter VI identify three principal options for meeting this projected long-range demand for supplemental supplies. These are: future waste water reclamation in addition to the 300,000 acre-feet per year which is now definitely planned, desalination of sea water, and supplemental imports via the State Water Project. Although these demands may possibly be met from any one of these supply options, they will probably be met by a combination of these sources.

The State Water Project has the potential for providing expanded service to the South Coastal area, as arrangements have been made by Southern California contractors to provide future use capacity in certain reaches of the California Aqueduct. This reserve capacity is about 190 cubic feet per second for Kettleman City southward or an annual delivery equivalent of 130,000 acre-feet.

For purposes of this analysis, this reserve capacity is assumed to be utilized and the State Water Project is assumed to supply supplemental water service of 130,000 acre-feet annually to the South Coastal area by 2020. The remainder of the projected supply deficiency could be met by waste water reclamation and/or desalination. Future studies by the Department and the concerned water agencies may, of course, indicate the desirability for either greater or less future deliveries from the State Water Project than assumed here. Considerable additional study is needed; however, ample time is available for such study and for a determination by the people concerned regarding the most favorable course of action.

Central Valley Project Water Demand-Supply Relationship

Figure 39 illustrates the water demand-supply time relationship for the Central Valley Project with the East Side Division, West Sacramento

Canals Unit, Cosumnes River Division, and the Allen Camp Unit added. The solid blue line indicates the water supplies that could be made available by the expanded Central Valley Project, incorporating those facilities. The broken blue line indicates the dependable water supplies developed by present project facilities, including both those completed and under construction. The solid and broken red lines represent the demand on the expanded project and the present project, respectively.

The figure illustrates that sufficient supplies are presently developed under the Central Valley Project (broken blue line) to accommodate a considerable expansion in future service without a requirement for additional conservation features. However, a requirement exists for construction of major conveyance facilities, namely the East Side Division and West Sacramento Canal, to serve areas of present and incipient deficiencies in the Tulare and Sacramento Basins.

Figure 39 further illustrates that additional conservation facilities (exclusive of those identified in that figure) may not be required under the Central Valley Project for water supply purposes alone until about 2000. The figure also indicates that by 2020 the possible expanded service could require additional water conservation features to provide new and supplemental supplies on the order of 1 million acre-feet annually. These additional features are not presently identified. They may include the full spectrum of the potential supply options which were discussed in Chapter V.

State Water Project Water Demand-Supply Relationship

Figure 40 illustrates graphically the current assessment by the Department of Water Resources of the rate of buildup in water demand from the State Water Project and the water supplies available from the initial conservation facilities. The blue line indicates the dependable water yield capability of the initial conservation facilities. The solid red line shows the projected total buildup in water demands, and the broken red line indicates the demand buildup under the present water service contracts, as estimated by the Department as a result of a review with the water supply contractors.

Figure 40 indicates that an additional conservation facility would first be needed in the mid-1990s on the basis of the currently estimated rate of buildup for water deliveries under present contracts. This represents a delay of some 10 years from the projected timing of need for an additional facility as published in Bulletin 160-66.

Figure 40 also shows that on the basis of projected total demand from the State Water Project, expanded conservation facilities may also be needed commencing in the mid-1990s, and that these facilities might need to provide a further dependable annual water supply of about 700,000 acre-feet by 2020, in addition to the existing contract entitlements.

It should be emphasized that the forecast of timing of need for additional water is premised upon assumptions regarding future events which cannot now be foreseen. For example, the Department of Water Resources believes that the commitments to provide good quality water in the Delta can be met by a minimum Delta outflow of 1,800 cubic feet per second. Should a decision by the State Water Resources Control Board impose conditions which might require greater releases than 1,800 cubic feet per second, the timing of need for additional water would be advanced.

FIGURE 39

THE CENTRAL VALLEY PROJECT

PROJECTED NET WATER DEMANDS AND DEPENDABLE WATER SUPPLIES

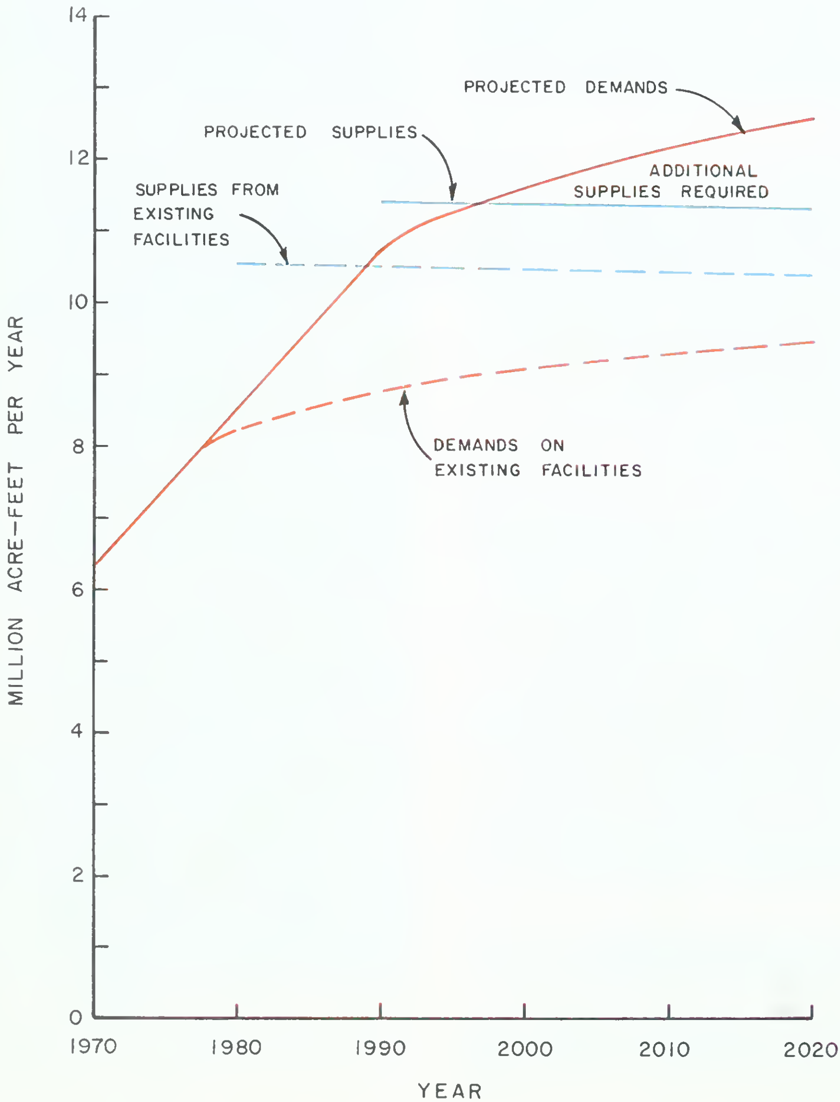
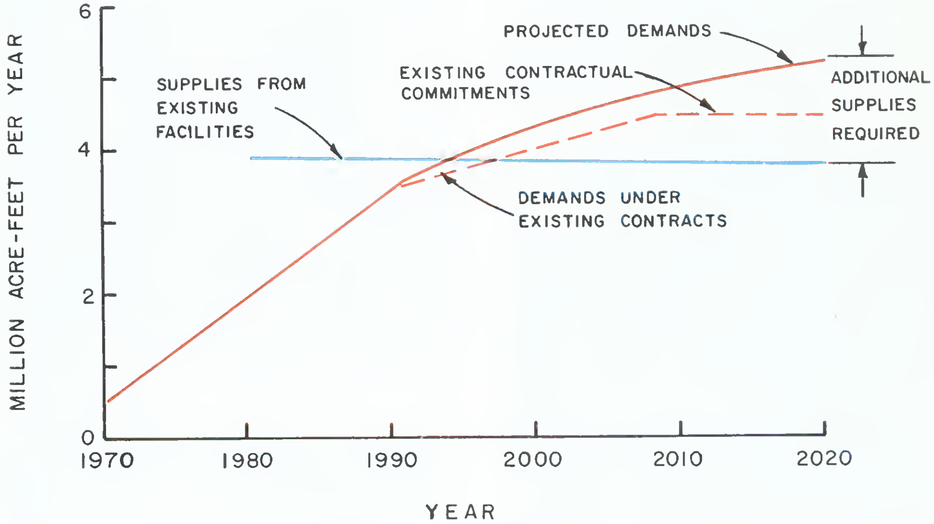


Figure 40

THE STATE WATER PROJECT

PROJECTED NET WATER DEMANDS AND DEPENDABLE WATER SUPPLIES



Other factors that would accelerate the need for additional water are: (1) problems of quality of Colorado River Water which might necessitate substitution of water from the State Water Project; (2) more rapid population increase than presently anticipated; (3) a demand for project water in service areas not now under contract; and (4) increased water use in areas tributary to the Delta.

Factors that would tend to delay additional need for water are: (1) a slower population growth than now anticipated; (2) more rapid development in technology of desalting than now anticipated; and (3) a greater reuse of reclaimed water than now projected. A continuing evaluation of all these factors will be necessary to effect the overall most acceptable means of satisfying future demands.

The Department of Water Resources is presently conducting studies of the various options for meeting its commitments to water contractors under the State Water Project and for supplying the future supplemental service which may be requested. Because of the slowdown in demand increase in relation to earlier estimates and the indicated delay in timing of need for additional facilities, the Department will have sufficient time available to study and analyze alternative sources with full consideration of environmental factors.

Recreational and Environmental Accomplishments

The water demands and the supply capabilities of the Central Valley Project and State Water Project have been presented in some detail to demonstrate their abilities to fulfill obligations to the water supply contractors and to meet probable future supplemental water demands. In addition to meeting these obligations, however, the multi-purpose facilities of the Central Valley Project and the State Water Project have made possible an array of other important services. These include: flood control, hydroelectric power production, water quality control, water-oriented recreation opportunities, and the improvement of fisheries and wildlife habitat. Each of these services is indeed a water resource management purpose in its own right. In most instances these services could not have been economically provided except through the advantages inherent in the multi-purpose management concept.

Contributions of the two projects in providing these services have substantially enhanced California's natural human environment. Flood control has eliminated the threat of damage to the lives and property of many of the State's citizens; hydroelectric power production provides a significant portion of the electric energy needed without pollution of the atmosphere or the water supplies; and water quality control provides for the availability of dry-period streamflows in many of California's rivers and estuaries for salinity repulsion and other purposes that were not available under natural or pre-project conditions.

The increase in population and the general movement from rural to highly urbanized areas have developed an unprecedented demand for water-oriented recreation and other experiences related to enjoyment of the environment. The following sections briefly describe what the State Water Project and the Central Valley Project are doing toward providing for the recreational and environmental needs, including flood control, of the people of California.

Environment and the Central Valley Project

Recreation has long been recognized by the Bureau of Reclamation as one of the benefits to be derived from the creation of new lakes. To enhance the public enjoyment these large bodies of water have been provided with campgrounds, picnic areas, piped water, sanitary facilities, riding and hiking trails, beaches, boat-launching ramps, and boat docks. As the need is demonstrated these facilities are improved and expanded. The major structures of the project are themselves an attraction to sightseers, and many visitors stop each year at the visitor facilities to view the dams, powerplants, and related facilities.

The project lakes are stocked with fish, and in many cases the fishing in streams below the dams is enhanced by maintenance of more stable flows, either specifically for fish enhancement or as a result of other project flow requirements. The operation of Shasta Reservoir and the Coleman Fish Hatchery has been largely responsible for the enhancement of the valuable steelhead trout fishery on the Sacramento River. Three fish hatcheries are operating to replace spawning areas cut off by dams on the Trinity, Sacramento, and American Rivers.

Central Valley Project reservoirs are also used by waterfowl for nesting and for resting during migration. It is estimated that in 1969 there were about 1,130,000 use-days by ducks and geese on project water areas. Hunters took about 36,000 waterfowl during the hunting season. In addition, for a number of years the project has supplied supplemental water for the State's Mendota Waterfowl Management area in the San Joaquin Valley.

Two facilities of the Central Valley Project now under construction, Auburn and New Melones Reservoirs, will contribute benefits from further recreation, fisheries and wildlife enhancement. In addition to the new lake areas for fishing and recreation, these deep reservoirs will supply water at temperatures lower than presently available for releases to maintain downstream trout and salmon fisheries. Also, the operation of Auburn Reservoir in conjunction with Lake Folsom will enhance the already high-quality recreation provided by the latter through a reduction in water level fluctuations and the maintenance of generally higher storage levels.

Located adjacent to the Sacramento metropolitan area, Lake Folsom has been the most popular of the project reservoirs. In 1969 more than 2.4 million visitor-days were recorded. Second in use was Lake Shasta, the largest of the project reservoirs, with more than 1.7 million visitor-days of recreation use.

The overall Central Valley Project provided a total recreation-use in 1969 of about 6.5 million visitor-days, as shown by project facility in Table 12.

The regulation of streamflow extremes is another significant environmental benefit inherent in the operation of the Central Valley Project conservation facilities. The catastrophic floods of 1964, which caused record damage in the North Coastal area, also produced new record peak runoff in the Central Valley Basin. In the latter area, however, operation of flood control facilities prevented extensive damage. On the American River, for example, the December 1964 peak inflow to Lake Folsom was 280,000 cubic feet per second. Downstream releases were limited by the operation of Lake Folsom to 115,000 cubic feet per second, the design capacity of the channel. Without Folsom Dam and Reservoir, the Sacramento metropolitan area would have been flooded.

During the storm of January 1970, Lake Shasta experienced its greatest peak inflow of record--210,000 cubic feet per second. Downstream releases were held to a maximum of 15,000 cubic feet per second at the time of peak inflow into the lake and were increased to a maximum of only 79,000 cubic feet per second. subsequently, during that storm period, thus minimizing overflow damage in the Sacramento Valley. Lake Shasta has regulated five such major flood flows since its completion in 1944.

Finally, mention should be made of improvement to salinity conditions in the Delta since Shasta Dam commenced operation in 1944. During the 25 years prior to construction of Shasta Dam there were seven years of severe salinity intrusion into the interior Delta channels, and in 1931 salinity from the ocean intruded upstream beyond the City of Stockton. Since 1944 water released through operation of Shasta Reservoir has prevented serious intrusion of saline water into interior Delta channels. Had no releases from storage been made, salt water would have advanced well into the interior of the Delta in 7 of the 10 years from 1955 through 1964. The State Water Project will share responsibility for, and maintenance of, water quality in the Delta.

Environment and the State Water Project

Completed facilities of the State Water Project have already seen intensive use by recreationists. The three Upper Feather area reservoirs (Frenchman, Antelope, and Lake Davis), designed primarily for recreational purposes, were among the first units completed and have supported an increasing use, with 933,000 recreation-days recorded in 1969. These projects are providing new lake habitat for fish, water-based sports opportunities, onshore camping and picnic areas, maintenance of downstream summer flow for fish, and general improvement of the streamshore environment.

Downstream on the Feather River, Lake Oroville became available for recreation-use in 1968; and the Oroville complex, including Thermalito Forebay and Afterbay, supported 517,400 recreation-days of use in 1969. In addition to the usual boating, fishing, and onshore recreational activities at Lake Oroville and Thermalito Forebay, the Afterbay, with 4,500 surface acres, offers waterfowl hunting. Besides the waterfowl habitat provided by the reservoirs, the 5,700-acre Oroville Borrow area will be developed for waterfowl and upland game habitat and for warmwater fishing in the numerous sloughs and ponds.

The Sacramento-San Joaquin Delta perhaps has received more attention than any other area in the study of the effects of proposed water control facilities on the preservation and enhancement of the aquatic environment. Consideration of fish and wildlife ecological requirements had much to do with the choice of the Peripheral Canal as the Delta facility for the State Water Project. The canal was proposed by a joint interagency committee as the best means of conveying water to the pumps of the U. S. Bureau of Reclamation Delta Mendota Canal at Tracy and the Delta Pumping Plant of the California Auqeduct, while at the same time providing for controlled releases into the Delta channels for salinity repulsion, maintenance of a balanced ecology in the Delta necessary for preservation and improvement of sports and commercial fisheries, and improvement of the general Delta environment as it relates to agriculture and recreation use. More than $9 million has been invested by the state agencies in planning and investigation related to recreation and fish and wildlife protection and enhancement in the Delta.

On the South Bay Aqueduct, in Alameda County, Del Valle Dam has been completed adjacent to the San Francisco Bay metropolitan area. The reservoir replaces a stream of intermittent flow with no fishery. It has been stocked with fish by the Department of Fish and Game and onshore facilities have been provided by the Department of Parks and Recreation for the many nearby residents who are this year beginning to enjoy the many recreational activities offered by this strategically located body of water.

Further south along the California Aqueduct, San Luis Reservoir, O'Neill Forebay, and Los Banos Reservoir present an opportunity for water-based recreation in an area historically void of significant bodies of water. Initial facilities for recreationists have been constructed at O'Neill Forebay which has had the heaviest use; however, facilities at three areas on the shore of San Luis Reservoir are now available and are coming into increasing use. Waterfowl shooting is also available at all three reservoirs.

The 280-mile completed section of the California Aqueduct in the San Joaquin Valley already possesses a sizable fish population, chiefly catfish and bass. Four fishing access sites have recently been constructed along the aqueduct by the Wildlife Conservation Board and opened to public use. More will be constructed as the demand develops.

South of the Tehachapi Mountains in Southern California, three reservoirs--Pyramid, Castaic and Silverwood--are under construction and Perris will soon be underway. They will help meet the demand in that heavily populated area for recreational experiences associated with large bodies of water. Plans for stocking of fish and for shore developments are progressing and will be implemented to provide access to and use of the reservoirs when they become operational. Also

TABLE 12

CENTRAL VALLEY PROJECT
RECREATION-USE IN 1969

Feature	Recreation-Days
Clair Engle Lake(Trinity)	148,000
Lewiston Lake	45,000
Whiskeytown Lake	1,044,000
Shasta Lake	1,717,000
Keswick Reservoir	5,000
Jenkinson Lake (Sly Park)	223,000
Folsom Lake	2,405,000
Lake Natoma (Nimbus)	370,000
Millerton Lake (Friant)	366,000
Lake Woollomes	108,000
San Luis Reservoir	*
O'Neill Forebay	*
Los Banos Reservoir	*
San Luis Wasteway	12,000
Contra Loma Reservoir	58,000
Red Bluff Diversion Dam	4,000
Delta Mendota Canal Angling Access Sites	25,000
TOTAL	6,530,000

*Federal-state joint-use features reported under State Water Project in Table 13.

DWR NO. 3872-5

One of four fishing access sites constructed along the California Aqueduct

under investigation is the development of wildlife habitat within the aqueduct right-of-way, particularly in the San Joaquin Valley and in the Antelope Valley-Mojave area.

Table 13 presents recorded recreational use of State Water Project facilities in 1969 and estimated use under full development for those units presently shceduled for construction. Additional developments such as aquatic recreation areas and ecological areas in connection with the Project facilities are under consideration for inclusion as the demand develops and as funding becomes available.

The State Water Project made its first major contribution in the interest of flood control during the period of the extensive 1964 flood. Oroville Dam, although only partially completed, received a maximum record peak inflow of 253,000 cubic feet per second and impounded 155,000 acre-feet of water during the storm period. The reduction of the peak flow to 158,000 cubic feet per second outflow from the reservoir is estimated to have prevented $30 million in damages in the Yuba City-Marysville area.

Summary

This chapter has described the roles of the Central Valley Project and the State Water Project in the management of California's water resources. It has indicated the present services provided by these projects, the coordination aspects of their operation, and their

TABLE 13

RECREATION-USE AT STATE WATER PROJECT FACILITIES

(in recreation-days)

Feature	Annual Recreation Use: 1969	Annual Recreation Use: Estimated Under Full Development
Antelope Lake	99,300	301,000
Lake Davis	439,300	476,000
Frenchman Lake	394,500	474,000
Lake Oroville and Thermalito Forebay and Afterbay	516,400	6,213,000
Peripheral Canal		2,500,000
Bethany Reservoir		50,000
Lake Del Valle		3,370,000
San Luis Reservoir, O'Neill Forebay, and Los Banos Reservoir	105,300	4,483,000 1/
Silverwood Lake		2,188,000
Lake Perris		5,346,000
Pyramid Lake		70,000
Castaic Lake		2,500,000
Aqueduct Angling Access Sites		2/
Frenchman Flat-Piru Creek Fishery Enhancement		320,000
TOTAL	1,554,800	28,291,000

1/ Federal-state joint-use facilities.
2/ Four sites were opened in late 1969 and 1970. More sites will be opened as the demand develops.

potential for providing future services to the people of California.

The chapter has identified and discussed the need for certain priority additions to the conveyance facilities of the two projects. Those additions are the joint federal-state Peripheral Canal and the East Side Division and West Sacramento Canals Unit of the Central Valley Project. Other proposed Central Valley Project extensions discussed, for which an incipient demand is forecast, are the Cosumnes River Division and the Allen Camp Unit.

The text and illustrations in Chapter VII indicate that there will be a need for future conservation facilities for both the Central Valley Project and the State Water Project, but that these latter facilities may not be required for water supply purposes as early in time as previous estimates had shown. This possible deferral in the need for the additional conservation facilities results primarily from the slower growth rates in population, industry and agriculture which are now projected for California.

No attempt has been made to identify or recommend, from among the array of potential source options (as discussed in Chapter V), those future water conservation measures or facilities which may be required after the mid-1990s. It is presently believed that ample study time is available before specific recommendations must be made and that ample review time is likewise available for public consideration of those recommendations.

The chapter concluded with brief discussions of the environmental accomplishments of the Central Valley Project and the State Water Project with emphasis on the recreational opportunities afforded.

CHAPTER VIII. POPULATION DISPERSAL-- IMPACT ON RESOURCES DEVELOPMENT

The population projections discussed in Chapter IV are based upon recent population trends. Generally these trends indicate the continued rapid growth of existing urban areas. The purpose of this chapter is to explore an approach based on possible alternative land use policies involving a redistribution of people and estimate the impact of these policies on water management. Time limitations have precluded an in-depth evaluation. As indicated in Chapter III, a thorough systems analysis is required to define the impacts and consequences of such land use policy alternatives. However, it has been possible to explore on a superficial basis, at least, some of the pertinent ramifications.

Considerable concern has been expressed by legislative and public groups that a continuation of the growth pattern may have serious social and environmental consequences. It is argued that existing metropolitan areas, particularly the South Coast, already are overcrowded and that the resultant environmental problems, such as urban congestion and air pollution, are so serious that a further population increase should not occur. Some proponents of land use and urban population control advocate control of population in Southern California by halting construction of the State Water Project. Others express the belief that the people should move to the northern areas of water surplus to avoid the necessity of sending more water to the south.

The need for land use and population policy has been widely discussed. This need is closely related to the view that resources development planning should take into account the total environment. Both the Federal Government and the State are taking steps leading toward definition and implementation of such policy.

At the federal level, legislation is being considered which calls for a National Land Use Council responsible for general land use policies. In addition, under the new communities provisions of Title IV of the Housing and Urban Development Act of 1968, the Department of Housing and Urban Development can guarantee debt to a maximum of $50 million on a single new town or new community project.

Chapter II mentioned that two important measures were passed by the State Legislature in 1970. The first, AB 2045, required all state agencies, boards, and commissions to include in any report on any public program which could have a significant effect on the environment of the State a detailed statement setting forth specified information concerning the impact on the environment. The second, AB 2070, established a comprehensive state planning function in the Office of the Governor known as the State Office of Planning and Research. This Office will be responsible for the development of long-range statewide goals and policies for land use, population growth and distribution, open space and other factors influencing quality of the State's environment. One of the first tasks will be to provide an analysis of alternative approaches to accommodating future population growth and urbanization within the State. The study will examine the probable consequences of continuing to accommodate future population within existing metropolitan and urban areas and will assess the physical, social and economic impacts which would result if a substantial number of people were located in areas where urbanization is not now anticipated. The Department of Water Resources is assisting in the land use and population policy study.

Concern has been expressed that a continuation of present urban growth patterns may have serious social and environmental consequences

The remainder of this chapter discusses the possible impact of three hypothetical alternative patterns of population distribution on water development, use and disposal. It also briefly discusses related considerations of electric power, transportation and air pollution. These three population distribution patterns, or models, are premised on the projected statewide total population of 45 million in 2020 described in some detail in Chapter IV, but with different geographical locations and densities. The distribution based on historical trends is included as a "base" projection to facilitate a more valid comparison of the impacts of these three models.

Study Criteria

As a first step in selecting hypothetical areas of future urbanization for study, the Department of Water Resources updated its mapped information on all lands presently irrigated and capable of irrigation (see Plate 2). The study was premised on the preservation of irrigable lands for agricultural purposes, and the identification of large blocks of land in both public and private ownership throughout the State which would be physically capable of accommodating urban development while avoiding agricultural lands. Other criteria for selecting these lands were that: lands have a slope no greater than 30 percent; urbanization would not result in the loss of lands with important value for resources management; weight be given to those lands that were (1) located in the coastal environment, (2) located in close relation to recreation resources (mountains, foothills, forests, reservoirs, desert areas, etc.), and (3) accessible by existing transportation facilities.

While the majority of land areas selected for analysis are in private ownership, some of the areas are within the public domain, administered by the Bureau of Land Management. Public lands in National Forests, national parks, wildlife refuges, and Indian and military reservations were excluded from consideration.

A basic assumption underlying the selection process was that the economic conditions required to support urbanization would exist. It was also assumed that different combinations of land areas would be capable of accommodating approximately 50 percent of the 25.2 million anticipated population growth during the period from 1970 to 2020. This would involve 12.6 million people. The remaining 12.6 million people were considered to be located within existing but expanded areas of metropolitan and urban development.

Three models for population distribution were developed within the context of the foregoing criteria and assumptions. Model "A" emphasizes a greater allocation of population to the northern portion of the State, Model "B" is oriented to the central portion, and Model "C" to the southern portion of the State. Figure 41 depicts the distribution of the total population in 2020 by hydrologic areas. Figure 42 illustrates the distribution of people for each of the three models.

The primary focus in the development of the three hypothetical population distribution models was to provide a basis for evaluation of the impact upon the California water development program. It should be emphasized that <u>the assumptions and parameters placed upon the study are very general and broad, and that the models should not be interpreted as recommended development policies.</u> The models were selected to provide a diverse set of options for review.

<u>The northern model</u> (Model "A") emphasizes the area from the Delta north to the Oregon border and reflects essentially a pattern of statewide development which would bring a far greater number of people to the primary sources of water. Approximately 50 percent of the 12.6 million distributed population would go to the northern area. Excepting the San Francisco Bay, Stockton and Sacramento areas, most of the distribution would be in the upper Sacramento Valley and adjacent foothill areas of the Coast Range and Sierra Nevada. The remaining 50 percent would be distributed to the central and southern areas of the State in roughly the same portions as would be expected by a continuation of current growth trends in these areas.

<u>The central model</u> (Model "B") emphasizes the area between the Delta and the Tehachapi Mountain Range in Kern County. Most of the distributed population would be allocated to the Santa Cruz-Monterey and San Luis Obispo-Point Conception areas of the Central Coast, and to the Sierra Nevada foothill areas in Fresno, Madera, Mariposa, Merced, Stanislaus and Tuolumne Counties. Lesser allocations were made to the eastern slope of the Coast Range along the west side of the San Joaquin Valley.

<u>The southern model</u> (Model "C") emphasizes the area between the Tehachapis and the Mexican border and reflects in large degree a continuation of current trends in population growth within the Southern California region as a whole. However, the model directs substantial population to essentially nonurban desert areas and to South Coastal areas between San Diego and San Clemente. Desert areas involve primarily lands in the public domain in the Palm Desert and in the vicinity of Blythe in the Mojave Desert. Lesser concentrations of urbanization are also shown in the foothills bordering the Antelope Valley.

The selection of areas for each of the three models was somewhat arbitrary, as there are other lands

FIGURE 41

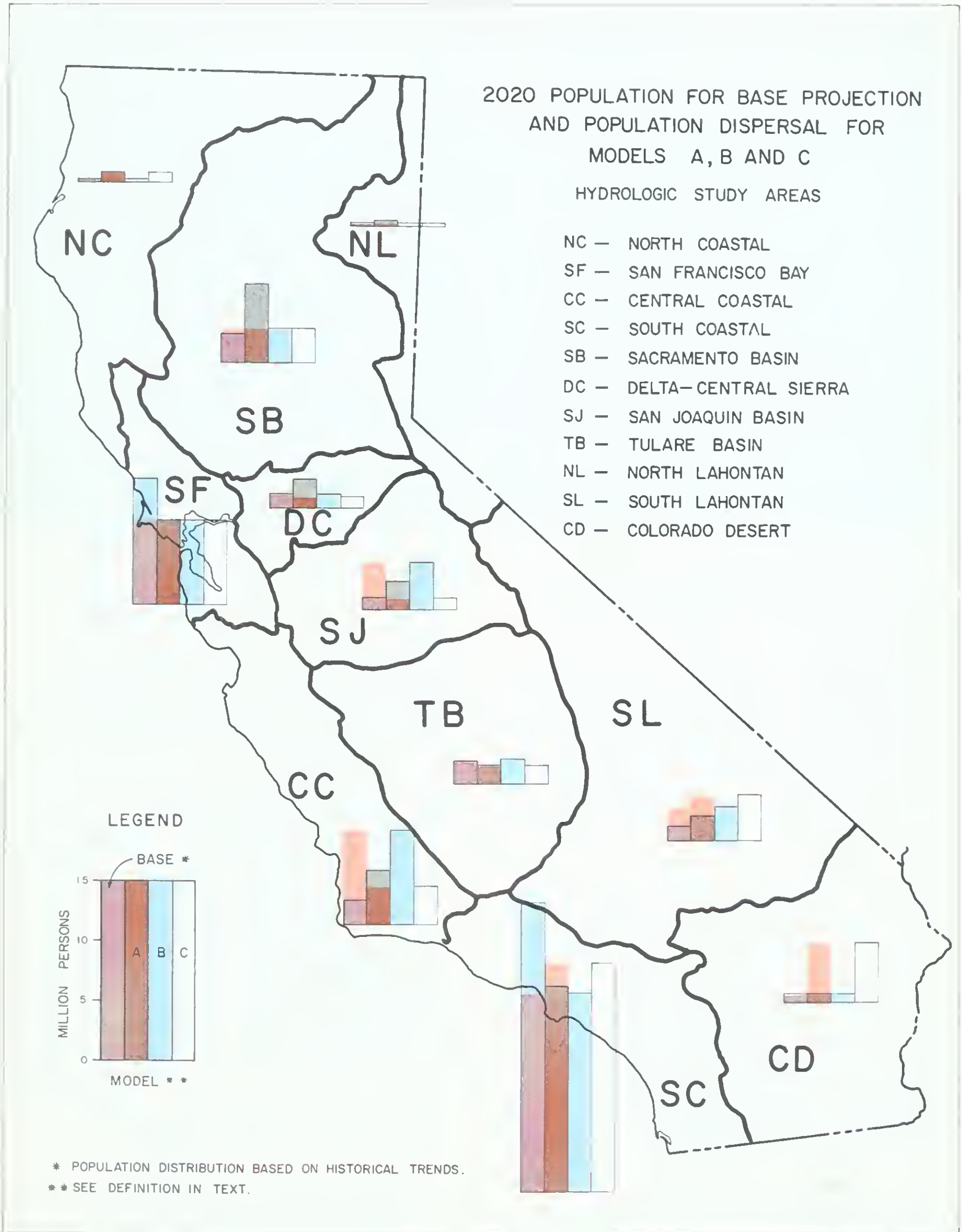
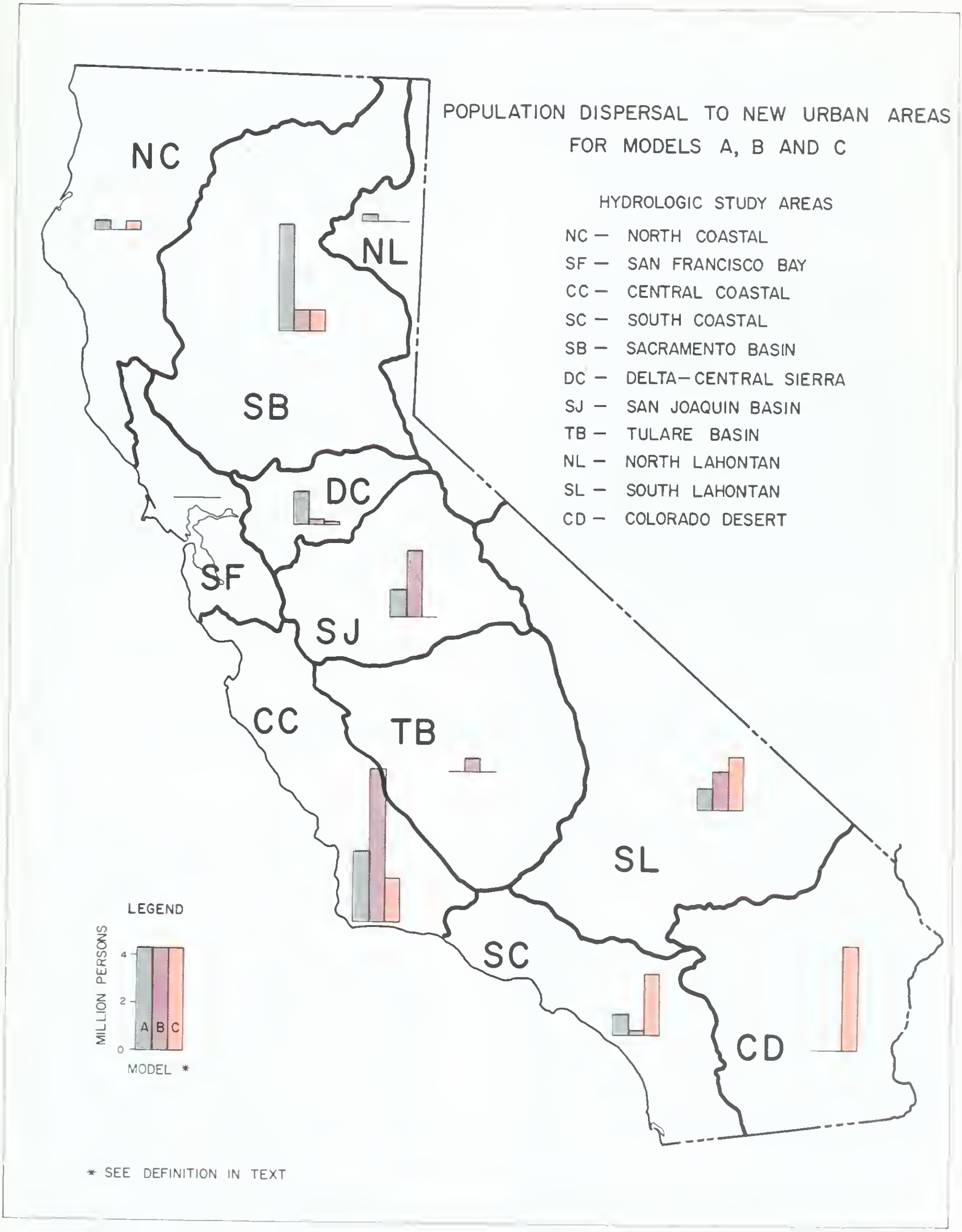

2020 POPULATION FOR BASE PROJECTION AND POPULATION DISPERSAL FOR MODELS A, B AND C
HYDROLOGIC STUDY AREAS
NC — NORTH COASTAL
SF — SAN FRANCISCO BAY
CC — CENTRAL COASTAL
SC — SOUTH COASTAL
SB — SACRAMENTO BASIN
DC — DELTA-CENTRAL SIERRA
SJ — SAN JOAQUIN BASIN
TB — TULARE BASIN
NL — NORTH LAHONTAN
SL — SOUTH LAHONTAN
CD — COLORADO DESERT
NC
NL
SB
SF
DC
SJ
TB
SL
CC
SC
CD
LEGEND
BASE *
15
10
5
0
MILLION PERSONS
A
B
C
MODEL * *
* POPULATION DISTRIBUTION BASED ON HISTORICAL TRENDS.
* * SEE DEFINITION IN TEXT.

FIGURE 42



* SEE DEFINITION IN TEXT

that meet the criteria and assumptions described. The amount of land utilized in each of the models is capable of accommodating the number of people allocated to the area, based on the assumption that future development in new areas would occur at roughly the same densities of development as exist in currently developed areas.

Impact of Population Dispersal on Water Development and the Environment

In considering the impact of the population dispersal models upon long-range planning and development of the State, particular consideration was given to the impact on water demands. Other aspects such as waste disposal, electric power requirements, transportation and air pollution are only touched upon, recognizing that more intensive planning and study would be required for an adequate assessment.

Water Demand and Supply

The three hypothetical population distribution models illustrate the consequences of a range of dispersions of future population growth with regard to water demands. The projected water demands in 2020 for the "base" projection and each of the three models are shown in Table 14.

The water development facilities presently existing and under construction by federal, state and local agencies throughout California have the physical potential and flexibility to accommodate a wide range of alternative future patterns of population growth and dispersal. Technological advancement in such areas as desalting and water reclamation further increase this potential and flexibility. Chapter VI provides information and estimates on the dependable water supplies which could be provided by these developments.

TABLE 14

NET URBAN WATER DEMANDS IN 2020
FOR SELECTED ALTERNATIVE PATTERNS OF FUTURE URBANIZATION

(1,000 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

Table 14 shows that the three population dispersal models reflect a lesser population increase and resultant slower buildup in net urban water demands within the San Francisco Bay and South Coastal hydrologic study areas than would occur under the "base" projection. However, there is essentially either the same or a greater future net urban water demand in each of the other study areas. It is also interesting to note that the total statewide water demand in 2020 is greater under Model "A" than under the "base" projection, and that demands are essentially the same under Models "B" and "C" as under the "base" projection. The higher water demand under Model "A" reflects the impact of dispersing people to inland areas where per capita water use is generally greatest.

The following paragraphs provide a very general discussion of the potential for supply exchanges in connection with existing development and the additional water supply measures and options indicated by the population growth patterns envisioned by the three models. It must be recognized that numerous legal and administration issues would need resolution to carry out some exchanges.

Northern Model "A". The resultant increase in anticipated urban water demands in the North Coastal region could be met by local streams development along the Mendocino Coast. In the Central Coastal region, future demands around Monterey Bay could be met from reserve supplies from the South San Francisco Bay area (water which would not be needed with a shift of future population increase); and similar demands in the southern portion of the region could be offset by transfers of reserve supplies from the South Coastal area.

Water demands for the new urban center in the upper Sacramento Basin could be provided by reserves, local streams development or by importation from the North Coastal area. Additional demands in the Delta-Central Sierra area could be supplied in part from American and Cosumnes Rivers sources with additional supplies obtained from reserves available to the San Francisco Bay area or by other imports from the Sacramento Basin.

New cities in the Sierra foothills and other new demands in the San Joaquin Basin could be served from the Friant Unit and the proposed East Side Division of the Central Valley Project. New urban developments on the east and west sides of the Tulare Basin could be served, respectively, by the East Side Division and by diversions of water supplies from the California Aqueduct that would not be needed in the South Coastal area under this population distribution alternative. Additional demands in the North Lahontan area could only partially be met by developing local streams and probably would require imports from the Sacramento Basin.

The projected additional urban water demands in the South Lahontan area could be supplied by diversions of water supplies from Los Angeles Aqueduct or the California Aqueduct that would not be needed in the South Coastal region under conditions imposed for this population model study. The Colorado Desert could similarly be served by diversions from the Colorado Aqueduct.

Central Model "B". Under this central-oriented model major new population centers are envisioned along the Central Coastal areas of Monterey Bay and the Santa Maria and Santa Ynez Valleys. New cities are also envisioned along the Sierra foothills in the San Joaquin Basin. As in the other models, the population increase in the San Francisco Bay and South Coastal areas would be less than anticipated under the "base" projection. The much larger demands in the Central Coastal area could be satisfied by a transfer of reserve supplies from the San Francisco Bay and South Coastal areas, coupled with local streams developments and by the desalting of sea water. Also, water reclamation could assist in extending the water supply. The additional Model "B" urban water demands in the Sacramento Basin could be supplied from reserves; and those in the Delta-Central Sierra could be met from American River sources. For the most part, the new communities along the east side of the San Joaquin Basin could be supplied by the proposed East Side Division of the Central Valley Project. The new cities on the east side of the Tulare Basin could also be served by the East Side Division, and the California Aqueduct could provide the necessary water supplies for those cities on the west side of the Basin. Demands in the North Lahontan area could be met by the development of local streams. Supplies for the new urban centers in the South Lahontan and Colorado Desert areas could be provided by diversions of water from the Los Angeles and Colorado Aqueducts that would not be needed in the South Coastal area under the assumptions of this population model.

Southern Model "C". For the southern-oriented population model the largest new cities are suggested in the South Lahontan and Colorado Desert areas. New cities in the desert region would require an importation of more water from greater distances than in the other models.

The large new cities suggested in the Mojave area could be served by increased deliveries via the California Aqueduct. Extension of the aqueduct could also serve portions of the water demand created by the suggested cities in the Colorado Desert. Colorado River water supplies presently allocated to the South Coastal region could also be used to meet part of the needs in these new cities.

The additional urban demands suggested by the southern-oriented model in the North Coastal, San Francisco Bay, South Coastal, Sacramento Basin, Delta-Central Sierra, Tulare Basin and North Lahontan areas could be met by essentially the same means as the projected demands in the central model. New cities in the Central Coastal area could be served by a reserve supply available to the San Francisco Bay area, by developing local streams, desalting, and water reclamation; and those in the San Joaquin Basin could be served in part by supplies from the San Francisco area and by the proposed East Side Division.

From the analysis of the water demand-water supply relationships for the "base" projection and the three hypothetical models it can be concluded that: (1) no matter how the population may be distributed in the future, demands for developed water will remain essentially the same, and it will be primarily a matter of the optional sources of water supply and variation of patterns and costs of transportation of supplies to areas of need (Table 14); (2) the water supplies available from existing or definitely planned facilities would be some 5 million acre-feet per year short of satisfaction of 2020 demands, thus requiring development of 5 million acre-feet annually from new sources (see Table 8 in Chapter VI); and (3) as compared with the "base" projection there would be a reduced opportunity for sea water conversion for Models "A" and "C", because of their greater inland concentration of population.

Waste Disposal

The concept of new cities offers an opportunity for applying a comprehensive systems approach to the entire problem of waste management. In existing urban areas, corrective measures generally are not taken until considerable damage has already been done to the environment. In a new city, however, waste management facilities can be designed concurrently with the total urban complex so that the most safe, esthetically pleasing and efficient results can be obtained. With proper zoning and other controls over growth and types of development, facilities for disposing of wastes need never become inadequate.

New cities in coastal locations would present about the same waste water disposal problems that would be expected if an equivalent development should take place adjacent to existing coastal metropolitan areas. The better quality waste waters could be reclaimed for selected reuse applications, such as environmental enhancement projects or ground water recharge with the poorer quality water disposed of in the ocean after adequate treatment. Carefully designed deep ocean disposal of adequately treated waste water should cause little ecological degradation and may be beneficial in some areas where present nutrient levels are not adequate for desirable biological growths. The future, however, holds the possibility of much greater recycling of waste water.

In the Central Valley large concentrations of people and the industrial base to support them could present major waste water management problems. The problems would intensify with distance from the ocean as the ocean is the ultimate natural repository of wastes, and added mineral loads in the water supply must be removed or find their way to the ocean.

Water reclamation would appear to be an essential element of any waste water management plan for new cities in the Central Valley. Excessive algal growths could cause particular damage to fisheries, recreational uses and esthetics. On the other hand, nutrients retained in the treated effluent when used for irrigation help meet fertilizer requirements and further reduce nutrient concentration in the return water. Overall salt loads returned to streams would remain about the same with or without a reclamation phase, however, because neither treatment methods nor irrigation would reduce dissolved minerals in the waste water.

In the Colorado Desert area disposal of waste water from large population centers may be even more complex than in the Central Valley. Waste effluents cannot be discharged into the Colorado River without adding to the already highly dissolved salt concentrations of the river. One solution that appears reasonable would be to allow waste water, after beneficial reuse, to drain into artificial salt lakes where evaporation would concentrate the salts and no further use would be intended. Sites would have to be selected where percolating highly mineralized water would not degrade usable ground water supplies. The ecologic impact of such new sinks would require study. Deep-well injection of waste water may be a possible alternative to evaporation lakes.

The problem of disposal of solid wastes is one which is growing more intense as our society becomes more affluent, complex and sophisticated. Solid waste disposal covers a wide range, including garbage, trash, clothing, furniture, automobiles, other miscellaneous household and commercial discards, debris from building construction or demolition, sewage sludge, agricultural wastes, industrial refuse, and last but not least, hazardous wastes such as explosives and radioactive materials. While production of solid wastes presumably would be the same, irrespective of population distribution, the disposal sites would be substantially influenced.

At the present time many methods of handling solid waste are being experimented with, including land fill, composting, improved methods of incineration, dumping at sea, destructive distillation, pyrolytic decomposition, wet digestion or combinations of these techniques. Most of the disposal methods create further pollution problems in other areas, i.e., land fill may pollute underlying ground water and may produce gaseous or other noxious effects, and sea dumping may pollute coastal areas.

Electric Power Requirements

In the "base" projection it was assumed that the primary source of additional electric power in the future would be from steam electric plants, mostly nuclear. In general, the plants would be located along the coastline, because of the need for large quantities of cooling water and because most of the population, and therefore power requirements, would be located in the coastal areas.

The hypothetical models would, in general, move the population inland. However, it is anticipated that the location of powerplants would remain along the coastline, with the power transmitted to inland areas of need, as necessary. This would require the construction of substantial transmission facilities of high capacity. Significant environmental issues would be involved. It is considered that the population dispersal would not have a significant effect on overall power requirements.

Dispersal of population to Northern California probably would be the most advantageous from an electric power standpoint. With the increase in population in Northern California, plants could be moved farther north into less populous coastal areas. In regard to transmission, power that would be wheeled to Southern California over the extensive grid traversing the valley could be absorbed enroute by construction of minimum facilities.

In the case of population increase along the foothills of the Sierra in Central California, extra transmission would be required from the coastal powerplants to the Sierra foothills. However, the major north/south bulk transmission grid in the Central Valley would minimize the additional transmission facilities which would be required.

The most difficult possibility with regard to electric power would result from dispersal of the population into the southern portion of the State. In this assumption, large numbers of people would be located in the desert areas in the Colorado Desert and the southern portion of the South Lahontan area. This would require substantial amounts of transmission facilities to serve the people in the desert areas. Due to the high population density of the Southern California areas, the addition of transmission facilities is difficult from an environmental as well as practical standpoint, and quite expensive. The southern dispersal of population, particularly to the desert areas, would require special attention with regard to electric power.

Other Considerations

Population dispersal would have an impact on a number of environmental and other factors which were not considered in the analysis of the hypothetical models. However, other state agencies provided some insight on air pollution and transportation as related to population distribution patterns.

With regard to air pollution, the Office of Planning and Research is undertaking a study to evaluate the impact of alternative population distribution patterns. It is anticipated that the Air Resources Board and other state and local agencies will be involved in providing a detailed assessment of this problem. At this point it is possible to do no more than draw attention to the major issues concerning air pollution and to hypothesize as to the relationship between population distribution and the problems of air pollution.

Land use and population policies can be utilized to control the quantity of pollutants emitted in an area, with a substantial effect on air quality. Generally the greater the population in an area, the greater the number of sources and the total emissions. Thus, prevention of concentrations of harmful pollutants may necessitate control of one or more of the following: (1) the total number of people in an area, (2) the population density, and (3) the location, size, number, and strength of sources of pollution.

Meteorological conditions determine the amount of air available to dilute concentrations of pollutants emitted to the air. Therefore, population policies which locate people in areas with favorable meteorological conditions will be beneficial in eliminating future pollution problems within the State. Generally, dilution is greater along the California Coast than inland and greater in Northern California than Southern California. The implication is that the air pollution problem can be reduced in intensity in metropolitan areas through population dispersal; but insufficient knowledge is available to enable a quantitative determination of the overall impact.

In our present automobile-oriented society, highways have served a dual role of reacting to development pressures while at the same time stimulating further development in and adjacent to the areas served. The approach being investigated by the Office of Planning and Research suggests new transportation priorities and probable shifts of resources.

All three models contain population redistribution centers within the Pacific Coastal Mountain Ranges to one degree or another. Primary corridor linkages in this area lie on a north-south axis, with only limited east-west connections to the central interior. Expansion of the number of large urban centers in the coastal area will require expansion of the north-south corridor facilities. Further, vastly improved connections between the coast and the central interior probably would be essential to improve communications between these two areas.

Current transportation corridors in the Sierra-Cascade foothills area lie on a north-south axis on the valley floor. Development of large urban centers within the foothills areas would require expanded transportation facilities within the north-south corridors as well as improvement of east-west corridor connections to urban centers on the valley floor and in the North and Central Coastal areas.

Development of new urban centers in the southern portion of the State would require expansion of the corridor facilities between the desert interior and the southern coastal area. Improved north-south corridor facilities within the southern coastal zone would probably be necessary to maintain an adequate level of intraregional communication. Expanded north-south corridor facilities between Southern California and Northern California areas most likely will be necessary to accommodate the demand generated by the growth centers in these respective regions.

Transportation is therefore easily identifiable as a major factor impacting upon population distribution. The type, speed, cost, convenience and comfort of various transportation modes can significantly affect the distribution of population and land uses.

In summary, the impacts of population dispersal discussed in this chapter are based only on very cursory examination. With exception of the impact on water demands, the conclusions that can be drawn are more significant in the questions raised rather than in definitive information. They point out the need for careful study of any proposed population center to evaluate meaningfully the potential problems. It is apparent that suggestions to direct people to areas of surplus water involve various problems, all of which must be considered together.

Collate.

2 pieces

125°
124°
123°
122°
121°
42°
41°
40°
39°
O R E G O N
DEL NORTE
S I S K I Y O U
M O D O C
HUMBOLDT
T R I N I T Y
S H A S T A
L A S S E N
T E H A M A
P L U M A S
B U T T E
G L E N N
M E N D O C I N O
C O L U S A
L A K E
S O N O M A
N A P A
Y O L O
S U T T E R
N E V A D A
S I E R R A
P L A C E R
E L D O R A D O
A M A D O R
A L P I N E
S A C R A M E N T O
T U O L U M N E
S T A N I S L A U S
P A C I F
GOOSE LAKE
Clair Engle L.
Shasta L.
Schneiders Bar Res.
Dinsmore Res.
Yellowjacket Res.
Dos Rios Res.
GRINDSTONE TUNNEL
Newville Res
Rancheria Res
Sites Res
Blue Ridge Res
CLEAR LAKE
Indian Valley Res
L. Berryessa
Tuscan Buttes Res.
Tehama Res.
Eagle L.
Honey L.
L. Almanor
Allen Camp Res
Lake Oroville
Marysville Res
Auburn Res
Folsom L.
Nashville Res
LAKE TAHOE
Camanche Res
New Hogan Res
New Melones Res
New Don Pedro Res
L. McClure
NORTH BAY AQUEDUCT
SAN FRANCISCO

PLATE 1

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER RESOURCES DEVELOPMENT IN CALIFORNIA

LEGEND

FEATURE	EXISTING OR UNDER CONSTRUCTION	AUTHORIZED	POSSIBLE* FUTURE
RESERVOIRS			
AQUEDUCTS			
TUNNELS			
POWERPLANTS			
PUMPING PLANTS			
REVERSIBLE PUMP TURBINE PLANTS			
DESALTING PLANTS			
FISH PROPAGATION FACILITIES			

* Includes projects ranging from those considered for authorization to those having received only reconnaissance study
Reservoirs of less than 100 surface acres are not shown.


SANTA CLARA
SANTA CRUZ
MERCED
MADERA CANAL
San Luis Res
Los Banos Res
SAN BENITO
CALIFORNIA
MONTEREY
KINGS
Tulare Lake
BRANCH
COASTAL
SAN LUIS OBISPO
SANTA BARBARA
I
C
O
C
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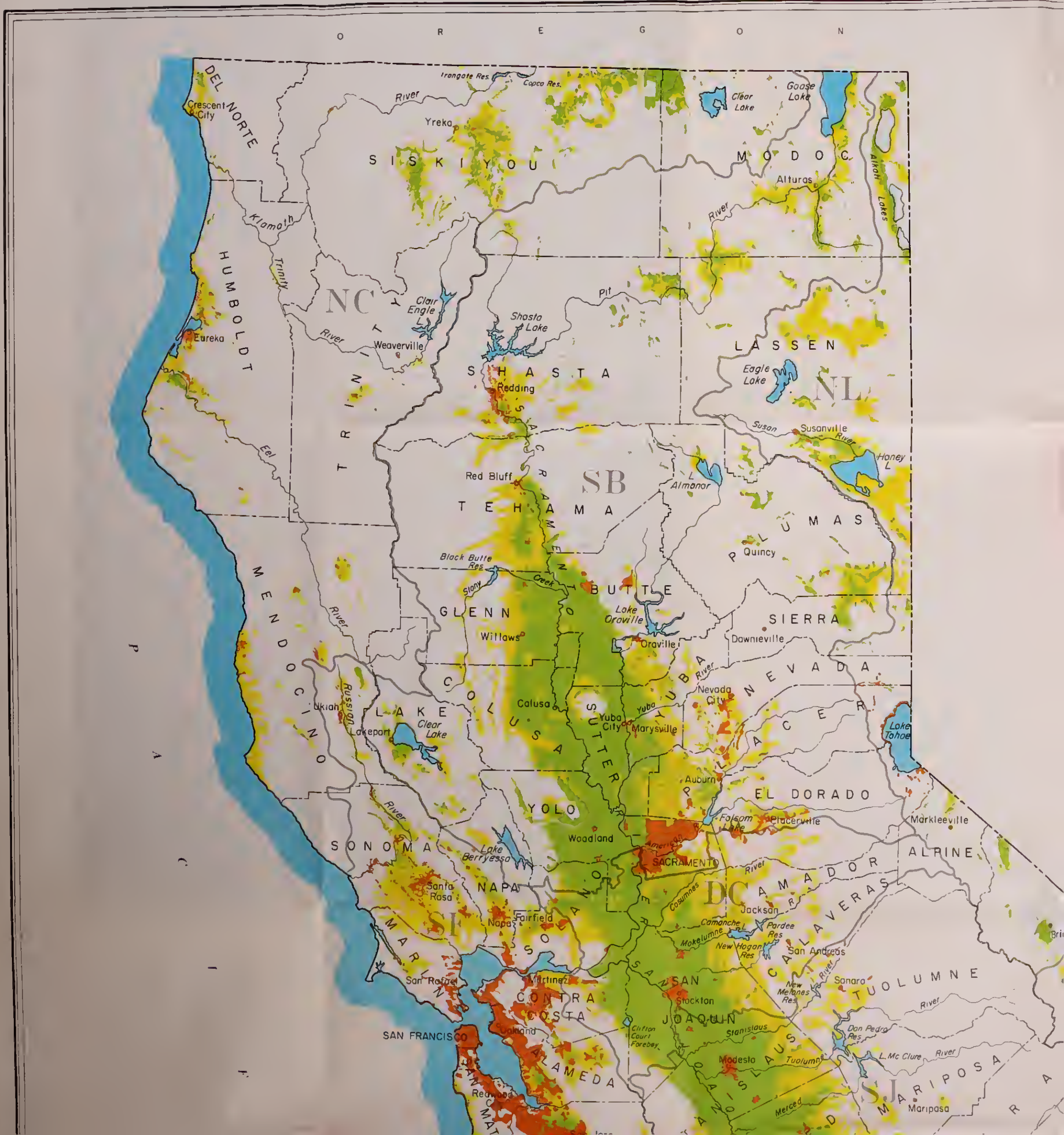
A
N
37°
36°
35°
34°
33°
124°
123°
122°
121°
120°

OCTOBER 1970



O R E G O N
P A C I F
DEL NORTE
Crescent City
SISKIYOU
Yreka
Irongate Res.
Copco Res.
River
Klamath
Clear Lake
Goose Lake
MODOC
Alturas
Alkali Lakes
River
HUMBOLDT
Eureka
Trinity
River
NC
Clair Engle L.
Weaverville
TRINITY
Shasta Lake
Pit
SHASTA
Redding
LASSEN
Eagle Lake
NL
Susan
Susanville
River
Honey L.
Eel
Red Bluff
SB
Almanor
TEHAMA
SACRAMENTO
PLUMAS
Quincy
MENDOCINO
Black Butte Res.
Stony
Creek
River
GLENN
Willows
BUTTE
Lake Oroville
Oroville
SIERRA
Downieville
YUBA
River
NEVADA
Nevada City
Russian
Ukiah
LAKE
Clear Lake
Lakeport
COLUSA
Colusa
SUTTER
Yuba City
Yuba
Marysville
PLACER
Lake Tahoe
Auburn
EL DORADO
River
YOLO
Woodland
Folsom Lake
Placerville
Markleeville
ALPINE
SONOMA
Lake Berryessa
American
SACRAMENTO
River
AMADOR
Santa Rosa
NAPA
Cosumnes
DC
Jackson
CALAVERAS
SF
Fairfield
Napa
Camanche
Pardee Res
MARIN
SOLANO
Mokelumne
New Hogan Res
San Andreas
San Rafael
Martinez
SAN JOAQUIN
Stockton
New Melones Res
River
Sonora
TUOLUMNE
CONTRA COSTA
River
SAN FRANCISCO
Oakland
Clifton Court Forebay
Stanislaus
Don Pedro Res
ALAMEDA
Modesto
STANISLAUS
Tuolumne
L. Mc Clure
River
SJ
MARIPOSA
Mariposa
Redwood
SAN MATEO
Merced

STATE OF CALIFORNIA
THE RESOURCES AGENCY

DEPARTMENT OF WATER RESOURCES

IRRIGATED, IRRIGABLE AND URBAN LANDS

LEGEND

URBAN LANDS

IRRIGATED LANDS

IRRIGABLE LANDS

HYDROLOGIC STUDY AREAS

NORTH COASTAL

SAN FRANCISCO BAY

CENTRAL COASTAL

SOUTH COASTAL

SACRAMENTO BASIN

DELTA – CENTRAL SIERRA

SAN JOAQUIN BASIN

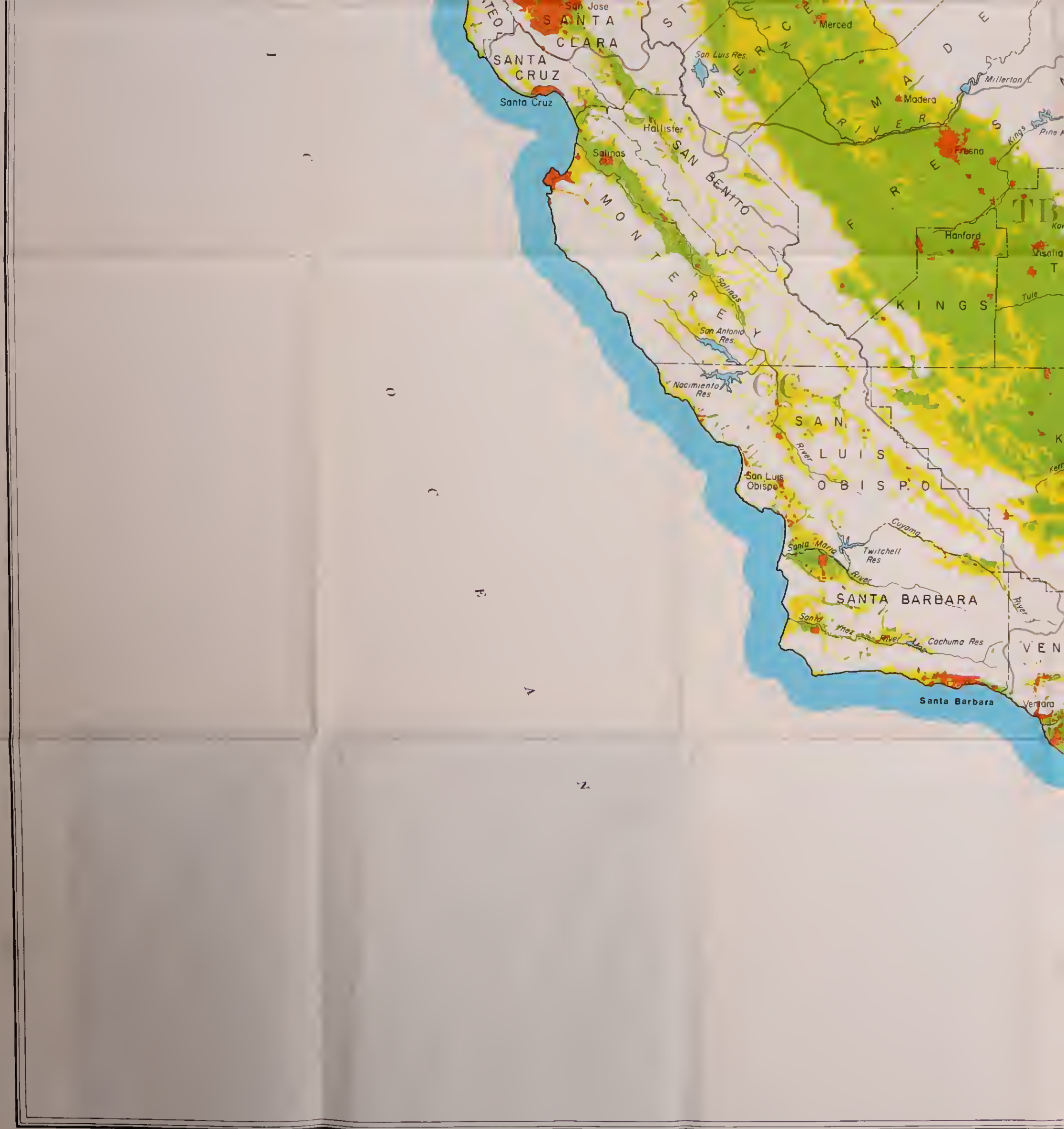
TULARE BASIN

NORTH LAHONTAN

SOUTH LAHONTAN

COLORADO DESERT

STUDY AREA BOUNDARIES



San Jose
SANTA CLARA
SANTA CRUZ
Santa Cruz
San Luis Res.
MERCED
Merced
MADERA
Madera
Millerton L
Kings
Fresno
FRESNO
Hollister
SAN BENITO
Salinas
MONTEREY
Hanford
Visalia
KINGS
Tule
Salinas
San Antonio Res.
Nacimiento Res
SAN LUIS OBISPO
River
San Luis Obispo
Cuyama
Santa Maria
Twitchell Res
River
SANTA BARBARA
River
Santa Ynez River
Cachuma Res
Santa Barbara
Ventura

Independence
INYO
Terminus Res
Success Res
Isabella Res
KERN
Bakersfield
SAN BERNARDINO
Mojave River
Lake Havasu
VENTURA
Castaic Lake
LOS ANGELES
San Bernardino
Riverside
Santa Ana
RIVERSIDE
Whitewater
Salton Sea
Colorado
SAN DIEGO
L. Henshaw
IMPERIAL
El Centro
San Diego
EDITION OF 1970