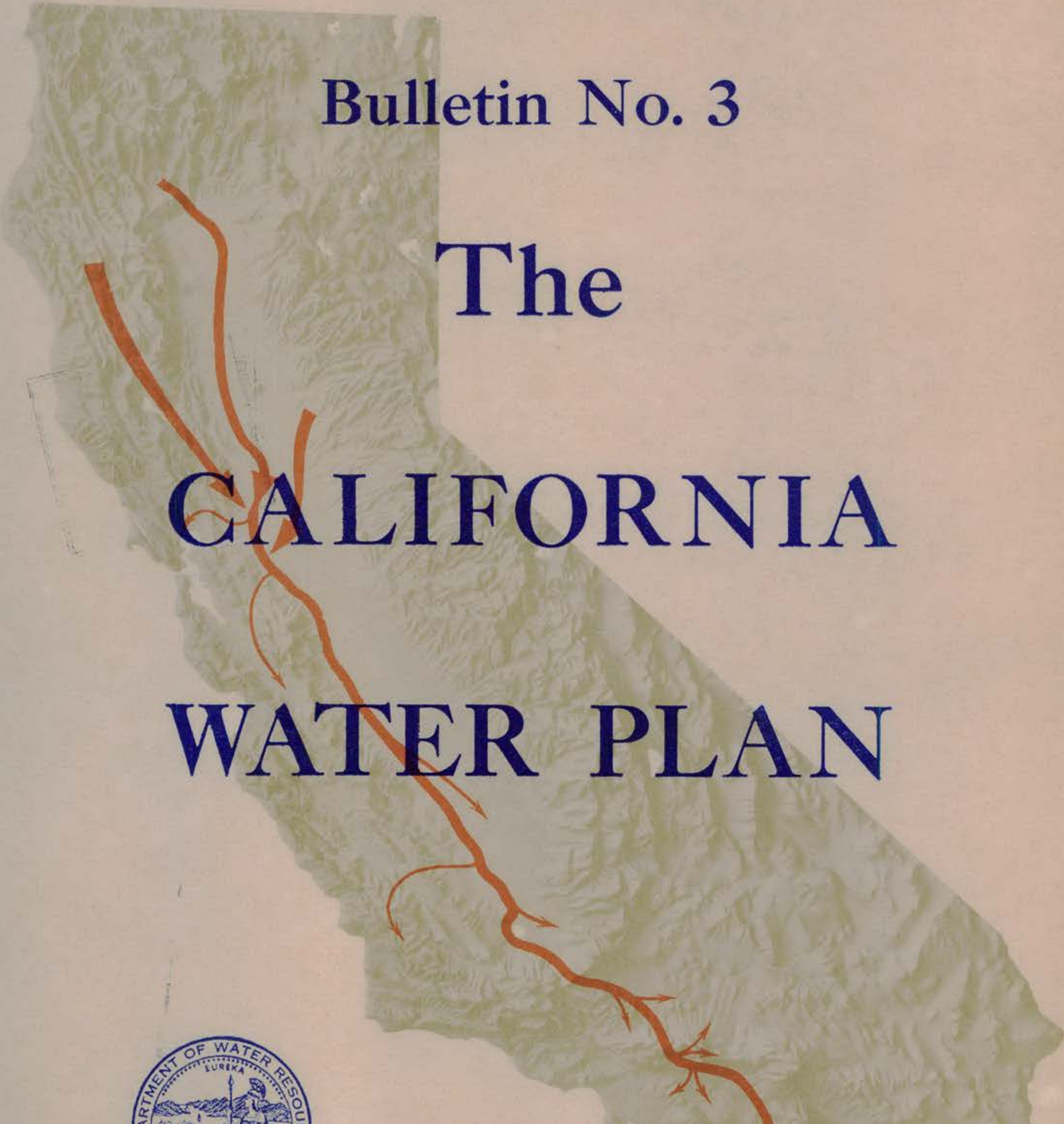
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

Bulletin No. 3

The CALIFORNIA WATER PLAN



GOODWIN J. KNIGHT
Governor

May, 1957

HARVEY O. BANKS
Director of Water Resources

STATE OF CALIFORNIA
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The CALIFORNIA WATER PLAN

GOODWIN J. KNIGHT
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Director of Water Resources

May, 1957

This publication is dedicated to the memory of the late State Engineer of California, A. D. Edmonston.

Mr. Edmonston, with an interest transcending the requirements of his office, developed and vigorously propounded the fundamental concepts of state-wide comprehensive development of California's water resources.

Mr. Edmonston had acquired an interest in the State's water resources by 1924 when he entered State service. He was instrumental in the formulation of the State Water Plan of 1930, which led to the authorization and subsequent construction of the Central Valley Project.

As a direct result of Mr. Edmonston's dedication and resolution, the first unit of The California Water Plan and the first truly State-wide water development in California—the Feather River Project—has been brought to fruition by legislative authorization and initiation of construction.

A. D. EDMONSTON
1886-1957

FOREWORD

California is presently faced with problems of a highly critical nature—the need for further control, protection, conservation, and distribution of her most vital resource—water. While these problems are not new, having been existent ever since the advent of the first white settlers, never before have they reached such widespread and serious proportions. Their critical nature stems not only from the unprecedented recent growth of population, industry, and agriculture in a semiarid state, but also from the consequences of a long period during which the construction of water conservation works has not kept pace with the increased need for additional water. Unless corrective action is taken—and taken immediately—the consequences may be disastrous.

What are the principal water problems facing the people of California? The most recently and tragically demonstrated problem—the floods of December, 1955—is still vivid in the memory of all. Taking the lives of 64 persons, destroying and damaging homes, farms, businesses, and utilities to the tangible toll of $200,000,000, with great additional intangible losses to the general economy, the streams of northern and central California went on a rampage unparalled in recent history.

Not so spectacular, but nonetheless significant, and constantly evident, is the problem of water deficiency in many areas of the State. A critical need for supplemental water supply now exists in many areas, including: Alameda, Santa Clara, and San Benito Counties; the east, west, and south portions of the San Joaquin Valley; Antelope Valley; Santa Maria Valley and Ventura County. The ground water basins in these areas are being pumped to the point of dangerous overdraft which threatens their welfare. There have been, for many years, severe overdrafts on the ground water basins in the South Coastal Area in Los Angeles, Orange, San Bernardino, and Riverside Counties. An acute need for additional water exists in San Diego County, which will be temporarily alleviated by the construction of an additional aqueduct to convey presently surplus Colorado River water, as now authorized by The Metropolitan Water District of Southern California and the San Diego County Water Authority. The supply which can be made available to the South Coastal Area under rights to Colorado River waters, while not now fully utilized, will be fully committed and used by about 1970. By 1975, or possibly much earlier, all of southern California will need more water. Moreover, many of the mountainous areas, such as the Upper Feather River Basin and portions of the North Coastal Area, need water development works, not only for municipal and irrigation water but also to maintain stream flow for preservation of fish and wildlife, and to enhance the recreational potential, an important economic asset.

The urgency of California's water problems can best be illustrated by citing the example of the recent rapid growth of the State. In 1940, just before the beginning of World War II, California had a population of about 6,900,000. By 1950 this population had increased to about 10,600,000, and by 1955 it had increased an additional 23 per cent to more than 13,000,000. In 1957 the population reached 14,000,000. Coincidentally, the use of water per capita has increased significantly and will continue to grow. In 1950 the estimated seasonal shortage of developed water in California was about 2,700,000 acre-feet, largely representing an overdraft on ground water storage. By 1955, water requirements had increased an additional 3,000,000 acre-feet per season. Allowing for the yield from new construction during the intervening period and for increase in the delivery of constructed works to their full potential wherever possible, the deficit aggregated nearly 4,000,000 acre-feet per year. Although the bulk of this supplemental water is needed for irrigation purposes, substantial quantities are required for urban and domestic uses.

Based upon reasonable forecasts of growth of the State during the next decade, it is indicated that the net shortage of developed water supply could amount to more than 10,000,000 acre-feet per season by 1965, taking into account increasing importations and deliveries from presently developed water sources.

The need for solution of the present and future water problems of California is clear. It is also clear from a study of the past history of water development in the State that the future growth of California will now depend upon a coordinated state-wide program for water development. The authorized Feather River Project, the first truly state-wide project, will be the first major step in this direction. However, even if the project were constructed and in operation today and serving all areas of water deficiency, it would barely overcome the deficiencies of the present. In other words, the large water supply to be gained from the Feather River Project is fully needed today. Furthermore, unless we assume that the population remains at present levels, one or more additional projects of comparable size should be rapidly planned for construction in the near future. This fact should be cause for concern, for there is no reason to believe that our phenomenal recent rate of growth will slow down now or in the near future. The responsibility of immediate initiation of a state-wide water development planning and construction program is particularly acute because of the often-demonstrated time lag between the planning stage and the financing and construction stage of any large-scale project.

The State Legislature in 1947 authorized comprehensive state-wide investigations and studies, which have culminated, after 10 years of intensive effort, in "The California Water Plan," a master plan to guide and coordinate the planning and construction by all agencies of works required for the control, protection, conservation, and distribution of California's water resources for the benefit of all areas of the State and for all beneficial purposes.

What does "The California Water Plan" purport to do?

1. It evaluates the water supply available to California and describes the places and characteristics of its occurrence.

2. It estimates the water requirements, both present and future, for all purposes for each area of the State, as best as can be foreseen now.

3. It points out (a) the watersheds where present estimates indicate surplus waters exist over and above the future needs for local development, and gives an estimate of such surplus, and (b) the areas of deficiency and the estimated deficiency for each such area.

4. It outlines existing and prospective water problems in each area of the State.

5. It describes the beneficial uses to which the remaining unappropriated waters of the State should be put for maximum benefit to the people of all areas of the State.

6. It suggests the manner in which the waters of the State should be distributed for the benefit and use of all areas.

7. It proposes objectives toward which future development of the water resources of the State should be directed in all areas of the State, and suggests broad patterns for guidance toward these objectives.

8. It defines these objectives in terms of potential physcial accomplishments, which may be used to measure the merits of projects proposed for construction by any agency.

9. Finally, it demonstrates that the waters available to the State of California, including the State's rights in and to the waters of the Colorado River, are not only adequate for full future development of the land and other resources of the State, but also that physical accomplishment of these objectives is possible.

The California Water Plan must be implemented by a state-wide program for the construction of projects needed to control and supply water wherever and whenever the need arises and as projects are found feasible. Physical works for the control, protection, development, and use of water do not pertain solely to the so-called "areas of deficiency." There are few areas which do not now or will not require physical works for the development of water resources. The job is a big one, and will require the combined efforts of the Federal Government, the State Government, and local agencies, as well as private entities and individuals, with the State logically taking a leading role in administration and coordination as well as financing and construction.

The Feather River Project, the initial unit of The California Water Plan, must be started immediately, and other projects must follow in the near future. The California Water Plan, a coordinated master plan, should be accepted as the general framework or pattern for future water development in the State. Finally, and this cannot be emphasized too strongly, solution of the water problems of California lies in the construction of physical works—not alone in laws and reservations of water, however necessary these may be as steps in the process.

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PHOTOGRAPHS

Photographs printed herein are shown, on the pages noted, through the courtesy of the following:

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ABBREVIATIONS: **t**, top; **c**, center; **b**, bottom; **r**, right; **l**, left.

APPENDIXES

At the present time the Department of Water Resources plans to publish appendixes on those considerations basic to the formulation of The California Water Plan and on certain other factors affecting the Plan. There follows a listing of these proposed appendixes, together with a general statement of their scope.

A. Detailed engineering report on The California Water Plan, describing local and interbasin transfer projects on an individual basis.

B. Basic assumptions, criteria, and procedures employed in formulating The California Water Plan.

C. General geology of California, geologic conditions affecting the location and design of engineering works, and ground water geology.

D. Utilization of ground water storage capacity, with particular reference to conjunctive operation of surface and underground reservoirs.

E. Factors involved in maintenance of water quality.

F. Effects of The California Water Plan on fish, wildlife, and recreation.

G. Flood problems and existing project works; flood control accomplishments of The California Water Plan.

H. Economic and financial aspects of The California Water Plan.

I. Water rights and attendant legal considerations and implications with respect to The California Water Plan.

J. Potentialities of other means of increasing water supplies, such as sea-water conversion, waste-water reclamation, artificial increase of precipitation, and watershed management.

K. Relationship of future power sources and energy requirements to The California Water Plan.

LETTER OF TRANSMITTAL

HARVEY O. BANKS
DIRECTOR

GOODWIN J. KNIGHT
GOVERNOR

ADDRESS REPLY TO
P. O. BOX 1079 SACRAMENTO 5
1120 N STREET GILBERT 2-4711

STATE OF CALIFORNIA
Department of Water Resources
SACRAMENTO

May 6, 1957

HONORABLE GOODWIN J. KNIGHT, *Governor, and*
Members of the Legislature of the
State of California

GENTLEMEN:

I have the honor to transmit herewith Bulletin No. 3 of the Department of Water Resources, entitled "The California Water Plan," as authorized by Chapter 1541, Statutes of 1947.

Bulletin No. 3 presents a master plan to guide and coordinate the activities of all agencies in the planning, construction, and operation of works required for the control, development, protection, conservation, distribution, and utilization of California's water resources for the benefit of all areas of the State and for all beneficial purposes.

It is believed that The California Water Plan provides the basis for achieving the most effective and comprehensive development of California's water resources. It is concluded that California does have enough water, including the State's present rights in and to the waters of the Colorado River, to satisfy the ultimate water needs if the available resources are wisely controlled, conserved, and distributed. The full solution of California's water problems thus becomes essentially a financial and engineering problem.

Bulletin No. 3 contains recommendations that The California Water Plan be accepted by the Legislature as the general and coordinated master plan for the progressive and comprehensive future development of the water resources of California by all agencies; that adequate funds be provided by the Legislature for a continuing, more detailed study under the California Water Development Program; that positive assurances be provided, to the maximum practicable extent, by constitutional amendment and legislative enactments, that water required to meet all future beneficial uses in all areas of the State will be available in adequate quantity and quality when and where needed; that a long-range water development fund and enabling policies to assure the financing and construction of needed water development works in California be established; that the financing and construction of the authorized Feather River Project be expedited; and that other presently needed water development works be undertaken immediately.

Very truly yours,

Harvey O. Banks
Director

LETTER OF TRANSMITTAL

GOODWIN J. KNIGHT
GOVERNOR

ADDRESS ALL COMMUNICATIONS
TO THE CHAIRMAN

P. O. BOX 1079
SACRAMENTO 5

CLAIR A. HILL, CHAIRMAN
REDDING

A. FREW, VICE CHAIRMAN
KING CITY

STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

STATE WATER BOARD

HARVEY O. BANKS
DIRECTOR

1120 N STREET
SACRAMENTO

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KENNETH Q. VOLK, LOS ANGELES

May 8, 1957

MR. HARVEY O. BANKS, *Director*
Department of Water Resources
401 Public Works Building
Sacramento, California

DEAR MR. BANKS:

The State-wide Water Resources Investigation, which culminated in The California Water Plan, was conducted under the direction of the State Water Resources Board, predecessor to the State Water Board, from its inception as provided in Chapter 1541, Statutes of 1947, until creation of the Department of Water Resources on July 5, 1956.

Although the name and responsibilities of the Board have been changed, membership on the two Boards has been continuous. Consequently, the members of the State Water Board, as a Board and individually, have the greatest interest in Bulletin No. 3, which presents The California Water Plan.

This bulletin, which joins the years of work of the engineers, the efforts of the Board members and countless others, the findings of the public hearings, and the advice and counsel of the Board of Engineering Consultants, has been reviewed by and has the approval of the State Water Board.

Very truly yours,

Clair A. Hill
Chairman

REPORT OF THE BOARD OF ENGINEERING CONSULTANTS

May 8, 1957

MR. HARVEY O. BANKS, *Director,*
Department of Water Resources,
P. O. Box 1079,
Sacramento 5, California

Subject: Bulletin No. 3—The California Water Plan

DEAR MR. BANKS:

This Board of Consultants was first retained on January 6, 1956 by the State Water Resources Board to review Bulletin No. 3, The California Water Plan. Upon establishment of the Department of Water Resources in July 1956, you reappointed the same members and assigned the same duties. Five meetings of this Board were held prior to July 1956 and six meetings thereafter.

This Board of Consultants endorses the principle of long-range planning for full development and use of the water resources of California, where such plans are subject to continuing review. However, The California Water Plan, as presented in Bulletin No. 3, includes projects of doubtful economic justification and works of unproven physical feasibility.

This Bulletin properly calls attention to the fact that the irrigation of desert areas involving net pumping lifts of several thousand feet is not now and may never be within the limits of economic justification and financial feasibility. This Board believes that further study should be given to the extent and cost of the works that would be needed to supply water for the irrigation of such desert areas and that more positive estimates should be made of the cost of an Aqueduct System designed to serve all other areas and purposes throughout the State.

This Board of Consultants endorses your recommendations: (a) that more detailed investigation and study be made of component features of The California Water Plan to determine their need, engineering feasibility, economic justification, financial feasibility, and recommended priority of construction; and (b) that there be continuing review, modification, and improvement of The California Water Plan in the light of changing conditions, advances in technology, additional data, and future experience. Such studies should include determination at then current price levels of: the capital and annual costs per acre-foot of water for its development and delivery within each hydrographic unit for use within the same area; and the capital and annual costs per acre-foot of water for its development in areas of surplus and its transportation and delivery to each area of shortage.

This Board of Consultants is confident that there is enough water in northern California, surplus to all potential local needs, to satisfy all requirements for additional water in the San Francisco Bay Region, in the San Joaquin Valley, in the Central Coastal area, and south of the Tehachapi Mountains. It believes that continuing development of these water resources as needed is essential to the future welfare of this State.

Accordingly, this Board recommends that the Legislature receive The California Water Plan as an evolving, continuing, coordinated proposal for the progressive and comprehensive future development of the water resources of California, and that this plan be commended to all agencies concerned with the development of these resources. This Board further recommends that no specific project be authorized for construction prior to detailed investigation of its engineering feasibility, economic justification, and financial feasibility.

Respectfully submitted,

BOARD OF CONSULTANTS

Walter L. Huber

Walter L. Huber

Samuel B. Morris

Samuel B. Morris

R. H. Ayers

A. H. Ayers

Ralph A. Tudor

Ralph A. Tudor

R A Hill

Raymond A. Hill

ACKNOWLEDGMENT

Valuable assistance and data used in the investigation were contributed by agencies of the Federal Government and of the State of California, by cities, counties, public districts, and by private companies and individuals. This cooperation is gratefully acknowledged.

Special mention is made of the helpful cooperation of the following:

Bureau of Reclamation, United States Department of the Interior
Corps of Engineers, U. S. Army
Federal Power Commission
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Forest Service, United States Department of Agriculture
Geological Survey, United States Department of the Interior
Soil Conservation Service, United States Department of Agriculture
California Department of Fish and Game
California Department of Public Works, Division of Highways
California Public Utilities Commission
University of California at Berkeley and at Davis
East Bay Municipal Utility District
Hetch Hetchy Water Supply, Power and Utilities Engineering Bureau, City of San Francisco
The Metropolitan Water District of Southern California
Department of Water and Power, City of Los Angeles
San Diego County Water Authority
City of San Diego
Pacific Gas and Electric Company
Southern California Edison Company

ORGANIZATION

STATE DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

HARVEY O. BANKS — Director of Water Resources
M. J. SHELTON — Deputy Director of Water Resources
WILLIAM L. BERRY — Chief, Division of Resources Planning

This bulletin was prepared under the supervision of

JOHN M. HALEY
Assistant Division Engineer

by

PRINCIPAL ASSISTANTS

ALBERT J. DOLCINI — Supervising Hydraulic Engineer
OSWALD SPEIR — Supervising Hydraulic Engineer

and

MEDILL P. THIEBAUD — Principal Hydraulic Engineer
WILLIAM L. HORN — Supervising Hydraulic Engineer
MEYER KRAMSKY — Supervising Hydraulic Engineer
HAROLD B. KNIGHT — Assistant Hydraulic Engineer

Responsibility for planning activities and preparing pertinent sections of this bulletin was delegated to

NORTH COASTAL AREA

EDWARD D. STETSON
Associate Hydraulic Engineer

Assisted by

HELEN J. PETERS — Associate Hydraulic Engineer
RICHARD E. SLYFIELD — Associate Hydraulic Engineer
JACK G. WULFF — Associate Hydraulic Engineer
J. PRESTON CEDARHOLM — Assistant Hydraulic Engineer
STEPHEN H. CHAN — Assistant Hydraulic Engineer
DONALD A. RALPH — Assistant Hydraulic Engineer

SAN FRANCISCO BAY AREA, RUSSIAN RIVER BASIN, AND MONTEREY COUNTY

ALBERT J. DOLCINI
Supervising Hydraulic Engineer

Assisted by

RICHARD W. MEFFLEY — Senior Hydraulic Engineer
JEAN H. JAQUITH — Associate Hydraulic Engineer
ROBERT J. ROONEY — Associate Hydraulic Engineer
PHILLIP E. BENJAMIN, JR. — Assistant Hydraulic Engineer
HAROLD B. KNIGHT — Assistant Hydraulic Engineer
J. BURTON YORK — Assistant Civil Engineer

SACRAMENTO VALLEY AREA

MYER SAMUEL
Supervising Hydraulic Engineer

Assisted by

STUART T. PYLE	Senior Hydraulic Engineer	CORTLAND C. LANNING	Assistant Hydraulic Engineer
JACOB ANGEL	Associate Hydraulic Engineer	HERBERT M. MATSINGER, JR.	Assistant Hydraulic Engineer
G. DONALD MEIXNER, JR.	Associate Hydraulic Engineer	GORDON N. BOYER	Assistant Civil Engineer
SAM L. STRINGFIELD, JR.	Associate Hydraulic Engineer	LOUIS R. MITCHELL	Assistant Civil Engineer
JERRY D. VAYDER	Associate Hydraulic Engineer	JAMES E. ALVERSON	Junior Civil Engineer
PHILIP H. SHEDD, JR.	Junior Civil Engineer		

SAN JOAQUIN VALLEY AREA

ROBIN R. REYNOLDS
Supervising Hydraulic Engineer

Assisted by

FRED E. BLANKENBURG	Senior Hydraulic Engineer	RICHARD G. FIELDS	Assistant Hydraulic Engineer
ERWIN DAMES	Associate Hydraulic Engineer	JAMES C. SCHELER	Assistant Hydraulic Engineer
HARRY E. ANDRUS	Photogrammetrist II	THOMAS P. WOOTTON	Assistant Hydraulic Engineer
AUGUST J. BILL	Assistant Hydraulic Engineer	WILLIAM H. BLACKMER	Junior Civil Engineer
ROBERT J. WAHL	Junior Civil Engineer		

LAHONTAN AND COLORADO DESERT AREAS

ROBERT O. THOMAS
Supervising Hydraulic Engineer

Assisted by

THOMAS C. MACKEY	Associate Hydraulic Engineer	DONALD W. FISHER	Junior Civil Engineer
ROBERT R. STUART	Assistant Hydraulic Engineer	JOHN E. FLACK	Junior Civil Engineer
CALVIN H. MAGNUSON	Junior Civil Engineer		

GROUND WATER STUDIES IN SACRAMENTO AND SAN JOAQUIN VALLEYS

JOHN R. EATON	Associate Civil Engineer	ELDON E. RINEHART	Associate Hydrographer

Assisted by

JOHN E. ANDERSON	Assistant Hydraulic Engineer	JAMES D. GOODRIDGE	Assistant Civil Engineer
FREEMAN H. BEACH	Assistant Hydraulic Engineer	WILLIAM G. BLAKE	Engineering Aid II
HAROLD T. VEDERA	Assistant Hydraulic Engineer	WILLIAM H. MILLER	Engineering Aid II

Sections of this bulletin dealing with work in the South Coastal Area, and in San Luis Obispo and Santa Barbara Counties, were prepared in the Southern California Branch Office under the direction of

MAX BOOKMAN
District Engineer

and

ROBERT M. EDMONSTON
Principal Hydraulic Engineer

by

LUCIAN J. MEYERS
Supervising Hydraulic Engineer

and

THOMAS M. STETSON
Senior Hydraulic Engineer

Assisted by

ROBERT H. BORN .... Associate Hydraulic Engineer
HAROLD M. CROOKER .... Associate Hydraulic Engineer
PAUL E. HOOD .... Associate Hydraulic Engineer
JOHN O. McCLURG .... Associate Hydraulic Engineer
ARNOLD F. NICOLAUS .... Associate Hydraulic Engineer
DAVID O. POWELL .... Associate Hydraulic Engineer
HUGO J. HANSON .... Associate Civil Engineer
RICHARD E. ANGELOS .... Assistant Hydraulic Engineer
THOMAS A. SANSON .... Assistant Hydraulic Engineer

Geologic studies in southern California were performed by

LAURENCE B. JAMES .... Supervising Engineering Geologist
ROBERT G. THOMAS .... Senior Engineering Geologist
GLENN A. BROWN .... Associate Engineering Geologist

Water quality studies in southern California were performed by

DAVID B. WILLETS .... Supervising Hydraulic Engineer
ROBERT F. CLAWSON .... Associate Hydraulic Engineer

Staff activities, including criteria, procedures, surveys, mapping, and statistical services

MEDILL P. THIEBAUD
Principal Hydraulic Engineer

Assisted by

DONALD P. THAYER .... Principal Engineer, Design and Construction of Dams
RICHARD W. JOHNSON .... Senior Electrical Engineer
E. PHILIP WARREN .... Associate Statistician
GEORGE D. WINKELBLACK .... Photogrammetrist I
SAMUEL A. WILLIAMS .... Junior Civil Engineer
CARL G. B. PETERSON .... Engineering Aid II
CHARLES D. SKINKLE .... Engineering Aid II
WILLIAM W. GEDDES .... Junior Engineering Aid
WILLIAM B. CHASTAIN .... Engineering Aid I

The following personnel have given special assistance to various studies related to the investigation

WALTER A. BROWN	Principal Engineer, Design and Construction of Dams
WILLIAM R. GIANELLI	Principal Hydraulic Engineer
JOSEPH I. BURNS	Supervising Hydraulic Engineer
JOHN W. KEYSOR	Senior Engineer, Design and Construction of Dams
JACK J. COE	Senior Hydraulic Engineer
JOHN W. SHANNON	Land and Water Use Specialist
ROY N. HALEY	Associate Soil Technologist

Geologic studies were performed under the direction of

ELMER C. MARLIAVE
Supervising Engineering Geologist

by

ROBERT T. BEAN
Supervising Engineering Geologist

Assisted by

DAVID M. HILL	Senior Engineering Geologist
PHILIP J. LORENS	Senior Engineering Geologist
COLE R. McCLURE, JR.	Senior Engineering Geologist
WILFERD W. PEAK	Senior Engineering Geologist
WALLACE D. FUQUA	Associate Engineering Geologist
HAROLD D. WOODS	Associate Engineering Geologist

Water quality studies were performed under the direction of

CARL B. MEYER
Principal Hydraulic Engineer

by

CARLETON E. PLUMB
Senior Hydraulic Engineer

Assisted by

CHARLES G. WOLFE	Senior Hydraulic Engineer
WILLIAM DURBROW, JR.	Associate Hydraulic Engineer
GORDON A. RICKS	Associate Hydraulic Engineer
MATHIAS HILLING	Assistant Civil Engineer
ROBERT F. MIDDLETON, JR.	Assistant Civil Engineer
EARL MOLANDER, JR.	Assistant Civil Engineer
JOHN E. STELLWAGEN	Assistant Civil Engineer

Power studies were made in consultation with, and reviewed by

FREDERICK J. GROAT, Supervising Electric Utilities Engineer, and RICHARD W. JOHNSON, Senior Electrical Engineer

Economic studies were performed by

NORMAN D. STURM
Supervising Economist

Assisted by

JAMES W. THURSBY
Senior Economist

Legal studies were performed by

FORMER DIVISION OF WATER RESOURCES

HENRY HOLSINGER .... Principal Attorney
(now Chairman, State Water Rights Board)

GAVIN M. CRAIG .... Senior Attorney
(now Principal Attorney, State Water Rights Board)

IRVING PFAFFENBERGER .... Senior Attorney

DEPARTMENT OF WATER RESOURCES

PORTER A. TOWNER .... Chief Counsel

MARK C. NOSLER .... Senior Attorney

RUSSELL KLETZING .... Associate Attorney

Maps and plates for the report were prepared under the supervision of

JOHN L. JAMES
Supervisor of Drafting Services

ADMINISTRATIVE

THEODORE R. MERRYWEATHER .... Administrative Officer
ISABEL C. NESSLER .... Coordinator of Reports

LENORE N. CASE .... Senior Stenographer-Clerk
H. ARLENE STEVENS .... Senior Typist-Clerk

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JOHN S. COTTON, Kentfield
and
LLOYD LUCKS, Kentfield

ENGINEERING CONSULTANT FOR REVIEW OF PROCEDURES

FREDERICK L. HOTES, Associate Professor of Civil Engineering
University of California

ENGINEERING CONSULTANT FOR REVIEW OF GROUND WATER STUDIES

FRANK B. CLENDENEN, Assistant Professor of Civil Engineering
University of California

SPECIAL CONSULTANT FOR ORGANIZATION OF BULLETIN

MASON A. JOHNSTON, Instructor of Public Speaking, Sacramento Junior College

Studies of fish and wildlife problems were conducted in cooperation with the California Department of Fish and Game

SETH GORDON .... Director
ROBERT M. PAUL .... Water Projects Coordinator
RICHARD J. HALLOCK .... Senior Fisheries Biologist
DAVID E. PELGEN .... Senior Fisheries Biologist
LEONARD O. FISK .... Assistant Fisheries Biologist

ORGANIZATIONAL CHANGES

The State-wide Water Resources Investigation, resulting in the formulation of The California Water Plan, was authorized by the State Legislature in 1947 and initiated on September 5, 1947, under direction of the former State Water Resources Board. Royal Miller was Chairman of the Board at the inception of the investigation, being succeeded by C. A. Griffith who, in turn, was succeeded by Clair A. Hill.

Changes in the membership of the Board were occasioned by the deaths of Messrs. L. S. Ready and B. A. Etcheverry; the retirements of Messrs. Royal Miller, H. F. Cozzens, C. A. Griffith, and R. V. Meikle; and the subsequent appointments of Messrs. Hill, W. P. Rich, A. Frew, and W. Penn Rowe. Upon the redesignation of the State Water Resources Board as the "State Water Board" on July 5, 1956, Messrs. John P. Bunker, Kenneth Q. Volk, and Everett L. Grubb were appointed as members, and W. Penn Rowe resigned to accept an appointment with the newly created State Water Rights Board.

Phil D. Swing is the only member of the State Water Board who has had continuous service since creation of the State Water Resources Board in 1945.

Edward Hyatt was State Engineer and Secretary of the State Water Resources Board at the inception of the State-wide Water Resources Investigation in 1947. The significant broadening of state policy relating to flood control and water conservation, encompassed in the State Water Resources Act of 1945, largely reflected Mr. Hyatt's enlightened and progressive thinking in these matters.

As State Engineer from 1927 to 1950, Mr. Hyatt directed the surveys which culminated in formulation of the State Water Plan, predecessor to The California Water Plan. Moreover, he was instrumental in initiation of the investigations which led to The California Water Plan, and determined many of the concepts upon which it is based.

A. D. Edmonston succeeded Mr. Hyatt as State Engineer in 1950. He vigorously carried forward the work on The California Water Plan, and was directly responsible for the authorization of the Feather River Project as the initial unit of the Plan. He retired on November 1, 1955.

Harvey O. Banks succeeded Mr. Edmonston and remained State Engineer until July 5, 1956, when the office of State Engineer was abolished and the Department of Water Resources was created.

The State-wide Water Resources Investigation was conducted successively under the general direction of Assistant State Engineers A. D. Edmonston; P. H. Van Etten, until his retirement on June 15, 1951; Thomas B. Waddell, until his retirement on November 1, 1955; and William L. Berry, until July 5, 1956, when the Department of Water Resources was created. Since the latter date, the organization of the Department has been as shown on page XVII.

During the final phase of the State-wide Water Resources Investigation, culminated by the preparation of this bulletin, a major change in the status of this organization has taken place pursuant to Chapter 52, Statutes of 1956, effective on July 5, 1956. The statute created the State Department of Water Resources, which succeeded to and was vested with all of the powers, duties, purposes, responsibilities, and jurisdiction in matters pertaining to water or dams formerly vested in the Department and Director of Public Works, the Division of Water Resources of the Department of Public Works, the State Engineer, and the Water Project Authority. The Department of Water Resources also succeeded to and was vested with the powers, duties, purposes, responsibilities, and jurisdiction of the Department of Finance under Part 2 of Division 6 of the Water Code.

In addition, the former State Water Resources Board was redesignated the "State Water Board," and was placed within the Department of Water Resources to confer with, advise, and make recommendations to the Director with respect to any matters and subjects under his jurisdiction.

Finally, the State Water Rights Board was created, which board succeeded to and was vested with all of the powers, duties, purposes, responsibilities, and jurisdiction formerly vested in the Department and Director of Public Works, the Division of Water Resources of the Department of Public Works, and the State Engineer, regarding the adjudication of water rights, and the issue, denial, or revocation of permits or licenses to appropriate water.

It should be pointed out at this time that the authority and responsibilities of the former State Water Resources Board, relative to the conduct of the State-wide Water Resources Investigation, special investigations, and the preparation of this bulletin, are now vested wholly in the Department of Water Resources.

SYNOPSIS

This is the final of a series of three bulletins setting forth the results of the State-wide Water Resources Investigation, which has been in progress for the past 10 years under provisions of Chapter 1541, Statutes of 1947. This investigation entailed a three-fold program of study to evaluate the water resources of California, to determine present and probable ultimate water requirements, and to formulate plans for the orderly development of the State's water resources to meet its ultimate water requirements. Funds to meet the cost of the investigation were provided by the cited statute and subsequent budgetary acts of the Legislature.

The first phase of the State-wide Water Resources Investigation comprised an inventory of data on sources, quantities, and characteristics of water in California. The results are available in State Water Resources Board Bulletin No. 1, "Water Resources of California," published in 1951. This bulletin comprises a concise compilation of data on precipitation, runoff of streams, flood flows and frequencies, and quality of water throughout the State.

The second phase dealt with present and ultimate requirements for water. The associated report, State Water Resources Board Bulletin No. 2, "Water Utilization and Requirements of California," was published in 1955. This study comprised determinations of the present use of water throughout the State for all consumptive purposes, and forecasts of ultimate water requirements based in general on the capabilities of the land to support further balanced development.

The final phase of the State-wide Water Resources Investigation is presented herein as "The California Water Plan." Bulletin No. 3 describes a comprehensive master plan for the control, protection, conservation, distribution, and utilization of the waters of California, to meet present and future needs for all beneficial uses and purposes in all areas of the State to the maximum feasible extent. The Plan is designed to include or supplement rather than to supersede existing water resource development works, and does not interfere with existing rights to the use of water.

The objective in the formulation of The California Water Plan has been to provide a logical, engineering basis for future administration of the water resources of the State and for coordination of the efforts of all entities engaged in the construction and operation of water development projects, to the end that maximum benefit to all areas and peoples of the State may ultimately be achieved.

The California Water Plan includes local works to meet local needs in all portions of the State. It also includes the California Aqueduct System, an unprecedented system of major works to redistribute excess waters from northern areas of surplus to areas of deficiency throughout the State. The Plan gives consideration to water conservation and reclamation; to flood control and flood protection; to the use of water for agricultural, domestic, municipal, and industrial purposes; to hydroelectric power development; to salinity control and protection of the quality of fresh waters; to navigation; to drainage; and to the interests of fish, wildlife, and recreation. It contemplates the conjunctive operation of surface and ground water reservoirs, which operation will be essential to regulation of the large amounts of water ultimately to be involved.

The very magnitude of the task involved in formulation of The California Water Plan was such that detailed surveys and studies, and economic and financial analyses, could not be undertaken in this initial phase of investigation. At this stage of its development, therefore, the Plan must be regarded as no more than a broad and flexible pattern into which future definite projects may be integrated in an orderly fashion. As additional data and experience are gained, as technology advances, and as future conditions change in manners that cannot be foreseen today, The California Water Plan will be substantially altered and improved. However, the basic concept of the Plan as a master plan to meet the ultimate requirements for water at some unspecified but distant time in the future, when the land and other resources of California have essentially reached a state of complete development, will remain unchanged.

Voluminous data and information have been compiled and assembled in connection with preparation of The California Water Plan. It is realized that the need of the general public, on the one hand, is for a summary report with a minimum of technical detail but containing all of the information essential to an adequate understanding of the Plan. The need of engineering and other professional people, on the other hand, is for more detailed technical information which would be of minor interest to the general public. Therefore, publication has been set up to meet these separate needs—Bulletin No. 3 itself to meet the general need and the several appendixes to Bulletin No. 3 to meet the engineering and other technical needs.

Bulletin No. 3 consists of a summary report on The California Water Plan. It discusses available water resources, present and probable ultimate water requirements, and associated problems. It describes the development works that may be necessary to meet local requirements, and the interbasin transfer facilities which could convey water from nothern areas of surplus to major areas of deficiency in the central and southern parts of the State. It also discusses briefly the basic considerations in implementation of The California Water Plan and the possible accomplishments accruing therefrom.

The several appendixes will present a more detailed engineering report on The California Water Plan, reports on geology and other technical subjects, as well as reports by other agencies concerned in specific phases of the investigations. All of these appendixes are listed in the Table of Contents and are described in more detail in Chapter I.

It should be mentioned at this time that although the publication of Bulletin No. 3 completes the State-wide Water Resources Investigation, it by no means signifies the termination of planning activities by the Department of Water Resources. Rather, it marks only the beginning of an intensive and continuing program of study of the needs for specific local and state-wide water development projects, analysis of their economic justification and financial feasibility, and determination of the recommended priority of their construction, using The California Water Plan as a general guide. This study program, known as the "California Water Development Program," will enable the planning endeavor to keep pace with the needs of a rapidly growing State.

CHAPTER I

INTRODUCTION

Today, the future agricultural, urban, and industrial growth of California hinges on a highly important decision, which is well within the power of the people to make. We can move forward with a thriving economy by pursuing a vigorous and progressive water development planning and construction program; or we can allow our economy to stagnate, perhaps even retrogress, by adopting a complacent attitude and leaving each district, community, agency, or other entity to secure its own water supply as best it can with small regard to the needs of others. The choice of these alternatives is clear. The need for coordinated planning on a state-wide basis has long been realized. Comprehensive plans have been formulated and reported upon in the past, and noteworthy accomplishments have been achieved by local enterprise and private and public agencies. But despite the great water development projects constructed in the past, California's water problems continue to grow day by day.

The construction of highways, schools, hospitals, and other public works has greatly accelerated since the end of World War II. However, to supply its necessary water, California is relying for the most part on works which were designed to meet the needs as anticipated 20 to 30 years ago. These facts are now becoming known and more generally understood by the people. It is apparent to most that the continued growth and prosperity of California is dependent upon prompt and substantial efforts by the responsible local governmental agencies, the State, and the Federal Government to ensure that the planning and construction of water development projects keeps pace with the growing needs for water.

The population of California has continued to grow at a phenomenal rate, and irrigated agriculture and industrial activity have increased proportionately. This recent rapid expansion of the economy has occurred largely in areas of inherent water deficiency, thus intensifying the problem in those areas. While in most instances the increases in water requirements are physically being met, they are provided for by drawing on diminishing ground water reserves in order to meet the deficiency. Such perennial overdraft has been increasing rapidly in recent years and has resulted in accelerated lowering of ground water levels in many parts of the State.

Effects of these overdrafts are presently manifested in the intrusion of sea water into the principal pumping aquifers of a number of coastal ground water basins, and the threat of such intrusion into others. Certain inland ground water basins have experienced degradation in quality of their fresh waters by mixture with underlying entrapped connate brines (i.e., salt water entrapped when the formation was deposited) or other waters of undesirable mineral quality. Furthermore, overdraft conditions may result in an accumulation of excess minerals or salts in a ground water basin, which in a period of time may degrade the water quality beyond acceptable limits. Thus, it is evident that continuing overdrafts will not only drastically reduce the reserves in storage, with possible exhaustion in some cases, but in many instances will irreparably damage the immensely valuable ground water reservoirs unless supplemental water supplies are developed.

While experiencing problems of water deficiency on the one hand, California is presently faced with the anomaly of other problems of the exact opposite nature—that of periodic floods which result in major damage and loss of life. Ironically, in many cases the same areas suffering deficiency in water supplies are besieged with winter floods when the water, so urgently needed for the economy, wastes to the ocean, accomplishing nothing but damage and grief. Historically, agricultural and urban development has occurred largely in valleys and on plains inherently subject to flooding. With the intensification of agriculture and expansion of urban and industrial areas, future flood problems will become more severe unless remedial action is taken.

Concurrently with the expanding population and increasing irrigation and industrial development in the valleys and metropolitan areas of the State, there has been increasing pressure for enhancement of fish and wildlife resources and for the provision of adequate recreational opportunities, particularly in the hill and mountainous areas. If these needs are to be adequately met, provision must be made therefor in future water development through development of water areas and live streams.

The magnitude of the foregoing water problems may be better appreciated by referring to Plate 1, entitled "Present Water Problems." The 1947 Legislature, recognizing these problems and appreciating the role of water in the future of the State, directed that the water resources and present and future water requirements of California be studied and evaluated, and that plans be formulated for the orderly development of the State's water resources to meet its ultimate water requirements. This directive initiated the "State-wide Water Resources Investigation," which has been under way for the past 10 years, culminating in the preparation of this bulletin.

BASIS AND AUTHORITY FOR STATE-WIDE WATER DEVELOPMENT PLANNING

The principle of state-wide planning for development of California's water resources is no innovation. Development of the water resources of California has long been recognized as a primary responsibility of the State. Expressions of state policy regarding water supply development are found in the State Constitution and numerous court decisions. The State Water Code incorporates the following pertinent sections which constitute the basis for a state-wide water development plan:

"100. It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such water is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare. . . .

"102. All water within the State is the property of the people of the State, but the right to the use of water may be acquired by appropriation in the manner provided by law.

"104. It is hereby declared that the people of the State have a paramount interest in the use of all the water of the State and that the State shall determine what water of the State, surface and underground, can be converted to public use or controlled for public protection.

"105. 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.

"12578. It is hereby declared that the people of the State have a primary interest in the control and conservation of flood waters, prevention of damage by flood waters, the washing away of river and stream banks by floods, and in the determination of the manner in which flood waters shall be controlled for the protection of life and property and the control, storage, and use of the State's water resources in the general public interest.

"12579. It is hereby declared that recurrent floods on streams and rivers, and other waterways of the State, causing loss of life and property, disruption of commerce, interruption of transportation and communications, and wasting of water, are detrimental to the peace, health, safety, and welfare of the people of the State. The control, storage and full beneficial use of flood waters, and the prevention of damage by flood waters, and the washing away of river and stream banks by floods are proper functions and activities of the State, in cooperation with counties, cities, state agencies and public districts, and in cooperation with the United States, or any of its departments or agencies.

"12580. It is further declared that the State should engage in the study and coordination of all water development projects, including flood control projects, undertaken by counties, cities, state agencies and public districts, and the United States or any of its departments or agencies in order that such allocations and appropriations as are made by the State Legislature for such purposes will be expended upon those projects which are most beneficial to the State, and which will bring maximum benefits to the people of the State from the expenditure of public funds, and also that the State should participate in the construction of flood control works and projects and render beneficial aid thereto, when the benefits are in excess of the estimated cost.

"12581. In studying water development projects, full consideration shall be given to all beneficial uses of the State's water resources, including irrigation, generation of electric energy, municipal and industrial consumption of water and power, repulsion of salt water, preservation and development of fish and wildlife resources, and recreational facilities, but not excluding other beneficial uses of water, in order that recommendations may be made as to the feasibility of such projects and for the method of financing feasible projects.

"12582. Fish and wildlife values, both economic and recreational, shall be given consideration in any flood control or water conservation program. . . ."

To implement state policy, the State Water Resources Board was established by legislative enactment in 1945, and was endowed with broad powers to initiate and conduct investigations of the water resources of the State. The Board was vested with the responsibility for conduct of the State-wide Water Resources Investigation by Chapter 1541, Statutes of 1947. Funds were provided in the 1947-48 budget for commencement of the investigation, and the Budget Acts of 1948 and subsequent years have made appropriations for completion of the investigation and for preparation of reports thereon.

During the final phase of the State-wide Water Resources Investigation, major functions of the State Water Resources Board were radically changed by provisions of Chapter 52, Statutes of 1956. This statute created the Department of Water Resources which succeeded to the responsibilities of the former Board for initiating and conducting water resources investigations.

THE STATE-WIDE WATER RESOURCES INVESTIGATION

The State-wide Water Resources Investigation has been conceived and developed as a fundamental, comprehensive survey, designed to serve as the basis for a logical and orderly pattern of development of the State's water resources. The first phase of the investigation consisted of an inventory of the basic water resources of California. All available data on sources, quantities, and characteristics have been evaluated, and the results are presented in State Water Resources Board Bulletin No. 1, "Water Resources of California," published in 1951. This bulletin contains a compilation of data on precipitation, natural stream runoff, flood flows and frequencies, and quality of water throughout the State.

The second major phase of the State-wide Water Resources Investigation dealt with present and ultimate requirements for water. Its findings are published in State Water Resources Board Bulletin No. 2, "Water Utilization and Requirements of California," June. 1955. This bulletin includes determinations of the present use of water throughout the State for all consumptive purposes, and presents forecasts of probable ultimate requirements based, in general, on the capabilities of the land to support further development. The bulletin also discusses implications of nonconsumptive requirements for water as they relate to planning for the future.

The foregoing studies provide basic data for the third and concluding phase of the State-wide Water Resources Investigation, presented herein. This phase correlates the determinations of water resources and ultimate requirements established in Bulletins Nos. 1 and 2, and, based on these findings, formulates The California Water Plan for satisfying these requirements, insofar as practicable, as well as for the solution of the State's many other water problems.

PREVIOUS STATE-WIDE PLANNING

The State-wide Water Resources Investigation, although the first truly comprehensive effort to evolve a complete state-wide plan for ultimate water supply development, has been preceded by a number of studies that approach it in scope and magnitude.

The first broad investigation of the irrigation problem of California was made by a board of commissioners authorized by Congress and appointed by the President. The commission's report on "The Irrigation of the San Joaquin, Tulare, and Sacramento Valleys of the State of California" was published by the House of Representatives in 1874 as Ex. Doc. No. 290, Forty-third Congress, First Session. It outlined a hypothetical irrigation system for the San Joaquin, Tulare, and Sacramento Valleys. Other investigations by federal and state agencies followed during the next several decades, the most noteworthy of which were made by Wm. Ham. Hall, State Engineer from 1878 to 1889. His reports contain meteorological and stream flow data, with notes on irrigation, drainage, and flood control, all of which proved of great value in planning water developments in the years that followed.

The most comprehensive recent investigations of the water resources of California were those made by the State Engineer under authority of acts of the Legislature in 1921, 1925, and 1929. First reports of these investigations were presented in Division of Engineering and Irrigation Bulletins Nos. 4, 5, and 6, and in Division of Water Resources Bulletins Nos. 9, 12, 13, 14, and 20. A report giving results of subsequent investigations, and outlining revised proposals, was published in 1930 as Division of Water Resources Bulletin No. 25, entitled "Report to Legislature of 1931 on State Water Plan." It outlined a coordinated plan for conservation, development, and utilization of the water resources of California. The plan was approved and adopted by the Legislature by Chapter 1185, Statutes of 1941, and designated the "State Water Plan." Division of Water Resources Bulletins Nos. 26, 27, 28, 29, and 31 outlined in greater detail project plans for coordinated development of the water resources of the Central Valley, and for water conservation and flood control in the Santa Ana River Basin. Bulletins Nos. 34, 35, and 36 dealt with collateral matters of water charges and costs and rates of irrigation development. Bulletin No. 31 discussed briefly the plans for diversion and transmission of Colorado River water to the South Coastal Basin under the project of The Metropolitan Water District of Southern California.

Contemporaneously with these studies by the State, agencies of the Federal Government, notably the Bureau of Reclamation and the Corps of Engineers, have conducted comprehensive studies of the development of water resources on various streams in California, particularly with respect to the Central Valley. The most noteworthy of these reports are: Senate Document 113, 81st Congress, First Session, "Central Valley Basin," by the U. S. Bureau of Reclamation, August 1949; and House Document No. 367, 81st Congress, First Session, "Sacramento-San Joaquin Basin Streams, California," by the Corps of Engineers, U. S. Army, 1949. It should be noted that none of these previous studies have envisioned the transfer of water from northern California to southern California.

CONCURRENT RELATED INVESTIGATIONS

A number of specific regional water resources investigations, complementing the state-wide studies, have been carried on concurrently by the Department of Water Resources and its predecessors. Some of these investigations utilized state funds entirely, while others were financed cooperatively by state and local interests. The planning for water development in those regions has been coordinated with and integrated into The California Water Plan. The features of the Plan in those regions of special investigation have been formulated and reported upon in more detail than are presented herein. The following bulletins present results of these regional studies.

California State Department of Public Works, Division of Water Resources. "Survey of Mountainous Areas." Bulletin No. 56. December, 1955.

——— "Santa Margarita River Investigation." Bulletin No. 57. June, 1956.

——— "Northeastern Counties Investigation. Report on Upper Feather River Service Area." (interim report) April, 1955.

——— "Program for Financing and Constructing the Feather River Project as the Initial Unit of The California Water Plan." February, 1955.

——— "Report to the California State Legislature on Putah Creek Cone Investigation." December, 1955.

California State Department of Water Resources. "Investigation of Upper Feather River Basin Development, Interim Report on Engineering, Economic, and Financial Feasibility of Initial Units." Bulletin No. 59. February, 1957.

——— "Interim Report to the California State Legislature on the Salinity Control Barrier Investigation." Bulletin No. 60. March 1957.

California State Water Project Authority. "Report to the California State Legislature on Feasibility of Construction by the State of Barriers in the San Francisco Bay System." March 1955.

California State Water Resources Board. "Santa Cruz-Monterey Counties Investigation." Bulletin No. 5. September, 1953.

——— "Sutter-Yuba Counties Investigation." Bulletin No. 6. September, 1952.

——— "Santa Clara Valley Investigation." Bulletin No. 7. June, 1955.

——— "Elsinore Basin Investigation." Bulletin No. 9. February, 1953.

——— "Placer County Investigation." Bulletin No. 10. June, 1955.

——— "San Joaquin County Investigation." Bulletin No. 11. June, 1955.

——— "Ventura County Investigation." Bulletin No. 12. October, 1953, Revised April, 1956.

——— "Alameda County Investigation." Bulletin No. 13. (preliminary report) July, 1955.

——— "Lake County Investigation." Bulletin No. 14. (preliminary report) October, 1955.

——— "Santa Ana River Investigation." Bulletin No. 15. (preliminary report) April, 1956.

——— "American River Basin Investigation, Report on Development Proposed for The California Water Plan." Bulletin No. 21. (preliminary report) June, 1955.

——— "Interim Report on Klamath River Basin Investigation, Water Utilization and Requirements." March, 1954.

——— "Interim Summary Report on San Luis Obispo County Investigation." October, 1955.

Other studies conducted by the Department and its predecessor agencies, the results of which are not yet available in final report form, include the following:

Cache Creek Watershed Investigation—Yolo County
Klamath River Basin Investigation
Northeastern Counties Investigation
Salinas River Basin Investigation
San Luis Obispo County Investigation
Shasta County Investigation

Data and information from the many other investigations conducted by the Department have been utilized. Pertinent investigations and plans of the U. S. Department of the Interior; the Corps of Engineers, U. S. Army; and the Department of Agriculture have been utilized and integrated into The California Water Plan.

THE CALIFORNIA WATER DEVELOPMENT PROGRAM

In order to plan intelligently for future development of California's water resources to meet increasing water needs, the investigation and study of water requirements, available resources, and potential water development projects must be a continuing process. This continuing need has been recognized, as is evidenced by legislative acts authorizing the Feather River Project provides for a multipurpose development, and, most recently, the Inventory of Water Resources, all of which are designated functions of the Department of Water Resources. These three investigations are discussed in the following sections. Complementing these investigations, and in close coordination therewith, the Department is engaged in an intensive and continuing program of study of the needs for specific projects, economic and financial analyses, and determination of recommended staging of construction. All of these investigations and studies collectively comprise the California Water Development Program, which incorporates subsequently authorized data gathering and planning activities.

Feather River Project

Many of the principles of The California Water Plan are embodied in the authorized Feather River Project, the initial unit of the Plan. The Feather River Project provides for a multipurpose development for firming water supplies, providing flood protection in the Feather River area, generating hydroelectric energy, and exporting surplus waters available in the Sacramento-San Joaquin Delta to areas of deficiency in the San Joaquin Valley, San

Francisco Bay Area, and southern California, with incidental fish, wildlife, and recreational benefits. This project was conceived by former State Engineer A. D. Edmonston and formulated by the former Division of Water Resources. It was first presented in 1951 in a publication of the State Water Resources Board entitled "Report on Feasibility of Feather River Project and Sacramento-San Joaquin Delta Diversion Projects Proposed as Features of The California Water Plan." The Legislature authorized the project in 1951 and provided funds for additional studies, including preparation of plans and specifications. These further studies are published in a report on "Program for Financing and Constructing the Feather River Project as the Initial Unit of The California Water Plan," submitted in February, 1955.

The Legislature, by the Budget Act of 1956, appropriated $9,350,000 for continued engineering design and exploration, including the preparation of construction plans and specifications and providing for acquisition of right of way for some of the project features. The 1957 Legislature passed an urgency appropriation for $25,190,000 to commence relocation of the Western Pacific Railroad and U. S. Highway 40 Alternate out of the Oroville Reservoir area.

Salinity Control Barrier Investigation

The need and feasibility of physical barriers to salt-water inflow in the San Francisco Bay system has been evaluated by the Division of Water Resources, pursuant to the Abshire-Kelly Salinity Control Barrier Act of 1953, Chapter 1104, Statutes of 1953. Incorporated in the report entitled "Feasibility of Construction by the State of Barriers in the San Francisco Bay System," March 1955, are provisions for conserving and developing waters presently being utilized for repulsion of sea water in the Sacramento-San Joaquin Delta. A conduit for conveying Sacrament River flow across the Delta is also proposed. These features, which are vital elements of The California Water Plan, are receiving further consideration through an extension of this study authorized by the Abshire-Kelly Salinity Control Barrier Act of 1955, Chapter 1434, Statutes of 1955. An interim report entitled "Salinity Control Barrier Investigation," March 1957, describes the recommended plan for accomplishing the foregoing objectives.

Inventory of Water Resources

Pursuant to Chapter 61, Statutes of 1956, the Department of Water Resources is conducting an investigation to determine in detail: the amount of water resources available in the separate watersheds in the State; the amounts of present and ultimate water required for beneficial uses in those watersheds; and, from the foregoing, the quantities of water, if any, available for export from the watersheds of origin. This investigation, which will continue over a period of years, will be accomplished in greater detail than has heretofore been undertaken and will serve as a basis for assuring reservation of adequate water resources for the areas of origin.

OTHER PROPOSALS FOR DEVELOPMENT OF THE STATE'S WATER RESOURCES

The increasing awareness of the present prevailing water problems, and of the need for state-wide development of California's water resources, has been manifested in a number of ideas or proposals paralleling The California Water Plan. In general, these proposals purport a common objective, that is, the transfer of surplus northern waters to southern areas of deficiency. However, they have been advanced without adequate engineering and geologic study. Furthermore, their objectives and scope, as compared with those of The California Water Plan, are inadequate.

One such proposal, which has been termed the "Gravity Plan," has received considerable publicity during recent years. This plan would convey water by gravity conduit extending from Shasta Dam southerly to the Merced River. There it would cross the San Joaquin Valley and would be pumped over the Coast Range, where it would continue by gravity conduit into southern California. It is a fact, however, that the water supplies involved in the Gravity Plan are not available in adequate quantity, nor in proper monthly distribution to enable operation of the plan.

Another serious shortcoming in the Gravity Plan and other similar proposals involves their conflict with presently vested water rights, and interference with existing projects of various agencies. These plans would involve exchanges of water which would be impossible of accomplishment.

All of these alternatives have been analyzed by the Department of Water Resources in the formulation of The California Water Plan, and those elements found feasible have been incorporated into the Plan.

SCOPE OF PLANNING PHASE OF STATE-WIDE WATER RESOURCES INVESTIGATION

The planning phase of the current State-wide Water Resources Investigation, broader in scope than that for earlier investigations, has as its objective the formulation of a long-range plan for the comprehensive development of the water resources of the entire State. It contemplates the full control, conservation, protection, distribution, and utilization of the water resources of California, both surface and underground, to meet present and future water needs for all beneficial purposes and uses in all areas of the State, insofar as practicable.

The scope of the planning phase includes studies of numerous physical and economic considerations necessary to the formulation of a realistic long-range water resource development plan. Use has been made of all available basic data and information pertinent to water supply, water requirements, characteristics of water service areas, hydroelectric power potentialities, flood control, fish and wildlife, recreation, drainage, water quality, physical features of dam sites and conduit routes, physical characteristics of ground water basins, construction methods, construction costs, and trends of social, economic, and technological advancement. These basic data have been utilized in an analytical process involving engineering design, cost estimates, and economic selection from alternative project proposals. Throughout the process a substantial measure of engineering judgment has been necessary, tempered by knowledge of the limitations of the information on hand, and with awareness of inherent unknowns in planning for the indefinite future.

One of the most outstanding aspects of the planning phase of the State-wide Water Resources Investigation is the consideration of unprecedented interbasin projects, by means of which large quantities of surplus water could be regulated and transported long distances from areas of surplus to areas of deficiency. These projects are of such scope and magnitude as to constitute in the aggregate a very real but not impossible challenge to the future of California. Of equal significance is the planning for local projects to meet present and future local water needs. Such projects are often intimately involved with the major export-import works. In areas of ultimate water deficiency, the distribution and use of additional supplies that may be developed locally would be coordinated with that of imported supplemental waters. In areas of ultimate surplus, works for local water service would be fully coordinated with those for export. In the case of all projects, involving either major or minor works, full consideration has been given to existing developments and interests and to vested water rights.

Formulation of The California Water Plan was based upon the concept of optimum utilization of the water resources of the State. It involves, where possible, the use of multipurpose reservoirs to gain their several advantages, including economy of construction and the conservation of project sites. Favorable dam and reservoir sites are rare and it is essential that the potentialities of each site be utilized to the maximum feasible extent. Water supplies would be developed and conserved for irrigation, municipal, and industrial purposes. Furthermore, the works would provide for flood control and flood protection; production of hydroelectric energy; quality control; salinity control; enhancement of fish, wildlife and recreation; drainage; and other beneficial purposes. Estimates of water requirements published in State Water Resources Board Bulletin No. 2 have been generally accepted as a measure of requirements, although minor modifications have been made, where such have been indicated by further study.

Concepts of Planning

The formulation of The California Water Plan was predicated upon and guided by certain basic concepts which are expressed herein as the essence of the Plan. These concepts should be clearly borne in mind when evaluating the various facets of the Plan subsequently described in this bulletin.

1. The California Water Plan is conceived as an ultimate plan, one that will meet the requirements for water at some unspecified but distant time in the future when the land and other resources of California have essentially reached a state of complete development.

2. The Plan is designed to be comprehensive. It provides for future beneficial uses of water by individuals and agencies in all parts of the State. Legislative acceptance of the Plan, and firm provision for its progressive project authorization as component projects become feasible, would tend toward elimination of sectional concern as to future availability of necessary water supplies.

3. The California Water Plan is a flexible pattern or framework into which future definite projects may be integrated in an orderly fashion, with due consideration being given to varying interests. As additional data and experience are gained, as technology advances, and as future conditions change in patterns that cannot be foreseen today, The California Water Plan will be substantially altered and improved.

4. The Plan is designed to be susceptible of orderly development by logical, progressive stages as the growing demands and requirements of the State may dictate. Certain of these features should be implemented immediately, while others should be deferred.

5. The many features broadly embraced in The California Water Plan, while believed to be endowed in common with physical feasibility, have widely variant relationships to present concepts of economic and financial feasibility. As an example, extremely costly works would be required to conserve and convey water long distances to irrigate certain lands of very limited present crop adaptability, or to serve lands lying at high elevations, requiring net pump lifts of several thousand feet in some cases, such as the desert area in southern California. Such works are for the indefinite future and their need may never be realized. However, the economics of the distant future cannot be foreseen, and the planning effort is deemed necessary at this time in order that provision may be made for such development if and when the requirement arises.

6. The California Water Plan is designed to include or supplement, rather than to supersede, existing water resource development works. It also incorporates certain of the planned works now proposed or authorized by public and private agencies and individuals. Of special significance in this respect is the Feather River Project, which is proposed as a unit for initial construction under The California Water Plan.

Summarized, the foregoing concepts define The California Water Plan as a comprehensive pattern, with broad flexibility and susceptible of orderly and progressive development as needed, under which the forecast ultimate requirements for water by individuals and agencies for all purposes in all parts of the State can be met. Water is not to be taken away from people who will need it; rather, it is proposed to supply the needs of areas of deficiency by transfer only of excess or surplus water from areas of abundance. Under The California Water Plan, water development by all agencies, federal, state, local, and private, can proceed in a coordinated manner toward common objectives and for maximum ultimate benefit. The Plan is not intended in any way to constitute an inflexible regulation or construction proposal.

The California Water Plan does not purport to include all possible water development projects in the State. Rather, it serves to demonstrate that the full satisfaction of ultimate water requirements in all parts of the State is physically possible of accomplishment. Therefore, the omission herein of any project does not preclude its future construction and integration into the Plan. Further investigation may indicate alternative projects which are more feasible than those discussed herein and which would accomplish the same results.

It is fully acknowledged that The California Water Plan, like any plan for the indefinite future, is based on present forecasts, utilizing data from the short recorded past and accepted technology of today, and, as such, is inherently subject to substantial alteration with the passage of time and the trial of experience. For these reasons, investigation and planning for further water resource development must be a continuing process.

Planning Considerations

In all planning for water resource development, first and prime consideration was given to the requirements, both present and future, for all water uses in areas of origin, before a determination was made of the surplus waters that might be available for exportation to areas of deficient supply. Interference with works of existing entities, or with their operations with respect to use of water, was avoided wherever possible. In fact, most existing facilities would be integrated into the Plan. Present rights and established interests in the use of water have been taken into consideration, although no detailed studies of the status of existing rights have been made specifically for this report. The significance of such studies to state-wide planning is fully recognized but is beyond the scope of this bulletin.

It should be recognized that the planning has necessarily been of a preliminary nature and is appropriate only to the initial definition of projects. In this connection, one controlling factor is dam site foundations, for which, in general, only limited engineering and geologic examination has been possible within the scope of the present investigation. Subsurface geologic conditions have been estimated in most cases only by reconnaissance surface inspection, which is generally not adequate to determine all essential subsurface features.

The need for further surveys involving foundation excavations and borings before projects can be definitely proposed for construction can be best appreciated with knowledge of the importance of foundation characteristics in engineering design. Not only does the foundation constitute one of the major factors in determination of type, height, cost, and feasibility of a dam, but quite often the inadequacy of a foundation leads to abandonment of one site and adoption of another. Similar geologic and engineering information must be developed with respect to availability and quality of construction materials in the vicinity of dam sites. Detailed subsurface investigations will also be needed along conduit routes. It will be imperative to conduct an extensive program of exploratory drilling and excavation under more detailed planning studies, prior to final determination of the feasibility of the features of definite projects. Even more detailed engineering and geologic studies will be required for preparation of construction plans and specifications.

Limitations inherent in the concept of "ultimate," on which are based the pattern of development and the water requirements under The California Water Plan, are of prime significance. This concept pertains to conditions after an unspecified but long period of years in the future when land use and water supply development will be at a maximum and essentially stabilized. It must be realized that any forecasts of the nature and extent of such ultimate development and resultant water utilization are inherently subject to appreciable errors. However, such forecasts, based upon best available data and judgment, are necessary in establishing long-range objectives for development of water resources. They are so used herein, with full knowledge that their re-evaluation, after the experience of a period of years, will result in considerable revision.

Possible advancement in certain fields of technology relating to water development may require consideration at a future time. The field of atomic energy may offer a most promising potentiality in this respect. Utilization and production of electrical energy under The California Water Plan have been based generally on current economic considerations. Future developments in utilization of atomic energy may become instrumental in making economically feasible the conversion of saline water to water of acceptable quality. At the present time, research studies by certain agencies are concerned with the various aspects and processes available for the desalting of sea water. It is reported that certain of these processes show promise for the distant future.

Large-scale availability of low-cost energy might effect future changes in The California Water Plan with respect to feasibility of pumping lifts and economic lengths of conveyance tunnels. In addition, economics of hydroelectric projects would be affected, since the cost of thermal energy production is a factor in evaluating hydroelectric energy. This would probably mean that the power plants proposed under the plan for hydroelectric generation, based upon prevalent concepts of value of power, may be subject to reconsideration under future concepts.

Another potentiality for change in requirement for imported water supplies exists in the possible advancement of technology and economy in treatment and reclamation of sewage. Currently, such waters are substantially wasted, with little consideration being given to their use either because of the cost involved or for esthetic reasons.

The technique of weather modification might advance to the point whereby The California Water Plan could be affected to some degree. It appears unlikely, however, that effects of this modification could be of sufficient proportions as to change materially the over-all plan as presented herein. If such did occur, it could result in a significant increase in water supply in areas of natural surplus of water, a minor increase in areas of deficiency, with both areas needing added flood protection.

One additional aspect of the planning process requires emphasis. It is evident that the development of water in California today deals largely with "leftover" projects, and must utilize dam sites and even entire stream systems which were passed over in the early days as being too difficult of development. Not so evident, however, nor as well recognized, is the fact that in order to effect the greatest benefit at the least cost for any water resource development project today, careful sorting of many alternative plans is required. This involves painstaking study, engineering judgment, and consideration of all possible aspects of the development as related to multiple and often incompatible demands for the water.

Thus, while it is apparent that the fundamental basis of The California Water Plan must rest on presently available economic and technical knowledge, it is recognized that future developments may change this basis. Accordingly, The California Water Plan has been formulated to perform an essential function, in that it forms the engineering basis for guidance and coordination in the planning, construction, and operation of water resource developments which are and will be required in meeting the needs for water throughout the State. It represents an assurance that the waters of the State can be developed in such a manner that the greatest public benefit will be derived, in the light of best available knowledge.

PUBLIC HEARINGS ON PRELIMINARY EDITION OF BULLETIN No. 3

In order to evaluate the adequacy of The California Water Plan, a preliminary draft of Bulletin No. 3, "Report on The California Water Plan," dated May, 1956, was released to responsible agencies and individuals throughout the State for their review and comment. Opportunity for presentation of written or oral comments on the Plan was afforded by a series of public hearings which all agencies and individuals were invited to attend. These hearings, conducted jointly by the Department of Water Resources and the State Water Board, were held as shown in the following tabulation:

San Francisco	August 31, 1956
Eureka	September 6, 1956
Redding	September 7, 1956
Quincy	September 8, 1956
Los Angeles	September 13, 1956
Santa Barbara	September 14, 1956
Fresno	September 24, 1956
Bakersfield	September 25, 1956
Sacramento	October 4, 1956

In addition to providing information to the public, thus facilitating a better understanding of the water problems of California and of plans for their solution, the public hearings were highly beneficial to the Department of Water Resources in the preparation of Bulletin No. 3 for final publication. Nearly 1,500 persons attended the hearings, and some 200 written or oral statements representing a wide diversification of areas and interests throughout the State were presented. These statements, which covered a variety of subjects, have been given careful review and analysis, and the recommendations have been incorporated into The California Water Plan wherever pertinent.

ORGANIZATION OF BULLETIN

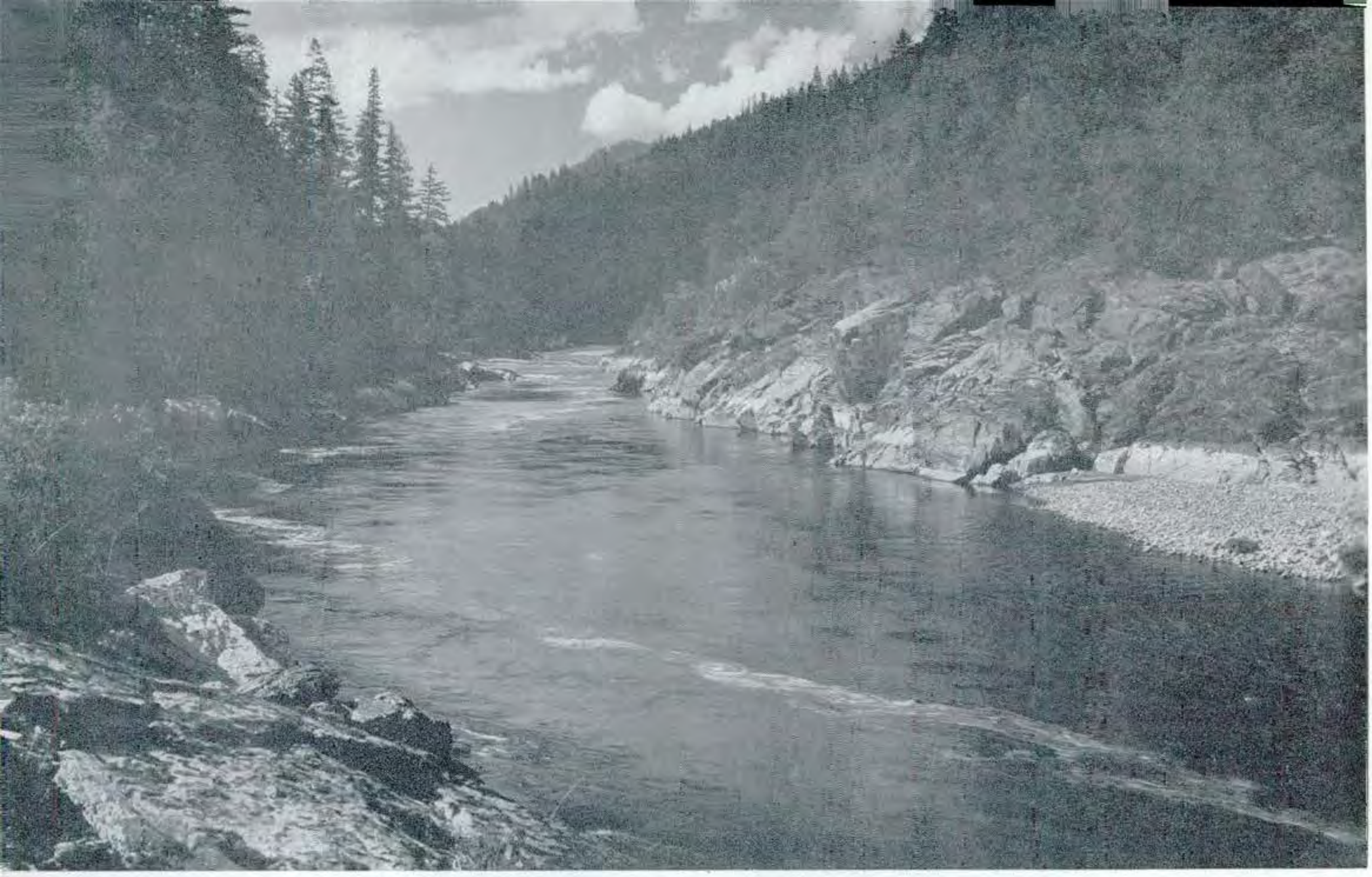
Results of the third and final phase of the Statewide Water Resources Investigation, comprising the planning necessary for the solution of California's water problems, are presented in this bulletin in the five ensuing chapters. Chapter II, "Water Problems of California," evaluates the primary water problem of California through a comparison of the water resources and water requirements as determined during the first two phases of the State-wide Water Resources Investigation, and corollary problems. Chapter III, "Water Development Planning," presents a brief historical account of water resource planning and development in California up to the present time, discusses the urgent need for comprehensive coordinated planning and development on a state-wide basis, and outlines the considerations necessary to the formulation of plans to accomplish the solution of California's water problems. Chapter IV, "The California Water Plan," describes the physical features and accomplishments of works, both local and state-wide, which would meet the basic objectives heretofore described. Chapter V, "Implementation of The California Water Plan," discusses various considerations, such as legal, economic, financial, and engineering, and others which are vital to the physical implementation of The California Water Plan. Chapter VI, "Summary, Conclusions, and Recommendations," summarizes the bulletin, and presents the conclusions resulting from the State-wide Water Resources Investigation and the recommendations based upon the conclusions.

Appendix A to this bulletin presents a more detailed engineering report on The California Water Plan. It describes both local and interbasin transfer projects on an individual basis, with accompanying tabulations of physical features and capital costs. It also discusses, in some detail, the accomplishments of The California Water Plan and the considerations upon which the operation of the plan will be contingent.

There will be published separately, and at later dates, additional appendixes which will elaborate on certain specific phases of The California Water Plan, and on considerations and premises on which the Plan was based. The basic assumptions, criteria, and procedures employed in formulating the Plan are presented in Appendix B. General geology of the State, geologic conditions affecting the location and design of engineering works, and ground water geology are described in Appendix C. Appendix D outlines the utilization of ground water storage capacity under The California Water Plan, particularly with regard to conjunctive operation of surface and underground reservoirs. Factors involved in maintenance of water quality are treated in Appendix E.

The effects of The California Water Plan on fish and wildlife are presented in Appendix F, as are the potentialities for enhancement of recreational facilities. Flood problems and existing project works are described in Appendix G, and flood control accomplishments of The California Water Plan are discussed. Economic and financial aspects of The California Water Plan are discussed in Appendix H. Water rights and attendant legal considerations and their implications with respect to The California Water Plan are presented in Appendix I.

In the State-wide Water Resources Investigation, due cognizance has been taken of all possibilities for augmenting the State's water supplies. The potentialities of sea-water conversion, waste-water reclamation, artificial increase of precipitation, and watershed management are discussed and evaluated in Appendix J. Future power sources and energy requirements as related to The California Water Plan are considered in Appendix K, which discusses the development of power requirements and future load characteristics, and the adaptability of atomic energy and its influence upon the development of hydroelectric energy.



"The primary water problem of maldistribution of California's water resources . . ."
Klamath River
San Joaquin Valley

CHAPTER II

WATER PROBLEMS OF CALIFORNIA

The past and future growth of California has been and will continue to be dependent upon the development of its water resources. The primary reasons for this are threefold: first, California is endowed by nature with millions of acres of fertile lands of high crop productivity; secondly, due to the semi-arid climatic characteristics, most agricultural lands in the State must be irrigated; and thirdly, California has a great potential for urban and industrial development, resultant in part from the substantial agricultural potential. However, the growth of the State, in itself made possible and stimulated by the development of water, has continually created water problems which have become progressively more and more difficult of solution as local sources of surplus water have been developed.

Why, we might ask, should California have water problems when nature has provided an abundance of water within the State? The answer to this question is simple and clear: the bulk of the waters of the State do not occur *where* they are needed and are not naturally available *when* they are needed. However, this answer—true as it is—grossly oversimplifies the far-reaching and serious basic water problem presently facing us, and becoming magnified and intensified year by year.

The primary water problem of maldistribution of California's water resources and requirements is evaluated in this chapter for each of the major hydrographic areas of the State. This is followed by a discussion of other corollary problems, namely surface water deficiency, ground water overdraft, floods, and impairment of water quality.

WATER RESOURCES

As previously mentioned, the first phase of the State-wide Water Resources Investigation was devoted to evaluation of the water resources of the State and determination of their characteristics, specific nature, occurrence, quantities, and distribution. These data, which have been published in State Water Resources Board Bulletin No. 1, form the basis for the generalizations presented herein.

Precipitation

From a practical standpoint, all water resources stem from precipitation. Its regimen and other characteristics profoundly affect the occurrence of water supplies. California receives most of its precipitation from north Pacific storms. Most of the precipitation occurs in the form of rain at lower elevations and snow in the higher mountain regions. Precipitation varies widely geographically throughout California, due principally to the topography and the Pacific storm pattern. This variation is illustrated by Plate 2, entitled "Geographical Distribution of Precipitation and Runoff." At sea level along the coast, precipitation varies from a seasonal depth of about 50 inches in the north to 10 inches in the south. In the Coast Range and Sierra Nevada, precipitation generally increases with elevation, reaching an average of 110 inches per season in the northwest corner of the State. By way of contrast, the deserts of the southeast, with elevations extending below sea level, average as little as 2 inches of precipitation per season. On the floor of the Central Valley, seasonal precipitation ranges from about 38 inches at Redding to about 6 inches at Bakersfield.

In addition to the wide range of geographical distribution, precipitation in California varies considerably with time, both within the season and from year to year. In general, more than 80 per cent of the total seasonal precipitation occurs during the five months of November through March. To add further to the problem, precipitation frequently departs widely from the mean from year to year, and it is quite common to experience a several-year period of greater than mean precipitation, followed by a period of somewhat similar or even greater length during which the precipitation is considerably less than mean. These two types of periods are commonly referred to as "wet periods" and "drought periods," and their generally alternating occurrence in the past has given rise to the term "cycles." These so-called cycles have varied both in length and intensity. One of the most severe drought periods of record occurred throughout most of the State from 1928 through 1934, with an average precipitation of less than 60 per cent of the mean. The seasons of 1923-24 and 1930-31 were generally the driest in California for the period of record.

Runoff

Runoff is defined as that portion of precipitation which drains from the land through surface channels. The amount of runoff constitutes that portion of the water resources that is available for control, regulation, and distribution to meet requirements for water. Most of the runoff in California originates on mountain and foothill lands, and debouches from these watersheds onto adjoining valley floors. For this reason, estimates of runoff presented herein generally represent that part of precipitation that flows from mountain and foothill areas.

The Sacramento River, which, along with the San Joaquin River, drains the Central Valley, is the largest stream in the State. The main stream originates in the Cascade Range at the northern end of the State and flows almost due south through the Sacramento Valley. It is joined at the Sacramento-San Joaquin Delta by the San Joaquin River, which drains the northern portion of the San Joaquin Valley, and both streams flow westward in a network of channels emptying into San Francisco Bay.

The Klamath-Trinity River system, second only to the Sacramento River, drains a large part of the northern mountain watershed, including lands across the state boundary in Oregon. Other major streams, including the Mad, Eel, and Russian Rivers in the north; Salinas, Santa Maria, and Santa Ynez Rivers in the central part of the State; and Santa Clara, Los Angeles, San Gabriel, Santa Ana, San Dieguito, and San Diego Rivers in the southern sector, convey runoff from the seaward slopes of the Coast Range to the ocean.

The remainder of the State, with the exception of a narrow strip adjoining the Colorado River, has no outlet to the ocean. The eastern slopes of the Sierra Nevada give rise to a number of rivers flowing eastward into Nevada, including the Truckee, Carson, and Walker. The Owens River, also rising along the east slopes of the Sierra, flows southerly along the foothills and terminates in Owens Lake. In the southern part of the State several streams originate on the landward side of the coastal mountains and extend easterly to natural sumps in the desert. Among these are the Mojave River, whose course traverses the Mojave Desert to Soda Lake, although its flow rarely reaches its terminus, and the Whitewater River, which extends to but seldom discharges into the Salton Sea.

Because runoff in California is derived from precipitation, it generally reflects similar monthly and seasonal variations, particularly in those portions of the State where precipitation occurs as rainfall. Moreover, the steep slopes, shallow soil mantle, and relatively sparse vegetative cover in many of the watersheds have little retarding effect on the precipitation as it collects and concentrates in stream channels on its inexorable journey to the ocean. Thus, with the exception of snow-fed streams, runoff in California is generally sporadic in nature, with short, intense floods followed by long periods of little or no flow.

A substantial portion of California's precipitation occurs in the form of snow in the Sierra Nevada and parts of the Cascade and Siskiyou Ranges, which contributes a modifying effect on runoff. This water accumulates during the winter in extensive snow fields at high elevations and is released, as runoff, months later during the late spring and early summer snowmelt period. This flow is far more uniform than runoff resulting directly from rainfall, and its value is greatly enhanced by its more or less predictable nature and the fact that it is sustained well into the growing season when precipitation is negligible. Outstanding examples of the retarding effect of snowpack storage on runoff are found in the flows of the San Joaquin River at Friant and the Kings River at Piedra, where 75 per cent of the runoff occurs during the April-July snowmelt period, during which time average precipitation approximates 15 per cent of the seasonal total.

It is estimated that seasonal natural runoff for the State (not including California's rights in and to the waters of the Colorado River) averaged some 71,000,000 acre-feet per season during the 53-year period 1894-95 through 1946-47. Runoff in individual years has varied from a high of 135,000,000 acre-feet in 1937-38 to a minimum of 18,300,000 acre-feet in 1923-24. The average seasonal runoff during the critical 10 years from 1927-28 through 1936-37 averaged only 69 per cent of the mean for the 53-year period, and in no season did runoff reach the long-time mean.

As previously stated, the bulk of the total seasonal natural runoff in California occurs in the northern portion of the State, with more than 40 per cent from the North Coastal Area and about 32 per cent stemming from the Sacramento Valley. In contrast, only 2 per cent of the total runoff occurs in the South Coastal and Colorado Desert Areas. Estimated mean seasonal natural runoff for the several major hydrographic areas of the State is listed in Table 1 and is graphically illustrated on Plate 2. The major hydro-

TABLE 1

ESTIMATED MEAN SEASONAL FULL NATURAL RUNOFF OF HYDROGRAPHIC AREAS

Area number on Plate 3	Hydrographic area	Runoff[a]	
		In acre-feet	In per cent of total
1	North Coastal	28,890,000	37.9
2	San Francisco Bay	1,245,000	1.6
3	Central Coastal	2,448,000	3.2
4	South Coastal	1,227,000	1.6
	Colorado River[b]	1,212,000	1.6
5A	Sacramento River Basin	22,390,000	29.4
5B, C	San Joaquin-Tulare Lake Basin	11,246,000	14.7
6	Lahontan	3,177,000	4.2
7	Colorado Desert	221,000	0.3
	Colorado River[b]	4,150,000	5.5
	TOTALS	76,212,000	100.0

[a] Values given represent runoff from mountain and foothill areas generally at the base of the foothills. Comparatively little control is possible below that point.
[b] Regulated flows representing California's rights in and to the waters of the Colorado River.

graphic areas are delineated on Plate 3, entitled "Major Hydrographic Areas and Planning Groups."

Ground Water

The extensive ground water basins of California provide natural regulation for runoff from tributary drainage areas and for precipitation directly on overlying lands. Some 250 ground water basins having valley floor areas of about 5 square miles or larger have been identified in California. A large part of the surface runoff from tributary mountain and foothill watersheds that would otherwise waste to the ocean is retained in these basins and conserved for later utilization. In effect, these ground water reservoirs provide a means for natural regulation of stream flow in much the same manner as is accomplished by surface reservoirs.

Sufficient data on the ground water basins of California are available to permit an estimate of gross storage capacity within certain depth limits for 211 valley floor areas. The areas for which such storage capacities were estimated comprise 96 per cent of the total valley floor area of all basins of the State. The depth limits vary from basin to basin, but the average weighted interval is approximately 185 feet, or generally between the depths of about 15 and 200 feet. The gross storage capacity within this depth interval is about 450,000,000 acre-feet. The Central Valley alone contains over 130,000,000 acre-feet of this total in approximately the same depth interval.

Only a portion of the gross storage capacity is usable storage, largely because of the presence of saline water or other waters of deleterious mineral quality. These waters either limit the depth to which ground water levels may be lowered or, in many areas, preclude the use of ground water. Enough information is presently at hand to estimate the usable storage capacity for only 80 ground water basins, comprising 43 per cent of the total valley floor area of the State. In the Central Valley, usable capacity in the depth interval from 15 to 200 feet aggregates about 100,000,000 acre-feet.

More than half the water presently consumptively used in California comes from underground sources. Many of these ground water basins have been intensively developed. In the San Joaquin Valley and parts of southern California particularly, the ready availability of ground water has been primarily responsible for supporting rapid expansion of agriculture and industry far beyond the firm capabilities of water resource developments. This has been accomplished by utilizing the vast reserves of water stored in these underground reservoirs, in many cases at rates greatly exceeding their replenishment. Presently available data concerning ground water are far less comprehensive than for surface water resources. Much more study will be necessary to evaluate reasonably accurately the capability of ground water resources of the State.

WATER REQUIREMENTS

Under the State-wide Water Resources Investigation all lands in the State have been classified as to their suitability for development under probable ultimate conditions. Determinations have also been made of the location, nature, and extent of present water service areas, and appropriate factors for the various types of water use have been evaluated. Estimates of present and probable ultimate water requirements developed from these data, and published in State Water Resources Board Bulletin No. 2, have been generally accepted as a measure of water requirements for the formulation of The California Water Plan. However, modifications have been made where the need for such has been indicated by further study. These estimates, modified where necessary, are summarized in this section.

In 1950, the year adopted as "present" in Bulletin No. 2, a gross area of about 7,300,000 acres was under irrigation in California. The actual area irrigated, or net area, was about 6,900,000 acres. A gross area of about 20,000,000 acres is classified as suitable for irrigated agriculture, of which an estimated 16,200,000 acres could be irrigated in any one season under ultimate conditions of development. In 1950, approximately 1,100,000 acres were devoted to urban, suburban, and industrial types of land use. It is estimated that urban, suburban, and industrial water service areas will ultimately occupy about 3,600,000 acres.

For the most part, the remaining lands of California include only scattered water service areas, largely in mountainous and desert regions and in national forests and monuments, public beaches and parks, private recreational areas, wildfowl refuges, and military reservations. It is expected that even under ultimate development the majority of these lands will be only sparsely settled and will have only very minor requirements for water service. About 180,000 acres of such remaining lands actually receive water service at the present time. It is assumed that all of the approximately 77,300,000 acres of such lands ultimately will be served with water in the minor amounts sufficient for their needs.

Table 2 summarizes data relative to present and ultimate water service areas in the seven major hydrographic areas of California, classified by broad land usage groupings. The potential water service areas under The California Water Plan, consisting of all lands included in the irrigated and urban-suburban-industrial categories, are delineated on Plate 4, entitled "Present and Ultimate Areas of Intensive Water Service."

TABLE 2

PRESENT AND PROBABLE ULTIMATE WATER SERVICE AREAS

(In acres)

Area number on Plate 3	Hydrographic area	Areas of intensive water service				Miscellaneous water service areas		Totals	
		Irrigated		Urban, surburban, and industrial					
		Present*	Ultimate	Present*	Ultimate	Present*	Ultimate	Present*	Ultimate
1	North Coastal	223,000	1,023,000	19,000	53,000	19,000	11,425,000	261,000	12,501,000
2	San Francisco Bay	163,000	66,000	225,000	1,408,000	50,000	1,222,000	438,000	2,696,000
3	Central Coastal	362,000	1,244,000	52,000	169,000	12,000	5,808,000	426,000	7,221,000
4	South Coastal	652,000	1,156,000	547,000	1,611,000	1,000	4,228,000	1,200,000	6,995,000
5A	Sacramento River Basin	1,130,000	3,603,000	101,000	127,000	28,000	13,380,000	1,259,000	17,110,000
5B, C	San Joaquin-Tulare Lake Basin	3,993,000	7,955,000	90,000	165,000	57,000	12,820,000	4,140,000	20,940,000
6	Lahontan	236,000	3,107,000	10,000	54,000	5,000	17,812,000	251,000	20,973,000
7	Colorado Desert	587,000	1,822,000	14,000	33,000	10,000	10,561,000	611,000	12,416,000
	TOTALS	7,346,000	19,976,000	1,058,000	3,620,000	182,000	77,256,000	8,586,000	100,852,000

* Present service areas determined as of 1950.

TABLE 3

ESTIMATED PRESENT AND PROBABLE ULTIMATE MEAN SEASONAL WATER REQUIREMENTS

(In acre-feet)

Area number on Plate 3	Hydrographic area	Irrigation		Urban, suburban, and industrial		Miscellaneous		Totals	
		Present*	Ultimate	Present*	Ultimate	Present*	Ultimate	Present*	Ultimate
1	North Coastal	483,000	1,880,000	21,000	85,000	9,000	99,000	513,000	2,064,000
2	San Francisco Bay	294,000	98,000	386,000	3,408,000	30,000	6,000	710,000	3,512,000
3	Central Coastal	572,000	2,010,000	52,000	217,000	6,000	19,000	630,000	2,246,000
4	South Coastal	1,020,000	1,901,000	885,000	3,635,000	2,000	16,000	1,907,000	5,552,000
5A	Sacramento River Basin	3,645,000	6,912,000	104,000	303,000	70,000	212,000	3,819,000	7,427,000
5B, C	San Joaquin-Tulare Lake Basin (Including Sacramento-San Joaquin Delta)	9,057,000	15,605,000	173,000	438,000	143,000	262,000	9,373,000	16,305,000
	Operation of Salinity Control Barrier	0	0	0	0	0	876,000	0	876,000
6	Lahontan	712,000	6,508,000	12,000	108,000	17,000	120,000	741,000	6,736,000
7	Colorado Desert	3,261,000	6,192,000	23,000	107,000	56,000	111,000	3,340,000	6,410,000
	TOTALS	19,044,000	41,106,000	1,656,000	8,301,000	333,000	1,721,000	21,033,000	51,128,000

* Present requirements determined as of 1950.

By far the largest use of water in California is for agriculture, a condition that will prevail even under conditions of complete development. The present consumption of water for irrigation is estimated to be about 90 per cent of the total for all beneficial purposes, and will amount to about 80 per cent ultimately. The actual requirement for water for irrigated agriculture, at present about 19,000,000 acre-feet per season, would more than double under conditions of complete development, to about 41,000,000 acre-feet per season. The total requirement for water in California for all consumptive purposes in 1950 was about 21,000,000 acre-feet per season. It is forecast that this will eventually increase to some 51,000,000 acre-feet per season.

Estimates of present and ultimate mean seasonal water requirements, under the broad land use groupings and by the major hydrographic areas, are presented in Table 3.

CALIFORNIA'S WATER PROBLEMS

From the discussion and data presented in the preceding sections of this chapter, it is apparent that California's water problems result primarily from the maldistribution of its water resources and water requirements, both geographically and with respect to time. The major sources of water are in the northern part of the State where stream flow wastes into the ocean virtually unused. The productive land and major urban areas are located in the central and southern regions, where water supplies are insufficient. Interposed between the major sources of water and the principal areas of deficiency are great distances and formidable ranges of mountains. Well over 70 per cent of the total stream flow in the State occurs north of an east-west line drawn through Sacramento. In contrast, an estimated 77 per cent of the present and 80 per cent of the forecast ultimate water requirements are found south of the same line. This geographic disparity is clearly indicated in Table 4, which shows a comparison of the water supply with the present and ultimate water requirement for each major hydrographic area of the State, expressed as percentages of the respective totals for the State.

In addition to the unequal areal distribution of California's water resources and requirements, its water problems are further intensified by the sporadic nature of the occurrence of runoff, both within the season and from year to year. The greater part of the runoff occurs during the winter and spring months when the demand for water is the least. Fortunately, a considerable portion of the runoff of most major inland mountain streams is detained in snowfields of the Sierra Nevada until the late spring and early summer snowmelt period. However, this natural regulation is not by any means sufficient to provide for the large demands in the summer and fall.

Although seasonal fluctuation of runoff is a serious problem, because its regulation requires a considerable amount of storage, it is the fluctuation of stream flow from year to year that presents the most difficult problem of regulation. California is subject to extended wet and dry periods. As previously stated, the State suffered a severe drought in the late 1920's and early 1930's, one of many in the past, during which the runoff of streams throughout the State for a 10-year period averaged only 69 per cent of the long-time mean. These periodic droughts have superimposed on the need for storage for normal seasonal regulation the need for provision of extremely large amounts of reservoir storage capacity for necessary cyclic regulation of water supply. A severe drought, superimposed upon present deficiencies in water supply development, could create widespread havoc and even economic disaster throughout California. Furthermore, there is no reason to believe that drought conditions in the future may not be more intense and of longer duration than those of the short recorded past.

All other water problems of California basically result from the primary problem of geographical maldistribution and seasonal and cyclic fluctuation of the water resources of the State, and are briefly discussed herein as problems of water deficiency, both surface and underground, floods, and impairment of water quality.

Problem of Water Deficiency

Because of the characteristic semiarid climate, nearly all areas of the State experience a natural surface water deficiency during the summer and fall months when rainfall is negligible and runoff is meager. This seasonal deficiency is often greatly intensified and prolonged by the extremely variable occurrence of California's water resources from year to year, whereby rainfall and resultant runoff is subnormal for varying periods of years. To add to the natural problems of seasonal and cyclic deficiency, the water resources are not geographically distributed in conformity with the requirements. This has necessitated a high degree of development of available resources in the central and southern parts of the State.

Works have been constructed by numerous entities for regulation of stream flow and conveyance to areas of use, and the water thus delivered has allowed extensive agricultural activity on fertile lands which formerly supported only hay, grain, and native grasses. Many fertile areas of potential productivity, however, are not close enough to surface supplies to allow their development within the limited means of some local agencies.

Further, during periods when runoff is deficient over a series of years, those agencies and individuals depending on facilities adequate only for seasonal regulation are faced with the necessity of cutback in their economy. Occasionally, agricultural develop-

TABLE 4

DISTRIBUTION OF WATER RESOURCES AND REQUIREMENTS

Area number on Plate 3	Hydrographic area	Natural stream flow, in per cent of total for State	Requirement for water, in per cent of total for State		Requirement for additionally developed water, in acre-feet	
			Present*	Ultimate	Present*	Ultimate
1	North Coastal	40.8	2.4	4.0	13,000	1,564,000
2	San Francisco Bay	1.7	3.4	6.9	42,000	**2,257,000
3	Central Coastal	3.5	3.0	4.4	65,000	1,681,000
4	South Coastal	1.7	9.1	10.9	370,000	**3,027,000
5A	Sacramento River Basin	31.6	18.1	14.5	124,000	3,732,000
5B, C	San Joaquin-Tulare Lake Basin (including Sacramento-San Joaquin Delta)	15.9	44.5	31.9	1,661,000	9,427,000
	Operation of Salinity Control Barrier	0.0	0.0	1.7	0	876,000
6	Lahontan	4.5	3.6	13.2	279,000	6,148,000
7	Colorado Desert	0.3	15.9	12.5	0	**2,181,000
	TOTALS	100.0	100.0	100.0	2,554,000	30,893,000

* Present requirements determined as of 1950.
** Assumes imports to full extent of claimed water rights.

ments—and urban developments as well—have overextended their economy during wet periods with extremely critical results during following periods of drought.

Surface diversions and interbasin transfers have done much in the past to develop the economy of the State and are the great potential of the future. However, it may be categorically stated that the degree of economic development which is enjoyed today would not have been possible without the utilization of ground water. The availability of what appeared to be an unlimited supply of ground water has been a great boon to this development. It has been necessary only to put down a well and utilize water from a vast underground reservoir at relatively small cost; expensive conservation and transmission systems have been unnecessary and distribution facilities minimized. Extensive areas overlying natural ground water basins have been developed to a high level of productivity. By utilization of a ground water source, many municipalities in the central and southern parts of the State have also experienced expansion which otherwise would have been impossible.

However, the high level of economic development in many areas of the State has been achieved at the expense of overdraft conditions on the underlying ground water basins, wherein the extraction has exceeded the replenishment. In many of these areas the overdraft is continuing—in fact increasing—generally with no active measures being taken to correct the serious problem. How long these conditions of overdraft, or "mining" of ground water resources, can continue without drastic and far-reaching detrimental consequences is a matter of serious concern. If the underground sources of water are allowed to be completely depleted and no other sources of supply are developed in the interim, the economy of the State will not just stand at the current level, but must of necessity regress to one supportable largely by surface developments. Surface water sources are meager in the central and southern areas of the State where the water requirements are the greatest. The calamity of economic depression attendant on the excessive depletion of ground water reservoirs would not be limited to those agricultural areas overlying the reservoirs. Just as the whole State now enjoys the benefits of an expanding economy, so would the whole State—north as well as south—feel the possible catastrophic effects of the destruction of ground water basins by continued overdraft.

Overdraft conditions presently exist in several of the major and in many of the minor ground water basins in the State. The most serious overdraft in terms of magnitude is manifested in the San Joaquin-Tulare Lake Basin where the present (1955) draft exceeds the mean seasonal replenishment by some 2,500,000 acre-feet. Conditions are particularly acute along the west and south sides of the basin. Overdraft conditions are also serious in the Antelope Valley, presently approximating 175,000 acre-feet per season. The overdraft on the coastal plain of Los Angeles, Orange, Santa Barbara, and Ventura Counties is estimated at 400,000 acre-feet per season. In addition to these areas of critical overdraft, substantial overdrafts are being experienced in portions of the Sacramento Valley, in the Santa Clara, Salinas, and Santa Maria Valleys in central California, and the Santa Clara River Valley in southern California. Twenty-four smaller ground water basins are also known to be overdrawn.

The present (1955) deficiency in developed water supply, both surface and underground, aggregates some 4,000,000 acre-feet per season on a state-wide basis, largely representing an overdraft on ground water supplies. It is forecast that, if California is to attain her full economic potential, additional water supplies amounting to some 31,000,000 acre-feet per season must ultimately be developed to meet consumptive requirements plus irrecoverable losses. On certain streams additional water will have to be developed for stream flow maintenance for fish, wildlife, and recreational purposes, and for maintenance of water quality.

Problem of Floods

It is ironical that the very forces which man now attempts to control to prevent flood damage have formed the flat fertile valleys which attracted him originally. Agricultural enterprise, with the resultant urban and industrial economy, has been developed almost entirely upon the fertile natural flood plains and basins and alluvial fans of active streams.

The great Central Valley is itself an evolvement of many centuries of periodic flooding of the Sacramento and San Joaquin Rivers and their tributaries. It also is the major example in California of the results of recent intensive improvements encroaching upon flood plains. During the flood of December, 1955, great havoc was wrought throughout this area, which includes that particular area of disaster in and about Yuba City. Protective works were generally designed for the economy existent prior to World War II. When the levees of the Feather River were breached, 38 lives were lost and some 100,000 acres flooded, including Yuba City. It should be noted that this tragic loss of lives and destruction of property would have been prevented had Oroville Dam and Reservoir been in operation in conjunction with existing downstream flood control works.

The combined effect of flood runoff of Central Valley streams and coincident extremely high tides during the 1955 flood, produced critical conditions in the Sacramento-San Joaquin Delta. Consisting as it does of a maze of reclaimed islands and separating chan-

". . . the State . . . has developed an economy which is largely contained on areas naturally subject to flooding."

Break on Feather River Near Yuba City, December, 1955 nels, the Delta is particularly vulnerable to the combination of flood flows, high tides, and strong winds, as is a great part of the shore of San Francisco Bay. The below-sea-level elevation of most of the islands in the Delta, and the poor bearing properties of the organic soils which limit the height to which levees can be built, constitute a flood problem. This resulted during the 1955 flood in the inundation of two islands and partial flooding of three others.

Flood conditions in the North Coastal Area are particularly acute on the isolated flood terraces along streams such as the Klamath, Trinity, Mad, Eel, and Van Duzen Rivers. During floods these streams discharge tremendous quantities of water with extremely destructive force. Floods have, in fact, removed whole villages and left little evidence to indicate their former existence. The isolated nature and partial development on these flood terraces restrict the amount of protection which could be economically afforded at the present time; but the nature of existing conditions does point up the flood damage potential as development proceeds in this and other comparable areas and the necessity for giving consideration to flood control needs in future water projects.

The critical position of extensive urban encroachment on alluvial fans, with respect to the inherent flood conditions on these fans, is particularly notable in the area along the east shore of San Francisco Bay and in the South Coastal Area, the major examples of this development in California. Constantly shifting channels, high flood velocities, and heavy debris loads are always a threat on active alluvial fans. The resultant danger to human life and concentrated economic developments was early realized, particularly in the South Coastal Area. Basin-wide flood control projects constructed in that area are indicative of the degree of planning which is necessary and which will become necessary in many other natural flood areas as they develop in the future. Although flood conditions still exist in the South Coastal Area, because many projects are not yet completed, the potential damage has been greatly reduced. Likewise, the Sacramento River Flood Control Project, first authorized in 1917, has provided a substantial degree of protection to valley lands, although additional upstream storage is required for full protection.

An important consideration in the matter of flood conditions is that of lack of watershed management. Early-day hydraulic mining contributed substantially to flood problems in the valley lands below areas of mining operations. The debris load of flooding streams was increased many fold over what would have been naturally transported. The debris load is a prime factor in the cause of flooding, because at slower stream velocities on the valley floor the debris settles out and effectively reduces the stream channel capacity.

Today hydraulic mining has virtually ceased in the mountains of California, but there are still causes existent which unnaturally increase the debris load of streams and, also, unnaturally increase the runoff of streams during periods of high flow. Overgrazing by stock, forest fires, and often excessive cutting of timber very seriously reduce the vegetative cover of mountainous watersheds, thereby lessening or destroying completely the natural retentive and retarding qualities of the watershed with regard to the precipitation which falls thereon.

In summary, the present population of the State—some 14,000,000 people—has developed an economy which is largely contained on areas naturally subject to flooding. While noteworthy progress in flood control has been achieved, particularly by the flood control projects constructed and under construction by the Corps of Engineers, U. S. Army, the growth of the State has been so rapid that these efforts still fall far short of providing an adequate degree of protection, even for the present population, in most areas of the State. Future increases in population of the State to an estimated ultimate total of some 40,000,000 will magnify and intensify present flood problems, as the increased development will continue to concentrate generally in the same areas naturally subject to flooding. Additional flood protection must be provided as rapidly as possible.

Problem of Water Quality

Deleterious effects on the quality of water are generally manifested as a consequence of surface and ground water deficiencies, lack of drainage, and improper disposal of wastes. Problems of water quality are common to nearly all other water problems.

In 1949 the State Legislature considered maintenance of the quality of the State's water resources of sufficient importance to warrant the formation of a State Water Pollution Control Board and nine regional water pollution control boards to protect the beneficial uses of the State's waters from adverse and unreasonable detriment due to disposal of sewage and industrial wastes. Responsibility for protection of the public health from hazard due to improper disposal of sewage and industrial wastes was continued in the State and local health departments. By a concurrent action, the Legislature added Sections 229 and 231 to the Water Code, which direct the Department of Water Resources to:

> "229. . . . , either independently or in cooperation with any person or any county, state, federal or other agency, to the extent that funds are allocated therefor, shall investigate conditions of the quality of all waters within the State, including saline waters, coastal and inland, as related to all sources of pollution of whatever nature and shall report thereon to the Legislature and to the appro-

priate regional water pollution control board annually, and may recommend any steps which might be taken to improve or protect the quality of such waters.

"231. . . . , either independently or in cooperation with any person or any county, state, federal or other agency, shall investigate and survey conditions of damage to quality of underground waters, which conditions are or may be caused by improperly constructed, abandoned or defective wells through the interconnection of strata or the introduction of surface waters into underground waters. The department shall report to the appropriate regional water pollution control board its recommendations for minimum standards of well construction in any particular locality in which it deems regulation necessary to protection of quality of underground water, and shall report to the Legislature from time to time, its recommendations for proper sealing of abandoned wells."

By these actions, it was recognized that the problem of water quality is essentially an unnatural one, caused largely by mismanagement of water resources as well as by inadequate treatment before disposal of utilized waters.

In numerous coastal ground water basins normally containing fresh water, overdraft conditions have resulted in the intrusion of sea water into the aquifers, or the natural underground formations which store and transmit water. This has been caused by reversal of the natural seaward ground water gradient due to excess of pumped extractions over the natural ground water replenishment. As the aquifers of the coastal ground water basins are generally below sea level, saline water has moved in to replace a portion of the extracted water. In some cases—the Salinas Valley, southern Alameda County, and Orange County are notable examples—sea water has intruded into these erstwhile fresh water aquifers for distances of two or more miles. The restitution of areas which have been lost to sea-water degradation or any other type of degradation will be a long process—if possible at all, since the saline water must be physically removed, either by pumping or by maintenance of favorable gradients for an extended period. Meanwhile, overlying users have lost an economical source of water which can be replaced only by the costly process of deepening wells to a lower undegraded aquifer—when existent, or by importing surface supplies.

There also exist potential sources of quality degradation from deep connate brines and adverse salt balance. Connate brines are ocean waters that were trapped in ground water basins which were inundated by the ocean in past geologic periods. Bodies of connate brines underlie large areas of the Sacramento and San Joaquin Valleys at varying depths. In some areas the upper surfaces are relatively close to the land surface, as along the west side of the San Joaquin Valley and in the Delta area, thereby reducing the potential yield of these basins by limiting the extent to which the ground water resources can be developed without infiltration of these brines. In many areas of the Central Valley connate brines have already been encountered in pumping operations where localized overdraft conditions exist. In some of these areas, the overlying fresh waters have become too saline for use.

The extent of adverse salt balance in ground water basins throughout the State is not known at the present time, due to the lack of long-term records of mineral analyses. Salt balance refers to that desirable condition wherein the amount of soluble salts entering a basin is balanced by the amount of salts leaving the basin—either by natural disposal, sewage outflow, or by pumping for export.

All waters contain some salts in solution. Circulation of available water by continued use and re-use in a ground water basin, with a gradual decrease in supply due to evaporation and transpiration while the mineral content of the basin remains relatively constant, will result in an increase in the proportion of salts in solution with respect to the remaining water available. Continued lack of supplementary water supplies in present areas of overdraft points to the fact that eventually the concentrations of soluble salts will reach limiting values beyond which the water will be unfit for beneficial use.

In the process of drilling and altering wells, improper methods are being employed in many instances, resulting in an inadequate seal between strata of usable and unusable waters, thus allowing interchange; and in lack of adequate surface seals, permitting inflow of inferior surface waters with consequent damage to ground water quality. Likewise, failure to seal abandoned wells, or improper sealing when attempted, has resulted in the degradation or pollution of ground water. These problems are rapidly becoming more serious as older well casings deteriorate and are abandoned and the drilling of new wells continues at an unprecedented rate. At the present time the Department of Water Resources is investigating well drilling conditions and methods in the State in order to formulate well drilling and abandonment standards to afford adequate protection to the quality of ground waters.

A quality problem involving surface water is presently manifested in the inherently high mineral content of streams draining the west side of the San Joaquin Valley. The problem is particularly acute during periods of low flow when, in traversing ground water basins on the valley floor, the water percolating into these stream beds contributes to adverse salt balance in those basins, particularly those suffering an overdraft condition.

Surface sea-water encroachment into the Delta region of the Central Valley has occurred in the past due to the seasonal and cyclic fluctuation in stream flow and the depletion by extensive upstream diversions. All irrigation supplies for fertile Delta islands, and for many of the lands along the Sacramento River, are diverted from the intervening streams and sloughs, and the threat to the agricultural economy of this area is serious.

Alleviation of the salt-water intrusion problem was of prime consideration in the planning and construction of the Central Valley Project. Stored winter surplus waters from reservoirs of the project have been used for repulsion of saline water by maintaining a certain minimum fresh-water outflow to Suisun Bay during periods of low natural flow in the summer and fall months. However, ultimate developments requiring greater beneficial use of all available waters will eventually require that repulsion of saline water by fresh-water outflow be substantially reduced. A plan for physical barriers, being considered in the ultimate development of the State's water supply, is discussed in Chapter IV.

So far, this discussion has dealt largely with problems of protection of mineral quality from deterioration due to man's development of the water resources concerned, a matter to which too little attention has been given to date. Better known are the disastrous results caused by disposal of inadequately treated sewage and industrial wastes to streams and to ground water basins. Waste disposal problems may arise not only from liquid-borne wastes but also from disposal of garbage, refuse, and industrial wastes. Notable progress has been made by the State and Regional Water Pollution Control Boards and by the State and local health departments in preventing and abating pollution and contamination due to waste disposal. Every effort must continue to be made in the future to maintain the quality of the State's waters by appropriate planning for and control of the treatment and disposal of wastes, giving consideration to the effect of such waste disposal upon future planned uses as well as the present uses of the receiving waters. In planning for future urban and industrial development, careful consideration must be given to problems of waste disposal to prevent damage to the quality of the State's water resources.

Man's development has characteristically exerted an adverse effect upon the native quality of waters. Most uses of water by man, for irrigation, for instance, as well as for the disposal of sewage and industrial wastes, add pollutants and degradants to the waters with resultant deterioration of the quality. Hence, as these uses increase, the necessity for adequate treatment and disposal of waste waters becomes increasingly imperative if the quality is to be maintained at satisfactory levels for the higher uses. This is particularly true in areas of deficiency, where the quality of imported waters must be maintained at sufficiently high levels to permit necessary re-use.

The removal and final disposal of harmful degradants or pollutants without danger or detriment, whether by means of separate lined conveyance conduits or in natural channels, in may cases is possible only by providing for dilution of the waste waters with waters of higher quality. This may require the use of a portion of developed local supplies or the importation of water specifically for that purpose. The use of water resources for waste disposal is a necessary one and must be considered along with other water requirements for beneficial use. It will be necessary to find and apply the degree of dilution of waste waters needed in order to arrive at the proper and economic balance in the use of water as between waste removal and higher uses. One of the determinants in the use of water for waste removal is the necessity for maintaining a favorable salt balance. These are problems requiring continuing study for proper solution.

In summary, it may be stated unequivocally that unless the quality of the State's water resources is maintained at proper levels, full satisfaction of California's ultimate water requirements will not be possible.

Problem of Production of Hydroelectric Energy

The further extensive development of hydroelectric power as an inseparable part and partner in California's water resource development is a fully recognized requisite. The power potential of the north coastal streams, certain tributaries of the Sacramento River, and remaining undeveloped sites on east side tributaries in the San Joaquin Valley almost equals the total present steam and hydroelectric capacity now available in California. Full future satisfaction of water demands in all parts of California will require mass movement of large volumes of water through long conveyance systems and over high mountain ranges. Considerably more energy will be needed for pumping than is presently developed in California. Moreover, it is estimated that by the year 2000, California's total energy demand will exceed by 10 to 12 times the present power capability; the pumping load will be only a small part of that total demand. Hydroelectric power now finds its greatest value as "peaking" energy, and efficiently and economically complements steam power generated from fossil fuels. Likewise, it will combine equally well with atomic power generation in the years ahead. It seems reasonably certain that the power market will absorb hydroelectric power output as rapidly as it can be made available. The problem then, is to make each hydroelectric power opportunity yield the maximum in terms of energy output and revenue, but in proper balance with the other demands on and for the water resources concerned.

Problems of Recreation, Fish, and Wildlife

The need for more and better opportunities for wholesome outdoor recreation in California is rapidly expanding, due to the impact of a growing population, increased awareness by the people of the joys and benefits of such activity, and increased time and opportunity available to them for such pursuits. Accessible water areas and flowing streams well stocked with fish constitute an important aspect of the public desire for recreational opportunities. Satisfaction of that desire to the maximum feasible extent is a problem inherent in the development of California's water resources. That development will provide several hundred new reservoirs with many thousands of acres of water area, and will make possible releases of water in hundreds of miles of natural streams for improvement of fish and wildlife habitat. Enhancement of fish and wildlife resources and development of the recreational potential will provide important economic assets to many areas in California, particularly in the mountains and foothills. Provisions of facilities and opportunities for such use by the public therefore becomes an important objective in further water development.

Problem of Drainage

An ever-present problem in irrigated agriculture is the necessity of providing adequate drainage. Extensive drainage systems may be necessary to maintain soil productivity. Leaching and drainage have made possible the reclamation and use of large areas formerly considered valueless. Adequate drainage and proper disposal of saline drain waters may be an important factor in maintenance of ground water quality.

At the present time, the most serious unsolved drainage problem in California is in the west side of the San Joaquin Valley. It is considered probable that full solution will require a master drainage channel extending from Buena Vista Lake in Kern County to Suisun Bay.

Drainage must be considered an integral and indispensable part of the development and utilization of water resources. Adequate provision must be made therefor in the total program.

Problem of Full Use of Available Storage Capacity

A highly important problem which must be continually kept in mind in the further development of California's water resources involves the proper use of available storage capacity, both surface and underground. With respect to surface storage development, the most economical dam and reservoir sites have already been developed, leaving the less desirable projects available for future construction. Remaining combinations of good dam sites with surface reservoir sites of adequate capacity are rare, particularly in the areas in which export waters must be developed. With regard to ground water, it has been demonstrated in many areas of the State that the ground water basins, once considered a source of virtually inexhaustible supply, must be carefully managed in order to ensure their continued usability.

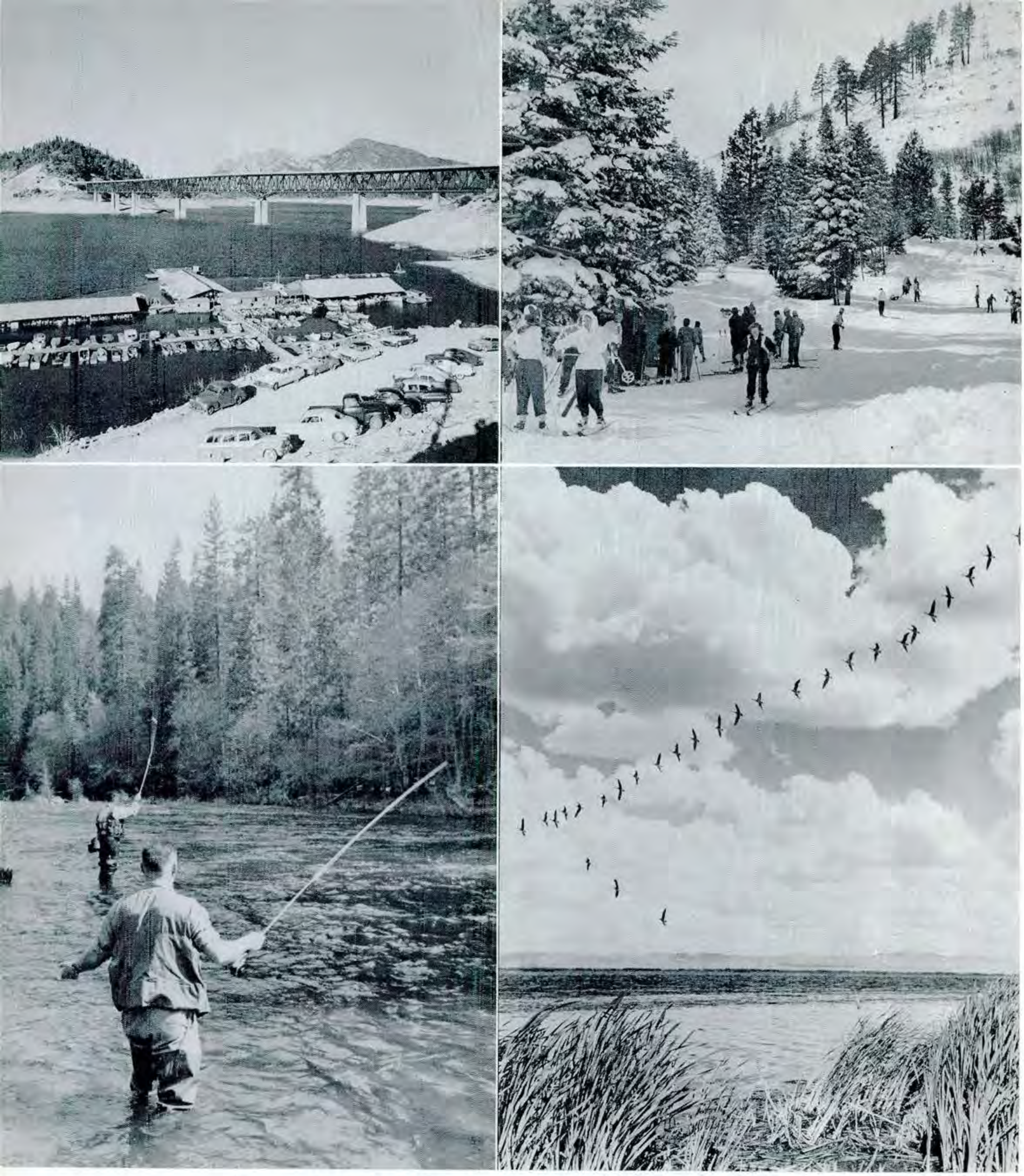
Because of the limited remaining surface storage capacity susceptible of development and the many purposes and uses to which the developed water must be put, it is highly important and urgently necessary that the available storage capacity be used wisely and for maximum benefit. This can be accomplished only by achieving the optimum development at each site selected for construction, which necessitates provision for the full development of the water production capabilities of the watershed and, in many instances, operation of the reservoir to meet the needs of several purposes, such as irrigation, urban, and industrial uses; flood control; power generation; recreation; fish and wildlife; and protection of water quality.

Failure to develop a site to its full potential through construction of a single-purpose project where a multipurpose project is necessary and justified initially in the public interest, or initial construction such as to preclude later full development, would result in the extravagant waste of the site.

Of paramount importance among the advantages inherent in multipurpose planning and development are economy and conservation of project sites. With respect to economy, it is generally cheaper to provide for several water uses in a single project than to build several single-purpose projects. Conservation of project sites is necessary because the scarcity of favorable dam sites dictates the fullest practicable development of the potential of each site.

In view of California's continuing growth in population and water demand, practices which result in the wasting of surface storage opportunities by inadequate development, without regard to future requirements for other purposes, should no longer be permitted on any stream in the State. These criteria should apply wherever storage is contemplated by the State or any other agency. In those cases where initial construction to optimum size of reservoir is currently infeasible, then provisions for future raising of the dam to full height should be incorporated in the original construction.

Careful management of California's underground storage capacity will be required not only in areas where increased use of ground water resources is expected, but also for preservation of the present level of use in those basins which are experiencing or are threatened with overdraft and deterioration of water quality. In other words, unless an effective management program is implemented in the near future, involving the maintenance of water quality and the limiting of pumping extractions within safe yield rates, the utility of the State's ground water basins cannot be perpetually maintained.



". . . water is the lifeblood of recreation and fish and wildlife."

CHAPTER III

WATER DEVELOPMENT PLANNING

The discussion and data presented in Chapter II have firmly established the fact that the number one present and future water problem in California centers around the disparities in the occurrence of water supply and requirements—both in terms of *time* and *place*. In brief review, the disparity in time refers to the natural occurrence of runoff principally during the winter and spring months and in highly varying quantities from year to year, while the requirements for water imposed by man's developments are characteristically the greatest during the summer months and are relatively uniform from year to year. The disparity in place refers to the varying distances between the sources of supply and the areas of need, with the bulk of the resources occurring in the north and the major requirements in the central and southern areas of the State. All planning and construction efforts by agencies and individuals have been and will continue to be dedicated mainly to the equalizing of the "time" and "place" factors. However, with a few notable exceptions, these efforts have in the past been limited in scope and objectives to local areas.

This chapter presents a brief historical account of water resource planning and development in California up to the present time, discusses the urgent need for comprehensive coordinated planning on a state-wide basis, and outlines the planning considerations utilized as bases for formulating The California Water Plan.

HISTORY OF WATER RESOURCE DEVELOPMENT

The history of water resource development in California has largely been that of control and regulation of the supply at its source, to insure its availability when needed, and conveyance to the area where needed. Fortunately, the greater portion of the water resources of the State so far developed and utilized have been regulated in ground water storage by nature, thus reducing the need for construction of surface storage reservoirs. Furthermore, the extensive occurrence and ready availability of ground water resources in these areas have greatly reduced the past need for extensive conveyance facilities. However, many areas of the State have been and will continue to be dependent primarily upon the development of surface water supplies. As future water requirements increase throughout the State, development of surface water supplies and transfer to areas of need will become increasingly important.

History of the use of water in California by white settlers began with the Spanish missions in the final third of the eighteenth century. Profiting by their experience in arid Baja California, the padres established most of the Alta California missions at locations where water for irrigation was available. Except for limited cultivation by Indians along the west bank of the Colorado River, it was in the mission gardens of fruits and vegetables, and perhaps in occasional fields of grain, that irrigation in California had its beginnings. Even today, more than a century and a half later, remnants of mission works to supply irrigation and domestic water may be seen, notably at San Diego Mission Dam on San Diego River, at Santa Barbara Mission Dam and Reservoir above Santa Barbara, and at Mission San Antonio de Padua near King City.

Acreage irrigated at the Spanish missions was small, yet it provided an important object lesson for American and European settlers who began arriving in California in the 1830's and 1840's. During the first two decades of American occupation, from 1850 to 1870, settlers in the southern part of California built small ditches diverting from streams of the coastal plain, mainly in the Los Angeles, San Gabriel, and Santa Ana River Basins. In the northern and central parts of the State water was also diverted from streams or obtained from artesian flows, and to a limited extent was lifted from streams with steam-driven pumps. In the foothills of the Sierra Nevada development of irrigated agriculture was accelerated by the expansion in population that accompanied and followed the Gold Rush. Mining ditches were subsequently utilized to convey irrigation supplies to areas of use after mining had ceased.

The first irrigation supplies were diverted from nearby streams, without storage, and lands irrigated were limited to those that could be watered from available low summer flows. In southern California, however, the need for storage reservoirs was soon recognized and several important dams, including Bear Valley, Hemet, Sweetwater, and Cuyamaca, were constructed or begun in the 1880's. In the remainder of the State all major storage reservoirs, primarily for irrigation and flood control, have been constructed since 1900. A number of these, such as Melones, Don Pedro, and Exchequer, were financially assisted by the hydroelectric power developed from the water stored.

Early irrigation following the Spanish and Mexican days was practiced mainly on an uncoordinated, individual basis. By 1856, however, a commercial company had constructed canals to irrigate wheat near Woodland in Yolo County, and about that time groups of settlers were joining together to build ditches in the south. Construction of larger irrigation works by development companies and cooperatives was well under way by the 1870's and 1880's, in both the southern part of the State and the central and southern parts of the San Joaquin Valley.

In 1887, the original Wright Irrigation District Act was passed by the Legislature, partly as a result of prior court decisions regarding water rights which were adverse to irrigation development. These decisions had established the doctrine of riparian rights, which largely limited the use of water to lands bordering natural stream channels. By providing for the organization and government of irrigation districts, declaring use of water for irrigation of district lands a public use, and vesting in the districts the power of eminent domain to acquire necessary water, riparian or otherwise, the Wright Act and subsequent acts which have developed from it have made possible much of the present great agricultural development of California. Activities of many individuals, cooperatives, and water utilities also have contributed to the dominant importance of irrigated agriculture to the economy of the State.

The large metropolitan areas of the State, under pressure of ever-increasing requirements and diminishing sources of undeveloped local water, have exercised initiative and leadership in solving their water supply problems. By their efforts, outstanding achievements in developing remote sources of supply and crossing mountains and deserts with extensive conveyance systems have been accomplished.

Typical of such accomplishments is the history of the City of Los Angeles which, as far back as 1905, had outgrown its local water supplies and had initiated studies to locate additional sources of water. These studies culminated in construction of a 238-mile aqueduct to convey waters developed on the Owens River, on the eastern slopes of the Sierra Nevada, to terminal reservoirs in the San Fernando Valley. This project was completed in 1913, and in 1940 the system was extended northward to develop additional supplies from the Mono Basin watershed. The present average capacity of the Los Angeles Aqueduct is estimated at 320,000 acre-feet per season. The system operates entirely under gravity flow, except that during periods of extreme drought the surface runoff has been augmented by pumping from wells in Owens Valley. Hydroelectric power generating installations are provided to utilize the substantial elevation differentials along the route of the aqueduct.

Ten years after completion of the Los Angeles Aqueduct, the City of Los Angeles and other communities in southern California foresaw the need for additional water supplies. Studies of the possibilities of importing water from the Colorado River were initiated by the Los Angeles Department of Water and Power, but were taken over in 1928 by The Metropolitan Water District of Southern California, then a newly formed organization of 11 southern California cities. The studies culminated in construction by the district of the Colorado River Aqueduct, which diverts water from the Colorado River at Lake Havasu behind Parker Dam. The water is lifted 1,617 feet over mountain barriers by a series of five pumping plants, and conveyed a distance of 242 miles to Lake Mathews, western terminus of the aqueduct proper. A distribution system from Lake Mathews serves lands in Los Angeles, Orange, Riverside, and San Bernardino Counties. The San Diego Aqueduct, a twin-barrelled conduit, conveys water from the Colorado River Aqueduct to San Diego County. The Colorado River Aqueduct, in operation since 1941, is the longest and largest domestic water supply line in the world. It is designed to deliver 1,212,000 acre-feet annually, the total right of the Metropolitan Water District, when completed to full capacity. It is now estimated that this source will furnish ample water for perhaps 10 or 15 years, at which time another and even longer step must inevitably be taken.

Other outstanding examples of initiative and leadership in water supply development in California are manifested by the major reservoirs constructed by communities of the San Francisco Bay Area on the Mokelumne and Tuolumne Rivers on the western slope of the Sierra Nevada, and the aqueducts which convey municipal and industrial water great distances to the Bay area, the South Bay area, and southern portions of Alameda County. The City and County of San Francisco foresaw many years in advance that its locally available water supply would be outgrown, and initiated planning studies as early as 1900 for developing a major system for importing large quantities of water from a distant source. The Tuolumne River system was chosen as the source of San Francisco's future water supply, and by 1934, when needed, Hetch Hetchy Reservoir and Lake Eleanor in the Tuolumne River watershed had been completed and water was delivered to the San Francisco Peninsula by the Hetch Hetchy Aqueduct, extending some 135 miles from the Tuolumne River to Crystal Springs Reservoir on the peninsula.

The Hetch Hetchy Aqueduct features a 25-mile tunnel through the Coast Range, the longest tunnel in the world at the time of completion. The aqueduct will convey not less than 448,000 acre-feet per season to the service area, as now constituted, of the Hetch Hetchy system when that system is developed to its ultimate capacity. This will require additional storage and duplication of present conveyance facilities, including a parallel bore through the Coast Range.

". . . the East Bay area . . . has developed the waters of the Mokelumne River . . ."
Pardee Dam

". . . water pumped from the Delta for use in Contra Costa County."
Contra Costa Canal

The many communities in the East Bay area, through the formation of the East Bay Municipal Utility District, have developed the waters of the Mokelumne River by Pardee Reservoir, and have constructed the Mokelumne Aqueduct to transport the developed waters from Pardee Reservoir to terminal reservoirs in western Contra Costa and Alameda Counties. The aqueduct presently delivers about 125,000 acre-feet per season, and has a conveyance capacity of some 162,000 acre-feet per season. The district contemplates an ultimate yearly delivery of 364,000 acre-feet through the Mokelumne Aqueduct. The district proposes to construct additional storage facilities on the Mokelumne River and additional aqueduct capacity to make this delivery possible.

All the aforementioned water supply projects have been conceived and consummated through local effort. However, especially during the past 20 years, federal agencies have entered the field of water resource development in California. The Corps of Engineers of the United States Army, through its responsibilities for flood control and navigation, as previously mentioned in Chapter II, and the Bureau of Reclamation of the Department of the Interior, in the interests of conservation and reclamation, have both constructed comprehensive projects. The most extensive of these is the Central Valley Project, now being completed in substantial accord with the State Water Plan, as published in Division of Water Resources Bulletin No. 25 and reported to the Legislature in 1931.

The Central Valley Project, constructed and operated by the Bureau of Reclamation, is a multipurpose development designed to supply water for irrigation, municipal, industrial, and other uses, improve navigation on the Sacramento River, provide adequate flows to maintain suitable water quality in the Sacramento-San Joaquin Delta, control floods in the Central Valley, and produce hydroelectric energy. In accomplishing the first-named function, it conserves surplus flows of the Sacramento River for use in the Sacramento Valley and in the Delta and for conveyance to and use in the San Joaquin Valley. Shasta Dam, key structure of the project, stores headwaters of the Sacramento River. Its regulated releases, after passing through hydroelectric power plants at Shasta and Keswick Dams, flow down the stream channel to the Sacramento-San Joaquin Delta. A pumping plant located near Tracy lifts water from sea level in the Delta to an elevation of about 200 feet and discharges it into the Delta-Mendota Canal, which extends 117 miles along the west side of the San Joaquin Valley to Mendota Pool in the San Joaquin River.

The second major element of the Central Valley Project consists of Friant Dam on the San Joaquin River and the Madera and Friant-Kern Canals. This unit supplies lands on the east side of the San Joaquin Valley in Madera, Fresno, Tulare, and Kern Counties. These diversions from the San Joaquin River are partly replaced by Sacramento River waters at Mendota Pool to supply certain former users of San Joaquin River flows under an exchange contract.

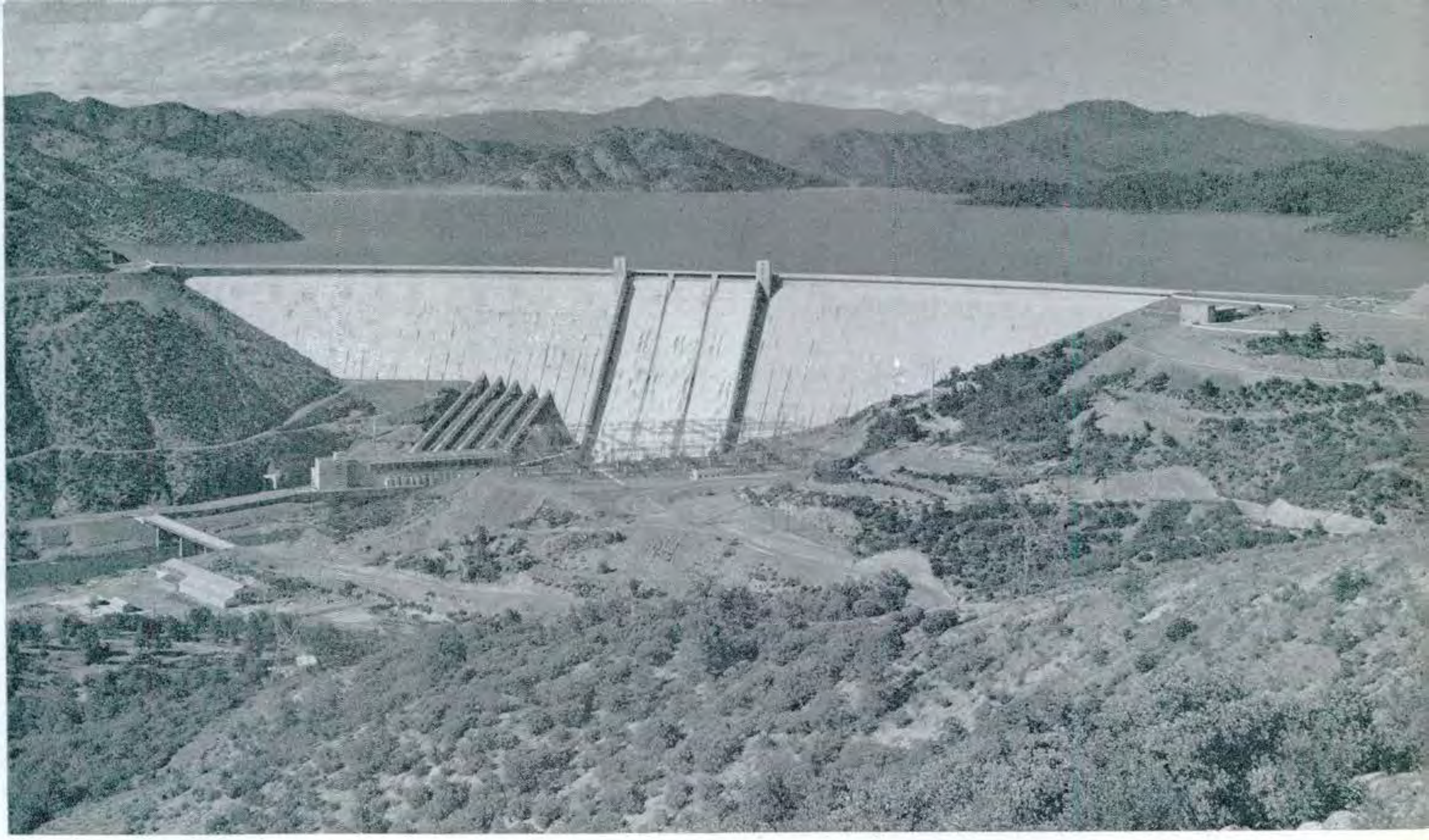
These basic elements of the Central Valley Project are augmented by additional associated units. The transfer of Sacramento River water across the Delta to the Tracy Pumping Plant is accomplished by the Delta Cross Channel. The Contra Costa Canal conveys water pumped from the Delta for use in Contra Costa County. A number of lesser conservation, conveyance, and distribution works provide additional water service, and an extensive transmission network has been established to facilitate utilization of energy from the several power features of the project.

Folsom Dam on the American River, now completed, will contribute to the over-all operations of the Central Valley Project. Consideration is now being given to the so-called Folsom South Canal to convey releases from Folsom Reservoir southward to supply lands in Sacramento and San Joaquin Counties. Latest addition to the Central Valley Project is the Trinity Project, incorporated in the original State Water Plan but later eliminated by action of the State Legislature. This unit, the only feature of the project extending beyond the Central Valley watershed, is now under construction. It will develop flows of the upper Trinity River and convey them eastward across the drainage divide to the Sacramento River, utilizing the elevation differential for production of hydroelectric power. It should be noted that Folsom Reservoir and Trinity Diversion Project, although incorporated in the Central Valley Project, as authorized by the Federal Government, and included in The California Water Plan, are not included in the Central Valley Project as defined in the State Water Code.

Several other projects have been completed recently or are under construction in the State by the Federal Government. The Solano Project of the Bureau of Reclamation consists of Monticello Dam and Reservoir on Putah Creek, now completed, and the Putah South Canal extending southerly through Solano County, presently under construction. The Sly Park Project, recently constructed by the Bureau of Reclamation, develops water in the mountain watershed of the Cosumnes River and conveys it to the American River Basin for use on foothill lands.

The Corps of Engineers has completed Pine Flat Reservoir on the Kings River and Isabella Reservoir on the Kern River for flood control and irrigation. The Corps is initiating construction of the Success Project on the Tule River and is preparing plans for construction of the Terminus Project on the Kaweah River, both also for flood control and water conservation.

In the Central Coastal Area the Bureau of Reclamation is constructing Vaquero Reservoir on the



"The Central Valley Project . . . conserves surplus flows of the Sacramento River for use in the Sacramento Valley . . . the Delta . . . and in the San Joaquin Valley."

Shasta Dam
Delta-Mendota Canal

Cuyama River, a tributary of the Santa Maria River. This reservoir will provide water conservation for recharge of ground water and flood control. In coordination with a levee project authorized for construction by the Corps of Engineers on the Santa Maria River, nearly complete flood protection will be provided in the Santa Maria Valley. Cachuma Reservoir, recently completed by the Bureau of Reclamation on the Santa Ynez River, provides supplemental water in Santa Barbara County. The Bureau of Reclamation also is constructing Casitas Reservoir on Coyote Creek, a tributary of the Ventura River, to increase supplemental water supply in Ventura County.

Several reservoir projects are presently under consideration by the Bureau of Reclamation, including Auburn Reservoir on the American River and San Luis Reservoir westerly of Los Banos in the San Joaquin Valley.

The United States Department of Agriculture under the authority of the federal "Watershed Protection and Flood Prevention Act" as amended, is participating to an increasing extent in water resource control and development in California. The federal legislation authorizes the Department of Agriculture in cooperation with the states and their political subdivisions to investigate, to provide financial and other assistance, and to undertake works of improvement for: (1) flood prevention, including structural and land treatment measures; and (2) the conservation, development, utilization, and disposal of water for all purposes and uses. The act provides that initial applications for projects be submitted to the appropriate state agency or the governor, and if not disapproved within 45 days, the Secretary of Agriculture may approve and proceed with the investigation, negotiations for, and construction of the proposed works. Projects are limited to watershed areas not exceeding 250,000 acres, and reservoirs are limited to a capacity not exceeding 2,500 acre-feet, unless specific congressional approval of larger reservoirs is given.

Despite the foregoing limitations on size of projects, this program if undertaken on a large scale may have far-reaching consequences in the development of California's water resources. It is therefore of primary importance that the closest coordination and cooperation be maintained as to these projects during planning and later stages among the state agencies concerned with land and water resource development, the federal agencies, and the local agencies involved. The coordination should be initiated long before official submission of proposals to the State for approval or disapproval, in order that the availability and the best use of the water resources involved may be determined and agreed upon.

Waters of the Colorado River are of vital importance to the developed economy of southern California. In addition to supplying The Metropolitan Water District of Southern California through the Colorado River Aqueduct, these waters are utilized to irrigate lands in Palo Verde, Imperial, and Coachella Valleys. The All-American Canal, built by the Bureau of Reclamation and now operated by the Imperial Irrigation District, originates at Imperial Dam on the Colorado River near Yuma and extends westerly across Imperial Valley along the California side of the Mexican border. The canal has an intake capacity of about 10,000 second-feet. Near the boundary of the Imperial Irrigation District, the Coachella Canal branches northward from the All-American Canal to supply lands along the eastern shore of the Salton Sea and in lower Coachella Valley. It should be noted that the All-American system, in common with the Colorado River Aqueduct, is dependent upon Hoover Dam and its reservoir, Lake Mead, for regulation of the Colorado River.

The foregoing water supply projects by no means represent the entire existing water development picture for California. Projects of lesser magnitude, though not necessarily of secondary significance, transport supplies to areas of use in other drainage basins. Localized conservation developments, many of them incorporating flood control and hydroelectric power features, constitute a large factor in the State's water supply program.

Not to be overlooked in the history of water supply development in California are the ground water reservoirs, which at present furnish more than one-half the water used on irrigated lands and for domestic, municipal, and industrial purposes. Extensive development of ground water is concentrated largely in the Central Valley and southern California, and consists primarily of a multitude of individually owned installations operated on a completely uncoordinated basis. Improvement of pumping equipment, and extension of electric power service generally over most of the important ground water basins since the turn of the century, together with the rapid growth of water requirements, particularly in recent years, have so stimulated development that in many basins the ground waters have been severely overdrawn. Serious losses have already resulted and more will follow until corrective measures are taken. The Raymond Basin area in Los Angeles County provides an example of properly managed ground water resources. This resulted from court action. Similar actions are in process for the West Coast Basin in Los Angeles County and the Tia Juana Basin in San Diego County.

Perennial lowering of ground water levels has been substantially retarded in several ground water basins by artificial recharge with both native and imported waters. About 25 public districts and private entities of various types are presently conducting such programs. Essentially, artificial recharge involves the use of stream channels, spreading basins, or abandoned gravel pits to supplement natural percolation. The recharge capability of these percolation works is commonly increased by detention of excess runoff in upstream reservoirs and the control of releases to rates within the percolation capacity of the works.

Notable achievements in artificial recharge have been accomplished by the Los Angeles County Flood Control District, the Orange County Flood Control District, United Water Conservation District in Ventura County, San Bernardino County Flood Control District, Santa Clara Valley Water Conservation District, and Kern County Land Company, among others.

COMPREHENSIVE COORDINATED PLANNING AT STATE-WIDE LEVEL

A great deal of progress has been made so far in the development of California's water resources. No one can refute the fact that the initiative and resourcefulness of local agencies in planning and constructing water development projects has been largely responsible for the present highly developed level of economy throughout the State. The assistance of the Federal Government has been most helpful. However, the growth of the State, made possible by the progressive development of water supplies, has constantly created new water problems, each of which has become successively more difficult of solution. All too often, limited planning for the future has resulted in construction of works sufficient only to meet the needs of the present, as growth throughout the State has continued at rates exceeding even the most optimistic forecasts.

The great water development projects conceived and constructed in the past, notable as they are and vital to the State's development as they have been, represent comparatively localized planning when considered from the state-wide standpoint. Even the Central Valley Project, a revolutionary plan when conceived and a phenomenal development as it is being constructed, is limited in its scope and benefits to a comparatively small part of the State as a whole, notably portions of the Sacramento Valley, the Sacramento-San Joaquin Delta, and of the San Joaquin Valley. It is but a magnification of what some 100 irrigation and reclamation districts have done on their own initiative with local financing. Without such local projects constructed in the past, however, California for the most part would still be a semiarid wasteland.

Because of the dictates of economics, which governs water development as well as all other engineering projects, the cheapest and easiest-to-develop water projects have always been selected first for construction. Naturally, local water supplies were developed first. Development of water from distant sources and conveyance through lengthy and costly aqueducts have been resorted to only after available local supplies have become insufficient. The same principle of economics has prevailed in the selection of alternative sources of imported water supplies. Thus, we are now faced with the inevitable consequences: future water development in California must involve "leftover" local projects and costly major import projects which are generally beyond the means of all but a very few local agencies.

Today, there is increasingly severe competition between areas and between uses for the remaining available water resources. In some streams there is no remaining unappropriated water available for the further development of areas which should logically be served therefrom. As previously mentioned, several of the major ground water basins are seriously overdrawn.

In view of this and of the previously discussed wide disparity between the occurrence of the State's water resources and needs, both as to time and place, it is apparent that the era of piecemeal water development planning and construction virtually has reached an end. Future development of the State's water resources must rely, to a constantly increasing extent, on coordinated, comprehensive planning on a state-wide level if the needs of all areas and all uses are to be met in the most effective and economical manner. The need for such planning is continually becoming more evident as undeveloped local water resources diminish and development of supplemental supplies becomes more complex, while water requirements increase in unprecedented proportions.

The purpose of such coordinated, state-wide planning must be to establish a framework into which all future water development projects, both local and state-wide, can be integrated, and which will serve as a guide to ensure optimum development and utilization of available water resources, with due consideration to the varying interests and uses involved. This is the objective of The California Water Plan. It will serve as the engineering basis for proper administration in the public interest of the State's water resources by the various agencies involved. It will provide the means for badly-needed coordination in further planning and in the construction and operation of water projects among the manifold entities, federal, state, local, and private, engaged in water control and development in California.

A continuing, coordinated, state-wide, planning program, implemented progressively by the construction of projects as necessary and justified, is the only means by which the logical, orderly, and economic development of California's water resources can be assured to the degree necessary to meet the ultimate requirements for all uses. The construction of projects to accomplish the objectives of the planning program will undoubtedly require the combined efforts of the Federal Government, the State Government, and local entities, but the State logically must take a leading role, since much of the development that will be needed is outside the scope of federal interest and beyond the capabilities of local entities. Further, the magnitude of the job to be done will require the financial support of all agencies involved.

PLANNING FOR DEVELOPMENT OF CALIFORNIA'S WATER

Solution of California's water problems will not be fully accomplished until the water resources are captured and controlled at their source, transported to areas of need, and reregulated to the demand schedules prevailing in the particular areas served in amounts sufficient to meet the ultimate requirements for all beneficial uses. The indicated solution will involve the redistribution of water supplies for use in local areas, and the transfer on a state-wide basis of water from northern areas of abundance to central and southern areas of deficiency. Thus, the planning of projects necessary for achievement of the required degree of water resource development to meet the ultimate requirements involves three primary considerations, each of which presents difficult but not insurmountable obstacles. As presented herein, these considerations concern the development of a solution of ultimate problems, but do not cover the many phases of interim uses and transfers of water that would inevitably occur during the step-by-step implementation of the ultimate plan.

Capture and Control of Water

The first consideration—capture and control of the water at its source—involves the planning of large surface storage reservoirs and substantial ground water storage to regulate the inherent seasonal and cyclic fluctuation of stream flow to a more or less uniform seasonal supply, for conveyance to areas of use both local and distant. Actually it is the variation of runoff from year to year, rather than that within the season, that imposes the large storage requirements, as sufficient storage must be available to capture surplus water during wet periods to carry through subsequent extended drought periods. Were it not for the variable or cyclic occurrence of the water resources, the storage requirement would be greatly reduced. The enormous storage requirement, as subsequently developed in this bulletin, probably could be met by surface storage alone on the north coast streams. However, full cyclic regulation of the flow of the Sacramento Valley streams would necessitate not only full development of all available surface storage opportunities but also conjunctive operation of the large underground reservoirs in the Sacramento and San Joaquin Valleys. Some 30 per cent of the developed runoff of the Sacramento Valley would need to be regulated by underground storage. This in turn would require the provision of conveyance canals adequate in capacity to transport this secondary water, of irregular occurrence and variable flow characteristics, to the areas of recharge of the underground storage basins.

Conveyance to Areas of Need

The second consideration—the conveyance of water over long distances to areas of need—involves large conduits which must pass over or through either or both the Coast Range and Tehachapi Mountains, and which would extend practically from the northern to the southern borders of the State. Economic and geologic considerations dictate the design of such conduits generally for continuous year-round conveyance of a uniform quantity of water, in order to minimize the size of tunnels, pumping plants, canals, siphons, and other conveyance facilities. In certain cases, however, pumping plants and conduits would be designed for larger capacities to enable the use of lower cost off-peak power. Moreover, conveyance of the variable seasonal secondary water from the Sacramento Valley to the San Joaquin Valley would necessitate the design of certain conduits to the maximum rather than the average seasonal flows. Even at their minimum possible size wherever possible, conveyance facilities required for interbasin transfer of water under ultimate conditions would be without precedent in magnitude and scope.

Reregulation in Areas of Use

Finally, the third consideration— the reregulation of delivered water to the monthly demand schedule prevailing in the areas of use—involves the planning of terminal storage reservoirs to regulate the largely uniform deliveries to the varying monthly demands for the various uses in the areas served. Because the bulk of the water would be delivered to most areas on a uniform seasonal basis, the required terminal storage facilities would be relatively small. However, in areas such as the San Joaquin Valley, where a portion of the supplemental water would be delivered on a variable basis from year to year, final regulation would be accomplished by use of ground water storage to a very large extent.

Development and Use of Water

In addition to the foregoing considerations of development, conveyance, and reregulation of water, planning for the ultimate solution of California's water problems also requires the consideration of other physical problems brought about by the development and use of water. Those problems associated with the development of water involve the operation of reservoirs for the several beneficial, although somewhat incompatible, purposes of providing municipal, irrigation, and industrial supplies; flood control; fish and wildlife; recreation; navigation; and power generation. Problems associated with the use of water involve the consideration of protection of water quality and provision for adequate drainage. Means of financing, although involving problems vital to the effectuation of the vast system of works necessary to the solution of California's water problems, are beyond the scope of planning considerations presented herein.

Certain basic legal concepts are inherent in the planning considerations necessary to the solution of California's water problems. Minimum possible interference with vested water rights is a major objective. However, some instances of conflict with vested rights are inevitable in a plan of such magnitude. In those instances of interference and to the extent vested rights might be adversely affected, the interference would have to be adjusted either by agreement, purchase, or condemnation. Exchanges of water, where necessary or desirable, would be accomplished by mutual agreement among the parties affected, including the State and Federal Government where pertinent. With respect to the protection of areas of origin of water and the areas of deficiency for which new water supplies must be made available, it is assumed that the legislation necessary to provide that protection would be enacted prior to its need. Similarly, with regard to ground water operations, it is assumed that necessary legislation would establish the policy and the authority which would enable the operation of ground water basins to the degree required under ultimate conditions, prior to the time such operation becomes necessary. Many other legal problems are certain to arise as the water resources are developed. For the purposes of this report it is assumed that they will be solved as the need arises.

Development of Water. As previously stated, problems associated with the development of water involve the operation of reservoirs for the somewhat incompatible purposes of providing municipal, irrigation, and industrial supplies; flood control; fish and wildlife; recreation; navigation; and power generation. This statement refers to the problem of resolving the inherent conflict in the allocation of limited available reservoir storage to each of those purposes. As an example, operation for flood control sometimes requires the use of storage that might otherwise be used for conservation. Operation for power generation similarly may encroach upon conservation storage, because of the required minimum storage for maintenance of power head. Moreover, the schedule of power releases is not in phase with the schedule of releases for irrigation purposes, although a large portion of the conservation releases also accomplishes the dual purpose of power generation. Operation of reservoirs for water supply, flood control, and power generation is not readily amenable to recreational use of the reservoir area because of the extreme and sometimes rapid fluctuations of water levels. Furthermore, reservoir releases for downstream fishery enhancement may adversely affect the conservation yield for other purposes. Conversely, any major storage structure would affect anadromous fish by blocking their passage to upstream spawning areas, necessitating the provision of adequate facilities for maintaining the fisheries resources. To minimize the effects of these conflicts and thus achieve the maximum degree of conservation consistent with the manifold benefits desired, carefully coordinated operation of multipurpose reservoirs is mandatory.

All of the foregoing purposes of water development are vitally necessary and must be fully considered in planning for the solution of the State's water problems. Such planning involves consideration of certain reservoirs to be operated solely for flood control, other reservoirs to be operated solely for fish and wildlife and recreational purposes, and certain reservoirs to be operated primarily for power generation. However, most major reservoirs would be operated for all of these and other beneficial purposes.

1. *Flood Control.* It should be pointed out that, in addition to planned operation for flood control, a measure of incidental flood protection would be derived from operation of any storage reservoir. However, storage capacity sufficient to contain all flood waters would require extremely large and expensive reservoirs. Generally, it is not feasible to attain complete conservation and flood control by storage alone. Improvement of downstream channels in combination with upstream storage reservoirs will probably provide the most economic solution to the important problem of flood control in California. Flood control has in the past and will continue to be largely a joint endeavor between the United States, the State, and local public interests.

2. *Recreation, Fish, and Wildlife.* Outdoor recreation and fish and wildlife conservation are essential considerations in planning for water resource development. When reservoir storage is contemplated on streams with recreation potential, sufficient reservoir releases must be planned to maintain favorable downstream conditions for recreational pursuits and propagation of fish life. Planning of major dams which would block passage of migratory fishes to their ancestral spawning grounds requires the concurrent planning of fish ladders, substitute fish hatcheries, or spawning ground, or development of other streams solely for fish life as compensatory measures. Planning for recreational purposes also involves the contemplated operation of reservoirs dedicated solely to the improvement of summer stream flow conditions in popular recreational areas where such flows are presently deficient.

"Generally, it is not feasible to attain . . . flood control by storage alone."
Sacramento Weir on Sacramento River

". . . hydroelectric power as an inseparable part and partner in California's water resource development is a fully recognized requisite . . ."
Electra Power Plant on Mokelumne River

At the time of acquisition of lands, easements, and rights of way for reservoirs and other water development works, additional lands should be included for public access and for development and use of recreational opportunities. Likewise, at the time water resource development planning is done, planning by those state, federal and local agencies responsible for associated recreational opportunities should be accomplished.

3. *Power Generation.* The essential role of hydroelectric power production in the further development of California's water resources and economy was discussed in Chapter II. As therein stated, the problem will be to make each hydroelectric power opportunity yield the maximum feasible output in terms of firm capacity, energy, and revenue, consistent with the other demands for the water resources concerned. Major planning considerations include in each case: determination of the most economic combination of height of dam, dead storage, head, and releases for power in balance with releases for other purposes; provision for generation of the most economically favorable peaking power capacity and energy, wherever pertinent, which includes adequate afterbay storage and forebay storage as needed; and utilization of power drops along major aqueduct routes where feasible, particularly on the descending side of mountain crossings. A possible future power opportunity may develop in the form of pumped storage power plants which would use low-cost off-peak power from other sources for pumping to a reservoir at a higher elevation and would generate high-value peaking power on return of the water to an afterbay or to the aqueduct system.

Use of Water. Delivery and use of supplemental water supplies in areas of need will solve the problems of water deficiency and directly resultant problems; but unless precautions are taken, other problems may result as a consequence. Of these corollary problems, water quality is one of the most significant. This is particularly serious in areas overlying ground water basins which are utilized to any appreciable extent in meeting the water requirements. The problems in point concern the protection of mineral quality of the local ground waters by importing waters of good mineral quality, by maintenance of proper salt balance, and by the maintenance of favorable drainage conditions through control of the ground water levels by pumps and drainage systems. Maintenance of proper quality in surface streams is equally important. Another serious problem is that of subsidence of lands, caused by heavy withdrawals of ground water and by application of surface water.

1. *Protection and Maintenance of Water Quality.* The basic objective with regard to quality of water in the State under ultimate development concerns the assurance that the available waters will meet the minimum quality requirements for all beneficial uses thereof. Planning toward this objective involves the evaluation of the native quality of waters in terms of their suitability for such uses, the careful maintenance of quality in areas of use, and protection of the quality of water in source areas in streams and reservoirs and of exported waters from degradation during transfer, at requisite levels to prevent injurious effects.

With respect to the suitability of waters for beneficial uses, certain minimum quality requirements have been set forth, and are generally accepted as standards for classification of waters for the various uses. Probably the most widely accepted standards are those formulated by the United States Public Health Service for drinking water, as shown in Table 5.

TABLE 5

MINERAL STANDARDS FOR DRINKING WATER

U. S. Public Health Service, 1946

(In parts per million)

Constituent	Limit
Mandatory limits	
Fluoride (F)	1.5
Lead (Pb)	0.1
Selenium (Se)	0.05
Hexavalent chromium	0.05
Arsenic (As)	0.05
Nonmandatory but recommended limits	
Iron (Fe) and manganese (Mn) together	0.03
Magnesium (Mg)	125
Chloride (Cl)	250
Sulphate (SO_4)	250
Copper (Cu)	3.0
Zinc (Zn)	15
Phenol	0.001
Dissolved solids	500 (1,000 permitted)

Quality requirements for irrigation water have been proposed by various investigators. Classifications of irrigation water presently in use by the Department of Water Resources are based on studies of the University of California at Davis. One such classification is set forth in Table 6. The classes shown in Table 6

TABLE 6

QUALITATIVE CLASSIFICATION OF IRRIGATION WATERS

Chemical properties	Class I	Class II	Class III
	Excellent to good	Good to injurious	Injurious to unsatisfactory
Total dissolved solids:			
In ppm*	Less than 700	700-2,000	More than 2,000
In conductance, $Ec \times 10^6$ at 25°C	Less than 1,000	1,000-3,000	More than 3,000
Chlorides, in ppm	Less than 175	175-350	More than 350
Sodium, in per cent of base constituents	Less than 60	60-70	More than 70
Boron, in ppm	Less than 0.5	0.5-2.0	More than 2.0

* ppm—parts per million.

are generally empirical, being based on average soil and crop adaptability.

Recent research has been conducted at the University of California at Davis, taking into account drainage characteristics of the soil and employing revised standards for evaluation of salinity of irrigation waters. These standards, which are coming into more general use, are presented in Table 7. Water quality standards will undoubtedly change in the future as a result of further study. Hence the standards given herein should not be regarded as absolute.

TABLE 7

TENTATIVE CLASSIFICATION FOR EFFECTIVE SALINITY OF IRRIGATION WATER

Soil conditions	Terms used	Class of water		
		I[1]	II	III[2]
Little or no leaching of the soil can be expected.	m.e./l[3] of ions ppm lbs/acre-foot	3 165 450	3-5 165-275 450-750	5 275 750
Some leaching but restricted. Deep percolation or drainage slow.	m.e./l of ions ppm lbs/acre-foot	5 275 750	5-10 275-550 750-1500	10 550 1500
Open soils. Deep percolation of water easily accomplished.	m.e./l of ions ppm lbs/acre-foot	7 385 1050	7-15 385-825 1050-2250	15 825 2250

[1] Upper limit—maximum limit.
[2] Lower limit—minimum limit.
[3] m.e./l—milli-equivalents per liter.

Planning considerations with respect to water quality involve the following: provision for protecting the mineral and sanitary qualities of waters at requisite levels; determination of natural base levels of radioactivity to facilitate the detection of any future increase in radioactive contamination; determination of the waste assimilation capacity of the various waters concerned, or, in other words, the degree to which these waters can be used for waste disposal without adverse and unreasonable detriment to the beneficial uses, considering future as well as present uses thereof; the necessity of providing water to dilute and carry away waste products resulting from man's activities without harmful effects; planning for further urban and industrial development with due regard to the problems of waste disposal; and maintenance of a favorable salt balance in the many basins of the State by provision for exporting from each basin at least as much salt as is brought into it each year by native and imported waters, as well as from other sources.

Because of the widely varying quality requirements for the manifold industrial uses, these requirements are not discussed in this chapter. Such information will be published in Appendix E to this bulletin. In general it may be said that waters meeting the United States Public Health Service drinking water standards and the requirements for irrigation can be made acceptable for even the most exacting industrial requirements by proper treatment at the point of use.

With respect to maintenance and enhancement of fish and wildlife, the maintenance of adequate dissolved oxygen in the water and freedom from toxic concentrations of harmful materials are prime considerations. Also important are low turbidity and freedom from floating oil and grease. Further, high-quality water is necessary for maintaining a suitable habitat, food supply, and spawning areas.

With respect to the quality of water necessary for the full effectuation of The California Water Plan, a Board of Water Quality Consultants, retained to advise on water quality problems under the ultimate pattern of water transfer and use, has submitted a report recommending specific limits of quality for water diverted from the southern boundary of the Sacramento-San Joaquin Delta.

These recommendations, as presented in Table 8, have been adopted by the Department of Water Resources as the quality objectives to be met at the points of diversion for water to be exported to the major areas of deficiency. These objectives have been used in formulation of The California Water Plan, and unless the quality is maintained at or higher than these levels, full implementation of the Plan will not be possible.

TABLE 8

WATER QUALITY LIMITS FOR WATER FOR EXPORT AT POINTS OF DIVERSION AT SOUTHERN BOUNDARY OF SACRAMENTO-SAN JOAQUIN DELTA

RECOMMENDED BY BOARD OF CONSULTANTS ON WATER QUALITY AND ADOPTED BY DEPARTMENT OF WATER RESOURCES

Item	Limit
Total Dissolved Solids	400 ppm
Electrical Conductance (Ec $\times$ 10[6] at 25°C)	600
Hardness as $CaCO_3$	160 ppm
Sodium Percentage	50%
Sulphate	100 ppm
Chloride	100 ppm
Fluoride	1.0 ppm
Boron	0.5 ppm
pH Value	7.0-8.5
Color	10 ppm
Other constituents as to which the U. S. Public Health Service has or may establish mandatory or recommended standards for drinking water	USPHS Limits

2. *Maintenance of Drainage.* Drainage of agricultural lands, already a serious problem in many areas of California, will become an increasingly important consideration in planning for the future development and use of California's water resources. The large imports of water and the greatly increased application of water, under ultimate conditions would aggravate present drainage problems, would create new problems by forming swamps or "water-logged" areas in the lower portions of ground water basins, and would increase the probability for salinization of

the soils unless prevented by appropriate measures. The existence of high-water-table areas and increased salinity problems would not only preclude the usefulness of large areas of potential agricultural lands, but would result in excessive, uneconomic consumptive use by swamp-type vegetation of water which otherwise could be salvaged for beneficial purposes.

Solution of drainage problems will involve consideration of drainage ditches and canal networks, and pumps to control the elevation of the water table in areas subject to waterlogging. In addition, studies should be made relative to the permeability of soils, particularly with regard to reclamation of vast acreages of presently saline and sodium saturated lands. Methods employed under ultimate development probably would be similar to present practices in the San Joaquin Valley, but on a broader scale. A further consideration in planning for drainage is the point of disposal of highly saline drainage waters. For the San Joaquin Valley, for instance, this may necessitate a master drain emptying into Suisun Bay.

3. *Subsidence.* Subsidence of the land surface presents unusual and difficult problems which must be considered in planning for the major conduits required for transportation of water to central and southern areas of deficiency. The most serious subsidence now is in the San Joaquin Valley, where sinking of the land surface has changed the gradient of a portion of the Delta-Mendota Canal of the U. S. Bureau of Reclamation enough in places to reduce its capacity. Subsidence also has damaged canals, wells, and pipe lines of numerous irrigation systems, as well as oil and gas pipe lines, electric transmission towers, and numerous buildings. Two separate types of subsidence have been identified in the San Joaquin Valley, namely: (1) regional or deep-seated, subsidence, and (2) local shallow subsidence.

The deep-seated subsidence is believed to be caused by withdrawal of ground water from pressure aquifers, the lowering of the pressure head being accompanied by sinking of the land surface. A related type of subsidence has occurred in the Long Beach area, where subsidence accompanying heavy withdrawals of oil has caused actual or threatened surface advance of the sea into certain areas. The deep-seated subsidence in the San Joaquin Valley is occurring principally on the west side of the valley in an elongated area stretching from north of Mendota to south of Huron, and in the southern part of the valley in an irregularly shaped area centering near Delano. The maximum amount of subsidence in the Mendota-Huron area is actually greater than 16 feet, and the area is presently subsiding at a rate of almost 1 foot per year. It is the effect of this deep-seated subsidence which has changed the gradient of the Delta-Mendota Canal. The maximum subsidence in the Delano area amounts to more than 13 feet. Other areas in the State, such as the Santa Clara Valley, also are affected by subsidence.

Notwithstanding the adverse effects from deep-seated subsidence, the local shallow type of subsidence probably has the potential to cause most damage to man-made structures. This type of subsidence occurs when water is applied in quantity, as by irrigation, on certain low-density soils which occur extensively on the semiarid west side of the San Joaquin Valley. Settlement of this type of land after irrigation is very irregular and causes heavy sinking of irrigation ditches, breaking of concrete-lined ditches and of pipe lines, tilting of high tension towers, and cracking and breaking of foundations of buildings after lawn irrigation which, in places, has caused houses to tilt at strange angles.

The areas affected by shallow subsidence extend around the western and southern borders of the San Joaquin Valley, at the base of the Coast Range. Local subsidence of 10 feet and more has occurred in locations where unlined ditches were attempted in earlier days. The surface of an experimental test plot, kept under water continuously for several months during 1956 and 1957, has subsided 7 feet in 7 months. Although the mechanism of shallow subsidence is not clear, it probably involves rearrangement and compaction of soil particles when wetted, accompanied perhaps by removal of gypsum and other solubles by solution.

Shallow subsidence also has occurred in the peat lands of the Sacramento-San Joaquin Delta, where much of the land is now below sea level, resulting in severe flood control problems. This subsidence may be due to a lowering of the water table, consumption of peat by plant growth, drying and blowing away of the peat by wind, or a combination of these and other factors.

The magnitude of the effect of subsidence on planning the routes and design of major conduits for transportation of water from north to south is evidenced by the large areas subject to subsidence, which must be either crossed or detoured. In addition to subsidence of peat lands in the Delta, which must be crossed by all water transferred to the central and southern portions of the State, there are more than 70 miles of lands along the contemplated conduit routes in the Mendota-Huron area which are subject to both shallow and deep-seated subsidence. Moreover, along these routes, some 50 miles of lands south of Kettleman City and Tulare Lake and 20 miles of lands south of Buena Vista Lake are subject, at least in part, to shallow subsidence.

Faced by these conditions, the Department of Water Resources is actively investigating the causes and mechanisms of land subsidence in cooperation with a number of other state and federal agencies, coordinated by the Inter-Agency Committee on Land Subsidence in the San Joaquin Valley.

CHAPTER IV

THE CALIFORNIA WATER PLAN

The water problems of California and the need for comprehensive planning have been described in the preceding chapters. This chapter presents a summary discussion of the physical features and accomplishments of the works which would fulfill the objectives of The California Water Plan in the solution of those problems. To facilitate a greater appreciation and better understanding of the Plan, its scope and objectives and the concepts basic to the attainment of its objectives should be clearly borne in mind, and are re-emphasized for this purpose in the following paragraphs.

The California Water Plan is a master plan for the control, conservation, protection, and distribution of the waters of California, to meet present and future needs for all beneficial uses and purposes in all areas of the State to the maximum feasible extent. It is a comprehensive plan which would reach from border to border both in its constructed works and in its effects. The Plan is a flexible pattern susceptible of orderly development by logical progressive stages, the choice of each successive incremental project to be made with due consideration to the economic and other pertinent factors governing at the particular time.

The water development works described in this chapter and shown on the plates accompanying this bulletin demonstrate one means believed practicable of accomplishing the objectives of The California Water Plan in each area of the State, based on presently available knowledge. As knowledge increases, as technology improves, as conditions change through the years, and as future patterns of development become more easily discernible, more suitable alternatives to any feature or features herein discussed are likely to be found. It is the intention that as the time approaches for construction in any given area, further studies will be made to determine the most feasible solution in the light of conditions then obtaining. That solution may depart considerably from the Plan as now conceived. In the meantime, the elements of The California Water Plan presented herein will provide a basis of comparison with other alternatives, and furthermore, will serve as a guide for the selection of works for future construction. It is anticipated that continuing study will be given to The California Water Plan and that it will be modified when and as necessary.

The California Water Plan, as now presented and as it may be modified from time to time, is designed to serve as the engineering basis for the administration of the State's water resources by the various agencies concerned, to the end that maximum benefit may ultimately be achieved. It will provide a much needed means of coordination of the efforts of the manifold federal, state, and local public agencies and private entities engaged in the planning, construction, and operation of water projects.

The California Water Plan is an ultimate plan, designed to meet the water requirements of the indefinite future when the land and other resources of the State are essentially fully developed. It is fully acknowledged that certain of the forecast ultimate requirements for water may never be realized, and that the facilities which would provide for those requirements may never be constructed. However, the planning effort is deemed necessary at this time in order that provision may be made for such development if and when such requirements arise. The Plan includes and would fully utilize existing works, as well as those works presently proposed by public and private agencies and individuals. It is designed so that it would interfere with vested water rights to the minimum possible extent. In those instances where such interference would be inevitable, it is contemplated that just compensation would be paid. Likewise, it is anticipated that exchanges of water, where necessary to achieve the most economical solution, would be consummated only after agreements had been reached with the holders of vested rights thereto.

The omission of a project from those described herein does not necessarily preclude the possibility of construction of that project. Nor does the inclusion of a particular project indicate that that specific element is the only one that should be considered. Rather, each project should be judged on its merits when it is proposed, in the light of its prospective accomplishments in meeting the basic objectives of The California Water Plan for the particular water resources concerned.

The California Water Plan consists of two principal categories of water resources developments. The first category embraces the local works designed to meet present and future water needs in each of the major hydrographic areas of the State. Water development projects within this category are hereinafter described under the heading "Development to Meet Local Requirements." The second category comprises a major system of works to conserve and export surplus waters from the North Coastal Area and the Sacramento

River Basin, and to transfer these waters to areas of deficiency elsewhere in the State in sufficient amounts to meet the forecast ultimate requirements. These interbasin transfer facilities are collectively designated the "California Aqueduct System," and are subsequently described under that heading.

The California Water Plan, comprising both the local development works and the California Aqueduct System, gives consideration to water conservation and reclamation, to flood control and flood protection, to the use of water for agricultural, municipal, and industrial purposes, to hydroelectric power generation, to salinity control and protection of the quality of fresh waters, to drainage, to navigation, and to the interests of fish, wildlife, and recreation. It contemplates the conjunctive operation of surface and ground water reservoirs, which operation would be essential to regulation of the large amounts of water ultimately to be involved.

DEVELOPMENT TO MEET LOCAL REQUIREMENTS

In the course of the current investigation, numerous preliminary plans have been made for development of local water resources to meet local needs throughout California. The formulation of these plans was based upon the premises that the water occurring in each hydrographic area would be developed to the maximum reasonable and practicable extent, that exports from areas of surplus would be limited to that water available over and above local needs, and that imports to areas of deficiency would be limited to only that water needed to supplement locally developed supplies.

Although this section is confined to a summary description of local developments insofar as possible, features of the California Aqueduct System necessarily enter into the discussion wherever their effects would supplement the accomplishments of local developments. However, the description of the aqueduct facilities is presented separately in a later section of the chapter.

Local development features of The California Water Plan are presented by the major hydrographic areas of the State, in the following order: North Coastal Area, San Francisco Bay Area, Central Coastal Area, South Coastal Area, Sacramento River Basin, San Joaquin-Tulare Lake Basin, Lahontan Area, and Colorado Desert Area. The location of these areas is shown on Plate 3, and the local development works are delineated on the 26 sheets of Plate 5.

North Coastal Area

The North Coastal Area is by far the most prolific water-producing area in California, with an aggregate mean seasonal unimpaired runoff of nearly 29,000,000 acre-feet. The estimated present and probable ultimate seasonal water requirements of 518,000 acre-feet and 2,160,000 acre-feet, respectively, represent but a fraction of the available supply. In spite of this abundance of water, the North Coastal Area is not without its water problems.

Because of the relatively low elevation of the North Coastal Area and its proximity to the ocean, most of the precipitation occurs as rainfall, and stream discharge into the ocean increases markedly within a short time following a storm. More than 85 per cent of the total seasonal runoff occurs during the 6-month period from November through April, on the average. The need for water is characteristically greatest during the dry summer months from July through October, when less than 10 per cent of the total seasonal runoff occurs. Thus, there is need for seasonal regulation by storage, whereby winter flood flows are stored for use during the following summer months of high demand. In addition to variation within the season, runoff in the North Coastal Area experiences considerable fluctuation in amount from year to year, resulting in so-called "wet" or "dry" periods. This characteristic of the water supply creates a need for cyclic carry-over storage in addition to the need for seasonal regulation.

The greatest water problem facing the North Coastal Area is that of occasional great floods such as occurred in 1907, 1938, 1950, and 1955. The last and worst of these great floods, in December, 1955, sent streams of the area to record heights, and caused loss of life and widespread destruction of communities, farm lands, industry, and utilities, particularly along the Eel, Klamath, Trinity, Mad, Smith, and Russian Rivers, and Redwood Creek. However, because of the large amount of storage required for effective flood control, single-purpose flood control reservoirs are generally not economically justified.

Except for the extensive Klamath Project of the United States Bureau of Reclamation, described hereafter, present development of the ample water resources of the North Coastal Area is very limited. Storage at Lake Pillsbury on the upper Eel River and a diversion into the Russian River Basin are operated primarily for generation of hydroelectric power. A power development is located on the Klamath River near the state line, the water supply for which is regulated in Oregon. Sweasey Dam on the Mad River provides municipal water supplies for the City of Eureka. Dwinnell Dam and Reservoir on the Shasta River furnishes irrigation water to lands in Shasta Valley. Several relatively small irrigation systems serve upland valleys, and minor pumping of ground water for domestic, municipal, and irrigation purposes is scattered throughout the area.

Two major projects are presently under construction in the North Coastal Area by federal agencies. The Coyote Valley Project, under construction by the Corps of Engineers, U. S. Army, on the East Fork of the Russian River, will develop water for municipal, industrial, and irrigation purposes, and will substantially enhance recreational opportunities and fish and wildlife resources in the Russian River Basin. The Trinity Division of the Central Valley Project, being constructed by the United States Bureau of Reclamation, will divert water from the upper Trinity River to the Sacramento Valley, to develop hydroelectric energy and to augment the water resources of the Central Valley. The project will also provide local benefits.

Local development works of The California Water Plan would meet future water requirements in the North Coastal Area. Both the local works and the works of the California Aqueduct System would provide much needed flood control and would enable releases of stored water to enhance summer and fall stream flow in the interests of fish, wildlife, and recreation. It should be emphasized that facilities of the California Aqueduct System, in addition to their primary export function, also would accomplish substantial benefits in the North Coastal Area in terms of flood control, stream flow maintenance, and power generation, and in this respect are difficult of differentiation from the local works.

For planning purposes the North Coastal Area has been subdivided into four units, and the local development works are segregated according to these units for discussion herein. These units are designated the "Klamath-Trinity Group," "Eel-Mad Group," "Russian River Group," and "Pacific Basins Group," and their locations are shown on Plate 3. The physical features and costs of all local works for the North Coastal Area are presented in Table 9 which follows this discussion under the heading "Summary of North Coastal Area."

Klamath - Trinity Group. The Klamath - Trinity Group consists of the California portion of the drainage system of the Klamath River, including the entire Trinity River system. Its area within California approximates 10,000 square miles, most of which is occupied by mountains and foothills. However, the Tule Lake area and Shasta, Scott, Hayfork, and Hoopa Valleys contain substantial areas of agricultural lands.

The Klamath Project, built and operated by the United States Bureau of Reclamation, is by far the largest existing water supply development in the Klamath-Trinity Group. This project utilizes waters of the Klamath River and Lost River system to irrigate nearly 200,000 acres of lands in Oregon and California. The project also controls water levels in Tule Lake, and reregulates the flows of the Klamath River for power generation. The previously mentioned Trinity Diversion of the Central Valley Project will divert 872,000 acre-feet of water annually from the upper Trinity River to the Central Valley, and will generate a substantial block of hydroelectric power.

The Klamath-Trinity Group, although favored with abundant water resources, is confronted with several present and future water problems. First, the group will require the development of an additional 640,000 acre-feet of water per season to meet the full irrigation, urban, and industrial potential. Second, there is an urgent need for the control of floods on the Klamath and Trinity Rivers. Floods threaten the valley lands adjacent to those rivers, and the threat is particularly acute in the urban and agricultural areas on the coastal plain. The community of Klamath near the mouth of the Klamath River, and Klamath Glen a few miles upstream, were virtually demolished by the flood of December, 1955. Third, there is the problem of maintenance of favorable anadromous fishery, which is not so much a problem at the present time, but which will arise after the development of major dams and reservoirs in the area which would block the passage of anadromous fish to their spawning grounds and would inundate spawning areas. Moreover, the streams of the Klamath-Trinity Group have a large hydroelectric power potential which is a prime consideration in future development of the water resources of the group.

The Klamath River Basin Compact, an interstate compact which has as its purpose the promoting of orderly and comprehensive development and the use of the water resources of the Klamath River Basin, has been ratified by the States of California and Oregon and is now awaiting approval of the Congress of the United States. This compact provides for the distribution and use of water within the Upper Klamath River Basin, which is defined as the drainage area of the Klamath River and all its tributaries upstream from the boundary between Oregon and California, including the closed basins of Butte, Red Rock, Swan Lake, and Lost River Valleys, and Crater Lake.

Terms of the Klamath River Basin Compact establish an order of preference of use of water within the Upper Klamath River Basin, with domestic and municipal use first and irrigation use second, followed in turn by recreational use, including use for fish and wildlife, industrial use, and use for hydroelectric power generation. Diversions of water outside the Upper Klamath River Basin are prohibited, with minor exceptions, by the compact, which also makes available to the California portion of the upper basin sufficient water from the Klamath River in Oregon for the future irrigation of 100,000 acres of undeveloped irrigable land which cannot feasibly be served from any other source. There is also established a permanent commission to administer the terms of the compact.

The objectives of The California Water Plan in the Klamath-Trinity Group are threefold: first, the de-

North Coastal Area—Redwood Grove

velopment of sufficient water supplies to satisfy the present and ultimate requirements for water for irrigation, urban, industrial, recreational, and power generation purposes, and to preserve and enhance fishery and wildlife resources; second, the provision of adequate flood protection; and third, the conservation of some 8,000,000 acre-feet of water per season for export to areas of deficiency elsewhere in the State. These objectives could be met by the planned local developments and the major reservoirs and conduits of the California Aqueduct System.

Local development works in the Klamath-Trinity Group could provide water to meet irrigation, urban, and industrial needs, and could considerably improve existing stream flow conditions in the interests of fishery resources and recreation. In addition, operation of these works could effect some flood control. Major reservoirs of the California Aqueduct System on the Klamath and Trinity Rivers, in developing some 8,000,000 acre-feet of water seasonally for export, could effect a high degree of flood control on those rivers, and generate an abundance of power for enhancement of the local economy. The adverse effect of these major reservoirs on the anadromous fishery could be offset somewhat by compensatory measures, such as improvement of downstream flow conditions and a new lake fishery. Also, the improvement of environmental conditions on other streams could be effected, as will be shown during the ensuing discussion.

Beatty, Boundary, and Chiloquin Narrows Dams, if constructed as parts of the Klamath Project of the Bureau of Reclamation, could augment the yield of that project by developing the waters of the Sprague and Lost Rivers. Boundary dam site is located on Lost River at the upper end of Langell Valley on the California-Oregon line. Beatty and Chiloquin Narrows Dams and Reservoirs would be located on the Sprague River in Oregon. Under terms of the aforementioned Klamath River Basin Compact, the water supply developed by these works would be utilized throughout the Upper Klamath River Basin, including lands in Oregon as well as in California. Water would be served to lands in California by appropriate conveyance facilities, as shown on Sheet 1 of Plate 5.

Iron Gate Dam and Reservoir, located on the Klamath River about 4 miles east of Hornbrook, California, could be constructed primarily to provide urgently needed reregulation of releases from the California Oregon Power Company's hydroelectric power developments on the Klamath River. It could also provide a forebay for pumping irrigation supplies for use in Shasta Valley. Under this plan the water developed in the upper basin would be conveyed to Shasta Valley by the Bogus Conduit, two pumping lifts along the route of the conduit being required.

Montague Dam and Reservoir, located on the Shasta River about 4 miles north of Yreka, if constructed would also provide water for irrigation use in Shasta Valley. In addition, sufficient releases would be made to the Shasta River to maintain a minimum flow of 20 second-feet for recreational purposes.

Grenada Ranch Dam and Reservoir, located on the Shasta River about 3 miles southeast of the town of Grenada, could be constructed to supply municipal water to the City of Yreka, as well as to provide a gravity irrigation supply for portions of Shasta Valley adjacent to the river.

Callahan Dam and Reservoir, located near the town of Callahan, could be constructed to regulate the Scott River and to develop water for irrigable lands in Scott Valley. Callahan Reservoir would also provide flood control for the valley. Releases would be made to maintain and improve the present fishery.

Layman Dam and Reservoir, located on Hayfork Creek just above its confluence with the South Fork of the Trinity River, if constructed would be utilized primarily to supply water for irrigable lands in Hayfork Valley. In addition, sufficient releases to the downstream channel would be made to maintain a minimum flow of 10 second-feet during the summer months, which would enhance fishery conditions below the dam.

The hydroelectric power potential of the Salmon River could be developed by Morehouse Reservoir and its associated power plant, located on the Salmon River just below the mouth of Morehouse Creek. Although Morehouse Reservoir would be utilized primarily for power production, the incidental stream flow regulation provided would materially enhance accomplishments of downstream units of the California Aqueduct System. Moreover, the reservoir would provide a measure of flood control.

Waters of the South Fork of the Trinity River could be regulated by Smoky Creek Reservoir, located about 7 miles upstream from Forest Glen and above Eltapom Reservoir, a feature of the California Aqueduct System. This reservoir would be dedicated solely to maintenance of favorable stream flow conditions throughout the summer months. A minimum flow of 45 second-feet would be maintained, whereas under present conditions the summer flows have upon occasion virtually ceased. Thus, a 22-mile reach of stream between Smoky Creek Dam and Eltapom Reservoir would be considerably improved as a habitat for fish life, particularly for the several trout species, and spawning areas would be available for the lake fishery that would develop in Eltapom Reservoir.

In summary, the 10 reservoirs and associated works constituting the local development works for the Klamath-Trinity Group under The California Water Plan would have an aggregate storage capacity of

1,920,000 acre-feet, and would make available additional water supplies amounting to some 760,000 acre-feet per season. About one-third of this yield would be utilized in Oregon, and the remainder would serve California lands. The described development would not fully satisfy the possible ultimate water requirements of the group, as there are a number of small scattered areas of irrigable land which are too remote to be economically reached by projects of the scope considered herein. However, adequate local water resources are available in the event that requirements for such lands materialize.

Facilities considered for conveyance of the developed water supplies to areas of use include 7 pumping plants and 53 miles of conduits. A yearly total of about 343,000,000 kilowatt-hours of electric energy could be made available by the Morehouse Power Plant. Furthermore, the foregoing local development works, operated in conjunction with facilities of the California Aqueduct System, would considerably enhance the recreational potential of the group by reservoir releases to maintain stream flow throughout the summer months.

Data on the general features and capital costs of the local development works in the Klamath-Trinity Group are presented in Table 9. The location and layout of their component features are delineated on Sheets 1 and 3 of Plate 5.

In addition to local developments, The California Water Plan envisages 10 storage reservoirs in the Klamath-Trinity Group, to be operated primarily as features of the California Aqueduct System. These reservoirs would provide nearly 27,500,000 acre-feet of additional storage capacity in the group. As previously stated, the aqueduct features are difficult of differentiation from local developments with respect to creation of recreational opportunities, protection from flood damage, and power generation. These 10 reservoirs would constitute large bodies of water adaptable for swimming, boating, and other recreational activities. The minimum pools maintained at many of these reservoirs would provide opportunities for development of trout fisheries. Furthermore, a large degree of protection from floods would be afforded by the conservation reservoirs, for both local and export purposes, which would provide about 870,000 acre-feet of surcharge storage in addition to their normal conservation pools. The detention effect of this storage capacity would substantially reduce peak flood flows, even without planned operation of the reservoirs for flood control. Damage caused by the floods of December, 1955, would have been considerably reduced had these units of The California Water Plan been in operation. Complete flood protection could be provided by reservation of storage space specifically for that purpose. However, the degree of flood protection warranted is a matter of economics and a factor for future determination.

Eel-Mad Group. The Eel-Mad Group includes the drainage basins of the Eel and Mad Rivers, and all the remaining coastal drainage between the Mattole River on the south and Redwood Creek on the north. The terrain, typical of most of the North Coastal Area, is predominantly mountainous. Valley and mesa lands comprise only about 5 per cent of the total area of 4,340 square miles, and are mostly located near the mouth of the Eel River and adjacent to Humboldt Bay. Eureka, the largest city in the North Coastal Area, is situated on the shore of Humboldt Bay.

The abundant water resources of the Eel-Mad Group are largely undeveloped at present. The Scott and Van Arsdale Dams on the upper Eel River are operated in conjunction with a diversion from the Eel River Basin to the Russian River Basin for hydroelectric power generation, and Sweasey Dam on the lower Mad River is operated for development of a municipal water supply for the City of Eureka. Small local surface diversions and minor ground water pumping constitute the only remaining water supply developments within the group.

Water problems of the Eel-Mad Group are of the same nature as those of the foregoing Klamath-Trinity Group. The demands for agricultural, domestic, and industrial water supplies are growing and will ultimately require a supplemental water supply of about 366,000 acre-feet per season, most of which will be for irrigated lands. However, the industrial potential for water is considerable, particularly in the processing of timber for pulp production. Although the foregoing estimate of ultimate supplemental water requirements includes provision for future pulp production, it is quite possible the estimated requirements for this purpose may have to be revised upward, with a resultant modification of water development plans. Adequate water could be made available for such possible increases if they materialize.

The pressing need for flood control projects in the Eel-Mad Group was demonstrated by the flood of December, 1955. Record flows in the Eel River caused widespread destruction in areas important to both the present and future economy of the group. Agricultural lands and a number of lumber mills on the alluvial plains near the mouths of streams, particularly those of the Eel and Mad Rivers and Redwood Creek, were severely damaged.

There exists a significant potential for improvement of summer stream flow characteristics in every major waterway of the Eel-Mad Group, not only for enhancement of the fish habitat, but also for the furtherance and development of recreational areas. Such areas are now in increasing demand by visitors from throughout the State. Recreation is bound to be important to the future economic welfare of the North Coastal Area.

The objectives of The California Water Plan in the Eel-Mad Group consist of the development of sufficient water supplies to satisfy the ultimate water requirements for all beneficial purposes, including irrigation, urban, industrial, recreational, fish and wildlife, and power generation; provision of adequate flood control; and the regulation of some 2,600,000 acre-feet of water per season for export to areas of deficiency elsewhere in the State. The ultimate water requirements within the group itself could be met by construction of storage reservoirs on local streams adjacent to the areas of need. Such reservoirs would also enhance the fishery and the recreational opportunity, and would provide some flood control. In addition, the major reservoirs of the California Aqueduct System on the Eel River could serve to generate a large block of hydroelectric power to support local industrial development, and effect a high degree of flood control on the Eel River. In compensation for adverse effects of the major reservoirs on the anadromous fishery, the South Fork of the Eel River and the Bear River could be developed solely for improvement of the fishery and of recreational conditions.

Local developments discussed herein generally fall into two categories. Reservoirs in the first category would be primarily for development of irrigation, municipal, and industrial water supplies, while those of the second category would provide for enhancement of the fishery and the general recreational potential.

Crannell Dam and Reservoir, located on Little River about 1 mile upstream from the community of Crannell, if constructed would provide domestic and industrial water for the Eureka-Arcata area. Water service would also be provided to the northernmost portion of the agricultural and domestic areas lying north of the Mad River.

The Butler Valley dam site is located on the Mad River about 1 mile northwest of the community of Maple Creek. If a dam were constructed at this site, releases from the reservoir would flow down the Mad River, from which water could be diverted at Sweasey Dam or pumped from the lower Mad River and conveyed to service areas lying both north and south of the river. In this connection, a dam and reservoir is contemplated for construction by the Humboldt Bay Municipal Water District on the upper Mad River at the Ruth site near the Humboldt-Trinity county line. Ruth Dam and Reservoir would develop municipal and industrial water for use in the Eureka area. This project has been approved by the Department of Water Resources as an initial local development on the Mad River. However, the development of the upper Mad and Van Duzen Rivers for export purposes, as subsequently described under the California Aqueduct System, would necessitate the eventual replacement of Ruth Dam with a similar development at the Butler site or an alternative downstream site.

Yager Dam and Reservoir, located on Yager Creek about 8 miles east of Fortuna, could serve lands lying north and south of the lower Eel River. Water would be released from the reservoir down Yager Creek and pumped to the service areas. In addition, releases from Yager Reservoir would improve summer stream flow conditions in lower Yager Creek, and in the lower Van Duzen and Eel Rivers into which it discharges, thus enhancing fishing and other recreational pursuits.

The South Fork of the Van Duzen River could be developed by Larabee Valley Dam and Reservoir, located at Larabee Valley about 7 miles east of Bridgeville. Water released from Larabee Valley Reservoir would flow down the Van Duzen River, improving summer flows for fishing and recreation along the lower river, an area of scenic beauty and the present location of a state park. The water could then be routed from a pumped diversion to the delta areas north and south of the Eel and Van Duzen Rivers.

The ultimate requirements for irrigation, urban, and industrial water in the vicinity of Willits in Little Lake Valley could be met by Valley's End Dam and Reservoir on Tomki Creek about 7 miles east of Willits. Under this project water would be diverted from Valley's End Reservoir through a tunnel into Berry Creek in Little Lake Valley, and rediverted from Berry Creek for delivery around the edge of the valley.

Streeter Dam and Reservoir could be constructed on Tenmile Creek, a tributary of the South Fork of the Eel River, about 5 miles northwest of Laytonville. The conserved water could be delivered to irrigable lands in the Laytonville area by means of pump lifts and conduits. In addition, the reservoir would be well suited for recreational development, because of its proximity to U. S. Highway 101.

Plans for provision of supplemental water to Round Valley involve a special situation. Under ultimate conditions the supplemental requirements of Round Valley could be met by water from Etsel Reservoir, a feature of the California Aqueduct System, and by pumpage from the Round Valley ground water basin. However, during the interim period preceding construction of Etsel Reservoir, Franciscan Dam and Reservoir which would be located on a tributary of the Middle Fork of the Eel River about 6 miles northeast of Covelo, could be operated in conjunction with a direct diversion of water from Williams Creek to meet the ultimate requirements of Round Valley. The construction of Etsel Reservoir would require the raising of Franciscan Dam which would then become an auxiliary dam of Etsel Reservoir, as can be seen on Sheet 5 of Plate 5.

Branscomb Dam would be located on the South Fork of the Eel River about 5 miles northwest of the community of Branscomb. If constructed, the reservoir would improve summer flows in that accessible stream as is flows through groves of great redwood trees. The South Fork is world famous as a scenic recreational area. Releases of water from the reservoir would eliminate summer stagnation in pools and temperatures intolerable to fish life. A minimum flow of 100 second-feet in the South Fork of the Eel River below the mouth of Rattlesnake Creek would be provided.

The fishery on the Bear River could be enhanced by construction of Brushy Creek Dam and Reservoir at a point 6 miles south of Scotia. Brushy Creek Reservoir would provide a minimum summer flow of about 14 second-feet in the Bear River for improvement of recreational and fishery conditions.

Caution Dam and Reservoir on the North Fork of the Eel River could similarly improve stream flow conditions in the interest of fish life and recreation. Caution Dam would be located 8 miles north of the Trinity-Mendocino county line. Releases of water would be made from the reservoir to maintain a minimum discharge of 30 second-feet in the downstream channel to the proposed Sequoia Reservoir, a feature of the California Aqueduct System.

In summary, the 10 reservoirs and associated facilities comprising local development works for the Eel-Mad Group under The California Water Plan could meet all local ultimate supplemental water requirements, with the exception of those for certain small scattered parcels of land. The reservoirs would have an aggregate gross storage capacity of about 450,000 acre-feet and could develop about 410,000 acre-feet per season of firm supplemental water, including water to be released from storage for fish and recreation.

The local developments, along with the major reservoirs of the California Aqueduct System in the Eel-Mad Group, could provide a high degree of flood control, particularly on the Eel River. It is estimated that the record peak flow of 500,000 second-feet in the Eel River at Scotia during the flood of December, 1955, would have been reduced to a peak flow of only 315,000 second-feet if all of the works proposed under The California Water Plan had been in operation. A considerable measure of flood control could also be provided on the Mad River by Ranger Station Reservoir, or a substitute therefor, of the California Aqueduct System, and by Butler Valley Reservoir, a local development feature.

Recreational opportunities associated with the local development works and the California Aqueduct System would be abundant for the Eel-Mad Group. In addition to improved stream flow conditions, approximately 73,000 acres of water surface area would be created by the 15 new reservoirs, thus affording expanded opportunities for such recreational pursuits as fishing, boating, picnicking, and swimming.

Russian River Group. The Russian River Group comprises the Russian River Basin and a small area to the south draining into the Pacific Ocean and Tomales Bay. Its area totals about 1,750 square miles, of which some 1,500 square miles comprise mountains and foothills and the remainder is classified as valley and mesa land.

Present water needs in the Russian River Group are met both by diversion of surface flows and pumpage of ground water. The largest existing water supply development is that of the Potter Valley Irrigation District which serves about 4,000 acres of land in Potter Valley, utilizing waters diverted from the Eel River and released into Potter Valley for power generation purposes. The Santa Rosa water works is the largest municipal water service agency, delivering supplies from both surface and underground sources.

Coyote Valley Dam and Reservoir, on the East Fork of the Russian River about 5 miles north of Ukiah, is presently under construction by the Corps of Engineers, U. S. Army, as a water conservation and flood control project. The project will develop irrigation and municipal water supplies for use on lands along the Russian River and in the lower basin extending south to the City of Santa Rosa. It will also enhance recreational opportunities and fish life in the lower Russian River by maintenance of desirable summer stream flow.

Coyote Valley Reservoir, when completed, will have a gross storage capacity of 122,000 acre-feet, including 48,000 acre-feet of flood control storage reservation. Provisions have been made in the planning for future enlargement of the dam and reservoir to an ultimate storage capacity of 199,000 acre-feet. The Corps of Engineers is authorized to construct downstream channel improvements as a part of this project.

The Russian River Group has ample water resources to meet its present and future water requirements. However, because of the large fluctuation in runoff from season to season and within the season, the control and development of the water resources presents a problem. Supplemental water supplies aggregating about 375,000 acre-feet per season would be necessary to fully meet requirements under ultimate conditions.

The requirement for water for fish and recreation is also a major consideration on the Russian River and its tributaries. The lower portion of the Russian River is a famed summer recreational area, with pleasant weather, water for swimming and fishing, pleasing scenery, and proximity to large centers of population. Summer stream flows have, in the past, dropped considerably below the minimum requirements for these purposes. This condition will be corrected by operation of Coyote Valley Reservoir, which will provide release of water in sufficient volume to maintain a minimum flow of 125 second-feet in the lower Russian River near Guerneville, particularly during the summer months.

In common with the rest of the North Coastal Area, the Russian River Group is presently faced with a serious flood control problem. The flood of December, 1955, inundated agricultural lands, commercial structures, and homes along the Russian River. Particularly heavy damage was inflicted on summer homes along the lower river, notably in and around Guerneville.

Under The California Water Plan, 14 new dams and reservoirs are contemplated in the Russian River Group, including the future enlargement of the Coyote Valley Reservoir to its ultimate stage. These reservoirs could supply sufficient water to meet ultimate requirements for irrigation, municipal, and recreational purposes, and provide a substantial measure of flood control as well.

The upper Russian River and tributaries could be developed by 6 reservoirs, in addition to the Coyote Valley Reservoir enlarged to its ultimate stage as proposed by the Corps of Engineers. These reservoirs, on Franz, Maacama, Big Sulphur, Cummisky, Feliz, Robertson, and Saysal Creeks, would be supplementary to and operated in coordination with Coyote Valley Reservoir. Their combined yield could be utilized throughout the Russian River area, the Santa Rosa plains, and the Tomales-Bodega area, and surplus water could be exported to the San Francisco Bay Area.

Knights Valley Reservoir would be unique in that it would involve two separate dams, one on Franz Creek and one on Maacama Creek, constructed to sufficient heights that they would form a common reservoir at higher water stages. Franz and Maacama Dams would be located about 6 miles east of Healdsburg. Knights Valley Reservoir could furnish water to local downstream lands and provide minimum summer and winter stream flows in Maacama Creek of 5 second-feet and 30 second-feet, respectively, for fishery enhancement.

Big Sulphur Dam and Reservoir, located on Big Sulphur Creek about 3 miles east of Cloverdale, could develop water for local downstream use and for conveyance to the Santa Rosa-Sebastopol and the Tomales-Bodega areas. In addition, the reservoir could provide 43,000 acre-feet of flood control storage space, and releases could be made to provide minimum summer and winter flows of 10 second-feet and 50 second-feet, respectively, for improvement of fishery conditions.

In addition to the foregoing, reservoirs could be constructed on four smaller tributaries to the upper Russian River. These include Cummisky Dam and Reservoir on Cummisky Creek, 5 miles north of Cloverdale; Feliz Dam and Reservoir on Feliz Creek, 1 mile west of Hopland; Robertson Dam and Reservoir on Robertson Creek, 4 miles north of Ukiah; and Saysal Dam and Reservoir on Saysal Creek, 6 miles northeast of Healdsburg. Lands downstream from these reservoirs could be served by local distribution works.

As previously stated, the seven reservoirs in the upper Russian River area could develop water for conveyance to the Santa Rosa plains, the Tomales-Bodega area and the San Francisco Bay Area, in addition to providing water for local downstream service areas. The water could be conveyed to all but the downstream service areas by the Sonoma Aqueduct, a feature of the California Aqueduct System, which would also convey water diverted from facilities of the Eel River Division of the California Aqueduct System. These facilities are delineated on Sheets 5 and 7 of Plate 5.

Dry Creek Dam and Reservoir, located on Dry Creek about 5 miles southwest of Cloverdale, could be operated to provide water for downstream service areas, and for fishery enhancement by releases of water to maintain minimum summer and winter flows of 10 second-feet and 75 second-feet, respectively. A minimum reservoir storage of 15,000 acre-feet would create favorable conditions for propagation of warmwater fish species. In addition, Dry Creek Reservoir could provide substantial flood protection by maintaining a flood control reservation of 43,000 acre-feet of storage capacity.

A dam and reservoir on Warm Springs Creek, 6 miles west of Geyserville, and one on Mill Creek, 3 miles east of Healdsburg, could augment the water supply developed by Dry Creek Reservoir. Releases sufficient to maintain minimum summer and winter stream flows of 5 second-feet and 25 second-feet, respectively, could be provided from each reservoir for maintenance of fish life. Furthermore, minimum reservoir pools could be reserved for propagation of warmwater fishes. In addition to providing water to local downstream service areas, water from these reservoirs and Dry Creek Reservoir could be pumped from the Russian River and conveyed to the northerly portion of the Santa Rosa plains.

Bearpen Dam and Reservoir on East Austin Creek about 7 miles above its mouth was planned for fishery and recreational purposes only, and as such would be operated to maintain summer stream flows in that creek below the dam. In addition to maintenance of a desirable stream flow for fishing and swimming, a minimum reservoir storage of 1,000 acre-feet could be provided for propagation of warmwater fish.

Mark West Dam and Reservoir on upper Mark West Creek and Laguna Dam and Reservoir on lower Mark West Creek near its junction with the Russian River could jointly develop sufficient water to meet the remainder of the ultimate requirements of the Santa Rosa plains. Although the primary purpose of these reservoirs would be for conservation, there

North Coastal Area Economic Activities—Recreation and Dairying would be major incidental benefits to the fishery and to recreation. The Laguna reservoir area is already one of the most popular places in the State for duck and pheasant hunting, and enlargement of the existing water area would substantially improve duck hunting. Furthermore, the reservoir would form a highly desirable warmwater fishing lake because of the shallow water and long shore line. Minimum summer and winter flows of 5 second-feet and 25 second-feet, respectively, could be maintained by releases from Mark West Reservoir for fishery enhancement.

Walker Dam and Reservoir on Walker Creek about 2 miles southwest of Tomales, could be constructed, to provide water for the Tomales-Bodega area. The water developed by Walker Reservoir would be used primarily in the Stemple Creek drainage area, which would require a substantial pumping lift.

In summary, the local phase of The California Water Plan for the Russian River Group would comprise 14 reservoirs and associated works. Operated coordinately and as a basin-wide development, these local works could accomplish a threefold purpose: namely, (1) provision of sufficient water to serve all potentially irrigable and urban lands within the Russian River Group, and to export a small supply to the San Francisco Bay Area (2) enhancement of the anadromous, resident trout, and warmwater fishery and of the recreational opportunity, and (3) provision of a substantial measure of flood control. The local development works would have an aggregate gross storage capacity of about 1,100,000 acre-feet and could make available additional water supplies aggregating some 415,000 acre-feet per season. As planned, the Russian River Group would receive about 375,000 acre-feet of this water per season, and about 40,000 acre-feet would be exported to the San Francisco Bay Area. A large portion of the yield made available would be conveyed to the Santa Rosa plains, the Tomales-Bodega area, and the San Francisco Bay Area by the Sonoma Aqueduct, proposed as a feature of the California Aqueduct System primarily for transferring Eel River water to the San Francisco Bay Area.

The importance of the Russian River and its tributaries to sport fishing and recreation is fully recognized in The California Water Plan. Releases of water could be made from the reservoirs on the more important fishing streams to assure conditions satisfactory for fish life and for public recreation.

In addition to the foregoing accomplishments, flood control storage reservations aggregating about 134,000 acre-feet could be maintained in Dry Creek, Big Sulphur, and Coyote Valley Reservoirs. This reserved storage capacity would provide a substantial measure of flood protection. Additional incidental flood control benefits could be derived from the remaining reservoirs and from authorized channel improvements to be constructed by the Corps of Engineers. These works would greatly reduce damage from flooding along the Russian River flood plain. However, complete prevention of damage to property would require appropriate flood zoning in conjunction with the foregoing works.

Pacific Basins Group. The Pacific Basins Group comprises three relatively small non-contiguous segments of the North Coastal Area adjacent to the ocean, which are isolated from each other by the Klamath-Trinity and the Eel-Mad River drainage basins. Its total area of 3,530 square miles is predominantly mountainous. The group includes the Smith River drainage area in the northernmost segment and the Redwood Creek drainage area in the middle portion, while the larger southern section includes the drainage areas of the Mattole, Noyo, Navarro, and Garcia Rivers.

Present water development in the Pacific Basins Group is insignificant compared to the available water resources, and includes only the minor works of a number of small public and private agencies formed to supply water for municipal and domestic use. Agricultural water is presently developed entirely on an individual basis.

The ultimate seasonal water requirement of the entire group is estimated to be only a little more than 180,000 acre-feet, compared to the total mean seasonal runoff of about 12,000,000 acre-feet. However, satisfaction of those requirements would require the construction of water storage facilities. Moreover, since the streams flow largely in deep narrow canyons, substantial pumping lifts and conduits with rather tortuous alignments would be required to deliver the conserved water to service areas which are located mainly on hills and ridge tops.

The streams of the Pacific Basins Group are a natural habitat for anadromous fish such as steelhead trout and silver salmon, as well as resident trout. However, under present conditions extremely low summer flows cause the loss of a large percentage of the young fish, while erratic flows during early winter and spring frequently severely reduce the success of the spawning runs. Because of the importance of recreation and the fishery to the present and future economy of the group, a number of reservoirs contemplated under The California Water Plan would be dedicated to the improvement of stream flow conditions by planned releases for that purpose.

In certain areas, notably on the Smith River Plain, on lands near the mouth of Redwood Creek, and along the lower Mattole River, large winter flows create a significant flood problem, causing considerable damage to utilities and low-lying farm lands.

The ultimate water requirements of the Pacific Basins Group could be met by local surface water development works and increased use of ground water. Summer stream flow conditions could be improved by releases of water from reservoirs in the interests of fish life and recreation.

The ultimate supplemental water requirement of about 55,000 acre-feet per season on the Smith River plain could probably be met by operation of the underlying ground water basin, without surface storage development. It appears that an adequate supply is available in the ground water basin if operated in conjunction with direct diversions from the Smith River. However, in the event that the yield of ground water should prove inadequate, Rowdy Creek Dam could be constructed on Rowdy Creek for development of the required additional yield.

Green Point Reservoir, which would be located on Redwood Creek a short distance upstream from Highway 299, could be operated for maintenance of favorable flow conditions in the downstream channel during the summer months. Releases of water from the reservoir amounting to 15 second-feet would supplement the natural flow below the dam, thus improving 42 miles of stream channel for fishery and recreational purposes.

Thorn Dam and Reservoir on the headwaters of the Mattole River could similarly be operated to improve downstream flow conditions by releases of water at the rate of 55 second-feet, resulting in improved conditions for fish on a 55-mile reach of the river.

Water to meet the requirements of the area along the Mendocino coast from Rockport south to Fort Bragg could be developed by dams and reservoirs on Pudding, Campbell, and Hayworth Creeks, and on the South Fork of Tenmile River. Glenblair Dam and Reservoir would be located on Pudding Creek about 4 miles east of Fort Bragg. Yesmar Dam and Reservoir would be located a short distance downstream from the confluence of Campbell Creek and the South Fork of Tenmile River. These two dams would create a common reservoir in Little Valley which normally drains into Pudding Creek. The yield of Glenblair-Yesmar Reservoirs could be used in the northern portion of the Mendocino coast, including Fort Bragg.

Hayworth Dam and Reservoir, located on Hayworth Creek about 3 miles north of its confluence with the Noyo River, could meet the remaining water requirements of the northern portion of the Mendocino coast. Although the primary purpose of Hayworth Reservoir would be water conservation to meet the foregoing requirements and not stream flow maintenance, its operation would provide a minimum release of 10 second-feet, which would improve stream flow conditions in the 26-mile reach between the dam and a downstream diversion point near the ocean.

The water developed by Caspar Dam and Reservoir, which would be located on Caspar Creek about 4 miles upstream from the town of Caspar, could be utilized in the southern portion of the Medocino coastal area.

Summer stream flow conditions in the Big River Basin could be improved by construction of Hellgate Reservoir on the South Fork of Big River about 5 miles above the main stem. Releases of water from Hellgate Reservoir could increase the natural summer flow in a 33-mile reach of the stream below the dam by 15 second-feet.

McDonald Dam and Reservoir, which would be located on the Albion River approximately 6 miles east of Albion, could develop water for use on lands lying on both sides of the Albion River.

The ultimate water requirements of Anderson Valley and other service areas of the Navarro River Valley could be met by Lone Tree, Big Foot, and Castle Garden Dams and Reservoirs. In addition, releases of water from the reservoirs could be made for improvement of the fishery and the recreational opportunity in the area.

Lone Tree Dam and Reservoir would be located on Indian Creek about 6 miles upstream of Philo. A portion of the water yielded from the reservoir could supply irrigable lands located along the Navarro River between Booneville and Philo. In addition, water released from the reservoir for the service area from Philo downstream to Navarro would utilize the natural stream channel, thus improving the fishery and the recreational conditions.

Big Foot Dam and Reservoir on Rancheria Creek about 4 miles south of Yorkville Post Office, could be operated for the maintenance of summer stream flow. Castle Garden Dam and Reservoir, located on the North Fork of the Navarro River, could also be operated for this purpose. Releases from Big Foot and Castle Garden Reservoirs could be made on a schedule designed to enhance the fishery and recreational opportunity, with minimum summer flows of 16 second-feet and 10 second-feet, respectively, provided below the dams. Thus, fish life on the main stem of the Navarro, as well as on two of its principal tributaries, would be considerably improved. Moreover, the attractiveness of the stream for recreational purposes, such as swimming, boating, camping, and picnicking in the redwood groves along the lower reaches would be enhanced.

Tin Can Dam and Reservoir, which would be located on Alder Creek about 5 miles northeast of Manchester, could serve lands lying along the coast from the mouth of the Navarro River southerly to the Gualala River at the Mendocino-Sonoma county line, including the relatively extensive irrigable area in the vicinity of Point Arena.

A headwater reservoir could be created in the Garcia River Basin by the construction of Garcia Dam and Reservoir just below the joining of Pardaloe and Mill Creeks. A minimum summer stream flow of 25 second-feet for recreational purposes and fishery enhancement could be assured by operation of Garcia Reservoir.

Three reservoirs in the Gualala River Basin could be operated for improvement of summer stream flow conditions. Billings Dam would be located on the North Fork just below the junction of Billings and Bear Creeks, and could provide a summer release of 20 second-feet into the downstream channel. Neese Ridge Dam and Reservoir, which would be located on the Wheatfield Fork just above Wolf Creek, could also release 20 second-feet in the downstream channel during the summer months. Houser Bridge Dam and Reservoir would be located on the South Fork of the Gualala River about 6 miles southeast of Stewarts Point. It could provide summer releases of 35 second-feet into the downstream channel to supplement natural flows. These three reservoirs in the Gualala River Basin would collectively improve the fishery and recreational conditions in 60 miles of stream channel, as well as maintain an open channel for the Gualala River all the way to the ocean.

In summary, the 16 reservoirs constituting the local development works for the Pacific Basins Group under The California Water Plan would have an aggregate gross storage capacity of 314,000 acre-feet. They could make available additional water supplies amounting to some 156,000 acre-feet per season, consisting of 84,000 acre-feet of conservation yield and 72,000 acre-feet of yield assigned to stream flow maintenance. An additional yield of approximately 55,000 acre-feet per season probably could be obtained from ground water storage underlying the Smith River plain.

Including the foregoing yield from the ground water basin in the vicinity of Crescent City, the prospective local development works could meet all estimated future water requirements of the Pacific Basins Group, with the exception of certain widely scattered small parcels of agricultural lands which are too remote to be economically reached by projects of the scope considered herein. However, sufficient water supplies are available in the event that those lands should ever require service.

In addition to meeting the agricultural, municipal, and industrial water requirements of the Pacific Basins Group, the local development works could substantially improve more than 310 miles of stream channels for sport fishing and for general recreational purposes, including camping, boating, swimming, and picnicking. The future development of further recreational facilities has been considered so significant in the North Coastal Area that, wherever possible, stream flow maintenance works have been planned on the smaller streams of this group to minimize impairment on the more important streams elsewhere in the area.

Summary of North Coastal Area. The California Water Plan in the North Coastal Area envisages a total of 50 new reservoirs for local water development purposes. Included are 25 reservoirs planned primarily for development of water supplies to meet increased consumptive use, 15 reservoirs planned primarily for stream flow maintenance, and 10 reservoirs that would provide water for both purposes. In addition, 15 major dams and reservoirs with associated power plants, pumping plants, and tunnels, would be constructed in the area as features of the California Aqueduct System. These facilities, which are described in a subsequent section of this chapter, would conserve surplus flows of stream systems of the North Coastal Area for export to areas of deficiency elsewhere in the State. The prospective reservoirs to meet local water requirements would have an aggregate storage capacity of about 3,280,000 acre-feet and could provide an estimated yield of some 1,310,000 acre-feet per season for this purpose, plus an additional yield of about 250,000 acre-feet per season for stream flow maintenance.

In addition to the yield of the foregoing reservoirs, an estimated 100,000 acre-feet per season of the ultimate local water requirement could be met by further development of ground water resources. The remainder of this requirement in the North Coastal Area, not satisfied from contemplated local works of The California Water Plan, would occur primarily in connection with irrigable lands lying in isolated small scattered tracts which, as previously stated, are considered too remote to be economically reached by projects of the scope considered in this bulletin. However, water resources are available for such lands for development by individuals or appropriate local agencies when and if the demand develops.

Planned and incidental releases of water to downstream channels from the local reservoirs and the incidental water releases from major reservoirs of the California Aqueduct System would increase the fish population and improve facilities for camping, boating, swimming, and other recreational activities. These improved conditions would attract many additional vacationists to the area, which is already famous for such attractions.

Features of the California Aqueduct System, in addition to enhancing the recreational potential of the North Coastal Area by provision of large water surface areas and improved stream flow would also result in a substantial measure of flood protection. This would be especially effective in the Eel River Basin. Studies indicate that the initial upstream features of the Eel River Division of the California Aqueduct System, consisting of Willis Ridge and Etsel Reservoirs, could have almost completely regulated the flow of the Eel River below Dos Rios during the flood of December, 1955.

Data on the general features and capital costs of the local development works of The California Water Plan in the North Coastal Area are presented in Table 9. The locations and layouts of these facilities,

TABLE 9

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN NORTH COASTAL AREA

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

Dam and reservoir	Stream	Dam: Location, MDB&M, and sheet of Plate 5 on which shown	Dam: Type	Dam: Height, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active	Seasonal yield, in acre-feet	Purpose	Place of water use	Capital cost [a]
Klamath-Trinity Group											
Beatty	Sprague River	Sec. 17 & 20, T36S, R13E WB&M Oregon	E	55	4,350	150,000	140,000	110,000	I		$4,687,000
Boundary	Lost River	Sec. 18, T48N, R7E & Sec. 20, T41S, R14W, WB&M 2	E	125	4,250	100,000	100,000	41,000	I	Klamath-Tule-Butte Basins	3,925,000
Chiloquin Narrows	Sprague River	Sec. 10, T35S, R7E, WB&M Oregon	E	135	4,300	440,000	430,000	180,000	I,P		7,086,000
Iron Gate	Klamath River	Sec. 9, T47N, R5W 1	CG	137	2,300	35,400	16,700	122,000	I,R,F	Shasta Valley	3,963,000
Montague	Shasta River	Sec. 7, T45N, R6W 1	E	108	2,500	87,000	75,300	84,000	I,R,F	Shasta Valley	5,293,000
Grenada Ranch	Shasta River	Sec. 36, T44N, R6W 1	E	62	2,580	22,800	20,800	20,000	I,U	Shasta Valley and Yreka	735,000
Callahan	Scott River	Sec. 17, T40N, R8W 1	E	271	3,355	133,000	126,000	61,700	I	Scott Valley	10,714,000
Layman	Hayfork Creek	Sec. 15, T31N, R11W 3	E	160	2,638	21,500	20,500	20,600	I,F,R	Hayfork Valley	3,345,000
Morehouse	Salmon River	Sec. 28, T11N, R7E, HB&M 1	R	575	1,530	910,000	540,000	550,000	P	----------	45,656,000
Smoky Creek	South Fork Trinity River	Sec. 5, T28N, R12W 3	E	190	2,635	16,800	16,500	16,500	R,F	----------	2,616,000
Eel-Mad Group											
Crannell	Little River	Sec. 9, T7N, R11E, HB&M 1	E	180	246	36,000	28,000	35,000	I,U	Eureka Plains	2,354,000
Butler Valley	Mad River	Sec. 6, T4N, R3E, HB&M 3	E	160	476	55,000	50,000	60,000	I,U	Eureka Plains	5,977,000
Yager	Yager Creek	Sec. 6, T2N, R2E, HB&M 3	E	221	646	124,000	117,000	105,000	I,U	Eel Delta	4,272,000
Larabee Valley	South Fork Van Duzen River	Sec. 19, T1N, R5E, HB&M 3	E	220	2,480	49,000	47,000	62,400	I,U,F	Eel Delta	5,134,000
Valley's End	Tomki Creek	Sec. 17, T18N, R12W 5	E	160	1,735	57,000	29,000	22,000	I,U	Little Lake Valley	1,843,000
Streeter	Ten Mile Creek	Sec. 21, T22N, R15E 5	E	83	1,520	16,000	13,000	13,400	I,U	Laytonville Valley	959,000
Franciscan	Short Creek	Sec. 28, T23N, R12W 5	E	155	1,548	33,000	29,000	14,000	I,U	Round Valley	1,991,000
Etsel	Middle Fork Eel River	(Franciscan Reservoir ultimately part of Etsel Reservoir. Additional yield allocated to 12,000 acre-feet for local development and 497,000 acre-feet for export. See Table 19.)									
Branscomb	South Fork Eel River	Sec. 29, T22N, R16W 5	E	176	1,517	46,000	44,000	40,000	F,R,FC	----------	6,000,000
Brushy Creek	Bear River	Sec. 7, T1S, R1E, HB&M 3	E	150	1,300	5,000	5,000	5,000	F,R	----------	1,730,000
Caution	North Fork Eel River	Sec. 31, T4S, R8E, HB&M 3	E	185	1,740	12,000	11,000	9,000	F,R	----------	2,250,000
Russian River Group											
Enlarged Coyote Valley	East Fork Russian River	Sec. 34, T16N, R12W 5	E	189	806	[b]77,000	[b]77,000	75,000	I,FC,R,F		12,969,000
Knights Valley	Franz Creek	Sec. 22, T9N, R8W 7	E	223	436	285,000	285,000	50,000	I,R,F		9,064,000
	Maacama Creek	Sec. 9, T9N, R8W 7	E	258	436						
Big Sulphur	Big Sulphur Creek	Sec. 10, T11N, R10W 7	E	320	808	92,000	87,000	43,800	I,FC,R,F		14,429,000
Cummisky	Cummisky Creek	Sec. 10, T11N, R10W 7	E	153	660	13,000	12,000	8,400	I		1,538,000
Feliz	Feliz Creek	Sec. 24, T13N, R12W 7	E	137	640	49,000	47,000	23,000	I		5,563,000
Robertson	Robertson Creek	Sec. 7, T14N, R12W 5	E	170	765	26,000	26,000	13,400	I		4,133,000
Saysal	Saysal Creek	Sec. 25, T10N, R9W 7	E	180	450	11,000	10,000	6,200	I	Russian River Basin, Tomales-Bodega area, North Bay area	2,295,000
Dry Creek	Dry Creek	Sec. 5, T10N, R11W 7	E	252	545	203,000	188,000	42,700	I,FC,R,F		9,921,000
Mill	Mill Creek	Sec. 25, T9N, R10W 7	E	180	425	48,000	45,000	12,000	I,R,F		5,006,000
Warm Springs	Warm Springs Creek	Sec. 24, T10N, R11W 7	E	190	460	39,000	37,000	12,000	I,R,F		4,209,000
Bear Pen	Big Austin Creek	Sec. 5, T8N, R11W 7	E	180	383	10,000	9,000	8,000	R,F		3,011,000
Laguna	Laguna de Santa Rosa	Sec. 34, T8N, R9W 7	CG	24	65	28,000	26,000	19,000	I,U,R,F		407,000
Mark West	Mark West Creek	Sec. 14, T8N, R8W 7	E	154	553	38,000	35,000	10,200	I,R,F		3,045,000
Walker	Walker Creek	Sec. 9, T4N, R9W 7	E	145	193	75,000	74,000	23,000	I		2,271,000

Pacific Basins Group												
Rowdy Creek	Rowdy Creek	Sec. 33, T18N, R1E, HB&M	1	(No detailed study made at this site)						I,U	Smith River Plain	
Green Point	Redwood Creek	Sec. 14 & 15, T6N, R3E, HB&M	3	E	130	965	5,000	5,000	5,100	F,R		2,945,000
Thorn	Mattole River	Sec. 22, T5S, R2E, HB&M	3	E	160	1,165	35,000	33,000	33,000	F,R		6,711,000
Glenblair	Pudding Creek	Sec. 3, T18N, R17W	5	E	160	152	75,000	61,000	24,000	I	Fort Bragg area	4,847,000
Yesmar	South Fork Tenmile River	Sec. 14, T19N, R17W	5	E	160	152						
Hayworth	Hayworth Creek	Sec. 33, T19N, R15W	5	E	160	600	9,000	8,000	7,000	U,R,F	Fort Bragg area	2,256,000
Caspar	Caspar Creek	Sec. 9, T17N, R17W	5	E	155	238	9,000	8,000	3,900	I	Fort Bragg area	1,876,000
MacDonald	Albion River	Sec. 17, T16N, R16W	5	E	155	185	27,000	25,000	15,000	I	Adjacent coastal plateau	2,511,000
Lone Tree	Indian Creek	Sec. 14, T14N, R14W	5	E	230	864	16,000	16,000	12,000	I,R,F	Navarro and Anderson Valleys	3,376,000
Big Foot	Rancheria Creek	Sec. 30, T12N, R12W	7	E	115	1,042	13,000	10,000	6,000	F,R		1,252,000
Castle Garden	South Branch, North Fork Navarro River	Sec. 19, T15N, R14W	5	E	140	520	5,000	4,000	3,600	F,R		2,204,000
Tin Can	Alder Creek	Sec. 11, T13N, R16W	7	E	250	744	67,000	67,000	22,600	I	Pint Arena area	3,732,000
Garcia	Garcia River	Sec. 12, T12N, R14W	7	E	180	1,065	15,000	14,000	9,200	F,R		2,986,000
Billings	North Fork Gualala River	Sec. 34, T12N, R14W	7	E	155	690	9,000	9,000	7,600	F,R		1,581,000
Neese Ridge	Gualala River	Sec. 31, T10N, R12W	7	E	130	450	9,000	9,000	8,100	F,R		1,234,000
Houser Bridge	Gualala River	Sec. 22, T9N, R13W	7	E	135	445	15,000	14,000	12,800	F,R		1,285,000
Totals							3,652,000	3,099,800				237,187,000

Power plant	Location, MDB&M, and sheet of Plate 5 on which shown		Average head, in feet	Installed capacity, in kilowatts	Average annual energy generation, in kilowatt-hours	Capital cost [a]
Klamath-Trinity Group						
Morehouse	Sec. 22, T11N, R7E, HB&M	1	470	90,000	343,500,000	$8,849,000

Associated features	Length of conduit, in miles				Pumping plants			Capital cost [a]
	Canal	Tunnel	Pipe	Total	Total number	Installed capacity, in kilowatts	Seasonal power consumption, in kilowatt-hours	
Klamath-Trinity Group	44.8	0.9	11.9	57.6	10	88,200	147,600,000	$25,411,000
Eel-Mad Group		2.0		2.0				1,697,000
Russian River Group	2.0		0.8	2.8	2	3,700	10,000,000	1,281,000
Pacific Basins Group								
Totals	46.8	2.9	12.7	62.4	12	91,900	157,600,000	$28,389,000

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

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

[a] At 1955 price levels.
[b] In addition to existing storage capacity of 122,000 acre-feet.

which have been described in all the foregoing sections, are delineated on Sheets 1, 3, 5, and 7 of Plate 5.

San Francisco Bay Area

Because of its mild and equable climate, its strategic location, its waterways and outstanding natural harbor, and its fertile agricultural lands, the San Francisco Bay Area has become one of the most highly developed regions of California. However, this high degree of development has imposed water demands far in excess of the yield of local water resources throughout most of the area. Had it not been for farsighted planning and progressive water resource development, wherein water is imported on a large scale from distant watersheds, the population growth could never have reached its present stage. Yet, in spite of the notable steps taken to obtain water supplies to meet the ever increasing needs, severe water problems exist in several portions of the San Francisco Bay Area.

The great need for water, coupled with the paucity of available water resources, has forced the people of the San Francisco Bay Area into a more advanced stage of water resource development than in many other areas of California. Opportunity for further development of local water resources is and has for some time been very limited, and has fostered the development of foreign watersheds and the importation of water through aqueducts many miles in length.

In efforts to solve water supply problems a number of public and private agencies have been formed, and by their initiative several outstanding water supply projects have been constructed. One of the most widely known of such projects, the Hetch Hetchy Project, was constructed by the City of San Francisco, and began delivery of water from Hetch Hetchy Reservoir and Lake Eleanor in Yosemite National Park to the San Francisco Peninsula in 1934. The Hetch Hetchy Aqueduct is about 150 miles in length and features a 25-mile tunnel through the Coast Range, the longest tunnel in the world at the time of completion. The East Bay Municipal Utility District likewise has constructed an outstanding water supply project, involving the importation of water from Pardee Reservoir on the Mokelumne River to the East Bay area, a distance of some 95 miles, through the Mokelumne Aqueduct.

Present water problems in the San Francisco Bay Area are manifested by serious overdrafts on the ground water resources of Santa Clara Valley, Livermore Valley, and the southern portion of Alameda County. Although these ground water basins are physically meeting the demands, their usefulness is threatened by the intrusion of sea water or of other waters of undesirable quality. The draft on these basins presently (1955) exceeds their mean annual replenishment by an estimated 41,000 acre-feet. The developed water surface supplies in Marin County are presently (1955) adequate to meet the requirements; however, the potential for further local development is limited, and water deficiency problems are imminent in the near future. Nearly all areas in the San Francisco Peninsula and the East Bay are dependent upon imported water supplies.

It is estimated that satisfaction of water requirements in the San Francisco Bay Area will ultimately involve the use of nearly 7 per cent of the total developed water supplies in the State. With less than 2 per cent of the water resources of the State, it is obvious that the area will be a major area of ultimate water deficiency. The requirements for supplemental water, in addition to the import of water through present facilities to the full extent of existing or claimed rights, are forecast to reach some 2,110,000 acre-feet per season under ultimate conditions. Nearly all of this water would of necessity be supplied by imports from areas of water surplus in other regions of California.

Flood problems in the San Francisco Bay Area are largely local in nature, and occur primarily on the highly developed urban areas immediately adjacent to stream channels and along the bay shore. The flood of December, 1955, exemplified this type of damage. Throughout the entire bay area that flood sent streams to record heights and caused considerable damage in upstream areas as well as along the bay shore. The Napa River overflowed its banks through most of its length in Napa Valley. Large areas of agricultural lands in the Livermore and Amador Valleys were inundated by overflow of tributaries of Alameda Creek, and industrial developments in Livermore Valley and the highway and railroads in Niles Canyon suffered heavy damage. Heavy damage was also inflicted upon southern Alameda County. The recently completed Lexington Dam and Reservoir on Los Gatos Creek averted a disaster of major proportions in Los Gatos and a portion of the City of San Jose.

The objectives of The California Water Plan in the San Francisco Bay Area are twofold: first, the development of local water resources to the maximum practicable extent to satisfy increasing needs for irrigation, urban, industrial, and recreational purposes, and a measure of flood control; and second, the importation of water through facilities of the California Aqueduct System to meet the ultimate requirements of all lands considered susceptible of water service. Because of the limited potential for further development of local water resources, elimination of present water problems and provision of water to meet future increased requirements in the area will necessitate substantial importation of water from areas of surplus in other regions of the State. In this regard, additional imports proposed by certain water service

San Francisco Bay Area

agencies, notably the City of San Francisco and the East Bay Municipal Utility District, by extension and enlargement of their existing facilities, have been taken into consideration in the formulation of plans for ultimate water supply in the area.

For convenience of presentation herein, the San Francisco Bay Area has been divided into three major subareas. These are designated and are hereinafter referred to as the "North Bay Group," "Southeast Bay Group," and "Peninsula Group," and their locations are shown on Plate 3. The layout of the water development works in the San Francisco Bay Area is delineated on Sheets 7, 8, and 10 of Plate 5. Data on the physical features and costs of the local works considered are presented in Table 10 which follows this discussion under the heading "Summary of San Francisco Bay Area."

North Bay Group. The North Bay Group embraces those portions of Marin, Sonoma, Napa, and Solano Counties draining into San Francisco, Bodega, Tomales, San Pablo, and Suisun Bays. It reaches from the Pacific Ocean on the west to the Sacramento-San Joaquin Delta on the east, and extends north to the drainage divides defining the Sacramento Valley and the Russian River Basin. The area is drained by the Napa River and Suisun, Sonoma, and San Antonio Creeks, which flow into San Francisco Bay, and Lagunitas Creek, which empties into Bodega Bay.

The meager water resources of the North Bay Group have been rather intensively developed. Lagunitas Creek, the principal stream in Marin County, has been almost fully developed by the Marin Municipal Water District. Present development on that creek includes Kent Lake, formed by the recently completed Peters Dam, Lagunitas Reservoir, and several smaller reservoirs. Surface water storage works in Napa Valley include, among others, Lake Henessey on Conn Creek, owned and operated by the City of Napa, and Rector Creek Dam, constructed by the State Department of Public Works to develop a water supply for the State Game Farm and the Veterans Home near Yountville.

The City of Vallejo operates several reservoirs in Solano County for development of water supplies. In addition, the city has recently constructed an import water supply project involving a pumped diversion of water from Cache Slough in the Sacramento-San Joaquin Delta and its conveyance to the city by pipe line. The capacity of this project is about 23,000 acre-feet per season, although present (1955) delivery is less than 10,000 acre-feet.

In addition to the foregoing surface water facilities, ground water is developed in Petaluma, Sonoma and Napa Valleys, and the Fairfield area of Solano County. It is estimated that these ground water basins have an aggregate yield equivalent to the present (1950) draft therefrom, or about 18,000 acre-feet per season. The potential for additional development of ground water in these basins is limited. In localized areas in each of the basins excessive pumping has lowered ground water elevations below sea level, so that sea-water intrusion has become an active threat.

Because of the paucity of suitable dam and reservoir sites on the greater water-producing streams, and prior development of the more feasible sites, opportunity for further development of the water resources of the North Bay Group is very limited. Marin and southern Sonoma Counties are faced with an imminent water shortage, and certain water service agencies there are looking to the Coyote Valley Project on the East Fork of the Russian River near Ukiah as an early available source of supplemental water. Solano County is similarly faced with the need of an imported water supply for future growth, although the problem in that area is not as urgent as in Marin and Sonoma Counties. The entire North Bay Group will be in need of an imported water supply in the near future, and will ultimately require an import of more than 1,200,000 acre-feet of supplemental water per year.

Flood problems exist along all the principal streams of the North Bay Group. Most of the lands subject to inundation lie in the lower reaches of the streams, being in large part reclaimed tidal marshes. However, flooding also occurs along the upper reaches, where agricultural lands and residences on lower-lying lands are inundated. Expansion of existing urban areas is intensifying this problem. Local public agencies and private land owners have built levees, cleared channels, and placed revetments to halt bank erosion. However, no coordinated plans have been followed, and in general works are inadequate to contain floods of any appreciable magnitude.

Local water development works contemplated as features of The California Water Plan in the North Bay Group comprise reservoirs on Sonoma and Nicasio Creeks, and on the Napa River and its tributaries. Operation of these reservoirs would provide water to meet irrigation, urban, and industrial uses, and improve existing stream flow conditions in the interests of the fishery and the recreational opportunity. In addition, these works could effect some flood control.

Municipal and industrial water supplies could be made available to service areas in Marin County from Nicasio Reservoir, located on Nicasio Creek about 3 miles east of the community of Nicasio. This reservoir and associated conveyance facilities are presently scheduled for construction by the Marin Municipal Water District to supplement its presently developed water supplies. Water would be conveyed from the reservoir to the service areas by means of a pipe line and booster pumping plants.

Bear Creek Dam and Reservoir, located on Sonoma Creek about 2 miles north of Kenwood, if constructed could provide domestic water for communities in the vicinity immediately downstream from the dam. Operation of Bear Creek Reservoir could also provide some flood control and enhance summer stream flows for recreational purposes.

Further conservation of the water resources of Napa Valley could be accomplished by dams and reservoirs on Dry and Sulphur Creeks, tributaries to the Napa River, and a pumped diversion of water from the Napa River to an off-stream storage reservoir near St. Helena. The reservoir formed by Wing Canyon Dam would be located on Dry Creek about 3 miles southeast of Yountville, and could serve downstream urban areas. Sulphur Springs Dam, located on Sulphur Creek about 1.5 miles southwest of St. Helena, could similarly serve urban lands in Napa Valley. The Spring Valley Project would involve a diversion of excess winter flows from the Napa River to a point about 2 miles west of St. Helena, and pumping of this water through an average lift of 75 feet into Spring Valley Reservoir, an off-stream storage unit, located about 1,000 feet east of the diversion point. The water stored during the winter months would be regulated to an irrigation demand schedule for release into the Napa River for downstream diversions.

The five reservoirs and associated facilities comprising the local development work of The California Water Plan in the North Bay Group would provide 29,000 acre-feet of new water per year, which would serve an estimated 8,400 acres of irrigated and urban lands in the group. The reservoirs would have an aggregate gross storage capacity of some 53,000 acre-feet, and would enhance the recreational and sport fishing potential of the area by creating new bodies of water and by improving summer flows in downstream channels.

It is apparent that the additional seasonal yield of 29,000 acre-feet to be obtained from further development of local water resources is insignificant compared to the estimated total ultimate supplemental water requirement of nearly 1,250,000 acre-feet per season in the North Bay Group. Even with full development of the local yield, there would remain an ultimate seasonal supplemental water requirement of 1,217,000 acre-feet. Provision of this water would be made by facilities of the California Aqueduct System, the Putah South Canal of the Solano Project, the North Bay Aqueduct, the Eel River Diversion, the Cedar Roughs Tunnel, and Montezuma Reservoir. These works are summarized herein and are described in more detail subsequently under the heading "California Aqueduct System."

The Solano Project, presently under construction by the United States Bureau of Reclamation, will serve water developed in Monticello Reservoir, on Putah Creek, to lands in Solano County through the Putah South Canal. Studies made by the Department of Water Resources in connection with the Salinity Control Barrier Investigation have indicated that 55,000 acre-feet per season of this water will be utilized in the portion of Solano County within the San Francisco Bay Area.

The North Bay Aqueduct would serve large areas of low lying lands to the north of Suisun and San Pablo Bays. It is contemplated that eventually the water would be diverted from Montezuma Reservoir on the Sacramento West Side Canal of the California Aqueduct System, located near Fairfield. However, initially the water would be diverted from Lindsay Slough in the Sacramento-San Joaquin Delta. From Lindsay Slough the water would be conveyed in a westerly and southwesterly direction past Fairfield and Cordelia, to a small terminal reservoir about 2 miles northeast of Novato. An ultimate seasonal delivery of about 308,000 acre-feet of water to the North Bay Group is contemplated, distributed as follows: Marin and Sonoma Counties, 156,000 acre-feet; Napa Valley, 28,000 acre-feet; and Solano County, 124,000 acre-feet. Delivery of this water would be accomplished by releases along the route of the aqueduct.

The Eel River Diversion contemplates a delivery of about 422,000 acre-feet of water per season to Marin and southern Sonoma Counties to meet the remaining ultimate supplemental water requirements in that area. The water would be conveyed from the Eel River by means of a tunnel from Willis Ridge Reservoir into Potter Valley, thence down the Russian River to a rediversion near Geyserville. From this point the water would be conveyed southerly about 40 miles by canal and pipe line to Stemple Reservoir, located on Stemple Creek about 3 miles southwest of Cotati. Stemple Reservoir would regulate the continuous diversion to the variable monthly demand schedule in the service area.

In Napa Valley, there would still remain a supplemental water requirement of about 224,000 acre-feet per season under ultimate conditions, in addition to the contemplated delivery of 28,000 acre-feet per season by the North Bay Aqueduct. This requirement could be met by a diversion of Eel River water, as described later in this chapter under the California Aqueduct System, from Monticello Reservoir on Putah Creek, and its conveyance westerly by a tunnel through Cedar Roughs Ridge, where it would be released into Conn Creek for regulation in Lake Hennessey.

Water to meet the remainder of the ultimate supplemental requirements in Solano County, over and above deliveries by the Putah South Canal and the North Bay Aqueduct, would be provided by diversion from Montezuma Reservoir at the terminus of the Sacramento West Side Canal near Fairfield. Although diversions could be made from any desired point along the Sacramento West Side Canal, which

San Francisco Bay Area—Napa Valley Grape Harvest would pass through Solano County, such diversions would have to be made at a constant rate so as not to sacrifice the delivery potential of the canal, and local storage would be required to regulate the constant diversions to the varying monthly demands in the service area.

In summary, facilities of the California Aqueduct System would ultimately deliver some 1,220,000 acre-feet of water per season to service areas in the North Bay Group, distributed as follows: Solano Project, 55,000 acre-feet; North Bay Aqueduct, 308,000 acre-feet; Eel River Diversion, 422,000 acre-feet; Cedar Roughs Tunnel, 224,000 acre-feet; and Montezuma Reservoir, 208,000 acre-feet. These deliveries, with the 28,000 acre-feet of water per season secured by further local development, would fully satisfy the ultimate water requirements of all lands considered susceptible of water service in the North Bay Group.

Southeast Bay Group. The Southeast Bay Group comprises the portions of Contra Costa, Alameda, and Santa Clara Counties within the San Francisco Bay drainage, being bounded by San Pablo and Suisun Bays on the north, the San Joaquin Valley drainage divide on the east, San Francisco Bay and San Mateo county line on the west, and the Santa Cruz Mountains and Morgan Hill Divide on the south. The group is occupied by a highly developed urban and industrial economy. Irrigated agriculture also plays a significant role in the economy, particularly in Santa Clara Valley.

The high degree of development attained in the Southeast Bay Group has been made possible, in large part, by exploitation of the extensive ground water storage in alluvial fill areas, notably the Santa Clara and Livermore Valleys, and southern Alameda County along the east shore of the bay. More than 100,000 acres of irrigated lands in north Santa Clara Valley are presently (1955) served from wells. The principal surface water development works consist of Calaveras Reservoir on Calaveras Creek, and installations on Alameda Creek at and above Sunol, operated by the City of San Francisco for local water service and export to the Peninsula; the Upper and Lower San Leandro, San Pablo, and Lafayette Reservoirs operated by the East Bay Municipal Utility District both for conservation of local water resources and for terminal storage for the Mokelumne Aqueduct; and reservoirs on Coyote, Arroyo Calero, Alamitos, Guadalupe, and Los Gatos Creeks, operated conjunctively with ground water storage by the Santa Clara Valley Water Conservation District.

Artificial recharge of ground water basins is practiced both in Alameda and Santa Clara Counties. The Alameda County Water District is utilizing abandoned gravel pits for spreading surplus flows in Alameda Creek, thus supplementing natural stream channel percolation in the Niles Cone area. The Santa Clara Valley Water Conservation District operates percolation ponds and natural stream channels in conjunction with surface reservoirs which control releases to rates within the percolation capacity of these works.

Water is presently imported to the Southeast Bay Group through the Contra Costa Canal, constructed by the United States Bureau of Reclamation; the Mokelumne Aqueduct of the East Bay Municipal Utility District; and the Hetch Hetchy Aqueduct of the City of San Francisco, which now serves supplemental water to the City of Hayward, the Alameda County Water District, other areas in southern Alameda County, and the portion of northern Santa Clara County included in the Milpitas-Sunnyvale-Palo Alto area.

The Contra Costa Canal diverts water from Rock Slough in the Sacramento-San Joaquin Delta, and serves lands along the northern portion of Contra Costa County extending generally from Oakley on the east to Martinez on the west. The present capacity of the system is estimated to be about 85,000 acre-feet per season to the Bay area. It is estimated that this delivery could be increased ultimately to 146,000 acre-feet per season.

The East Bay Municipal Utility District serves lands in western Contra Costa and northwestern Alameda Counties. The Mokelumne Aqueduct furnishes the principal water supply for the service area of the district. Although the present capacity of the system is limited to 162,500 acre-feet of water per season, the district has secured permits, and plans to ultimately import some 364,000 acre-feet per season, which quantity will meet the ultimate requirements of its service area. Construction of additional local reservoir storage is contemplated by the district, for the joint purposes of providing terminal storage for the Mokelumne Aqueduct, and developing local water resources. These planned local works comprise Pinole Reservoir on Pinole Creek, Briones Reservoir on Bear Creek, both in western Contra Costa County, and enlargement of the existing Upper San Leandro Reservoir.

As a result of heavy long sustained drafts on ground water resources in the Southeast Bay Group, and the continuing trend toward increasing municipal, industrial and irrigation demands, the ground water basins of Livermore Valley, Santa Clara Valley, and southern Alameda County are seriously overdrawn at the present time. Ground water pumping levels in the vicinity of San Francisco Bay are substantially below sea level in the latter two areas, with the resultant threat of destruction of the ground water resources by intrusion of sea water from beneath the bay. In fact, sea water has already intruded into the upper aquifer in southern Alameda County, rendering the water unsuitable for use, and has entered the lower aquifer, largely through abandoned or defective wells. Overdrafts on ground water in these areas presently (1955) aggregate an estimated 41,000 acre-feet per season.

In addition to ground water overdrafts, the surface water supplies of the Southeast Bay Group are inherently deficient, and the group depends primarily on imported water supplies to meet present requirements. Under ultimate conditions, some 825,000 acre-feet per season of supplemental water will be required, in addition to the delivery of water through present import facilities to the full extent of existing or claimed rights.

The Southeast Bay Group is presently faced with a two-fold flood problem: tidal flooding of lands adjacent of San Francisco Bay, and storm water flooding by streams flowing across the coastal plain. Lands adjacent to the bay have been reclaimed by dikes, with tidal gates across stream outlets which hold back the tides but limit outflow to the bay and cause ponding of surface runoff on the valley floor behind them. A number of streams have thus been completely cut off from direct access to the bay. Flood problems other than those directly related to tidal influence occur principally in the Walnut Creek watershed in Contra Costa County, along Alameda and San Lorenzo Creeks in Alameda County, and on the flood plains of streams tributary to San Francisco Bay in Santa Clara County. These streams flow through some of the most rapidly developing urban areas in the San Francisco Bay Area, the problem being intensified in recent years by encroachment of urban and industrial development on the flood plains.

The principal flood problems of the Southeast Bay Group are within the boundaries of the three county flood control districts in the group. These districts are actively engaged in planning and constructing works for the alleviation of flood conditions, taking cognizance of the probable urban nature of development under ultimate conditions in their respective areas. When completed, these flood control works should provide adequate flood protection.

Opportunity for further development of local water resources toward meeting ultimate water requirements in the Southeast Bay Group is very limited. In fact, full practicable development could not meet the present supplemental water requirement, assuming existing imports were continued in their present quantities. The objectives of The California Water Plan in the group are, therefore, development of the remaining local water resources within the limits of feasibility, and importation of water through facilities of the California Aqueduct System in amounts sufficient to meet the ultimate water requirements of all lands considered susceptible of water service. The utility of the ground water resources would be preserved by maintaining a proper balance between ground water replenishment and the pumping draft from the basins.

Local water development works contemplated as features of The California Water Plan in the Southeast Bay Group consist of reservoirs on the Alameda Creek system in Alameda County; and a reservoir on San Francisquito Creek, a well field, and a percolation canal to augment ground water replenishment, all in the Santa Clara Valley.

Sanatorium Dam and Reservoir, located on Arroyo del Valle about 5 miles south of Livermore, and Mocho Dam and Reservoir on Arroyo Mocho, 5 miles southeast of Livermore, could, if operated in conjunction with downstream ground water storage in Livermore Valley, develop a new seasonal yield of about 9,300 acre-feet for use in the valley. In order to develop this yield, the use of considerable cyclic ground water storage capacity would be required. Such operation would involve the detention of runoff in surface storage only for the time required for regulation of releases to rates which could be absorbed in downstream channels for replenishment of ground water storage.

In addition to its local function in developing the waters of Arroyo del Valle, Sanatorium Reservoir could provide regulation for water imported to Alameda County through the South Bay Aqueduct, described subsequently. A portion of the available storage could be allocated to development of local runoff, and the remainder could serve to regulate the imported waters.

La Costa Dam and Reservoir on San Antonio Creek about 3 miles above its confluence with Alameda Creek, when constructed would control the waters of La Costa, Indian, and San Antonio Creeks. This reservoir could be operated effectively in conjunction with ground water storage capacity in the Niles Cone area, and the conserved water could provide a portion of the present supplemental requirements in that area. However, the City of San Francisco proposes to construct La Costa Dam and Reservoir, under claim of water rights on Alameda Creek and tributaries, as an integral portion of the water supply operated by San Francisco; and, under such circumstances, the reservoir would not be operated conjunctively with the Niles Cone ground water basin.

Prospective local water resource developments in the Santa Clara Valley consist of a dam and reservoir on San Francisquito Creek, a well field for the salvage of ground water adjacent to Coyote Creek, and a diversion canal from Calero Reservoir to Los Gatos Creek to augment ground water replenishment.

Little Francis Dam and Reservoir would be located on San Francisquito Creek about 5 miles upstream from U. S. Highway 101 in San Mateo County. The Coyote Valley well field would be located near the north end of Coyote Valley, and could provide an urban water supply for the City of San Jose by sal-

Calaveras Reservoir on Calaveras Creek Provides Water for San Francisco Metropolitan Area vaging ground water which presently wastes to San Francisco Bay because of existing high ground water levels. The well field would consist of a series of deep wells spaced about a quarter of a mile apart in a line adjacent and parallel to Coyote Creek.

The Calero Diversion would extend northwesterly from the existing Calero Reservoir on Arroyo Calero, to Los Gatos Creek, intercepting flows from Alamitos and Guadalupe Creeks, and conveying these waters in open canal for a distance of about 9 miles to Guadalupe Creek and then in pipe line an additional 6 miles to Los Gatos Creek. The waters would be discharged into Los Gatos Creek for percolation in the channel of that creek.

The total seasonal new yield developed by the foregoing works in the Santa Clara Valley would aggregate about 12,900 acre-feet. However, it should be mentioned that the Santa Clara Valley Water Conservation District is presently proposing a program, including recharge of ground water basins, to improve and expand its existing system for conservation of water that would otherwise waste to San Francisco Bay. This program includes enlargement and extension of the present distribution system, and construction of dams and reservoirs on Penitencia, Guadalupe, Silver, and Calabazas Creeks. The district estimates that these four reservoirs, with a combined storage capacity of 17,500 acre-feet, would develop a new yield of about 10,000 acre-feet per season when operated in conjunction with ground water storage.

The seasonal yield of the new local water development works in the Southeast Bay Group contemplated under The California Water Plan would aggregate only 34,000 acre-feet, including the proposed developments of the East Bay Municipal Utility District on Pinole, Bear, and San Leandro Creeks. These works could only partially offset the present supplemental water requirements in the group, even though they represent essentially the full practicable development of local water resources. This fact points up the real necessity for the early development of an imported water supply.

In addition to the yield from the foregoing local developments, there would remain a total ultimate supplemental water requirement of some 1,148,000 acre-feet per season in the Southeast Bay Group. Of this total, the following supplies could be made available by existing agencies: (1) an additional 201,000 acre-feet per season could be imported by the East Bay Municipal Utility District for service within the district, (2) an additional 61,000 acre-feet per season could be delivered to Contra Costa County by the Contra Costa Canal of the Central Valley Project, and (3) the City of San Francisco states that an additional 109,000 acre-feet per season could be delivered to the Santa Clara Valley and an additional 125,000 acre-feet to the southern Alameda County and Livermore units by the Hetch Hetchy Aqueduct of the City of San Francisco. The remainder necessary would be provided by the Kirker Pass Aqueduct and the South Bay Aqueduct, both features of the California Aqueduct System.

The Kirker Pass Aqueduct contemplates the delivery of 164,000 acre-feet per season to lands in Contra Costa County not considered susceptible to service by facilities of the Contra Costa Canal and the East Bay Municipal Utility District. The aqueduct would convey water from the Antioch Crossing of the Delta Division of the California Aqueduct System in a general southwesterly direction about 21 miles to Lime Ridge Reservoir, about 2 miles west of Clayton. The Kirker Pass Aqueduct would provide the balance of the ultimate supplemental water requirement in Contra Costa County.

The South Bay Aqueduct would provide water in amounts sufficient to meet the remainder of the supplemental water requirements of Alameda County and Santa Clara Valley under ultimate conditions. As contemplated, the aqueduct would be constructed in two stages. The initial stage would comprise the Alameda-Contra Costa-Santa Clara-San Benito Counties Branch of the authorized Feather River Project Aqueduct, presently under intensive study by the Department of Water Resources for possible early construction. Deliveries of water by the Alameda-Contra Costa-Santa Clara-San Benito Counties Branch would be supplemented at a future time by construction of additional diversion and conveyance works which would parallel the facilities of the initial stage. The total contemplated deliveries under ultimate conditions would be about 627,000 acre-feet per season, distributed as follows: Livermore Valley, 187,000 acre-feet; southern Alameda County coastal plain, 198,000 acre-feet; and Santa Clara Valley, 242,000 acre-feet.

Regulation of water delivered by the initial stage of the South Bay Aqueduct would be provided in Airpoint Reservoir, about 2 miles east of Mission San Jose, and Evergreen Reservoir located about 6 miles southeast of San Jose, or alternatives thereto. These reservoirs would regulate the constant or uniform delivery to the variable monthly demands in the Southeast Bay Group. In this connection, available data indicate that the use of Airpoint Reservoir might be questionable from the geologic standpoint, due to possible excessive leakage.

Construction of the South Bay Aqueduct to the ultimate stage contemplates the use of a portion of the storage space in Sanatorium Reservoir on Arroyo del Valle. However, it is now apparent that the ridges on either side of the reservoir are capped with gravels which are probably permeable. Thus, storage in the reservoir would probably be limited due to the possibility of leakage at higher water stages.

Delivery of water to southern Contra Costa County and the northern portion of Livermore Valley could be accomplished by an alternative route of the South Bay Aqueduct. This alternative would consist of a diversion of water at the outlet portal of Brushy Peak Tunnel, and the conveyance along the northerly edge of Livermore Valley to a regulatory storage reservoir in Doolan Canyon, as shown on Sheet 10 of Plate 5. A reservoir at this site would be strategically located with respect to serving lands in Contra Costa County not within feasible reach of any existing water service agency. Studies of this alternative route have been of only a preliminary nature.

In summary, the objectives of The California Water Plan in the Southeast Bay Group would be met by local water developments which would provide 34,000 acre-feet per season; an increase in delivery capacity of existing import facilities, amounting to 357,000 acre-feet per season, and imports through facilities of the California Aqueduct System, in the amount of 791,000 acre-feet per season, distributed as follows: Kirker Pass Aqueduct, 164,000 acre-feet; and South Bay Aqueduct, 627,000 acre-feet. Together, the foregoing deliveries would fully satisfy the ultimate water requirements of all land considered susceptible of water service in the Southeast Bay Group.

Sanatorium, La Costa, and Little Francis Reservoirs would provide a measure of incidental flood control. However, the bulk of the required flood control works in the Southeast Bay Group are planned for construction by the three county flood control agencies in the area. Benefits to recreation and fish life would probably be slight because of operation primarily for water conservation.

Peninsula Group. The Peninsula Group comprises the City and County of San Francisco and nearly all of San Mateo County. San Francisco County occupies only the northern tip of the peninsula, forming an approximate square about 7 miles on each side. A major topographic feature of the peninsula is a mountain range lying north and south, forming its backbone. The City of San Francisco and adjacent communities in the northern portion of the bay side of San Mateo County constitute one of the most highly developed urban areas in the United States. The major segment of the economy is based upon industrial development, primarily manufacturing and food processing.

The Peninsula Group is drained principally by streams on the western slope which discharge into the Pacific Ocean. There are no undeveloped streams of any significance draining the eastern slope into the bay, with the exception of San Francisquito Creek, which forms the southerly boundary of the group.

The high degree of urban development attained in the Peninsula Group has been made possible, for the most part, by water supplies imported from foreign watersheds. Development of local water resources had been virtually completed prior to 1900, with the construction of Pilarcitos, San Andreas, and Upper and Lower Crystal Springs Reservoirs by the Spring Valley Water Company, predecessor to the San Francisco Water Department. Alameda Creek in the Southeast Bay Group was first developed for a water supply for San Francisco and the peninsula around 1900, and was fully developed and outgrown by the early 1930's.

The need for imports of water from distant sources on a large scale was foreseen by the City of San Francisco sufficiently in advance that Lake Eleanor and Hetch Hetchy Reservoir on the Tuolumne River watershed and the Hetch Hetchy Aqueduct were completed by the time the peninsula and Alameda Creek systems became insufficient to meet the water requirements. Water was first delivered from Hetch Hetchy Reservoir and Lake Eleanor in Yosemite National Park to Crystal Springs Reservoir on the peninsula through the Hetch Hetchy Aqueduct in 1934.

Other than possible minor localized water problems along the coast in San Mateo County, there are no water shortage problems in the Peninsula Group. Moreover, the City and County of San Francisco plan to import sufficient water through the Hetch Hetchy Aqueduct to meet the ultimate water requirements of San Francisco, the bay side of San Mateo County, and the coastal side of the county south nearly to Half Moon Bay.

Present flood problems in the Peninsula Group occur principally on the bay side of the peninsula, and are of a localized nature due to the comparatively small drainage areas of the uncontrolled streams. However, during intense storms these streams present serious flood threats to the highly developed urban areas which are rapidly extending along the bay shore over the entire length of the peninsula. Encroachment of these developments on the channels and flood plains has restricted channel capacities and has made maintenance difficult, as well as subjecting high-value property to possible inundation. Flood plains of streams on the coastal side of the peninsula are utilized mainly for agricultural pursuits, and flood damage has not been great. However, predictions of future land use patterns indicate a predominantly urban culture under conditions of ultimate development, and future flood problems will become greatly magnified.

The objectives of The California Water Plan in the Peninsula Group would be met by local development works on Pescadero and Butano Creeks to serve the coastal portion of San Mateo County south of Half Moon Bay, and by increased imports by the City and County of San Francisco to serve the remainder of the group.

Waters of the Pescadero Creek system would be developed by two dams, one on Pescadero Creek, about

1.5 miles east of Pescadero, and another on Butano Creek about 1 mile southeast of Pescadero and just above the confluence of Butano and Pescadero Creeks. Pescadero Dam would be limited in height to avoid inundation of any portion of Memorial Park with its beautiful grove of virgin redwoods. Water conserved by Butano Point Reservoir would be augmented by a gravity diversion through a pipe line from Pescadero Reservoir. The water supply made available by these reservoirs could be conveyed in a pressure pipe from Butano Point Dam northerly along the coast to the vicinity of Half Moon Bay. A pumping plant located at the downstream toe of the dam would lift the water to an elevation of about 400 feet at a summit about 6 miles north of the dam. From this point the water would flow by gravity to the vicinity of Half Moon Bay. Releases would be made to service areas along the conduit route.

The Pescadero Creek development would make available a seasonal supply of 40,000 acre-feet, which quantity could meet the ultimate water requirements of the forecast exclusively urban-type land use in the areas south of the service area of the San Francisco Water Department. In addition, considerable incidental flood control would be accomplished, and warmwater fishery could be enhanced. The balance of 196,000 acre-feet of ultimate supplemental water requirements in the Peninsula Group would be met by service of water imported through the Hetch Hetchy Aqueduct by the City and County of San Francisco.

Summary of San Francisco Bay Area. Objectives of The California Water Plan in the San Francisco Bay Area would be met by further development of local water resources, by increases in deliveries of existing import projects operated by local water service areas, and by imports through facilities of the California Aqueduct System. Further development of the meager and presently highly developed local water resources is limited. Of the total ultimate supplemental water requirements of 2,111,000 acre-feet per season, only 103,000 acre-feet would be provided by increased development of local water resources, and the remaining 2,008,000 acre-feet would be delivered by the facilities of the California Aqueduct System indicated in the following tabulation:

Solano Project	55,000 acre-feet
North Bay Aqueduct	308,000 acre-feet
Eel River Diversion	422,000 acre-feet
Cedar Roughs Tunnel	224,000 acre-feet
Montezuma Reservoir	208,000 acre-feet
Kirker Pass Aqueduct	164,000 acre-feet
South Bay Aqueduct	627,000 acre-feet

The foregoing developments would make available sufficient water to meet the ultimate requirements of the highly developed urban economy of the San Francisco Bay Area. The prospective local developments would include 10 storage reservoirs with an aggregate capacity of 227,500 acre-feet, of which 199,000 acre-feet would be devoted to local water conservation. These works could provide a measure of incidental flood control, although there would be no primary flood control operation. Maintenance of minimum pools in proposed reservoirs, although small, would create conditions favorable to the warmwater fishery. Moreover, recreational opportunities could be increased by construction and operation of these reservoirs.

Data on the general features and capital costs of the local development works contemplated as features of The California Water Plan in the San Francisco Bay Area are presented in Table 10. The locations and layouts of all of these facilities are delineated on Sheets 7, 8, and 10 of Plate 5.

Central Coastal Area

The Central Coastal Area is primarily an agricultural region, situated between the heavily populated San Francisco Bay and Los Angeles metropolitan areas. While agricultural, industrial, and population growth in the area, in general, has not been as rapid or extensive as that which has occurred in these adjoining regions, certain localized portions have achieved a high degree of development where adequate water supplies are available.

Irrigated agriculture and associated industries for the processing of agricultural products comprise the major economic activity in the Central Coastal Area, particularly in the fertile valleys, such as the Pajaro and Salinas Valleys, where underlying ground water is readily available. Other industries of lesser importance consist of oil refineries, lumber mills, and fishing.

Water supplies in the Central Coastal Area are presently obtained principally from ground water sources. Although these water supplies are physically meeting present requirements, most of the ground water basins are highly developed, and in some cases are overdrawn. Such conditions have developed in the Pajaro and southern Santa Clara Valleys, the Hollister area, and the Salinas, Santa Maria, and Cuyama River Valleys. As a result of these overdraft conditions, degradation of quality of ground water supplies, resulting from sea-water intrusion, has occurred in the Monterey coastal area of the Salinas and Pajaro Valleys, and perennial lowering of ground water levels is manifested in the San Benito, Pajaro, and lower Salinas Valleys. The overdraft on the ground water resources in the Central Coastal Area is presently (1955) estimated to aggregate some 65,000 acre-feet per season.

There are at the present time eight surface storage developments in the Central Coastal Area, with an aggregate capacity of about 626,000 acre-feet and an estimated safe seasonal yield of about 115,000 acre-feet. The largest of these developments is Nacimiento

TABLE 10

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SAN FRANCISCO BAY AREA

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

Dam and reservoir	Stream	Dam			Normal pool elevation, in feet	Storage capacity, in acre-feet		Seasonal yield, in acre-feet	Purpose	Place of water use	Capital cost[a]
		Location, MDB&M, (Shown on sheets 7 and 10 of Plate 5)	Type	Height, in feet		Gross	Net				
North Bay Group											
Bear Creek	Sonoma Creek	Sec. 21, T7N, R6W	E	200	730	4,900	4,800	2,700	U	Upper Sonoma Valley	$2,933,000
Nicasio	Nicasio Creek	Sec. 28, T3N, R8W	E	175	160	22,800	22,700	12,000	U	Marin Municipal Water District	3,418,000
Spring Valley	Unnamed stream	Sec. 32, T8N, R5W	E	86	267	7,000	7,000	5,400	I	Napa Valley	1,329,000
Sulphur Springs	Sulphur Creek	Sec. 1, T7N, R6W	E	110	395	6,200	6,100	2,900	U	Napa Valley	2,168,000
Wing Canyon	Dry Creek	Sec. 14, T6N, R5W	E	171	400	12,300	12,000	6,400	U	Napa Valley	3,645,000
Southeast Bay Group											
Mocho	Arroyo Mocho	Sec. 1, T4S, R2E	E	65	840	2,000	2,000	[c]0	I,U	Livermore Valley	731,000
Sanatorium[b]	Arroyo del Valle	Sec. 3, T4S, R2E	E	175	708	44,000	[d]44,000	[c]3,000	I,U,S	Livermore Valley	
LaCosta	San Antonio Creek	Sec. 22, T4S, R1E	E	131	431	20,000	[e]20,000	[e]5,000	I,U	Niles Cone	2,290,000
Little Francis	San Francisquito Creek	Sec. 17, T6S, R3W	E	91	290	7,300	7,200	3,000	U	Palo Alto	2,203,000
Peninsula Group											
Butano Point	Butano Creek	Sec. 15, T8S, R5W	E	178	168	77,000	75,000	40,000	U	San Mateo coast	4,645,000
Pescadero	Pescadero Creek	Sec. 12, T8S, R5W	E	140	168	31,000	30,000				2,357,000
Totals						234,500	230,800				$25,719,000

Associated features	Length of conduit, in miles			Pumping plants			Capital cost[a]
	Canal	Pipe	Total	Total number	Installed capacity, in kilowatts	Seasonal power consumption, in kilowatt-hours	
North Bay Group		8.7	8.7	2	680	1,800,000	$2,031,000
Southeast Bay Group	10.3	17.6	27.9	[f]7	270	2,000,000	2,222,000
Peninsula Group		16.8	16.8	1	3,590	19,700,000	4,092,000
Totals	10.3	43.1	53.4	10	4,540	23,500,000	$8,345,000

Symbol of Type of Dam
E—Earthfill

Symbols of Purpose
I—Irrigation
U—Urban (Domestic, municipal, industrial)
S—Reregulation of imported waters to local demand schedules

[a] At 1955 price levels, with exception of Spring Valley Reservoir which is 1956.
[b] Possibility of excessive leakage. See comment on page 60.
[c] Mocho and Sanatorium Reservoirs would be operated in conjunction with Livermore Valley ground water storage to develop a total yield of 9,300 acre-feet per season.
[d] 17,000 acre-feet of storage allocated to local development, and 27,000 acre-feet to regulation of deliveries by South Bay Aqueduct.
[e] LaCosta Reservoir would be operated in conjunction with southern Alameda bayside ground water storage to develop a total yield of 6,700 acre-feet per season.
[f] Coyote Valley well field, see page 60.

Reservoir on the Nacimiento River, constructed to a storage capacity of 350,000 acre-feet by the Monterey County Flood Control and Water Conservation District. It is planned that this reservoir will be operated in conjunction with ground water storage in the Salinas Valley. Among other significant developments in the Central Coastal Area are Cachuma Reservoir on the Santa Ynez River, recently constructed by the United States Bureau of Reclamation, and Vaquero Reservoir on the Cuyama River, presently under construction by the same agency. Vaquero Reservoir will be operated in conjunction with ground water storage in the Santa Maria Valley.

The present (1955) water requirement in the Central Coastal Area, amounting to about 630,000 acre-feet per season, will ultimately increase to about 2,246,000 acre-feet per season. The present requirement for supplemental water will ultimately be increased from the present (1955) total of 65,000 acre-feet per season to about 1,681,000 acre-feet per season. Ground water resources of the area could meet little more than the present supplemental water requirements, even if developed to their full potential. It is evident, therefore, that the future development to meet ultimate requirements must rely upon local surface storage works, and upon imports through facilities of the California Aqueduct System.

In addition to the serious water supply problems in the Central Coastal Area, there exists a problem of the opposite nature—the periodic occurrence of major floods which have caused extensive damage to agricultural lands and urban development. Flood damage has been experienced along the lower reaches of the San Benito, Salinas, San Lorenzo, and Pajaro Rivers; Soquel Creek; the Santa Maria and Santa Ynez Rivers; and Arroyo Grande Creek.

The channels of the streams in the area have generally steep gradients and storms produce relatively high precipitation intensities. Resultant flood flows in these streams are characterized by very high intensities of relatively short duration. On San Lorenzo River and Soquel Creek, the recent flood of December, 1955, is considered to be the most damaging flood that ever occurred. Continuing development of urban and suburban areas will increase the flood damage potential adjacent to all the foregoing streams.

The objectives of The California Water Plan in the Central Coastal Area are twofold: first, the control and development of local water resources to the maximum practicable extent to satisfy increasing needs for irrigation, urban, industrial, and recreational purposes, to provide flood control, and to enhance the fishery wherever feasible; and second, the importation of water through facilities of the California Aqueduct System to satisfy fully the ultimate requirements of all lands considered susceptible of water service.

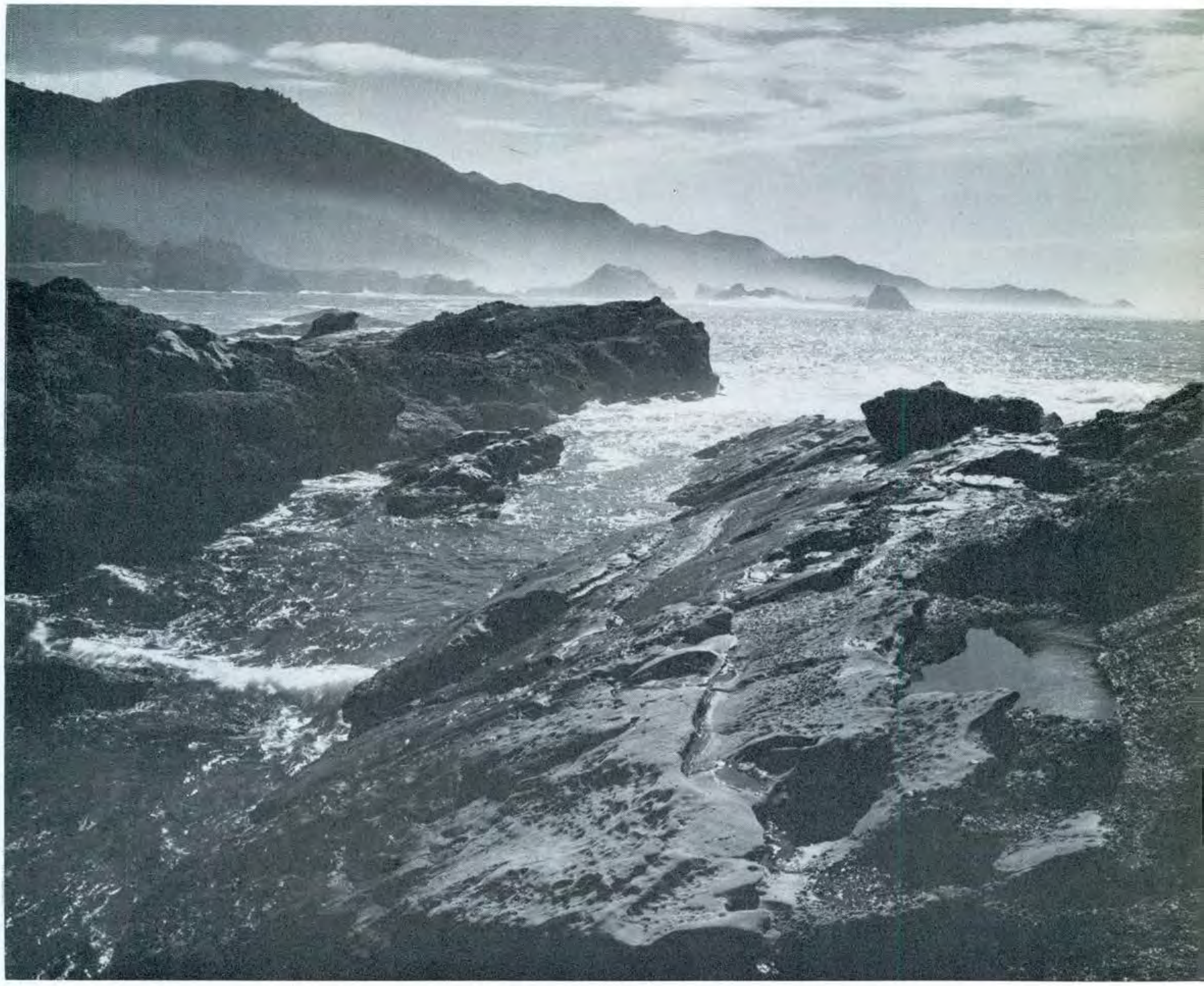
Local development works contemplated as features of The California Water Plan in the Central Coastal Area are considered under nine geographical subdivisions. These are designated and are hereinafter referred to as the "Santa Cruz-Pajaro Group," "San Benito Group," "Monterey-Carmel Group," "Salinas River Group," "Carrizo Plain," "San Luis Obispo Group," "Santa Maria Valley," "Cuyama Valley," and "Santa Barbara Group"; and their locations are shown on Plate 3. Suggested plans for local water supply development are presented individually for each of these divisions. Possible methods for importation of supplemental water will be described in the ensuing section entitled "California Aqueduct System."

The layout of the projected water development works in the Central Coastal Area is delineated on Sheets 10, 13, 16, 17, and 20 of Plate 5. Physical features and costs of all the local works are presented in Table 11, which follows this discussion under the heading "Summary of Central Coastal Area."

Santa Cruz-Pajaro Group. The Santa Cruz-Pajaro Group embraces nearly all of Santa Cruz County, the southerly tip of San Mateo County adjacent to the Pacific Ocean, and the Pajaro Valley, portions of which lie in Monterey and San Benito Counties. The area totals some 500 square miles, of which 425 square miles comprise mountains and foothills. The mountains are generally well covered with timber, including extensive growths of redwood.

About three-fourths of all the water developed in the Santa Cruz-Pajaro Group is presently supplied by water pumped from underlying ground water basins. Lands utilizing ground water are generally served by individually owned wells and pumps. Surface diversions are made from numerous streams rising in the Santa Cruz Mountains, principally for urban and recreational uses. The largest surface diversions are made by the Cities of Santa Cruz and Watsonville. The City of Santa Cruz diverts water from Liddell, Laguna, and Majors Creeks, and from the San Lorenzo River; while the City of Watsonville diverts from Corralitos Creek and Brown Valley Creek in the Pajaro Valley.

Although the Santa Cruz-Pajaro Group has ample water resources to meet present and probable ultimate water requirements, except in Pajaro Valley, the area is presently faced with serious water problems. Heavy irrigation season pumping draft from the confined ground water aquifers in the Pajaro Valley has resulted in the intrusion of sea water into the lower portion of the aquifers near Monterey Bay. The overdraft is estimated (1953) to be about 4,000 acre-feet per season. The City of Santa Cruz, which depends almost entirely upon surface diversions, is faced with the threat of a deficiency of available supplies during the late summer months of low runoff, because



Central Coastal Area—Point Lobos

of the lack of adequate storage facilities. Recurrence of a very dry year, such as 1931, would undoubtedly force late summer water rationing throughout the Santa Cruz area.

Another major water problem in the Santa Cruz-Pajaro Group is manifested in periodic floods, resulting from high rainfall intensities, particularly on the Santa Cruz Mountains. The recurring threat of flooding along the lower reaches of San Lorenzo and Pajaro Rivers and Soquel and Branciforte Creeks is great, as was demonstrated by the flood of December, 1955. As an example, the San Lorenzo River at Big Trees reached a peak discharge of 30,000 second-feet during that flood. The previous high for this stream was 24,000 second-feet in February of 1940.

With the exception of Pajaro Valley, the ultimate water requirements in the Santa Cruz-Pajaro Group could be met by development of local water resources. Fulfillment of the objectives of The California Water Plan in the Pajaro Valley would require an import of water through the facilities of the California Aqueduct System.

Agricultural and urban water requirements of lands along the coastal strip north of the City of Santa Cruz could be met by development of Scott Creek. Water of Scott Creek would be conserved in Archibald Reservoir, located about 3 miles north of the town of Davenport.

The probable ultimate supplemental water requirements of the area tributary to Monterey Bay between Meder Creek, immediately west of the City of Santa Cruz, and the Pajaro drainage area, could be provided by storage reservoirs on Bear, Zayante, Soquel, and Aptos Creeks, on the upper reaches of the San Lorenzo River and Soquel drainage basins, and a pumped diversion from the San Lorenzo River near the City of Santa Cruz to an off-stream storage reservoir on Doyle Gulch.

Bear Creek Dam and Reservoir would be located on Bear Creek 4 miles west of the town of Boulder Creek. The reservoir would provide water for urban and recreational uses along the upper reaches of the San Lorenzo River drainage area. Zayante Creek Dam and Reservoir on Zayante Creek, about 4 miles east of the town of Felton, would develop water for use along Zayante Creek and the San Lorenzo River between Zayante Dam and the City of Santa Cruz.

The City of Santa Cruz and surrounding areas near Soquel and Capitola could be served by a pumped diversion of winter runoff of the San Lorenzo River at Santa Cruz, and conveyance of the water by pumping facilities and pipe line to an off-stream storage reservoir on Doyle Gulch about 3 miles east of Santa Cruz. Water could be delivered to the service areas directly from the diversion works during the winter months, and by releases from Doyle Gulch Reservoir through the conveyance facilities by gravity during the summer months.

Glenwood Dam and Reservoir would be located on the West Branch of Soquel Creek, about 6 miles north of the town of Soquel. The reservoir would develop water for use along the down stream channel, and along the coast generally east of Capitola. A similar development on Soquel Creek, about 6 miles northwest of the town of Soquel, would provide water for use along Soquel Creek and on the coastal area in the vicinity of Soquel and Capitola.

Aptos Creek Dam and Reservoir would be located on Aptos Creek about 1 mile north of the town of Aptos. The reservoir could provide urban and agricultural water supplies in the vicinity of the town of Aptos.

The foregoing works could meet the ultimate supplemental water requirements in all of Santa Cruz County, with exception of Pajaro Valley. In addition, operation of these reservoirs would sustain summer flows in the upper reaches of the San Lorenzo River and Soquel Creek, thus enhancing stream fishing and recreation. Although a measure of flood protection would be provided by these developments, such protection would be inadequate for the lower reaches of the San Lorenzo River and Soquel Creeks because of insufficient storage for full control. In this connection, flood control on the San Lorenzo River by means of reservoir storage is not feasible of accomplishment because of the lack of storage sites anywhere on the river. However, the Corps of Engineers, U. S. Army, is preparing to construct an authorized project for levee and channel improvement on the lower San Lorenzo River, which will relieve the present flood threat in the City of Santa Cruz and vicinity.

The ultimate supplemental water requirement in the Pajaro Valley could be met by a diversion of surplus winter flows from the Pajaro River and conveyance of the diverted water to an off-stream storage reservoir in Corn Cob Canyon, and by import through the South Bay Aqueduct of the California Aqueduct System. Surplus flows in the Pajaro River would be diverted during the winter months and conveyed by canal to the vicinity of Watsonville Reservoir, in Corn Cob Canyon, about 1 mile southeast of Watsonville Junction. The water would be pumped into the reservoir and would be released through the same facilities during the irrigation season for use along the lower Pajaro River, in the area where the present ground water overdraft exists.

In addition to the new yield developed by the Pajaro diversion, an additional amount of about 15,000 acre-feet of water per season would be required to satisfy fully the ultimate supplemental requirements in Pajaro Valley. This quantity of water would be conveyed to Pacheco Creek by facilities of the South Bay Aqueduct and released into that creek, where it would flow by gravity down the Pajaro River to be available for rediversion in the Pajaro Valley.

With respect to flooding along the lower Pajaro River, there are no storage sites on the main stream, and no upstream storage development offers sufficient protection. As in the case of the San Lorenzo River, channel improvement and levee construction affords the most satisfactory solution to flood problems. The Corps of Engineers, U. S. Army, has improved the lower Pajaro River, and has plans for further channel improvement.

In summary, prospective local development works by which the objectives of The California Water Plan in the Santa Cruz-Pajaro Group would be accomplished comprise eight dams and reservoirs and two diversion features. Together these works would develop a seasonal new yield of 48,000 acre-feet which would provide for the ultimate water needs in all but the Pajaro Valley, where an additional amount of about 15,000 acre-feet per season would be imported by facilities of the California Aqueduct System. Thus, about 63,000 acre-feet per season would be developed for use in the Santa Cruz-Pajaro Group, which amount would fully meet the ultimate requirements of all the lands considered susceptible of water service. In addition to the conservation accomplishments, the prospective local developments in conjunction with downstream channel improvement would provide flood control on the San Lorenzo River and Soquel Creek, and would enhance recreation and stream fishing in those streams by maintenance of improved summer flows.

San Benito Group. The San Benito Group generally comprises those lands lying in Santa Clara and San Benito Counties which make up the drainage basin of the Pajaro River above Chittenden. Its area totals about 1,190 square miles, of which some 950 square miles comprise mountain and foothills and the remainder is classified as valley and mesa lands.

The present (1954) irrigated acreage in the San Benito Group approximates 70,000 acres, of which about 40,000 acres are located in the Hollister area and the remainder is found in south Santa Clara Valley. The relatively high degree of development has been achieved by exploitation of the extensive ground water storage in alluvial fill areas, notably the south Santa Clara Valley and the Hollister area. The development of the ground water basins has been aided by the facilities operated by local water service agencies for ground water recharge by controlled releases from surface storage reservoirs.

The principal storage works in the San Benito Group consist of the recently completed Chesbro Dam on Llagas Creek and Uvas Creek Dam on Uvas Creek, both projects developed by the South Santa Clara Valley Water Conservation District; Paicines Reservoir, an off-stream storage site for water diverted from the San Benito River, constructed by the Hollister Irrigation District to serve irrigated lands during winter and spring months when water is available; and the North Fork Reservoir on the North Fork of Pacheco Creek, owned and operated by the Pacheco Pass Water District for controlled percolation in Pacheco Creek. The combined storage capacity of these reservoirs is about 28,000 acre-feet, and their yield, obtained by operation in conjunction with ground water storage, is about 22,000 acre-feet per year.

As a result of the sustained drafts on ground water resources in the San Benito Group and the continually increasing irrigation demands, the ground water basin underlying the Hollister area is overdrawn at the present time. The present (1954) seasonal overdraft in this area is estimated to be about 8,000 acre-feet. To meet fully the ultimate requirements of the group, supplemental water supplies totaling 132,000 acre-feet per season would be required in addition to the presently developed supplies. The quality of the ground water underlying about 5,000 acres skirting the foothills easterly of Hollister is somewhat adversely affected by a relatively high boron content.

Recurrent flooding is a threat to the intensively cultivated lands along the Pajaro River where the flood plains of Llagas and Carnadero Creeks merge with the bottom land lake area, extending westward from San Felipe Lake to the vicinity of Sargent. This area is flooded by discharge of tributaries to Tequisquito Slough, as well as Llagas and Carnadero Creeks. In addition, the banks of the San Benito River are subject to severe erosion during periods of high runoff such as that which occurred during the December, 1955, flood.

The opportunity for further development of local water resources of the San Benito Group is very limited. Therefore, accomplishment of the objectives of The California Water Plan in that group must rely primarily on the importation of supplemental water from areas of surplus elsewhere in the State. However, further development of local water resources could provide sufficient water to meet the ultimate water requirement in the south Santa Clara Valley and to overcome the present deficiency in the Hollister area.

Enlargement of the existing Uvas Creek Reservoir from its present capacity of 10,000 acre-feet to a capacity of 34,000 acre-feet could, if operated in conjunction with the downstream ground water basin in south Santa Clara Valley, provide sufficient water to meet the ultimate supplemental water requirement of the valley. Diversion facilities have been provided so that when releases from this reservoir exceed percolation capacity of the downstream channel in Uvas Creek, excess flows would be diverted into the absorptive Llagas Creek channel.

Water supplies for the Hollister area could be made available by four dams and reservoirs on tributaries to the Pajaro River, consisting of a reservoir on Pacheco Creek, two reservoirs on the San Benito River, and a diversion dam from Tres Pinos Creek.

Harper Canyon Dam and Reservoir would be located on Pacheco Creek about 11 miles northeast of Hollister. Initially, the reservoir could be operated entirely for conservation, with releases being made for augmenting stream channel percolation in Pacheco Creek. However, under ultimate operation, the reservoir could be enlarged to provide sufficient additional storage for regulation of deliveries through the South Bay Aqueduct to the variable monthly demands in the Hollister area.

San Benito Dam and Reservoir, located on the San Benito River about 6 miles downstream from the town of San Benito, would develop an irrigation supply for lands along the river between the dam and the town of Paicines. Cienega Dam and Reservoir, located about 1 mile east of the town of Paicines, would augment the ground water supplies in the Hollister area by releases to the downstream channels. Yield developed by Cienega Reservoir could be augmented by a diversion from Tres Pinos Creek of surplus flows in excess of the percolation capacity of that creek. The diversion dam on Tres Pinos Creek would be located about 2 miles southeast of the town of Paicines, and the water would be conveyed about 1 mile by canal to Cienega Reservoir.

In summary, the prospective local development works in the San Benito Group would provide a total seasonal new yield of 20,700 acre-feet, of which 6,400 acre-feet would be provided in south Santa Clara Valley and 14,300 acre-feet in the Hollister area. A measure of flood control would be provided by operation of these works, although no planned operation for that purpose is contemplated. The Corps of Engineers is investigating the control of floods in the area by channel improvement and/or reservoir control. Water supplies in the amount of 113,000 acre-feet per season would be delivered through facilities of the California Aqueduct System in order to satisfy fully the ultimate water requirements of lands in the San Benito Group.

Monterey-Carmel Group. The Monterey-Carmel Group embraces the Carmel River Basin and the area tributary to the Pacific Ocean immediately to the south, extending to the Monterey-San Luis Obispo county line. Its area totals about 610 square miles, of which nearly 600 square miles comprise mountains and foothills. The Carmel River Basin contains the majority of the irrigable lands, most of which are in the Carmel Valley, and the Monterey Peninsula, a widely known resort area.

Irrigated lands in the Carmel Valley and the urban and suburban areas on the Monterey Peninsula make up the total present (1950) water requirement of about 10,400 acre-feet per year in the Monterey-Carmel Group. The only existing major surface water supply developments in the group consist of Los Padres and San Clemente Reservoirs on the Carmel River, owned and operated by the California Water and Telephone Company. The remainder of the water service is generally supplied by individuals who utilize ground water or who divert directly from the many small streams emanating from the Santa Lucia Range.

The Monterey-Carmel Group has ample water resources to meet present and probable ultimate requirements, water now wasting to the ocean substantially exceeding the latter requirement. The ultimate supplemental water requirement of the group is estimated to be about 37,500 acre-feet per season. As contemplated under The California Water Plan, this requirement would be furnished by increasing the present yield of the ground water basin in Carmel Valley by greater ground water utilization, and by a surface storage development on the Carmel River, which would also have some recreational values.

Development of the Carmel River could be completed by construction of a dam at the Klondike site about 15 miles upstream from Carmel Bay. Klondike Reservoir would inundate the present San Clemente Dam and the filtration plant below the dam. The reservoir would be operated in conjunction with the present Los Padres Reservoir and filter plant, releasing water into existing facilities for urban and industrial distribution on the Monterey Peninsula. In addition, 2,200 acre-feet of water per season would be released directly to the Carmel River for agricultural use along the river below the dam.

The present ground water yield of 2,300 acre-feet per season in the Carmel Valley ground water basin could be increased to 4,600 acre-feet as the acreage of overlying irrigated lands increases in the future. The increased yield would be developed by greater extraction from the ground water basin, thus providing a greater seasonal and cyclic storage depletion during dry periods, which would create additional storage for conservation of water supplies which would otherwise waste to the ocean during ensuing wet periods.

The ultimate supplemental water requirements of about 8,000 acre-feet per season in the coastal portion of the Monterey-Carmel Group south of the Carmel River could be provided by direct diversions from the high-producing streams of the area. Available data indicate that the minimum summer flows in the streams of that area, particularly the Sur and Little Sur Rivers, would always be adequate to meet the peak monthly demands for water in their immediate areas, including sufficient flow for maintenance of fish life. Thus, the diversion of water under ultimate conditions should not impair the present high recreational, fishery, and wildlife value of the area. Should the necessity occur, small headwater reservoirs could be constructed for maintenance of stream flow.

The 8,000 acre-feet of water per season available from direct diversion from the coastal streams, along with the 27,200 acre-feet developed by Klondike Reservoir and 2,300 acre-feet secured by greater utilization of ground water in the Carmel Valley, would meet the ultimate supplemental water requirement of 37,500 acre-feet in the Monterey-Carmel Group.

Salinas River Group. The Salinas River Group embraces the total area of some 4,330 square miles drained by the Salinas River and its tributaries. From the southern coastal portion of Monterey Bay, just north of the Monterey Peninsula, this group extends generally southeasterly for a distance of 150 miles through major portions of Monterey and San Luis Obispo Counties and a small part of San Benito County. The topography is generally mountainous and hilly, but is split longitudinally for a distance of nearly 100 miles along its major axis from Monterey Bay to Wunpost by the floor of the Salinas Valley and the meander of the Salinas River.

Described by early visitors as the "Salinas Desert," the Salinas Valley has developed to the point where 80 per cent of the lands susceptible of irrigation are presently irrigated from underlying ground water resources. The major economy of the valley is based upon its agricultural development and allied industries which process and package agricultural products.

Development of agriculture in the Salinas Valley has been possible due to the availability of water in large quantities and of excellent quality. Underlying almost the entire valley floor is an extensive ground water basin which, until recently, has economically yielded sufficient water to satisfy all agricultural, industrial, and domestic water requirements.

Present (1954) water requirements in the Salinas River Group are estimated to be about 267,000 acre-feet per season, nearly all of which are supplied by pumping from underlying ground water storage, particularly in the Salinas Valley north of San Lucas. Net seasonal pumping draft from the extensive ground water basin underlying that valley presently averages 225,000 acre-feet.

Nacimiento Dam and Reservoir, recently constructed by the Monterey County Flood Control and Water Conservation District, and Salinas Reservoir are the only major existing surface water developments in the Salinas River Group. Nacimiento Reservoir, located on the Nacimiento River about 12 miles upstream from its confluence with the Salinas River, has a storage capacity of 350,000 acre-feet, of which 150,000 acre-feet is to be reserved for control of floods on the Nacimiento and Salinas Rivers. The district plans to operate the conservation storage to retain winter flood flows for release during the ensuing months to recharge ground water basins underlying the Salinas River. Salinas Reservoir, with a capacity of 26,000 acre-feet, was built by the Corps of Engineers, U. S. Army, in 1942 for water supply for Camp San Luis Obispo. It is now used for the municipal supply of the City of San Luis Obispo.

Although the safe yield of the ground water resources of the Salinas River Group exceeds the total pumping extraction on an over-all basis, serious overdrafts prevail in the vicinity of Monterey Bay and along the easterly fringe of the valley floor from Salinas southeast to the vicinity of Gonzales. The problem of overdraft in the vicinity of Monterey Bay is typical of many coastal basins where ground water occurs in confined aquifers, or water-bearing zones, which are open to the ocean at their lower end. The present (1954) overdraft on the confined aquifer in the vicinity of Monterey Bay is estimated to be 20,000 acre-feet per season. Sea water has already intruded for a distance of about 3 miles and has necessitated the abandonment of pumping from the intruded aquifer in an area of some 5,000 acres. The deficiency along the eastern fringe of Salinas Valley is due to the inherent deficiency in natural water supplies in that area, and presently (1954) amounts to 8,000 acre-feet per season. The probable ultimate supplemental water requirements of the potential service areas in the Salinas River Group are estimated at 483,000 acre-feet per season, which substantially exceeds the developable local water resources.

In addition to the water conservation problem in the Salinas River Group, the periodic occurrence of floods causes damage to agricultural lands and utilities on the Salinas River flood plain below Wunpost. Operation of the 150,000 acre-feet of flood control storage space in Nacimiento Reservoir will greatly reduce flood hazards and flood damages. However, attainment of the required degree of flood protection for the highly developed economy of the lower Salinas Valley will ultimately necessitate a control structure and channel improvements on the main stem of the Salinas River below its major tributaries.

Objectives of The California Water Plan in the Salinas River Group could be accomplished by both local development works and by imports through facilities of the California Aqueduct System. The local development phase would consist of eight storage reservoirs and three conveyance conduits. The reservoirs would be operated coordinately and in conjunction with downstream ground water storage to attain the optimum degree of local water resource development, and to correct the present problem of sea-water intrusion into the confined aquifer in the vicinity of Monterey Bay. Such operation would necessitate the limiting of draft in the confined aquifers to the safe yield rate, and the delivery of a supplemental surface supply to meet the balance of the water requirements of overlying areas. It would also require the rearrangement of the present pattern of pumping draft in the forebay area, or zone of unconfined ground water, and the increased utilization of underground storage, thus creating greater space for recharge by water which would otherwise waste to the ocean. It is estimated that the safe ground water yield could be so increased by some 50,000 acre-feet per season under ultimate development, in addition to the yield of surface storage facilities.

The contemplated local development works in the Salinas River Group would provide surface water service to the lower and a portion of the upper Salinas Basin by releases and direct conveyance to service areas. Reservoir releases would also be made for control of downstream ground water levels to effect their efficient operation. The prospective surface storage reservoirs include single units on Santa Rita and Jack Creeks, the Arroyo Seco, and the Salinas River, and two units each on the Nacimiento and San Antonio Rivers.

Santa Rita Dam and Reservoir would be located on Santa Rita Creek about 3 miles upstream from its confluence with Paso Robles Creek. Water developed by the reservoir could be released into Santa Rita Creek for diversion downstream to supply urban and irrigation demands in and around the communities of Atascadero and Templeton along the upper Salinas River. Jack Creek Reservoir on Jack Creek, about 2 miles upstream from its confluence with Paso Robles Creek, would supplement the yield developed in Santa Rita Reservoir by similar downstream releases.

Development of the Nacimiento River would be completed by San Miguelito and Jarrett Shut-in Reservoirs. San Miguelito Reservoir would be formed by a dam about 34 miles upstream from the existing Nacimiento Dam. Jarrett Shut-in Reservoir would be located about 8 miles downstream from the San Miguelito site. Both reservoirs would be operated coordinately to conserve the flows of Nacimiento River in excess of the amounts controlled by Nacimiento Reservoir. The yields developed by these reservoirs would be released downstream through Nacimiento Reservoir, and diverted from the Nacimiento River and conveyed to areas of use in the Nacimiento-Shandon Conduit.

This Nacimiento-Shandon Conduit would convey the water easterly from the Nacimiento River, in pressure conduit, to a wye east of San Miguel. The main conduit would continue easterly to Shandon Terminal Reservoir about 1 mile southeast of the town of Shandon. Water would be pumped into the reservoir at an elevation of about 1,190 feet.

The Creston Lateral would extend from the wye near San Miguel in a general southeasterly direction, terminating in the Creston Terminal Reservoir about a mile south of Creston. The foregoing facilities would deliver new urban and irrigation water to valley and foothill lands along the east side of the upper Salinas Valley and to the City of Paso Robles.

Two storage developments on the San Antonio River would complete development of its water resources. Milpitas Dam and Reservoir would be located about 40 miles upstream from the confluence of San Antonio and Salinas Rivers. Pleyto Dam and Reservoir would be located at the lower end of Lockwood Valley, about 10 miles upstream from the confluence of San Antonio and Salinas Rivers. Water from these reservoirs would serve Lockwood and Hames Valleys.

Runoff of the Arroyo Seco would be controlled by Greenfield Dam and Reservoir about 5 miles southwest of Greenfield. A portion of the yield of Greenfield Reservoir would be released into the stream channel to support pumping withdrawals from ground water storage underlying the Arroyo Seco and Salinas River channel. However, the major portion of the new water yield would be diverted and delivered through the Greenfield-Monterey conduit to areas along the west side of Salinas Valley, particularly the area between Salinas and Monterey Bay.

The runoff in the main stem of the Salinas River could be controlled by San Lucas Dam and Reservoir, located about 3 miles downstream from San Lucas and 4 miles upstream from King City. San Lucas Reservoir, which has been authorized and adopted by the Legislature, would be operated both for conservation and flood control, with 150,000 acre-feet of storage reserved for control of flood flows on the Salinas River and its tributaries.

With San Lucas Reservoir in operation, the total new seasonal yield of the surface storage developments contemplated on the Salinas River system would approximate 102,000 acre-feet. An additional yield of 18,000 acre-feet per season could be obtained by transferring the 150,000 acre-feet of flood control storage space in Nacimiento Reservoir downstream to San Lucas Reservoir, at such time as the latter reservoir would become operational, and by operating the additional storage space in Nacimiento Reservoir for conservation. Transfer of the flood control space from Nacimiento to San Lucas Reservoir would be a logical move because of the high degree of control of the drainage area of the basin at the San Lucas site. In addition to its efficacy in the control of floods, San Lucas Reservoir would be necessary for capture and reregulation of the substantial return flows which would result from irrigation of large areas of lands in the upper Salinas Basin under ultimate conditions.

The waters conserved by San Lucas Reservoir, and portions of the yields of the future reservoirs on the Nacimiento and San Antonio Rivers would be utilized to eliminate present overdraft conditions and to meet future increases in water requirements in the Salinas Valley. Water would be made available to the lower portion of the valley north of Gonzales, where overdraft conditions prevail, by a surface diversion from the Salinas River and conveyance in the San Lucas-East Side Conduit. This conduit would originate at the San Lucas Dam and be constructed along the west side of the Salinas River, crossing the river in a siphon near Soledad, and continuing along the east side of the river to a terminus about 3 miles north of the City of Salinas. The conduit would also provide water service for foothill lands on the east side of the valley by means of takeouts and pump lifts along the conduit route.

In summary, the local development works contemplated in the Salinas River Group would make available 120,000 acre-feet of supplemental water per season by operation of eight conservation reservoirs with a total storage capacity of 1,130,000 acre-feet. These reservoirs would be operated coordinately and in conjunction with downstream ground water basins to facilitate the development of an additional seasonal yield of 50,000 acre-feet from increased utilization of ground water storage. Thus, a total yield of additional water in the aggregate amount of 170,000 acre-feet per season would be made available to meet a portion of the estimated ultimate water requirements of lands in the Salinas River Group. However, as previously stated, the ultimate supplemental water requirements within the group are estimated to be 483,000 acre-feet per season. Therefore, additional water in the net amount of 313,000 acre-feet per season, requiring a gross delivery of 335,000 acre-feet, would be supplied from the Central Coastal Aqueduct, a feature of the California Aqueduct System.

In addition to the foregoing water conservation accomplishments of the contemplated local development works, a large measure of flood control would be provided by operation of flood control storage in San Lucas Reservoir, and by incidental flood flow reduction from operation of 755,000 acre-feet of conservation storage in the seven other reservoirs.

Carrizo Plain. The Carrizo Plain is a large arid valley of internal drainage, located between the Temblor and Caliente Ranges adjacent to the upper Salinas and Cuyama Valleys. The valley floor lies at an elevation of about 2,000 feet above sea level. Mean seasonal precipitation varies from about 8 inches on the valley floor to 10 inches in the surrounding mountains. Runoff in streams tributary to the Carrizo Plain is insignificant in amount and is largely disposed of naturally through evaporation from Soda Lake, a natural sump located near the center of the plain.

At the present time a dry-farmed economy exists which probably will continue for many years in the future. A large portion of the potentially irrigable lands is utilized for dry-farm production of a high-quality Baart wheat for which the flour milling industry pays premium prices. The remainder of the area is devoted to cattle grazing, with small acreage of irrigated pasture to supplement the natural forage.

Small amounts of water are presently pumped from ground water storage underlying the Carrizo Plain; but the supplies are very meager, and no opportunity exists for further development of local water supplies. If irrigation in this area were to expand, water to satisfy the needs therefor would have to be imported from outside sources. The cost of such water would be high. The possible ultimate seasonal water requirements, amounting to 245,000 acre-feet, could be provided through facilities of the Carrizo-Cuyama Aqueduct, a feature of the California Aqueduct System.

San Luis Obispo Group. The San Luis Obispo Group consists generally of that portion of San Luis Obispo County lying on the western slopes of the Santa Lucia Range. A small portion of the group extends northward along the coast into Monterey County. The area consists of mountain and foothill lands interlain by numerous small stream valleys and the more extensive valley and coastal plain area of Arroyo Grande Creek.

Present (1953) developed water supply in the San Luis Obispo Group totals about 16,000 acre-feet per season, the majority of which is obtained by pumping from underlying ground water storage. Water supplies for the City of San Luis Obispo, however, are presently obtained largely by importation from Salinas Reservoir on the upper Salinas River near Santa Margarita, as described in the foregoing section dealing with the Salinas River Group. There are no local surface storage developments in the San Luis Obispo Group.

The present net draft on ground water in the San Luis Obispo Group, amounting to nearly 14,000 acre-feet per season, is obtained without any overdraft problem. It is estimated that pumping draft could be increased to some 28,000 acre-feet per season without exceeding the safe yield of local ground water resources. The largest ground water basin in the group underlies the lower valley and coastal plain of Arroyo Grande Creek. Numerous small ground water basins underlie or are adjacent to the lower reaches of the coastal streams.

The objectives of The California Water Plan in the San Luis Obispo Group would be met mainly by further development of local water resources. However, full satisfaction of ultimate water requirements, amounting to an estimated 156,000 acre-feet per season, would necessitate a delivery of some imported water through facilities of the California Aqueduct System.

Most of the favorable local water development sites are located on the streams in the northern portion of the group, whereas the majority of potential water service areas are located in the southern portion, particularly in the vicinity of Arroyo Grande, the coastal plain, and the City of San Luis Obispo. Con-

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Nacimiento Reservoir on Nacimiento River Provides Water for Agricultural Uses in the Salinas Valley templated water development works would consist of an integrated system of reservoirs, comprising two dams on San Carporforo Creek; single dams on Arroyo de la Cruz, San Simeon Creek, Santa Rosa Creek, and Old Creek, all connected by a coastal conduit conveying the developed water supply southward to areas of use; and a reservoir on Arroyo Grande Creek.

Waters of San Carporforo Creek would be controlled by dams and reservoirs at the Bald Top and Ragged Point sites, located about 5 miles and 2 miles, respectively, above the mouth of that creek. Bald Top Reservoir would be operated coordinately with the downstream Ragged Point Reservoir, both facilities releasing water for conveyance in the coastal conduit.

Yellow Hill Reservoir, located on Arroyo de la Cruz about 1.6 miles upstream from its mouth, San Simeon Reservoir on San Simeon Creek about 3 miles north of the town of Cambria, and Santa Rosa Reservoir on Santa Rosa Creek about 5 miles east of Cambria would augment the southward delivery of water in the coastal conduit.

Water to supply future needs of the City of San Luis Obispo and vicinity could be provided by construction of Whale Rock Dam and Reservoir on Old Creek about a mile east of the town of Cayucos. This project was recommended in October, 1955, for construction in the immediate future, under a program of staged development. The Whale Rock Project is contemplated as a joint venture of the State and the City of San Luis Obispo. The Legislature is presently considering an appropriation of funds to finance the State's interest in the project as a water supply for the California Polytechnic Institute and the California Men's Colony. The City of San Luis Obispo has recently authorized the issue of bonds to finance the local cost of the project.

In order to deliver the water to the areas of need, the Cambria Conduit would be constructed from San Carporforo Creek on the north to a terminal point in the vicinity of the City of San Luis Obispo. The Cambria Conduit would proceed along the coast, intercepting waters released from the reservoirs on San Carporforo Creek, Arroyo de la Cruz, and San Simeon, Santa Rosa, and Old Creeks. It would leave the coast near the mouth of Morro Creek, proceeding up Las Osos Valley where the water would be lifted over the low divide into San Lans Valley, and the conduit would finally terminate at Indian Knob Terminal Reservoir on a small tributary of San Luis Obispo Creek about 5 miles south of San Luis Obispo.

Water requirements of the service areas along Arroyo Grande Creek could be met by Lopez Reservoir, on Arroyo Grande Creek about 7 miles upstream from the City of Arroyo Grande. Water would be provided by gravity releases from the reservoir. Lopez Reservoir would be operated to provide water for additional development in the Arroyo Grande area, both by conjunctive operation with downstream ground water storage and by diversion of controlled reservoir releases either from the stream or from a conveyance conduit. Moreover, Lopez Reservoir would provide a substantial degree of incidental downstream flood control, although it would not entirely eliminate the problem.

In summary, the local development phase of The California Water Plan for the San Luis Obispo Group would comprise seven dams and reservoirs and a conduit for conveying portions of the yields of these reservoirs to the areas of use. These reservoirs, with aggregate capacity of 315,000 acre-feet, would, together with increased ground water utilization, provide a safe seasonal yield of 111,500 acre-feet, which would meet a substantial portion of the ultimate water requirements of the group. However, in order to satisfy fully the ultimate requirements, an additional net amount of some 26,000 acre-feet of water per season, requiring a gross delivery of 30,000 acre-feet, would have to be imported through the Central Coastal Aqueduct of the California Aqueduct System.

Santa Maria Valley. The Santa Maria Valley comprises the drainage area of the Santa Maria River, excluding the drainage area of the Cuyama River above Vaquero Dam, and embraces portions of San Luis Obispo and Santa Barbara Counties. The valley includes the intensively developed agricultural area on the coastal plain, centered around the City of Santa Maria; the adjoining Nipomo Mesa; and tributary mountain and hill areas.

Essentially all developed water in the Santa Maria Valley is now obtained from the ground water basin underlying the coastal plain. Water is used principally for agricultural purposes on the floor of Santa Maria Valley and the adjacent Nipomo Mesa. Until recently there have been no major surface storage developments on the Santa Maria River or its tributaries. However, the Santa Maria Project, comprising a 214,000 acre-foot reservoir at the Vaquero site on the Cuyama River, and channel improvements along the Santa Maria River and Bradley Canyon, are now under construction by the Bureau of Reclamation and the Corps of Engineers, respectively. Proposed operation of Vaquero Reservoir contemplates the reservation of 89,000 acre-feet of storage for control of floods, and the balance of the reservoir storage capacity for water conservation. Water retained in the conservation storage pool will be released to the Santa Maria River at rates within the percolation capacity of the channel.

It has been estimated by the Bureau of Reclamation that recharge to ground water by operation of Vaquero Reservoir will be increased by an average amount of 18,500 acre-feet per season. In addition, the flood control accomplishments of the reservoir will be augmented by the construction of levees along Bradley Canyon and along Santa Maria River downstream therefrom to confine large flood flows within the leveed channel.

For many years, pumping extraction from the ground water resources of Santa Maria Valley has exceeded replenishment, resulting in perennial overdraft. Although the large amount of ground water storage capacity has so far made possible the maintenance of overdraft without lowering of water levels below sea level, continuation of overdraft conditions would inevitably result in such lowering, with the resultant threat of sea-water intrusion. It is estimated that the present (1950) seasonal net draft on the ground water basin is about 91,000 acre-feet and that the safe seasonal yield of the basin is only 54,000 acre-feet. It should be noted that the new yield developed by Vaquero Reservoir will not entirely eliminate the present ground water overdraft in Santa Maria Valley.

The water requirements of Santa Maria Valley are forecast to be about 227,000 acre-feet per season under ultimate development. Taking credit for the new yield of the ground water basin operated in conjunction with Vaquero Reservoir, there will ultimately be a demand for supplemental water in the amount of about 154,000 acre-feet per season.

It is estimated that waste of water to the ocean after completion of Vaquero Reservoir will be about 15,000 acre-feet per season on the average. There exists a possibility of saving part of this wasted water by construction of Round Corral Reservoir on the Sisquoc River. However, it is considered that the yield developed at this site would be extremely costly, and, in addition, it is questionable whether sufficient ground water storage would be available for operation in conjunction with storage at the Round Corral site. Therefore, no further local water supply developments in the Santa Maria Valley are considered to be practicable.

It is concluded that the accomplishment of the objectives of The California Water Plan in the Santa Maria Valley will be contingent on ultimate gross import of about 180,000 acre-feet per season from the Central Coastal and Carrizo-Cuyama Aqueducts of the California Aqueduct System. This would provide a net seasonal supply of about 154,000 acre-feet. Provision of supplemental water in this amount would fully satisfy the ultimate water requirements of all lands considered susceptible of water service in the Santa Maria Valley.

Cuyama Valley. The Cuyama Valley consists of the drainage area of the Cuyama River above Vaquero Dam, and embraces portions of San Luis Obispo, Santa Barbara, Ventura, and Kern Counties. The floor of Cuyama Valley lies at an elevation of about 2,000 to 2,500 feet above sea level along the upper reaches of the Cuyama River. Below the lower end of the valley the river flows in a relatively narrow canyon through a rugged mountain area.

Mean seasonal natural runoff from the entire Cuyama Valley drainage area is estimated to be only 22,500 acre-feet, most of which originates in the mountainous area at the lower end of the valley. Runoff is directly responsive to precipitation, and the greatest portion occurs immediately after rain during the winter months. Runoff varies greatly from season to season, there being essentially no flow during some years.

Irrigated lands are located principally on the floor of the Cuyama Valley. In addition, there are small irrigable areas lying along the Cuyama River and its major tributaries. At the present time water is used almost entirely for agricultural purposes, and it is believed that this will still be true under ultimate conditions of development.

Essentially all water utilized within the Cuyama Valley is obtained by pumping from the ground water basin underlying the valley floor. Available data indicate that present net draft on the ground water basin exceeds replenishment, and that ground water levels are experiencing a perennial lowering. No existing service storage developments are in the valley.

As has been indicated, water resources of the Cuyama Valley are relatively meager. With the exception of infrequent peak flood flows, essentially all of the stream flow originating in the mountain area of the upper end of the valley percolates to the ground water basin underlying the valley. The relatively large amount of ground water storage capacity in this basin is adequate to conserve this percolating water for pumped withdrawals by overlying landowners. It is therefore not considered practicable to give consideration to plans for further local water supply developments in the upper valley. Moreover, the runoff originating in the mountain areas at the lower end of the valley passes down the canyon of the Cuyama River and will be almost entirely controlled by conjunctive operation of Vaquero Reservoir and the Santa Maria ground water basin, as previously described.

As is the case with the Santa Maria Valley, it is concluded that accomplishment of the objectives of The California Water Plan in the Cuyama Valley would be contingent upon an import from areas of surplus elsewhere in the State. The cost of such water would be high. Provision of supplemental water supplies in the amount of 53,000 acre-feet per season would satisfy fully the requirements of all lands considered susceptible of water service in the Cuyama Valley. However, because of the very limited opportunity for re-use of applied water in the valley, a gross seasonal delivery of 80,000 acre-feet would be required. This delivery would be provided through facilities of the Carrizo-Cuyama Aqueduct. The excess water, amounting to 27,000 acre-feet per season, would be available for re-use in the downstream Santa Maria Valley.

Santa Barbara Group. The Santa Barbara Group consists of the area lying south of the southerly boundary of the Santa Maria River watershed and westerly of the boundary of the South Coastal Area. Included are the watersheds of San Antonio Creek and the Santa Ynez River, as well as many minor streams. The group is situated almost entirely within Santa Barbara County with the exception of a small area of Ventura County along the easterly edge.

Presently developed irrigated areas in the Santa Barbara Group are located near the City of Santa Barbara, on the Lompoc Plain at the mouth of the Santa Ynez River, and in the narrow valley along the Santa Ynez River inland from the Lompoc Plain. The principal urban areas are the City of Santa Barbara and the City of Lompoc and suburban areas adjacent thereto. The City of Santa Barbara receives its water supply principally from surface storage facilities. However, surrounding areas obtain water from small local ground water basins.

The present (1950) seasonal water requirement of lands in the Santa Barbara Group is estimated to be about 93,000 acre-feet. Of this total requirement, about 62,000 acre-feet is developed from underlying ground water resources and the remainder is supplied by surface storage developments. Although the ground water basins are physically meeting the present draft thereon, certain small local ground water basins in the vicinity of Santa Barbara are presently experiencing an aggregate overdraft of about 2,300 acre-feet per season.

The principal ground water basins in the Santa Barbara Group are located on the coastal plain at the mouth of San Antonio Creek, and in the rolling hill area inland from the Lompoc Plain and north of the Santa Ynez River. Smaller ground water basins are situated along the Santa Ynez River and on the Lompoc Plain. The presently developed ground water yield aggregates about 60,000 acre-feet per season.

At the present time, there are three surface storage developments of significant size on the upper reaches of the Santa Ynez River, namely: Jameson Lake, with a storage capacity of 6,700 acre-feet; Gibraltar Reservoir, with a capacity of 14,500 acre-feet; and Cachuma Reservoir, a United States Bureau of Reclamation project, with a capacity of 210,000 acre-feet. Water conserved by these reservoirs is conveyed by tunnels through the Santa Ynez Mountains for use in and adjacent to Santa Barbara.

The probable ultimate mean seasonal water requirement of lands in the Santa Barbara Group is estimated to be about 343,000 acre-feet. Considering the developed yield of ground water and existing surface storage works, the requirement for supplemental water may ultimately amount to about 229,000 acre-feet per season.

Plans for further development of local water resources of the Santa Barbara Group are limited to the further control of the Santa Ynez River. Because of the relatively small amount of water available for further development, the objectives of The California Water Plan in the group would necessarily be accomplished by an import of water from areas of surplus in other parts of the State.

Camuesa Dam and Reservoir on the Santa Ynez River upstream from Gibraltar Dam, and Salsipuedes Dam and Reservoir on Salsipuedes Creek about 2.5 miles upstream from the confluence with the Santa Ynez River would jointly develop about 11,200 acre-feet per season of additional local water supplies. Water conserved by Camuesa Reservoir would be released into the channel of the Santa Ynez River, passing through the existing Cachuma Reservoir, for diversion to lands adjacent to the river downstream therefrom. Water from Salsipuedes Reservoir would be released into the stream channel to recharge the ground water basin underlying the Lompoc Plain, to be pumped therefrom; or it could be conveyed directly from the dam to the Lompoc area by pipe line.

It should be noted that all or a portion of the yield developed by Camuesa Reservoir could be conveyed through existing tunnels to the area south of the Santa Ynez Mountains. On the other hand, it would be possible to use all or a portion of the yield of the presently constructed reservoirs in the Santa Ynez watershed. However, the changes in the distribution of the local waters would not affect the total quantity of imported water required within the Santa Barbara Group, but would merely redistribute this import requirement between the various areas of the group.

As an alternative to Camuesa Reservoir, consideration was also given to possible developments on the Santa Ynez River at the Hot Springs site and at the Santa Rosa site. However, it was found that a development at either site would be much more costly than at the Camuesa site, and that a development at the Santa Rosa site would flood the majority of the irrigable lands on the floor of Santa Ynez Valley.

The foregoing local water development works would control the runoff of the Santa Ynez River to the maximum degree considered practicable, developing 11,200 acre-feet per season of new yield for use in the area. The remainder of the supplemental water requirements under ultimate conditions, amounting to about 240,000 acre-feet per season, would be imported through facilities of the Central Coastal Aqueduct, a feature of the California Aqueduct System. A gross seasonal delivery of 255,000 acre-feet would be necessary to meet this requirement.

Although no consideration was given to possible improvement of channels or reservation of reservoir storage for the purpose of flood control, operation of Camuesa and Salsipuedes Reservoirs, with total capacities of 156,000 acre-feet, could provide some reduction of peak flows in the Santa Ynez River as a result of temporary surcharge storage above the spillway lip, and by the probable availability of some unused storage space during most years because of the large reservoir capacity on that stream. Operation of the foregoing reservoirs would also provide a measure of enhancement of fishery resources and recreational opportunities.

Summary of Central Coastal Area. The Central Coastal Area is an area of inherent water deficiency, because the yield obtainable from local water resources developed to their maximum practicable extent would be substantially less than the probable ultimate water requirements of the area. Objectives of The California Water Plan in the Central Coastal Area would be accomplished by further development of local water resources and by imports through facilities of the California Aqueduct System. Of the total ultimate supplemental water requirement of some 1,680,000 acre-feet per season, only 468,000 acre-feet would be provided by increased development of local water resources.

The prospective local developments in the Central Coastal Area would consist of 30 storage reservoirs with an aggregate active capacity of 1,800,000 acre-feet, of which 1,650,000 acre-feet would be devoted to water conservation, and 150,000 acre-feet of storage would be reserved in San Lucas Reservoir for control of floods. In addition, surface reservoirs would be operated in conjunction with downstream ground water storage, to develop the optimum yield from local water resources wherever available. Certain of these reservoirs could be operated for flood control in addition to conservation, while the others would provide a measure of incidental flood control. Operation of these reservoirs would considerably enhance the recreational potential and warmwater fishery.

Supplemental water in the net seasonal amount of about 1,160,000 acre-feet to meet the ultimate requirements of all lands considered susceptible of water service in the Central Coastal Area would be provided through facilities of the California Aqueduct System. This would require an aggregate gross delivery of 1,213,000 acre-feet per season, as shown in the following tabulation:

Aqueduct facility	*Group*	*Delivery, in acre-feet*
South Bay Aqueduct	Santa Cruz-Monterey	15,000
Central Coastal Aqueduct	San Benito	113,000
	Salinas River	335,000
	San Luis Obispo	30,000
	Santa Maria Valley	140,000 *
	Santa Barbara	255,000
Carrizo-Cuyama Aqueduct	Carrizo Plain	245,000
	Cuyama Valley	80,000
Total		1,213,000

* An additional 27,000 acre-feet would be available from return flow from Cuyama Valley.

Data on the general features and costs of the local development works investigated as features of The California Water Plan in the Central Coastal Area are presented in Table 11. The locations and layouts of all of these facilities are delineated on Sheets 10, 13, 16, 17, and 20 of Plate 5.

South Coastal Area

The South Coastal Area comprises the drainage areas of those streams discharging into the Pacific Ocean between the southeastern boundary of the Rincon Creek watershed near the Santa Barbara-Ventura county line on the north, and the Mexican border on the south. All of Orange County, major portions of the Counties of Los Angeles, Riverside, San Bernardino, San Diego, and Ventura, and small areas in the Counties of Kern and Santa Barbara are included within the boundaries of the area.

The South Coastal Area contains over one-half of the State's population, with about seven per cent of its area, but receives less than two per cent of the total runoff of the State. Because of its desirable climate, and other factors such as strategic location for military and industrial installations, this area has experienced a growth in population and industry during the past half century which is unparalleled in the history of the United States. This rapid growth has accelerated during the past decade and as yet has shown no indication of levelling off. The population of the entire area in 1955 was about 7,000,000. It is estimated that within the next century the State will attain a population of over 40,000,000, of which about 45 per cent will be located within the South Coastal Area.

The principal population centers in the South Coastal Area are the Cities of Los Angeles and San Diego, both surrounded by densely populated metropolitan areas. These cities owe their phenomenal growth and present large population not only to the influx of retired folks and tourists attracted by the climate, but to the migration of large numbers of workers attracted by the industrial and commercial growth which the area has experienced. It has been estimated that the Los Angeles and Orange Counties area ranks third among the industrial areas in the

TABLE 11

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN CENTRAL COASTAL AREA

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

Dam and reservoir	Stream	Dam: Location, MDB&M, and sheet of Plate 5 on which shown	Dam: Type	Dam: Height, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Net	Seasonal yield, in acre-feet[a]	Purpose	Place of water use	Capital cost[b]
Santa Cruz-Pajaro Group											
Archibald	Scott Creek	Sec. 18, T10S, R3W 10	E	134	152	20,000	19,800	10,000	I,U	Coastal area north of Santa Cruz	$2,011,000
Bear Creek	Bear Creek	Sec. 10, T9S, R2W 10	E	185	861	8,500	8,200	4,900	U,R	San Lorenzo Basin	2,469,000
Zayante	Zayante Creek	Sec. 36, T9S, R2W 10	E,R	140	603	6,900	6,800	3,900	U,R	San Lorenzo Basin	1,299,000
Doyle Gulch	Rodeo Gulch	Sec. 4, T11S, R1W 13	E	210	314	14,500	14,300	13,200	U	Santa Cruz-Soquel	2,497,000
Glenwood	West Branch Soquel Creek	Sec. 10, T10S, R1W 10	E,R	111	500	2,500	2,400	2,000	I,U	Soquel Creek Basin	632,000
Upper Soquel	Soquel Creek	Sec. 12, T10S, R1W 10	E,R	109	555	1,700	1,600	2,100	I,U	Soquel Creek Basin	709,000
Aptos Creek	Aptos Creek	Sec. 7, T11S, R1E 13	E	132	164	4,100	4,000	2,300	I,U	Aptos area	1,406,000
Watsonville	Corn Cob Canyon	Sec. 14, T12S, R2E 13	E	158	205	21,000	20,400	9,700	I,U	Pajaro River area	3,256,000
San Benito Group											
Enlarged Uvas	Uvas Creek	Sec. 18, T10S, R3E 10	E	158	534	[c]24,000	[c]24,000	6,400	I	South Santa Clara Valley	2,597,000
San Benito	San Benito River	Sec. 5, T16S, R8E 13	E	190	1,317	50,000	43,700	7,000	I	San Benito River area	3,214,000
Cienega	San Benito River	Sec. 10, T14S, R6E 13	E	113	663	40,000	34,000	5,300	I	Hollister area	2,978,000
Harper Canyon	Pacheco Creek	12,000 acre-feet of storage allocated to local development, 53,000 acre-feet to the South Bay Aqueduct. See Table 23.						2,000	I,S	Pacheco Creek area	Table 24
Monterey-Carmel Group											
Klondike	Carmel River	Sec. 11, T17S, R2E 13	E,R	216	525	56,100	55,100	27,300	U,I	Monterey Peninsula	10,753,000
Salinas River Group											
Santa Rita	Santa Rita Creek	Sec. 4, T28S, R11E 16	E	153	1,143	15,000	14,500	3,200	I,U	Atascadero-Templeton area	1,404,000
Lower Jack	Jack Creek	Sec. 18, T27S, R11E 16	E	160	1,130	25,000	24,500	4,600	I,U	Atascadero-Templeton area	1,751,000
San Miguelito	Nacimiento River	Sec. 19, T23S, R7E 16	E	175	1,268	130,000	130,000	13,000	I,U	Salinas Valley and Paso Robles	3,017,000
Jarrett Shut-in	Nacimiento River	Sec. 19, T24S, R8E 16	CA	233	1,114	110,000	110,000	11,000	I,U	Salinas Valley and Paso Robles	4,691,000
Milpitas "B"	San Antonio River	Sec. 11, T22S, R6E 13	E	225	1,288	175,000	174,000	18,500	I	Salinas and Lockwood Valleys	8,139,000
Pleyto "B"	San Antonio River	Sec. 34, T24S, R10E 16	E	168	753	200,000	197,000	21,000	I	Salinas and Lockwood Valleys	4,667,000
San Lucas	Salinas River	Sec. 26, T20S, R8E 13	E	103	405	375,000	361,000	14,600	I,FC	Salinas Valley	22,476,000
Greenfield	Arroyo Seco	Sec. 16, T19S, R6E 13	E	225	555	100,000	96,000	24,100	I	Salinas Valley	8,296,000
Carrizo Plain (no local works)											
San Luis Obispo Group											
Bald Top	San Carporforo Creek	Sec. 2, T25S, R6E 16	E	190	845	20,000	19,500	....	....	San Luis Obispo area	2,249,000
Ragged Point	San Carporforo Creek	Sec. 15, T25S, R6E 16	E	250	300	30,000	29,500	22,500	I,U	San Luis Obispo area	5,420,000
Yellow Hill	Arroyo de la Cruz	Sec. 35, T25S, R6E 16	E	204	220	80,000	79,000	79,300	I,U	San Luis Obispo area	6,401,000
San Simeon	San Simeon Creek	Sec. 10, T27S, R8E 16	E	182	224	60,000	59,500	18,200	I,U	San Luis Obispo area	6,944,000
Santa Rosa	Santa Rosa Creek	Sec. 16, T27S, R9E 16	E	210	438	35,000	34,500	11,100	I,U	San Luis Obispo area	4,121,000
Whale Rock	Old Creek	Sec. 34, T28S, R10E 16	E	175	203	40,000	39,500	8,900	I,U	San Luis Obispo area	2,884,000
Lopez	Arroyo Grande	Sec. 32, T31S, R14E 16	E	159	518	50,000	49,000	6,500	I,U	Arroyo Grande area	4,228,000
Santa Maria Valley	(no local works)										
Cuyama Valley	(no local works)										
Santa Barbara Group											
Camuesa	Santa Ynez River	Sec. 7, T5N, R26W SBB&M 20	E	202	1,555	110,000	103,000	5,800	I	Santa Ynez River Basin	7,419,000
Salsipuedes	Salsipuedes Creek	Sec. 13, T6N, R34W SBB&M 20	E	180	332	46,000	45,000	5,400	I	Lompoc Plain	3,686,000
Totals					....	1,850,300	1,799,800	....	....	....	131,614,000

TABLE 11—Continued

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN CENTRAL COASTAL AREA

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

Associated features	Length of conduit, in miles			Pumping plants			Capital cost[b]
	Canal	Pipe	Total	Total number	Installed capacity, in kilowatts	Seasonal power consumption, in kilowatt-hours	
Santa Cruz-Pajaro Group	1.0	5.0	6.0	3	5,740	7,300,000	$1,745,000
San Benito Group	1.3		1.3				663,000
Monterey-Carmel Group							
Salinas River Group	117.0	31.0	148.0				17,493,000
Carrizo Plain							
San Luis Obispo Group		59.0	59.0				21,369,000
Santa Maria Valley							
Cuyama Valley Group							
Santa Barbara Group							
Totals	119.3	95.0	214.3	3	5,740	7,300,000	$41,270,000

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

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

[a] Reservoirs of the Salinas River Group would be operated in conjunction with ground water storage to develop an additional yield of 50,000 acre-feet per season
[b] At 1955 price levels.
[c] Enlarged to 34,000 acre-feet from its present capacity of 10,000 acre-feet.

nation, and that nearly one-third of the two million persons employed in the two counties are engaged in manufacturing enterprises.

There are many military reservations in the South Coastal Area, the largest of which are under the jurisdiction of the Department of the Navy. The headquarters of the Eleventh Naval District with training, air, and repair facilities, is located at San Diego, and is a very important element in the economy of that area. Other Department of Navy facilities in the South Coastal Area include several Marine bases, the largest of which is Camp Pendleton, and two major bases in Ventura County. Army and Air Force establishments are distributed throughout the area, the principal base being March Air Force Base in Riverside County.

Concurrently with, but not always paralleling, the population expansion in the South Coastal Area has been the growth of irrigated agriculture. The mild climate allows the production of citrus, avocados, fruits, and nuts, all of which are high-value crops. The phenomenal expansion of population, agriculture, and industry has created ever increasing demands for water. Local water supplies have been obtained to a great extent through exploitation of the large ground water reservoirs. However, these local water supplies are limited and are far from sufficient to support the existing development. In 1950, about one-fourth of the total water used represented overdraft on ground water storage, and one-fourth was water imported from sources outside the area.

The South Coastal Area has a long history of irrigated agriculture dating back to the days of the missions in the eighteenth century. Intensive development of irrigated agriculture began in the late nineteenth century and has progressed rapidly to recent times. In 1950, it was estimated that the net irrigated area totaled some 617,000 acres, nearly one-half being devoted to the production of citrus, avocados, and other specialty crops.

During the past half century, there has been an increasing expansion in the area occupied by urban and industrial developments, with the gross urban area estimated to have been 548,000 acres in 1950. Urbanization has been greatly accelerated in the past few years. This development has taken place largely on agricultural lands immediately adjacent to existing urban areas, and it is considered probable that future urbanization will generally be at the expense of present agricultural areas. The area that will be ultimately occupied by urban and industrial development is estimated to be 1,611,000 acres.

Increase in the area of irrigated lands probably will be dependent in large part upon the availability of an imported water supply, and will occur both by application of water to presently dry-farmed areas and by bringing under cultivation lands not presently farmed due to lack of adequate water supplies. It is estimated in State Water Resources Board Bulletin No. 2 that a gross area of 1,156,000 acres will be devoted to irrigated agriculture under conditions of ultimate development.

The climate of the South Coastal Area is characterized by relatively mild temperatures and light precipitation in the coastal areas, and by somewhat wider temperature variation and heavier precipitation in the inland areas. Precipitation on the area generally varies from as little as 10 inches along the coast to over 40 inches in some of the higher mountain areas.

At present, water supplies in the South Coastal Area are obtained principally by pumping from underlying ground water basins, by storage in and diversion from surface reservoirs, and by importation from the Colorado River and from the Owens River and Mono Basin. Although a large quantity of water is obtained by individual pumping, most of the lands requiring water are served by a multitude of water companies or public agencies, with service areas varying from a few acres to many square miles in extent.

The Metropolitan Water District of Southern California has a right, presently under litigation, to 1,212,000 acre-feet of Colorado River water annually, of which amount about 400,000 acre-feet was delivered in fiscal year 1956. Operating at full capacity, the Owens-Mono Aqueduct of the City of Los Angeles presently delivers about 320,000 acre-feet annually into the area. Water requirements in the South Coastal Area under probable ultimate conditions of development are estimated to total 5,552,000 acre-feet per season. With the Colorado River and Los Angeles Aqueducts operating at full capacity, there will remain about 3,000,000 acre-feet of water per season which must be obtained from further development of local water resources, or from importation through facilities of the California Aqueduct System. Plans for further development of local water supplies subsequently presented herein would increase the safe seasonal local yield by only about 149,000 acre-feet, which appears to be the maximum practicable amount of additional conservation, leaving in excess of 2,800,000 acre-feet of water per season which must be imported from northern California.

Although the South Coastal Area is classified as an arid region, the tributary watersheds occasionally receive precipitation in torrential amounts which produce extremely high intensities of flood runoff in the streams draining the area. These floods have resulted in large financial losses in property damage due to inundation, erosion, and deposition of debris, as well as loss of life. Intensive development of urban areas adjacent to the flood channels has greatly increased the flood damage hazard in most of the area.

The most comprehensive system of flood control works in the area is that of the Los Angeles and San

South Coastal Area—Los Angeles River

Gabriel Rivers and Ballona Creek project now under construction by the Corps of Engineers, U. S. Army, in cooperation with the Los Angeles County Flood Control District, with financial participation by the State of California. Flood control works of lesser magnitude have been constructed on streams throughout the remainder of the area, and additional small flood control works will probably become necessary in the future as a result of intensive urbanization of the area. However, these works would consist mainly of channel improvement measures which are not considered to be within the scope of The California Water Plan. The additional reservoir developments described hereinafter, with the exception of the enlarged Hodges Reservoir on San Dieguito River, include no specific storage reserves for flood control purposes.

Plans for accomplishment of the objectives of The California Water Plan for the South Coastal Area envision the development of additional yield from local water resources to the maximum practicable degree by capture of waters presently wasting to the ocean, and construction of works adequate to convey and regulate sufficient additional imported water to provide fully for water requirements which will exist under probable ultimate conditions of development. In the formulation of plans, consideration was given to coordination of their construction and operation with existing water supply developments in the area, both surface and underground, to the maximum practicable extent.

Inasmuch as a high degree of conservation of runoff from most streams in the South Coastal Area has already been effected by surface storage developments and by artificially recharged underground storage, further conservation of the infrequent waste to the ocean by means of surface reservoirs will necessitate very large storage capacities with respect to the magnitude of the conserved supplies, with attendant long carry-over periods. Developments will be quite costly, and the additional yield quite small with respect to ultimate water requirements. The desirability of constructing a local conservation development at a given time, or the question of whether such developments should be undertaken at all, will be matters for local decision, and will be based upon many factors, including the financial capacity of the constructing agency, the amount of water required at the time construction is contemplated, the availability of a firm supply of imported water at that time, and the unit cost of imported water as compared to the unit cost of yield from a local water resource development. However, because of the small quantities of water involved, future deviation in the plans for local water resource development considered herein would have little material effect upon the over-all plan.

It must be realized that there are numerous factors which, under constant change, tend to alter ground water recharge and the safe yield of ground water basins. Urbanization, with accompanying increase in impervious areas, produces two opposite phenomena. On the one hand consumptive use of precipitation is greatly reduced, increasing the water supply available for conservation, while on the other hand runoff is increased, which, with increased storm drain facilities, may reduce recharge opportunity. Impervious channel lining for flood control purposes decreases the opportunity for recharge of underground basins from flood waters, while construction of spreading grounds tends to compensate for this effect. The effect of operation of flood control reservoirs on the regimen of stream flow can generally increase the opportunity for percolation of flood flows.

Artificial recharge of ground water basins in conjunction with the operation of both flood control and conservation reservoirs is presently accomplished or is planned where practicable. For purposes of this bulletin it is assumed that this practice will result in the maintenance of the present safe yields of the ground water basins. Because, as stated, waste to the ocean now occurs infrequently, the amounts by which the present safe yields might be increased through artificial recharge will be relatively small.

For purposes of analysis, the South Coastal Area has been subdivided into three groups; namely the Ventura Group, the Los Angeles-Santa Ana Group, and the San Diego Group. The location of these groups is shown on Plate 3. In the following sections, plans are presented for the development of local water supplies in each of these groups.

Ventura Group. The Ventura Group consists of the drainage areas of streams flowing into the ocean between the northerly boundary of the South Coastal Area and Topanga Creek, including the Ventura and Santa Clara Rivers, Calleguas Creek, and several smaller creeks. The largest part of the area comprising the group is occupied by mountains and hills. The mountains northerly of the Santa Clara River are quite rugged and reach elevations in excess of 8,000 feet. The majority of the valley lands are on the coastal plain near the mouths of the Santa Clara River and Calleguas Creek, with smaller valley areas located inland along these streams and the Ventura River.

The 1950 federal census reported the population of Ventura County to be 114,647, and by January, 1957, the population had increased to an estimated 159,300. In 1950, the populations of major cities in the county included: Oxnard, 21567; Ventura, 16534; and Santa Paula, 11,049. The oil industry is the leading industry in the county. Other principal industries include agriculture and the associated processing and packing of vegetables and citrus fruits and the processing of sugar beets.

At the present time the Santa Clara River Valley, the coastal plain, and portions of the Ventura River and Calleguas Creek drainage areas are extensively developed to irrigated agriculture. Land use surveys conducted in Ventura County during 1949-50 showed that there were in excess of 109,000 acres of irrigated land. Principal crops were citrus with about 43,000 acres, beans with about 33,000 acres, and walnuts with slightly less than 18,000 acres.

The mild climate typical of the South Coastal Area prevails in the Ventura Group, with proximity to the ocean providing a moderating effect throughout most of the developed area. In excess of 80 per cent of the mean seasonal precipitation occurs during the months of December through March. Killing frosts in the Ventura County area are extremely rare, and consequently, portions of this region are producing as many as three crops per year.

With the exception of small amounts of direct surface diversion, the presently utilized water supplies in the Ventura Group are obtained by pumping from several major ground water basins which underlie most of the developed area. It is estimated that the total usable ground water storage capacity in these basins is over 1,000,000 acre-feet, of which about 400,000 acre-feet has been utilized to date. Off-stream spreading works have been operated by the Santa Clara Water Conservation District and its successor, the United Water Conservation District, since about 1927. During the wet year 1951-52 about 11,800 acre-feet of water was diverted from Piru Creek and percolated in the Piru spreading grounds. During the same year about 25,400 acre-feet of water diverted from the Santa Clara River was spread in the Saticoy grounds. Diversion capacities were 75 second-feet and 145 second-feet, respectively. During 1955, the capacity of the conduit leading to the Saticoy spreading grounds was increased to 375 second-feet, and a 42-inch diameter conduit with a capacity of about 150 second-feet was extended to the El Rio spreading ground a short distance downstream. Presently developed safe yield from ground water and from relatively small diversions of unregulated surface flow is estimated to be about 126,000 acre-feet per season.

There are presently only two major surface storage reservoirs in the area. Matilija Reservoir on Matilija Creek, a tributary of the Ventura River, is owned and operated by the Ventura County Flood Control District. It has a storage capacity of about 7,000 acre-feet, and an estimated safe yield of about 1,400 acre-feet per season. Santa Felicia Reservoir on Piru Creek, a tributary of the Santa Clara River, was recently completed by the United Water Conservation District. Storage capacity is about 100,000 acre-feet, and it is estimated that the reservoir will increase the safe yield available from the Santa Clara River system by about 15,000 acre-feet per season if conveyance facilities, hereinafter described, are constructed to carry water from the reservoir to the coastal plain to alleviate present ground water overdraft therein.

Work was recently started on construction of the Ventura River Project by the United States Bureau of Reclamation. This project will provide a new yield of about 27,000 acre-feet per season, which is more than sufficient to provide for the present supplemental water requirement of 4,000 acre-feet per season in the area included within the Ventura River Municipal Water District, the local contracting agency, and would satisfy all but about 3,000 acre-feet of the probable ultimate seasonal water requirements therein. The project includes a reservoir of 250,000 acre-foot capacity at the Casitas site on Coyote Creek, a tributary of the Ventura River. In addition to storage of flows of Coyote Creek, the reservoir would store flows diverted from the main stem of the Ventura River by means of Robles Diversion Dam and a 500 second-foot conduit to Casitas Reservoir.

It was estimated in State Water Resources Board Bulletin No. 12 that draft on ground water in the coastal plain of Ventura County in 1951 exceeded the safe yield by 59,000 acre-feet per season. It is estimated that, with full realization of the safe yield of the recently completed Santa Felicia Reservoir, this overdraft would be reduced to about 44,000 acre-feet per season. This overdraft may be attributed to two factors: inadequate cyclic carry-over storage capacity in the ground water forebay area, and a lack of sufficient carrying capacity in the pressure aquifers underlying the coastal plain to transmit enough water to prevent the pressure surface elevations from dropping below sea level during periods of heavy pumping draft, thus creating conditions conducive to the intrusion of sea water.

In the uppermost reaches of the Santa Clara River in Los Angeles County, there is a substantial area of irrigable land partly underlain by ground water basins. These basins are presently being pumped but show no evidence of overdraft. However, irrigation of all the lands in the valley will require importation of water, as natural recharge to the basin is limited.

In the Piru, Fillmore, and Santa Paula Basins, lying along the Santa Clara River between the Los Angeles County boundary and the coastal plain of Ventura County, there is no present overdraft, nor is it anticipated that there will be one under ultimate conditions of development.

In the inland portion of the Calleguas Creek watershed, it is estimated that usable ground water storage capacity totals about 200,000 acre-feet. However, due to the generally light precipitation and limited flow in tributary streams, mean seasonal recharge is quite limited, and there is virtually no opportunity for further conservation of local supplies. In State Water Resources Board Bulletin No. 12 it was estimated that, in 1951, there was a ground water overdraft of about 9,000 acre-feet per season in this area. Temporary relief could be obtained by importation of water from Santa Clara River if water rights problems involved in diversion of water from that stream were resolved. Ultimate solution of the water problems in the Calleguas Creek area will, in any event, necessitate importation of large quantities of water through facilities of the California Aqueduct System.

The area southerly of Calleguas Creek is, in large part, mountainous, and is drained by several creeks discharging directly into the ocean, the largest of which is Malibu Creek. Water is obtained primarily by pumping from numerous small ground water basins. Although there are some localized water shortages, it is believed that the present over-all safe yield is just about in balance with present water requirements. However, further increase in water requirements will necessitate importation of water from outside sources.

Present and probable ultimate seasonal water requirements in the Ventura Group are summarized in the following tabulation, wherein the safe yield of local water supplies for ultimate conditions includes the yields of the additional water supply developments hereinafter described.

	Acre-feet per season
Present conditions (1950)	
Water requirement	199,000
Safe yield of local water supplies	142,000
Supplemental water requirement	57,000
Probable ultimate conditions	
Water requirement	512,000
Safe yield of local water supplies	229,000
Requirement for imported water	283,000

Further conservation of runoff in the Santa Clara River could be effected by construction of surface storage on major tributaries thereof. Possible storage developments include a 50,000 acre-foot reservoir at the Blue Point site on Piru Creek, a 100,000 acre-foot reservoir at the Topatopa site on Sespe Creek, and a 100,000 acre-foot reservoir at the Cold Spring site on Sespe Creek. The Santa Clara River Conduit, with a maximum capacity of 120 second-feet, could be constructed from the existing Santa Felicia Reservoir to a distribution system serving the pressure area of the coastal plain. Water released from the reservoirs on Sespe Creek would be diverted from the stream channel downstream from Topatopa Dam, and conveyed into the Santa Clara River Conduit at its crossing of Sespe Creek for delivery to the coastal plain. The locations of the foregoing facilities are shown on Sheet 21 of Plate 5.

Conveyance of waters from the reservoirs in a conduit would increase the amount of water available to the coastal plain. If the stream channel were used for conveyance, a large portion of the water released from the reservoirs would percolate before reaching the coastal plain during extended periods of drought, and would not be available for use thereon. Solution of the problem of sea-water intrusion would require construction of a surface distribution system on the coastal plain area so that, by delivery of surface water supplies, ground water withdrawals could be reduced to amounts within the limits of transmissibility of the underlying aquifers without drawing the pressure gradients down below sea level. Such a system covering a portion of this area is presently under construction by the United Water Conservation District. Solution of the problem would also require the pumping of water from the coastal plain forebay and its operation in conjunction with upstream surface and ground water reservoirs.

In addition to the new yield made available to the coastal plain from the foregoing surface developments, it is estimated that an ultimate net increase in ground water yield in the amount of 26,000 acre-feet per season could be developed by increased extractions of water from ground water basins along the Santa Clara River upstream from the coastal plain. Under ultimate conditions of development, and after construction of further local developments as previously discussed, an estimated 238,000 acre-feet per season of imported water would be needed in the coastal plain, in the portion of the Santa Clara River watershed in Los Angeles County, in the upper Calleguas Creek watershed, in the Malibu Creek drainage area, and along the coastal strip southerly from Calleguas Creek. The California Water Plan envisions conjunctive operation of underground and surface storage in the Ventura Group.

Los Angeles-Santa Ana Group. The Los Angeles-Santa Ana Group includes the San Fernando, San Gabriel, upper Santa Ana, and San Jacinto Valleys; the coastal plain of Los Angeles and Orange Counties; and tributary mountain and hill areas. Included are the drainage areas of the Los Angeles, San Gabriel, and Santa Ana Rivers, as well as several minor streams discharging into the Pacific Ocean between Santa Monica and Newport Beach. About one-half of the total area is occupied by valley and mesa lands. The tributary mountain area separating this group from the Lahontan and Colorado Desert Areas is quite rugged and reaches elevations in excess of 10,000 feet. A range of hills of lower relief separates the inland valleys from the coastal plain.

The Los Angeles-Santa Ana Group contains one of the most populous urban regions in the nation. Population within the group in 1955 was about 6,000,000, or approximately 45 percent of the total for the State. In excess of 2,000,000 people now reside within the City of Los Angeles. In addition, there is extensive agricultural development. In 1950, nearly 70 percent of the irrigated lands in the South Coastal Area were located within the Los Angeles-Santa Ana Group.

Water supplies required by the foregoing urban and agricultural development were first obtained by direct surface diversions and some small surface storage developments. Continuation of the development resulted in intensive utilization of the large ground water basins underlying the valley and coastal plain lands. Of the total underground storage capacity, about 7,000,000 acre-feet of capacity is considered usable, on the basis of those factors of basin configuration, economic pumping lift, and others, as described in the appendix on ground water. The utilization of about 4,500,000 acre-feet of this storage historically has resulted in the development of a safe yield from the local water supplies of 780,000 acre-feet per season.

In the light of the great importance of ground water basins to the economy of the Los Angeles-Santa Ana Group, many steps have been undertaken to assure the fullest practicable utilization of these basins. Percolation in natural stream channels is augmented by spreading operations during periods of flood. At the present time there are 70 artificial recharge projects in the Los Angeles-Santa Ana Group, with a capacity sufficient to spread a continuous flow of about 17,000 second-feet. An additional 55 artificial recharge projects, with capacity of about 4,000 second-feet, are proposed for construction by various local agencies in the group. It is estimated that over 1,000,000 acre-feet of water have been spread since 1900 in the upper Santa Ana Valley alone. The Los Angeles County Flood Control District is constructing spreading works throughout pervious areas of the county to enhance natural percolation, and to attempt, insofar as possible, to replace losses in percolation capacity resulting from lining of stream channels for flood control purposes. The district is also presently engaged in injecting Colorado River water into confined aquifers in the Manhattan Beach area of the West Coast Basin to create a pressure ridge along a portion of the coast line, in an effort to repel sea water. Additional Colorado River water is spread in the forebay areas of the Los Angeles and Orange Counties coastal plains.

In addition to providing the equalizing storage capacity necessary to regulate the erratic natural inflow, the ground water basins provide a natural distribution system. A considerable part of the water used for agricultural lands is obtained from ground water by individual effort, and the use of ground water basins eliminates much of the cost which would otherwise be incurred in the construction of necessary distribution facilities.

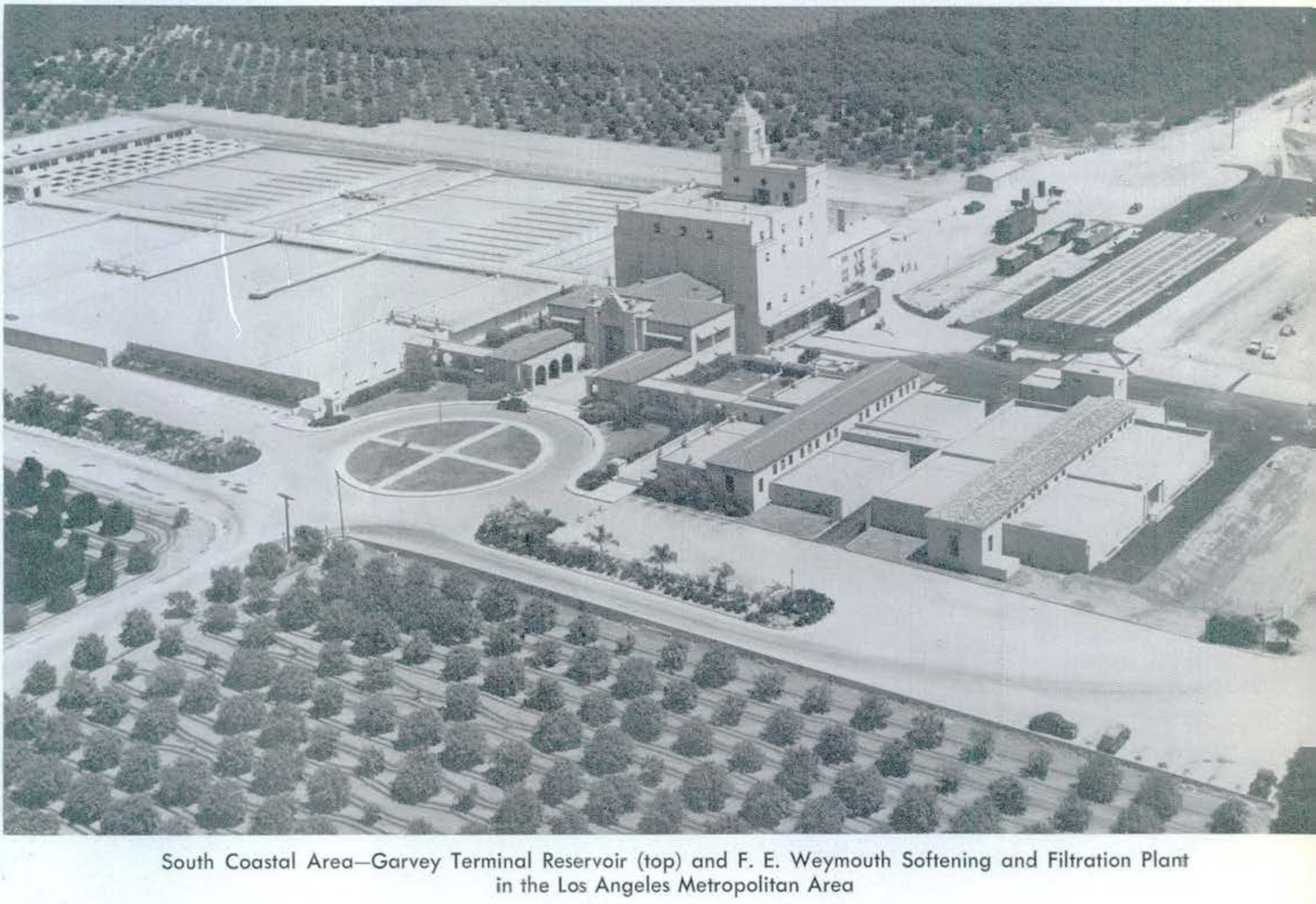
Urbanized areas in the Los Angeles-Santa Ana Group are served water by surface distribution systems of a number of agencies, the largest of which is the Department of Water and Power of the City of Los Angeles. However, even in some of these urbanized areas supplied in part from ground water storage, ground water basins function as a means of conveyance of water to convenient points of delivery to the numerous water service agencies.

Water has been imported to the South Coastal Area from the Owens River and Mono Basin via the Los Angeles Aqueduct by the City of Los Angeles since 1916, and from the Colorado River via the Colorado River Aqueduct by The Metropolitan Water District of Southern California since 1941. The Department of Water and Power of the City of Los Angeles reports that about 319,000 acre-feet per season can be imported from the Owens River and Mono Basin through the Los Angeles Aqueduct and that the full capacity of this facility is presently being utilized.

The Metropolitan Water District of Southern California has rights to the waters of the Colorado River for service in both the Los Angeles-Santa Ana and San Diego Groups in the amount of 1,212,000 acre-feet per season, although this is presently under litigation. It is estimated that due to conveyance and regulation losses, only 1,140,000 acre-feet would be actually available to meet requirements in the South Coastal Area. During 1956, the capacity of the Colorado River Aqueduct was increased to 1,000 second-feet, or about 700,000 acre-feet per season. Plans are under way to complete the aqueduct to its full capacity of about 1,600 second-feet by the year 1960. Representatives of The Metropolitan Water District of Southern California estimate that the full conveyance capacity of this facility will be utilized by the year 1975.

In 1950, draft upon ground water storage in the Los Angeles-Santa Ana Group exceeded replenishment by an estimated average amount of 307,000 acre-feet per season. The most serious manifestations of this overdraft are exhibited in the coastal plain area where, in addition to an actual insufficiency of recharge, the confined aquifers which underlie a large portion of the coastal plain are of inadequate capacity to convey required water supplies from areas of recharge to points of extraction without creation of conditions conducive to the intrusion of sea water. Montebello Forebay, the free ground water area which supplies a large part of the coastal plain pressure area, was essentially full in the early 1940's, while ground water levels coastward thereof were below sea level. At the present time, water levels over the major part of the coastal plain are below sea level, and as a result, sea water has invaded actively pumped aquifers along much of the coast line.

In addition to the foregoing, there are also overdrafts in certain of the interior groundwater basins. Increased use of water in the interior valleys, although not necessarily causing overdraft therein, will tend to diminish the natural supply to the coastal basins,



South Coastal Area—Garvey Terminal Reservoir (top) and F. E. Weymouth Softening and Filtration Plant in the Los Angeles Metropolitan Area thereby tending to increase overdraft in the coastal areas.

As a result of these overdraft conditions, ground water rights have been adjudicated in the Raymond Basin Area in San Gabriel Valley and are in process of adjudication in the West Coast Basin, which occupies the westerly portion of the coastal plain. Extractions from ground water of the Raymond Basin Area were limited to the safe yield thereof by terms of the judgment rendered by the Trial Court in 1944, confirmed by the Supreme Court in 1949. The Superior Court has retained jurisdiction in each of these cases. In the West Coast Basin, most of the parties to litigation have by agreement limited their ground water extractions pending final settlement. In both areas the court appointed the Department of Water Resources as Watermaster to administer provisions of the court decree in the case of Raymond Basin Area and provisions of the current stipulated agreement in the West Coast Basin. In each instance, use of imported water has substantially increased since commencement of watermaster service. Further litigation, such as that now pending in other portions of the group, and subsequent adjudication of rights to extract ground water would save these basins from possible eventual exhaustion and, in some cases, destruction. As a consequence, the use of imported water would be greatly accelerated.

Serious consideration must be given to the problem of salt balance in the underground reservoirs which are so extremely important to the Los Angeles-Santa Ana Group if they are to be preserved for the regulation, distribution, and re-use of native and imported waters. The problems of salt balance have been previously discussed in Chapter II.

Although there are indications of possible present adverse salt balances in several basins in the group, it is believed that, except for certain localized conditions, serious problems will not result under the present level of development. In the future, anticipated large exportations of sewage directly to the ocean should prevent occurrence of adverse salt balance in the San Gabriel and San Fernando Valleys. Similarly, the coastal plain area is provided with necessary outflow in the form of the relatively large extractions from the confined aquifers, the unconsumed residuum of which is largely prevented from returning to the pumped zone. However, in the upper Santa Ana Valley, a very serious situation could develop if careful attention is not given to the problem of salt balance in operation of the ground water basins and in the disposal of waters. As hereinafter discussed, salt balance considerations also influenced the planning of importation facilities with respect to the effect on water quality of imported water supplies from various sources considered.

Present and probable ultimate water requirements, safe local yield, and requirements for imported water in the Los Angeles-Santa Ana Group are summarized in the following tabulation. In 1949-50, a total of about 400,000 acre-feet of water was imported, and about 307,000 acre-feet represented ground water overdraft.

Present conditions (1950)	*Acre-feet per season*
Water requirement	1,483,000
Safe yield of local supplies	776,000
Requirement for imported water	707,000
Probable ultimate conditions	
Water requirement	3,535,000
Safe yield of local supplies	776,000
Requirement for imported water (including importation from Owens-Mono and Colorado River Basins)	2,759,000

It is considered that the present degree of conservation of local surface runoff in the Los Angeles-Santa Ana Group is very near to the maximum that is practicable. Therefore, no plans for additional local water supply developments are hereinafter presented. However, a future recreational development at Lake Elsinore is contemplated by stabilizing and maintaining adequate lake levels.

It is possible that a small amount of additional water could and will be developed from local water supplies by construction of additional artificial ground water recharge works and improved methods of ground water storage operation. However, the amounts of water that could be so obtained are relatively insignificant as compared with the probable ultimate water requirements of the area.

In recent years there have been increasing discussion and study of methods of reclaiming water of suitable quality for irrigation and other uses from the sewage flows presently being discharged into the ocean from the Los Angeles and San Diego metropolitan areas. In connection with statutory responsibilities of the Department of Water Resources, the possibility of reclamation of water from sewage has been studied. The objective of this study was to determine the quantities of water that could be reclaimed, the costs thereof, and potential markets for the reclaimed supply. In certain areas, particularly the upper Santa Ana Valley, involuntary reclamation is occurring by land disposal of sewage treatment plant effluent from interior communities and from cesspools of suburban dwellings. The trend, however, is toward construction of large-scale sewerage systems with ocean disposal because of aesthetic and public health considerations.

Conclusions of the sewage reclamation studies to date are generally that: (1) in the order of 500,000 acre-feet of sewage is discharged annually to the ocean from the Los Angeles metropolitan area and this quantity will increase substantially with continued urban growth; (2) the total quantity of sewage should not be all classed as "waste," since it is serving a beneficial purpose in providing necessary outflow of ground water extracted for municipal and industrial purposes, thereby removing undesirable salts from the underlying ground water basin; (3) the mineral pickup inherent in urban and industrial use of water makes the use of reclaimed water for ground water recharge limited in scope because of the possibility of producing an unfavorable salt balance in the ground water basin; (4) by its very nature sewage or water reclaimed therefrom accumulates in greatest quantity at the coast at an elevation very near sea level, requiring expensive conveyance and pumping facilities to make it available for use for ground water recharge or for industrial uses in the Los Angeles area or farther inland; (5) the effect upon public health of use of water reclaimed from sewage for agricultural or urban purposes cannot be fully evaluated at this time and, because of aesthetic and public health considerations, the market for reclaimed sewage waters may be limited to comparatively small quantities for certain industrial purposes, at least in the near future; and (6) continuing study and periodic evaluation should be given to the feasibility of use of this possible source of water supply, with regard to changes in technological methods and varying conditions by land use and water supply development that the future may bring. At the present time it does not appear that reclamation of water from sewage will affect to a significant degree the demand of the Los Angeles-Santa Ana Group for imported water.

San Diego Group. The San Diego Group includes the drainage areas of those streams flowing into the Pacific Ocean between Newport Beach and the Mexican border. Included are the Santa Margarita, San Luis Rey, San Dieguito, San Diego, Sweetwater, Otay, and Tia Juana Rivers, as well as many minor streams. About 85 per cent of the area is classified as mountains and foothills. However, much of the hill area near the coast is gently rolling and suitable for agricultural or urban developments. With the exception of the Temecula-Murrieta area in the upper Santa Margarita River watershed, valley lands are found in scattered small coastal and inland valleys along the major streams, and on coastal mesas near San Diego Bay.

Included in the San Diego Group are the densely populated San Diego metropolitan area surrounding San Diego and Mission Bays and the less populous but rapidly growing communities of Escondido, Oceanside, Carlsbad, Fallbrook, and Rainbow. It is estimated that the population of San Diego County increased from about 550,000 in 1950 to more than 850,000 in January, 1957. About 700,000 of these people reside in the San Diego metropolitan area.

Aircraft manufacture and fishing are major industries in the area. The capital investment in plant and equipment for these industries has almost doubled since 1950. In addition, the headquarters of the Eleventh Naval District including training, repair, air, supply, and radio facilities, are located in the San Diego metropolitan area, and Camp Pendleton, the largest Marine Corps base in the nation, is located near Oceanside.

Agriculture, principally the raising of subtropical fruits, has expanded rapidly in San Diego County during recent years. Although the citrus industry in the South Coastal Area has declined in importance in recent years, the raising of avocados and specialty crops has expanded rapidly. These latter crops have a very high monetary return.

The climate in the San Diego Group is generally mild near the coast, with relatively light precipitation. Proceeding inland, temperature variations become wider and precipitation becomes heavier as elevation increases. Mean seasonal precipitation is approximately 10 inches near the coast and in excess of 40 inches at the highest inland elevations of the tributary watersheds.

Water supplies in the San Diego Group are obtained from numerous small ground water basins, from 12 major and several lesser surface storage developments, and from importations through the two-barreled San Diego Aqueduct. The ground water basins in the area have relatively small capacity and limited recharge. Ground water rights in the Tia Juana Basin are under adjudication, and the basin has been under watermaster service since 1947. Court proceedings have been instituted to adjudicate ground water rights in the San Luis Rey River Basin.

In the years 1941, 1942 and 1943 the United States acquired most of the Rancho Santa Margarita by condemnation and purchase. To these acquisitions it added, by executive order, some public domain lands and established thereupon the United States Naval Ammunition Depot at Fallbrook, the United States Naval Hospital, and Camp Joseph H. Pendleton. Since that time a controversy has arisen between the United States and other water users with regard to the respective right of each to make use of the waters of the Santa Margarita River, which flows through and empties into the ocean on this land held by the United States.

Congress in 1954 undertook to resolve the controversy through legislation. The solution decided upon was the authorization of $22,636,000 for the De Luz Dam on the Santa Margarita River, to be constructed and operated by the Secretary of the Interior acting pursuant to federal reclamation law. The act apparently contemplates a solution of the controversy only as between the Department of the Navy and the Fallbrook Public Utility District. The district must agree, under the terms of the act, that it will not assert against the United States any prior appropriative right it may have to water in excess of the quantity which may be delivered to it under the terms of the act. Sixty per cent of the water impounded by De Luz Dam is allotted by the act to the Secretary of the Navy and forty per cent to the Fallbrook Public Utility District. Storage may not begin, however, until Camp Pendleton and the adjoining naval installations have received all the water to which the United States would be entitled under the laws of California had the dam not been built. The Secretary of the Navy is required to comply with water right acquisition procedures under the laws of California when he is satisfied, with the advice of the United States Attorney General, that such action will not adversely affect rights of the United States under California law. The act provides that water rights are to be determined by the laws of California.

The Executive Branch of the Federal Government sought to resolve the controversy through the prosecution of judicial proceedings. In January, 1951, the United States brought an action against some three thousand defendants to quiet title to water rights claimed to be appurtenant to the lands acquired by the United States. After granting the motion of the State of California to intervene in the proceedings, *United States* v. *Fallbrook Public Utility District*, 101 Fed. Supp. 298 (1951), defining issues affecting Fallbrook, Santa Margarita Mutual Water Company and the State, *United States* v. *Fallbrook Public Utility District*, et al., 108 Fed. Supp. 72 (1952), and ordering a separate trial as against the State and Santa Margarita Mutual Water Company, with their acquiescence, at the same time rendering a decision later described as superfluous and in the nature of proposed findings, *United States* v. *Fallbrook Public Utility District* et al., 109 Fed. Supp. 28 (1952), the United States District Court adjudged, that the Santa Margarita Mutual Water Company and the State of California and each of them "are forever barred from any and all claim of right, title, or interest in and to those rights to the use of water" which the court found vested in the United States. Declaration of Judgment No. 16, *United States* v. *Fallbrook Public Utility District*, et al., 110 Fed. Supp. 767, 788 (1953). The Court of Appeals for the Ninth Circuit reversed the judgment of the District Court, finding error in the breadth of the judgment entered against the State and the Santa Margarita Mutual Water Company. *People of the State of California* v. *United States*, 235 Fed. 2d. 647. The Court of Appeals declared that many of the declarations, findings and conclusions contained in the judgment of the District Court were premature and not well founded in the record before it. The action, which includes the entire Santa Margarita River watershed, was described as being in the nature of a plenary suit to settle the correlative rights of everyone interested in the water. The standard procedure in such a case, the Court declared, is to enter a decree setting up all the rights as of the same date. The case has been remanded to the District Court with a direction that no judgment be entered until the entire suit can be disposed of at the same time.

Due to the limited storage capacity of ground water basins in the San Diego Group, surface development plays a much more important role than in other portions of the South Coastal Area. Of the 148,000 acre-feet per season of presently developed net safe yield, an amount of 73,000 acre-feet, or about one-half, is obtained from surface reservoirs with an aggregate storage capacity of over 700,000 acre-feet. The remaining yield of 75,000 acre-feet is obtained by pumping from ground water or by diversion of unregulated stream flow.

The foregoing safe yield of local surface water supplies is obtained from surface storage reservoirs constructed on all of the major streams in southern San Diego County, including: Morena and Barrett Reservoirs on Cottonwood Creek and Lower Otay Reservoir on Otay River; Loveland and Sweetwater Reservoirs on Sweetwater River; San Vicente, Cuyamaca, and El Capitan Reservoirs on the San Diego River system; Lake Hodges and Sutherland Reservoir on the San Dieguito River; and in the northern part of the county, Lake Henshaw on San Luis Rey River and Vail Reservoir on Temecula Creek, a tributary of Santa Margarita River.

The San Diego Group has been supplied with imported Colorado River water through the existing San Diego Aqueduct since November, 1947. During the season of 1955-56, the flow in this aqueduct averaged about 195 second-feet and totaled about 140,000 acre-feet which is estimated to be equal to its maximum conveyance capacity. It is noted that this amount of imported water is substantially in excess of the annual amount of Colorado River water which the San Diego County Water Authority estimates as its entitlement.

The Department of Water Resources recently completed an investigation of alternative routes for an additional aqueduct to San Diego County, and recommended construction of conveyance facilities to be located generally parallel to the existing line but passing generally from immediately adjacent to 7 miles west of it. The recommended facility would comprise about 30 miles of canal with a capacity of 1,000 second-feet, estimated to be necessary to provide for future water requirements in the service area until about the year 2000, and 73 miles of pipe line with a capacity varying from 432 to 98 second-feet. This pipe line capacity would supply the additional imported water requirements forecast for the year 1980, and represents one-half the capacity estimated to be required in the year 2000. It is contemplated that this aqueduct would convey Colorado River water until Feather River Project water becomes available.

The Metropolitan Water District of Southern California and the San Diego County Water Authority have announced that they intend to undertake financing and construction of an aqueduct along the alignment recommended by the Department of Water Resources. The district has stated that the upper portion of the aqueduct will be constructed to a capacity of 500 second-feet, or one-half that recommended by the department. The capacity of the portion of the pipe line section to be constructed by the authority has not yet been decided.

The sum of the potential safe yield of the existing local water supply developments and the conveyance capacity of the existing San Diego Aqueduct exceeds the present water requirement in the San Diego Group. However, because the full capacity of the existing San Diego Aqueduct was not available or was not utilized at all times during the current and recent series of years of low runoff, storage reserves in local water supply developments have been overdrawn and the nominal safe yields of these developments cannot now be realized prior to the occurrence of flood years. The area is now experiencing a rapid growth with attendant increase in use of water, and additional imported water will be needed as soon as construction of the proposed new aqueduct facilities can be completed.

The opportunity exists for development of some additional local water supplies but the amounts of these supplies are small when compared to the estimated future water requirements of the San Diego Group, so that it will be necessary to import large quantities of water in the future through facilities of the California Aqueduct System. The following tabulation presents the present and probable ultimate need for imported water in the group, giving consideration to the eventual development of local water supplies to the maximum extent practicable:

	Acre-feet per season
Present conditions (1950)	
Water requirement	225,000
Safe yield of local water supplies	148,000
Requirement for imported water	77,000
Probable ultimate conditions	
Water requirement	1,505,000
Safe yield of local water supplies	210,000
Requirement for imported water	1,295,000

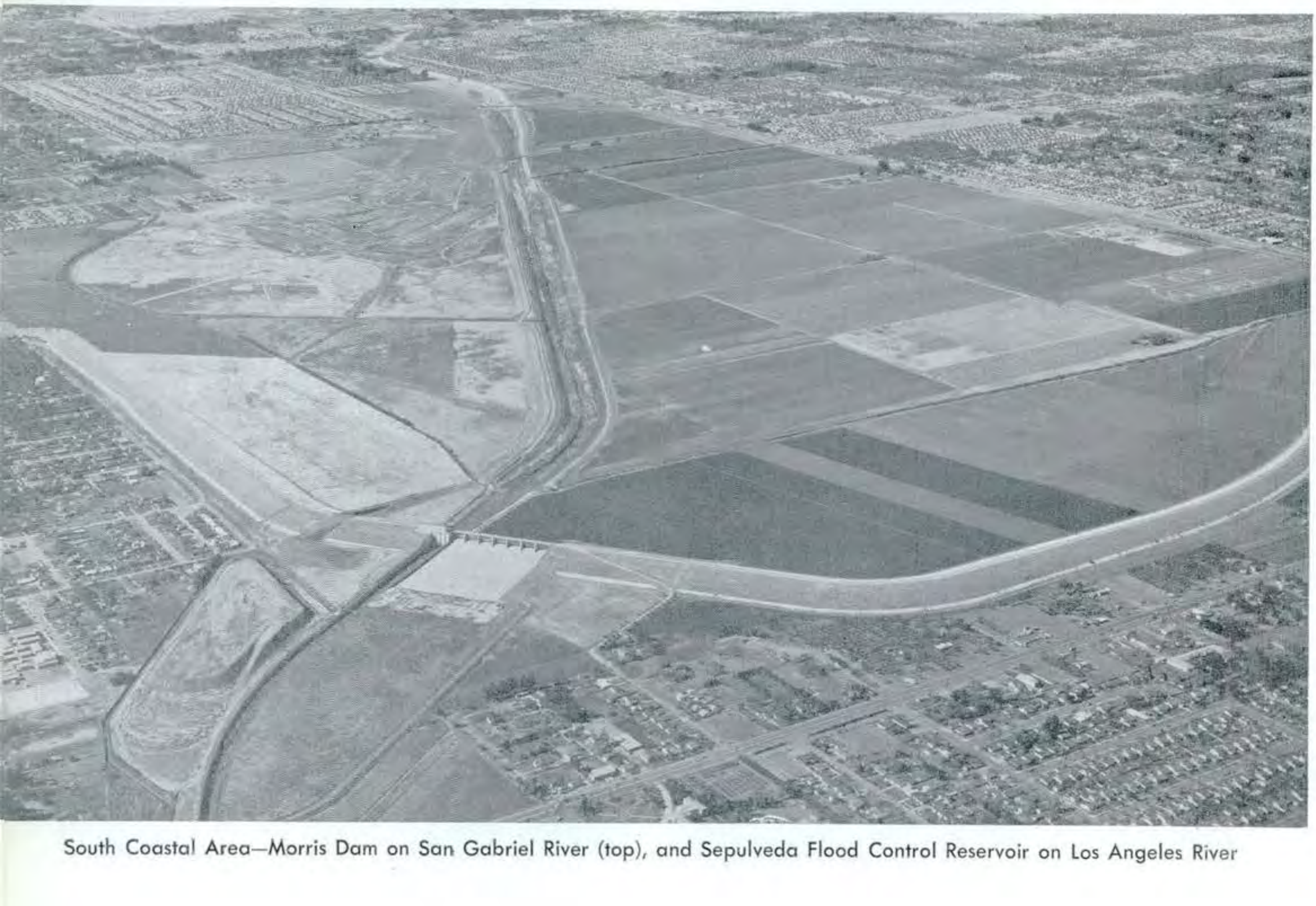
Conservation of the waters of the streams in the San Diego Group to the maximum practicable extent could be accomplished by construction of a 143,000 acre-foot reservoir at the De Luz site and a 65,000 acre-foot reservoir at the Fallbrook site, both on Santa Margarita River; a 145,000 acre-foot reservoir at the Monserate site on San Luis Rey River; a reservoir of 310,000 acre-foot capacity at the Hodges site in lieu of the existing 34,000 acre-foot reservoir; a reservoir of 174,000 acre-foot capacity at the San Vicente site in lieu of the existing 90,000 acre-foot reservoir; and a 100,000 acre-foot reservoir at the Daley site on Jamul Creek, a tributary of Otay River, including enlargement of the existing Dulzura Conduit to bring additional spill waters to the Otay River Basin from Cottonwood Creek, along with controlled releases from the existing storage reservoirs there.

By construction of the foregoing facilities, it would be possible to increase the safe yield of local water supplies of the San Diego Group by about 62,000 acre-feet per season. However, as previously shown, there would still be a demand for imported water of almost 1,300,000 acre-feet under ultimate conditions of development. This supplemental water could be supplied from the Southern California Division of the California Aqueduct System, discussed later in this chapter.

It should be noted that alternative reservoir developments might be selected in lieu of these reservoir projects just enumerated. These alternative projects include: construction of a 188,000 acre-foot reservoir at the De Luz site on Santa Margarita River with no development at the Fallbrook site; construction of a 163,000 acre-foot reservoir at the Pamo site on the San Dieguito River, rather than enlarging Hodges Reservoir; and construction of a 163,000 acre-foot reservoir at the Bonsall site on San Luis Rey River in place of Monserate Reservoir. These alternative possibilities would produce safe yields essentially equal to those that could be obtained from the previously stated projects, but their capital and annual costs, on the basis of preliminary estimates, are close enough to those for the projects shown in Table 12, that further studies should be conducted prior to construction of any of the developments involved. The Department of Water Resources, in cooperation with the City of San Diego, is currently conducting an investigation of the San Dieguito River for the purpose of selecting the best project for further storage on that stream.

Summary of South Coastal Area. The South Coastal Area is extremely deficient in native water resources, being dependent to a major extent upon imported water supplies. Under ultimate conditions nearly 80 per cent of the forecast total water requirements in the area will have to be imported from other regions through existing works and through facilities of the California Aqueduct System. With import of water through the Los Angeles and Colorado River Aqueducts to the full extent of existing and claimed rights, amounting to some 1,530,000 acre-feet per season, there would remain a supplemental requirement of 3,027,000 acre-feet per season in the South Coastal Area under ultimate development.

Under The California Water Plan, local water resources in the South Coastal Area would be developed to their fullest practicable extent. However, the yield



South Coastal Area—Morris Dam on San Gabriel River (top), and Sepulveda Flood Control Reservoir on Los Angeles River which could be secured by such development would aggregate only 149,000 acre-feet per season, or 5 per cent of the total ultimate supplemental water requirements of the area. The balance of the supplemental requirements, amounting to 2,878,000 acre-feet per season, would be provided by importation through facilities of the Southern California Division of the California Aqueduct System.

Increased yield of local water resources would be accomplished by construction of nine reservoirs with aggregate active storage capacity of 1,020,000 acre-feet. These reservoirs would be operated in conjunction with ground water storage, wherever practicable, to secure optimum development of both surface and underground resources. Artificial ground water recharge, presently practiced quite extensively, would be substantially increased, not only for spreading of local runoff and reservoir releases, but for recharge with imported water supplies as well.

Adequate flood protection would be provided under The California Water Plan in the South Coastal Area by existing and planned flood control works of the several flood control agencies in the area, and by the nine new local reservoirs hereinbefore described. In addition, the recreation potential would be developed to the maximum feasible extent at existing and future reservoirs. Because of the scarcity and value of water in this area, little or no opportunity is expected for the release of water in stream channels for fishery development. However, the reservoirs would provide opportunities to develop a warmwater fishery.

Data on the general features and costs of the local development works contemplated as features of The California Water Plan in the South Coastal Area are presented in Table 12. The locations and layouts of all of these facilities are delineated on Sheets 20, 21, 24, and 26 of Plate 5.

Central Valley Area—Sacramento River Basin

The Sacramento River Basin is second only to the North Coastal Area as a region endowed with water supplies far in excess of its ultimate requirements. Precipitation occurs principally in the late fall, winter, and early spring months, but melt from the snowpack in the high Sierra Nevada tends to extend the runoff period of the major streams. Some of the streams in the northern part of the basin have their source in perennial springs of considerable magnitude, and flow at a fairly constant rate the year round. The runoff of others draining from the Coast Range and from the lower elevations of the Sierra Nevada closely follows the precipitation. Like the North Coastal Area, a considerable variation occurs in the amount of runoff from year to year, and long drought periods have been experienced. Warm winter rains sometimes extend to the higher elevations of the Sierra Nevada and, as exemplified by the disaster of December, 1955, can result in record floods in the Sacramento Valley, especially if snow is present in the mountains.

The present water resource development of the Sacramento River Basin is considerable and varied, but by no means approaches the feasible potential. With the recent completion of Monticello Dam on Putah Creek, the basin now has about 10,000,000 acre-feet of reservoir storage capacity, including 1,600,000 acre-feet in Monticello Reservoir, 1,000,000 acre-feet in Folsom Reservoir, 4,500,000 acre-feet in Shasta Reservoir, 1,308,000 acre-feet in Lake Almanor, and 319,000 acre-feet in the normal operating range of Clear Lake.

While much of the present water development in the Sacramento River Basin has been accomplished by private interests and public utilities, the major developments are those of the Federal Government. The most important and comprehensive of these is the Central Valley Project of the United States Bureau of Reclamation which closely follows original plans of the State of California. The project develops surplus waters in the Sacramento River Basin for local use and export to the San Joaquin Valley. Principal completed features of the project pertinent to the Sacramento River Basin are the large multipurpose Shasta and Folsom Reservoirs, and the Sly Park Unit serving lands on the divide between the American and Cosumnes Rivers. Work has been partially completed on the Sacramento Canals Unit of the project diverting from the Sacramento River at Red Bluff to serve lands on the west side of the valley. More recently, work has been initiated on the Trinity River Division of the project, involving the interbasin diversion of some 872,000 acre-feet of regulated water per year from the North Coastal Area to the Sacramento Valley for local use and export, with attendant generation of large amounts of hydroelectric power.

Irrigation in the Sacramento River Basin is centered largely on the Sacramento Valley floor and along the Pit River, but is also practiced to some extent in the mountain areas, generally in places where old mining ditches are available for diversion and distribution. The vast ground water resources of the basin have been used extensively only in the Sacramento Valley, where the present pumpage is about 1,000,000 acre-feet per season. Upon the completion of licensed works on the North Fork of the Feather River by the Pacific Gas and Electric Company, hydroelectric power will be generated at 44 utility-owned and public power plants with an aggregate installed capacity of about 2,000,000 kilowatts. However, only parts of the Pit River, the Bear and Yuba Rivers, and the North Fork of the Feather River have been intensively de-

TABLE 12

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SOUTH COASTAL AREA

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

Dam and reservoir	Stream	Dam: Location, SBB&M, and sheet of Plate 5 on which shown	Dam: Type	Dam: Height, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Net	Seasonal yield, in acre-feet	Purpose	Place of water use	Capital cost[a]
Ventura Group											
Blue Point	Piru Creek	Sec. 10, T5N, R18W 21	E	240	1,280	50,000	38,000	34,000	I	Ventura County	$8,171,000
Topatopa	Sespe Creek	Sec. 36, T6N, R20W 21	CA	370	2,455	100,000	95,000				15,544,000
Cold Springs	Sespe Creek	Sec. 6, T5N, R22W 21	E	272	3,452	100,000	97,000				8,571,000
Los Angeles-Santa Ana Group	(no local works)										
San Diego Group											
De Luz	Santa Margarita River	Sec. 32, T9S, R4W 24	E	210	307	143,000	129,000	15,500	I,U,FC	Downstream basin	9,609,000
Fallbrook (Lippincott)	Santa Margarita River	Sec. 12, T9S, R4W 24	E	210	497	65,000	56,000				4,823,000
Monserate	San Luis Rey River	Sec. 6, T10S, R2W 24	E	160	407	145,000	145,000	9,000	I,U	Downstream basin	8,634,000
Enlarged Lake Hodges	San Dieguito River	Sec. 18, T13S, R2W 24	CG	210	395	[b]276,000	[b]276,000	17,000	I,U	San Diego coast	21,388,000
Enlarged San Vicente	San Vicente Creek	Sec. 31, T14S, R1E 26	CG	270	714	[c]84,000	[c]84,000	9,000	I,U	San Diego coast	6,719,000
Daley	Jamul Creek	Sec. 22, T17S, R1E 26	E	200	878	100,000	100,000	9,000	I,U	San Diego coast	[d]5,028,000
Totals						1,063,000	1,020,000				$88,487,000

Associated features	Conduit: Maximum capacity, in second-feet	Conduit: Total length, in miles		Capital cost[a]
Ventura Group	120	32.0	Santa Clara River Conduit from Santa Felicia Reservoir to Oxnard Plain	[e]$4,899,000
Los Angeles-Santa Ana Group				
San Diego Group				

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

Symbols of Purpose
I—Irrigation
U—Urban (domestic, municipal, industrial)
FC—Flood control

[a] At 1955 price levels.
[b] In addition to existing storage capacity of 34,000 acre-feet.
[c] In addition to existing storage capacity of 90,000 acre-feet.
[d] Cost includes $800,000 to extend Dulzura Conduit to Daley Reservoir.
[e] Includes cost of Sespe feeder conduit.

veloped for power to date. Large power plants are located at the bases of Shasta and Folsom Dams with smaller plants located below their afterbays. In addition to irrigation facilities, works on the valley floor include the Sacramento River Flood Control Project, an extensive system of river levees and by-passes to protect agricultural and urban areas against damaging floods. Also, storage for flood control is specifically reserved in Shasta and Folsom Reservoirs, and is provided to some extent in other reservoirs of the basin. However, additional works are required, particularly reserved storage space in reservoirs, to provide well balanced flood protection to all areas of the valley.

Shallow-draft navigation is maintained on the Sacramento River as far upstream as Colusa by releases from Shasta Reservoir, but the official head of navigation is at Red Bluff. A separate deep-water ship channel to Sacramento has been authorized for construction, with some work under way and completed. Repulsion of sea water from the channels of the Sacramento-San Joaquin Delta by release of water from storage is another highly important aspect of present water resource development in the Sacramento River Basin.

The runoff of the Sacramento River Basin under natural conditions has been estimated to average some 22,400,000 acre-feet per year. This is exclusive of a presently indeterminate but probably substantial quantity of water which is known to flow from the basin into the Sacramento-San Joaquin Delta through the alluvium of the Sacramento Valley. It is anticipated that at least a portion of this underflow will eventually be recovered through more intensive utilization of ground water in the Sacramento Valley and by construction of a salinity control barrier at the Delta. In addition, change in land use from natural to ultimate conditions will decrease the consumptive use of precipitation by native vegetation and will therefore tend to increase the runoff substantially. With these factors taken into account, it is estimated that the future runoff of the Sacramento River Basin may be in the order of 24,000,000 acre-feet per year.

The present gross water requirements of the Sacramento River Basin are estimated to aggregate about 4,670,000 acre-feet per season. These requirements are met principally by direct stream flow diversions, supplemented by releases from storage and by pumping from ground water. About 30,000 acre-feet of the requirement is met by imports from the Truckee and Cosumnes River Basins. Additional imports for local use and for export will become available in the near future from the Trinity River Division of the Central Valley Project.

Taking into account the availability of return flow from the upland service areas for downstream use, and based on the consideration that certain mountain lands classified as irrigable in State Water Resources Board Bulletin No. 2 are now considered to be better suited to forest use, the ultimate water requirement in the Sacramento River Basin has been estimated to be 7,430,000 acre-feet per year. Of this total, it is estimated that approximately 6,290,000 acre-feet will be consumed in plant growth and by urban and industrial users; 470,000 acre-feet will be recoverable as return flow at the Delta; and the remainder, 670,000 acre-feet, represents irrecoverable losses, including poor-quality waters and sewage and industrial wastes that would be disposed of by a separate waste conduit entering the Delta waste-way channels below a future barrier pool.

In addition to the major problem of floods in the Sacramento Valley and to some extent in the uplands, the Sacramento River Basin contains several local areas of limited water supply. These are located at fairly high altitudes, principally around Goose Lake, in the vicinity of Alturas, and in Sierra Valley. In other mountain areas, notably in the Sierra Nevada, the irrigable lands are often situated on the broad ridges separating the main watercourses, and despite the abundant flow of these streams, cannot be served except by pumping from great canyon depths or through long and difficult gravity conduit routes. The diversion of water to serve these lands often conflicts with otherwise desirable hydroelectric power developments. Seepage from the Sacramento River and rising saline waters in the Peach Bowl area of Sutter County have caused considerable damage on the valley floor. Not the least of the water problems of the Sacramento River Basin is the need to preserve and in some instances enhance its recreational potential and its highly important recreational and anadromous fishery.

Objectives of The California Water Plan in the Sacramento River Basin are fourfold: first, the development of sufficient water supplies to satisfy ultimate water requirements for all beneficial local purposes, including irrigation, urban, industrial, fish and wildlife, recreational, and navigation; second, protection of urban and agricultural areas from damaging floods; third, the development of the hydroelectric power potential of the basin to its feasible maximum; and, fourth, the development of about 10,000,000 acre-feet of surplus water per season for export to water-deficient areas elsewhere in the State. Corollary with these objectives is the need to preserve the quality of the water to a degree consistent with its anticipated use.

Although this section is concerned primarily with developments to meet local requirements, it is pointed out that, like Shasta and Folsom Reservoirs, certain prospective works of the basin would have important export as well as local functions, and, as such, would be extremely difficult of classification as either solely local or solely export facilities. In general, these dual-function works would consist of large multipurpose reservoirs at the foothills of the major streams, and certain smaller irrigation or flood control reservoirs at the foothill line on the less important streams. Although these works are designated and grouped together later as features of the Sacramento Division of the California Aqueduct System, they are described in this section along with those which would primarily serve local purposes. All works of the basin, existing and prospective, are conceived as an integrated system designed to conserve and regulate the native and imported water supplies to an optimum degree, to develop the hydroelectric, recreational, and fishery potential of these waters, and to provide flood protection.

The works of the Sacramento River Basin are considered under 10 separate geographical subdivisions, as follows: the Goose Lake Unit in the extreme northeastern part of the basin; the Pit River Unit northeast of Redding; the Mt. Shasta Stream Group north of Redding; the Redding Stream Group between Red Bluff and Shasta Dam; the West Side Stream Group, comprising the mountain and foothill area on the west side of the basin south of Red Bluff; the Antelope-Butte Stream Group, comprising the mountain and foothill area on the east side of the basin between Red Bluff and the Feather River drainage divide; the Feather River Unit; the Yuba-Bear River Unit; the American River Unit; and the Sacramento Valley Floor. Following the discussion of works in each of these subdivisions, there is a summary statement with tables showing principal characteristics of the various suggested works and their estimated cost.

Goose Lake Unit. The Goose Lake Unit comprises the California portion of the Goose Lake Basin. This basin has an area of about 1,100 square miles, of which 688 square miles are in Oregon and 412 square miles are in California. The streams of the basin drain into Goose Lake, a large shallow body of water situated in both states at an elevation of about 4,800 feet. The lake occupies a shallow depression separated from its outlet to the North Fork of the Pit River by a low divide. Evaporation from the lake surface and consumptive use of water from influent streams tend to balance the inflow to the extent that there has been virtually no outflow during historic times. The lake is important as a wild fowl refuge. Its waters are brackish and not suited to domestic or agricultural use. About 97 square miles of the Goose Lake Unit are mountainous and 315 square miles have been classified as valley and mesa land, but this includes about 120 square miles of water area when the lake is at its highest level.

Precipitation in the Goose Lake Unit ranges from less than 15 inches per season on the flat lands to about 24 inches in the Warner Mountains east of the lake. The principal streams of the unit drain from these mountains, and are, from north to south, Pine, Cottonwood, Willow, Lassen, and Davis Creeks. None of these streams is more than 15 miles long, but several flow perennially. These and the minor streams of the unit have an aggregate natural runoff of only about 68,000 acre-feet per year on the average.

The water problems of the Goose Lake Unit relate entirely to the limited supplies available for development for consumptive purposes. There are no present or future flood problems to deal with and, insofar as the streams are concerned, no quality problems. Although the unique scenic, wildlife, and historical attractions of the area are not widely known, they may become more important in the future, but no special water problems are foreseen in their development.

The Goose Lake Unit is sparsely settled, with virtually no industries except a few small sawmills. Present water development is limited to direct diversion of natural stream flow, augmented by releases from a few small reservoirs aggregating less than 4,000 acre-feet of storage capacity. About 24,000 acre-feet of water per season is developed in this manner to irrigate about 8,500 acres of land along the east shore of the lake, in Fandango Valley, and at the mouths of small streams draining into the lake from the west.

Under ultimate conditions it is anticipated that the Goose Lake Unit will continue to be sparsely settled, with only nominal water requirements for urban use and industry. The water service areas, however, may expand to as much as 30,000 acres if satisfactory supplemental water supplies for irrigation can be developed at reasonable cost. Based on prevailing irrigation practices in the unit, this would require a total of about 80,000 acre-feet of water per season—an amount 12,000 acre-feet in excess of the natural runoff.

Plans to drain Goose Lake to obtain additional water supplies for local use and export to the Pit River Unit have been considered but were found to be impracticable in view of the desirability of preserving the lake as a natural wild fowl refuge. Further complications are added by its interstate location. Plans to import water from the Oregon tributaries of the lake are likewise considered to be impracticable because of future requirements in that state. For these reasons and because of the limited local water supply, full irrigation development of the land resources of the Goose Lake Unit may never be realized.

Under The California Water Plan it is anticipated that some further development of the remaining water resources of the Goose Lake Unit may be obtained through the construction of additional small reservoirs by individual owners, as at present; but any substantial increase in the developed water supply would depend on possibilities for ground water utilization. Although little is known concerning the subsurface geology of the unit, existing and prospective

Sacramento River Basin—Bear River Canal in the Sierra Nevada, Constructed in 1850 water service areas are believed to be underlain with alluvial deposits which may contain water of a quality suitable for irrigation. If such ground water basins can be delimited and developed for use, including recharge through spreading works and deep percolation of applied water, it is believed that all of the potentially irrigable lands of the unit could be irrigated without import. Under these circumstances much of the return flow could be recovered for re-use, and a supplemental water supply of only about 26,000 acre-feet per season would be required as compared with 56,000 acre-feet without such re-use.

Another way of bringing additional land under irrigation would be through the use of sprinkler methods of water application. With these methods there would be very little return flow wasted and supplemental water requirements would be nominal. General acceptance of these methods would depend on the economic conditions prevailing in the future.

Pit River Unit. The Pit River Unit comprises all of the 5,350 square-mile drainage basin of the Pit River. About 3,080 square miles of the basin area are mountainous, and 2,270 square miles have been classified as valley and mesa land. The Pit River forms near Alturas with the junction of its North and South Forks, and flows westwardly for a distance of about 170 miles to join the Sacramento River in Shasta Reservoir.

Precipitation in the Pit River Unit averages about 24 inches at the headwaters in the Warner Mountains, 15 inches in the middle reaches, and as much as 80 inches in the Cascade Range, which forms the westerly part of the watershed. The mean natural runoff from the headwater area above Canby is about 260,000 acre-feet per year and, for the basin as a whole, 3,430,000 acre-feet. Stream flow in the upper and middle reaches of the basin is sporadic; but, in the lower reaches it is remarkably uniform due to the fact that the principal tributaries in this area have their source in perennial springs of considerable magnitude. An average of about 11,000 acre-feet of water per season is exported from tributaries of the South Fork of the Pit River into Madeline Plains in the Lahontan Basin. There are no present imports.

Present water development of the headwater area of the Pit River Unit is quite extensive, with most of the 50 or more reservoirs of the unit concentrated in this area. These have been constructed by both individuals and organized water districts, and range in size from a few acre-feet to 77,000 acre-feet for Big Sage Reservoir on Rattlesnake Creek near Alturas. Together they have an aggregate capacity of about 150,000 acre-feet. Releases from these reservoirs are combined with natural stream flow to irrigate an average of about 82,000 acres of land each year in the upper and middle reaches of the basin. Another 23,000 acres are irrigated by direct stream flow diversion in the lower basin area, principally along Fall River and in the vicinity of McArthur and Pittville. The hydroelectric power potential of the lower basin area is partially developed by the Pacific Gas and Electric Company. The company has six large plants on Hat Creek and on the Pit River below Fall River, with application pending before the Federal Power Commission to complete the chain by constructing three additional units on the Pit River and involving a diversion from the McCloud River. Conflicting proposals for development of the latter stream are discussed under the Mt. Shasta Stream Group. A small locally owned plant develops power on Pine Creek near Alturas.

Despite an abundant water supply for the Pit River Unit as a whole, the upper and middle sectors, where most of the irrigable land is situated, are areas of limited supply. Furthermore, these areas are 1,000 to 1,500 feet higher than possible major sources of import from Fall River and other productive tributaries of the unit. Except for some flooding in the vicinity of Alturas, there are no present flood problems of consequence in the unit, and, with the possible exception of Big Valley, none are foreseen for the future. Swampy conditions in the highly developed main valley of the South Fork and in the vicinity of McArthur are alleviated to some extent by drainage ditches and pumping. These conditions probably account for considerable uneconomic consumption of water. The unit is widely used for fishing and hunting and, in some areas, for general outdoor recreation. Lakes and reservoirs are used by wild fowl as nesting places. The preservation and possible enhancement of these resources is a prime consideration in The California Water Plan.

Under ultimate conditions it is anticipated that present water service areas in the Pit River Unit will expand to about 324,000 acres, supporting a population of about 38,000 people. Taking into account the possibilities for re-use of return flow, it is estimated that the ultimate water requirements of the unit for consumptive use would be about 478,000 acre-feet per season, as compared with a present requirement of 244,000 acre-feet.

Objectives of The California Water Plan in the Pit River Unit would be met insofar as possible by the construction of local works. Plans for water development in the Alturas area, comprising lands in the valleys of the North and South Forks and in Hot Springs Valley on the main stem of the Pit River, contemplate the eventual construction of small reservoirs on Parker Creek near its mouth, on South Fork at Jess Valley, on Stony Canyon Creek at Sears Flat, and on Crooks Canyon Creek by enlargement of Bayley Reservoir. Flood protection for Alturas would probably be accomplished by construction of a bypass channel on the North Fork, together with channel improvements on the North and South Forks and the main stem of Pit River to relieve unsatisfactory drainage conditions. None of these small works has been considered in detail for this report, nor have their costs and accomplishments been firmly established. They are simply suggested for future consideration. In general, due to the very limited water supply of the Alturas area, any considerable expansion of irrigation would be dependent mainly on water supplies obtained from downstream areas. The possibilities for obtaining such supplies are intimately related to and entirely contingent upon the feasibility of ground water development in Big Valley, which is situated on the Pit River below Hot Springs Valley. Although little is now known about the ground water resources of Big Valley, further investigations are scheduled to begin in fiscal year 1957-58.

Plans for water development for Big Valley contemplate the construction of Allen Camp Reservoir at the head of the valley on the Pit River, and Round Valley Reservoir on Ash Creek with feeder canal from Willow Creek, its principal tributary. Ash Creek enters Big Valley from the south. It is anticipated that the combined yield of Allen Camp and Round Valley Reservoirs would be in the order of 120,000 acre-feet per season. However, should it be found feasible in the future to operate these reservoirs in conjunction with possible, but not assured, ground water storage capacity in Big Valley, the combined yield might exceed 200,000 acre-feet per season. In this event, it would be possible not only to meet the full ultimate water requirements of Big Valley, but to allow pumped diversions, in the amount of about 50,000 acre-feet per season, to be made from Allen Camp Reservoir into Hot Spring Valley. Due to the relatively low cost of storage in Allen Camp Reservoir, it is believed that it may be feasible in the future to reserve about 40,000 acre-feet of its capacity for flood control.

Supplemental water supplies for Dixie Valley, which is located on the upper reaches of Horse Creek, would be obtained by pumping from Little Valley Reservoir to be located downstream. Horse Creek enters the Pit River from the south below Big Valley.

Lands in the Fall River, McArthur, and Pittville areas could obtain their supplemental water supplies by diversions from Fall River and/or pumping from Fall River Mills Reservoir, which would be formed by a dam on the Pit River below Fall River near the town of Fall River Mills. Although it is believed that a safe dam could be constructed at this site, blanketing of the reservoir area in some places might be required to avoid large loss of conserved water. The reservoir would be at the same level as the present Pacific Gas and Electric Company diversion dam on Fall River, and would replace that facility as well as improve the output of an associated power plant by providing forebay capacity not now available. Because of its narrow operating range, the reservoir would afford exceptional opportunity for recreational development, especially including an ideal lake fishery.

Lands in the Burney area and in Goose Valley would continue to be served as at present by pumping from ground water and by direct stream flow diversion. Most of the land in these areas is considered better suited to continued forest use and recreation rather than to future irrigated agriculture. No storage works are now contemplated except possibly a small reservoir on Burney Creek in the general vicinity of Dry Lake, but there is some question concerning the ability of a reservoir in this porous lava area to retain water.

The remaining hydroelectric power resources of the Pit River Basin would be developed by the construction of Pit River Power Plants Nos. 2, 6, and 7 as has been proposed by the Pacific Gas and Electric Company, with the water supply for Plants Nos. 6 and 7 possibly augmented by diversion from the McCloud River, if approved by the Federal Power Commission. For purposes of this report, however, it was assumed that the McCloud River would not be diverted into the Pit River. With the existing plants, these plants would develop the full power potential of the Pit River between Fall River and Shasta Reservoir, involving a total head of about 2,000 feet. A small development on Hat Creek at Sugar Loaf Mountain is also contemplated. This development would utilize the natural spring-fed flow of Hat Creek through a drop of about 600 feet.

In summary, prospective works in the Pit River Unit would consist of major reservoirs at Allen Camp, Round Valley, and Fall River Mills; several minor reservoirs at various locations; channel improvement works in the vicinity of Alturas; and four hydroelectric power plants. The reservoirs would add more than 500,000 acre-feet of capacity to the present storage system of the basin, including 40,000 acre-feet that would be reserved in Allen Camp Reservoir for future flood control. Depending on the feasibility of conjunctive operation with ground water, the reservoirs would make supplemental water supplies of from 160,000 to 240,000 acre-feet per season available for local use. The new power plants would have a combined installed capacity of about 183,000 kilowatts and would generate an average of about 886,000,000 kilowatt-hours per year. In addition to the probably excellent recreational and fishery potential of Fall River Mills Reservoir, it is anticipated that the other reservoirs may afford opportunities for recreational development, and there will be some incidental enhancement of stream flow for these purposes.

Mt. Shasta Stream Group. The Mt. Shasta Stream Group comprises the drainage basin of the McCloud River and the area tributary to the main stem of the Sacramento River above Shasta Dam. The combined

1,300 square-mile drainage area of these streams is essentially mountainous and heavily forested.

Precipitation in the Mt. Shasta Stream Group is the heaviest in the entire Sacramento River Basin, varying from about 34 inches per season at the City of Mt. Shasta to more than 80 inches on the higher peaks and ridges. The runoff averages about 2,300,000 acre-feet per year, of which the McCloud River contributes 1,400,000 acre-feet from 685 square miles of watershed area and the Sacramento River provides 900,000 acre-feet from 618 square miles.

Except for Shasta Reservoir, which regulates the water of the Pit River as well as the streams considered herein, there is no present significant development of the water resources of the Mt. Shasta Stream Group. Towns, industries, and individuals obtain their water supplies from springs and wells. Minor diversion of natural stream flow is made for irrigation on the gentle lower slopes of Mt. Shasta in the vicinity of the towns of Mt. Shasta and McCloud. Shasta Reservoir, a feature of the Central Valley Project, develops water for power and irrigation and provides flood protection to downstream areas. Releases are coordinated with downstream accretions to provide for navigation on the Sacramento River below Red Bluff and to repulse sea water at the Delta, as well as for diversion from the Sacramento River for local use and from the Delta for export. Because of its export function, Shasta Reservoir is considered to be a feature of the California Aqueduct System and is further discussed subsequently in that section.

There are no present water problems of consequence in the Mt. Shasta Stream Group. Consumptive water requirements are and will continue to be relatively small. With the exception of some minor flooding of low-lying areas at Dunsmuir, there are no present flood problems, nor is there any indication that floods will constitute a hazard in the future. Maintenance of stream flow for fish, wildlife, and recreation is considered to be a fundamental requirement for all water development planning in this area.

The basic plan for development of the water resources of the Mt. Shasta Stream Group under The California Water Plan, as outlined herein, contemplates that the headwater runoff, not required for irrigation and stream flow maintenance, would be conveyed to and regulated in an off-stream storage reservoir on Squaw Valley Creek, principal tributary of the McCloud River, and then released through a system of works to develop the power head to Shasta Reservoir.

Supplemental water supplies for irrigation of lands in the vicinity of the City of Mt. Shasta could be obtained by pumped diversions from Wagon Valley Reservoir. This reservoir would be located on the Sacramento River near Mt. Shasta and would also conserve water for stream flow maintenance on the Sacramento River. After fulfilling these requirements, surplus water would be diverted from Wagon Valley Reservoir and conveyed eastward by canal and tunnel into Willow Reservoir on Squaw Valley Creek, with return flow from the Mt. Shasta area and the surplus flow of Soda Creek, a tributary of the Sacramento River, intercepted enroute. Water from the McCloud River, in excess of stream flow maintenance requirements, would be diverted at a point about 5 miles southeast of the town of McCloud, and conveyed by tunnel to Willow Reservoir, with the surplus flow of Elk Creek, a minor tributary, intercepted enroute. Willow Reservoir would be created by constructing a dam at the lower end of Squaw Valley, about 7 miles south of the town of McCloud.

From Willow Reservoir the water would be conveyed southward by tunnel to the Willow Power Plant, discharging into the McCloud River arm of Chonton Tubas Reservoir. This reservoir would be formed by constructing a dam on the McCloud River immediately below the mouth of Squaw Valley Creek, also known as North Fork of McCloud River. From Chonton Tubas Reservoir the water would be conveyed by tunnel to the Chonton Tubas Power Plant, discharging into the McCloud River arm of Shasta Reservoir. Releases for stream flow maintenance would be made from both reservoirs.

Under an arrangement proposed by the Pacific Gas and Electric Company in its application to the Federal Power Commission for a license to develop the power resources of the McCloud River, the water from Willow Reservoir would be conveyed eastward by tunnel to a power drop at the head of a McCloud Diversion Reservoir on the McCloud River north of Hawkins Creek. From this reservoir the water would then be conveyed southeastward by tunnel, intercepting the flow of Hawkins Creek enroute to an Iron Canyon Reservoir on Iron Canyon Creek, a tributary of the Pit River. From Iron Canyon Reservoir the water would be conveyed southward by tunnel to a power drop on the Pit River opposite Pit No. 5 Power Plant of the Pacific Gas and Electric Company. The remaining head to Shasta Reservoir would then be developed through the proposed additional power plants of the Pit River power system, discussed in the foregoing section dealing with the Pit River Unit. Although the application for license shows no import from the Sacramento River, this feature could easily be added.

An application for power license by the California Oregon Power Company proposes to develop the power potential of the McCloud River in six plants between Bartle and Shasta Reservoir in a stepped arrangement, each step consisting of a small diversion or regulating reservoir on the McCloud River, a conduit, and a power drop returning the water to the river. This is essentially a "run-of-river" type of development, dependent upon the natural spring-fed regulation of the river for its feasibility. Under this plan, Willow Reservoir would not be constructed, nor would water be imported from the Sacramento River for power development, as in the basic plan.

The Department of Water Resources is currently (1957) giving further study to the proposals of the Pacific Gas and Electric Company and the California Oregon Power Company as to the accomplishments of these proposals in relation to The California Water Plan. The department has filed a petition to intervene in any future hearings of the Federal Power Commission concerning pending applications for license.

In summary, the basic plan of the Mt. Shasta Stream Group would comprise three reservoirs and two power plants with associated conduits and diversion facilities. The reservoirs would have a gross storage capacity of about 324,000 acre-feet, of which 19,000 acre-feet would be inactive and 305,000 acre-feet would conserve water for local consumptive use, stream flow maintenance, and power. Because of their relatively small capacities, the reservoirs would contribute little to the safe yield of Shasta Reservoir. The Willow and Chonton Tubas Power Plants would have a combined installed capacity of 208,000 kilowatts and would generate an average of about 1.1 billion kilowatt-hours per year.

Redding Stream Group. The Redding Stream Group is situated directly north of the Sacramento Valley and includes the stream basins tributary to the Sacramento River between Red Bluff and Shasta Dam. These tributary streams are Clear Creek and Cottonwood Creek, entering the Sacramento River from the west, and Cow Creek with its many tributaries, and Bear, Battle, and Paynes Creeks flowing from the east. The stream group encompasses a total area of about 2,610 square miles, comprising rich farm land on the valley floor, rolling grass-covered foothills, a gently sloping volcanic plain in the middle sector of the easterly watershed, and rugged mountains at the eastern and western boundaries. About 1,830 square miles of the stream group area are mountainous and 780 square miles have been classified as valley and mesa land.

Precipitation in the Redding Stream Group varies from about 25 inches per season on the valley floor to 70 inches in the high mountains, generally as a direct function of the elevation. The mean natural runoff of the stream group is about 2,740,000 acre-feet per year.

Present water requirements for agriculture are met substantially by direct stream flow diversions, principally from the Sacramento River to serve lands in the Anderson-Cottonwood Irrigation District, and from Cow Creek and its tributaries to serve contiguous lands. Water supplies for Happy Valley are obtained by long canal diversions from tributaries of Clear Creek and the North Fork of Cottonwood Creek, augmented by releases from Musselbeck (Rainbow Lake) Reservoir on the latter stream. The City of Redding pumps it water supply from the Sacramento River. Other communities obtain their water supplies principally from wells. Hydroelectric power is developed on Cow and Battle Creeks at six small plants of the Pacific Gas and Electric Company, utilizing the natural spring-fed headwater runoff of these streams, with some minor storage regulation. A large block of power is developed at the federally owned Keswick Power Plant, situated at the Keswick Afterbay Dam on the Sacramento River below Shasta Dam.

Mandatory controlled releases from Shasta Reservoir sometimes cause flooding of urban developments which, in recent years and notwithstanding posted warnings, have encroached upon the flood plain of the Sacramento River in the vicinity of Redding. Otherwise, there are no present water problems of consequence in the Redding Stream Group. Abundant water supplies are available for local development to meet all future supplemental requirements. The main objectives of The California Water Plan in the group are to conserve and regulate the runoff of the tributary streams to an optimum degree for local and downstream use for irrigation, power, fishery, and recreation purposes; and to provide flood protection for local and downstream areas.

Plans for development of the water resources of the Redding Stream Group contemplate the eventual construction of eight main foothill reservoirs on tributary streams, together with certain related minor storage and diversion works, conduits, and one hydroelectric power plant. All of these works would be in addition to, and, in certain respects, complementary to the storage, conduit, and hydroelectric power facilities of the California Aqueduct System in the area.

Storage features of the California Aqueduct System in the Redding Stream Group would consist, principally, of Kanaka, Saeltzer, and Girvan Reservoirs on Clear Creek, and Iron Canyon Reservoir or suitable alternative thereto on the Sacramento River. The capacity of the latter reservoir under The California Water Plan would be about 950,000 acre-feet; whereas the authorized Iron Canyon Project of the Corps of Engineers, U. S. Army, contemplates a reservoir with a capacity of about 500,000 acre-feet. However, the difference in normal pool elevations would be only about 20 feet. These reservoirs, together with associated conduits and power plants, are described later in this chapter as features of the Klamath-Trinity and Sacramento Divisions of the California Aqueduct System.

Local works on Cottonwood Creek would consist of Dippingvat Reservoir on the South Fork; Rosewood Reservoir on Dry Creek, a tributary of the South Fork, with diversion from Cold Fork, also a tributary of the South Fork; Fiddlers Reservoir with power plant and afterbay on the Middle Fork; and Hulen Reservoir on the North Fork. These reservoirs would provide water for local use in Cottonwood Valley and in the Reeds Creek area west of Red Bluff. They would also provide flood protection for the Sacramento Valley as well as local areas, and improve and enhance stream flow to encourage the development of anadromous fishery in Cottonwood Creek in conjunction with fish ladder provisions at Iron Canyon Reservoir. In addition to a small block of power that would be developed by the Fiddlers Power Plant, the water developed by these reservoirs, and not required for local use, would contribute to the supply available for use through the Iron Canyon Power Plant of the California Aqueduct System.

As previously stated, the developments on Clear Creek are considered to be features of the California Aqueduct System in connection with import from the North Coastal Area. However, these features, particularly Kanaka Reservoir, would be effective in conserving and regulating the runoff of Clear Creek. In this regard it is anticipated that Kanaka Reservoir would eventually assume the conservation and flood control functions of Whiskeytown Reservoir, which is authorized for federal construction as a feature of the Trinity River Division of the Central Valley Project. The transfer of these functions would be required because Whiskeytown Reservoir, located farther upstream, would be at too high an elevation and of too small a capacity to regulate the future imports of the Klamath-Trinity Division. Studies indicate that it would not be economic at the present time to construct the larger Kanaka Reservoir rather than Whiskeytown Reservoir. As contemplated under The California Water Plan, small quantities of the conserved waters of Clear Creek would be used locally in Happy Valley and other places as required, but the bulk of the water supply would flow through the aqueduct features for downstream use, including the generation of hydroelectric power.

Developments contemplated on tributaries of Cow Creek would consist of: Bella Vista Reservoir on Little Cow Creek, with natural water supply augmented by the diversion of Clover Creek into a small Oak Flat Reservoir on Oak Run, with further conveyance by large tunnel into Norton Gulch which drains into Little Cow Creek; and Millville Reservoir on South Cow Creek, which would be connected by a short equalizing tunnel with a small reservoir on Old Cow Creek. The inflow to the Millville-Old Cow Creek Reservoir combination would be augmented by the diversion of the winter flow of Bear Creek through a natural saddle into South Cow Creek. Part of the conserved and regulated waters of Cow Creek would be used locally as required, and the remainder would flow into Iron Canyon Reservoir for further disposition. Flood protection for the Sacramento Valley as well as local areas would be provided by the reservoirs, and they would improve and enhance stream flow for the maintenance of fish life in Cow Creek.

The regulation of Battle and Paynes Creeks for conservation and flood control could be accomplished by partial conservation of Battle Creek in Battle Creek Reservoir, supplemented by off-stream storage in a large Wing Reservoir on Inks Creek. Spills from Battle Creek as well as the winter runoff of Paynes Creek would be diverted into Wing Reservoir through large-capacity flood channels. There would be no local use of the developed water supplies, except for stream flow maintenance for fish life on the lower reaches of Battle and Paynes Creeks, and all releases would flow into Iron Canyon Reservoir for further downstream regulation and use, including power generation.

In summary, the local works of the Redding Stream Group would provide 1,325,000 acre-feet of reservoir storage capacity, of which about 100,000 acre-feet would be inactive and 260,000 acre-feet would be reserved for flood control. Fiddlers Power Plant, a local development, would have an installed capacity of about 8,000 kilowatts. Specifically, the local reservoirs would provide about 600,000 acre-feet of firm water per season from the tributary stream runoff for local and downstream use. When considered in conjunction with Kanaka and Iron Canyon Reservoirs, and after taking into account future local consumptive requirements within the Redding Stream Group, the reservoirs would regulate for downstream use an average of about 2,150,000 acre-feet of local runoff per season, of which about 800,000 acre-feet would be a firm supply. The local reservoirs, together with Kanaka and Iron Canyon, would contain about 550,000 acre-feet of storage space specifically reserved for flood control. This space operated in conjunction with reserved storage space in Shasta Reservoir would be highly effective in reducing flood flows in the Sacramento River at Redding and Red Bluff, and at the same time would afford local flood protection elsewhere within the Redding Stream Group. The flood control storage space would be utilized to regulate the flood flows in such a manner as to yield substantial quantities of secondary water for power generation, ground water recharge, and export. Fiddlers Power Plant could generate an average of about 45,000,000 kilowatt-hours per year.

West Side Stream Group. The West Side Stream Group comprises all streams of the Sacramento River Basin draining from the easterly slopes of the Coast Range south of Cottonwood Creek. The eastern boundary of the area between Red Bluff and Arbuckle is defined approximately by the projected location of the Corning and Tehama-Colusa Canals of the Bureau of Reclamation. These canals comprise features

Sacramento Valley—Agriculture and Navigation of the Sacramento Canals Unit of the Central Valley Project. South of Arbuckle the boundary is more clearly defined by the natural topography. Capay Valley on Cache Creek is considered to be part of the Sacramento Valley floor area. The combined drainage area to the base of the foothills is about 4,000 square miles, of which 3,000 square miles are mountainous and 1,000 square miles have been classified as valley and mesa land. The principal streams of the group are, from north to south, Redbank, Elder, Thomes, Stony, Cache, and Putah Creeks.

Precipitation in the West Side Stream Group occurs largely as rainfall and varies from about 20 inches per season at the eastern foothill boundary to more than 80 inches in some places at the summit of the Coast Range. The aggregate natural runoff of the streams averages about 1,900,000 acre-feet per year.

East Park and Stony Gorge Reservoirs on Stony Creek, Clear Lake on Cache Creek, and Monticello Reservoir on Putah Creek, comprise the present major water storage facilities within the West Side Stream Group. All other reservoirs have an aggregate capacity of less than 3,700 acre-feet, of which about 1,700 acre-feet are contained in Detert Reservoir near Middletown on Bucksnort Creek, a tributary of Putah Creek. Water conserved in reservoirs on Stony Creek and in Clear Lake is used in Sacramento Valley floor areas. Water conserved in Monticello Reservoir is also used in Sacramento Valley floor areas, but a large quantity will shortly be exported to parts of Solano County located south and west of the Sacrament River drainage divide boundaries. Because of its large capacity, Monticello Reservoir effectively controls and regulates the flood flows of Putah Creek. Clear Lake on Cache Creek and the reservoirs on Stony Creek provide only limited regulation of the flood flows of their respective streams. Operation of Clear Lake for irrigation and flood control is governed by court decree to a considerable extent.

There are at present about 13,000 acres of land under irrigation within the West Side Stream Group. This land is irrigated principally by pumping from ground water, with some direct diversion of natural stream flow and releases from storage. Irrigable lands of the stream group aggregate about 270,000 acres, with an ultimate water requirement of about 635,000 acre-feet per season when land that would be inundated by reservoirs is taken into account. The irrigable lands occur in parcels of varying size throughout the middle and lower reaches of the stream group area, with principal concentrations located in the vicinity of Middletown and Pope Valley in the Putah Creek Basin; around Clear Lake and in Bear Valley in the Cache Creek Basin; around East Park Reservoir in the Stony Creek Basin; and in the foothill area between Red Bluff and Arbuckle. It is estimated that the future population of the stream group may be about 26,000 people.

There is no present water deficiency in the West Side Stream Group and no flood problems of consequence except around Clear Lake, caused principally by the limited capacity of the outlet channel. The quality of the water supplies is generally good, but somewhat inferior to the supplies of other parts of the Sacramento River Basin. In the Cache Creek Basin below Clear Lake some of the minor tributaries have an especially high boron content.

The objectives of The California Water Plan in the West Side Stream Group are to conserve the water for local and downstream use, and to provide flood protection for local and downstream areas. Maintenance of stream flow for recreation is generally not of importance in this area, but the major reservoirs themselves may develop important recreational opportunities. In addition, small reservoir impoundments designed specifically for recreation and fishing may be desirable in some localities. There is little concern with hydroelectric power, except insofar as local water supplies may be combined with imported supplies from the Eel River under the California Aqueduct System and used for this purpose.

Under The California Water Plan it is contemplated that the waters of Redbank Creek, together with spill from Dippingvat Reservoir on the South Fork of Cottonwood Creek, would be conserved for irrigation and regulated for flood control in Schoenfield Reservoir on Redbank Creek; and the waters of Elder Creek would be conserved for irrigation and regulated for flood control in Galatin Reservoir on Elder Creek. These reservoirs would serve lands as far south as Thomes Creek and would provide partial protection for downstream areas against damaging floods.

The waters of Thomes Creek would be partially conserved in Paskenta Reservoir on Thomes Creek, with spill diverted through a saddle into Newville Reservoir on the North Fork of Stony Creek for further conservation and regulation for flood control. Newville Reservoir would also conserve surplus water diverted from Stony Creek below East Park Reservoir and from Grindstone Creek, principal tributary of Stony Creek. A small power plant would be installed at the base of Newville Dam. The remaining waters of Stony Creek would be conserved for irrigation and regulated for flood control in Black Butte Reservoir on the main stem of the stream near the foothill line. This reservoir has been authorized for construction by the Corps of Engineers, U. S. Army, and is classified as a feature of the Sacramento Division of the California Aqueduct System. New water supplies developed by Paskenta, Newville, and Black Butte Reservoirs would be used along and between Thomes and Stony Creeks and in the foothill area of the stream group as far south as Arbuckle. Secondary water supplies, comprising regulated flood releases from Black Butte Reservoir, would be used for ground water recharge and export.

The runoff from some of the minor foothill streams between the drainage divides of Stony and Cache Creeks could be partially conserved for recreation by constructing small reservoirs at Clark Valley on the South Fork of Willow Creek, Squaw Flat on Logan Creek, High Peak on Hunters Creek, and Golden Gate on Funks and Stone Corral Creeks. These small reservoirs could possibly also be used for flood control and for terminal storage of pumped diversions from the Tehama-Colusa Canal to serve contiguous lands.

Irrigation developments in the Clear Lake area of Cache Creek would consist of Excelsior Reservoir on Copsey Creek with feeder canal from Seigler Canyon Creek, both tributary to the outlet channel of Clear Lake, to serve lands near the lake outlet; Boggs and Kelseyville Reservoirs on Kelsey Creek, with feeder canal from Cold Creek into the latter reservoir, to serve Big Valley and other lands south of the lake; and Pitney Ridge Reservoir on Middle Creek and Lakeport Reservoir on Scott Creek, a tributary of Middle Creek, to serve lands on the north and west sides of the lake.

Flood control in the Clear Lake area could be provided by conducting spills from Kelseyville and Lakeport Reservoirs into Clear Lake through separate floodway channels; by improving and leveeing the channel of Middle Creek; and by enlarging the outlet channel of Clear Lake with downstream flood control storage space provided in Guinda Reservoir at the head of Capay Valley, or in alternative reservoirs at Blue Ridge or Wilson Valley. These alternative sites are presently (1957) under detailed investigation. Present court decrees governing the operation of Clear Lake for flood control would have to be rescinded and/or modified before the outlet channel could be enlarged.

Firm water supplies developed in Guinda or suitable alternative reservoir would be used in Capay Valley and other downstream areas. Secondary supplies, comprising regulated flood releases, would be used for ground water recharge and export. Because of the latter function, Guinda Reservoir, or suitable alternative, would be classified as a feature of the Sacramento Division of the California Aqueduct System.

Other local developments in the Cache Creek Basin would consist of Indian Valley Reservoir on the North Fork of Cache Creek for conservation and flood control, and pumped diversions from East Park Reservoir on Stony Creek to serve irrigable lands in Bear Valley. A small reservoir could be constructed on Bear Creek at the lower end of Bear Valley to impound water for recreational purposes.

Local works in the drainage basin of Putah Creek would consist of Middletown Reservoir on Putah Creek to serve lands in the vicinity of Middletown, and Goodings Reservoir on Maxwell Creek, a tributary of Pope Creek which flows into Putah Creek, to serve lands in Pope Valley by pumped diversions. Local inflow to Goodings Reservoir would be augmented by importations of surplus water from Middletown Reservoir and Pope Creek.

The principal feature of the California Aqueduct System on Putah Creek would be Monticello Reservoir of the Eel River Division. No increase in capacity of Monticello Reservoir is contemplated under The California Water Plan, but considerable revision in its planned operation may be desirable. In its local function this reservoir would serve downstream areas and provide flood protection thereto. It would also afford opportunities for recreational development. With respect to future local development it is pertinent to note that recent permits issued by the State Water Rights Board to the United States Bureau of Reclamation in furtherance of the Solano Project, contain a condition subjecting the permits to depletion of stream flow above Monticello Reservoir in an amount not to exceed 33,000 acre-feet annually by future appropriations of water for reasonable beneficial use within the watershed of Putah Creek above said reservoir; provided such future appropriations shall be initiated and consummated prior to full beneficial use of water within the Solano Project service area. This permit term may make it necessary that any developments constructed in the area upstream from Monticello Reservoir for conservation of local water resources subsequent to the time that full beneficial use has been made under the Solano Project be based on an exchange of water imported from the Eel River or other sources under The California Water Plan.

In summary, the local works of the West Side Stream Group would consist of 17 reservoirs together with associated diversion dams and a power plant; feeder and service conduits, including pump lifts where required; and leveed stream channel improvements and floodway channels. The reservoirs would have a combined gross storage capacity of 1,920,000 acre-feet, of which only 154,000 acre-feet would be inactive. Operated in conjunction with ground water storage in local areas, these reservoirs would insure virtually full irrigation development of the land resources of the stream group and would provide opportunities for recreational development. In conjunction with features of the California Aqueduct System, these reservoirs would regulate water for downstream use, including ground water recharge and export. Together with Monticello Reservoir and Clear Lake, the reservoirs would contain about 400,000 acre-feet of storage space specifically reserved for flood control and strategically disposed throughout the stream group to protect downstream areas. Flood protection for the Clear Lake area would be accomplished by

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enlarging the lake outlet and other appropriate measures. The Newville Power Plant at the base of Newville Dam would have an installed capacity of about 8,500 kilowatts and would generate an average of about 33,000,000 kilowatt-hours per year.

Antelope-Butte Stream Group. The Antelope-Butte Stream Group comprises the small stream basins of the Sierra Nevada located between the Feather River and the Battle and Paynes Creek drainage divides. The principal streams of the group, from north to south, are Antelope, Mill, Deer, Big Chico, and Butte Creeks. These streams, together with the smaller streams of the group, drain a mountainous area of about 1,140 square miles. They are distinguished from most other streams of the Sierra by their parallel courses and steep descent from the headwaters or headwater valleys to the Sacramento Valley floor, with few tributaries and little opportunity for storage enroute.

Precipitation varies from about 25 inches per season at the western foothills to more than 70 inches at the eastern mountain boundary. Much of this precipitation falls as snow which, along with the porous character of the upper watersheds, tends to equalize the runoff to some extent. The mean natural runoff of the stream group is about 1,180,000 acre-feet per season, of which the minor foothill streams contribute about 210,000 acre-feet.

The irrigable lands of the Antelope-Butte Stream Group are situated mainly on the Paradise Ridge between the West Branch of the Feather River and Butte Creek. Smaller parcels are located on the broad ridges on both sides of Big Chico Creek. A fairly large parcel at the headwaters of Antelope Creek is considered now as being better suited to continued forest use rather than for irrigated agriculture. Lands of the Paradise Irrigation District are served from Magalia and recently completed Mosquito Junction Reservoirs on Little Butte Creek. Mountain meadows and downstream areas are irrigated by direct diversion of stream flow without benefit of storage. Hydroelectric power is generated on Butte Creek at the De Sabla and Centerville plants of the Pacific Gas and Electric Company. These plants utilize the natural stream flow of Butte Creek, supplemented by a diversion from the West Branch of the Feather River. There are no other present water developments of consequence in the Antelope-Butte Stream Group. All of the major streams of the group and several of the minor streams provide spawning ground for anadromous fish.

There are no serious present water problems within the area of the Antelope-Butte Stream Group, but the streams often cause damage on contiguous areas of the Sacramento Valley floor. Flood problems are sometimes aggravated by the abrupt dislodgment of logs and debris.

Under The California Water Plan it is contemplated that the waters of Antelope Creek, together with Salt and Little Antelope Creeks on the immediate north and south, respectively, would be conserved through spreading and ground water recharge and regulated for flood control in Antelope Basin Reservoir. This reservoir would be created in an exceedingly permeable area on the valley floor at the base of the foothills east of Red Bluff by constructing a long earthen dike across the several stream channels to form a closed basin. The lands which would be occupied by the reservoir are not classified as irrigable and could be used for grazing most of the time, as at present.

The waters of Mill and Deer Creeks would be developed for power and conserved and regulated, together with several adjacent minor foothill streams, for irrigation and flood control. The power features would consist of Morgan Springs Reservoir at the headwaters of Mill Creek, with releases diverted by canal to Deer Creek Meadows Reservoir on Deer Creek, whence the head would be developed by canal, tunnel, and pipe line in a series of four power drops to the base of the foothills. Flow from the intermediate reaches of Mill Creek below Morgan Springs Dam would be diverted into the power system by tunnel entering Deer Creek below the first power drop. Except for the headwater reservoirs on Mill and Deer Creeks, no structures are planned that, with adequate fish ladders, could not be negotiated by anadromous fish.

The power releases from the terminal plant of the system on Brush Creek would be reregulated in Brush Basin Reservoir, a feature of the California Aqueduct System located east of Vina. Like Antelope Basin, this reservoir would also be formed on the valley floor at the base of the foothills by constructing a long earthen dike to create a closed basin. In this case the inundated lands, though not classified as irrigable, are not permeable and very little direct ground water recharge could be anticipated. The reservoir itself would intercept the direct flow of a number of minor foothill streams besides Brush Creek; but the flood flows of Mill, Toomes, Deer, and Rock Creeks would be conveyed to the reservoir for storage and regulation through large-capacity floodway channels. Low diversion dams on these streams would permit the passage of anadromous fish; and normal stream flow would not be diverted.

Irrigation supplies for lands on Keefer Ridge, north of Big Chico Creek, would be conserved in Butte Creek House Reservoir at the headwaters of Butte Creek. Water released from this reservoir would be diverted downstream at Butte Meadows into Big Chico Creek and from Chico Meadows on that stream to Keefer Ridge. Supplemental water supplies for the Paradise Ridge area and for the area between Big Chico and Butte Creeks would be developed in

Grizzly Gulch Reservoir on Butte Creek and diverted downstream at Carpenter to both areas. Grizzly Gulch Reservoir would also be used to maintain stream flow for subsequent downstream diversion for power through the De Sabla and Centerville plants of the Pacific Gas and Electric Company, as at present. Additional water supplies for the Paradise Ridge area would also be developed by enlargement of Magalia Reservoir and by construction of a large Forks of Butte Reservoir on Butte Creek.

Foothill development of Big Chico and Butte Creeks would consist of a small conservation reservoir on Big Chico Creek, which would be used during the flood season to divert flood flows through a large tunnel into Butte Creek for storage and regulation in Castle Rock Reservoir, a feature of the California Aqueduct System. While no insurmountable interference with the anadromous fishery of these streams would result from construction of the upstream reservoirs, the foothill dams definitely would present serious barriers to migration. Remedial measures would include fish hatcheries, development of downstream spawning grounds, and possibly fish ladders—at least at Big Chico Dam.

In summary, prospective works of the Antelope-Butte Stream Group would consist of 10 new and enlarged reservoirs; 4 power plants; a number of small diversion and afterbay dams; and necessary conveyance and service conduits, comprising tunnels, pipe lines, and canals. The reservoirs would add about 550,000 acre-feet of storage capacity to the stream group system, of which about 48,000 acre-feet would be inactive and 125,000 acre-feet would be reserved in Antelope Basin, Brush Basin, and Castle Rock Reservoirs for flood control. The new power plants would have a combined installed capacity of 97,000 kilowatts and would generate an average of about 456,000,000 kilowatt-hours per year. Releases would be made for stream flow maintenance from all reservoirs in the interest of fish, wildlife, and recreation. In combination with parallel levees, where needed, floods on Antelope, Mill, Deer, Big Chico, and Butte Creeks could be reduced to future leveed channel capacities.

Feather River Unit. The Feather River Unit comprises the entire drainage basin of the Feather River above Oroville and the adjoining foothill area drained by Little Dry Creek on the north and Honcut Creek on the south. The unit has an area of about 3,740 square miles, of which about 3,000 square miles are mountainous and the remainder comprises valley and mesa lands. The Feather River has three principal tributaries which, in order of size and importance, are the North, Middle, and South Forks. The North Fork has two main tributaries, namely West Branch and East Branch. Irrigable lands of the Feather River Unit are located principally in the large headwater valleys of the Feather River Basin and in the foothill area south of Oroville.

Precipitation over the Feather River Unit ranges from about 25 inches per season at the western foothill boundary to as much as 90 inches at the summit of Mt. Lassen, but only about 15 inches in Sierra Valley. The estimated mean natural runoff of the Feather River at Oroville is 4,600,000 acre-feet per year. The combined mean natural runoff of Little Dry Creek and Honcut Creek amounts to about 80,000 acre-feet per year.

The main stem of the North Fork of the Feather River has been extensively developed for power by the Pacific Gas and Electric Company with storage provided principally in Mtn. Meadows, Lake Almanor, Butt Valley, and Bucks Lake Reservoirs. The main power system, when completed, will comprise nine plants with a combined installed capacity of about 686,000 kilowatts, exclusive of Big Bend Plant which eventually will be abandoned due to submergence by Oroville Reservoir. Separate diversions for power are also made by the company from the West Branch of the North Fork to serve the small De Sabla and Centerville plants on Butte Creek, as described in the Antelope-Butte Unit, and to serve the small Lime Saddle and Coal Canyon plants of the Feather River Unit.

The mountain valleys of the Feather River are irrigated by direct stream flow diversion, supplemented, in the case of Sierra Valley, by a small import of partially regulated water from the Truckee River Basin. Water supplies for the Oroville-Wyandotte Irrigation District, comprising lands in the foothill area of the unit south of Oroville, are diverted from the South Fork of the Feather River through the Palermo Canal; from Lost Creek Reservoir on Lost Creek, a tributary of the South Fork, through the Forbestown Ditch; and directly from North Honcut Creek with minor storage in Lake Wyandotte. Foothill lands northwest of Oroville are served from the Lime Saddle-Coal Canyon Power Canal. Valley floor lands are served by direct diversions from the Feather River. Communities of the unit obtain their water supplies from wells, springs, and streams.

Present water requirements of the Feather River Unit amount to about 189,000 acre-feet per season for water service areas aggregating about 92,000 acres. In the future, it is estimated that the water service areas will expand to about 218,000 acres with an ultimate water requirement of about 547,000 acre-feet per season when opportunities for re-use of developed water are taken into account.

Except for Sierra Valley and the community of Portola, there are no present major problems of water deficiency within the Feather River Unit. Floods on the Feather River do not constitute a major problem in upstream areas, but in the Sacramento Valley floor they are the main concern and, in the past, have caused great damage and loss of life.

The objectives of The California Water Plan within the Feather River Unit are to develop and regulate the water supplies to an optimum degree for local use and export, flood control, power, recreation, and stream flow maintenance for fish and wildlife. Recreation and stream flow maintenance for the enhancement of fish is considered especially important to the economy of the basin, with particular values attached to the streams of the upper Indian Creek area, the Middle Fork Canyon system, and the Lake Almanor area.

Under the California Water Plan it is assumed that the present undeveloped power potential of the North Fork of the Feather River between Lake Almanor and Belden will be developed in the near future by tunneling for three drops, as planned by the Pacific Gas and Electric Company. The remaining undeveloped water resources of the North Fork, comprising principally the East Branch of the North Fork, would be developed by projects on Indian and Spanish Creeks, main tributaries of the East Branch. The waters of Indian Creek would be conserved and regulated for irrigation, power, recreation, and stream flow maintenance for fish and wildlife, in five headwater reservoirs above Indian Valley, namely, Genesee and Antelope Valley on Indian Creek; Squaw Queen and Dixie Refuge on Last Chance Creek, an important tributary of Indian Creek; and Abbey Bridge on Red Clover Creek, also an important tributary of Indian Creek. The plan also contemplates that Dixie Creek, a tributary of Red Clover Creek, would be diverted by canal into Squaw Queen Creek, a tributary of Last Chance Creek, for storage and regulation in Squaw Queen Reservoir.

Water released from Antelope Valley and Abbey Bridge Reservoirs for stream flow maintenance would flow into Genesee Reservoir for further disposition. Water released from Dixie Refuge Reservoir for stream flow maintenance, together with water diverted from Dixie Creek, would enter Squaw Queen Reservoir, whence the flow would be diverted by tunnel to develop the power head to Genesee Reservoir. Releases from Genesee Reservoir would be used for irrigation in Indian Valley, for stream flow maintenance in Indian Creek and in the main stem of the East Branch, and for power. The power head below Genesee Reservoir would be developed by tunnel in a single drop between a forebay above Indian Falls on Indian Creek and an afterbay on the East Branch below the mouth of Indian Creek.

The works on Spanish Creek would consist of a large Meadow Valley Reservoir with feeder tunnels from Bear Creek, a tributary of the Middle Fork of the Feather River, and from Nelson Point Reservoir on the Middle Fork of the Feather River. Water released from Meadow Valley Reservoir would be used for irrigation and urban purposes in American Valley, for stream flow maintenance on Spanish Creek, and for power with the head between the reservoir and Rich Bar on the North Fork of the Feather River developed by tunnel in a single drop.

On the Middle Fork of the Feather River, water supplies for Sierra Valley would be conserved in three reservoirs on separate headwater tributaries, namely Grizzly Valley on Big Grizzly Creek, Frenchman on Little Last Chance Creek, and Sheep Camp on Craycroft Creek, with minor streams intercepted by feeder canal and pumped into the latter reservoir. These reservoirs could also be used to a limited extent for stream flow maintenance on the Middle Fork. Additional supplies, if needed, could be obtained by gravity diversion from Squaw Queen Reservoir to Abbey Bridge Reservoir, and thence by pumping from Abbey Bridge Reservoir through a tunnel into Grizzly Valley Reservoir, in which event development of the power head to the floor of Sierra Valley might be warranted. The head could be developed by pipe line with an afterbay below the power plant on Big Grizzly Creek to reregulate the power releases to an irrigation and stream flow maintenance demand schedule. Other less favorable opportunities for reservoir development of additional water supplies for Sierra Valley exist at Clover Valley on Smithneck Creek near Loyalton, and at Randolph on Cold Stream near Sierraville. Finally, additional supplies might be obtained from ground water sources if well development should prove to be feasible.

Supplemental water supplies for Portola and other communities along the main stem of the upper Middle Fork could be made available from the improved stream flow of Middle Fork but the local development of minor spring-fed streams would probably be more desirable.

Development on the Middle Fork of the Feather River below Sierra Valley would consist of Nelson Point Reservoir to conserve water for stream flow maintenance and for power by diversion to Meadow Valley Reservoir, as previously noted. Below Nelson Point Dam at Hartman Bar the remaining flow of the Middle Fork, in excess of stream flow maintenance requirements, could be diverted by tunnel to Swayne Reservoir on French Creek, a tributary of the North Fork, with the flow of Little North Fork, a tributary of the Middle Fork, intercepted enroute. From Swayne Reservoir the water would be released through penstocks to a power plant on the North Fork arm of Oroville Reservoir.

Under an alternative arrangement proposed by the Richvale Irrigation District, the headwaters of the Middle Fork would be conserved and regulated in Frenchman and Grizzly Valley Reservoirs above Sierra Valley, in Gold Lake Reservoir on Frazier Creek, in Clio Reservoir on the Middle Fork above

Genesee Valley in Feather River Basin

Sacramento Valley—Foothill Hay Production

Blairsden, and in Nelson Point Reservoir, for power development along the Middle Fork and for irrigation of district lands on the Sacramento Valley floor. Water conserved in the upstream reservoirs would flow down the stream channel of the Middle Fork into Nelson Point Reservoir, whence the power head to the Middle Fork arm of Oroville Reservoir would be developed by tunnel in a series of five drops with regulatory and diversion facilities provided enroute on the Middle Fork, as required. The feasibility of this proposal may depend upon utilizing for power virtually all of the present water supply in critical years without further impairment by additional upstream use in Sierra Valley. The district has been granted a preliminary permit by the Federal Power Commission. The Department of Water Resources is currently (1957) giving further study to this proposal, as well as to the other developments discussed herein for the Middle Fork.

Other developments on the Middle Fork of the Feather River would probably consist of small reservoirs on downstream tributaries to maintain stream flow for fish, wildlife, and recreation. Typical but not necessarily desirable sites are Mt. Ararat on Willow Creek, Whiskey Hill on South Branch, and Quartz Hill on Fall River.

Water supplies for areas dependent on the South Fork of the Feather River would be made available under The California Water Plan by a combination power and water supply development involving the utilization of surplus flows from Canyon and Slate Creeks, tributaries of the North Yuba River, as well as from the South Fork itself. Under the plan the waters of the South Fork would be conserved in Little Grass Valley Reservoir and released to the stream channel of the South Fork for subsequent diversion by tunnel into an enlarged Lost Creek Reservoir on Lost Creek, a tributary of the South Fork. Water from Canyon and Slate Creeks would also be diverted by tunnel and conserved in the enlarged Lost Creek Reservoir.

Part of the water released from Lost Creek Reservoir would serve lands along the Forbestown Ditch, as at present, and new lands in the Dobbins-Oregon House area west of the North Yuba River. The remainder would be conveyed by tunnel to a power drop on the South Fork at the mouth of Lost Creek and thence again by tunnel to another power drop on the South Fork near Forbestown. From this point, the water would be diverted from the river and conveyed by canal and tunnel to serve the foothill lands of the unit south of Oroville.

A number of other plans for development of the water and power resources of the South Fork of the Feather River, both with and without imports from the North Yuba River, have been proposed by various agencies from time to time. Among these are plans by the Pacific Gas and Electric Company, the Oroville-Wyandotte Irrigation District, and Yuba County and the Yuba County Water District. In an effort to resolve differences between the plans of the Oroville-Wyandotte Irrigation District and the Yuba County interests, the State Engineer on October 7, 1955, pursuant to Water Right Decision No. 838, suggested a compromise plan wherein the capacity of Little Grass Valley Reservoir would be made much larger than contemplated in the plan first described above, and the South Fork diversion to Lost Creek Reservoir would include unregulated water imported by tunnel from Fall River, a tributary of the Middle Fork of the Feather River. The existing Lost Creek Reservoir would not be enlarged, and water supplies imported by tunnel from Canyon and Slate Creeks would be conserved in a Sly Creek Reservoir immediately upstream. Regulated water supplies made available by this alternative plan would be released from existing Lost Creek Reservoir and utilized for irrigation and power in much the same manner as first described above.

The various proposals for development of the South Fork of the Feather River are currently (May, 1957) under consideration by the State Water Rights Board in acting upon the conflicting application of Oroville-Wyandotte Irrigation District and Yuba County and Yuba County Water District.

Additional small local developments in the foothill area of the Feather River Unit south of Oroville would consist of South Honcut Reservoir on South Honcut Creek for irrigation and flood control, and Bangor Reservoir on North Honcut Creek for recreation and stream flow maintenance. Wicks Corner Reservoir on Cottonwood Creek, a tributary of Dry Creek which drains the foothill area north of Oroville, would provide recreation and stream flow maintenance on that stream.

Features of the California Aqueduct System within the Feather River Unit would consist of Oroville Dam and Reservoir, Oroville Power Plant, a diversion dam below the power plant, and canal serving another power plant enroute to an off-stream afterbay. In their local function these features would protect Sacramento Valley floor areas against damaging floods, conserve and regulate water for use on the valley floor, enhance and improve stream flow in the Feather River, and afford opportunities for recreational development. Oroville Reservoir will have a capacity of 3,500,000 acre-feet with 500,000 acre-feet tentatively reserved for flood control. Oroville Reservoir and related facilities have already been authorized as a part of the Feather River Project, the initial unit of The California Water Plan, and work thereon is currently under way.

In summary, local works of the Feather River Unit would consist of at least 21 new and enlarged reservoirs; six new power plants, exclusive of those existing or proposed for the Pacific Gas and Electric Company North Fork System; and associated conveyance, feeder, and service conduits, with diversion structures, afterbays, and other auxiliary features as required. The local reservoirs would have a combined gross storage capacity of about 2,100,000 acre-feet, of which about 77,000 acre-feet would be inactive. They would provide water for local use in the upland and foothill areas of the unit, while Oroville Reservoir would serve dependent areas on the Sacramento Valley floor and would provide flood protection thereto. Releases would be made from the local reservoirs for stream flow maintenance in the interests of fish and wildlife, and many of the reservoirs themselves would afford opportunity for recreational development. The new local power plants would add about 331,000 kilowatts of installed capacity to the basin power system, and would generate an average of about 1.3 billion kilowatt-hours of new energy per year.

Yuba-Bear River Unit. The Yuba-Bear River Unit is located on the western slope of the Sierra Nevada between the Feather and American River Units. It consists of the drainage basins of the Yuba and Bear Rivers, and the minor drainage areas of Auburn Ravine, Doty Ravine, and Coon Creek south of the Bear River; Dry Creek between the Bear and Yuba Rivers; and French Dry Creek and the southern drainage of South Honcut Creek north of the Yuba River. Included within the unit are approximately 1,720 square miles of land area ranging from rugged mountains to rolling foothills. Only about 75 square miles of the area have been classified as valley and mesa land.

Precipitation in the Yuba-Bear River Unit varies from about 25 inches per season at the western foothill boundary to as much as 70 inches in the high mountains. The mean natural runoff of the Yuba River is about 2,420,000 acre-feet per year. The Bear River has a mean natural runoff of about 360,000 acre-feet per year, and the minor foothill streams together have a mean natural runoff of about 144,000 acre-feet per year.

Most of the presently irrigated area as well as potentially irrigable land lies within the boundaries of the Browns Valley and Nevada Irrrigation Districts and the Yuba County Water District. Some of the reservoirs and canals presently employed to serve these areas date back to the days of hydraulic mining. The Browns Valley Irrigation District obtains its water supply principally from the North Yuba River by diversion from the Colgate power tunnel. Existing works of the Nevada Irrigation District include about a dozen large and small reservoirs which are used to regulate the headwater runoff of the Middle and South Yuba Rivers, Bear River, and Deer Creek which enters the Yuba River from the south below Englebright Dam. Except for releases from Scotts Flat Reservoir on Deer Creek and from Van Geisen (Combie) Reservoir on the Bear River, the water developed by these reservoirs flows through local power facilities of the Pacific Gas and Electric Company, after which it is distributed to the lands of the district.

The Camp Far West Irrigation District, located west of the Yuba-Bear River Unit boundary, develops its water supply in Camp Far West Reservoir on the Bear River to serve downstream areas on both sides of the river. The Pacific Gas and Electric Company owns and operates 12 power plants within the unit. In addition to utilizing the water developed by the works of the Nevada Irrigation District as previously noted, the company operates approximately 20 of its own dams and reservoirs, ranging in size from small diversion structures to the 74,500 acre-foot capacity Lake Spaulding Reservoir on the South Yuba River.

The water problems of the Yuba-Bear River Unit relate mainly to the conflicting uses of developed water for power, irrigation, and stream flow maintenance for fish and wildlife. Although some local flood problems exist within the unit, much of the runoff of the streams is uncontrolled and heavy damage is inflicted upon the Sacramento Valley floor during major floods.

Development of the Yuba-Bear River Unit under The California Water Plan contemplates that part of the remaining undeveloped headwaters of the Yuba River would be concentrated by further diversion of tributaries into Lake Spaulding, whence the developed water would be released for power and irrigation. Under this plan, the waters of the South Fork of the North Yuba River would be diverted below the mouth of Haypress Creek and conveyed by tunnel to Jackson Meadows Reservoir on the Middle Yuba River. Releases from Jackson Meadows Reservoir would flow into the existing Milton-Bowman-Spaulding diversion facilities of the Nevada Irrigation District and into Lake Spaulding through an enlarged Spaulding No. 3 Power Plant. Water from Fordyce Lake on Fordyce Creek, now draining into Lake Spaulding, would be conveyed by canal, together with the intercepted water of Rattlesnake Creek and the South Yuba River, into an enlarged Lake Valley Reservoir on the North Fork of the North Fork of the American River. After satisfying nominal stream flow maintenance requirements for fish on that stream, releases from Lake Valley Reservoir would be returned to the South Yuba River by pipe line with a power drop into Lake Spaulding. From Lake Spaulding the developed and regulated waters of the upper Yuba River Basin would be released through two separate existing conduit systems; namely, the Drum System of the Pacific Gas and Electric Company and the South Yuba Canal.

Water conveyed by the Drum System would enter the Bear River through the Dutch Flat Power Plant as at present. Here the water would be diverted and would flow in a canal into a proposed Rollins Reservoir on the Bear River through a new power drop. Releases from Rollins Reservoir would flow through a power plant at the base of the dam, and, after reregulation in an afterbay, would again be diverted into the Drum System as at present, where it would be available for irrigation on the divide between the Bear and American Rivers and for power generation at enlarged Halsey and Wise Power Plants. The winter power releases from the latter plant would be conveyed by tunnel to Auburn Reservoir on the North Fork of the American River, and stored for subsequent summer release to Auburn Ravine for irrigation of the foothill lands north of Folsom Reservoir.

The South Yuba Canal would continue to serve lands in the Nevada City-Grass Valley area as at present, but with an increased supply made available in part by additional releases from Lake Spaulding and in part by enlarging Scotts Flat Reservoir on Deer Creek to store the winter power releases from Deer Creek Power Plant. Both this plant at the terminal and the Spaulding No. 2 Power Plant at the head of the South Yuba Canal would be enlarged to utilize the additional water supplies made available by new upstream storage works.

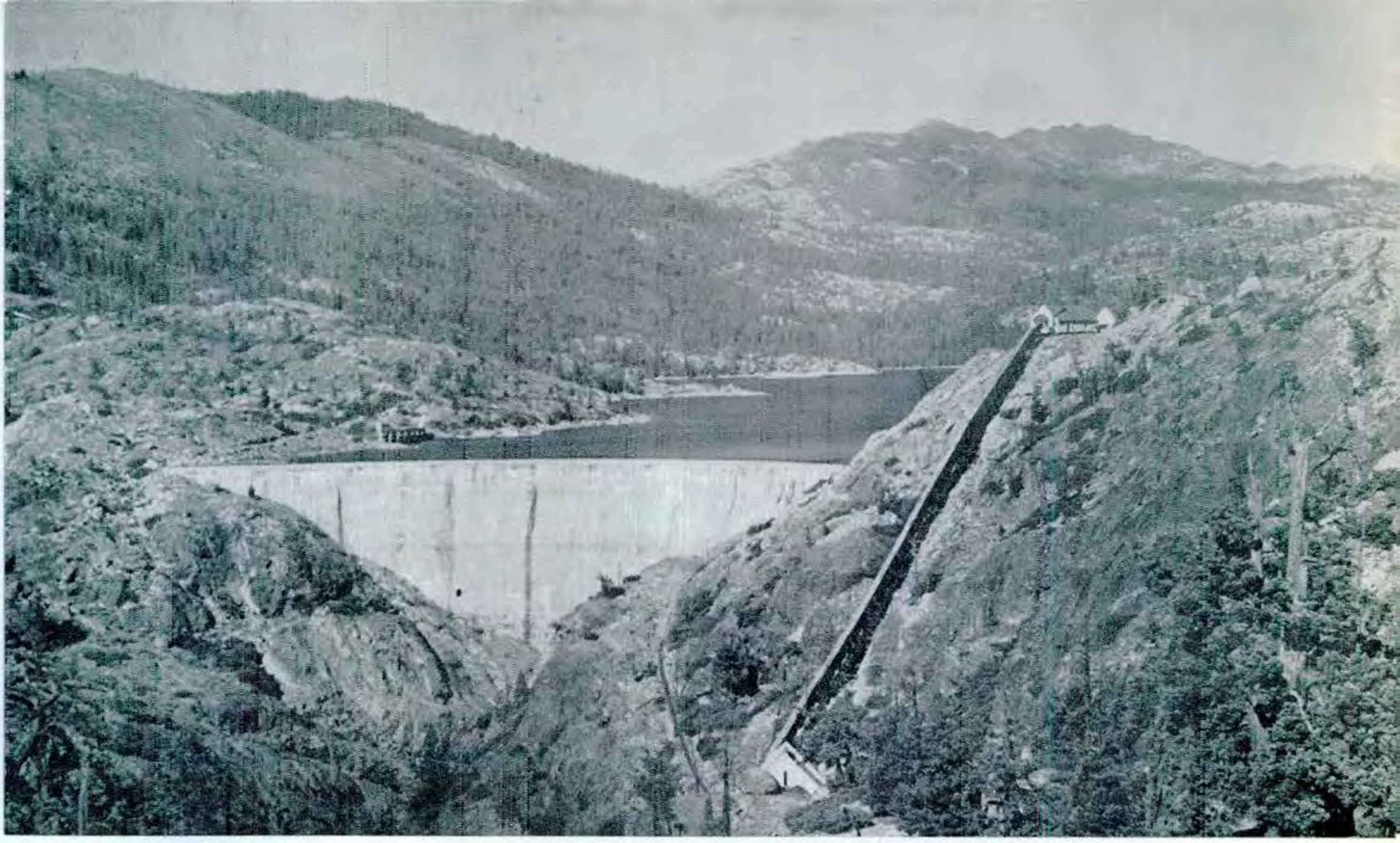
Additional water supplies for the Nevada City-Grass Valley area and new water supplies for the North San Juan area would be made available by a combination power and water supply development that would concentrate the runoff from the middle sectors of the Middle and South Yuba Rivers in a large storage reservoir near Washington on the South Yuba River. In this project the waters of the Middle Yuba River would be diverted at a point near Allegheny and would flow through a tunnel into Washington Reservoir. Releases from Washington Reservoir would then be conveyed by tunnel to a forebay near Nevada City, whence diversions for irrigation and power would be made. A main irrigation canal would divert southward into the Nevada City-Grass Valley area. A smaller irrigation conduit would cross the South Yuba River by inverted siphon to serve lands in the North San Juan area. Releases for power would flow through a penstock to the Devils Slide Power Plant on the South Yuba River. Part of the power releases from this plant would be diverted from an afterbay on the South Yuba River through the existing Excelsior Ditch into a proposed Anthony House Reservoir on Deer Creek, where it would be stored for subsequent irrigation use. The remaining power releases would be diverted from the same afterbay and conveyed by tunnel to a Jones Bar Power Plant on the South Yuba River near the head of Englebright Reservoir.

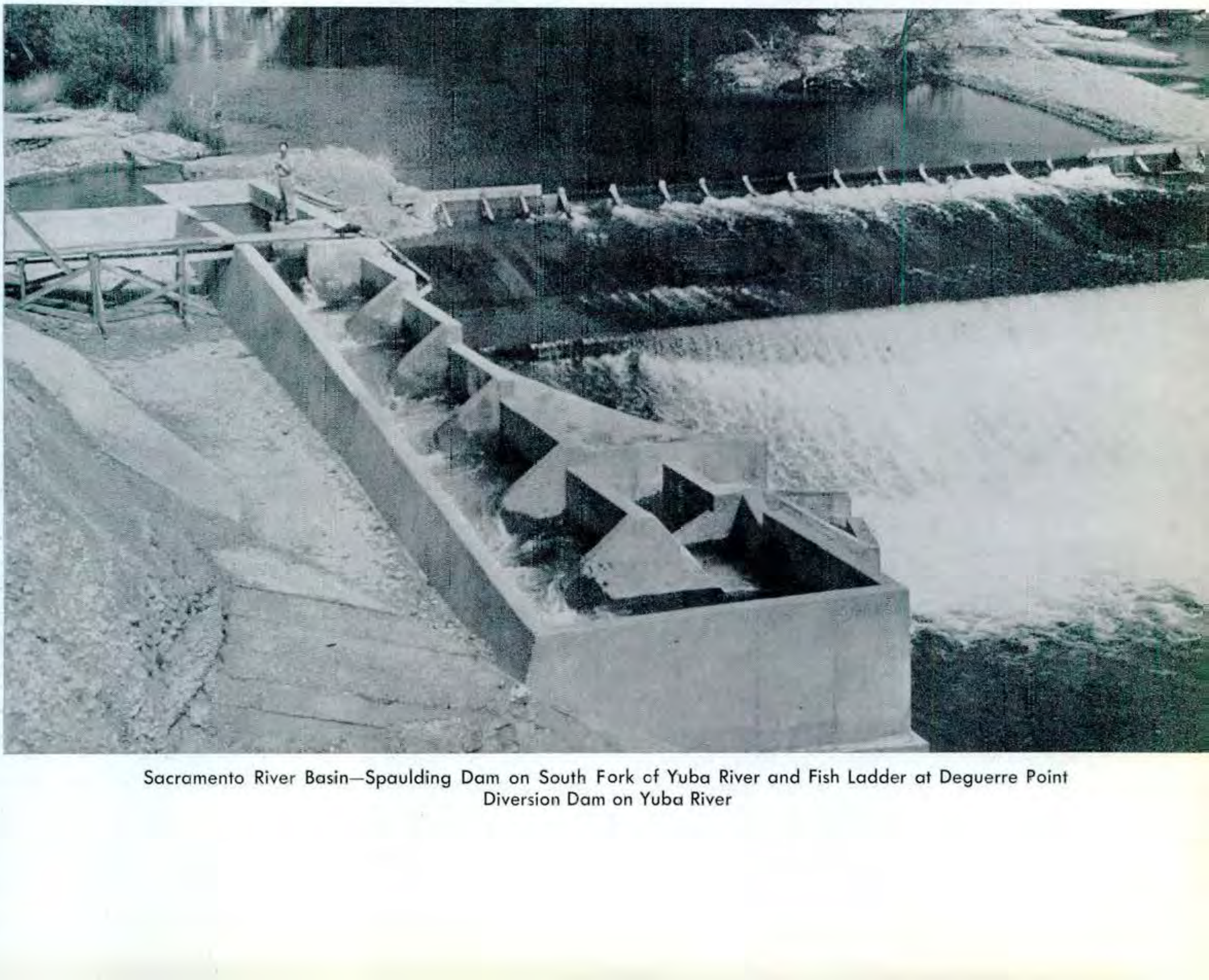
Except for the diversion of the South Fork of the North Yuba River into Jackson Meadows Reservoir, the only other headwater development contemplated for the North Yuba River would be the diversion of Canyon and Slate Creeks, tributary thereto, into Lost Creek Reservoir in the drainage basin of the South Fork of the Feather River. These latter works would comprise a part of the South Fork Feather River Development and have been previously discussed under the heading "Feather River Unit."

The Department of Fish and Game considers that the main stem of the North Yuba River has certain unique and desirable natural flow characteristics for angling that should be preserved in perpetuity for future generations to enjoy. Furthermore, the stream flows through an area rich in historical background. For these reasons no developments are now considered for the accessible reaches of the river above the mouth of Canyon Creek; but in future, more detailed investigation, careful consideration should be given to the relative advantage of adhering to this principle or of further water development, if the need arises for additional water. Historic Downieville, in this area, sometimes suffers damage from floods, but it is improbable that corrective measures, other than the possible relocation of some buildings to a safe level, could ever be justified under presently accepted methods of evaluating flood control benefits.

Prospective works on the North Yuba River below the mouth of Canyon Creek would consist of Wambo Dam and Reservoir, with a short tunnel to develop about 400 feet of power head into an enlarged Bullards Bar Reservoir on the North Yuba River. This latter reservoir would be connected by a short equalizing tunnel with a large Freemans Reservoir on Middle Yuba River. The two connected reservoirs would thus, in effect, constitute a single large multipurpose reservoir, with the power head to Englebright Reservoir then developed by tunnel. About 160,000 acre-feet of the combined storage space would be reserved in the reservoirs for flood control.

Foothill development of the Yuba River would consist of Parks Bar Reservoir below Englebright Dam for flood control, and Waldo Reservoir, on Dry Creek, a tributary of Bear River, to provide off-stream storage for surplus Yuba River water. Water supplies for Waldo Reservoir would be diverted by tunnel from Englebright Reservoir into Deer Creek, combining therewith for further diversion to a small distributing reservoir south of Parks Bar Dam. From this point the surplus water would be further conveyed by canal to Waldo Reservoir for storage and regulation. The head available between the distributing reservoir and the main stem of the Yuba River below Parks Bar Dam would be developed for power, utilizing firm water supplies developed by upstream storage works and conveyed to this point by the foregoing described diversion facilities. A low afterbay dam on the Yuba River below the power plant would reregulate the power releases. All of the prospective foothill works of the Yuba River would have important export as





Sacramento River Basin—Spaulding Dam on South Fork of Yuba River and Fish Ladder at Deguerre Point Diversion Dam on Yuba River well as local functions, and have therefore been designated as features of the California Aqueduct System.

Major foothill storage regulation of the remaining water resources of the Bear River below Rollins Reservoir would be accomplished by enlarging the present Camp Far West Reservoir east of Wheatland. This reservoir would be used for both conservation and flood control, and has also been designated as a feature of the California Aqueduct System.

The waters of French Dry Creek, principal downstream tributary of the Yuba River entering from the north, would be conserved for local use in Virginia Ranch Reservoir located about 7 miles above Browns Valley. Waters of Coon Creek would be conserved for local use by construction of a small Coon Creek Reservoir on the middle reaches of Coon Creek. Other possibilities for storage development on the minor foothill streams of the unit would be a small Auburn Ravine Reservoir on Auburn Ravine below the town of Auburn and a Doty Ravine Reservoir on Doty Ravine northeast of Lincoln.

In summary, prospective works of the Yuba-Bear River Unit under The California Water Plan would consist of about 16 new and enlarged reservoirs; a number of diversion works at various locations; necessary conveyance and service conduits; and 15 new and enlarged hydroelectric power plants. The new reservoirs would add about 2,000,000 acre-feet of capacity to the present storage system of the unit. Of this, about 400,000 acre-feet would be reserved for flood control. The reservoirs would provide supplemental water supplies for all dependent areas and would regulate substantial quantities of water for export. They would provide a measure of flood control for local areas and would afford substantial flood protection to downstream areas. Releases would be made from the reservoirs to maintain and in some instances enhance the stream flow in the interests of fish, wildlife, and recreation. The power plants would provide about 325,000 kilowatts of new capacity and would generate an average of about 1.2 billion kilowatt-hours of new energy each year. Of this, about 40,000 kilowatts and 83,000,000 kilowatt-hours are considered to be creditable to the Parks Bar Power Plant, a feature of the California Aqueduct System. This takes into account the loss of power at the upstream Narrows Power Plant, which eventually would be abandoned due to submergence by Parks Bar Reservoir.

American River Unit. The American River Unit comprises the drainage basin of the American River above the Fair Oaks gaging station and the adjoining foothill area north to the southern drainage boundary of Auburn Ravine. The total area, measured to the base of the foothills, is 2,050 square miles, of which the American River Basin itself contains 1,920 square miles. About 1,900 square miles of the American River Basin are considered to be mountainous. Elevations range from about 150 feet at the western foothill boundary to about 10,000 feet along the crest of the Sierra.

The main stem of the American River is formed by the junction of its North and South Forks in Folsom Reservoir. The North Fork has no important tributaries except the Middle Fork which joins it near Auburn. The Middle Fork has one important tributary, the Rubicon River. The South Fork has two main tributaries, namely Silver Creek and Silver Fork. The forks of the American River and their principal tributaries flow from the headwaters through deeply incised canyons separated from each other and from adjoining streams by comparatively broad east-west trending ridges. The irrigable lands of the unit are located on the main ridges and on the rolling foothills.

Precipitation in the American River Unit ranges from about 25 inches per season at the base of the foothills to more than 70 inches in the high mountains. The estimated full natural runoff of the American River amounts to about 2,770,000 acre-feet per year at the Fair Oaks gage. The runoff of the minor streams of the unit north of Folsom Reservoir amounts to only about 79,000 acre-feet per year. Under ultimate conditions of development it is anticipated that exchanges of water with neighboring basins will result in a small increase in the water supply of the unit.

The economy of the American River Unit is based mainly on activities relating to agriculture, lumbering, mining, and recreation. Because of its proximity to large centers of population in northern California and because of an excellent road network, including two transcontinental highways, the recreational opportunities, in particular, are being rapidly developed. These include skiing resorts, summer home and camp sites, trout fishing, etc. Indicative of the interest in recreation is the almost unprecedented attraction of the recently completed Folsom Reservoir and Lake Natoma to boating, fishing, and water sports enthusiasts. Development of the lake shore at both of these reservoirs has been authorized as part of the State Park System.

Present water development in the American River Unit consists of: about 67,000 acre-feet of headwater storage located principally in Lake Valley, Loon Lake, Medley Lakes, Twin Lakes, and Silver and Webber Reservoirs for power, irrigation, and stream flow maintenance; 14,600 acre-feet of debris control storage in North Fork Debris Storage Reservoir near Auburn; and 1,000,000 acre-feet of multipurpose storage in Folsom Reservoir. Folsom Afterbay at Nimbus, called Lake Natoma, contains about 9,000 acre-feet of storage capacity. The El Dorado Irrigation District in the vicinity of Placerville obtains water from the El Dorado Forebay and Webber Reservoir in the watershed of the South Fork of the American River and from Diamond Ditch and Sly Park Reservoir in the

Cosumnes River Basin. The Georgetown Divide Public Utility District, serving lands on the divide between the Middle and South Forks, obtains its water supply principally from Loon Lake on Gerle Creek through a long and inefficient conduit system dating back to the mining days.

The foothill area north of Folsom Reservoir is served from the Drum Power System of the Pacific Gas and Electric Company with water originating principally in the Bear and Yuba Rivers, but including a modest supply diverted from the North Fork of the North Fork of the American River at Lake Valley Reservoir. There is no important water development at present on the Foresthill Divide between the North and Middle Forks other than for municipal and industrial requirements of the town of Foresthill. Downstream areas are served from Folsom Reservoir and by pumping from the American River. There are four existing hydroelectric power installations in the American River Basin, namely, the El Dorado and American River plants of the Pacific Gas and Electric Company and the Folsom and Nimbus plants of the Federal Government.

The present water requirements of the American River Unit, for consumptive purposes, amount to some 63,000 acre-feet per season for water service areas aggregating about 31,000 acres. These requirements are met, without deficiency, by releases from some of the foregoing works, together with importations of developed water from adjoining basins. Future demands on the American River for agriculture and urban purposes may amount to about 217,000 acre-feet per season when dependent lands in the Cosumnes River Basin, as well as those within the unit, are taken into account. The problem of floods is not a major concern in the upper American River Basin; and Folsom Reservoir, in conjunction with river levees, provides a high degree of protection for downstream areas. The preservation of fish and wildlife in the basin does not constitute a problem except as regards conflicting uses of developed water for other purposes. The former anadromous fishery of the upper basin has been blocked by the construction of Folsom Dam, but the provision of a salmon and steelhead fish hatchery below Lake Natoma is proving to be remarkably effective as a remedial measure.

Main objectives of The California Water Plan in the American River Unit are the development of its land, water, power, fish, wildlife, and recreational resources to the highest practicable degree.

Plans for development of the water resources of the American River Unit, in accordance with the principles of The California Water Plan, were first published in preliminary draft form in State Water Resources Board Bulletin No. 21, entitled "American River Basin Investigation, Report on Development Proposed for The California Water Plan". Following release of the preliminary draft report in June, 1955, the Board held public hearings which culminated in the adoption of a somewhat modified plan of basin development proposed by the Sacramento Municipal Utility District as an acceptable alternative to the basic plan presented in Bulletin No. 21. The Board directed that both plans be presented in the final edition of Bulletin No. 21 and in this bulletin. Accordingly, both plans are discussed herein under the general headings of "Basic Plan" and "Modified Plan".

1. *Basic Plan.* Prospective works in the watershed of the North Fork would consist of the enlargement of Lake Valley Reservoir on the North Fork of the North Fork for off-stream storage of water from the South Yuba River as discussed in the Yuba-Bear River Unit; a small reservoir on the headwaters of the North Fork at The Cedars, or suitable alternative site, to conserve water for stream flow maintenance in the interests of fish, wildlife, and recreation; a group of three small reservoirs on the Foresthill Divide, namely, Sugar Pine on North Shirttail Canyon, and Forbes and Big on Forbes Creek, with feeder canal or possible future tunnel from Secret Canyon and other tributaries of Middle Fork, for irrigation of the divide area and possibly for fish, wildlife, and recreational purposes; and a large Auburn Reservoir and Power Plant at the head of the North Fork arm of Folsom Reservoir, to conserve and regulate water for local use and export. Because of its export function, Auburn Reservoir is classified as a feature of the California Aqueduct System. The other works on the North Fork have strictly local functions.

Water developed and/or regulated for export in Auburn Reservoir would enter Folsom Reservoir for further disposition through the Auburn Power Plant at the base of the dam. In its local function, Auburn Reservoir, in addition to fishing and recreation, would store the winter power releases of Wise Power Plant for subsequent release for use on the foothill lands of the American River Unit north of Folsom Reservoir during the irrigation season. This would involve a tunnel between Auburn Reservoir and Auburn Ravine with connecting shaft to the afterbay of the Wise Power Plant. The tunnel would be gated at each end to control flow in either direction. Irrigation diversions would be made downstream from Auburn Ravine, as required, with possible additional regulatory storage provided in Whitney Ranch Reservoir on Pleasant Grove Creek. This small reservoir would also be used to conserve the local runoff of Pleasant Grove Creek.

Plans for the Middle Fork contemplate that water supplies for the Georgetown Divide area between the Middle and South Forks would be conserved in a large Stumpy Meadows Reservoir on Pilot Creek, a tributary of the Rubicon River. The water would be conveyed to the service area through a renovated and enlarged Georgetown Ditch, comprising a portion of the present conveyance system from Loon Lake Reservoir. Upper portions of this conveyance system would likewise be enlarged and improved by tunneling to convey surplus water from Gerle Creek and the South Fork of the Rubicon River to Stumpy Meadows Reservoir to augment natural inflow from Pilot Creek. A small feeder canal from Onion Creek, a tributary of Silver Creek, would be provided. In addition to its irrigation function, Stumpy Meadows Reservoir would afford opportunities for fishing and recreation, including stream flow releases to Pilot Creek for these purposes.

The excellent power potential of the Middle Fork of the American River and its headwater tributaries would be developed by a separate system of works comprising: four headwater reservoirs with associated conduits and power plants above a regulating and diversion reservoir at Parsley Bar on the Rubicon River; a main power conduit, consisting of a tunnel to Long Canyon and a canal along Ralston Ridge to a forebay at the end of the ridge; a high head Ralston Power Plant, served by pressure tunnel from Ralston Forebay and discharging into the Rubicon River arm of an American Bar Reservoir on the Middle Fork; and a low head American Bar Power Plant, developing the remaining head to the Middle Fork arm of Auburn Reservoir by tunnel. The headwater reservoirs would consist of French Meadows on the Middle Fork with feeder tunnel from Duncan Creek; Lower Hellhole on the Rubicon River; enlarged Loon Lake on Gerle Creek with feeder conduits from the South Fork of the Rubicon River and from upper Rubicon River by way of Rockbound and Buck Island Lakes; and Gerle below Loon Lake on Gerle Creek. Releases from all of the foregoing reservoirs would be made for stream flow and fishery maintenance purposes prior to diversion for power. The power head between these reservoirs would be developed by tunnel as follows: French Meadows to Lower Hellhole to Parsley Bar and Loon Lake to Gerle to Parsley Bar.

Plans for development of Silver Creek in the watershed of the South Fork of the American River contemplate that its headwater runoff would be conserved for power and for irrigation of the Placerville Divide area in a large Junction Reservoir, with dam located below the forks of Silver Creek and with a feeder canal diverting from the South Fork of the American River in lieu of far more costly on-stream storage. The regulated water from Junction Reservoir would be conveyed southward by tunnel to a power plant on a small tributary of the South Fork, and thence, after reregulation in an afterbay, by canal and tunnel to the existing Sly Park Reservoir in the Cosumnes River Basin, crossing the South Fork of the American River by inverted siphon. Sly Park Reservoir, under the basic plan, would continue to regulate Cosumnes River water as at present, functioning primarily as a conduit for the water imported from Junction Reservoir. From Sly Park Reservoir the water would be conveyed to an enlarged Webber Reservoir on Webber Creek, a tributary of the South Fork of the American River, with power drops enroute below Sly Park Dam and into Webber Reservoir. The latter reservoir would also receive additional inflow by feeder canal from the South Fork of Webber Creek. Stream flow maintenance releases for fish and recreation would be made from all of the above-mentioned reservoirs and diversions prior to any diversions for power or irrigation.

From Webber Reservoir the water would be conveyed to a small distributing reservoir on Hangtown Creek south of Placerville, with power drops enroute below the dam and into the distributing reservoir. From this reservoir a main irrigation conduit would extend westward along the ridge between the American and Cosumnes Rivers, while another conduit would return unused water to the South Fork of the American River with a power drop at Gold Hill, discharging into Salmon Falls Reservoir, which is subsequently described.

A variation of the basic plan for Silver Creek would route the water from Junction Reservoir by tunnel through two successive power drops, namely Jaybird on Silver Creek, and Camino on the South Fork of the American River at a point opposite the existing El Dorado Power Plant of the Pacific Gas and Electric Company. Releases from the Camino Power Plant would be reregulated in a Slab Creek Reservoir on the South Fork of the American River. From Slab Creek Reservoir the water would be diverted by tunnel to Webber Creek, whence it would be further diverted for irrigation on the Placerville Divide and returned to the South Fork for power as in the basic plan. Another variation would substitute three small reservoirs for the single large Junction Reservoir of the basic plan. The substitute reservoirs would consist of Lower Ice House on the South Fork of Silver Creek, with feeder canals from the South Fork of the American River and the Jones Fork of Silver Creek; Union Valley Reservoir on the main stem of Silver Creek, also receiving inflow from a Lower Ice House Power Plant; and a small Junction Diversion Reservoir, regulating the discharge from a Union Valley Power Plant. The works below the latter reservoir would follow either of the two foregoing suggested alignments.

Under the basic plan, additional water supplies would be made available for the Placerville Divide area through development of Silver Fork, with the surplus waters of that stream diverted by canal and tunnel for off-stream storage and regulation in a large Alder Creek Reservoir on Alder Creek. Water released from this reservoir in excess of stream flow maintenance for recreation and fishing would flow through a power plant on Alder Creek and would then enter the El Dorado Ditch of the Pacific Gas and Electric Company, whence it would flow to the El Dorado Forebay for further disposition. Part of the developed water would then be conveyed through an enlarged El Dorado Irrigation Ditch to serve lands in the eastern part of the Placerville Divide area, while the remainder would flow through and improve the output of the existing El Dorado and American River Power Plants.

The basic plan also contemplates that major conservation of the waters of the South Fork would be accomplished in a large Salmon Falls Reservoir, a feature of the California Aqueduct System, with dam and power plant located at the head of the South Fork arm of Folsom Reservoir. In its local function, Salmon Falls Reservoir would afford excellent opportunity for fishing and recreational development as well as increase the degree of flood protection made available to downstream areas. However, this important reservoir would, unfortunately, inundate the site of gold discovery in California; and as a consequence thereof the Legislature has directed that "In no event shall a permit to appropriate water be issued by the State for the purpose of a project which would flood any portion of the Gold Discovery Site State Park at Coloma unless such issuance is specifically authorized by law." Studies indicate that there are no feasible alternative storage sites for a large reservoir on the South Fork. The best alternative would be to divert the flow of the South Fork into the Cosumnes River for storage in Nashville Reservoir. This would require a diversion dam at Slab Creek on the South Fork and a tunnel to Webber Creek and then to Nashville Reservoir. This plan, however, would be virtually ineffective in regulating the heavy flood runoff of the South Fork to any considerable degree.

2. *Modified Plan.* Under the modified plan of complete basin development, as proposed by the Sacramento Municipal Utility District and adopted by the State Water Resources Board as an acceptable alternative to the basic plan, many features would remain the same or substantially the same as in the basic plan. For this reason and in order to avoid repetition, discussion of the modified plan is presented essentially on the basis of differences between it and the basic plan, wherever such differences exist.

Under the modified plan the water stored in Loon Lake Reservoir and the natural flow of Gerle Creek would be diverted to Union Valley Reservoir on Silver Creek for power development. The effect of this diversion would be to reduce the water supply available for power development on the Middle Fork and for diversion to Stumpy Meadows Reservoir on the Georgetown Divide. As a consequence, the basic plan for the Middle Fork power development would necessarily be revised to exclude the power drops from Loon Lake into Gerle Reservoir and from that reservoir into Parsley Bar Reservoir. Gerle Reservoir would be eliminated. Below Parsley Bar to Ralston the power head of the Middle Fork would be developed in two drops instead of the single large Ralston drop. Below Ralston Power Plant to the head of Auburn Reservoir the power head would likewise be developed in two drops with reservoirs at American Bar and Volcano, instead of the single larger American Bar power development described above in the basic plan. The modified plan also proposes the conveyance of water in tunnels instead of open canals. Preliminary estimates indicate that, even with the reduced water supply and the increased cost occasioned by the substitution of tunnels for open canals, the altered Middle Fork power development would still be sufficiently attractive to warrant early development.

Irrigation supplies for the Georgetown Divide would be developed in a smaller Stumpy Meadows Reservoir on Pilot Creek with feeder canal from Onion Creek, and in four other small reservoirs situated on streams draining from the divide area, namely, Tipton Hill on Rock Creek, and Traverse, Canyon, and Greenwood on streams of like name. Water developed in Canyon Creek Reservoir would be diverted by tunnel to Greenwood Reservoir for further disposition. This system of small reservoirs would afford about the same degree of development for the Georgetown Divide area as the single large Stumpy Meadows Reservoir described in the basic plan. An added advantage would be that additional increments of water could be obtained more readily by the construction of the small reservoirs than by successively raising Stumpy Meadows Reservoir as would be required in the basic plan. Except as discussed above, the remaining features of the North and Middle Fork developments of the American River would remain substantially the same as in the basic plan.

The diversion of Middle Fork water to Silver Creek under the modified plan contemplates the eventual full utilization for power of some 1,600 feet of head between Loon Lake Reservoir and Union Valley Reservoir. This would be accomplished by the construction of two small power plants enroute to the point of diversion at Sawmill on Gerle Creek, and by a small terminal power plant at the end of a Robbs Peak tunnel diverting into Union Valley Reservoir. Other works on Silver Creek, under the modified plan, would consist of Ice House Reservoir on the South Fork of Silver Creek at a site upstream from the one discussed in the basic plan; a tunnel diversion from Ice House Reservoir with a power plant discharging into Union Valley Reservoir; and a small Junction Diversion Reservoir regulating the discharge from

Union Valley Power Plant. There would be no feeder canal diverting from the South Fork of the American River as in the basic plan, since the Sacramento Municipal Utility District determined that diversion from the Middle Fork of the American River to Silver Creek for water development is more economical than diversion from the South Fork of the American River.

From Junction Diversion Reservoir the water would flow by tunnel to Jaybird Power Plant on Silver Creek, and then again by tunnel to Camino Power Plant at the head of a Slab Creek diversion and regulating reservoir on the South Fork of the American River. From Slab Creek Reservoir the water would be diverted by tunnel and flow through a White Rock Power Plant with the remaining head to Folsom Reservoir, then developed in three drops comprising, successively, a small Kelsey Reservoir and Power Plant, a large Coloma Reservoir and Power Plant, and a very small Salmon Falls Reservoir and Power Plant.

The waters of Silver Fork, under the modified plan, would be developed in the same manner as in the basic plan, except that releases from the Alder Creek Power Plant would flow down the stream channel of Alder Creek for subsequent diversion from the South Fork of the American River into an enlarged Sly Park Reservoir, whence the water would be conveyed to an enlarged Webber Reservoir with power drops en route as in the basic plan. From the enlarged Webber Reservoir the water would be conveyed with a terminal power drop into a small distributing reservoir on Hangtown Creek near Placerville, whence diversions would be made for irrigation as in the basic plan, but with no further power development by return of water to the South Fork of the American River. Additional water supplies for the area would be obtained as required by pumping from Folsom Reservoir, combined with terminal storage for the pumped water in a small Malby Reservoir on Carson Creek near White Rock.

In summary, two alternative plans have been described for development of the water resources of the American River Unit in accordance with the objectives of The California Water Plan. The first of these, designated as the basic plan, contemplates the eventual construction of 17 new and enlarged reservoirs; a number of diversion works at various locations; necessary conveyance and service conduits; and 15 new power plants. The new reservoirs would add almost 2,300,000 acre-feet of capacity to the present storage system of the unit. None of this storage capacity would be specifically reserved for flood control, but incidental flood control benefits would result from the large amount of surcharge storage available in the reservoirs. The reservoirs would provide supplemental water supplies for all dependent areas and would regulate substantial quantities of water for export. Releases would be made from the reservoirs to maintain, and, in some instances, enhance the stream flow in the interests of fish, wildlife, and recreation. The power plants would provide 565,000 kilowatts of new capacity and would generate an average of about 2.5 billion kilowatt-hours of new energy each year. Variations of the basic plan might increase the number of reservoirs and reduce the number of power plants. Of the foregoing estimates, about 1,500,000 acre-feet of the new storage capacity and 153,000 kilowatts of installed power capacity would be developed by features of the California Aqueduct System.

The second plan was suggested by the Sacramento Municipal Utility District and has been designated as the modified plan. It would utilize about 25 reservoirs to provide about the same storage as in the basic plan and would develop the power potential at 22 new plants. The basic plan is superior to the modified plan from the standpoint of over-all costs and ultimate accomplishments; but parts of the modified plan are more adaptable to staged construction and it is therefore considered to be an acceptable alternative to the basic plan. The Sacramento Municipal Utility District has recently (March, 1957) been issued water right permits by the State Water Rights Board to begin its development.

Sacramento Valley Floor. The Sacramento Valley Floor embraces an area of about 4,300 square miles south of Red Bluff between the foothills of the Sierra Nevada and the Coast Range. Except for Sutter Buttes, which rise precipitously from the valley floor near Yuba City, the land is relatively flat or gently rolling in most areas. The stream system includes the Sacramento River, flowing in the trough of the valley, and the various tributary streams flowing into the river from the surrounding mountains.

Economic development of the Sacramento Valley Floor is based primarily on agriculture and its allied food-processing industries. In addition, major industries are engaged in the extraction or mining and the production of natural gas, clay, limestone, sand and gravel, and gold. The Sacramento River and the valley floor portions of its tributaries are important spawning streams for salmon, on which the salmon fishing industry depends in large measure, and also as spawning areas for steelhead, shad, and striped bass. All of these are of vital concern to sport fishing, which is of major economic importance to the area and to the State. Likewise, the Sacramento Valley Floor area is regarded as a major hunting area, as it contains excellent shooting grounds for waterfowl, pheasant, quail, and dove.

Precipitation on the Sacramento Valley Floor averages about 22 inches per season, decreasing slightly from north to south. Much of the precipitation not consumed by plant growth probably penetrates to the ground water, since the estimated mean seasonal natural surface runoff from the valley floor amounts to only about 321,000 acre-feet as compared with a mean seasonal precipitation of about 5,000,000 acre-feet.

Present (1949) water service areas of the Sacramento Valley Floor aggregate about 900,000 acres, supporting a population of about 400,000 people according to the 1950 census. Present gross urban and agricultural water requirements, amounting to some 3,810,000 acre-feet per season, are substantially met in most areas of the valley by direct stream flow diversions from the Sacramento River and its several tributaries, supplemented by releases from upstream storage and by pumping from ground water. According to a land use survey conducted in 1949, there is a present supplemental requirement of about 124,000 acre-feet per season for the Tehama, Arbuckle, Yuba, Marysville-Sheridan, and Carmichael areas.

Present flood protection on the Sacramento Valley Floor, though grossly inadequate in some areas, comprises a vast system of river levees and by-pass channels, as part of the Sacramento River Flood Control Project, supplemented by reserved storage space in Shasta and Folsom Reservoirs. Some reduction in flood peaks is also afforded by unfilled reservoir space and surcharge storage available above the spillway lip in all other reservoirs of the Sacramento River Basin.

In addition to flood control and water development and distribution works on the Sacramento Valley Floor, a large salmon and steelhead fish hatchery is located on the American River below Lake Natoma; and a 30-foot depth ship channel is being constructed from Collinsville to Sacramento, via the Sacramento River and Yolo By-Pass on the west side of the river.

Protection against damaging floods is the most important, and in some areas the most urgent, of the water problems of the Sacramento Valley Floor. Other problems relate to adverse seepage from the Sacramento River; rising connate saline waters in the Peach Bowl area of Sutter County; the disposal of sewage, industrial wastes, and drainage waters; and the protection and enhancement of the fishery resources and recreational values of the Sacramento River and its tributaries. No particular problems are foreseen in providing adequate water service for the rapidly growing urban, agricultural, and industrial areas. Under ultimate conditions it is anticipated that the water service areas of the Sacramento Valley Floor may expand to about 2,400,000 acres, supporting a future population of about 1,400,000 people, and requiring a supplemental water supply of about 2,460,000 acre-feet per year.

Under The California Water Plan it is contemplated that flood protection for the Sacramento Valley Floor would be substantially increased by assigning and specifically reserving about 1,850,000 acre-feet of storage space in prospective reservoirs of the Sacramento River Basin for that purpose. This storage space would be strategically disposed on the tributary streams; and, in addition, the new reservoirs would contain a large volume of surcharge storage space effective in reducing peak rates of flow. On the valley floor, stream channels would be improved and leveed, wherever necessary, to protect adjoining developed areas to the extent warranted.

Methods to alleviate damage from seepage in specific local areas will require further detailed study; but, in general, it is believed that the full coordinated use of the ground water basins in the alluvium of the Sacramento Valley, under conditions of ultimate development, could limit the deleterious effects of seepage to small areas immediately adjacent to the river levees. Further study may indicate the necessity and feasibility of additional measures. Coordinated use of ground water is further discussed in this chapter under the heading of "Utilization of Ground Water Storage."

Insofar as disposal of sewage, and industrial wastes and drainage waters are concerned, The California Water Plan envisages a trunk line waste conduit into which such waters could be pumped for disposal. The conduit would be built only if experience should indicate that the water resources would otherwise be seriously impaired. It would begin at Redding with a capacity of about 50 second-feet, and would flow through that area in a buried conduit to a pumping station south of Cottonwood Creek. Here, the water would be lifted to the divide between Cottonwood and Dibble Creeks, whence it would flow by gravity in both open and closed conduit along the west side of the Sacramento Valley into the Sacramento River Deep Water Ship Channel, or by separate conveyance conduit to the Delta below any future barrier. It is anticipated that the terminal capacity of the waste conduit would not exceed 500 second-feet, and its cost would be in the order of $20,000,000.

Supplemental water supplies to meet present deficiencies and near future requirements on the west side of the valley and in the vicinity of Chico would be obtained from the Corning and Tehama-Colusa Canals, diverting from the Sacramento River at Red Bluff, and from the Chico Canal diverting near Chico. Water supplies for these canals will be made available from the authorized Trinity River Division of the Central Valley Project of the Federal Government. Folsom Reservoir will relieve the present deficiency in the Carmichael area and may, with full upstream development, supply all of the future needs of the Sacramento metropolitan area. Remaining present and future supplemental requirements on the Sacramento Valley Floor would be obtained from developments on the tributary streams, as described in preceding sections, and by increased pumping from ground water.

Under The California Water Plan, the anadromous and other fishery resources of the Sacramento River and its tributaries would be enhanced to the maximum feasible extent. The recreational potential would likewise be developed.

In summary, The California Water Plan for the Sacramento Valley Floor would satisfy present and future supplemental water requirements, provide substantial increased flood protection, maintain high-quality water and improve the quality where necessary, and enhance the fishery and recreational potential.

Summary of Sacramento River Basin. The California Water Plan for the Sacramento River Basin contemplates the gradual addition of about 17,500,000 acre-feet of storage capacity to the present basin reservoir system. This capacity would be contained in about 130 strategically disposed storage, diversion, and regulatory reservoirs, ranging in size from small impoundments for recreation to about 3,500,000 acre-feet in Oroville Reservoir on the Feather River. Twenty-four of the new reservoirs, with a combined capacity of about 9,000,000 acre-feet, are classified as features of the Klamath-Trinity, Eel, and Sacramento Divisions of the California Aqueduct System, but many of these would have important local as well as export functions. The new reservoirs would contain about 1,850,000 acre-feet of storage space specifically reserved for flood control, to augment about the same amount of such storage space now reserved in Shasta and Folsom Reservoirs and made available in other existing reservoirs of the basin.

Under The California Water Plan, the present and future reservoirs of the Sacramento River Basin would yield an average of about 17,700,000 acre-feet of water per year for local use and export, of which about 12,500,000 acre-feet would be a firm supply. Of this, about 6,000,000 acre-feet may be regarded as new water. Assuming that all local demands would be met from firm water supplies and taking into account the availability of return flow, there would be an average of about 10,000,000 acre-feet per year of regulated water available to meet present and future export demands on the water supplies of the Sacramento River Basin.

Based upon conventional concepts of reservoir operation, and considering the probable incidental safe ground water yield of the Sacramento Valley, about 6,000,000 acre-feet of the export supply would be on a firm basis. The remainder would be a variable supply, ranging from zero in dry years to about 6,000,000 acre-feet in wet years, and averaging about 4,000,000 acre-feet per year over a long-time period. Conventional reservoir operation is defined herein as the achievement of optimum safe surface reservoir yield, as distinguished from conjunctive operation wherein optimum combined safe surface and ground water yield is the objective.

Under full conjunctive operation of surface and ground water storage in the Sacramento River Basin, with the foothill reservoirs of the basin operated substantially to regulate seasonal flows and the ground water reservoirs operated for cyclic storage, about 8,000,000 acre-feet per year of the export supply would be on a firm basis. The corresponding variable supply would then average only about 2,000,000 acre-feet per year, ranging from zero in dry years to about 3,000,000 acre-feet in wet years. For purposes of this report it was assumed that there would be a gradual transition from conventional to conjunctive reservoir operation as the need to utilize ground water storage to a greater extent develops. Further discussion of the general subject of conjunctive operation is presented in greater detail later in this chapter.

Specifically, the reservoirs of the Sacramento River Basin which have been classified as local works would have an aggregate capacity of about 8,700,000 acre-feet. These reservoirs would contain a total of about 550,000 acre-feet of storage space specifically reserved for flood control. In the aggregate their combined safe yield in terms of new water would be about 3,000,000 acre-feet per year. Their cost, including feeder conduits where pertinent, would be in the order of $600,000,000.

There would be about 45 new and enlarged hydroelectric power plants associated with the local reservoirs. These plants would have a combined installed power capacity of about 1,600,000 kilowatts and would generate an average of about 7.2 billion kilowatt-hours per year. Including related diversion works, conduits, penstocks, forebays, afterbays, etc., their cost would be in the order of $375,000,000.

Other local works would consist of main conveyance and service canals for irrigation, wells for irrigation and urban purposes in some areas, additional levees and floodway channels where needed, distribution and drainage systems, and possibly a main waste conduit extending southward from Redding the full length of the Sacramento Valley. The cost of this conduit and the main conveyance and irrigation conduits in the upland areas of the basin would be in the order of $70,000,000. No estimates of cost were made for the various drainage and distribution systems and other local works on the Sacramento Valley Floor that would be required for complete development of the land and water resources of the Sacramento River Basin.

In summary, the local works of The California Water Plan would provide sufficient regulated water to meet the local needs, develop the hydroelectric power potential to the maximum economic limit, substantially increase the flood protection in the local areas, maintain the high-quality water and improve it where necessary, and maintain and enhance the fish, wildlife, and recreational potential to the maximum feasible extent.

The general features and costs of the principal local development works contemplated in the Sacramento River Basin are presented in Table 13. Similar information for the aqueduct features of the basin development is presented later in this chapter in Tables 17 through 22, under appropriate divisions of the California Aqueduct System.

Central Valley Area—San Joaquin-Tulare Lake Basin

California's greatest present and future water deficiencies are in the San Joaquin and Tulare Lake Basins. These two great basins, which are separable as to their drainage characteristics, contain 40 per cent of the irrigable lands of the State but share only 16 per cent of the State's total water resources. Together they comprise the greatest and most productive single agricultural area of the State and are grossly deficient in native water supply.

The San Joaquin-Tulare Lake Basin is approximately 300 miles long and 130 miles wide, and embraces an area of 33,000 square miles, or about one-fifth of the area of the State. In the central portion of the basin, surrounded by mountains on three sides and by the San Joaquin Delta at its northerly end, lies the San Joaquin Valley, a region of 13,500 square miles of gently sloping plains, with predominantly fertile soils well adapted to agriculture. The highest peaks of the Sierra Nevada rise above the valley along its entire eastern length. In these rugged scenic mountains lie the southern portion of the historic Mother Lode region, a large area of national forest, three national parks, and many state parks, all of which afford excellent opportunities for recreation.

Because of favorable soil and climatic conditions, the San Joaquin-Tulare Lake Basin has pioneered irrigation development in California. About 3,700,000 acres of a total irrigable area of about 8,000,000 acres have been placed under irrigation. More than 50 irrigation districts have been formed, as well as other types of public districts and private companies, and by their initiative many notable water works have been constructed to furnish water and other services to irrigators.

Precipitation in the San Joaquin-Tulare Lake Basin ranges from less than 5 inches per season at the southern end of the San Joaquin Valley to 60 to 70 inches on higher ranges of the Sierra Nevada. About 90 per cent of the precipitation falls during the months of November through April, with little or no rainfall on the valley floor during the growing season when the moisture demands of the crops are at their peak. Runoff of streams tributary to the basin comes largely from snow which provides a beneficial natural regulation.

The major portion of the San Joaquin-Tulare Lake Basin is drained by the San Joaquin River and its many tributaries which comprise one of the largest stream systems in California. Principal tributaries of the San Joaquin River include the Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, Chowchilla, and Fresno Rivers. The Tulare Lake Basin, a closed basin, constitutes the southern portion of the area, and the Kings, Kaweah, Tule, and Kern Rivers, as well as numerous minor streams, are tributary to it.

The present water requirements in the San Joaquin-Tulare Lake Basin are being met in several ways. At the north end of the basin there are diversions from Delta channels. Along the east side of the trough of the San Joaquin Valley there are substantial diversions from the major streams, some of which have been virtually completely developed for use. In addition, water from the Sacramento-San Joaquin Delta is imported in the Delta-Mendota Canal which began operation in 1951. There is also considerable pumping from ground water throughout the basin, particularly in the southern Tulare Lake Basin where development of ground water, combined with surface storage, has resulted in virtually complete conservation of the surface runoff.

During 1954 approximately 8,250,000 acre-feet of water were withdrawn from underlying ground water storage in the San Joaquin-Tulare Lake Basin, representing over two-thirds of the ground water utilized in the entire State. Two of the major rivers of the basin, the Mokelumne and the Tuolumne, furnish water which is conveyed westerly across the valley in pipe line aqueducts for use in the San Francisco Bay Area. Substantial hydroelectric power development has taken place on the Mokelumne, Stanislaus, Tuolumne, Merced, San Joaquin, Kings and Kern Rivers.

Objectives of The California Water Plan in the San Joaquin-Tulare Lake Basin are: first, to develop fully and distribute local water supplies for all beneficial purposes, including irrigation, municipal, industrial, fish and wildlife, recreation, and power generation; second, to protect urban and agricultural areas from damaging floods; third, to convey and distribute the imported water supplies necessary to satisfy fully the ultimate water requirements for all beneficial purposes; and fourth, to protect the quality of water by adequate drainage and removal of unsuitable waters. The necessity for protection and enhancement of fish and wildlife resources and for development of the recreational potential are important considerations that must be borne in mind in further development of the surface water resources of the basin.

Virtually all portions of the San Joaquin-Tulare Lake Basin are now experiencing or are threatened with serious water problems of one kind or another. The most serious and widespread problem is the in-

TABLE 13

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SACRAMENTO RIVER BASIN

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

Dam and reservoir	Stream	Dam: Location, MDB&M, and sheet of Plate 5 on which shown	Dam: Type	Dam: Height, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active	Seasonal yield, in acre-feet[a]	Purpose	Place of water use	Capital cost[b]
Goose Lake Unit	(Ground water development if feasible)										
Pit River Unit											
Parker	Parker Creek	Sec. 33, T43N, R13E 2							I	Alturas area	
Jess Valley	South Fork Pit River	Sec. 10, T39N, R14E 2							I	Alturas area	
Sears Flat	Stony Canyon	Sec. 32, T39N, R12E 2							I	Alturas area	
Bayley (enlarged)	Crooks Canyon	Sec. 32, T40N, R12E 2							I	Alturas area	
Allen Camp	Pit River	Sec. 35, T41N, R7E 2	E	138	4,285	195,600	185,000	85,000	I,FC	Big Valley	$4,871,000
Round Valley	Ash Creek	Sec. 21, T39N, R9E 2	E	85	4,281	85,000	83,000	52,000	I	Big Valley	3,057,000
Little Valley	Horse Creek	Sec. 3, T35N, R7E 4	E	70	4,216	25,000	20,000	8,000	I	Dixie Valley	731,000
Fall River Mills	Pit River	Sec. 31, T37N, R5E 4	CG	113	3,324	175,000	20,000	80,000	I,P,R	Fall River-McArthur-Pittville area	4,614,000
Burney	Burney Creek	Sec. 11, T34N, R2E 4	E	100	3,986	5,000	5,000	5,000	I	Burney area	581,000
Pit No. 1 Afterbay	Pit River	Sec. 15, T36N, R4E 4	CG		2,835				P	Pit River	(Included with power plants, Pit Nos. 2, 6, 7)
Pit No. 5 Afterbay	Pit River	Sec. 5, T35N, R1W 4	CG	150	1,410	12,000	7,800		P	Pit River	
Pit No. 6 Afterbay	Pit River	Sec. 31, T35N, R1W 4	CG	230	1,270	34,000	16,500		P	Pit River	
Mt. Shasta Stream Group											
Wagon Valley	Sacramento River	Sec. 29, T40N, R4W 1	CA	185	3,175	22,300	17,500	60,000	I,F	Mt. Shasta City area	2,000,000
Willow	Squaw Valley Creek	Sec. 11, T38N, R3W 1	E or R	291	2,894	250,000	246,000	460,000	P,F	McCloud River	23,670,000
Chonton Tubas	McCloud River	Sec. 28, T37N, R3W 1	R	258	1,730	52,000	42,000	720,000	P,F	McCloud River	10,400,000
Redding Stream Group											
Dippingvat	South Fork Cottonwood Creek	Sec. 36, T27N, R7W 3	E	205	1,150	55,000	51,300	47,000	I	Redding area and Sacramento Valley	3,220,000
Cold Fork	Cold Fork Cottonwood Creek	Sec. 17, T27N, R7W 3	E	100	1,340			76,000 (Cold Fork and Rosewood)	D	Divert to Rosewood Reservoir	580,000
Rosewood	Dry Creek	Sec. 16, 21, T28N, R6W 3	E	200	783	200,000	196,000		I,FC	Redding area and Sacramento Valley	11,858,000
Fiddlers	Middle Fork Cottonwood Creek	Sec. 28, 33, T29N, R7W 3	R & E	310	1,050	310,000	270,000	126,000	I,P,FC,F	Redding area and Sacramento Valley	18,900,000
Fiddlers Afterbay	Middle Fork Cottonwood Creek	Sec. 23, T29N, R7W 3	E	73	750	5,400	1,000		P		Included with Fiddlers Power Plant
Hulen	North Fork Cottonwood Creek	Sec. 16, T30N, R6W 3	E	205	850	96,400	93,400	42,000	I,FC	Redding area and Sacramento Valley	3,700,000
Bella Vista	Little Cow Creek	Sec. 20, T32N, R3W 4	E	110	600	146,000	138,000	90,000 (Bella Vista and Oak Flat)	I,FC	Redding area and Sacramento Valley	9,194,000
Oak Flat	Oak Run	Sec. 25, T33N, R2W 4	E	80	1,490	5,300	5,000		I,D	Oak Run Creek and divert to Bella Vista Reservoir	1,137,000

TABLE 13—Continued

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SACRAMENTO RIVER BASIN

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

Dam and reservoir	Stream	Dam: Location, MDB&M, and sheet of Plate 5 on which shown	Dam: Type	Dam: Height, in feet	Normal pool elevation, in feet	Storage capacity, in acre-feet: Gross	Storage capacity, in acre-feet: Active	Seasonal yield, in acre-feet [a]	Purpose	Place of water use	Capital cost [b]
Redding Stream Group —Continued											
Old Cow Creek	Old Cow Creek	Sec. 9, T31N, R2W 4	E	145	815	18,000	10,000		D	Old Cow Creek and divert to Millville Reservoir	$2,130,000
Millville	South Cow Creek	Sec. 17, T31N, R2W 4	E	215	800	206,000	200,000	140,000	I,FC,F	Redding area and Sacramento Valley	9,320,000
Bear Creek	Bear Creek	Sec. 25, T31N, R2W 4	R	140	1,180				D	Divert to Millville Reservoir	3,280,000
Battle	Battle Creek	Sec. 25, T30N, R2W 4	E	230	890	40,000	36,000	10,500	D,F	Divert to Wing Reservoir	2,140,000
Wing	Inks Creek	Sec. 25, T29N, R3W 4	E	185	500	243,000	222,000	74,500	I,FC	Sacramento Valley	7,150,000
Paynes	Paynes Creek	Sec. 3, T28N, R2W 4	E	100	650				D	Divert to Wing Reservoir	1,590,000
Iron Canyon	Sacramento River	(Aqueduct feature—see Table 21)									
West Side Stream Group											
Schoenfield	Redbank Creek	Sec. 16, T26N, R6W 3	R	280	990	174,000	170,000	32,400	I,FC	Area southwest of Red Bluff	7,560,000
Galatin	Elder Creek	Sec. 14, T25N, R6W 3	E	215	923	183,000	176,000	33,000	I,FC	Area southwest of Red Bluff	4,700,000
Paskenta	Thomes Creek	Sec. 6, T23N, R6W 5	E	180	960	67,000	62,000	55,000	I,D	Thomes Creek area	4,900,000
Newville	North Fork Stony Creek	Sec. 3, T22N, R6W 5	E	238	838	950,000	900,000	204,000	I,P	Stony Creek foothill area	20,880,000
Clark Valley	South Fork Willow Creek	Sec. 34, T20N, R5W 5	E	94	480	6,300	3,000	1,400	R		467,000
Squaw Flat	Logan Creek	Sec. 29, T19N, R4W 5	E	60	315	8,000	3,000	700	R		425,000
High Peak	Hunters Creek	Sec. 9, T18N, R4W 5	E	80	290	11,300	3,800	700	R		515,000
Golden Gate	Stone Corral and Funks Creeks	Sec. 20, T17N, R4W 5 Sec. 9, T17N, R4W 5	CA E	63 90	315	48,000	24,500	1,400	R		904,000
Pitney Ridge	Middle Creek	Sec. 10, T16N, R10W 5	E & R	77	1,542	5,400	4,600	4,800	I	Clear Lake area	765,000
Lakeport	Scott Creek	Sec. 22, T14N, R10W 5	E	100	1,542	33,100	30,300	20,200	I	Clear Lake area	2,102,000
Kelseyville	Kelsey Creek	Sec. 34, T13N, R9W 7	E & R	150	1,595	36,000	35,000	18,200	I	Clear Lake area	2,557,000
Boggs	Kelsey Creek	Sec. 13, T12N, R9W 7	E	190	2,333	56,500	51,200	16,700	I	Clear Lake area	2,150,000
Excelsior	Copsey Creek	Sec. 11, T12N, R7W 7	E	90	1,420	38,000	35,000	9,800	I	Clear Lake area	1,205,000
Indian Valley	North Fork Cache Creek	Sec. 9, T14N, R6W 5	E	180	1,457	200,000	188,000	48,000	I	Capay and Sacramento Valleys	3,270,000
Bear Valley	Bear Creek	Sec. 9, 10, T14N, R5W 5	E	80	1,323	37,000	20,000	10,600	R		710,000
Middletown	Putah Creek	Sec. 15, T11N, R7W 7	E	65	1,080	14,200	12,400	16,000	I	Middletown area	1,400,000
Goodings	Maxwell Creek	Sec. 19, T9N, R4W 7	E	109	619	50,300	45,100	23,000	I	Pope Valley area	2,838,000
Black Butte	Stony Creek	(Aqueduct feature—see Table 21)									
Guinda or alternative at Wilson Valley or Blue Ridge	Cache Creek	(Aqueduct feature—see Table 21)									
Antelope-Butte Stream Group											
Antelope Basin	Antelope, Salt, and Little Antelope Creeks	Sec. 11, 12, 13, T27N R3W; S18, 19 and 20, T27N, R2W 4	E	65	336	37,000	35,000		FC	Sacramento Valley	5,800,000
Morgan Springs	Mill Creek	Sec. 23, T29N, R4E 4	E	90	4,900	7,600	7,000		D	Divert to Deer Creek Meadows Reservoir	2,500,000
Deer Creek Meadows	Deer Creek	Sec. 20, T28N, R5E 4	E	215	4,705	200,000	178,000	136,000	P	Deer Creek	3,800,000
Butte Creek House	Butte Creek	Sec. 21, T26N, R5E 4	E	100	5,840	10,000	9,400	9,600	I	Keefer Ridge	870,000
Grizzly Gulch	Butte Creek	Sec. 6, T25N, R4E 4	E	180	4,160	12,000	11,000	4,900	I	Keefer and Paradise Ridge areas	3,640,000

TABLE 13—Continued

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SACRAMENTO RIVER BASIN

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Antelope-Butte Stream Group —Continued											
Magalia (enlarged)	Little Butte Creek	Sec. 25, T23N, R3E 6	E	121	2,252	6,500	6,400	4,000	I	Paradise Ridge area	$740,000
Forks of Butte	Butte Creek	Sec. 26, T24N, R3E 6	E	280	2,345	57,000	55,000	52,000	I	Paradise Ridge area	6,967,000
Big Chico	Big Chico Creek	Sec. 35, T23N, R2E 6	E	145	800	16,000	15,000	98,500	I,D	Sacramento Valley and divert to Castle Rock Reservoir	1,511,000
Castle Rock	Butte Creek	(Aqueduct feature—see Table 21)									
Brush Basin	Mill, Deer, etc.	(Aqueduct feature—see Table 21)									
Feather River Unit											
Antelope Valley	Indian Creek	Sec. 22, T27N, R12E 4	E	77	5,000	22,000	8,000	5,000	R,I	Upper Feather River	479,000
Dixie Refuge	Last Chance Creek	Sec. 23, T26N, R14E 4	E	81	5,740	14,000	12,000	6,000	R,I	Upper Feather River	620,000
Squaw Queen	Last Chance Creek	Sec. 1, 2, T25N, R12E 4	E	200	5,480	140,000	122,000	37,000	I,P,R	Upper Feather River	3,232,000
Genesee	Indian Creek	Sec. 7, T25N, R11E 4	E	195	3,800	276,000	275,000	82,000	I,P,R	Upper Feather River	8,531,000
Abbey Bridge	Red Clover Creek	Sec. 32, T25N, R13E 6	E	70	5,420	11,000	6,000	7,000	R, I	Upper Feather River	660,000
Indian Falls	Indian Creek	Sec. 35, T26N, R9E 4	CG	50	3,485	500	500	160,000	P	Upper Feather River	1,239,000
Frenchman	Little Last Chance Creek	Sec. 33, T24N, R16E 6	E	119	5,588	50,000	48,000	16,000	I,F	Sierra Valley	1,469,000
Grizzly Valley	Big Grizzly Creek	Sec. 1, T23N, R13E 6	E	116	5,775	80,000	78,000	15,000	I,F	Sierra Valley	916,000
Sheep Camp	Craycroft Creek	Sec. 4, 5, 8, T21N, R14E 6	E	96	5,013	20,000	20,000	70,500	I,F	Sierra Valley	3,823,000
Nelson Point	Middle Fork Feather River	Sec. 16, T23N, R10E 6	E	219	4,030	52,900	49,300	375,000	R,D,F	Upper Feather River and diverts to Meadow Valley Reservoir	5,216,000
Meadow Valley	Spanish Creek	Sec. 17, T24N, R9E 6	E	426	3,890	740,000	735,000		I,P,R,F	Upper Feather River	55,062,000
Hartman Bar	Middle Fork Feather River	Sec. 11, T22N, R7E 6	CG	145	2,445	----------	----------	----------	D,F	Divert to Swayne Reservoir	3,196,000
Swayne	French Creek	Sec. 35, 36, T22N, R5E 6	E	418	2,355	404,000	394,000	240,000	P,R	----------	37,644,000
Little Grass Valley	South Fork Feather River	Sec. 31, T22N, R9E 6	E	175	5,016	50,500	50,000	40,000	P,I	Between Feather and Yuba Rivers	3,007,000
Lost Creek (enlarged)	Lost Creek	Sec. 24, T20N, R7E 6	E	370	3,509	140,000	138,000	157,000	P,I	Between Feather and Yuba Rivers	24,723,000
Wicks Corner	Cottonwood Creek	Sec. 28, T20N, R3E 6	E	40	216	2,000	1,000	700	R	Area northwest of Oroville	242,000
South Honcut Creek	South Honcut Creek	Sec. 25, T18N, R5E 6	E	165	886	30,000	28,000	13,000	R	Between Feather and Yuba Rivers	2,273,000
Bangor	North Honcut Creek	Sec. 25, T18N, R4E 6	E	53	275	5,200	2,000	3,600	R	----------	572,000
Clover Valley	Smithneck Creek	Sec. 30, 31, T21N, R16E 6	E	88	5,168	6,000	5,500	6,300	I	Sierra Valley	----------
Randolph	Cold Stream	Sec. 19, T20N, R15E 6	E	157	5,197	21,000	19,000	23,000	I	Sierra Valley	----------
Mt. Ararat	Willow Creek	Sec. 14, T23N, R7E 6	E	80	5,480	4,000	3,500	11,000	R	----------	----------
Whiskey Hill	South Branch Middle Fork	Sec. 34, T22N, R7E 6	E	115	3,900	3,300	3,000	3,600	R	----------	----------
Quartz Hill	Fall River	Sec. 21, T21N, R7E 6	E	200	3,500	22,000	20,000	36,000	R	----------	----------
Oroville	Feather River	(Aqueduct feature—see Table 21)									
Yuba-Bear River Unit											
Jackson Meadows	Middle Yuba River	Sec. 18, T19N, R13E 6	E	159	6,010	45,000	43,000	49,200	P,I,F	Yuba and Bear Rivers	5,672,000
Wambo	North Yuba River	Sec. 8, 9, T19N, R8E 6	R	300	2,230	62,000	36,000	199,200	P	North Yuba River	8,490,000
Bullards Bar (enlarged)	North Yuba River	Sec. 24, 25, T18N, R7E 6	R	495	1,850	455,000	450,000	662,400	I,P,FC,F	Yuba River and Sacramento Valley	53,690,000
Freemans	Middle Yuba River	Sec. 32, T18N, R8E 6	R	495	1,850	300,000	295,000		I,P,FC,F	Yuba River and Sacramento Valley	38,220,000

TABLE 13—Continued

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SACRAMENTO RIVER BASIN

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

Dam and reservoir	Stream	Dam			Normal pool elevation, in feet	Storage capacity, in acre-feet		Seasonal yield, in acre-feet[a]	Purpose	Place of water use	Capital cost[b]
		Location, MDB&M, and sheet of Plate 5 on which shown	Type	Height, in feet		Gross	Active				
Yuba-Bear River Unit —Continued											
Washington	South Yuba River	Sec. 10, T17N, R10E 6	R	400	2,820	125,800	111,000	169,200	I,P,F	Yuba River and Grass Valley-Nevada City area	$22,982,000
Virginia Ranch	French Dry Creek	Sec. 21, T17N, R6E 6	E	120	1,160	36,000	35,000	27,600	I,F	Yuba River foothills	1,990,000
Lake Valley (enlarged)	North Fork of North Fork American River	Sec. 35, T17N, R12E 6	E	150	5,863	41,000	38,000	105,600	P,I,F	Foothill area between Bear and American Rivers	7,505,000
Scotts Flat (enlarged)	Deer Creek	Sec. 10, T16N, R9E 6	E	180	3,090	62,500	62,000	68,000	I,F	Grass Valley-Nevada City area	2,360,000
Anthony House	Deer Creek	Sec. 20, T16N, R7E 6	E	90	1,222	15,000	14,000	28,000	I,F	Smartville area	1,060,000
Rollins	Bear River	Sec. 22, T15N, R9E 6	E	260	2,200	100,000	74,000	256,000	P,I,F	Foothill area between American and Bear Rivers	8,700,000
Coon Creek	Coon Creek	Sec. 8, 17, T13N, R7E 8	E	215	552	59,000	----------	56,000	I	Sacramento Valley	----------
Doty Ravine	Doty Ravine	Sec. 30, 31, T13N, R7E 8	E	115	330	32,000	----------	28,000	I	Sacramento Valley	----------
Auburn Ravine	Auburn Ravine	Sec. 11, 14, T12N, R7E 8	E	185	640	11,700	----------	13,000	I	Sacramento Valley	----------
Parks Bar	Yuba River	(Aqueduct feature—see Table 21)									
Waldo	Dry Creek	(Aqueduct feature—see Table 21)									
Camp Far West	Bear River	(Aqueduct feature—see Table 21)									
American River Unit (Basic Plan)											
Lake Valley (enlarged)	(See Yuba-Bear River Unit)										
The Cedars (or suitable alternative)	North Fork American River	Sec. 13, T16N, R 14E 6	R	75	5,845	2,400	2,000	5,400	F	North Fork American River	540,000
Sugar Pine	North Shirttail Canyon	Sec. 24, T15N, R10E 6	E & R	180	3,670	17,000	17,000	10,400	I	Foresthill Divide	2,061,000
Big (enlarged)	Tributary of Forbes Creek	Sec. 17, T15N, R11E 6	E	92	4,108	6,500	6,500	8,800	I	Foresthill Divide	1,066,000
Forbes	Forbes Creek	Sec. 20, T15N, R11E 6	E	145	4,000	5,300	5,300	7,100	I	Foresthill Divide	1,545,000
French Meadows	Middle Fork American River	Sec. 36, T15N, R13E 6	R	225	5,224	90,000	87,000	72,000	P,F	Middle Fork American River	9,971,000
Lower Hellhole	Rubicon River	Sec. 16, 21, T14N, R14E 6	R	310	4,545	120,000	115,000	175,700	P,F	Middle Fork American River	14,400,000
Loon Lake (enlarged)	Gerle Creek	Sec. 4, 5, T13N, R15E 6	R	106	6,403	56,000	55,000	48,200	P,F	Middle Fork American River	6,092,000
Gerle	Gerle Creek	Sec. 2, 3, T13N, R14E 6	E	60	5,870	8,300	8,000	59,100	P,F	Middle Fork American River	930,000
Parsley Bar	Rubicon River	Sec. 29, T14N, R14E 6	CG	75	4,098	4,000	3,400	237,800	P,F	Middle Fork American River	1,410,000
American Bar	Middle Fork American River	Sec. 33, T14N, R11E 6	E & R	125	1,165	6,300	1,300	248,600	P,F	Middle Fork American River	2,260,000
Stumpy Meadows	Pilot Creek	Sec. 11, T12N, R12E 8	E	225	4,322	47,500	45,700	38,600	I	Georgetown Divide	6,626,000
Junction	Silver Creek	Sec. 30, T12N, R14E 8	CA or R	500	4,810	317,000	309,000	239,900	I,P,F	Placerville Divide	31,782,000
Webber (enlarged)	Webber Creek	Sec. 18, T10N, R12E 8	E	168	2,340	6,100	5,200	235,800	I,P,F	Placerville Divide	1,812,000
Alder Creek	Alder Creek	Sec. 8, T10N, R15E 8	E & R	265	5,385	80,000	79,000	70,700	I,P,F	Placerville Divide	9,965,000
Whitney Ranch	Pleasant Grove Creek	Sec. 11, T11N, R6E 8	E	72	193	10,300	----------	9,500	I	Sacramento Valley	----------
Auburn	North Fork American River	(Aqueduct feature—see Table 21)									
Salmon Falls	South Fork American River	(Aqueduct feature—see Table 21)									
Totals	----------	----------	----------	----------	----------	8,661,300	7,861,400				601,332,000

TABLE 13—Continued

SUMMARY OF WORKS TO MEET WATER REQUIREMENTS IN SACRAMENTO RIVER BASIN

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

Power plant	General location and sheet of Plate 5 on which shown		Average head, in feet	Installed capacity, in kilowatts	Average annual energy generation, in kilowatt-hours	Capital cost[b, c]
Sugarloaf Mountain	Hat Creek	4	548	5,000	42,000,000	$2,963,000
Pit No. 2	Pit River	4	105	14,000	95,000,000	3,244,000
Pit No. 6	Pit River	4	118	50,700	210,000,000	15,200,000
Pit No. 7	Pit River	4	182	98,000	333,000,000	22,300,000
Willow	McCloud River	1	1,126	122,000	644,000,000	22,550,000
Chonton Tubas	McCloud River	3	650	86,000	476,000,000	22,310,000
Fiddlers	Middle Fork Cottonwood Creek	3	250	8,000	45,000,000	2,550,000
Newville	North Fork Stony Creek	5	188	8,500	33,000,000	2,100,000
Deer Creek No. 1	Deer Creek	4	1,602	29,200	118,000,000	12,400,000
Deer Creek No. 2	Deer Creek	4	813	27,100	135,000,000	14,420,000
Deer Creek No. 3	Deer Creek	4	1,047	35,400	173,500,000	6,300,000
Deer Creek No. 4	Deer Creek	6	179	5,500	29,700,000	2,750,000
Squaw Queen	Feather River	4	1,660	14,000	51,900,000	3,093,000
Indian Falls	Feather River	4	650	25,000	126,000,000	7,936,000
Meadow Valley	Feather River	4	1,675	125,000	503,300,000	33,120,000
Swayne	Feather River	6	1,365	84,000	300,000,000	10,847,000
Woodleaf	Feather River	6	1,648	70,000	168,800,000	12,527,000
Forbestown	Feather River	6	785	13,000	146,800,000	10,278,000
Spaulding No. 3[d]	South Yuba River	6	318	3,200	9,300,000	475,000
Lake Valley	South Yuba River	6	812	17,500	82,000,000	2,669,000
Spaulding No. 2[d]	South Yuba River	6	305	2,300	14,900,000	385,000
Drum[d]	Bear River	6	1,375	68,000	276,000,000	2,180,000
Dutch Flat[d]	Bear River	6	643	7,000	25,000,000	820,000
Chicago Park	Bear River	6	488	25,000	96,000,000	8,910,000
Rollins	Bear River	6	205	11,000	57,500,000	2,904,000
Halsey[d]	Colfax Divide	8	331	3,500	6,400,000	450,000
Wise[d]	Colfax Divide	8	519	10,000	5,700,000	900,000
Deer Creek[d]	Colfax Divide	6	837	8,100	25,900,000	1,400,000
Devils Slide	South Yuba River	6	935	33,600	100,000,000	11,265,000
Jones Bar	South Yuba River	6	765	23,700	78,000,000	8,130,000
Wambo	North Yuba River	6	385	17,700	116,000,000	4,040,000
Bullards Bar	North Yuba River	6	1,157	131,000	800,000,000	25,650,000
French Meadows	Rubicon River	6	618	11,000	52,300,000	4,110,000
Lower Hellhole	Rubicon River	6	385	18,000	78,300,000	4,060,000
Loon Lake	Gerle Creek	6	512	5,500	26,100,000	2,690,000
Gerle	Rubicon River	6	1,687	21,000	109,700,000	4,810,000
Ralston	Rubicon River	8	2,743	135,000	684,000,000	27,146,000
American Bar	Middle Fork American River	8	203	16,000	106,000,000	6,800,000
Junction	South Fork American River	8	1,120	60,000	301,600,000	15,890,000
Sly Park	Sly Park Creek	8	154	10,000	34,100,000	4,840,000
Camino	Webber Creek	8	838	45,000	184,800,000	9,894,000
Webber	Webber Creek	8	142	7,000	30,900,000	1,200,000
Placerville	Placerville	8	347	19,000	73,600,000	4,760,000
Gold Hill	South Fork American River	8	887	45,000	103,500,000	6,150,000
Alder Creek	Alder Creek	8	1,372	20,000	104,500,000	4,153,000
Totals				1,594,500	7,213,100,000	$373,569,000

Conduits	Length, in miles				Capital cost*
	Canal	Tunnel	Pipe	Total	
Feeders for reservoirs	185	82	11	278	[e]$102,277,000
Power conduits	68	99	21	188	[f]160,836,000
Main upland irrigation conduits	685	8	3	696	48,767,000
Sacramento Valley waste conduit	135		40	175	20,514,000
Totals	1,073	189	75	1,337	$332,394,000

[a] Includes yield of upstream works, if any.
[b] At 1955 price levels.
[c] Cost of each plant includes associated works except reservoirs.
[d] Tabulated data pertain to enlarged portion of existing plant.
[e] Cost included with reservoirs.
[f] Cost included with power plants.

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

Symbols of Purpose
I—Irrigation
P—Power
FC—Flood control
F—Enhancement of fish environment
R—Recreation
D—Diversion

San Joaquin River Basin—Diversion Flume From Mokelumne River adequacy of the available water supply to meet many present needs, to support continued expansion, and to sustain and protect the vast agricultural wealth of the basin during periods of drought which may occur at any time. The present annual water deficiency, estimated to be about 2,300,000 acre-feet in 1957, is so great that if a severe drought period, such as those experienced in the past, should now occur, the necessary water conservation and conveyance works could not be constructed fast enough to prevent widespread havoc and economic disaster.

Major reservoirs have been constructed on virtually all streams on the east side of the San Joaquin-Tulare Lake Basin. In addition to this substantial development of surface water sources, many of the local public water districts supplement their water supplies by use of ground water. Many other areas are completely dependent upon ground water supplies. Use of ground water is increasing, and this trend is certain to continue.

Operation of the surface reservoirs and use of the underground basins have resulted in a high degree of conservation and utilization of the natural runoff of the tributary streams of the basin, particularly those streams south of the Merced River. In addition, large quantities of water, amounting to 675,000 acre-feet during 1956, are imported from the Sacramento-San Joaquin Delta in the Delta-Mendota Canal. Despite such extensive development, there is an urgent need for additional supplemental water supplies. There is also a need for works which will make available a portion of the local water supplies for mountain and foothill lands so that these lands may develop. In those stream basins where water supplies are fully utilized on valley floor lands, exchange or purchase agreements will be necessary.

As of 1950, the seasonal requirement for water in the San Joaquin Valley was estimated to be 9,300,000 acre-feet. Ultimate realization of the full potential for agricultural and other types of development would increase this requirement to about 16,300,000 acre-feet annually, a virtual doubling of the water requirement. Runoff of tributary streams, which already has been almost fully developed, can support only about one-half of this requirement; the remainder, over 8,500,000 acre-feet annually, ultimately must be imported.

At the present time there are large overdrafts in all valley hydrographic units in the Tulare Lake Basin and in several of the valley units of the San Joaquin River Basin. These deficiencies are particularly serious in the western and southern portions of the valley and in certain areas of the eastern portion which, although located close to the Friant-Kern Canal, cannot be supplied therefrom because the limited supply available has already been contracted for in other areas.

For some years past the expansion of irrigated areas devoted to permanent crops has occurred chiefly by the utilization of ground water supplies, and the recent and increasing development of the west side area has been dependent entirely upon the development and use of ground water. Many other areas which have limited or no surface supplies, and which depend mainly upon ground water, are experiencing serious water deficiencies. In many of these localities, particularly in the southeastern part of the valley and, more recently, on the western side of the valley, expansion of irrigated areas has continued in the face of this deficiency. With the continued recession of the ground water levels, amounting to as much as 30 feet per year in some instances, water supplies in some areas have become almost exhausted, while in others pumping lifts have become so excessive as to be nearly economically prohibitive. Annual overdrafts, accumulating for many years, have so depleted many portions of the ground water basins that excessive pumping lifts will reduce net agricultural profits for years to come, until costly imported water, supplied in quantities in excess of actual water requirements, has refilled the basins.

In certain of the west side areas the surface and much of the ground water supplies are of poor quality, and it is probable that in some cases their use is even now detrimental to the utility of the soil. Other serious problems of water quality are developing on the west side of the San Joaquin Valley. In much of this area the usable aquifer for pumping is found between overlying unusable perched water and underlying connate brines, and improperly constructed wells permit a commingling of the waters in the three zones to the detriment of the usable water. There is also a serious water quality problem along the lower reaches of the San Joaquin River during much of the irrigation season when the flow is composed entirely of drainage and return waters.

There are also many areas in the San Joaquin-Tulare Lake Basin where serious drainage problems exist. In some instances increased use of ground water would alleviate such problems; in other areas surface drainage systems are needed. There is an urgent need to intercept, collect, and drain from the basin increasing quantities of agricultural, municipal, and industrial waste waters and other waters of degraded or impaired quality. As additional supplemental water supplies become available, there will be an increased need for drainage, particularly in the closed Tulare Lake Basin.

In past years of subnormal runoff and prior to the construction of Shasta Dam on the Sacramento River, available inflow to the Delta from the Sacramento and San Joaquin River systems was insufficient during certain months to meet water demands in the

Delta. During such periods the invasion of saline water from San Francisco Bay into the Delta channels rendered the water unfit for irrigation and other uses, not only in the Delta and adjacent uplands but also in the adjacent upper portions of the San Francisco Bay. At the present time, when necessary, releases of water are made from Shasta Reservoir to flow out into the bay to prevent the recurrence of this situation.

Damaging floods have occurred in past years of large runoff, and their possible repetition is a menace to some of the improved valley lands in populated areas. Although works for flood protection, including major flood control reservoirs such as Pine Flat and Isabella, have been provided for considerable portions of the area subject to flooding, there is still a need for additional flood control works on many streams to protect many of the valley lands of the basin.

The San Joaquin-Tulare Lake Basin has been subdivided into five separate geographical subdivisions, and the development works to meet local requirements are segregated according to these subdivisions for discussion herein. Under the first two subdivisions, "San Joaquin-Sierra Group," and "Tulare-Sierra Group," major works of The California Water Plan on east side streams and tributaries of the San Joaquin-Tulare Lake Basin are described. Such works would be operated to accomplish the necessarily high degree of conservation of runoff, and would furnish large amounts of incidental hydroelectric energy and provide a large measure of flood control. There are also described additional works, generally of smaller size, which would be necessary adjuncts to the major works, in order that local requirements would be met in all foothill and mountain watersheds above the floor of the San Joaquin Valley. The two groups include all mountain and foothill lands of the basin, and their common boundary is the watershed divide between the San Joaquin and Kings Rivers. The third subdivision, "West Side Group," encompasses the Coast Range slopes of the San Joaquin-Tulare Lake Basin with its numerous minor peripheral streams, from Marsh Creek on the northwest side to Buena Vista Creek near Taft. The fourth subdivision, "North Valley Group," includes the northern portion of valley floor lands of the basin. Works in the southern portion are described in connection with the fifth subdivision, "South Valley Group." The locations of the various units are shown on Plate 3. Following the discussion of all works in the basin, there is a summary statement, with tables, showing principal characteristics of the various works and their estimated costs. The works included in the California Aqueduct System and lying within the San Joaquin-Tulare Lake Basin are described separately in a later part of this chapter.

San Joaquin-Sierra Group. The San Joaquin-Sierra Group includes all mountain and foothill lands of the San Joaquin-Tulare Lake Basin lying north of the watershed divide between the San Joaquin and Kings Rivers. Consisting of mountainous and foothill areas, the region is favored by forest, mineral, and recreational resources and developments typical of such areas. There is a considerable amount of irrigable land, approximately 278,000 acres, of which only 11,700 acres were irrigated in 1950. Large timber resources are located in this group.

Much of the flow of the streams draining the San Joaquin-Sierra Group has already been developed for use on the San Joaquin Valley floor and for export to the San Francisco Bay Area. Flood problems within the group are of minor importance; however, foothill reservoirs are now and in the future will be operated to give flood protection to lands on the valley floor. Hydroelectric power is presently developed on the Mokelumne, Stanislaus, Tuolumne, Merced, and San Joaquin Rivers. Other streams of the group include the Cosumnes, Calaveras, Chowchilla, and Fresno Rivers, and minor east side streams which are directly tributary to the valley floor.

As of 1950, the seasonal water requirements for lands in the San Joaquin-Sierra Group aggregated about 41,000 acre-feet and were met, for the most part, by direct stream diversion, with only little use of reservoir storage. It is estimated that ultimate water requirements will total about 520,000 acre-feet, which could be met by contemplated future reservoirs and diversion works of The California Water Plan subsequently described. As indicated previously, the streams of this group furnish water not only to foothill and mountain lands therein, but also to lands on the San Joaquin Valley floor and for export to the San Francisco Bay Area. Under full development it is estimated that the firm yield of all reservoirs on streams in the group would be about 4,070,000 acre-feet annually, of which about 520,000 acre-feet would be allocated to foothill and mountain lands.

Development on the Cosumnes River for use in that watershed has been relatively minor. There are several small diversions in the foothills and lower mountain regions for irrigation and domestic purposes; however, the total quantity of water which is now diverted from the upper river for local use is small in comparison with the total runoff of the watershed. The most substantial export from the watershed, about 17,000 acre-feet per season, is conveyed from the recently completed Sly Park Reservoir on Sly Park Creek, with a capacity of 41,000 acre-feet, to the American River watershed.

The Mokelumne River is subject to heavy draft for irrigation, power, and municipal purposes. Salt Springs and Bear River Reservoirs in the headwater area supply the Pacific Gas and Electric Company power development. Pardee Reservoir in the foothills, with a capacity of 239,000 acre-feet, develops municipal water supply for the East Bay Municipal Utility District in Alameda and Contra Costa Counties, with some attendant hydroelectric power generation.

Existing developments on the Stanislaus River include Melones Reservoir, with a capacity of 112,500 acre-feet, owned jointly by the Oakdale and South San Joaquin Irrigation Districts; and the Tri-Dam Project, consisting of Donnells, Beardsley, and Tulloch Reservoirs and associated power plants, presently under construction by the same districts. The Tri-Dam Project will add substantially to the present irrigation supplies and hydroelectric energy developed by Melones Reservoir.

Existing developments on the Tuolumne River include works by the City and County of San Francisco in the upper watersheds to provide water, hydroelectric power, and conveyance of the water to the San Francisco Peninsula for use in the San Francisco Bay Area. These works include three reservoirs, Hetch Hetchy, Lake Eleanor, and Cherry Valley, with a combined storage capacity of 656,000 acre-feet. In 1954-55, about 123,000 acre-feet of water were conveyed in the Hetch Hetchy Aqueduct to the Bay area. Additional works, including Don Pedro Reservoir, with a capacity of 289,000 acre-feet, have been constructed on the main river by the Modesto and Turlock Irrigation Districts to generate power and to provide water for use in their service areas in the San Joaquin Valley.

Exchequer Dam on the Merced River forms McClure Reservoir, owned by the Merced Irrigation District. The reservoir, with a capacity of 289,000 acre-feet, is operated to store water for irrigation use in the valley and for hydroelectric power production.

There are no existing developments of any consequence on the Fresno or Chowchilla Rivers, which rise too far from the crest of the Sierra and at too low an elevation to be snow-fed in the summer months. Runoff from these streams varies from little or no flow to flashy floods.

The San Joaquin River rises on the western slope of the Sierra Nevada and flows southwesterly, discharging from the foothills to the trough of the valley floor, where it turns northwesterly and traverses the San Joaquin Valley to its confluence with the Sacramento River at the head of Suisun Bay. The Southern California Edison Company has developed an extensive system of power plants and four major storage reservoirs on the upper watersheds, comprising Florence, Huntington, Shaver, and Vermillion Lakes Reservoirs, with a combined storage capacity of about 448,000 acre-feet. This system utilizes a large part of the flow of the river for hydroelectric power production. The Pacific Gas and Electric Company, with 46,000 acre-feet of regulatory storage in Crane Valley Reservoir, also develops power in the lower watershed. Releases from the two systems are combined in the small Kerckhoff Reservoir and are discharged through the Kerckhoff Power Plant. Friant Dam, forming Lake Millerton with a storage capacity of 520,000 acre-feet, has been constructed at the valley floor line by the United States Bureau of Reclamation and is operated for irrigation and flood control purposes.

Plans for development of the water resources of the San Joaquin-Sierra Group contemplate the eventual construction of 57 dams and reservoirs to make water available for use on mountain and foothill lands and on the valley floor. The reservoirs would also protect the watershed lands, preserve and enhance fish, wildlife, and recreation, and give flood protection to the valley floor. A number of the reservoirs would be operated either primarily or partly to produce hydroelectric energy. The contemplated works in each of the major river basins are described separately.

Works in the Cosumnes River Basin would include 12 dams and reservoirs on the North, Middle, and South Forks of the Cosumnes River and their tributaries, on the main river, and on Deer, Sutter, and Dry Creeks. Additional water would be made available to the basin from works on the South Fork of the American River and by the Amador Canal which conveys water from the Mokelumne River. Works on the North Fork would include Capps Crossing and Middle End Reservoirs. Two reservoirs, Bakersford and Pi Pi, would be located on the Middle Fork. Sopiago Reservoir would be located on Sopiago Creek, a tributary of the Middle Fork. Works on the South Fork would include two reservoirs, Bridgeport and Case Valley. Other reservoirs in the basin would include Volcano on Sutter Creek, Deer Creek on Deer Creek, and Irish Hill on Dry Creek.

Water conserved in these reservoirs would supplement existing diversions to meet water requirements in the Cosumnes River Basin and on adjacent lands above the valley floor. In addition, all of the reservoirs would be operated to preserve and enhance the fish, wildlife, and recreation values of the watershed. Two major reservoirs, Nashville and Michigan Bar, would be constructed on the main river. Water conserved in Nashville Reservoir would be discharged through a power plant for power generation, and then to the natural channel of the Cosumnes River for downstream irrigation and to augment low flows in the interests of fish and wildlife. A substantial portion of these waters would be diverted immediately below the power plant and conveyed in a southerly direction to serve lands south of the river. The remaining waters would be impounded downstream in Michigan Bar Reservoir, together with the intervening tributary runoff, reregulated to meet irrigation demands, and released to the natural channel for downstream diversion and for use on the valley floor. Nashville and