PREVIEW OF

THE CALIFORNIA WATER PLAN

STATE OF CALIFORNIA
GOODWIN J. KNIGHT
GOVERNOR

PUBLICATION OF
STATE WATER RESOURCES BOARD

March, 1956
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## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LETTER OF TRANSMITTAL, STATE WATER RESOURCES BOARD</td>
<td>i</td>
</tr>
<tr>
<td>ORGANIZATION, STATE WATER RESOURCES BOARD</td>
<td>iv</td>
</tr>
<tr>
<td>ORGANIZATION, STATE DEPARTMENT OF PUBLIC WORKS, DIVISION OF WATER RESOURCES</td>
<td>iv</td>
</tr>
<tr>
<td>ORGANIZATIONAL CHANGES</td>
<td>v</td>
</tr>
<tr>
<td>PREFACE</td>
<td>vi</td>
</tr>
<tr>
<td>PREVIEW OF THE CALIFORNIA WATER PLAN</td>
<td>1</td>
</tr>
<tr>
<td>The Problems</td>
<td>3</td>
</tr>
<tr>
<td>The Geographic Problem</td>
<td>3</td>
</tr>
<tr>
<td>The Problem of Regulation</td>
<td>7</td>
</tr>
<tr>
<td>Other Physical Problems</td>
<td>9</td>
</tr>
<tr>
<td>Solving the Problems</td>
<td>10</td>
</tr>
<tr>
<td>Local Development</td>
<td>13</td>
</tr>
<tr>
<td>North Coastal Area</td>
<td>13</td>
</tr>
<tr>
<td>San Francisco Bay Area</td>
<td>14</td>
</tr>
<tr>
<td>Central Coastal Area</td>
<td>15</td>
</tr>
<tr>
<td>South Coastal Area</td>
<td>16</td>
</tr>
<tr>
<td>Central Valley Area-Sacramento River Basin</td>
<td>17</td>
</tr>
<tr>
<td>Central Valley Area-San Joaquin River and Tulare Lake Basins</td>
<td>19</td>
</tr>
<tr>
<td>Lahontan Area</td>
<td>20</td>
</tr>
<tr>
<td>Colorado Desert Area</td>
<td>21</td>
</tr>
<tr>
<td>The California Aqueduct System</td>
<td>21</td>
</tr>
<tr>
<td>Klamath-Trinity Division</td>
<td>22</td>
</tr>
<tr>
<td>Eel River Division</td>
<td>23</td>
</tr>
<tr>
<td>Sacramento Division</td>
<td>24</td>
</tr>
<tr>
<td>Delta Division</td>
<td>26</td>
</tr>
<tr>
<td>South Bay Aqueduct</td>
<td>27</td>
</tr>
<tr>
<td>San Joaquin Division</td>
<td>28</td>
</tr>
<tr>
<td>Central Coastal Aqueduct</td>
<td>30</td>
</tr>
<tr>
<td>Southern California Division</td>
<td>31</td>
</tr>
<tr>
<td>Costs</td>
<td>34</td>
</tr>
<tr>
<td>Summary</td>
<td>36</td>
</tr>
</tbody>
</table>
Honorabe Goodwin J. Knight, Governor, and Members of the Legislature of the State of California

Gentlemen:

We have the honor to transmit herewith a report entitled "Preview of The California Water Plan", authorization of which was initiated by Chapter 1541, Statutes of 1947.

Under the provisions of the cited statute and subsequent budget acts, the Legislature directed the State Water Resources Board to investigate the water resources of California and formulate plans for their orderly development. The investigation is being conducted by the Division of Water Resources of the Department of Public Works, under direction of the State Water Resources Board.

This report provides a summary statement of the works planned to ensure the conservation and control of water resources necessary for continued growth and economic development of the State. These works will provide sufficient water supplies to meet anticipated water requirements for all beneficial uses in all areas of the State, insofar as practicable. In addition, substantial benefits will accrue to the people of the State by reason of the flood control provided, by salinity repulsion, and by enhancement of fish and wildlife resources and recreational facilities.

State Water Resources Board Bulletin No. 3, "Report on The California Water Plan", to be published in preliminary form later this year, will discuss the plan in more detail.

Very truly yours,

Chairman

By Clair A. Hill

Chairman
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William L. Berry . . . . . . . . . . Assistant State Engineer

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John M. Haley
Principal Hydraulic Engineer
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Isabel C. Nessler, Coordinator of Reports

ORGANIZATIONAL CHANGES

The investigation resulting in the formulation of The California Water Plan was authorized by
the State Legislature in 1947 and initiated on September 5, 1947, by adoption of a program of investigation
by the State Water Resources Board.

Royal Miller was Chairman of the Board at the inception of the investigation, being succeeded
by C. A. Griffith, and later by the present Chairman, Clair A. Hill. Changes in the membership of the Board
have been occasioned by the resignation of Mr. Miller on January 15, 1953, the retirement of Mr. H. F.
Cozzens on January 1, 1954, and the death of Mr. B. A. Etcheverry on October 26, 1954.

Edward Hyatt was State Engineer at the inception of the investigation. Mr. Hyatt retired on
January 31, 1950, and was succeeded by A. D. Edmonston, who retired on November 1, 1955. The investigation
has been successively under the general supervision of Assistant State Engineers A. D. Edmonston to January
31, 1950; 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.

Conduct of the investigation has been successively under the direction of the following principal hydraulic engineers:
P. H. Van Etten, until January 31, 1950, at which time he assumed duties as Assistant State Engineer; T. R. Simpson, until September 15, 1950, at which time he resigned to accept appointment as Professor of Civil Engineering at the University of California; William L. Berry, until November 3, 1955, at which time he assumed duties as Assistant State Engineer; and John M. Haley, since November 3, 1955.
It is engineeringly and physically feasible to provide the works to control, conserve, and distribute our water resources. The California Water Plan, which is briefly described in this report, will be presented to the Legislature in greater detail later this year. It will provide 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. This plan should be adopted by the Legislature at the earliest practicable time, and thereafter future water developments by all agencies should reasonably conform thereto.

There are few, if any, areas of the State which will not need physical works for the development of water resources. The problem cannot be considered as one pertaining solely to the so-called "areas of deficiency". The California Water Plan must be implemented by a state-wide program for the construction of needed projects to control and supply water wherever the need arises and as projects are found feasible. The job is a big one, and will require the combined efforts of the Federal Government, the State Government, and local entities. But the State must take a leading role.

The Feather River Project is the initial unit of The California Water Plan. It is urgently needed now, and must be started immediately. But this project alone will not meet all of our current needs for water in all areas of the State. Other projects must follow. Finally, and this cannot be emphasized too strongly, solution to the water problems of California lies in the construction of physical works—not alone in reservations and laws, however necessary these may be as steps in the process.

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and prosperity of California is dependent upon prompt and substantial efforts by the responsible local, State, and Federal governments to provide physical solutions to the problems of water, commensurate with the needs.

The State Water Resources Board, created in 1945 to advise the Legislature in matters of water, was authorized by the Legislature in 1947 to conduct an investigation of the water resources of California. The adopted investigational program, being conducted for the Board by the Division of Water Resources, has the objective of formulating a long-range plan for comprehensive development of the water resources of the entire State. Basically, the planning is being done in order that urgently needed water projects of today may be designed to fit a pattern appropriate for the future.

The first phase of the 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, Bulletin No. 2, "Water Utilization and Requirements of California", has just been printed and is now available from the State Printer. This bulletin includes determinations of the present use of water throughout the State for all consumptive purposes, and presents forecasts of ultimate water requirements, based in general on the capabilities of the land to support further development. The term "ultimate" is used as descriptive of conditions of essentially complete development.

The third and final phase of this initial planning program has been proceeding concurrently with the foregoing studies, and will soon be completed. This constitutes the surveys and studies for The California Water Plan, the results of which will be presented in Bulletin No. 3 on or about next June 30th.

The Problems

Correlation of the data from Bulletin No. 1 on the quantities and characteristics of our water resources with that from Bulletin No. 2 on our requirements for water, enables an understanding of the physical problems of water development in California. In addition, many difficult legal, financial, and organizational problems are inherent to the physical problems in the future control, conservation, protection, and use of water. While the importance of this latter group of problems is fully recognized, this report is largely concerned with solution of the physical problems of water development in our State.

In order to facilitate the state-wide studies, the land area of California was divided into seven major hydrographic areas. Locations and boundaries of these areas are shown on Plate 1.

The Geographic Problem

For practical purposes, the amount of stream flow constitutes the measure of that portion of the natural water resources
that is available for control, regulation, and distribution to meet requirements for water. The outstanding characteristic of runoff in California is its geographic maldistribution. The major sources of water are in the northern part of the State where they can conveniently waste into the ocean unused. On the other hand, the great productive land areas are located in the central and southern regions where water supplies are insufficient. The picture is complicated by the intervening mountain ranges. Well over 70 percent of the stream flow occurs north of a line drawn roughly through Sacramento. In contrast, an estimated 77 percent of the present consumptive water requirement and 80 percent of the forecast ultimate are found south of the same line.

The estimated mean seasonal natural runoff of all California streams is about 71,000,000 acre-feet. The greatest contributions come from streams of the North Coastal Area, which furnish about 41 percent of the total for the State, and from streams of the Sacramento River Basin in the Central Valley Area, which furnish about 32 percent. Most of the remainder of the natural water supplies, some 16 percent of the State's total, is in the San Joaquin Valley of the Central Valley Area. The San Francisco Bay, Central Coastal, and South Coastal Areas, and the Lahontan and Colorado Desert Areas receive only relatively insignificant portions of our vital water resource.

Now, what about our growing requirements for water? In this connection, the continuing population growth is rightfully recognized as a prime factor in accentuating our historic water problems. Furthermore, forecasts, based generally on the capability of the land to support a balanced economy, indicate that the present population of more than 13,000,000 may increase to more than 40,000,000 under conditions of complete development.

Along with much greater domestic and municipal needs for water, the future population growth will bring increased demands for water for industries founded on local resources, including the processing of agricultural products, ores, chemicals, petroleum, steel, and timber. It is anticipated that the total use of water for all urban and related purposes will increase about five-fold from the present, in the ultimate future, from about 1,600,000 acre-feet per season to about 8,400,000. These values are measured in terms of consumptive use of applied water plus unavoidable losses. The estimates of "present" values actually represent conditions as of about 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 90 percent of the total for all beneficial purposes, and will decrease only to about 80 percent ultimately. The actual requirement for water for irrigated agriculture, at present about 19,000,000 acre-feet per season, should more than double under conditions of complete development, to more than 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 nearly two and one-half times, to some 50,000,000 acre-feet per season. It is most significant to compare the geographical distribution of this forecast of ultimate requirements with the runoff estimates.
previously presented. The comparison, which is graphically illustrated on Plate 1, demonstrates the geographic problem inherent in major water supply development in California.

The North Coastal Area with its large natural water supply, 41 percent of the State's total, should ultimately require only about 4 percent of the water consumptively used throughout California. As regards the Central Valley Area, it is coincidental that with 48 percent of the State's runoff this area should ultimately require almost exactly 48 percent of the developed water supplies. However, more than two-thirds of this ultimate use should be in the water-deficient San Joaquin Valley, while the Sacramento River Basin enjoys two-thirds of the Central Valley's runoff.

It is forecast that the San Francisco Bay Area and the South Coastal Area, despite their tremendous metropolitan communities, will need only about 6 and 11 percent, respectively, of the ultimately developed water supplies. Between them they receive a sparse 3.5 percent of our natural water supplies. Finally, the extremely arid Lahontan and Colorado Desert Areas, with less than 5 percent of the runoff of California between them, have the potential to use 14 and 12 percent, respectively, of the ultimately developed water supplies of the State.

These data, developed in State Water Resources Board Bulletins Nos. 1 and 2, not only demonstrate the basic geographical water problem of California, but also indicate the solution to that problem. From the abundant water supplies of the North Coastal Area and the Sacramento River Basin, an average of approximately 21,000,000 acre-feet of water per season will ultimately
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have to be developed and exported to the remaining inherently water-deficient areas of the State. These exports will be surplus waters, over and above the waters needed in the North Coastal Area and the Sacramento River Basin for local use. With the full practicable development of local water resources in all areas of the State for local use, and with the water available under California's rights in and to the waters of the Colorado River, these exports from the north will satisfy the probable ultimate requirements for water in all parts of the State.

The Problem of Regulation

The problem attendant with the geographic maldistribution of our water resource has been described. Another outstanding characteristic of the water resource of California is the sporadic timing of its occurrence. Throughout the State the bulk of precipitation occurs in a few winter months, while the summers are almost always long and dry. Although runoff from the higher mountain ranges is regulated to a considerable extent by the effect of the mountain snow packs, most of the stream flow in California closely follows the pattern of precipitation, and comes during the winter and early spring months--frequently in the form of damaging floods of high intensity and short duration. The economically important part of the stream flow that is delayed until the late spring and early summer snowmelt period is insufficient to provide for the large demands for water in the summer and fall.

In addition to the characteristic variation in its natural water supply within the year, California is subject to extended wet and dry periods. In the late 20's and early 30's we
suffered a severe drought—one of a great many in the past—dur­ing which runoff in the streams throughout the State for a 10-
year period averaged only a little more than 50 percent of the 
long-time mean. In this connection, while the state-wide runoff 
has averaged some 71,000,000 acre-feet per season, the actual sea-
sonal flows have varied from as little as 18,000,000 acre-feet to 
more than 135,000,000 acre-feet.

The normal monthly variations in occurrence of the wa­
ter supplies of California, as well as the periodic droughts, 
create a most basic problem relative to the development and use 
of water. They dictate the provision of extremely large amounts 
of reservoir storage capacity, for necessary seasonal and cyclic 
regulation to meet the needs as they occur.

The importance of ground water storage capacity in meet­
ing the problem of water supply regulation should be emphasized. 
Extensive ground water basins provide natural regulation for more 
than half of the water presently used in California. The avail­
able underground storage capacity, estimated to be over 130,000,000 
acre-feet within 200 feet of the ground surface in the Central 
Valley Area alone, constitutes one of the most valuable natural 
resources of the State. The significance of this vast ground wa­
ter storage capacity may be appreciated by relating it to the 
4,500,000 acre-feet of surface storage capacity that has been 
made available at great expense in Shasta Reservoir on the Sacra­
mento River. When operated coordinate with existing surface 
reservoirs, and with those feasible of future construction, ground 
water basins will provide relatively inexpensive regulation for 
sufficient water to meet the forecast ultimate requirements.

However, draft on many of these basins now exceeds replenishment, 
and in some instances the overdraft is of such magnitude as to 
threaten irreparable damage to these valuable storage reservoirs.

Other Physical Problems

A multiplicity of other physical problems is involved 
in the development and use of the waters of California for benefi­
cial purposes. These include flood control, repulsion of sea 
water from underground basins, drainage of high-water-table lands, 
maintenance of salt balance on irrigated lands, and protection 
and maintenance of the quality of fresh waters.

The critical need for flood control and protection in 
California has been tragically emphasized by recent events, and 
must not be minimized in any planning for future water develop­
ment. The occurrence of intense winter rains over extensive areas 
periodically creates flood conditions which result in major damage 
and loss of life. The great floods of 1907, 1938, 1950, and 1955 
resulted from rainfall of this type. In addition, accelerated 
snowmelt, caused by unseasonable early spring temperatures, fre­
quently creates serious problems in controlling the resultant 
runoff and preventing the flooding of agricultural and urban areas. 
Flood control and protection may be effected by storage of flood 
waters in reservoirs, improvement of flood channels by levees and 
revetments, and by the creation of by-pass floodways, or by a 
combination of these measures. In general, flood control works 
can be advantageously integrated with water conservation works, 
and the operations of the two types of works are susceptible of 
coordination.
Solving the Problems

As has been stated, Bulletin No. 3 of the State Water Resources Board, presenting The California Water Plan, will be published later this year. The bulletin will describe two principal categories of water resource developments. The first group will consist of local works in each of the major hydrographic areas of California designed to meet present and future needs within the respective areas. The second group will comprise a major system of works to conserve and export surplus waters from the North Coastal Area and the Sacramento River Basin, and to transport these waters to areas of deficiency elsewhere in the State, in sufficient amounts to meet the forecast ultimate requirements. These export-import facilities are collectively termed "The California Aqueduct System". Operation of both the local water resource developments and The California Aqueduct System will be outlined in Bulletin No. 3, and their achievements and costs estimated.

The California Water Plan, comprising both The California Aqueduct System and the more local works, will give consideration to water conservation and reclamation, to flood control and flood protection, to the use of water for agricultural, domestic, and industrial purposes, to hydroelectric power development, to salinity control and protection of the quality of fresh waters, to navigation, and to the interests of fish, wildlife, and recreation. It will contemplate 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 following concepts have entered into the planning studies, and, for proper evaluation of the results, should be borne in mind:

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 will provide for future beneficial uses of water by individuals and agencies in all parts of the State. With adoption and authorization of the plan, and with firm provision for its progressive implementation as component projects become feasible, sectional concern as to future availability of necessary water supplies should be eliminated.

3. The California Water Plan is a flexible pattern into which future definite projects may be integrated in an orderly fashion, with due consideration to varying interests. 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.

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 its 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 engineering 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. Such works are for the indefinite future, and 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 the unit for initial construction under The California Water Plan.

Construction of the Feather River Project by the State of California, acting through the Water Project Authority, was authorized by the Legislature by Chapter 1441, Statutes of 1951. The Feather River Project is the first state-wide project ever proposed for California, and is designed to deliver water outside of the Sacramento and San Joaquin Valleys, as was never envisioned in the earlier Central Valley Project. All future large-scale transfers of water will, of necessity, supplement or parallel the principle of this project.
The Feather River Project, with an estimated capital cost in the order of $1,500,000,000, is but the first unit of The California Water Plan. It is apparent that the plan will involve the eventual construction of new works throughout California. The most efficient use of water, and the full practicable reclamation of waste waters will be required. It is also apparent that the full amount of the rights of California in and to the waters of the Colorado River must be protected to meet present and future requirements within the State. In addition, intelligent and planned use must be made of our natural ground water reservoirs.

Local Development

It is beyond the scope of this brief report to more than generally refer to the numerous preliminary plans being made for local water resource development to meet local needs throughout California. It is contemplated, however, that under The California Water Plan water in all hydrographic areas would ultimately be developed to the maximum practicable extent. Exports from areas of surplus would be excess waters, over and above those required to meet local needs, and limited to the amounts needed to supplement the locally developed supplies in deficient areas.

North Coastal Area. Present development of the ample water resources of the North Coastal Area is very limited. There is a diversion from the Upper Eel River into the Russian River Basin primarily for the generation of hydroelectric power, as
well as a power development 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. 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.

As has been stated, The California Water Plan would meet all future local water requirements in the North Coastal Area. In certain instances the works for local water supply would be integrated with the export features. The reservoirs of The California Aqueduct System would also provide much needed local flood control, and releases of water to enhance summer and fall stream flow in the interests of fish, wildlife, and recreation. Furthermore, a substantial portion of the energy created by the hydroelectric power plants of The California Aqueduct System would be available for local needs. The strictly local water developments in the North Coastal Area would include small conservation reservoirs to provide water for consumptive needs, and for stream flow maintenance. Levees and stream channel improvements would provide flood protection. These works of a local nature would include nearly 50 reservoirs with an aggregate storage capacity of about 3,500,000 acre-feet, yielding about 2,200,000 acre-feet of new water each season.

San Francisco Bay Area. The somewhat limited water resources of the San Francisco Bay Area are already highly developed. This condition, which has existed for a number of years, is coupled with large urban water demands, and has fostered the importation of water from distant watersheds by major aqueduct systems. Locally, the City of San Francisco has developed the waters of the Peninsula, and of the Alameda Creek system across the bay. The East Bay Municipal Utility District similarly utilizes local waters of the east bay area. Water supplies of the north bay have been almost fully developed by the Marin Municipal Water District and other agencies and communities. In addition, the ground water resources of the Santa Clara and Livermore Valleys and southern Alameda County are utilized to a degree of substantial overdraft for urban and agricultural purposes.

The California Water Plan contemplates further development of local water resources of the San Francisco Bay Area to the extent of practicability, and the coordinated operation of existing and proposed import works under The California Aqueduct System. Works for further local conservation development would include nine small reservoirs, with aggregate storage capacity of about 200,000 acre-feet, and new seasonal yield of about 86,000 acre-feet. Channel improvements would provide protection from the flood waters of local streams.

Central Coastal Area. Under present conditions in the Central Coastal Area, relatively large amounts of surface runoff waste to the ocean. However, intensive development of ground water supplies for municipal, domestic, and agricultural purposes has occurred in the South Santa Clara and San Benito Valleys, the Pajaro and Lower Salinas River Basins, the Arroyo Grande, Santa Maria, and Cuyama Valleys, and the Lompoc Plain area. Small
reservoirs have been constructed, principally for municipal use, in the South Santa Clara Valley, on the Carmel River, and on the upper Salinas River. Three reservoirs to conserve runoff of the Santa Ynez River meet demands for water in the Santa Barbara coastal area. The Nacimiento Project, in the Salinas River Basin, is now under construction by the Monterey County Flood Control and Water Conservation District. The California Water Plan includes works to accomplish a higher degree of control and conservation of waters of the Central Coastal Area now wasting to the ocean. The works planned, including the cited Nacimiento Project, comprise reservoirs with an aggregate conservation storage capacity of some 2,300,000 acre-feet, from which a new yield of about 430,000 acre-feet per season would be obtained. Further storage capacity in the amount of approximately 240,000 acre-feet would be provided for the control of floods. In addition, the present seasonal yield of the underground basins in the area could be increased by an estimated 72,000 acre-feet by use of approximately 550,000 acre-feet of additional ground water storage capacity.

South Coastal Area. The tremendous population and economy of the South Coastal Area have imposed very large demands upon the limited local water resources. As a result, there is a high degree of utilization of these local water supplies, supplemented by major importations from distant sources. Ground water basins underlying or contiguous to the Ventura, Santa Clara, Los Angeles, San Gabriel, and Santa Ana Rivers are all developed to the point of substantial overdraft. Conservation reservoirs have been constructed on a number of the tributaries of these streams. Comprehensive systems of flood control reservoirs, detention basins, and channel works protect the highly developed urban areas. The effect of these developments, together with the operation of artificial water-spreading works which enhance natural percolation into all the major ground water basins, has resulted in conservation of most of the available water supplies to very nearly the maximum practicable extent. Surface storage developments accomplish a high degree of conservation of the runoff of streams draining San Diego County.

Limited opportunity exists for the development of additional surface water supplies in Ventura and San Diego Counties. To this end The California Water Plan contemplates surface reservoirs with aggregate conservation storage capacity of some 1,200,000 acre-feet, which would produce a new seasonal yield of about 120,000 acre-feet. In addition, by use of presently unused ground water storage capacity of about 150,000 acre-feet, the seasonal yield of certain ground water basins in the area could be increased by approximately 30,000 acre-feet.

Central Valley Area-Sacramento River Basin. Water resources of the Sacramento River Basin far exceed all foreseeable local requirements. The present water development is considerable and varied, but by no means approaches the feasible potential. Among the outstanding works are those of the Central Valley Project, which, in addition to making water available for export from the basin, serve local purposes including irrigation and municipal use of water, generation of hydroelectric power, salinity...
control in the Sacramento-San Joaquin Delta, navigation, and flood control. The Sacramento River Flood Control Project comprises an extensive system of levees and by-pass channels to protect the rich valley lands and urban communities. Many reservoirs have been constructed in the mountains and foothills for water conservation, power generation, and flood control. Irrigation is largely centered on the Sacramento Valley floor and along the Pit River, although scattered irrigated lands add to the economy of the mountain areas. The great ground water reservoir of the Sacramento Valley is utilized to only a small part of its potential, surface developments being relied upon for the major part of the water supplied.

Additional water development of the Sacramento River Basin under The California Water Plan would include about 15,000,000 acre-feet of new reservoir storage capacity, of which some 7,000,000 acre-feet would be located in foothill reservoirs related to The California Aqueduct System. The new storage capacity would be strategically disposed in 85 reservoirs to irrigate both the uplands and the valley floor, to develop the power and recreational potential, and, in conjunction with the ground water storage capacity, to regulate the stream flow for export.

Forty-two new hydroelectric power plants are proposed for the Sacramento River Basin, with an installed power capacity of 2,100,000 kilowatts and capable of generating about 10,000,000,000 kilowatt-hours annually. The planned conservation works would yield about 6,000,000 acre-feet of new water seasonally, including about 3,500,000 acre-feet to be developed in the reservoirs of The California Aqueduct System. The new reservoirs
would contain about 2,000,000 acre-feet of storage space specifically reserved for flood control.

Central Valley Area—San Joaquin River and Tulare Lake Basins. With its tremendous flat area and favorable soil and climatic conditions the San Joaquin Valley has pioneered irrigation development in California. Over 50 irrigation districts and numerous other public water districts have been formed, and by their initiative at the local level many notable water developments have been achieved. Over 4,500,000 acre-feet of reservoir storage capacity has been constructed to conserve and control the stream flow of the San Joaquin Valley. In addition to conservation of water for consumptive use, hydroelectric power is generated and flood control provided. The use of surface water supplies has been supplemented with development and use of the vast ground water resources, resulting in a relatively high degree of utilization of the local water supplies. In addition, works of the Central Valley Project convey surplus water from the Sacramento River Basin for use in the San Joaquin Valley. Despite this extensive development, supplemental water supplies are urgently needed.

Features of The California Water Plan in the San Joaquin Valley would include over 50 new major reservoirs on east side streams. With a total storage capacity of about 6,500,000 acre-feet, these reservoirs would produce about 2,000,000 acre-feet of new yield seasonally, and provide a large measure of flood control. Additional smaller reservoirs would supplement yield from the major works to meet local water requirements in
the foothills and the mountainous watershed areas. New hydro-electric power plants, with about 1,500,000 kilowatts of installed power capacity, would generate approximately 7,000,000,000 kilowatt-hours of energy seasonally. In order to achieve economic utilization of both local and imported supplies, the surface reservoirs would be operated in coordination with the storage capacity of the underground basin.

Lahontan Area. The several basins of the Lahontan Area have markedly differing physical and climatic characteristics. Consequently, the nature and degree of water development in these basins have likewise been variable. In the areas of high altitudes and short growing season, little development has ensued except for direct stream diversion for minor irrigation activities. In the Truckee River, Walker River, and Mono Lake Basins, some hydroelectric power as well as minor irrigation developments have taken place. In the Owens River Basin there is a relatively high degree of development, comprised primarily of the water conservation and power generation works of the Los Angeles Aqueduct system. Considerable ground water development has occurred in the Antelope Valley Basin, wherein a heavy overdraft prevails.

Under The California Water Plan, additional local development would involve the construction of eight reservoirs with an aggregate storage capacity of some 580,000 acre-feet, and a seasonal yield of about 490,000 acre-feet. In addition, eight hydroelectric power plants are planned, having a total installed capacity of approximately 100,000 kilowatts, and an annual generation of about 400,000,000 kilowatt-hours.

Colorado Desert Area. Due to the extremely limited stream flow originating in this area, surface development works for local water supplies are virtually nonexistent. However, considerable irrigation development has taken place on lands bordering the Colorado River, whence water supplies have been diverted by gravity flow. In addition, large-scale irrigation development has taken place in the Imperial and Coachella Valleys, utilizing water diverted and transported from the Colorado River. Appreciable development of local ground water supplies for irrigation use has taken place in the Coachella, Lucerne, and Borrego Valleys.

Local development works in the Colorado Desert Area under The California Water Plan would generally comprise features for implementing the planned utilization of ground water basins in conjunction with imported supplies.

The California Aqueduct System

The California Aqueduct System, comprising a complex combination of reservoirs and conduits to export surplus waters from the North Coastal Area and the Sacramento River Basin to water-deficient areas to the south, would extend from the Oregon line to the Mexican border. As has been stated, it would ultimately transport more than 21,000,000 acre-feet of regulated water each season, about half of which would be from the North Coastal Area and half from the Sacramento River Basin.

The California Aqueduct System would be unprecedented in its concept and scope. For purposes of study and description, this immense interarea water conservation and transportation
system has been divided into the eight components or divisions which are described in the ensuing sections. Principal features of The California Aqueduct System are shown on Plate 2.

**Klamath-Trinity Division.** This division, in the North Coastal Area, would develop surplus flows of the South Fork of the Smith, the Klamath, the Trinity, the Van Duzen, and the Mad Rivers, and convey the waters to the Sacramento Valley. It would include a series of major regulating reservoirs, which for the most part would be located contiguously along the Klamath and Trinity Rivers from the vicinity of their junction upstream. However, other reservoirs would be located on nearby streams for the conservation and transport of waters to the Klamath and Trinity Rivers system. Conduits, pumping plants, and hydroelectric power plants would be appurtenant to the dams and reservoirs. The waters conserved would be conveyed by gravity flow and pumping to a collecting reservoir on the Trinity River, and then by gravity through a tunnel beneath the Trinity Mountains to the Sacramento River Basin. A considerable amount of hydroelectric power would be developed in the drop to the floor of the valley. In addition, a portion of the waters of the Trinity River would be regulated and transported to the Sacramento Valley by means of facilities contemplated in the Trinity Diversion Project, authorized for construction by the federal Bureau of Reclamation.

The Klamath-Trinity Division would involve the construction of 16 dams and reservoirs with aggregate active storage capacity on the order of 15,500,000 acre-feet, 7 hydroelectric power plants with installed power capacity totaling about 1,700,000 kilowatts, 3 pumping plants with total installed capacity of approximately 900,000 kilowatts, and 6 tunnels having a total length of about 76 miles. The works, which are susceptible of staged development, eventually would make available some 8,200,000 acre-feet of water seasonally for export, not including the yield from the Trinity Diversion Project. They would also produce nearly 6,800,000,000 kilowatt-hours of electrical energy each season. However, in excess of 3,800,000,000 kilowatt-hours of energy would be required seasonally to pump the water to the collecting reservoir from where it would flow through the Trinity Divide into the Sacramento Valley.

The works of the Klamath-Trinity Division would provide substantial local benefits to the North Coastal Area. These benefits would vary in type and magnitude with the stage of development of The California Aqueduct System. They would include reservoir control of the very large rain floods that are characteristic to the area. Furthermore, regulated water would be made available to meet local requirements for beneficial consumptive uses downstream from the reservoirs. Reservoir releases would also be made to maintain summer and fall stream flow and enhance fish, wildlife, and recreational values. Finally, a very large pool of hydroelectric power would be created locally in the area to facilitate industrial growth and development.

**Eel River Division.** This division would include a series of major reservoirs on the Eel River and one on its Middle Fork. Pumping plants would transport the conserved water from reservoir to reservoir, up the Eel River, to gravity flow tunnels...
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Klamath-Trinity Division. This division, in the North Coastal Area, would develop surplus flows of the South Fork of the Smith, the Klamath, the Trinity, the Van Duzen, and the Mad Rivers, and convey the waters to the Sacramento Valley. It would include a series of major regulating reservoirs, which for the most part would be located contiguously along the Klamath and Trinity Rivers from the vicinity of their junction upstream. However, other reservoirs would be located on nearby streams for the conservation and transport of waters to the Klamath and Trinity Rivers system. Conduits, pumping plants, and hydroelectric power plants would be appurtenant to the dams and reservoirs. The waters conserved would be conveyed by gravity flow and pumping to a collecting reservoir on the Trinity River, and then by gravity through a tunnel beneath the Trinity Mountains to the Sacramento River Basin. A considerable amount of hydroelectric power would be developed in the drop to the floor of the valley. In addition, a portion of the waters of the Trinity River would be regulated and transported to the Sacramento Valley by means of facilities contemplated in the Trinity Diversion Project, authorized for construction by the federal Bureau of Reclamation.

The Klamath-Trinity Division would involve the construction of 16 dams and reservoirs with aggregate active storage capacity on the order of 15,500,000 acre-feet, 7 hydroelectric power plants with installed power capacity totaling about 1,700,000 kilowatts, 3 pumping plants with total installed capacity of approximately 900,000 kilowatts, and 6 tunnels having a total length of about 76 miles. The works, which are susceptible of staged development, eventually would make available some 8,200,000 acre-feet of water seasonally for export, not including the yield from the Trinity Diversion Project. They would also produce nearly 6,800,000,000 kilowatt-hours of electrical energy each season. However, in excess of 3,800,000,000 kilowatt-hours of energy would be required seasonally to pump the water to the collecting reservoir from where it would flow through the Trinity Divide into the Sacramento Valley.

The works of the Klamath-Trinity Division would provide substantial local benefits to the North Coastal Area. These benefits would vary in type and magnitude with the stage of development of The California Aqueduct System. They would include reservoir control of the very large rain floods that are characteristic to the area. Furthermore, regulated water would be made available to meet local requirements for beneficial consumptive uses downstream from the reservoirs. Reservoir releases would also be made to maintain summer and fall stream flow and enhance fish, wildlife, and recreational values. Finally, a very large pool of hydroelectric power would be created locally in the area to facilitate industrial growth and development.

Eel River Division. This division would include a series of major reservoirs on the Eel River and one on its Middle Fork. Pumping plants would transport the conserved water from reservoir to reservoir, up the Eel River, to gravity flow tunnels
beneath the southerly divide. One tunnel would receive water for export to the Sacramento River Basin by way of Clear Lake, the head made available in the Sacramento Valley being developed for electric power production. The other tunnel would discharge water for export to the Russian River Basin and to lands on the north shore of San Francisco Bay. The transportation facilities involved include the Russian River and a series of conduits. Incidental hydroelectric power generation would be accomplished in operation of this system.

The Eel River Division would involve 9 dams and reservoirs with aggregate active storage capacity of over 7,200,000 acre-feet, 9 hydroelectric power plants with installed power capacity totaling about 670,000 kilowatts, 2 pumping plants with total installed capacity of approximately 660,000 kilowatts, and 4 tunnels having a total length of about 22 miles. The works, which are susceptible of staged development, eventually would make available some 2,600,000 acre-feet of water seasonally for export. They would also produce about 2,800,000,000 kilowatt-hours of electrical energy each season. However, nearly 1,700,000,000 kilowatt-hours of energy would be required seasonally to pump the water over the divide to the San Francisco Bay Area and into the Sacramento Valley. Local benefits from the works would be similar to those described for the Klamath-Trinity Division.

Sacramento Division. This division would comprise the foothill reservoirs of the Sacramento River Basin, the natural underground storage in the alluvium of the Sacramento Valley, and
the conduits, both natural and artificial, through which surplus waters developed for export in both the North Coastal Area and in the Sacramento River Basin would flow southward. In general, the water for export would move to the south in the Folsom South Canal on the east side of the Sacramento Valley, in a large canal on the west side of the valley, and in the natural stream channels of the Sacramento River and its tributaries. Separate drainage conduits would convey wastes and low-quality drainage water, including water pumped from ground water basins to maintain salt balance, into the lower river through the Sacramento Deep Water Channel.

In addition to at least 28,000,000 acre-feet of usable ground water storage capacity, the Sacramento Division would include 14 major reservoirs, strategically located near the foothill line on tributaries of the Sacramento River, with gross storage capacity aggregating about 14,000,000 acre-feet. Existing storage in Shasta and Folsom Reservoirs, and that which will be made available by the construction of Monticello Reservoir, is included in this figure. Water released from the surface reservoirs, augmented in some instances by imports, would flow through hydroelectric power plants with installed power capacity totaling nearly 2,000,000 kilowatts. These plants would generate an average of approximately 10,000,000,000 kilowatt-hours of energy seasonally. Facilities of the Sacramento Division, when operated in conjunction with upstream developments and available ground water storage capacity, would make available from the Sacramento River Basin an average of about 10,000,000 acre-feet of water seasonally for export to the south, in addition to providing capacity for the
southward conveyance of about 11,000,000 acre-feet of North Coastal Area water.

**Delta Division.** This division would include the works necessary to transport regulated waters from northern areas of surplus southward across the Sacramento-San Joaquin Delta. The crossing would be made by at least two major routes. One of these would be a cross-delta channel upstream from the Junction Point Barrier proposed in connection with the so-called Biemond Plan. This plan involves a physical salinity control barrier upstream from the confluence of the Sacramento and San Joaquin Rivers. The other route would lead from the canal along the west side of the Sacramento Valley, and would include a number of siphons under the Sacramento River in the vicinity of Antioch. A lateral conduit would extend southwesterly from the vicinity of Antioch to supply supplemental water to areas in Contra Costa County. Supplemental water required in Solano, Marin, and lower Napa Counties would be supplied from a branch conduit extending westerly along the north bay from a point south and east of Fairfield.

Studies indicate that unregulated flows of the Sacramento and San Joaquin Rivers will be reduced in the future by increasing upstream conservation and use of water. Water is now released from upstream reservoirs, in addition to return flows from irrigation, for the purpose of repelling intrusion of salt water from San Francisco Bay into the Delta. In the future, however, the valuable fresh-water supplies will be required for higher uses, and it will be necessary to segregate and prevent commingling of the higher quality conserved waters and the lower quality drainage and flushing waters which now find their way to the Delta in natural channels. This would be accomplished under the Junction Point Barrier Plan by providing separate drainage channels for low-quality waters in both the Sacramento and San Joaquin River Basins, and by closing off minor channels in the Delta from the main channels of the Sacramento, Mokelumne, and San Joaquin Rivers. The minor channels would then convey high-quality water for use on the delta lands, and the main river channels would convey flood and other flows into Suisun Bay. Encroachment of sea water up the rivers from the bay would be prevented by installation of low weirs or barriers. The high-quality water in the Sacramento River would be conveyed across the Delta in an enlarged and improved crossing with siphons under the San Joaquin River. Pumping plants located on Old River near Tracy, and on other adjacent channels, would lift the water into conduits of The California Aqueduct System.

In the manner described, an average of over 18,000,000 acre-feet of high-quality water would be transported southward across the Delta each season. Of this amount, about one-half would be from the Sacramento River Basin and the remainder from the North Coastal Area.

**South Bay Aqueduct.** This conduit system would convey regulated water from the Sacramento-San Joaquin Delta to areas of deficiency in Alameda, Santa Clara, San Benito, and Santa Cruz Counties. Its facilities would include the works of the Alameda-Santa Clara-San Benito Branch of the authorized Feather River Project. In addition to 160 miles of canal and pipe line, the
The works of the San Joaquin Division would include three parallel conduits along the western side of the San Joaquin Valley. The Feather River Project Aqueduct, including San Luis Reservoir and the pumping plants, would comprise the initial stage of this development. Major pumping plants at the south edge of the San Joaquin Delta would lift water into the west side canals, from where it would flow southward by gravity to the San Luis Forebay. Pumping plants at the forebay would pump water either into San Luis Reservoir or into conduits extending on to the south. From San Luis Forebay water would also be diverted for storage and use in the San Joaquin Valley. The main canals of the San Joaquin Division would convey water from both San Luis Forebay and Reservoir to the Buena Vista Forebay, from where additional pumping plants would lift the water through the Tehachapis and on to southern California. An important feature of the development in the San Joaquin Division would be a drainage conduit, situated roughly in the trough of the valley. This drain, to accommodate waste and low-quality waters, as well as pumpage from the ground water basin necessary to maintain salt balance, would be separate from the natural drainage channels, and would extend from Buena Vista Lake to the Delta.

The San Joaquin Division would involve the construction of 1 major reservoir and 2 regulating reservoirs providing active storage of over 2,000,000 acre-feet, 9 pumping plants with a total installed pumping capacity of approximately 1,600,000 kilowatts, and an aggregate of 930 miles of main canals. The works would make available some 7,000,000 acre-feet of water seasonally for use in the San Joaquin River and Tulare Lake Basins, and would
with a length of 10.5 miles, on the Feather River Project Aqueduct, and two at an elevation of 3,140 feet with a length of about 9 miles each. The tunnels would convey the water through the Tehachapi Mountains to regulatory storage in the vicinity of Quail Lake. The main aqueduct system would then extend along the south side of the Antelope Valley, crossing the Mojave Desert in an easterly direction, and turning to the south in the vicinity of Cajon Pass.

The California Aqueduct System would continue through a series of parallel tunnels to the vicinity of San Bernardino, from which point water would be delivered to the southerly portion of the South Coastal Area and to portions of the Colorado Desert Area by two major routes. One route would comprise that of the Feather River Project Aqueduct, terminating in Horse Thief Canyon, tributary to the reservoir created by Barrett Dam in San Diego County. The second route would traverse the Upper Santa Ana River Basin, at a lower elevation but generally parallel to the Feather River Project Aqueduct. It would continue southward, terminating in the vicinity of San Vicente Reservoir in San Diego County. In addition to the foregoing, supplemental water supplies for San Diego County would be provided by a second San Diego Aqueduct. This facility would begin at the west portal of the San Jacinto Tunnel and continue southward and just west of the existing San Diego Aqueduct to an enlarged Lower Otay Reservoir near the City of San Diego.

There are numerous alternative possibilities for delivering supplemental water from The California Aqueduct System to the northern portion of the South Coastal Area. Among the more
favorable from the standpoint of hydroelectric power generation would be a diversion to a reservoir on Castaic Creek in the upper reaches of the Santa Clara River watershed, where about 1,800 feet of power drop are available. Another attractive diversion site is at Devil's Canyon near San Bernardino in the upper Santa Ana Valley, where a power drop of about 1,400 feet could be developed. Large amounts of water could be delivered to both of these strategic points and distributed therefrom. From Castaic Reservoir delivery could be made to the San Fernando Reservoirs of the City of Los Angeles, and thence to users in the Los Angeles metropolitan area. Service could also be provided from this point to areas of deficiency in Ventura County. From Devil's Canyon a connection could be effected to Morris Reservoir on the San Gabriel River and to the Colorado River Aqueduct at the western end of San Jacinto Tunnel. From these points distribution to users could be made through the system of the Metropolitan Water District of Southern California.

When the need develops, about 4,800,000 acre-feet of water per season would be diverted from The California Aqueduct System for use in the southern portion of the Lahontan Area. This water supply would be diverted along the desert reaches of the Southern California Division, and distributed through the Antelope-Mojave area by a system of surface conduits. Available ground water storage capacity would be utilized in reregulation of the supplemental water supply.

Required supplemental water for lands in the Colorado Desert Area, excepting those lands having rights in and to the
involved, and, like the well-conceived water resource developments of the past, the indirect benefits to the people and to the general economy would far outweigh the expenditures for construction.

Summary

The California Water Plan envisions the construction and operation of some 260 new major reservoirs in the State. These would add approximately 60,000,000 acre-feet of surface storage capacity to the present 20,000,000, providing a total of about 80,000,000 acre-feet. In addition, the ample ground water storage resources of California would be more intelligently and more extensively utilized than at present. The plan, if fully implemented, would furnish water in sufficient quantities to permit the presently irrigated agricultural area of about 7,300,000 acres to expand to more than 19,000,000 acres. It would permit an accompanying increase in urban and suburban areas from the present 1,000,000 acres to about 3,400,000 acres. Lands in the Colorado Desert Area having rights in and to the waters of the Colorado River, with an aggregate area of 1,320,000 acres, are not included in the accomplishments of the plan set forth above. The California Water Plan would also furnish water for all non-consumptive beneficial uses and water in the minor amounts necessary for the remaining 77,000,000 acres of land in California.