STATE OF CALIFORNIA
GOODWIN J. KNIGHT
GOVERNOR

PUBLICATION OF
STATE WATER RESOURCES BOARD

Bulletin No. 12

VENTURA COUNTY INVESTIGATION

Volume II
APPENDIXES AND PLATES

October, 1953
Revised April, 1956

STATE OF CALIFORNIA
GOODWIN J. KNIGHT
GOVERNOR

PUBLICATION OF
STATE WATER RESOURCES BOARD

Bulletin No. 12

VENTURA COUNTY INVESTIGATION

Volume II
APPENDIXES AND PLATES

October, 1953
Revised April, 1956

TABLE OF CONTENTS

APPENDIXES

PLATES

(Plates 1-42 are bound at end of Volume II)

PLATES
(Continued)

PLATES
(Continued)

late No.

PLATES
(Continued)

APPENDIX A

AGREEMENT, AND ITS SUPPLEMENT, BETWEEN THE STATE WATER RESOURCES BOARD, THE COUNTY OF VENTURA, AND THE DEPARTMENT OF PUBLIC WORKS

MEMORANDA OF UNDERSTANDING BETWEEN THE DIVISION OF WATER RESOURCES, UNITED WATER CONSERVATION DISTRICT, AND THE VENTURA COUNTY FLOOD CONTROL DISTRICT

TABLE OF CONTENTS

APPENDIX A

AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE VENTURA COUNTY FLOOD CONTROL DISTRICT, AND THE DEPARTMENT OF PUBLIC WORKS

THIS AGREEMENT, entered into as of the 15th day of April, 1951, by and between the State Water Resources Board, hereinafter referred to as the "Board", the Ventura County Flood Control District, hereinafter referred to as the "District", and the Department of Public Works, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer":

W I T N E S S E T H:

WHEREAS, by the State Water Resources Act of 1945, as amended, the Board is authorized to make investigations, studies, surveys, hold hearings, prepare plans and estimates, and make recommendations to the Legislature in regard to water development projects, including flood control plans and projects; and

WHEREAS, by said act, the State Engineer is authorized to cooperate with any county, city, state agency or public district on flood control and other water problems and when requested by any thereof may enter into a cooperative agreement to expend money on behalf of any thereof to accomplish the purposes of said act; and

WHEREAS, the District has requested the Board to enter into a cooperative agreement to conduct a comprehensive investigation of the water resources of Ventura County; and

WHEREAS, the State Engineer has reported to the Board that, as a result of a preliminary investigation it was concluded that emergency water problems exist in Ventura County and that a cooperative investigation is warranted and within the scope and intent for which matching funds are allocated by the State Water Resources Board; and

WHEREAS, the Board has requested the State Engineer to cooperate in conducting a comprehensive investigation of the water resources of Ventura County and to formulate a report thereon;

NOW THEREFORE, in consideration of the premises and of the several promises to be performed by each as hereinafter set forth, the Board, the District, and the State Engineer do hereby mutually agree as follows:

ARTICLE I - WORK TO BE PERFORMED:

The work to be performed under this agreement shall consist of (1) a complete review of reports of prior investigations concerning the water resources of Ventura County; (2) field investigations and office studies to determine (a) the location, occurrence, and condition of water resources of the County, both surface and underground, (b) present water utilization including its nature, extent, and a survey of water service agencies, (c) ultimate water requirements, (d) preliminary general plans and estimates of cost for development and utilization of local water resources of the County to the maximum practicable extent, (e) required supplemental water supply from outside sources, (f) possible outside sources for required supplemental supply including preliminary plans for importation and estimates of costs; and (3) the formulation of a report thereon.

The work shall include the following:

(a) A plan for the development and utilization of the water resources of Sespe Creek, including features for their use in the Santa Clara River Valley and Oxnard Plain.

(b) A plan for the development and utilization of the water resources of Piru Creek, including features for their use in the Santa Clara Valley and Oxnard Plain.

(c) A plan for meeting the present and future needs of Calleguas Creek Basin either from Santa Clara River Basin or from other sources.

(d) A plan for the development and utilization of the water resources of the Ventura River and tributaries including their use in the Ventura River Basin.

In connection with the study of dam and reservoir sites on streams of Ventura County, the following work shall be undertaken initially: (a) Devil's Canyon site on Piru Creek--water testing of dam foundation; (b) Topa Topa site on Sespe Creek--exploration of dam site and borrow areas; (c) Fillmore site on Sespe Creek--exploration of dam site and borrow areas and topographic survey of dam and reservoir sites.

The Board by this agreement authorizes and directs the State Engineer to cooperate by conducting said investigation and formulating said report and by otherwise advising and assisting in formulating solutions to the water problems in Ventura County.

During the progress of said investigation, all maps, plans, information, data and records pertaining thereto which are in the possession of any party hereto, shall be made fully available to any other party hereto for the due and proper accomplishments of the objectives hereof.

The work to be done under this agreement shall be diligently prosecuted with the objective of completing the investigation and report on or before June 30, 1953. A progress report containing findings on possible development of surface water supplies of Sespe and Piru Creeks shall be completed by February 1, 1952, or as soon thereafter as possible.

ARTICLE II - FUNDS:

On execution of this agreement, the District shall transmit the sum of Five Thousand Dollars ($5,000) to the State Engineer for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditure by the State Engineer in performance of the work provided for in this agreement. Also upon execution of this agreement, the Board shall request the Director of Finance to approve the transfer of the sum of Five Thousand Dollars ($5,000) from funds appropriated to the Board by Item 257 of the Budget Act of 1950 to the said Water Resources Revolving Fund for expenditure by the State Engineer in performance of work provided for in this agreement.

On or before July 1, 1951, the District shall transmit the further sum of Fifteen Thousand Dollars ($15,000) to the State Engineer for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditure by the State Engineer in performance of the work provided for in this agreement. Following July 1, 1951, as soon as practicable the Board shall request the Director of Finance to approve the transfer of the further sum of Fifteen Thousand Dollars ($15,000) to said Water Resources Revolving Fund from any funds which may be made available for such purposes, for expenditure by the State Engineer in performance of the work provided for in this agreement.

In the event that on or before July 1, 1952, the District shall transmit the sum of Ten Thousand Dollars ($10,000) to the State Engineer for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditure by the State Engineer in performance of the work provided for in this agreement, thereupon as soon as practicable the Board shall request the Director of Finance to approve the transfer of the sum of Ten Thousand Dollars ($10,000) to said Water Resources Revolving Fund from any funds which may be made available for such purposes, for expenditure by the State Engineer in performance of the work provided for in this agreement.

Of the funds made available under this agreement, not more than Ten Thousand Dollars ($10,000) shall be expended on exploration work and surveys at dam and reservoir sites.

Notwithstanding anything contained in this agreement contrary hereto or in conflict herewith, this agreement is made contingent upon the funds being deposited in or transferred to the Water Resources Revolving Fund as provided herein for expenditure by the State Engineer in performance of the work provided for in this agreement. In the event any of the funds are not transferred to the Water Resources Revolving Fund by the Director of Finance as provided for herein within 30 days after the Board requests such transfer, this agreement shall terminate and the unexpended balance of any funds deposited by the County shall be returned, provided that neither the Board nor the State Engineer shall be obligated to the County for any portion of the funds already expended.

The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for under this agreement any amount in excess of the funds made available hereunder.

Upon completion and final payment for the work provided for in this agreement, the State Engineer shall furnish to the Board and to the County a statement of all expenditures made under this agreement. One-half of the total amount of all said expenditures shall be deducted from the sum advanced from funds appropriated to the Board and one-half of the total amount of all said expenditures shall be deducted from the sum advanced by the County and any balance which may remain shall be returned to the Board and to the County in equal amounts.

Notwithstanding anything herein contained to the contrary, this agreement may be terminated and the provisions of this agreement may be altered, changed, or amended, by mutual consent of the parties hereto.

IN WITNESS WHEREOF, the parties hereunto have executed this agreement as of the date first herein written.

Approved as to Form:

/s/ Roy A. Gustafson
Attorney, Ventura County
Flood Control District

VENTURA COUNTY FLOOD CONTROL DISTRICT

By /s/ R. E. Barrett
Chairman, Board of Supervisors

SEAL

Approved as to Form
and Procedure

/s/ Henry Holsinger
Attorney for Division
of Water Resources

STATE WATER RESOURCES BOARD

By /s/ Royal Miller
Member

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS

C. H. PURCELL

Director of Public Works

By

/s/ Frank B. Durkee
Frank B. Durkee
Deputy Director

SEAL

APPROVED:

/s/ James S. Dean
Director of Finance

/s/ A. D. Edmonston
A. D. Edmonston
State Engineer

E.J.R.	F.J.M.		
Form	Budget	Value	Descript.

DEPARTMENT OF FINANCE
APPROVED
May 7 1951

SUPPLEMENTAL AGREEMENT
BETWEEN
THE STATE WATER RESOURCES BOARD,
THE VENTURA COUNTY FLOOD CONTROL DISTRICT, AND THE
DEPARTMENT OF PUBLIC WORKS

THIS AGREEMENT, executed in quintuplicate, entered into as of May 1, 1952, by the State Water Resources Board, hereinafter referred to as the "Board"; the Ventura County Flood Control District, hereinafter referred to as the "District"; and the Department of Public Works of the State of California, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer".

W I T N E S S E T H:

WHEREAS, by agreement heretofore entered into as of April 15, 1951, by and between the District, the Board, and the State Engineer, it was provided that the work to be performed by the State Engineer thereunder shall consist of (1) a complete review of reports of prior investigations concerning the water resources of Ventura County; (2) field investigations and office studies to determine (a) the location, occurrence, and condition of water resources of the County, both surface and underground, (b) present water utilization including its nature, extent, and a survey of water service agencies, (c) ultimate water requirements, (d) preliminary general plans and estimates of cost for development and utilization of local water resources of the County to the maximum practicable extent, (e) required supplemental water supply from outside sources, (f) possible outside sources for required supplemental supply including preliminary plans for importation and estimates of costs; and (3) the formulation of a report thereon; and

WHEREAS, under said agreement the District made available the sum of Five Thousand Dollars ($5,000) and Fifteen Thousand Dollars ($15,000) which were matched in equal amounts by the Board for expenditure by the State Engineer in the performance of the work provided for in said agreement; and

WHEREAS, it was the expressed intention in said agreement that at the commencement of the second year of said investigation the District would make available a further sum of Ten Thousand Dollars ($10,000) subject to a matching or contribution in an equal sum by the Board for the completion of said investigation and report; and

WHEREAS, the funds provided for under said prior agreement, to which this agreement is supplemental, have been exhausted and additional funds are now required to complete said investigation and report, and it is the desire of the parties hereto that an additional sum of Twenty Thousand Dollars ($20,000) shall be provided, Ten Thousand Dollars ($10,000) by the District and Ten Thousand Dollars ($10,000) by the Board;

NOW THEREFORE, in consideration of the premises and of the several promises to be faithfully performed by each as hereinafter set forth, the Board, the District, and the State Engineer do hereby mutually agree as follows:

1. The County, upon execution by it of this agreement, shall transmit to the State Engineer the sum of Ten Thousand Dollars ($10,000) for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury for expenditure by the State Engineer in continuing performance of the work provided for in said prior agreement to which this agreement is supplemental.

2. Upon execution of this agreement by the Board, the Director of Finance will be requested to approve the transfer of the sum of Ten Thousand Dollars ($10,000) from funds appropriated to the Board by Item 269 of the Budget Act of 1952 for expenditure by the State Engineer in continuing performance of the work provided for in said prior agreement to which this agreement is supplemental, and the State Controller will be requested to make such transfer.

3. The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for in said prior agreement to which this agreement is supplemental any amount in excess of the sum of Sixty Thousand Dollars ($60,000) as made available under said prior agreement and this supplemental agreement and if funds are exhausted before completion of said work the Board and the State Engineer may discontinue said work and shall not be liable or responsible for the completion thereof.

4. In so far as consistent herewith and to the extent adaptable hereto, all of the terms and provisions of said prior agreement to which this agreement is supplemental are hereby made applicable to this agreement and are hereby confirmed, ratified, and continued in effect.

IN WITNESS WHEREOF, the parties hereto have executed this agreement to be effective as of the date hereinabove first written.

Approved as to Form and
Procedure

/s/ Donald H. Benton
Attorney, Ventura County
Flood Control District

VENTURA COUNTY FLOOD CONTROL DISTRICT

By /s/ R. E. Barrett
Chairman, Board of Supervisors

Approved as to Form and
Procedure

/s/ Henry Holsinger
Attorney for Division of
Water Resources

STATE WATER RESOURCES BOARD

By /s/ B. A. Etcheverry
Vice Chairman

Approved as to Form and
Procedure

Attorney, Department of
Public Works

State of California
Department of Public Works

FRANK B. DURKEE
Director of Public Works

By /s/ Russell S. Munro

APPROVED:

/s/ James S. Dean
Director of Finance

/s/ A. D. Edmonston
A. D. Edmonston
State Engineer

L.E.Z.	F.J.M.		
Form	Budget	Value	Descript.

DEPARTMENT OF FINANCE
APPROVED
May 19 1952

MEMORANDUM OF UNDERSTANDING

WITH REFERENCE TO WATER RESOURCES INVESTIGATION OF VENTURA COUNTY

The objective of this memorandum of understanding is to coordinate the work of the State of California, Ventura County Flood Control District, and the United Water Conservation District in the investigation of the water problems in the County of Ventura and the formulation of plans for their solution.

It is contemplated that an agreement will be executed between the State Water Resources Board, the Ventura County Flood Control District, and the Department of Public Works acting through the State Engineer for the purpose of conducting a county-wide comprehensive investigation of the water resources of Ventura County.

This memorandum is a prerequisite of the execution of the aforesaid agreement.

This memorandum sets forth only that part of the county-wide investigation in which all three of the named agencies are interested. Other parts of the county-wide study will go forward simultaneously under plans approved by the State and the District, and work primarily of interest to the Conservation District will be done and/or paid for by that agency. However the work of all agencies shall be closely coordinated, and information shall be freely exchanged. Any work done by the Conservation District with funds furnished by the Flood Control District shall be of sufficient scope to serve the purposes of the county-wide survey, as determined by the State Engineer.

This memorandum is preliminary in nature and shall be revised as necessary as the work proceeds, and all revisions shall be approved by representatives of the State, Flood Control District and Conservation District.

1. General Water Supply Studies

   a. State

      1. Geologic investigation of Santa Clara River Basin and Oxnard Plain, including Pleasant Valley. Any geologic work beyond that which the State does shall be paid for by whatever agencies request additional work.

      2. Water supply available from all streams in Santa Clara Basin.

      3. Method of utilization of conserved water.

   b. United Water Conservation District

      1. Make an independent check on previously reported values on water supply available at various reservoir sites on Sespe and Piru Creeks.

      2. Make yield studies of reservoirs under consideration on Sespe and Piru Creeks in conjunction with utilization of ground water storage, up to maximum practicable capacity at each site.

      3. Determine a method of conservation and determine location, capacity and size of spreading grounds in the Santa Clara River Basin.

2. Dam and Reservoir Site Investigations

   a. Sespe Creek

      1. Fillmore Site, approximately two miles above Telegraph Road.

         (a) State

         Locate drill holes and obtain rig and drill churn drill holes, obtain and operate geophysical rig for determining seismic profile and make a geological report.

Study availability of materials suitable for an earthfill dam of maximum planned height.

(b) Ventura County Flood Control District

Topographic survey and map of dam site, Scale 1" = 200', contour interval 5', to a height of 400' above stream-bed. Survey to be tied into U.S.G.S. surveys. Contour at an elevation of approximately 200' above stream-bed at dam site, to be located and mapped in order to check new U.S.G.S. sheet of this area.

Locate all cultures in dam and reservoir site and estimate cost of acquisition of lands. Calculate height, capacity and surface area curves for reservoir using new U.S.G.S. sheet. Obtain permissions to enter on lands for purpose of drilling holes or seismic work.

(c) United Water Conservation District

If this site is found feasible geologically, make preliminary designs and cost estimates for several heights of dam.

2. Hammel Site

(a) State

Make geological investigation of dam site. Investigate availability of materials.

(b) Ventura County Flood Control District

Provide topographic maps of reservoir and dam sites. Make estimate of cost of acquisition of lands and right of way.

(c) United Water Conservation District

Make preliminary designs and cost estimates for several heights of dams.

3. Topa Topa Site

(a) State

Investigate geology and availability of materials.

(b) Ventura County Flood Control District

Make estimate of cost of acquisition of lands and/or right of way.

(c) United Water Conservation District

Make preliminary designs and cost estimates for several heights of dam.

4. Cold Spring Site

(a) State

Investigate geology and availability of materials.

(b) Ventura County Flood Control District

Make estimate of cost of acquisition and right of way.

(c) United Water Conservation District

Make preliminary designs and estimates of cost for several heights of dam.

b. Piru Creek

1. Devil Canyon Site

(a) State

Investigate geology and availability of materials.

(b) Ventura County Flood Control District

Provide maps of reservoir and dam site. Make estimate of cost of acquisition of lands and right of way.

(c) United Water Conservation District

Make preliminary designs and estimates of cost for several heights of dam.

c. Santa Paula Creek

1. Ferndale site

(a) State

Make estimate of flood control benefits. Make estimate of conservation benefits. Investigate geology and availability of materials.

(b) Ventura County Flood Control District

Make topographic survey and map of dam site, scale 1" = 100', contour interval 5', to a height of 300' above stream-bed. The new U.S.G.S. sheet will be used to calculate a height, capacity and surface area curve for this dam. Make estimate of cost of acquisition of lands and right of way.

(c) United Water Conservation District

Make preliminary designs and estimates of costs for several heights of dam.

As soon as the most satisfactory dam site or dam sites are decided upon in the Santa Clara River Basin, United Water Conservation District will proceed with detailed investigation of said sites. Such investigation, if paid for with funds advanced by the Ventura County Flood Control District, shall be sufficiently broad to cover the needs of the county-wide investigation.

All work outlined herein to be done by the State of California and by the Ventura County Flood Control District is to be paid from funds to be made available under the aforementioned cooperative agreement between the State Water Resources Board, the Ventura County Flood Control and the State Engineer. Work to be done by United Water Conservation District will be paid for from funds provided by that agency.

April 23, 1951	/s/ A. D. Edmonston A. D. Edmonston, State Engineer
April 24, 1951	/s/ Robert L. Ryan Robert L. Ryan, County Surveyor Ventura County
April 23, 1951	/s/ Julian Hinds Julian Hinds, Consulting Engineer United Water Conservation District

MEMORANDUM OF UNDERSTANDING
With Reference to Water Resources Investigation of Ventura County

---

A memorandum of understanding was entered into on April 23 and 24, 1951, between representatives of the State Division of Water Resources, the Ventura County Flood Control District, and the United Water Conservation District, with the objective of coordinating the work of the three agencies in the investigation and study of the water problems of Ventura County. The Memorandum set forth the part of the coordinated program each agency would perform in the investigation and the cooperation that would be effected in the exchange of data so that there would be a minimum of duplication of effort and so that completion of the work would be effected as expeditiously as possible. Such coordination has been effectively carried out.

A meeting of the representatives of the foregoing three agencies was held in the office of the State Engineer on September 29 and 30, 1952, for the purpose of reviewing the results so far accomplished by the three agencies and to program certain further work to be done. At the conclusion of said meeting it was mutually agreed that both the United Water Conservation District and the State Division of Water Resources would:

1. Prepare independent cost estimates for concrete arch dams at the Topa Topa site on Sespe Creek to create gross storage of water in the amounts of 50,000 acre-feet, 75,000 acre-feet, and 100,000 acre-feet respectively.

2. Review existing yield studies for reservoirs created by the foregoing sizes of dams on the Topa Topa site on Sespe Creek.

3. Review existing yield studies for a reservoir of 100,000 acre-foot storage capacity at the Santa Felicia site on Piru Creek.

Said work to be accomplished by October 15, 1952, the results thereof to be submitted to the other parties to this agreement on or about that date, and a further meeting between the parties to be held in Santa Paula on October 24, 1952.

It was also mutually agreed, based on preliminary information available, that a rolled earth-fill type of dam is suitable and appropriate for the Santa Felicia site on Piru Creek, and that the capacity of Santa Felicia Reservoir should be limited to a maximum storage capacity of about 100,000 acre-feet in order to preserve from inundation the upstream Blue Point Dam and Reservoir site and to permit future development of said Blue Point site.

It was further mutually agreed that any dam constructed at the Topa Topa site on Sespe Creek should preferably be built initially to the maximum practicable size without provision for future enlargement.

/s/ A. D. Edmonston
A. D. Edmonston, State Engineer

/s/ Robert L. Ryan
Robert L. Ryan, County Surveyor
Ventura County

/s/ Julian Hinds
Julian Hinds, Consulting Engineer
United Water Conservation District

Sacramento, California
October 1, 1952

MEMORANDUM OF UNDERSTANDING
With Reference to Water Resources Investigation of Ventura County
November, 1952

Pursuant to a memorandum of understanding entered into on October 1, 1952, by representatives of the State Division of Water Resources, the Ventura County Flood Control District, and the United Water Conservation District, a meeting was held in the offices of the United Water Conservation District in Santa Paula on October 24, 1952, among representatives of the foregoing agencies. Under terms of the aforementioned memorandum of understanding, both the United Water Conservation District and the State Division of Water Resources were to prepare estimates of cost for concrete arch dams at the Topa Topa site on Sespe Creek creating reservoir capacities of 50,000, 75,000, and 100,000 acre-feet, respectively, and to review existing yield studies for reservoirs of these capacities. In addition, existing yield studies for a reservoir of 100,000 acre-feet capacity at the Santa Felicia site on Piru Creek were also to be reviewed.

As a result of these studies and in accordance with the conclusions derived and concurred in by the attendant parties at the meeting of October 24, 1952, it is mutually agreed that:

1. The reservoir yields independently determined under terms of the memorandum of understanding, dated October 1, 1952, are in agreement.

2. A fill type dam will be constructed at the Santa Felicia site on Piru Creek creating a gross reservoir capacity of not less than 90,000 acre-feet nor more than 100,000 acre-feet.

3. A concrete arch dam, creating a gross reservoir capacity of not less than 50,000 acre-feet, will be constructed at the Topa Topa site on Sespe Creek.

4. The United Water Conservation District will prepare plans and call for bids for construction of concrete arch dams at the Topa Topa site, which would create reservoir capacities of 50,000 and 60,000 acre-feet, with the objective of constructing as large a capacity reservoir as financial limitations will permit.

5. The State Division of Water Resources will study and report on the feasibility of an overpour spillway for concrete arch dams at the Topa Topa site for gross reservoir capacities of 50,000 acre-feet and larger.

6. Construction of not less than 90,000 acre-feet nor more than 100,000 acre-feet of gross reservoir storage capacity at the Santa Felicia site on Piru Creek, and of not less than 50,000 acre-feet of gross reservoir storage capacity at the Topa Topa site on Sespe Creek, is consistent with an overall plan for the conservation and utilization of the water resources of Ventura County.

/s/ A. D. Edmonston
A. D. Edmonston, State Engineer

/s/ Robert L. Ryan
Robert L. Ryan, Engineer
Ventura County Flood Control District

/s/ Julian Hinds
Julian Hinds, Consulting Engineer
United Water Conservation District

APPENDIX B

GEOLOGY AND GROUND WATER OF VENTURA COUNTY, CALIFORNIA

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLES

TABLE OF CONTENTS (Continued)

PLATES

ACKNOWLEDGMENTS

Data of considerable value in interpretation of geology and ground wa hydrology of Ventura County have been made available by the following agencies a companies.

Ground Water Branch, Geological Survey, U. S. Department of Interior
Soil Conservation Service, U. S. Department of Agriculture
Office of Public Works, U. S. Naval Construction Battalion Center,
U. S. Naval Advanced Base Depot, Port Hueneme
Office of Public Works, Point Mugu Air Missile Test Center
California Department of Natural Resources, Division of Oil and Gas
and Division of Mines
Ventura County Water Survey
Santa Clara Water Conservation District
City of Ventura Water Department
Standard Oil Company of California
General Petroleum Corporation
Superior Oil Company

The following individuals and organizations have contributed valuable criticisms and suggestions during the course of this investigation.

Thomas L. Bailey, Consulting Geologist
Frank Bell, Shell Oil Company
Harold Conkling, Consulting Engineer
K. O. Emery, University of Southern California
Spencer Fine, Richfield Oil Company
Edward Hall, Union Oil Company
Robert F. Herron, MJM&M Oil Company
John F. Mann, Consulting Geologist
Wm. R. Merrill, Standard Oil Company
Henry H. Neel, Tidewater Associated Oil Company
Robert H. Paschall, Amerada Petroleum Corporation
F. P. Shepard, Scripps Institute of Oceanography
Edward L. Winterer, U. S. Geological Survey

The assistance of all of the above organizations and individuals, as well as numerous other geologists, landowners, well drillers, and individuals is gratefully acknowledged.

CHAPTER B-I. INTRODUCTION

Ventura County includes an area of approximately 1,857 square miles which is bounded by surveyed lines chosen irrespective of watershed boundaries or geologic features, except along its southwest and in part its west sides. The southwestern boundary is the Pacific Ocean.

This appendix includes a description of the geology of Ventura County and adjacent areas with particular emphasis placed upon those geologic features which influence the occurrence and movement of ground water. Its purpose is threefold, namely:

1. To describe the geology and water-bearing properties of the rocks.

2. To discuss the effects of geologic structure upon the movement of ground water and the infiltration of sea water, and to describe briefly the history of events involving the evolution of the principal structures.

3. To describe the procedures followed in estimating the changes in ground water storage and estimating sub-surface ground water movement that occurred within the principal basins during selected periods of study.

The older less permeable formations which yield little water are treated briefly. These rocks are mentioned because: they are the parent source of sediments which fill the ground water basins, in certain localities they affect the chemical character of the ground water, their position in part controls the movement and occurrence of ground water, and they form or delimit the ground water basins.

The permeable water-bearing formations are described in greater detail. These deposits comprise the fill of the ground water basins, the principal sources of ground water supply in the County.

Subsurface ground water geology was interpreted largely from the logs of some 1,534 water wells, most of which were obtained from the Ventura County Water Survey and some from field canvass. Considerable shallow subsurface data in the form of 138 electric logs, drillers logs, and core descriptions were obtained from the State Division of Oil and Gas and from oil companies operating in various areas. Ground water level data and water analyses were amassed and in certain areas the transmissibility of sediments was estimated by pump testin of wells. All of these data were drawn upon freely in interpreting the geology

A perusal of geologic literature revealed a number of maps and report prepared by earlier investigators covering various parts of the County. These existing data were drawn upon freely in the preparation of this report and are listed in the accompanying bibliography.

In the course of this investigation, two geologic maps were prepared by compiling data from existing geologic maps, from aerial photographs and from field mapping by the Division of Water Resources in areas where existing data were insufficient. One of these maps is of small scale and depicts the entire County and tributary drainage areas (Plate 10); the second is a detailed map covering the area containing the ground water basins (Plates B-1A, B-1B, and B-1C).

CHAPTER B-II. PHYSIOGRAPHY

The southern portion of Ventura County is to a large extent located in he Transverse Ranges geomorphic province, while that portion north of the Santa nez fault (see Areal Geology, Plate 10) is in the southerly section of the Coast anges province (Jenkins 1943). The mountains and valleys in the southern porion of the County trend nearly east-west, while in the northern portion of the ounty they trend more in a northwest-southeast direction. The physiography of he County can best be described by covering the following features: mountains, valley areas, the coastal plain, and submarine topography.

Mountains

The principal mountains in Ventura County include the Piru Mountains (named by Axelrod, 1950), the Santa Ynez Mountains, the Topatopa Mountains and the Santa Monica Mountains. Smaller mountain areas include Oak Ridge, the Santa Susana Mountains north of the Simi Valley area, and the Simi Hills south of Simi Valley. All mountain areas are generally maturely dissected and rugged, with relief ranging from 500 to 2,000 feet. Soil cover is generally thin, but some areas of rolling topography are found where soil cover becomes quite thick. Such areas are generally found in the higher parts of the ranges and may represent remnants of one or more old erosion surfaces.

Valley Areas

In general, many of the valleys were formed under earlier geologic conditions when the area was nearer base level (in most cases sea level). Since being formed most of the valleys have been uplifted and have undergone additional erosion. Generally, cycles of erosion and alluviation have been repeated. A few of the valleys are largely the result of structural movements.

The Santa Clara River Valley is the most prominent valley in Ventura

County and trends east-west. It is controlled essentially by structural features. In general, it is a downfolded and faulted trough between mountains to the north and south. Deposition by the Santa Clara River and by smaller tributaries has been fairly continuous in most of the valley, while terraces on the side slopes may be due in part to periodic uplift of the sides of the valley with respect to the valley floor.

Physiography of the Ventura River drainage area has been discussed in considerable detail by Putnam (1942). Streams in Ojai Valley and the Coyote Creek drainage evidently originally drained westward and eastward respectively toward the Ventura River. Headward erosion of San Antonio and Coyote Creeks has captured those drainages so that they now drain in a southerly direction. Ojai Valley is in a structural depression in which over 700 feet of fluviatile sediments have been deposited. The Coyote Creek drainage area is also in a structural depression, but apparently the area has not been as active as the Ojai Valley area and only thin deposits of alluvium are found there.

The small Upper Ojai Valley, according to Putnam (1942), originally drained westward and the headwaters included the upper portion of the present Santa Paula Creek. Most of the alluvial material now found in Upper Ojai Valley was deposited at that time. Subsequent headward erosion of Santa Paula Creek, possibly aided by tectonic movements, has resulted in the capture of the present drainage system, so that Upper Ojai Valley now drains both to the west and to the east.

The north-south trending Ventura River Valley has been essentially an erosional feature, a relatively small thickness of alluvial fill being found in the valley at the present time. Terrace deposits indicate that the valley has undergone at least two cycles of erosion. Putnam (1942) presents evidence that the most prominent of the terraces has been gently warped upward, with the axis of the upwarping near Casitas Springs.

The Las Posas upland area extends eastward from Oxnard Plain almost to mi Valley, and lies between Oak Ridge to the north and the Camarillo and Las osas Hills to the south. This broad upland area slopes generally to the south. oth erosion and deposition are occurring in places within the area at the present me. It is possible that Arroyo Las Posas once flowed westward from the vicinity Somis, north of the Camarillo Hills, to the Oxnard Plain. If so, it was prob- bly diverted south at Somis into the valley it presently occupies by the building- p of alluvial fans extending from Oak Ridge in the area northwest of Somis.

Simi Valley is located in a structurally depressed area in which over 00 feet of alluvial sediments has accumulated. Simi Valley has been through more han one cycle of erosion as indicated by the exposure and present dissection of he older alluvium on the southwest side of the valley. The Simi fault, extending long the north side of the valley, has apparently been active during deposition f most of the alluvial fill. This is inferred from the 60-foot thickness of the lluvium in the valley just west of where the Simi fault crosses the alluvium. his area is north of the Simi fault or on the uplifted side. The bulk of Simi alley and the greatest thickness of sediments is south of the Simi fault.

Conejo Valley is a broad valley which has been a part of a larger gen- rally east-west valley system lying in part in Los Angeles County. This old alley system was evidently originally developed by a through stream flowing ither east or west. The former drainage system has been captured by headward rosion of Conejo Creek in Conejo Creek Canyon north of Newbury Park, aided by robable northward tilting of the Conejo Valley area and fracturing of rocks.

Tierra Rejada and Santa Rosa Valley are both essentially erosional eatures, although up to 200 feet of alluvium has been deposited in Santa Rosa alley. The harder portions of the existing volcanic rocks have created tem- orary base levels resulting in erosion of Tierra Rejada and another smaller valley in the upper drainage of Santa Rosa Valley.

There are several other valley areas in Ventura County which are not described here since they lie outside that portion of the County with which thi report is principally concerned.

Coastal Plain

The Coastal Plain has been formed by deposition of sediments from the Santa Clara River and from the Calleguas-Conejo drainage area. The land surface resembles a large compound alluvial fan having one apex near Saticoy and another near Somis. A group of smaller, but steeper, alluvial fans has been deposited by the smaller creeks draining the hills north of the area, forming an alluvial piedmont. Remnants of terraces along the northern edge of the coastal plain indicate uplift of this part of the plain. This rise might be du to relatively recent upwarping in the Ventura River drainage area (Putnam 1942) possibly augmented by changes of sea level.

Submarine Topography

Principal features of offshore topography are shown on Plate B-3 whic is taken from U. S. Coast and Geodetic Survey chart number 5202 (Point Dume to Purisima Point). These features are also discussed in papers by Emery and Shepard (1945) and Emery and Rittenberg (1952). Santa Rosa, Santa Cruz and Anacapa Islands are extensions of the Santa Monica Mountains. A scarp-like feature extends in an east-west direction on the south side of the islands and the Santa Monica Mountains. This scarp is cut by the southerly trending Huenem and Mugu submarine canyons which end in the floor of the Santa Monica submarine basin lying south of the Santa Monica Mountains. In addition to these major canyons, three poorly developed or incipient canyons exist between the two majo canyons. The Santa Barbara basin lies due west of the Coastal Plain of Ventura County. This basin is relatively shallow and the slope of the surface west of the Oxnard Plain is gentle, being as low as five to fifteen feet per mile. In comparison, the slopes of the east-west scarp and the heads of the submarine canyons are quite steep. Hueneme Canyon cuts across the southeastern corner of the gently sloping Santa Barbara basin.

The heads of the submarine canyons are within a quarter of a mile of the shore, and water-bearing materials are probably exposed along the canyon walls, allowing free contact between sea water and permeable formations. This contact is very important in considering movement of ground water, since, depending on the direction of the gradient, fresh water can be discharged into the ocean or sea water may move into the aquifers.

General descriptions of all geologic formations and a short discussio of their role in the hydrology of Ventura County are included in this section.

The detailed geologic maps of the southern part of Ventura County (Plates B-1A, B-1B, and B-1C) show the areal extent and distribution of formations based on lithology. Plate 10 is a generalized geologic map of the entir Ventura County and Santa Clara River drainage area. The stratigraphic columns Plate B-2 indicate the age relationship between the various formations by area.

The complex geology of Ventura County has been mapped by many people over a period of more than forty years. As a result, present terminology is somewhat confusing to those not familiar with the problems of the area. An attempt has been made in this report to use names of formations which are commonly accepted by local geologists. Wherever lack of agreement seemed to exist the formation names which appeared to be most familiar to local geologist were adopted.

Basement Complex

The basement complex is composed of granitic and metamorphic rocks of pre-Cretaceous age. The metamorphic rock types include gneiss, schist, hornfel, quartzite, and limestone, indicating that the rocks, before they were metamorphosed, were mostly sediments. These metamorphic rocks were intruded in Jurassic (?) time by granitic and dioritic rocks (Kew 1924, Wallace 1949, and Crowell 1950 and August and October, 1952 and others).

Large areas of the Piru Creek-Santa Clara River drainage area are underlain by deeply weathered granitic and dioritic rocks. Both the igneous an metamorphic rocks are fractured and jointed, being more extensively fractured near large faults.

The basement complex is essentially nonwater-bearing, but scattered mestic and stock wells obtain small quantities of water from weathered residual terials and from fractures. Small springs are fairly common in areas of basement complex, especially during wet periods.

Surface water derived from areas of basement complex is generally a lcium bicarbonate type with moderately low dissolved solids.

Cretaceous System

Consolidated sediments of Cretaceous age in the Ventura Region have een called the Chico formation by early workers, but oil company geologists in e last few years have generally dropped this term. Since the formations have t been assigned local names, they are generally called Upper Cretaceous rocks, simply Cretaceous rocks. The rocks consist of marine shales, siltstones, ndstones, and conglomerates having an aggregate thickness in excess of 7,000 feet. e shales and siltstones are generally well bedded and dark gray to black in lor. Upon weathering, they splinter, ultimately disintegrating to gray clayey ils. The sandstones are mostly medium to coarse grained, arkosic, locally caceous, dark gray in color, and wherever weathered they are usually gray or ite. Most exposures show the rocks to be well cemented and indurated; although some areas the degree of cementation is slight.

The Upper Cretaceous rocks in the Simi Hills are essentially massive ndstones with thin interbedded shales (Kew 1924; Stipp 1943). In the Santa ez Mountains and in a small area of the Piru Mountains, they consist of thin eds of shale, siltstone, sandstone, and lenticular conglomerates. Conglomerates the Wheeler Springs area contain well rounded, well cemented sandstone, ranitic and metamorphic pebbles (Merrill 1952). The Upper Cretaceous rocks re generally folded and faulted and exhibit complex fracture and joint systems.

Fossils found in this series include Baculites chicoensis and other arine invertebrates indicative of the age of the rocks.

The Upper Cretaceous rocks are generally nonwater-bearing. In the hill south and east of Simi Valley, however, water wells obtain domestic and limited irrigation supplies from the massive poorly cemented and fractured sandstones. A well drilled into one of the sandstones has yielded over 1,000 gallons per minute probably from fracture systems. Small springs generally occur near fractures and faults in the Santa Ynez Mountains. Most of the springs yield cool, fresh water; but some of them which may be associated with faults such as Wheeler Hot Springs, produce warm water of good quality which is generally low in mineral constituents except boron. Surface water from areas of outcrop of these rocks is generally of good quality.

Paleocene-Eocene Series

Several formations are included in this series in Ventura County. The Martinez formation comprises the oldest rocks of the series. This formation is found in the Piru Creek area (Clements 1937), the Castaic Creek area (Clements 1937 and Dehlinger 1952), and in the Santa Monica Mountains, but has not been differentiated on Plate 10. In these areas, the Martinez formation consists of marine shale, sandstone, and conglomerate.

The Santa Susana-Martinez formation of Paleocene and middle and lower Eocene age (Stipp 1943) in the Simi Hills and on the south side of Simi Valley consists of up to 3,500 feet of light colored sandstone, some interbedded shale and a massive basal conglomerate. The lower Llajas formation (Meganos of Kew 1924) consists of about 2,000 to 3,000 feet of olive drab and blue shale, minor interbedded sandstone, and a basal conglomerate. The upper Llajas formation (Tejon formation of Kew 1924) consists of about 2,000 feet of brown to gray micaceous sandstone, siltstone, and some conglomerate (Stipp 1943). Both the upper and lower Llajas formations are exposed in the Simi Hills, and are of middle Eocene age.

The formations described below are all exposed north of the Santa Clara

Rver Valley and are of upper Eocene age. The Juncal formation consists of
sout 5,000 feet of marine olive drab to grey siltstone and shale grading down-
rd into concretionary dark grey siltstone and shale. Near the base of the
ncal formation, there is a black calcareous shale which is the equivalent of
e Sierra Blanca limestone in Santa Barbara County (Merrill 1952). The Matilija
ndstone lies conformably on the Juncal and consists of about 2,400 feet of
rine light colored sandstone with minor interbedded grey siltstone. The Cozy
ll shale lies conformably over the Matilija sandstone and consists of about
800 feet of olive drab to grey siltstone and shale. North of the Santa Ynez
ult, a prominent mapable white sandstone member has been included within the
zy Dell (Merrill 1952). Coldwater sandstone conformably overlies the Cozy Dell
ale. It consists of about 2,200 feet of white massive sandstone with inter-
dded red and green silty shale and lenticular conglomerate.

In the extreme northwest part of Ventura County a series of brackish
ater and marine sandstones and shales of Eocene age have been named the Patti-
y formation (Carlson 1952, Dibblee 1952).

Index fossils commonly found in the Paleocene-Eocene formations are
isted below:

Santa Susana-Martinez formation	*Turritella pachecoensis* *Venericardia venturensis*
Upper and lower Llajas formations	*Turritella lawsoni* *Galeodea susanae*
Juncal formation, Matilija sandstone, Cozy Dell shale, and Coldwater sandstone	*Turritella andersoni* *Turritella uvasana*

Shales of the Paleocene-Eocene series are generally well indurated, and the sandstones are fairly well cemented. The entire series generally forms rugged topography with thin sandy soils. Sandstone beds form particularly massive outcrops and very rugged topography. Rocks of this series are strongly fractured, faulted, and folded. They are generally nonwater-bearing. However, in the hills south and east of Simi Valley domestic and limited irrigation supplies are obtained from poorly cemented sandstones of the upper Llajas and the Santa Susana-Martinez formations. Occasional windmills in the Santa Ynez, Topatopa, and Piru Mountain regions obtain water from the sandstone members of this series. Generally, wells tapping these rocks at depths exceeding 300 to 400 feet encounter water of poor quality. Small springs are generally found in these rocks in the region north of the Santa Clara River.

Surface water derived from areas of outcrop of the Paleocene-Eocene series is generally of calcium sulphate type with about 600 to 1,500 and above parts per million (ppm) total dissolved solids.

Oligocene Series

The Oligocene series in the Ventura County region consists of continental lenticular interbedded conglomerate, sandstone, and shale. No Oligocene marine deposits are known to exist in the area covered by the geologic maps. Th sandstones are poorly to well cemented and generally buff to grey in color. Conglomerates generally contain granitic, metamorphic, sandstone, and chert pebbles and cobbles in a matrix of sandstone or siltstone. The siltstones and sha are generally micaceous and red, maroon, blue, or grey in color. The formation generally weather into red sandy clay soils which are characteristic of areas o outcrop of the series.

In most of Ventura County, the Oligocene series is called the Sespe formation. In the eastern Santa Clara River drainage area, it has been called the Vasquez formation (Sharp 1935). Beds of probable Oligocene age in the extreme northern part of the County have been called the Simmler formation (ibblee 1952).

The Sespe formation varies in thickness from 1,200 to 7,300 feet and nges in age from upper Eocene to lower Miocene, as determined by vertebrate ssils (Bailey 1947).

The Vasquez formation is of lower Miocene and Oligocene age (Jahns 40) and is up to 9,000 feet thick with about 4,000 feet of interbedded basaltic ows near its base. The Simmler formation is about 3,000 feet thick and contains intrusive andesites in the Lockwood Valley area.

The Oligocene series is essentially nonwater-bearing. Sandstones and nglomerates in the Ojai region and in the Simi Valley area usually yield from to 100 gallons per minute to wells. One well in the sandstones northwest of mi Valley, however, yields up to 700 gallons per minute. Wells deeper than 0 or 500 feet generally obtain brackish water unsuitable for irrigation.

Surface waters derived from outcrop areas of the Oligocene series are nerally of a calcium and bicarbonate-sulphate type with about 300 to 800 ppm tal dissolved solids. In Lockwood Valley and in the Tick Canyon area in Los geles County, a borax mineral, colemanite, is commonly interbedded with the diments, and as a result, surface runoff from these areas may be high in boron ntent especially during periods of low flow.

Miocene Series

The Miocene series in the Ventura County region consists of several rine and non-marine formations, and includes volcanic rocks. Reference may be de to the stratigraphic columns (Plate B-2) while reading the short descriptions of the formations which follow.

Marine Formations

Sediments deposited under marine conditions include the Vaqueros, Rincon, Topanga, Modelo, and "Santa Margarita" formations. The Vaqueros formation of lower Miocene age consists of 100 to 1,800 feet of gray to brown marine sandstone and shale. The Vaqueros formation has been mapped by some geologists in the southwestern part of the Santa Monica Mountains where it consists of black calcareous shale and minor sandstone beds, but it is included with the Topanga formation on the geologic map of this report because of the extreme geologic complexity.

The Rincon formation consists of over 2,000 feet of dark gray to brow concretionary shale and is exposed only north of the Santa Clara River.

The Topanga formation is mapped only in the Santa Monica Mountains ar Conejo Valley area. It is possibly the equivalent of the Rincon formation and the Vaqueros. Vaqueros fossils are found near the ocean south of Boney Mountai but the beds are included in the Topanga formation because of the complexity of the area. The Topanga formation is mostly black or gray shale in the area sout-west of Boney Mountain. It is composed of sandstone, conglomerate, and brown shale in the Conejo Valley area, and grades into sandstone and conglomerate in the easternmost portion of the area shown on the geologic map (Plate B-1C). Th Topanga formation is closely associated with volcanic rocks. The sediments of the Topanga formation have an aggregate thickness of 6,000 to 9,000 feet, while the intercalated volcanics have a maximum aggregate thickness of about 13,000 feet. The Topanga formation is unconformably overlain by Modelo sandstone and shale.

The Modelo formation is variable in lithology but has been subdivided into sandstones and shales by Kew (1924). This subdivision has been followed and used on Plates B-1A, B-1B, and B-1C. Thickness of the Modelo formation varies from zero to 6,500 feet. The sandstones of the Modelo formation are generally ight grey to tan in color and are fine to medium grained, and they contain iterbedded clay shales, and conglomerates. The shales of the Modelo formation nerally consist of laminated diatomaceous and cherty shales and clay shales, th minor interbedded sandstones and conglomerates. Fish scales and foraminifera e usually abundant.

The "Santa Margarita" formation includes up to 2,000 feet of tan, lty, diatomaceous shales, and sandstones of uppermost Miocene age. Some of the cks have been called the Pico formation by Kew and other names by other workers. e status of some of the sediments included in the "Santa Margarita" formation this report is somewhat uncertain. This term has been adopted because of its edominant usage in the western portion of the county. The quotation marks are cessary, since lithology is not consistent and may not resemble that of the pe locality.

Distinctive fossils of the Miocene marine formations are listed below:

"Santa Margarita" formation	Delectopecten pedroanus
Modelo formation	Foraminifera only
Topanga formation	Turritella ocoyana Turritella boesei
Rincon formation	Foraminifera only

For foraminifera in these formations, see Kleinpell (1938) and Hanna d Hertlein (1943).

ntinental Sediments

Continental sediments of Miocene age include the Quatal formation in e Cuyama Valley area and the Mint Canyon formation in the Los Angeles County rtion of the Santa Clara River drainage area. The Quatal formation consists of ,500 feet of red gypsiferous clay, sand, and poorly cemented conglomerate underin by 3,000 feet of red sandstone and poorly cemented fanglomerate (Dibblee 952). The Mint Canyon formation (Kew 1924) consists of 4,600 feet of lacustrine and fluviatile sandstone, conglomerate, clay, and some marl. Fresh water molluscs, plant remains, and land vertebrate remains have been found in the Min Canyon formation (Jahns, 1940).

Volcanic Rocks

The volcanic rocks, mostly of Miocene age, associated with the Topang formation include up to 13,000 feet of pyroclastics and basaltic flows. The pyroclastics include agglomerates, mud flows, and rhyolitic rocks. Andesitic ar basaltic dikes, sills, and plugs intrude the flows and the associated Topanga sediments. Fossiliferous marine shales, sandstones, and conglomerates occur from place to place interbedded with the flows. The volcanics are faulted, highly fractured, and moderately folded.

Hydrologic Properties

Most of the formations of the Miocene series are essentially nonwater bearing. Until 1953, the volcanics in the Conejo Valley and Tierra Rejada area constituted the principal formation in the Miocene series which was significant as far as water supply is concerned. Further discussion of the water-bearing properties of the volcanics is included in the description of the ground water basins.

Present information indicates that none of the Miocene marine sediments are potential major ground water reservoirs. That is, few wells could be drilled which would yield large quantities of water from these rocks. Deep wells in the Miocene marine formations generally obtain brackish or salty water. The Mint Canyon formation contains permeable beds which are potential sources of supply. As far as is known, no irrigation wells obtained water from the Mint Canyon formation up to 1953. The Quatal formation, of Miocene age, in the Cuyama Valley area contains extremely permeable gravels. It is possible that wels yielding sufficient water for irrigation could be obtained if drilled in suitable locations. At present, only domestic wells are known to be supplied rm this formation in Ventura County.

Surface water derived from areas of Miocene marine formations is generally a sodium-calcium-magnesium sulphate type containing from 400 to over 2,000 ppm cal dissolved solids. The runoff from areas of Miocene continental beds is generally a calcium sulphate type with from 200 to over 1,500 ppm total dissolved solids.

Pliocene Series

Formations of Pliocene age include the Pico, Saugus, and Morales formations, and the Ridge Basin Group.

The Pico formation consists of marine gray sandstone, blue gray shale, d lenticular conglomerate. These materials weather to a dull brown silty clay il. Landslides are common in areas of outcrop. The Pico formation is unconformable with underlying and overlying formations in the Las Posas area but elsewhere is generally conformable. It varies in thickness from 12,000 feet in the ntura area to zero in the Las Posas area. In the Ventura area, the Pico, Modelo, d Santa Barbara formations are conformable and interfinger. The Pico-Saugus ntact in the Saugus-Castaic area in Los Angeles County transgresses time so that e lower part of the Saugus formation, near the town of Saugus, is the age equivent of the upper portion of the Pico formation to the west. Typical fossils und in the Pico formation include Turritella cooperi, Pecten healyi, and Chione rnandoensis.

The Saugus formation consists of up to 2,500 feet of non-marine brown nd, slightly cemented gravel, and gray or tan clay. Kew (1924) originally cluded the San Pedro and portions of the Santa Barbara formation as described this report in the Saugus formation, but it is limited here to the eastern d of the Santa Clara River Valley in Los Angeles County. Vertebrate fossils collected by W. H. Corey and identified by Chester Stock indicate that the Saugus formation in the Castiac-Saugus area is of upper and middle Pliocene age (verbal communication from W. H. Corey, April, 1953).

The Ridge Basin group of sediments is located between the San Andreas and San Gabriel faults south of Quail Lake, largely in Los Angeles County. This group consists of up to 18,000 feet of continental shale, sandstone, and conglomerate (Eaton 1939, Crowell 1950, August 1952, and Dehlinger 1952). Fresh water fish, vertebrate, and plant remains indicating Pliocene age are found in the Ridge Basin group (Axelrod 1950 and Crowell August, 1952).

The continental Morales formation is located in the northwest portion of Ventura County to the east and north of the Cuyama River. It consists of about 4,000 feet of gray to buff gravels and sands (Dibblee 1952).

Hydrologic Characteristics

The Pico formation is generally nonwater-bearing or yields salty water to wells. Some water wells in the Los Angeles County portion of the Santa Clara River drainage area probably obtain water from the permeable sands and gravels of the Saugus formation. A few water wells were observed which penetrate the Ridge Basin group in Hungry Valley and Peace Valley, upper tributaries of Piru Creek near U. S. Highway 99. A few irrigation wells are drilled into the Morales formation in Santa Barbara County. Both the Morales formation and the Ridge Basin group are possible potential ground water reservoirs. However, low rain-fall in these areas would probably result in limited replenishment of the formations after the ground water was depleted by pumping.

Surface water from the Pliocene formations is generally a sodium sulphate type with from about 400 to over 2,000 ppm total dissolved solids.

Lower Pleistocene Series

Sediments of the lower Pleistocene series comprise some of the most nportant water-bearing formations in Ventura County. These include the Santa arbara and San Pedro formations.

anta Barbara Formation

The Santa Barbara formation is of lowermost Pleistocene and uppermost liocene age (Bailey 1935). It had been previously included in the Pico formaion by Kew (1924). It has been called upper Pico by Cartwright (1928), Driver 1928), and Waterfall (1929). The thickness and lithology of the Santa Barbara ormation varies considerably from about 4,000 feet of mudstone, shale, and minor andstone beds near the City of Ventura to about 1,000 feet of sand, gravel, and inor clay in the Tapo Canyon area and 800 feet of sand and clay in the southern art of the Oxnard Plain. Most of the clays and shales are blue in color when resh, and contain plant remains and distinctive foraminiferal faunas. The lightly cemented buff colored gravels and sands on Oak Ridge referred to in this eport as the Grimes Canyon member of the Santa Barbara formation extend southvestward under the Las Posas area and into the Pleasant Valley area, where they ecome mostly fine to medium sand. Typical fossils found in the Santa Barbara formation are listed below:

Vertebrates (Bailey 1935)	Equus cf. occidentalis
Invertebrates (Bailey 1935)	Pecten caurinus Pecten bellus
Foraminifera (Natland 1952)	Cassidulina limbata

The foraminifera found in the Santa Barbara formation in the Hall Canyon area indicate deposition at depths of 125 to 900 feet below sea level, while the lithology of the Grimes Canyon member near Grimes Canyon indicates beach or littoral deposition. The lithology and fossils indicate that the present area of the Santa Clara River Valley was under fairly deep water during deposition of sediments which comprise the Santa Barbara formation. A fluctuating shoreline extended from near the Santa Monica Mountains through Moorpark and eastward through the Tapo Canyon area. The northward extension of the shoreline is now concealed by structure or destroyed by erosion.

San Pedro Formation

The San Pedro formation is of lower Pleistocene age. North of the Santa Clara River, it interfingers with the underlying Santa Barbara formation. South of the Santa Clara River, it is generally unconformable on the Santa Barbara formation. In the Oxnard Plain-Pleasant Valley area, the available oil well logs indicate a conformable contact. The San Pedro formation consists of up to 4,000 feet of marine and continental gravel, sand, and clay. North of th Santa Clara River, the San Pedro formation consists of extremely lenticular bed with many scour and fill features. The base of the San Pedro in this area contains abundant marine fossils, but from near the middle of the formation to the top, marine fossils are rare except near the City of Ventura and the Ventura River. An oil well drilled through part of the San Pedro formation near the mouth of Aliso Canyon encountered mostly blue-green clay with abundant wood fragments and plant remains, indicating fresh water swamp deposits. A prominent s and gravel zone up to 300 feet in thickness containing marine fossils on the sou side of Oak Ridge and beneath the Las Posas area is called the Fox Canyon membe in this report. The Fox Canyon member can be traced on the surface and in wate and oil well logs in the Las Posas area and is found at or near the base of the San Pedro formation. The Fox Canyon member extends into Pleasant Valley and th Oxnard Plain, but available well logs indicate that it is probably not as homogeneous there as it is in the Las Posas area.

During deposition of the San Pedro formation the Oxnard Plain was ostly submerged to depths of about 125 feet and was being filled by deposition rom the ancient Santa Clara River. The Santa Clara River Valley itself was subiding so that the thickness of sediments is now greater there than anywhere else n Ventura County. As the basin filled with sediments, the shoreline moved westard, and some of the San Pedro formation is, therefore, of continental origin. s a result, nearly all the San Pedro formation exposed near the Ventura River ontains marine fossils, but only the base of the formation contains marine ossils just east of Santa Paula.

Nearly all the San Pedro formation in the Las Posas and Oxnard Plain reas was deposited in shallow water, probably partially in lagoons.

Typical fossils in the San Pedro formation are listed below:

Vertebrates (Bailey 1943)	*Equus cf. occidentalis* *Chendytes lawi*
Invertebrates (Bailey 1935)	*Crepidula princeps* *Cancellaria tritonidea* *Cantharus fortis* *Pecten Circularis*
Foraminifera (Natland 1952)	*Elphidium hannai* *Rotalia becarrii*

Some of the deeper sediments deposited in Simi Valley and Ojai Valley ay be of lower Pleistocene age but are described herein with the upper Pleistoene Series.

ydrologic Properties

Ground water occurs in sands and gravels of the Santa Barbara and San

Pedro formations. The Santa Barbara formation probably contains water of poor quality in the Santa Clara River area and portions of the Oxnard Plain-Pleasant Valley area as is indicated by electric logs of a few oil wells. The Grimes Canyon member contains fresh water of good quality in the Las Posas area and in the Pleasant Valley area. At the time of this investigation, only a few wells were obtaining water from the Grimes Canyon member or other sands of the Santa Barbara formation alone. A few other wells obtained water from the Santa Barbar as well as the overlying San Pedro formation.

The San Pedro formation yields water to wells in the Santa Clara River Valley and in the Las Posas, Oxnard Plain, and Pleasant Valley areas. As far as is now known, all water in the San Pedro gravels and sands is of good quality except that below about 2,000 feet in the Santa Clara River area, where a few electric logs indicate that the water may be slightly brackish.

Surface runoff from the Santa Barbara and San Pedro formations is gene-ally of fair quality.

Upper Pleistocene and Recent Series

Sediments of upper Pleistocene age include most of the gravels, sands, and clays younger than the San Pedro formation. In general, they are all undisturbed or only gently folded in contrast to the San Pedro and older formation.

The upper Pleistocene series in the Oxnard Plain-Pleasant Valley area extends from the top of the San Pedro formation to within about 20 to 50 feet of the surface. It consists of up to 500 feet of interbedded marine blue clay and sand, alluvial silt, and stream deposited sand and gravel. The principal aquifer on the Oxnard Plain is a stream deposited gravel of upper Pleistocene age which is called the Oxnard aquifer in this report. In the Pleasant Valley area, the upper Pleistocene series contains lenticular gravels which yield water t wells. From available well log data, the base of the upper Pleistocene series apears to lie unconformably on the San Pedro formation in Pleasant Valley and i parts of the Oxnard Plain.

The alluvium in Simi and Ojai Valleys is probably largely of upper and lwer Pleistocene age, approximately the upper 50 feet being Recent. Most of te alluvium in the Santa Clara River Valley is also Pleistocene, and the total tickness of alluvium in the river bottom ranges from five or six feet at Blue t to over 200 feet elsewhere. Most of the terrace deposits in Ventura County e probably upper Pleistocene.

Recent Alluvium is quite thin over most of Ventura County, probably no ore than 60 or 70 feet thick. It consists of sand, gravel, and clay. Most ter wells obtain water from materials underlying the Recent alluvium except those areas where the water table is high.

Both upper Pleistocene and Recent sediments are more fully discussed nder the description of ground water basins.

CHAPTER B-IV. STRUCTURE

The purpose of this chapter is to discuss the geologic structure of Ventura County, placing particular emphasis on those features which affect the occurrence and movement of ground water.

Ventura County is located in two regions of fairly distinct structural characteristics which coincide with the geomorphic provinces mentioned in Chapte B-II. The portion of the County north of the Santa Ynez fault (see Plate 10) is in the southern Coast Range province, and the portion south of this fault is generally included in the Transverse Range province. At the extreme northeast corner of Ventura County, the Sierra Nevada and Mojave Desert provinces meet bot the Coast Range and Transverse Range provinces near Lebec.

Many major structural features in Ventura County trend east-west, although considerable variation in direction exists. Principal structural feature of Ventura County and adjacent areas are shown on Plate 10. Plates B-1A, B-1B a B-1C show additional details of structure of the southern portion of the County. Geologic cross-sections are also included on these latter plates to illustrate structural features.

Faults

Faults in the Ventura County region may be divided into northwest-southeast trending, northeast-southwest trending, and east-west trending faults. Some faults have been displaced horizontally and some vertically, while both com ponents of movement have occurred on others. Aside from the major or prominent faults shown on the geologic maps, there are minor faults and fractures too numerous to indicate. Nearly all faults are actually zones of faulting, the width of the zone generally being greatest on the larger faults. Relative direc tions of movement along the faults, where known, are shown on the geologic maps.

...rthwest-Southeast Trending Faults

Major faults trending in a northwest-southeast direction include the ...n Andreas, Nacimiento, Pine Mountain, Hot Springs, San Gabriel, and Santa ...sana faults. The San Andreas fault is well known and is the longest fault in ...lifornia. Horizontal or more correctly right lateral movement has been pre-...minant, with over 300 miles displacement possibly occurring since Jurassic time ... suggested by Hill and Dibblee (1953). The Nacimiento fault extends into Ventura ...unty near the Cuyama River. The Hot Springs fault, which is located southwest ... Lockwood Valley, may be an extension of the Nacimiento fault, the two having ...en displaced by the Big Pine fault. The San Gabriel fault is another major ...ult of California. Like the San Andreas fault, the predominant movement has ...en horizontal, and Crowell (Oct. 1952) has presented evidence for about 25 miles ...rizontal displacement along the fault since Miocene time. The Santa Susana ...ult, in the Santa Susana Mountains of Ventura and Los Angeles Counties, is a ...rust fault which dips to the north and appears to override the east end of the ...k Ridge fault (Herron 1952 and Sheller and Bien 1947).

...rtheast-Southwest Trending Faults

The most prominent northeast-southwest trending faults are the Big Pine ...d Sycamore Canyon faults. According to Hill and Dibbleo (1953), the Big Pine ...ult is probably an extension of the Garlock fault (not shown), the two having ...en displaced by movement on the San Andreas fault. Hill and Dibblee report a ...ssible horizontal displacement on the Big Pine fault of 14 miles. The Sycamore ...nyon fault and associated faults in the Santa Monica Mountains are about 15 ...les long, and as far as can be determined have had mostly a vertical component ... movement.

It is possible that a major northeast-southwest trending fault exists ...ong the southeast edge of Pleasant Valley, but no evidence could be found that such a fault affects water-bearing materials, and it has not been shown on the geologic maps.

East-West Trending Faults

Most of the remaining major faults in Ventura County are essentially east-west trending. The northernmost of these faults will be discussed first, and those on the south side of the county last.

The Pine Mountain fault is a north dipping reverse fault, and is apparently a branch fault connecting the Big Pine and Hot Springs faults. The Tule Creek fault, although more than 20 miles long, is apparently not directly connec with other major faults. The Santa Ynez fault is another of the major Californi faults which have probably had both horizontal and vertical components of movement.

The Santa Ana fault, which crosses the Ventura River drainage area, ha had fairly recent movement, and probably has been an important factor in the accumulation of the alluvial fill in Ojai Valley.

The San Cayetano fault is a north dipping reverse or thrust fault with a known low dip of about 20 degrees near Fillmore, and of about 60 degrees north of Santa Paula. The San Cayetano fault actually consists of two or more branche often with soft, easily deformed sediments between them (Sheller and Bien 1947). Nonwater-bearing formations have been thrust over the San Pedro formation along h San Cayetano fault in the area northeast of Fillmore. North of Santa Paula, Eocene sediments have been thrust over Pliocene sediments as shown on Section C- Plate B-1B.

The Oak Ridge fault extends along the south edge of the Santa Clara River Valley from Saticoy to a point about two miles southeast of Piru, where i turns southward into Oak Ridge and is cut off by the Santa Susana fault. The Saticoy fault may be a westward extension of the Oak Ridge fault or a branch of t The Oak Ridge fault has been penetrated by several oil wells drilled on Oak

.dge, and it has been found that the fault dips southward about 60 degrees. .der formations have been thrust up from the south over younger San Pedro sedi- ents (see Section C-C', Plate B-1B).

Evidence for the location of the Saticoy fault shown on Plate B-1B was ound in logs of oil wells and in differences in water level elevation across it. ; is not certain what happens to this fault at depth, but it does appear to die it westward and cannot be detected in well logs north of Montalvo or along the each south of Ventura. The south side of the Saticoy fault has been uplifted elative to the north side.

The Simi-Santa Rosa fault system consists of several branches and tensions. The north side of this fault system has been generally uplifted elative to the south and has apparently been one of the causes for the accumula- .on of the thick alluvium in Simi Valley. East of Simi Valley the relative .rection is reversed, with the south side being uplifted, suggesting a hinge or cissors type fault.

It could not be determined during this investigation whether either the pringville fault zone or the Camarillo fault are extensions of the Simi-Santa osa fault system. The Springville fault zone is located on the south side of ie Camarillo Hills and consists of at least two parallel faults, portions of iich are well exposed on the surface. It is possible that the fault zone con- .nues eastward south of Somis, but outcrops and well log data are not available) show this. This fault zone does not appear to affect the Oxnard aquifer in ie Oxnard Plain although it does affect the San Pedro and older formations, at east near the Camarillo Hills. The Springville fault zone dips steeply to the rth with the north side being uplifted relative to the south.

The Camarillo fault extends along the south side of a low hill near ie town of Camarillo and curves northeastward toward Santa Rosa Valley. Evi- ence for this fault is found in well logs, physiographic features and water level data. The fault is probably nearly vertical and the north side is uplifted. The fault appears to fade out eastward and cannot be detected beyond the Camarill Airport.

Faults of Hydrologic Significance

The major faults in Ventura County which are known to have a barrier effect on ground water are the Saticoy and Springville faults and a portion of th Camarillo fault. Some of the other major faults described above with accompanyir folding generally affect ground water indirectly by deformation of the water-bear ing materials. This deformation in some cases has resulted in changes of cross-section area of water-bearing formations, and in exposure and erosion of portion of the formations so that they can be recharged by surface waters.

Some of the faults of Ventura County may also be avenues of escape for deeper waters of poor quality. Faults which may be in this category include the Hot Springs and Santa Ynez and possibly the San Cayetano and Oak Ridge faults. Evidence for escape of deeper waters appears in the analyses of spring water, and in some cases in analyses of ground water in alluvium near the faults.

The Saticoy fault affects the San Pedro formation and possibly the over lying alluvium. It appears to act as a partial barrier to flow of ground water with a water level differential across it of up to 100 feet (see Plates 14B, 15B, and 16B). The barrier effect of the fault seems to be most pronounced near the town of Saticoy. Its effect on ground water in the area of the Santa Clara River bed is not known due to lack of well control. The fault also appears to die out or become less effective so that no prominent differentials in water levels can be detected across the fault two or three miles westward of Saticoy. The barrier portion of the Saticoy fault also results in the deflection of a part of the underflow from Santa Paula Basin westward into Mound Basin, the remainder flowing through or over the fault into Oxnard Forebay Basin.

The Springville fault zone has displaced the San Pedro and underlying rmations. This displacement and the reduction of permeability caused by move-
nt as shown on surface exposures of the fault has caused a barrier to south-
d movement of ground water from beneath the Camarillo Hills into Pleasant Val-
Basin. The barrier effect is evidenced by up to 60 feet water level differ-
ial across the fault in aquifers of the San Pedro and Santa Barbara formations.
is probable that the Springville fault zone has not affected alluvium in the
ard Plain area.

Study of well logs indicates that the Camarillo fault displaces the
Pedro formation and probably some of the alluvium near the town of Camarillo.
und water contours generally do not indicate that this fault acts as a barrier
flow of ground water in the San Pedro formation. Field observations indicate,
ever, that local drawdown of pumping wells does not extend across the fault.
er levels in the lenticular aquifers of the alluvium do appear to be higher
the north side of this fault, suggesting that it may act as a barrier to the
thward movement of ground water in the alluvium.

Folds

All rocks and sediments in Ventura County, except those most recently
osited, have been folded. Most of the folds, like the faults, trend in an
t-west direction. In general, there are three prominent anticlinal areas which
ually consist of several smaller folds. These are the Topatopa Mountains near
Santa Ynez fault, Oak Ridge, and the Simi Hills south of Simi Valley. The
ta Monica Mountains in the Ventura County area are essentially a north dip-
g homocline. The principal areas which are essentially synclinal in structure
: the Cuyama drainage area northwest of the Big Pine fault, the area between
near the intersection of the San Andreas and San Gabriel faults which has
n called the "Ridge Basin" in geologic literature, the Santa Clara River syn-

cline, and the area south of Oak Ridge.

Some of the folded formations in the high hills and mountains may form limited ground water basins under certain conditions, but since most of these structures are not explored by wells, they are not discussed further.

Folds of Hydrologic Significance

The most significant folds from a ground water standpoint are the Sant Clara River syncline, the Montalvo anticline, and the series of folds in the synclinal area south of Oak Ridge, all of which affect water-bearing materials.

Santa Clara River Syncline. The Santa Clara River syncline extends from the ocean south of Ventura up the Santa Clara River into Los Angeles County The origin of this syncline was closely related to movement of the Oak Ridge and San Cayetano faults, as well as the Ventura Avenue anticline (see Plates B-1 and B-1B). It is probable that the Santa Clara River syncline was initially folded without faulting, and faulting occurred later when the sides of the fold became fairly steep (Reed, 1933). Of interest here is the fact that the water-bearing San Pedro formation has been folded in the Santa Clara River syncline, resulting in erosion and exposure of the upturned edges so that ground water is now replenished by surface water . The north flank of the folded San Pedro formation is exposed from the ocean to a point about three miles east of Santa Paula and may be recharged by rainfall penetration and stream percolation. The south flank of the syncline may be partially eroded and covered by alluvium along the e of the Santa Clara River and partially covered by older formations which have been thrust up along the Oak Ridge fault.

Montalvo Anticline. The Montalvo anticline, which affects the San Pedro formation, extends from the ocean up the south side of the Santa Clara River, crosses the river near Montalvo, and continues eastward south of the Saticoy faul. The Montalvo anticline appears to be cut off by the Saticoy or Oak Ridge fault ar the west end of Oak Ridge. This anticline is shown on the geologic map late B-1B) as a single continuous fold, but may consist of two or more indi-dual anticlines. The area in the vicinity of the anticline is complicated by nor faults and folds and it is difficult to determine details of the structure d their effect on the movement and occurrence of ground water. It seems clear at the Montalvo anticline has folded the San Pedro formation so that it has en eroded and covered by alluvial gravels in Oxnard Forebay Basin. As a re-lt, some aquifers of the San Pedro formation are most likely in hydrologic ntinuity with ground water in the overlying alluvium.

Folds South of Oak Ridge. The folds in the area south of Oak Ridge in e Las Posas area (see Plate B-1C) affect the principal aquifers there. These lds result in the aquifers being exposed in certain areas where they can be charged by surface waters and buried in other areas where water wells can be illed into them. The upturned edges of the aquifers and in some cases the ests of anticlines serve as ground water storage reservoirs for the deeper por-ons of the aquifers. Change of storage probably occurs in the Fox Canyon aqui-r in portions of the Long Canyon, Moorpark, and Camarillo anticlines. In the eper synclinal areas ground water within the aquifers is usually confined by erlying silts and clays.

CHAPTER B-V. GEOLOGIC HISTORY

The geologic history of Ventura County has been very complex. Portion of the area have been repeatedly covered by the sea and then uplifted, while oth portions have been below sea level nearly all the time. A few areas have been generally above sea level so that sediments were not deposited on them. The Ter tiary history of Ventura County has been closely related with the history of a larger region which includes much of Santa Barbara County, the Channel Islands, and a portion of Los Angeles County, and is designated Ventura Basin in this report. The term basin as used here means geologic basin. The northern portion of this large area has been called the Santa Barbara embayment. The Channel Islands and parts of the Santa Monica Mountains have been called Anacapia by Reed (1933) and Reed and Hollister (1936), but for purposes of discussion the two are are discussed here as one. Ventura Basin during most of Tertiary time was a bro east-west trending downfolded belt, with gentle uplifting occurring to the north and south. History of events prior to Tertiary time is obscure due to lack of e posures of pre-Tertiary rocks. The axis or deepest portion of the basin where t thickest sediments are found varied during Tertiary time. During Eocene time th axis was located in the northern portion of the County. In Oligocene time, the axis appears to have been along the central part of the County, and in Miocene time the major axis appears to have been in the south portion in the Santa Monic Mountains, with perhaps a secondary basin existing in the central portion of the County. During Pliocene and Pleistocene time the axis near the central part of the County remained the most prominent. It appears to have migrated slowly sout ward, so that at the present time the deepest part of Ventura Basin coincides wi the axis of the Santa Clara River syncline (see Plate B-1B).

Since Eocene time, much of the northern portion of Ventura County has been eroded. The eroded area has grown larger as the axis moved southward and the northerly areas were uplifted. In the Santa Monica Mountains great thickısses of volcanics and marine sediments accumulated during Miocene time, but tɜ area was apparently uplifted in the Pliocene since no Pliocene sediments have ɔen found there. These flexures in the earth's crust were accompanied by fault-ig and gentle folding of the sediments. In middle Pleistocene time, however, ɫlding and faulting was accelerated during the Santa Barbaran orogeny. This ıddle Pleistocene orogeny resulted in overturning of folds, subsequent breaking ɔ the folds into thrust fault, (Reed 1933), and the development of geologic fea-tres essentially as they are today. Evidence is available that thrusting occur-ɾd first from the south and later from the north (Herron 1953). After the mid-ˈeistocene orogeny the land was eroded into gently rounded hills and mountains, ıile upper Pleistocene deposits were still being deposited in the valleys. Dur-ig upper Pleistocene time, however, fluctuations in sea level, possibly related ɪ world wide glaciation, caused changes in base level of the streams. During ɾriods of low sea level, renewed erosion of portions of the valley fills and the ɪlling uplands occurred. As the water level rose after the last glacial period, ɾreams deposited their loads and filled the valleys once more.

The latest events appear to include the following: (1) continued ɪtivity along certain faults; (2) continued folding such as the folded terraces the Ventura River drainage area (Putnam 1942); (3) renewed downcutting and ɪadward erosion of streams, which may be due to a combination of man's alternation natural conditions and climatic changes.

The events since the mid-Pleistocene orogeny have had considerable effect . development of the submarine canyons. It is not known if the canyons existed fore that period. Whether they did or not, however, it is possible that the ɪad of sediments carried by the ancient Santa Clara River may have been of con-ıderable importance in present development of the canyons. During the upper .eistocene, the Santa Clara River continually shifted its course so that at var-ɪus times all parts of the Oxnard Plain were covered, and the river probably discharged at various times into the ocean at all points along the coast from the Santa Monica Mountains to its present position. Discharge of sediments onto the ocean floor in the area of the steep east-west submarine scarp south of the Coastal Plain may have resulted in submarine landslides, mudflows, and turbidity currents, which once started would continue from time to time as river sediments and transported beach sediments were dumped into the head of the canyons. The ocean floor west of Oxnard has a gentle slope, and it is probable that canyons have not been started there due to low velocities of turbidity currents and other transporting agents. It would appear that the submarine area west of Oxnard has been aggrading while the area to the south of Oxnard has been undergoing degradation and dissection which has been at least in part responsible for the formation of the submarine canyons.

CHAPTER B-VI. GROUND WATER STORAGE AND SUBSURFACE FLOW

The purpose of this chapter is to explain the procedures used to determine quantitative estimates of ground water storage and subsurface flow.

Ground Water Storage

Ground water is stored within the interstices of sediments and in cracks or fractures of solid rocks. The changes in ground water storage occurring over selected periods of study were estimated for the more important ground water basins within the County. Results of these studies are discussed in Chapter I. In general, the procedures of estimation required first a determination of the change in the volume of saturated sediments that occurred over a selected study period and second an estimate of the percentage of this volume that contained extractable ground water. The first factor was obtained by computing the volume of sediments that lay between the water tables that existed at the start and close of the study period; the second factor from evaluating the average weighted specific yield of the sediments between water tables from available well logs. Storage changes over the periods of study were computed by multiplying changes in volume of saturated sediments by average weighted specific yield.

Specific Yield

The specific yield of a sedimentary deposit is the ratio of the volume of water which it will yield by gravity after being saturated, to its own volume, customarily expressed in per cent. In its South Coastal Basin Investigation, the Division of Water Resources conducted extensive field and laboratory investigations for the purpose of assigning specific yield values to various types of material appearing in well logs. These procedures are described in Bulletin No. 45 "Geology and Ground Water Storage Capacity of Valley Fill" (Division of Water Resources, 1934). With slight variations, the values determined in this earlier work and Bulletin 46 "Ventura County Investigation" were adopted for compiling the change of storage estimates presented here.

The task of assigning specific yield values to the sediments appearing in logs was simplified by dividing all basin sediments into eight general categories. These included soil, clay, clay-sand, clay-gravel, tight sand, sand tight gravel, and gravel. Sand, gravel, and clay, which constitute the bulk of the basin sediments, were generally found to be well differentiated on the driller's logs. Combinations of these materials, however, were frequently described by such unique terms as "ooze", "muck", "cement", etc. Materials so described were placed, based on the judgment of a geologist, into one of the above eight categories. Table B-1 indicates specific yield values assigned to the general categories. In certain instances, these values were altered slightly whenever field observations indicated the advisability of changes.

TABLE B-1

SPECIFIC YIELDS OF SEDIMENTS

Material	Specific Yield (Per Cent)
Soil, including silty clay	3
Clay, including adobe and hard pan	0
Clayey sand, including sandy silt	5
Clayey gravel	7
Sand	25
Tight sand, including cemented sand	18
Gravel, including gravel and sand	21
Tight gravel, including cemented gravel	14

Selection of Increments

Each ground water basin was subdivided into smaller areas. Units of 100 acres were adopted in the larger basins where well logs were abundant and larger areas were used in basins for which little data were available. The sediments underlying each such subarea were separated at selected depth intervals. In this manner, each basin was divided into zones, the storage capacity of which culd be conveniently estimated. The change in ground water storage for each etire basin was then computed as the sum of the changes occurring within the znes.

Subsurface Flow

Two methods were used to determine subsurface flow. These were the sope-area method and the rising water method.

ope-Area Method

The slope-area method is based on the commonly used form of Darcy's law, PAI, where Q equals subsurface flow in gallons per day passing through the oss-sectional area A in square feet; P is permeability in gallons per day per uare foot; and I is slope of water table at the cross-section in feet per foot. is method is fairly reliable in cases where cross-sectional area can be deterned from well logs, permeability can be estimated by pump tests, and the ground ter slope can be accurately measured.

sing Water Method

The rising water method of computing subsurface flow is applicable ere rising water occurs perennially and where the cross-sectional area of turated sediments is unknown. The method has been mentioned by Tolman (1937) d a variation of the method was used by Kimble (1936). The rising water method also based on Darcy's law.

Let Qt equal total subsurface flow past a cross-section of the valley ll at the point of zero rising water, X, upstream from the point of maximum sing water, Y (see diagram below). Let Qu be the subsurface flow at the point maximum rising water and Qr the maximum rising water at any time. Assuming at little or no water is lost by diversion or evapo-transpiration between X and

Y, and that steady flow conditions exist it follows that:

$$Qt = Qu + Qr$$

At point X the total subsurface flow may be expressed as

$$Qt = PAI$$

and

$$Qu + Qr = (PA)\ I$$

where

P = permeability

A = cross-sectional area

I = slope of water table at point X, as measured in wells just upstream from X.

It is assumed that:

1. Flow is horizontal.
2. The materials are essentially homogeneous.
3. The change in cross-sectional area due to change in water levels is negligible.
4. Permeability is constant throughout the section.

Under these assumptions, the variations in Qr must be dependent only upon I.

Two periods t_1 and t_2 may be taken so that

$$Qu + Qr_1 = (PA)I_1 \qquad (1)$$

and

$$Qu + Qr_2 = (PA)I_2 \qquad (2)$$

Subsurface flow or Qu is nearly constant as long as any rising water occurs, since I at Y is essentially determined by the surface of the stream.

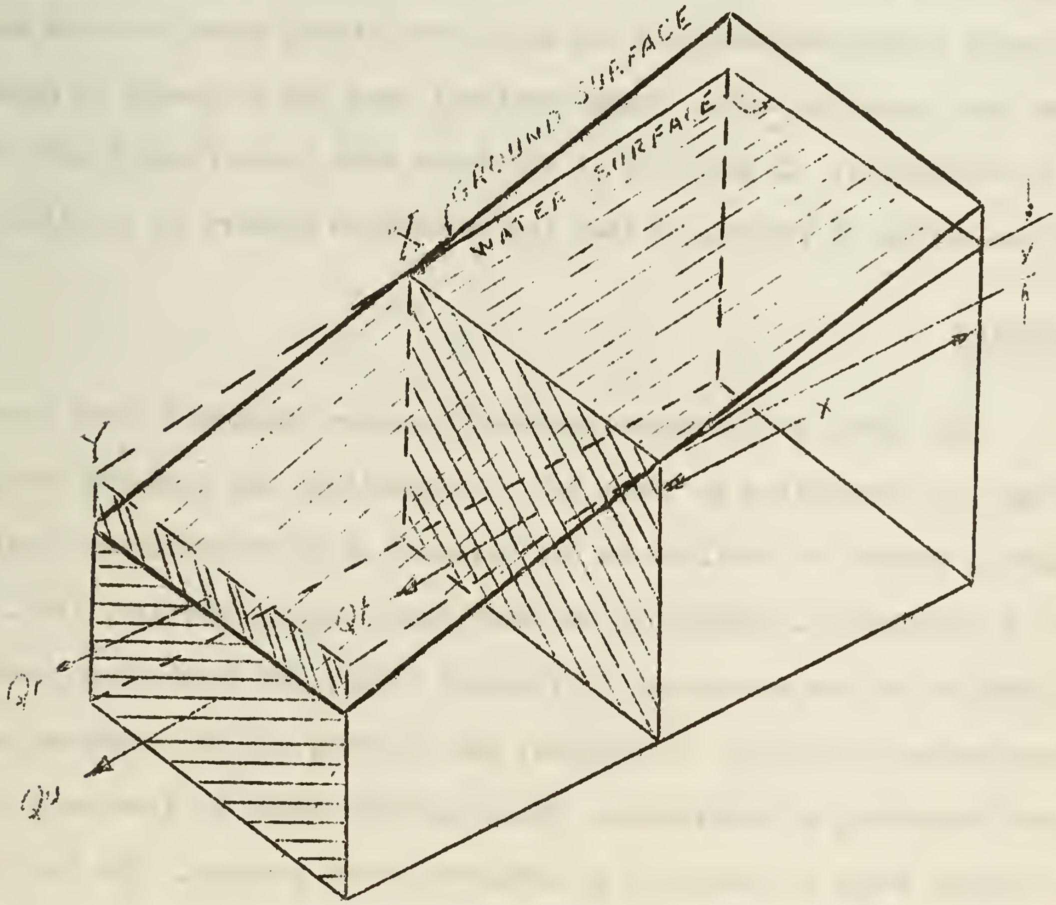
Dividing (1) by (2).

$$\frac{Qu + Qr_1}{Qu + Qr_2} = \frac{PA\ (I_1)}{PA\ (I_2)}$$

and solving for Qu

$$Qu = \frac{I_1(Qr_2) - I_2(Qr_1)}{I_2 - I_1}$$

The maximum rising water, Qr, must be measured. Error may be intro-
ıced if water losses are not taken into account or if the stream is not measured
t the point of maximum rising water. Rising water measurements obtained by
ɔth the Division of Water Resources and the Ventura County Water Survey were
sed to compute subsurface flow in the basins of the Santa Clara River by this
ethod.



Qt = PAI
Qt = Qr+Qu

Slope of Water Surface = I = $\frac{y}{x}$

In order to complete the hydrologic studies of the Santa Clara River basins it was necessary to estimate the decrease in subsurface flow when water level of the basins were drawn down and rising water stopped. In order to do this the logarithm of rising water plus previously estimated subsurface flow wa plotted against basin storage depletion and found to be nearly a straight line. This line was then projected past the point where zero rising water occurred an the projected line was used to estimate subsurface flow for conditions of zero rising water. This method of estimating subsurface flow with zero rising water is based on the assumption that the storage depletion of the basin and the slop of the water table upstream from the area where rising water occurred are relati and that the change of wetted cross-sectional area due to change in ground wate level is negligible. In general, it was found that these factors were related during the period of record, so that the assumption appears to be valid.

Permeability

Pump tests to determine permeability were conducted where possible. These data are summarized in Table B-2. Permeability was computed using non-equilibrium methods as outlined in the Division of Water Resources "Draft of Report of Referee" No. 506806, of the West Coast Basin, February, 1952. Slight variations in methods as suggested by Wenzel (1942) and Jacobs and Cooper (194 were used where necessary. In general, the recovery and the drawdown methods were used depending on conditions. These methods depend on time-rate of recove after pumping stops or time-rate of drawdown during pumping. The last column c Table B-2 indicates relative reliability of results due to conditions at the ti of the tests.

TABLE B-2

SUMMARY OF PERMEABILITY PUMP TESTS

Well	Test Method	Basin and Aquifer	Transmissibility Gallons per Day per Foot	Thickness of Aquifer from Well Log	Permeability Gallons per Day per Square Foot	Storage Coefficient	Conditions of Test
1N/21W-14B1 Camarillo Hospital	Drawdown	Pleasant Valley - Older alluvium, San Pedro fm., and volcanics	54,800	280	220	.043	Poor
1N/22W-17C1 U.S. Navy	Recovery	Oxnard Plain - Oxnard aquifer	198,000	100	1,980	---	Good
1N/22W-17C2 U.S. Navy	Recovery	Oxnard Plain - Oxnard aquifer	264,000	100	2,640	---	Good
2N/19W-15B2	Drawdown	Tierra Rejada - volcanics	120,000	600	200	.096	Fair
2N/20W- 4F1 Las Posas Orchards	Recovery	East Las Posas - Fox Canyon aquifer	177,300	426	416	---	Good
2N/23W-14M1 Ventura City	Drawdown	Mound - San Pedro fm.	220,000	280	780	.00057	Poor
3N/23W- 8G Ventura City	Drawdown	Upper Ventura River - alluvium	36,000 (average)	20	1,800	.00056 to 0.25	Fair (Composite of 4 wells)
4N/19W-33D4 State Fish Hatchery	Recovery	Piru-Fillmore San Pedro fm.	1,220,000	338	3,600	---	Poor

CHAPTER B-VII. DESCRIPTION OF GROUND WATER BASINS

Seventeen ground water basins delineated in Ventura County in the course of this investigation are discussed in the following paragraphs. The boundaries of these basins are shown on Plate 11. In addition, there is discussed herein an additional basin known as Eastern Basin, which is located in Los Angeles County but which affects the regimen of flow in the Santa Clara River in Ventura County. Several further ground water bodies which presently yield but little water, are discussed under the name of the locality in which they occur, namely, Malibu hydrologic unit, Rincon subunit and Rincon Creek drainage area, Cuyama River drainage area, and upper portions of Piru Creek drainage.

The boundaries of ground water basins in most instances conform with geologic features such as contacts between permeable and impermeable formations, fault zones of low permeability, or changes in subsurface lithology which affect movement or mode of occurrence of ground water. These boundaries were established from available data, including well logs, areal geology, and hydrologic observations.

In general, there are three types of ground water basins in the County. These include (1) basins composed of unconsolidated sediments or alluvium, (2) volcanic rock basins, and (3) basins composed of consolidated rocks. The first type of basin comprising unconsolidated sediments or alluvium has been further divided into two sub-types: the simple type basin in which ground water occurs in a single unconfined body, and the complex basin in which ground water occurs in more than one aquifer. The characteristics of these types of basins are summarized in Table B-3.

TABLE B-3

CHARACTERISTICS OF TYPES OF GROUND WATER BASINS

Type of basin		Basin or subunit	Type of wells and general characteristics	Nature of basin fill	Water table conditions at wells
Unconsolidated Sedimentary or Alluvial Basins	Simple	Ojai Upper Ojai Ventura River Basins Simi Piru Fillmore Santa Paula Oxnard Forebay Miscellaneous Areas	Irrigation mainly. Many wells, yields generally high.	Lithologically heterogeneous, but permeable zones interconnected to form one water body.	Generally unconfined.
	Complex	Mound Oxnard Plain Pleasant Valley East and West Las Posas Santa Rosa Miscellaneous Areas	Irrigation mainly. Many wells, yields generally high. Commonly show pressure effects.	Usually two or more aquifers, frequently in well defined depth zones. Some free ground water areas.	Frequently confined. May be partly unconfined or both.
Volcanic Rock Basins		Tierra Rejada Parts of Conejo Basin Parts of Malibu Hydrologic Unit	Domestic and limited irrigation. Wells numerous with moderate yields.	Basin structure may be complex. Water occurs in fractures. Highly fractured zones produce more water	Generally unconfined.

TABLE B-3 (Continued)

CHARACTERISTICS OF TYPES OF GROUND WATER BASINS

Type of basin	Basin or subunit	Type of wells and general characteristics	Nature of basin fill	Water table conditions at wells
Consolidated Rock Basins	Parts of Ventura River Subunits Simi Subunit (Hill areas) Parts of Conejo Basin Parts of Malibu Hydrologic Unit Miscellaneous Areas	Domestic, stock watering, and limited irrigation. Few wells-yields generally low.	Structure may be extremely complex. Water occurs in fractures and/or interstices.	Confined, unconfined, or both.

Ground water basins of most economic importance in Ventura County are those possessing a combination of sufficient replenishment, sufficient storage volume to regulate the water supply, and materials which will readily yield water to wells. In general, the unconsolidated sedimentary basins are of greatest economic significance.

Ground Water Basins Within Ventura Hydrologic Unit

Ground water basins in the Ventura Hydrologic Unit include Upper Ojai, Ojai, Upper Ventura River, and Lower Ventura River Basins. Locations of the basins are shown on Plate 11, and physical characteristics are summarized in Table 9. Other portions of the Ventura Hydrologic Unit contain relatively small areas of shallow water-bearing materials. Water wells in such areas are usually shallc and have low yields. Some wells in these areas obtain water from the fractures and pervious zones within consolidated Tertiary sediments.

Plate B-1A (Areal Geology) depicts the details of structure and extent of formations within this unit.

Upper Ojai Basin

This basin lies within the Upper Ojai Subunit. It comprises a surface area of about 1,950 acres situated in the northeasterly portion of Ventura Hydrologic Unit. Elevations vary from 1,200 feet to 1,600 feet above sea level. Surface waters drain westerly through Lion Canyon into San Antonio Creek and easter] along Sisar Creek to Santa Paula Creek.

Geology. The water-bearing materials comprising the ground water basir include Recent and Pleistocene stream deposited gravel, sand and clay, and to a limited extent deeply weathered older formations. The alluvial materials are known to exceed 300 feet in thickness at a well near Sisar Creek, though their average thickness is estimated to be about 60 feet. The Tertiary sediments that flank the basin consist of consolidated marine and continental sandstone, conglomerate, and shale, and contain water of poor quality in some areas. These Tertiary sediments include the Pico, "Santa Margarita", Modelo, Rincon, Vaqueros, and Sespe formations, all of which are folded and faulted.

Occurrence of Ground Water. The alluvium comprises the principal urce of ground water. In general, ground water is unconfined and surface ters percolate relatively freely to the water table. Ground water also occurs fractures in the consolidated Tertiary sediments which flank and underlie the luvium. There are a few springs supplied from such fractures in the rocks. st wells in the basin penetrate the alluvium and bottom in the older rocks. e alluvium underlying much of the basin drains rapidly to Lion Canyon and Sisar eek and consequently only a few feet of water accumulate above the base of ese materials.

Movement of Ground Water. The ground water in Upper Ojai Basin divides, rt flowing eastward to Sisar Creek and the remainder flowing westward into Lion nyon. The location of the ground water divide and the directions of movement e depicted by contours on Plate 16-A.

Replenishment and Depletion of Ground Water. The principal sources of ound water replenishment are deep penetration of precipitation, percolation of rface water in streams, and percolation of the unconsumed portion of water plied for irrigation and other uses. Ground water is depleted by pumped ex- actions, consumptive use of phreatophytes, and drainage of springs into Sisar eek and Lion Canyon.

Subsurface Inflow and Outflow. Consolidated Tertiary formations flank e alluvial deposits, preventing appreciable subsurface outflow to Ojai Basin. rings exist near the base of the alluvium in both Sisar Creek and Lion Canyon, ough this water leaves the basin as surface flow.

Ground Water Storage Capacity and Specific Yield. Alluvium in this sin is relatively shallow, with an average estimated depth of about 60 feet. ter in these sediments drains rapidly to springs situated at lower elevations, as indicated in the preceding paragraphs. Though no estimates were made, the usable storage capacity is believed to be small.

Yield of Wells. The yield of wells ranges from about 10 to 200 gallons per minute, with an estimated average yield of about 50 gallons per minute.

Ojai Basin

This basin, with an areal extent of about 6,040 acres, lies in the northerly portion of the Ventura Hydrologic Unit and to the northwest of Upper Ojai Basin. Elevations vary from about 700 feet to over 1,200 feet above sea level. Surface waters within this basin drain to the southwest in San Antonio Creek toward the Ventura River.

Geology. Rock types of Ojai Basin consist of permeable stream deposits of Recent and Pleistocene age flanked and underlain by older consolidated sedimentary formations as shown on Geologic Sections E-E' and F-F' on Plate 12-A.

The alluvium consists chiefly of gravelly clay and gravel up to 700 feet in thickness. Boulders and pebbles in the gravel consist chiefly of sandstone or conglomerate derived from the surrounding drainage area. Well logs show less clay in the easterly end of the valley than in the vicinity of the City of Ojai. Only a few well logs are available in the area west of the city, but here the low yield of wells indicates that the clay content is probably high. Samples of the deeper alluvium obtained during the drilling of wells appeared to be strongly weathered. The alluvium of Recent age is composed of about 50 to 100 feet of sediments similar to those occurring in the underlying Pleistocene alluvium though usually less weathered. Distinction between the two formations is usually difficult.

The older Tertiary formations including the Modelo, Rincon, Vaqueros, Sespe, Coldwater, and Cozy Dell are usually consolidated or cemented, and may contain water of poor quality.

Ojai Valley is essentially a down-faulted and folded area, which has een filed with permeable stream deposits consisting of the Recent and Pleistocne alluvium. Surface exposures of the Pleistocene alluvium indicate that the ds dip from 10 to 30 degrees.

Occurrence of Ground Water. Ground water occurs within alluvial deposits d to some extent in fractures and interstices of the flanking Tertiary formaons. Ground water is generally unconfined except in the southwestern portion the basin where flowing wells during periods of high water level indicate local nfined conditions. Percolation of surface water to the water table appears to relatively unrestricted in the balance of the area.

Movement of Ground Water. Directions of ground water movement are shown water level contours on Plates 14-A, 15-A, and 16-A. In general the movement toward the south and west converging on San Antonio Creek near its outlet from ai Valley. During periods of low water levels (Plate 16-A) the water table slope reversed in the southwest portion of the basin.

There are no known barriers to movement of ground water in this basin.

Replenishment and Depletion of Ground Water. Ojai Basin is replenished percolation of surface water in stream channels, by water diverted from Matija Dam into the Ojai spreading grounds, by deep penetration of precipitation and rcolation of the unconsumed portion of water applied for irrigation, and to a ight extent by subsurface inflow from the surrounding Tertiary formations. The sin is depleted by pumped extractions, by consumptive use of phreatophytes, and effluent discharge into San Antonio Creek.

Subsurface Inflow and Outflow. Ojai Basin is isolated from Upper Ojai sin by nonwater-bearing Tertiary formations which prevent the movement of appreable quantities of ground water between these basins. At the westerly end of

Ojai Valley near the outlet of San Antonio Creek, bedrock is exposed along the creek bottom. A short distance northeast of this outlet, nonwater-bearing sediments of the Sespe formation are exposed in a small hill. North of this hill there are a few deep wells in the valley floor which yield only small amounts of water although their logs indicate only sedimentary material. These observations suggest that at the westerly end of Ojai Valley, a relatively thin mantle of alluvium overlies essentially nonwater-bearing Sespe formation. Subsurface outflow from Ojai Valley to Ventura River Basin is therefore probably insignificant.

Ground Water Storage Capacity and Specific Yield. Specific yield and storage capacity of the water-bearing materials and changes in storage occurring over selected study periods were computed in the manner described in Chapter B-VI, and results are discussed in Chapter II. Total usable storage capacity of Ojai Basin is estimated to be about 70,000 acre-feet.

Yield of Wells. Wells in the alluvial basin generally yield from 100 to 600 gallons per minute with a range in specific capacity of from three to twenty. Wells tapping the older surrounding formations usually yield from two to five gallons per minute but occasionally yield as much as 50 gallons per minute. The specific capacity of wells in the older formations is usually very small.

Upper Ventura River Basin

Upper Ventura River Basin lies within the Upper Ventura River subunit which includes the Ventura River Valley, the Coyote Creek drainage area, and that portion of the San Antonio Creek drainage area that lies downstream from Ojai Valley. The basin ranges in elevation from 200 to more than 800 feet above sea level, and consists of about 4,990 acres underlain by alluvium. Water-bearing alluvial deposits of very limited areal extent also occur along Coyote Creek and San Antonio Creek, but these deposits are not considered to be of sufficient size to be regarded as ground water basins.

Geology. The alluvium consists of Upper Pleistocene and Recent deposits of gravel, sand, and clay. Well logs indicate the alluvium of Ventura River valley to vary from 60 to 100 feet in depth. In the San Antonio and Coyote Creek areas, it apparently varies from 5 to 30 feet in depth. These deposits are flanked by Tertiary sediments consisting of marine and continental sandstone, conglomerate, and shale, and include the Rincon, Modelo, Vaqueros, Sespe, Coldwater, and Cozy Dell formations. The Sespe formation underlies a large portion of the Coyote Creek drainage area and is composed chiefly of well cemented sandstone with intercalated lenses of conglomerate. The sandstone is locally fractured. The conglomerates occur as both poorly and well cemented deposits. It is often difficult to distinguish the conglomerates from overlying alluvium in well logs. Some water wells penetrating the Modelo formation obtain water of inferior quality.

The Ventura River is an antecedent stream that has cut across the regional structure and does not flow along a structural trough. The Tertiary rocks are generally folded and faulted, but the Recent deposits are relatively undisturbed.

Occurrence of Ground Water. Ground water occurs in alluvium and to some extent in the fractures and interstices of the Tertiary formations. In general, free ground water conditions prevail throughout the entire subunit. However, locally confined bodies of ground water may exist. While wells in the Sespe formation are being drilled, the water level occasionally rises, indicating the existence of localized confined bodies of ground water.

Movement of Ground Water. Ground water moves through the alluvium following the slopes of the surface drainage, ultimately [illegible]g Lower Ventura River Basin below Foster Park. Directions of [illegible] are mor[illegible]sely [illegible] by ground water contours on Plates 14-A, [illegible] and 16[illegible]le f[illegible]ated as crossing this basin in an east-west direction [illegible] is n[illegible]ce suggesting that they cut the alluvium or form barriers to movement of ground water.

Replenishment and Depletion of Ground Water. Ground water is replenished chiefly by percolation from the Ventura River and to a lesser extent by percolation of direct rainfall and the unconsumed portion of water applied for irrigation and other uses. A slight amount of recharge is probably derived from subsurface inflow through the flanking Tertiary formations. Ground water is deplete by pumped extractions, consumptive use of phreatophytes, effluent discharge, and subsurface outflow.

Subsurface Inflow and Outflow. Subsurface inflow is practically negligible being limited to seepage through fissures and pores in the Tertiary formations. In 1906, the City of Ventura constructed a partial subsurface barrier in the alluvium of the Ventura River near Foster Park. The purpose of the barrier was to create rising water to be diverted for domestic and irrigation purposes. The easternmost end of this barrier was not completed, and a perennial subsurfac flow exists around this end. This flow was estimated by the slope area method described in Chapter B-VI and was found to vary between 75,000 and 100,000 gallo per day or about 100 acre-feet per year.

Ground Water Storage Capacity and Specific Yield. Total storage capacy of the basin is estimated to be about 10,000 acre-feet. The average specific yield of the contained sediments is estimated to be about eight per cent.

Yield of Wells. Irrigation wells in the alluvium yield about 600 gall per minute with specific capacities ranging from 10 to 200. Both well yield and specific capacity are influenced by the regimen of the Ventura River. Following cessation of surface flow in the river, both yields and specific capacities fall below the above values.

ɩer Ventura River Basin

Lower Ventura River Basin includes the alluvial deposits of the Ventura ɩver that lie between Foster Park and the ocean, and the basin ranges in elevaɔn from sea level to about 200 feet above sea level. It has a surface area of but 2,670 acres. The valley floor of Canada Larga has been excluded from this sin, since the alluvial deposits in this valley are shallow and contain little ter. In the southern end of the basin, alluvium overlies and is probably hyulically isolated from the San Pedro formation. The San Pedro formation in s area appears to be hydraulically connected with the Mound Basin and is conlered herein a part of that basin.

Geology. The alluvial fill of the basin consists of gravel, sand, and ay. It is surrounded and underlain by older, generally less permeable sedimenry formations. These include the San Pedro, Santa Barbara, Pico, Modelo, Rincon, queros, and Sespe formations. At its north end, the basin is connected to Upper ntura River Basin near Foster Park, and at the south end it is bounded by the ean.

Within this basin, Ventura River is an antecedent stream. It crosses e axis of the Ventura Avenue anticline near the center of the basin. Downstream om this axis, formations older than the alluvium dip southward and strike in an sterly direction. With the exception of the Pleistocene San Pedro formation, e flanking formations are generally nonwater-bearing. The San Pedro formation nsists chiefly of gravel, sand, silt, and clay.

Sea-Water Intrusion. No evidence available conclusively indicates that ean water has invaded the basin. The electric log of one well near the river uth shows that at the time of drilling, the alluvial deposits contained highly neralized water. It is uncertain as to whether this condition was due to inusion of sea water or to pollution from local sources. Two wells near the river mouth tap only the underlying San Pedro formation and provide no indicatio of the quality of water occurring in the alluvium.

Occurrence of Ground Water. The principal water-bearing formation is the late Quaternary alluvium of the Ventura River which varies from 60 to 100 fe in thickness. Terrace and alluvial deposits flanking the main body of alluvium, Plate B-1A, are shallow and would produce only minor quantities of water.

The San Pedro formation flanks and underlies the alluvium near the mou of Ventura River. It dips about 35 degrees toward the south and strikes to the east extending into Mound Basin. Available data suggest that the San Pedro form tion near the river mouth is at least partially hydraulically isolated from the river alluvium by relatively impervious material, possibly of lagunal or Paludal origin. The alluvium is considered to be within the Lower Ventura River Basin overlapping the San Pedro formation which belongs hydrologically within Mound Basin. This conclusion is substantiated by the following observations:

1. Static water levels in wells tapping the San Pedro formation have been above the elevation of the bed of the Ventura River indicating that ground water in the San Pedro formation is confined.

2. The electric log of one of the above wells indicated water of poor quality in the river alluvium; yet this same well has continually produced fresh water from the underlying San Pedro formation.

3. Water levels in wells tapping the San Pedro formation fluctuate in rapid response to tidal fluctuations, further indicating that ground water in th San Pedro formation is confined.

Movement of Ground Water. There are few wells situated in Lower Ventu River Basin; consequently, no ground water contour map was constructed of this area. In general, ground water moves in a downstream direction, ultimately discharging into the ocean. No barriers to ground water movement are known to exis

Replenishment and Depletion of Ground Water. The basin is replenished by percolation from the Ventura River, by percolation of rainfall and the unconsumed portion of water applied for irrigation and other uses, as well as by subsurface inflow from Upper Ventura River Basin. Inflow from flanking Tertiary sediments is probably small. Depletion occurs by surface and subsurface outflow, limited pumped extractions, and consumptive use of phreatophytes.

Subsurface Inflow and Outflow. Subsurface flow in the alluvium of the Ventura River near Foster Park constitutes one of the principal sources of supply to Lower Ventura River Basin. Subsurface outflow from the basin probably discharges to the ocean during periods of high ground water level.

Ground Water Storage Capacity and Specific Yield. Pumping draft on Lower Ventura River Basin is negligible. There are no irrigation wells, a few abandoned domestic wells, and one sump pump. For this reason, no estimates of change in storage were compiled for this basin.

Yield of Wells. There are no known irrigation or domestic wells operating in Lower Ventura River Basin which obtain water from the alluvial fill.

Ground Water Basins Within Santa Clara River Hydrologic Unit

Ground water basins within the Santa Clara River Hydrologic Unit inclu Piru, Fillmore, Santa Paula, Mound, Oxnard Forebay, Oxnard Plain, and Pleasant Valley Basins. These basins are the most productive in Ventura County. Plate 1 shows the location of the ground water basins, and their physical characteristic are summarized in Table 11. Plate B-1B shows details of geologic structure and extent of formations in this hydrologic unit.

Eastern Basin

Eastern Basin lies within Los Angeles County; more explicitly it comprises the water-bearing formations of that part of the Santa Clara River Valley lying east of Ventura County. Since it is not in Ventura County, it was not studied in detail during the course of this investigation. It is discussed here because it is tributary to other basins in Ventura County. Pumping from this basin effects the regimen of both surface and subsurface flow in the Santa Clara River. The boundaries of Eastern Basin were not determined exactly, except for the boundary with Piru Basin on the west.

Geology. The watershed tributary to Eastern Basin contains sedimentar formations of marine and non-marine origin, some volcanic rocks, and large areas of granitic and metamorphic rocks. These formations are shown on Plate 10 and include alluvium, Saugus and Pico formations, Ridge Basin group, "Santa Margarit" Modelo, Vaqueros, Mint Canyon and Martinez formations. Of these formations, the Saugus and Quaternary alluvium are of principal interest. Water derived from a:eas of non-marine formations may be fairly high in boron due to occurrence of b:ron minerals in these sediments.

The Saugus formation in this area consists of continental sand, clay, ad poorly cemented gravel and attains a maximum thickness of 2,500 feet. These mterials have been faulted, folded, and eroded. In the valley areas the Saugus frmation is overlain by up to 100 feet of alluvial sand and gravel with some cay and silt.

Occurrence of Ground Water. Ground water is derived principally from wlls tapping the Saugus formation and the Quaternary alluvium. It is known tat ground water within the deeper aquifers often occurs as confined water where- that within the alluvium is usually unconfined. No attempt was made in this ivestigation to delimit the extent of the different aquifers in Eastern Basin.

Movement of Ground Water. No ground water contour maps were constructed Eastern Basin by this Division during this investigation. Ground water contour ps of this area are published in "The Annual Report on Hydrologic Data" by the os Angeles County Flood Control District.

Replenishment and Depletion of Ground Water. Ground water is reple- ished by stream percolation, penetration of direct precipitation and the uncon- umed portions of water applied for irrigation and other uses as well as imported ater released by the City of Los Angeles from Bouquet Canyon Reservoir, and also a minor extent by subsurface inflow from the older semi-permeable formations hat flank the basin. The ground water basin is depleted by pumped extractions, onsumptive use of phreatophytes, and effluent discharge.

Subsurface Inflow and Outflow. An undetermined amount of inflow enters he basin from older semi-permeable formations that flank the water-bearing sedi- ents. Subsurface outflow from Eastern Basin is negligible and is discussed in he paragraph on subsurface inflow to Piru Basin.

Ground Water Storage Capacity and Specific Yield. No attempt was made to estimate change of storage or total storage capacity within Eastern Basin during this investigation.

Yield of Wells. No measurements of well discharge were made in this basin, although both irrigation and domestic wells exist. Several highly productive wells tap the alluvial sands near the river and are supplied directly by percolation from that source. One such well reportedly yields 2,000 gallons per minute. Irrigation wells are also known to tap the Saugus formation, but the yields of such wells are not known.

Piru Basin

Piru Basin ranges in elevation from 470 feet to 800 feet. The highest elevation within the watershed is 4,592 feet attained at Hopper Mountain. It comprises a surface area of about 6,520 acres. The greater portion of the ground water basin underlies the alluvial area of the Santa Clara River Valley. The eastern boundary of the basin is at Blue Cut which is located about one mile west of the Los Angeles County line. The western boundary is arbitrarily located as shown on Plate B-1B.

Geology. The principal water-bearing formations of Piru Basin are alluvium of Recent and upper Pleistocene age and the San Pedro formation. Rocks adjacent to the valley floor include the Sespe, Vaqueros, Modelo, "Santa Margarita", and Pico formations, all of which are essentially nonwater-bearing in this area but which may contribute water of poor quality to the water-bearing material.

Alluvium in Piru Basin is about 85 to 200 feet thick and consists of river deposited sand and gravel of Recent and upper Pleistocene age which is not readily differentiated from the San Pedro formation. In Blue Cut at the extreme east end of the basin, alluvium is about 6 to 15 feet thick. On the south side of

u Basin alluvium overlies a shelf-like feature of nonwater-bearing rocks (see
ologic Section J-J', Plate 12-A).

The San Pedro formation does not outcrop in this basin, but it is
oped at depth by many wells.

Water wells reach depths of up to 1,000 feet in Piru Basin and their
gs indicate that the San Pedro formation is characterized by gravel, sand, and
me clay. Several water wells which were in the process of being drilled were
sited in the course of the investigation. Samples of material taken from these
lls indicate that most of the San Pedro formation, to depths of 800 feet, was
posited under conditions similar to those which prevail in the Santa Clara
ver today. The nature of the sediments deeper than 800 feet is not well known.
mples from an oil well drilled near Cavin Road on the north side of the river
st west of the center of the basin are comprised of similar materials to depths
1,000 feet. The silt content increases appreciably to 1,200 feet, the maximum
pth of the well. The electric log of an oil well about one mile east of the
wn of Fillmore indicates that thick interbedded sands and clays extend to depths
4,000 feet.

The San Pedro formation has been folded along the Santa Clara River
ncline. At the Oak Ridge and San Cayetano faults older rocks have been thrust
er the formation. Two oil wells in the mountains about one mile north of the
lley first penetrate the Modelo sandstone and shale, then the San Cayetano
ult, and finally the San Pedro formation which is only gently folded. The
west angle of dip of the San Cayetano fault as shown by these wells is about
degrees toward the north. The Oak Ridge fault dips about 60 degrees southward
evidenced in oil wells drilled on Oak Ridge south of the Santa Clara River
lley.

The trough axis of the Santa Clara River syncline is folded upward south-
st of the town of Piru, where the San Pedro formation has apparently been

truncated by erosion. The San Pedro formation is reduced in cross-sectional ar westward from Piru to the State Fish Hatchery, where the narrowest part of the valley is located. Well log data indicate that the cross-sectional area may al be slightly reduced by a gentle upwarp of the base of the San Pedro formation near the fish hatchery.

Occurrence of Ground Water. Ground water is generally unconfined in both the San Pedro formation and the overlying alluvium.

Movement of Ground Water. Ground water generally moves westward, as shown on the water level contour maps, with minor contribution from the north a south sides of the basin (see Plates 14-B, 15-B and 16-B). The water table slo appears to be fairly steep just southeast of Piru, and it is possible that this steep slope may be related to the upturned edge of the San Pedro formation beneath the alluvium.

Slope of the water table decreases from an area south of Piru and continues to decrease toward the State Fish Hatchery which is located on the Piru-Fillmore Basin boundary. Cross-sectional area of the water-bearing materials i the least near the Fish Hatchery where it results in a steeper water table slope. Farther west the slope decreases as the cross-sectional area increases. The point where the steepening occurs cannot be accurately determined, but its location appears to vary with water levels in Piru Basin. The boundary of Piru Basin was drawn arbitrarily near the Fish Hatchery where the maximum amount of rising water usually occurs, but could also be located to the east or to the wet of the assumed boundary. It is clear that as long as a westward gradient of th water table exists, subsurface outflow will continue. Historically, this westward gradient has always existed; although it has become less as the basin was depleted and greater as the basin was replenished. Because of the considerable depth of the San Pedro formation at the State Fish Hatchery it is likely that subsurface low out of Piru Basin will continue as long as water levels are higher than in Fillmore Basin. There is no evidence available indicating the presence of a fault which would function as a ground water barrier, as suggested by previous investigators.

Replenishment and Depletion of Ground Water. Ground water in Piru Basin is replenished by percolation in stream channels and in the Piru spreading grounds, by percolation of direct precipitation and the unconsumed portion of water applied for irrigation and other uses, and probably by a minor amount of subsurface inflow from adjacent semi-permeable formations. Ground water is depleted by pumped extractions, consumptive use of phreatophytes, effluent discharge, and by subsurface flow into Fillmore Basin.

Subsurface Inflow and Outflow. Subsurface flow into the Piru Basin from the Eastern Basin is probably negligible because of the thin alluvial cover at the basin boundary in Blue Cut. Subsurface flow out of Piru Basin into Fillmore Basin has been estimated by the rising water method (see p. B-42) to be thirty second-feet. Subsurface flow out of Piru Basin will occur whether there is rising water or not, but will be decreased somewhat after rising water stops and as the water table is lowered and its gradient decreased.

Ground Water Storage Capacity and Specific Yield. Results of change of ground water storage estimates are discussed in Chapter II. Forty-five well logs were used to determine specific yield of the sediments. The mean weighted specific yield of the interval between the highest water levels of 1944 and the lowest of 1951 is estimated to be 16 per cent. To estimate total storage capacity of the ground water basin, it was assumed that usable depth of the ground water basin is 1,000 feet, that the average area at depth is about 6,000 acres, and that the specific yield does not change appreciably with depth. By multiplying these figures, the storage capacity for Piru Basin is estimated to be 6000 x 1000 x .16 or 960,000 acre-feet, or on the order of one million acre-feet.

Yield of Wells. Yield of irrigation wells in Piru Basin varies from 600 to about 2,000 gallons per minute, with an estimated average of 800 gallons per minute. Specific capacity averages about 70. Yield of wells on the shelf on the south side of Piru Basin is fairly high when water levels are high, but when the water level falls and the alluvium is dewatered the wells go dry.

Fillmore Basin

Fillmore Basin which comprises a surface area of about 16,870 acres ranges in elevation from 280 to 470 feet in the Santa Clara River channel. Maximum elevation in the immediate drainage area is 4,959 feet at Santa Paula Peak. Two prominent features of this area include Timber Canyon which reaches an elevation of about 2,200 feet, and the Sespe uplands north of the Santa Clara River and west of Sespe Creek.

Geology. Water-bearing materials underlying the basin include alluvium of Recent and Pleistocene age and the San Pedro formation. Formations adjacent to Fillmore Basin include the Santa Barbara, Pico, Modelo, Vaqueros, and Sespe which are essentially nonwater-bearing, but may contribute limited amounts of water of poor quality to the water-bearing materials. See Geologic Section H-H, Plate 12-A, for general relationships of the water-bearing materials.

The alluvium comprises gravel, sand, and some clay up to 250 feet in thickness. The alluvium is difficult to differentiate from the underlying San Pedro formation in the valley floor area of the basin. A study of water well logs in the Sespe uplands indicates that the alluvium is underlain, at least in part, by the San Pedro formation. The alluvium in the Sespe uplands consists of upper Pleistocene and Recent alluvial fans which have been deposited on the iturned and eroded edges of the San Pedro and older formations (See Geologic ection H-H', Plate 12-A). The upper Pleistocene (or older) alluvium has been rtly dissected and somewhat folded. It is being dissected in some areas and vered by Recent alluvium in others. The alluvium in the Sespe uplands comprises avel, gravelly clay, and clay and is generally reddish in color.

Timber Canyon, located about four miles northeast of Santa Paula, is oored by Recent alluvium. A large alluvial cone extends from Santa Clara River lley up the floor of Timber Canyon. The surface material on this cone is tremely coarse, poorly sorted, subangular gravel. Water well logs indicate at this coarse material contains considerable clay and that the cone is up to 0 feet thick just north of Highway 126.

On the south side of Fillmore Basin, in the Bardsdale area, the alluvium erlies a shelf of semi-permeable rocks which have been thrust up by the Oak dge fault. The alluvium overlying this shelf is up to 180 feet thick. It is obable that this alluvium includes upper Pleistocene materials.

The San Pedro formation outcrops north of the valley floor from the wn of Santa Paula to the Sespe uplands, where it is concealed beneath alluvium. e San Pedro formation dips about 40 degrees to the south near Santa Paula and comes steeper eastward until it is overturned at Timber Canyon. Cores from an l well northwest of the town of Fillmore indicate that the San Pedro formation relatively flat lying at depth below the gently dipping San Cayetano fault and the valley area of Sespe Creek. The structure of the San Pedro formation in e Sespe uplands is concealed by alluvium, but available data suggest that additional unknown faults complicate the geology of this area.

The San Pedro formation is about 4,000 feet thick in this basin and it nsists of gravel, sand, and clay. The uppermost portion of the formation is ream deposited, probably by the ancient equivalent of the Santa Clara River. e lower and some of the middle portion of the San Pedro formation contains marine fossils which indicate deposition in a shallow marine environment. Field inspection of the San Pedro formation on the north side of the Fillmore Basin indicates that the beds are extremely lenticular and discontinuous. Clays are fairly common, but are also discontinuous.

Structurally Fillmore Basin is a part of the Santa Clara River syncline. Along the Oak Ridge fault on the south of the basin, the semi-permeable formations underlying Oak Ridge have been thrust up against the San Pedro formation. The San Cayetano fault swings northward near the town of Fillmore and does not directly affect the ground water geology west of Sespe Creek.

The cross-sectional area of the San Pedro formation is slightly reduce by local warping of the Santa Clara River syncline east of Santa Paula, where th assumed boundary of the basin is located. Water levels and available geologic data do not indicate faulting in this area.

A complex feature exists in Fillmore Basin on the south edge of the Sespe uplands just north of Highway 126. Inspection of the older alluvial sediments in the small hills in this area indicates that an anticlinal structure is present as shown on the geologic map (Plate B-1B). Cores from an oil well drilli here indicate the presence of faulted and folded sediments at shallow depths. I is possible that an east-west trending fault which may affect ground water exist in this area, but water level contours do not indicate the presence of such a fault.

Occurrence of Ground Water. Ground water occurs in the San Pedro formtion and in the overlying alluvium and is essentially unconfined.

Movement of Ground Water. Ground water moves westerly in Fillmore Basn with some minor contribution from the south and north sides. There is a decreas in cross-sectional area of water-bearing materials from the vicinity of Sespe Creek to the arbitrary boundary between Fillmore and Santa Paula Basins. Slope

' the water table decreases westward toward this boundary. Near the narrowest ›int which is taken as the western boundary of Fillmore Basin, the slope of the ıter table increases, decreasing again as the cross-sectional area increases ıto Santa Paula Basin. The point of steepest slope appears to be variable under .fferent water level conditions, and is actually a fairly wide zone rather than sharp line. This is the reason that an arbitrary boundary is used, just as :tween Piru and Fillmore Basins. As far as can be determined, no cross fault ıich affects ground water exists at this boundary.

Replenishment and Depletion of Ground Water. Ground water in Fillmore ısin is replenished by subsurface inflow, by stream percolation, by percolation ' direct precipitation and the unconsumed portion of water applied for irrigation ıd other uses, and probably by a minor amount of subsurface flow from the San :dro formation and adjacent semi-permeable formations. Ground water is depleted pumped extractions, consumptive use of phreatophytes, effluent discharge, and ıbsurface outflow.

Subsurface Inflow and Outflow. Subsurface inflow into Fillmore Basin ·om Piru Basin has been estimated by the rising water method to be about thirty :cond-feet. Well log data are not sufficient to accurately check this estimate the slope-area method. Subsurface outflow from Fillmore Basin into Santa ıula Basin has been estimated by the rising water method to be about sixteen :cond-feet. Subsurface outflow from Fillmore Basin will continue, even after .sing water stops, but it is likely that the underflow would decrease somewhat.

Ground Water Storage Capacity and Specific Yield. Results of ground ıter storage estimates are discussed in Chapter II. One hundred five well logs :re used to estimate specific yield and change of storage. The change of storage :timate includes the Sespe upland area. The mean weighted specific yield of the interval between the highest and lowest historic water table is estimated to be 12 per cent. The total storage capacity of the upper thousand feet of Fillmore Basin is probably on the same order of magnitude as Piru Basin, or about one million acre-feet using an estimated area of 12,000 acres. The average specific yield is smaller in Fillmore Basin, but the area is larger than Piru Basin. The maximum total storage capacity of the basin is unknown because the effective depth of the basin has not been determined. This depth may reach 4,000 feet, which is the base of the San Pedro formation as found in oil wells near the town of Fillmore.

Yield of Wells. Irrigation wells in Fillmore Basin yield up to 2,100 gallons per minute, and their average yield is about 700 gallons per minute. Specific capacity of the wells varies considerably but probably averages 50. Yields of wells on the shelf on the south side of the basin and on part of the Sespe uplands are generally smaller than in the valley floor, due to limited depth of alluvium.

Santa Paula Basin

Santa Paula Basin ranges in elevation from 140 to 280 feet, although the maximum elevation in the local drainage area is 2,750 feet on Sulphur Mountain. The ground water basin underlies the flat alluvial area of the Santa Clara River Valley and comprises a surface area of about 13,520 acres. The boundary between Santa Paula and Fillmore Basins has been discussed under the description of the latter basin. Between Santa Paula Basin and Mound Basin, the boundary is also an arbitrary line as discussed below.

Geology. Water-bearing materials in Santa Paula Basin include the alluvium of Recent and upper Pleistocene age and the San Pedro formation. Rocks underlying the San Pedro formation and adjacent to the basin include the Santa

Brbara, Pico, Modelo, Vaqueros, and Sespe formations, which are generally semi-prmeable and may contain water of poor quality.

The alluvium consists of up to 200 feet of stream deposited gravel, snd, and some clay and cannot be easily differentiated from the underlying San Pdro formation. The alluvium near Saticoy and in the northwestern portion of the bsin consists of yellow silty clay overlying and interbedded with stream gravels a shown on Geologic Section G-G' of Plate 12-A. Lenticular gravels interbedded wth this clay may locally yield water of poor quality to wells. The clay forms a cap over the gravels and pinches out to the south and to the east. This yellow silty clay was probably deposited as alluvial fans by streams draining the area nrth of the basin. Similar silts are still being deposited in the area.

The San Pedro formation consists of 4,000 feet of gravel, sand, and clay. The lower third of this formation contains fossils indicating a marine origin. The upper two-thirds is generally devoid of fossils and consists primrily of stream deposits. Exposures of the San Pedro formation exhibit irregular bdding. Scour and fill features are common with individual gravels often grading laterally into sands or silts within a very short distance. It is probable that xtreme variations also exist in the San Pedro formation underlying the valley loor, but local changes cannot be detected from drillers' logs.

The deepest water well logs indicate that gravels of the San Pedro formation persist to depths of at least 800 feet. Oil well logs and outcrops indiate that the total thickness of the San Pedro formation may be 4,000 feet. The otal effective thickness is unknown, as far as water-bearing characteristics are oncerned, but it is probably at least 1,000 feet as indicated by one oil well log.

The most significant structural features in Santa Paula Basin are the anta Clara River syncline, the Oak Ridge fault, and the Saticoy fault. As disussed in Chapter B-IV of this appendix, it is probable that the Saticoy fault is branch of the Oak Ridge fault, although it may simply be an extension. Where it can be traced, the Saticoy fault forms the boundary between Santa Paula and Oxnard Forebay Basins, but since it cannot be traced in the bed of the Santa Clar River, an arbitary boundary was used at that location. The San Pedro formation has been cut off on the south by the Oak Ridge fault. The upturned edge of the San Pedro formation is exposed on the north side of the basin. It has been folde into the Ventura Avenue anticline and the Canada Larga syncline as shown on Plate B-1B. These structures probably affect ground water in the outcrop area of the San Pedro, but they appear to die out to the east and probably do not affect ground water in Santa Paula Basin.

Occurrence of Ground Water. Ground water occurs in the San Pedro forma tion and in the overlying alluvium. The ground water body in most of the basin is unconfined, but where clay lenses exist, confined ground water is evident fro water level records of wells.

Movement of Ground Water. Ground water generally moves in a westerly direction as shown by ground water elevation contour maps (Plates 14-B, 15-B, an 16-B). At the west end of the basin the Saticoy fault forms a barrier impeding movement of ground water into Oxnard Forebay Basin. The effectiveness of this fault as a ground water barrier is demonstrated by a pronounced difference in water level elevation on either side of the fault. On the upstream side of this fault, near Saticoy, water levels range from 50 to 100 feet higher than the leve existing on the downstream side.

Between Santa Paula Basin and Mound Basin a relatively steep gradient in water levels exists. The cause of this steeper gradient is not readily apparent. There is no distinct and sudden drop in water level as characterized by a fault barrier, and it is believed that the steep gradient is due to a decrease in the permeability of the sediments underlying the area, although there may be some faulting in the San Pedro formation.

Replenishment and Depletion of Ground Water. Ground water is replen-hed by stream percolation, by penetration of direct precipitation and the un-nsumed portion of water applied for irrigation and other uses, by subsurface flow from Fillmore Basin, and probably by a minor amount of subsurface inflow om older formations on the south side of the basin.

Field inspection of outcrops of the San Pedro formation reveals great regularity in bedding, and also considerable amounts of silt and clay. It can assumed that the upturned edge of the San Pedro is in hydrologic continuity th the aquifers in the same formation from which pumping occurs underlying the lley floor. Water level data and geologic control are not available for a liable estimate of subsurface inflow to the basin from the outcrop.

The ground water basin is depleted by pumped extractions, consumptive e of phreatophytes, effluent discharge, and subsurface flow into Oxnard Forebay d Mound Basins.

Subsurface Inflow and Outflow. Ground water movement into and out of nta Paula Basin was estimated by the rising water method. Sixteen second-feet s estimated as subsurface inflow from Fillmore Basin. Ten second-feet was timated as outflow into the Oxnard Forebay Basin. Additional subsurface out-ow also occurs into Mound Basin through the San Pedro formation and could ount to more than ten second-feet. Geologic data necessary for an accurate timate of subsurface outflow into Mound Basin are lacking.

Ground Water Storage Capacity and Specific Yield. Estimates of change storage are discussed in Chapter II. Some 67 well logs were used to obtain ese estimates. Weighted average specific yield of the sediments in the interval tween the water table elevations of 1944 and 1951 is estimated to be ten per nt. Change of storage in the outcrop area of the San Pedro formation could not determined because water level and well log data were unavailable. Such anges could conceivably be large.

Using an estimated area of 10,000 acres and a depth of about 800 feet, total storage capacity of the ground water basin was estimated to be about 800,000 acre-feet. Additional storage capacity probably exists below this depth and in the outcrop area, but data to estimate its amount are lacking.

Yield of Wells. Irrigation wells in Santa Paula Basin yield from 300 to 1,500 gallons per minute and average about 700 gallons per minute.

Mound Basin

Mound Basin ranges in elevation from sea level to over 400 feet and has a surface area of about 12,300 acres. It is bounded by hills to the north, Santa Paula Basin to the east, and Oxnard Plain and Oxnard Forebay Basins to the south.

Geology. The principal water-bearing formation in Mound Basin is the San Pedro. Other formations include the overlying alluvial deposits and the unde-lying Santa Barbara formation. The Recent and upper Pleistocene alluvium is cha-racterized by yellow silty clay containing occasional lenses of sand and gravel. It varies from 100 feet to 500 feet in thickness. The yellow silty clay has beer deposited as alluvial fans by streams draining the area to the north. It appears that these yellow clays grade into and interfinger with deposits of Oxnard Plain Basin along the present course of the Santa Clara River. Gravel, sand, silt and clay of upper Pleistocene age outcrop along the north edge of the basin and dip southward as much as 12 degrees. These particular outcrops are at the base of the upper Pleistocene deposits and contain marine fossils which indicate littoral deposition.

The San Pedro formation lies unconformably beneath the alluvium and outcrops in the hills north of Mound Basin where it is 4,000 feet thick. It consists of gravel, sand, silt, and clay. Marine fossils are found throughout th ection of outcrop, but previous investigators believe that most of the upper rt of the San Pedro formation is continental in origin and that the marine fosls are reworked. The upper 500 to 1,000 feet of the San Pedro formation contins many permeable sand and gravel members. Below these members are a series beds which are predominantly silts and clays and are in turn underlain by avels. The permeable members of the outcrop may be continuous with those beath the Mound Basin. Exposures show these sands and gravels to be extremely nticular. Scour and fill features are common, and individual beds cannot be aced more than several hundred feet.

From the outcrop, the San Pedro formation extends westward under the luvium of the Ventura River Valley and into the ocean. Contours of the ocean oor indicate small irregularities which parallel the trend of the San Pedro rmation and suggest that it outcrops there. The San Pedro formation west of e Ventura River is mostly coarse gravel, with minor sands and clays. On the st side of the Ventura River, however, the formation is mostly fine sand, silt d clay with only minor gravels. This rapid lateral change in lithology cannot ually be traced down the dip of the beds, but where suitable exposures are und it appears that the down dip variations are as great as the lateral riations.

The structure of Mound Basin is essentially that of a syncline as own by cross-section B'-B", Plate B-1B. The San Pedro formation is folded in e Santa Clara River syncline and in the Montalvo anticline, and is displaced the Saticoy fault (see Plate B-1B). The north limb of the Santa Clara River ncline is exposed in the hills north of the basin. Well log data indicate that e Saticoy fault extends a short distance westward from Saticoy, but either dies t or cannot be detected westward from a point north of Montalvo. Water well gs south of Ventura do not indicate that the Saticoy fault extends to the beach. rface exposures and well logs indicate that complex folding and faulting has affected the area north of the Santa Clara River and south of the Saticoy fault. Cores from oil wells in and near the Santa Clara River west of Montalvo indicate that the south flank of the Santa Clara syncline dips steeply to the north. The Montalvo anticline in the area west of Montalvo appears to be assymetrical and probably overturned to the north. North and east of Montalvo the Montalvo anticline appears to be nearly symmetrical but is probably displaced by the Saticoy fault.

An excavation on the small hill due north of Montalvo reportedly exposed sediments which dip sixty-five degrees southward. This outcrop is now covered, but the sediments in the area appear to be similar to the non-marine San Pedro formation. Cores from an oil well northwest of Montalvo indicate faults and steeply dipping sediments below 200 feet. These examples of faults and steeply dipping sediments are in themselves of little significance, since they cannot be correlated. They are important because they indicate that the water-bearing sediments in this part of Mound Basin have been involved in complex folding and faulting.

Seaward Extension and Hydraulic Continuity of Aquifers With the Ocean. A question of some importance in Mound Basin is the possibility of hydrologic continuity of the aquifers of the San Pedro formation with the ocean. The only place where this continuity may exist is west of the Ventura River where the south dipping beds strike westward into and beneath the ocean. Slope of the offshore topography is very gentle and it is unlikely that the San Pedro formation near the axis of the Santa Clara River syncline would outcrop on the ocean floor unless the syncline were folded upward. Offshore seismic data suggests that the syncline continues seaward without such upwarping. The gently sloping sea floor is underlain by silty clay in areas where samples have been taken.

When water levels are high in Mound Basin, a seaward gradient exists, ıgesting subsurface outflow. Water levels fall below sea level during dry ɛiods, suggesting that sea water intrusion occurs. Detailed measurements of ɛch wells and wells in and west of the Ventura River Valley perforated in the a Pedro formation show tidal fluctuations which lag behind the ocean tides by ry a few minutes. This short time lag indicates that the aquifer is affected ytidal loading but does not necessarily indicate hydraulic continuity with the ean. A shallow abandoned well near one of the City of Ventura's deep wells on beach showed more than an hour's time lag, indicating possible hydraulic tinuity of the minor shallow aquifers with the ocean.

Available evidence indicates, therefore, that outflow of fresh water or low of sea water is possible, but data are not available to estimate the quan-y. Up to the time of writing this report no evidence of sea water intrusion been found in quality of water from wells in the San Pedro formation which closest to the ocean.

Occurence of Ground Water. Wells obtain water from sands and gravels the San Pedro formation and possibly from alluvium of upper Pleistocene age. has been necessary to drill water wells in Mound Basin to depths of 400 to 00 feet in order to obtain water from these gravels. The gravels of the Pedro formation are overlain by up to 500 feet of confining silty clay. ls near the beach south of Ventura flow when water levels are high.

Movement of Ground Water. Ground water in Mound Basin generally moves stward toward the ocean as shown by the water level contours on Plates 14-B, -B, and 16-B. Movement may occur from Oxnard Forebay Basin as well as Santa ula Basin. Some movement may possibly occur from Oxnard Plain Basin and from outcrop area of the San Pedro formation north of the Mound Basin. A water vel recorder installed on a well about 60 feet south of Highway 101 and just west of the Ventura River showed no fluctuations as a result of pumping a well about 500 feet to the south, which has a drawdown of about 60 feet. Both wells are perforated, however, in the San Pedro formation which dips about 35 degrees southward in this vicinity. The lack of reaction in the recorder well indicates that there is limited movement of ground water across the bedding of the San Pedr formation.

Replenishment and Depletion of Ground Water. Replenishment of Mound Basin occurs by subsurface inflow from adjacent basins and from the outcrop area of the San Pedro formation, which is in turn replenished by rainfall penetration and stream percolation. The basin is depleted by pumped extractions and possibly subsurface outflow.

Subsurface Inflow and Outflow. Subsurface inflow occurs from Santa Paula Basin, from the outcrop area of the San Pedro formation and possibly from Oxnard Forebay and Oxnard Plain Basins when water levels are favorable. As discussed in the paragraphs on Lower Ventura River Basin, inflow from the alluvium of that basin is probably negligible. Some subsurface inflow from the seaward extension of the aquifers probably occurs during periods of low water level.

Subsurface outflow from Mound Basin into Oxnard Plain Basin may occur through the San Pedro formation beneath Oxnard Plain Basin when water levels are suitable, but the degree of hydrologic continuity of the San Pedro formation between these two areas is uncertain and may be negligible. Some subsurface outflow toward the ocean may occur during periods of high water level.

Ground Water Storage Capacity and Specific Yield. It is estimated that very little, or no change of storage occurs within Mound Basin. Since water leve and well log data are lacking in the outcrop area, change in storage in the San Pedro formation north of the basin could not be estimated, although such changes may be fairly large.

Yield of Wells. Wells in Mound Basin yield from 300 to 1,500 gallons minute from the San Pedro formation. The estimated average yield is 700 lons per minute and the average specific capacity about 70.

ard Forebay Basin

Ground surface elevations within Oxnard Forebay Basin vary from about to 150 feet above sea level and the basin occupies an area of about 6,170 acres. water-bearing sediments of Oxnard Forebay Basin are similar in several respects those of Oxnard Plain Basin except that the Oxnard Forebay is a free ground er area. This basic difference is so important that the areas have been ferentiated and will be described separately.

Geology. Formations in Oxnard Forebay Basin include Recent and upper istocene alluvium underlain unconformably by the San Pedro formation and, in mall area, by the Santa Barbara formation.

Alluvium of Recent and upper Pleistocene age is the most important mater- in the Oxnard Forebay since it forms the ground water reservoir for most of water used in Oxnard Plain Basin. The alluvium consists of up to about 400 t of river deposited gravels, clays and sand being common below 200 feet. alluvium has been deposited unconformably upon the upturned San Pedro and ta Barbara formations. Geologic Section K-K', Plate 12-B, shows that the base the upper Pleistocene has also been folded, while the upper gravels have not n appreciably disturbed, resulting in a local unconformity within the materials e designated alluvium. This interpretation of the data would suggest that some the lower part of "upper Pleistocene" alluvium may be middle Pleistocene in age, ce parts of it would have been deposited while the unconformity was being formed the middle Pleistocene orogeny; or the lower part of the alluvium is in reality er Pleistocene in age, and folding has occurred in upper Pleistocene time. The latter possibility is preferred, since upper Pleistocene vertebrate fossils have been found near Ventura in the terrace deposits which dip 10 to 15 degrees southward. It is probable that the sediments are still being actively folded.

The upper gravels are continuous with the Oxnard aquifers of Oxnard Plain Basin. The gravels are poorly sorted and consist of cobbles and pebbles of sandstone, conglomerate, and igneous rock. They occur in a matrix of medium to coarse sand and contain small, irregular beds of silt and clay. Oxnard Forebay Basin is the apex of the large Oxnard Plain alluvial fan where the coarser materials are found. The nature of the clay capping the oxnard aquifer in Oxnard Plain Basin as it approaches Oxnard Forebay Basin is rather complex, as might be expected. In general, the clay cap interfingers with the gravels of the Forebay, the percentage of clay decreasing to zero in the Forebay. The bottom and top of the clay cap also slope downward away from the Forebay. As a result of the slope of the bottom of the cap and the interfingering with gravels, the actual contact o the free water surface with the clay cap will vary over a wide zone depending on the water levels in the Forebay.

The San Pedro formation underlies the alluvium unconformably, as shown in Section K-K', Plate 12-B, but appears to become conformable near the south and west edges of Oxnard Forebay Basin. A medium to coarse grained sand is found near or at the base of the San Pedro formation. This sand is the equivalent of the Fox Canyon member in West Las Posas Basin. The surface outcrop of the Fox Canyon member on the south slope of South Mountain continues westward into Oxnard Forebay Basin. Its outline beneath the alluvium has been traced by the use of water and oil well logs and by inspection of materials from wells drilled during this investigation. The probable extent of the Fox Canyon member is shown on the geologic map (Plate B-1B). The Fox Canyon is folded into a westward plunging anticline, the anticlinal structure of which is confirmed by deeper oil well logs. A few oil well logs indicate that the Fox Canyon member of the San Pedro formation scontinuous into and beneath Oxnard Plain Basin, although areas of low per-ebility may exist which could retard flow of water toward Oxnard Plain Basin.

The nature of the San Pedro formation above the Fox Canyon member and eow the upper Pleistocene alluvium is not well known. Available oil well logs icate that other permeable beds exist above the Fox Canyon member and possibly erlie unconformably the alluvial gravels of the Forebay. These aquifers in San Pedro formation cannot be traced by well logs into Mound Basin, but there be some continuous beds since water levels can be contoured into Mound Basin m the west end of Oxnard Forebay Basin.

The oldest formation of interest is the Santa Barbara formation of lower istocene and upper Pliocene age which consists of impervious clay and silt. s formation underlies the San Pedro formation and both have been folded and tially removed by erosion in Oxnard Forebay Basin prior to deposition of uvium. As a result of this folding and erosion, the Santa Barbara formation lies immediately under the alluvium in the area between the Saticoy spreading unds and the westernmost exposures of the formation on Oak Ridge. Several well gs indicate that the depth to the eroded surface of the Santa Barbara formation erages about 75 feet but ranges up to 140 feet.

The Saticoy fault separates Oxnard Forebay Basin from Santa Paula Basin. exact location of the fault beneath the Santa Clara River east of Saticoy is known, hence the boundary there is arbitrary, but is guided by the point where face water from Santa Paula Basin begins to percolate into the river gravels. boundary between Oxnard Forebay Basin and Mound Basin is also somewhat arbi-ary and has been placed along the north edge of the Santa Clara River, where ll logs indicate the approximate limit of the permeable gravels of the alluvium. boundary between Oxnard Forebay Basin and Oxnard Plain Basin has been estab-shed from well logs and is the probable limit of the area where rainfall penetra-on and excess applied irrigation water returns to the aquifer. This does not necessarily coincide with the actual pressure-nonpressure boundary which has been discussed above.

Occurrence of Ground Water. Ground water occurs in the Recent and upper Pleistocene alluvium and in permeable sands and gravels of the San Pedro formation. Oxnard Forebay Basin is essentially a free ground water area, with changes of water level and corresponding changes in ground water storage occurri in the alluvium. Apparently, the permeable zones in the San Pedro formation underlie and are in hydrologic continuity with the alluvium. The Santa Barbara formation underlying the San Pedro consists of fine silt and clay and is general impervious.

Movement of Ground Water. Ground water moves southwesterly in Oxnard Forebay Basin toward Oxnard Plain Basin as shown on the water level contour maps (see Plates 14-B, 15-B, and 16-B). The shape of the water table contours in the upper portion of the Forebay resemble those of a ground water mound produced by an injection well. The Saticoy fault and the eastern boundary of Oxnard Plain Basin near the Forebay may be visualized as enclosing a segment of a circle. Slope of the water table decreases away from the apex in much the same way the hydraulic gradient decreases away from an injection well. A difference in eleva tion of 50 to 100 feet occurs across the Saticoy fault in a distance as short as 500 feet.

Movement of water into Oxnard Plain Basin may be complex when water levels in Oxnard Forebay Basin are low. For example, when the westerly end of the Forebay has been lowered greatly by pumping, some water may leave the upper part of the Forebay, where water levels are high, and move into the area just south of the spreading ground, then back into the Forebay in the vicinity of the junction of Highways 101 and 101A.

Replenishment and Depletion of Ground Water. Oxnard Forebay Basin is :plenished by subsurface inflow, by percolation in the Santa Clara River channel ad in the Saticoy spreading grounds, and by percolation of direct precipitation ad the unconsumed portion of water applied for irrigation and other uses. The orebay is depleted by subsurface outflow, pumped extractions, and probably by ffluent discharge over the clay cap and consuptive use of phreatophytes during eriods of high water level.

Subsurface Inflow and Outflow. Subsurface inflow occurs from Santa aula Basin through and possibly over the Saticoy fault. Some subsurface inflow ay occur from Mound Basin when water levels there are higher than in the Forebay. ubsurface outflow occurs into Oxnard Plain Basin through the aquifers of the lluvium and San Pedro formation. Subsurface outflow into Pleasant Valley Basin ossibly occurs through the aquifers of the San Pedro formation, primarily hrough the Fox Canyon member. Some subsurface outflow into Mound Basin probably ccurs at various times through the San Pedro formation in the area near Montalvo. hen water levels in the Forebay are above the clay cap of Oxnard Plain Basin, ome subsurface outflow may occur into the semi-perched zone overlying the clay ap.

Ground Water Storage Capacity and Specific Yield. Estimated changes of torage in Oxnard Forebay Basin are discussed in Chapter II. Estimated weighted ean specific yield of sediments between the interval of the 1944 and 1951 water evels is 16 per cent. Estimated total storage capacity of the alluvium in xnard Forebay Basin is about 300,000 acre-feet. When water levels are lowered n Oxnard Forebay Basin, water levels also drop in Oxnard Plain Basin. If water evels were drawn down so the Oxnard aquifers were entirely dewatered, then total torage of the Oxnard aquifer in Oxnard Plain and Oxnard Forebay Basins is pro- ably on the order of 800,000 acre-feet.

Yield of Wells. Irrigation wells in the Oxnard Forebay Basin yield fro 200 to 2,000 gallons per minute, the average being of about 1,100 gallons per minute. Specific capacity of wells averages about 200.

Oxnard Plain Basin

The Oxnard Plain Basin ranges from sea level to about 100 feet in elevation, and occupies an area of about 46,460 acres. Included in the basin is about one-fourth of the irrigated area of Ventura County. This basin is bounded on the west by the Pacific Ocean, on the north by Mound Basin, and on the east by West Las Posas and Pleasant Valley Basins. The boundary between Oxnard Plain and Mound Basins is arbitrarily placed along the Santa Clara River.

Geology. Water-bearing formations in Oxnard Plain Basin include alluvium of Recent and upper Pleistocene age, the San Pedro formation of lower Pleistocene age, and to a minor extent the Santa Barbara formation of lower Pleistocene and upper Pliocene age. Formations underlying the Santa Barbara are penetrated only by oil wells and include the Pico, "Santa Margarita", Modelo, Topanga, and Sespe formations as well as volcanic rocks of Miocene age.

The principal aquifers underlying Oxnard Plain Basin are shown on Geologic Sections K-K' and M-M', Plate 12-B. The most important aquifer underlying Oxnard Plain Basin is the Oxnard aquifer, which is part of the upper Pleistocene alluvium. The Oxnard aquifer is a series of river deposited gravels and is continuous with gravels in Oxnard Forebay Basin. The east and northwest boundaries of Oxnard Plain Basin coincide with the extent of the Oxnard aquifer. The Oxnard aquifer is characterized by medium to coarse gravel interbedded with lenticular deposits of coarse sand and some clay streaks. Well logs indicate considerable irregularity in areal extent and thickness of clay and sand lenses, as would be expected of river deposits. The Oxnard aquifer is capped by yellow ad blue clay and silt, the base of which ranges in elevation from sea level nar the forebay to about 130 feet below sea level near the coast. The overlying cay cap varies from 50 to 150 feet in thickness, and well logs indicate that it cntains lenticular sands and gravels, which causes some increase in permeability c the cap.

The clay cap is overlain by up to 50 feet of sand and gravel, which etends to the ground surface. These permeable sediments contain semi-perched gound water and are considered to be of Recent age.

The boundary between Oxnard Forebay and Oxnard Plain Basins is placed, a noted above, to include in Oxnard Plain Basin the area where applied water des not return to the principal aquifers. As also stated, above, the pressure-rnpressure line coincides with the intersection of the unconfined water table wth the base of the confining clay cap, which intersection shifts laterally as wter levels in Oxnard Forebay Basin fluctuate.

The base of the Oxnard aquifer is rather poorly defined since most wter wells do not penetrate more than a foot or two of clay below the gravel. I some cases, this basal clay may be only five or six feet thick and additional gavels may be beneath. In general, however, the Oxnard aquifer is about 75 to 20 feet in thickness, and the base varies in elevation from 180 feet to 250 feet tlow sea level.

Well log control of the sediments below the Oxnard aquifer is poor. Aailable logs indicate that the base of the upper Pleistocene sediments is about 10 to 500 feet below the surface (about 200 to 300 feet below the Oxnard aquifer) ad that other aquifers of unknown areal extent and hydrologic continuity exist. I the southeast portion of Oxnard Plain Basin, a fairly continuous gravel sratum about 70 feet in thickness occurs at depths of 400 feet and extends at least partly into Pleasant Valley Basin. Scattered well logs in other parts of Oxnard Plain Basin also indicate gravels at this depth. Near the City of Port Hueneme, however, a 600 foot water well penetrated only fine silt and clay from 300 to 600 feet, indicating that the 400 foot gravels do not underlie the entire Oxnard Plain Basin.

The Recent and upper Pleistocene alluvium is underlain by the San Pedr formation which varies from about 600 feet in thickness in the southern part of the Oxnard Plain to about 1,800 feet just south of the Santa Clara River. Only two water wells on the Oxnard Plain are known to completely penetrate the San Pedro formation. Several oil wells also penetrate it, but logs of these wells a generally poor. From a study of the available oil well logs, electric logs, and water well logs, it appears that the basal 100 to 300 feet of the San Pedro formation consists of sand and some gravel which is most likely continuous with the F Canyon aquifer in Pleasant Valley and West Las Posas Basins and is a potentially important aquifer in Oxnard Plain Basin. Electric logs of oil wells in the Oxna oil field, about four miles due east of the City of Oxnard, indicate that the Fo Canyon member consists of a series of sands containing irregular interbedded sil and clay layers. Fossils indicating shallow marine or lagoonal conditions of deposition have been found in the few wells which have been inspected by geologist during drilling. Oil well logs suggest a thickening of the Fox Canyon northward toward the Santa Clara River, but it is extremely difficult to determine whether this member continues into Mound Basin. Some electric logs suggest that the bas part of the San Pedro formation near the Santa Clara River may contain water of poor quality. All sources of information indicate that sands and gravels occur the San Pedro formation above the basal Fox Canyon member. The degree of hydrologic continuity of these additional pervious zones with areas of recharge, or w h the Fox Canyon member, cannot presently be determined.

The Santa Barbara formation underlies the San Pedro formation in the Oxnard Plain and varies from about 2,000 feet in thickness near the Santa Clara River to about 800 feet in the southern part of the area. Electric logs of two water wells near Port Hueneme and Mugu Lagoon indicate that thick permeable zones may exist here and also that the lower half or two-thirds of the formation probably contains water of poor quality. Electric logs in the Oxnard oil field area indicate fairly fresh or slightly brackish water in the formation, while electric logs in the Santa Clara River area indicate that nearly all the Santa Barbara probably contains water of poor quality. These electric logs also indicate that the Santa Barbara formation contains few permeable zones near the Oxnard oil field and the Santa Clara River areas. The outcrop of the Santa Barbara formation on the south slope of Oak Ridge adjacent to this basin similarly contains few permeable zones.

Structure of Oxnard Plain Basin is relatively simple. The water-bearing materials are generally nearly flat lying, and are not known to be affected by faulting. Total thickness of alluvium and the San Pedro formation south of the Santa Clara River is about 2,000 feet, while north of the river in the Santa Clara River syncline the total thickness is over 4,000 feet. See Geologic Section B-B", Plate B-1B, for structure of the area.

<u>Seaward Extension and Hydraulic Continuity of Aquifers With the Ocean.</u> The relationship of the Oxnard and Fox Canyon aquifers with the offshore topography and geology is of considerable interest in arriving at an understanding of the ground water hydrology of Oxnard Plain, Oxnard Forebay, and Pleasant Valley Basins. The pertinent submarine topographic features are discussed in Chapter BII and are shown on Plate B-3.

It is apparent that both the Oxnard and Fox Canyon aquifers extend for some unknown distance seaward beneath the ocean as illustrated by Geologic Sections K-K' and M-M' on Plate 12-B.

The seaward extension of the aquifers presents two important problems in the consideration of the ground water hydrology of the Oxnard Plain Basin. While data are lacking in many respects, the operation of the ground water basins is partly dependent on the conditions seaward of the coastline. The two problems are that the aquifers may outcrop at some unknown distance seaward on the ocean floor resulting in hydraulic continuity of the ground water with sea water, and that the seaward extension of these aquifers may act as ground water storage rese- voirs not inventoried in the hydrologic study whose utilization is dependent on t seaward distance of the outcrop.

Seaward extend of the Oxnard aquifer is unknown, though the presence of two sharply defined submarine canyons a short distance southerly of the coastline offers reasonable possibilities for the outcropping of the aquifer close to shore thereby limiting utilization of the storage capacity, at least in the vicinity of the canyons. Evidence suggesting that the Oxnard aquifer outcrops in the vicinit of the head of Hueneme Canyon includes the following: (1) the development of a landward gradient during periods of low water levels of the piezometric surface near Port Hueneme, the contours having a roughly circular shape with the canyon a the center, (2) historic reports of fresh water outflow in the Hueneme Canyon are at times of high water levels, (3) fluctuations of water levels in wells correspond- ing to but lagging up to three hours behind tidal fluctuations, and (4) water qua- ity indicating possible sea-water intrusion in 1951 near Port Hueneme. The only indications for seaward extension of the Oxnard aquifer or connection with the oca in the vicinity of Mugu Canyon are a landward gradient in the ground water surfac and a response to tidal fluctuations in the wells. These canyon outcrops, as sh on Plate B-3, may be within a quarter of a mile of the shoreline.

Well log control on the Fox Canyon aquifer of the San Pedro formation i Oxnard Plain Basin is poor, but available data indicates that this aquifer thins southward, rising gently, so that it would be closer to the surface near Mugu

Canyon. It is possible that the Fox Canyon outcrops in both the submarine canyons, but available geologic evidence is not conclusive.

The offshore extensions of aquifers constitute additional ground water storage space, the volume of which is undeterminable at this time and has not been considered quantitatively in the hydrologic balances compiled in the course of this investigation. It is conceivable that such storage could be considerable. For purposes of speculation, the Oxnard aquifer was projected westward beneath the ocean as indicated on the sections of Plate B-3. Projection of the Oxnard aquifer to the ocean floor indicates that it would outcrop in the vicinity of the 120 to 1[illegible]0 foot depth contours as shown on Plate B-3. Postulating further from the geology of Oxnard Plain Basin it was estimated that the average thickness of the Oxnard aquifer offshore is about 100 feet and that the specific yield is about 10 per cent. The maximum area underlain by the offshore extension was estimated to be about 51,000 acres. These values are based upon assumptions that may be considerably in error; however, they conform with and are believed to be the most reasonable values that can be obtained with available information. An estimate of offshore storage based on these values indicates the Oxnard aquifer may contain up to 510,000 acre-feet of ground water. The possible capacities of offshore extensions of the Fox Canyon and other aquifers do not lend themselves even to such approximations. It is conceivable, however, that offshore storage in these aquifers can be great.

It is obvious that data are not available to determine accurately either the degree of hydraulic continuity with the ocean or the offshore storage capacity of the aquifers. Full utilization of offshore storage is improbable because of the outcrop of the aquifers within the submarine canyons. Wells situated in the vicinity of these canyons may become polluted by inflow through the canyon walls before offshore storage in more remote submarine areas is exhausted. Water levels in the Oxnard Plain Basin should, therefore, be maintained at such levels as to prevent accumulative intrusion of sea water.

Occurrence of Ground Water. Ground water occurs in a semi-perched zone in the Oxnard aquifer which is the principal aquifer, in the Fox Canyon aquifer, and in less easily traced gravels between these aquifers. At the present time, only two wells in this basin obtain water from the Santa Barbara formation. The semi-perched zone is unconfined, has no wells withdrawing water from it, and contains water of poor quality. All aquifers underlying the semi-perched zone contain confined ground water. Wells along the coast in the Oxnard aquifer flowed prior to 1927 and during the period from 1942 to 1944. The area of flowing wells in the spring of 1944 is shown on Plate 15-B.

Movement of Ground Water. Movement of ground water in the Oxnard aquifer is shown by the ground water elevation contour maps (Plates 14-B, 15-B, and 16-B). When Oxnard Forebay Basin is filled as in 1944, water moves southwestward from the Forebay toward Hueneme and Mugu Canyons. When the water levels are lowered in the Forebay by pumping in Oxnard Plain and Oxnard Forebay Basins, the hydraulic gradient toward the ocean decreases until no outflow to the ocean occurs. Further pumping on Oxnard Plain Basin or further lowering of the Forebay causes a landward hydraulic gradient with a resultant landward movement of water in the seaward extension of the aquifer. When the landward gradient occurs, a trough is formed. The formation of the trough will depend on elevation of the water table in Oxnard Forebay Basin and the amount of pumping in the Oxnard Plain Basin. Detailed water level contours indicate that the position of the trough axis approximates the shape of two circular segments with Hueneme and Mugu Canyons as centers of the circles. The position of the trough axis varies seasonally as pumping rates and water levels in Oxnard Forebay Basin change. The trough position in the fall of 1951 is shown on Plate 16-B, along with the area in which water levels were below sea level.

Movement of ground water in the Fox Canyon aquifer is not well known because few water wells are drilled into it and water level data are largely lacking. From available evidence it appears that water in the Fox Canyon aquifer moves from Oxnard Forebay Basin toward the southern portion of Oxnard Plain Basin. When pumping occurs in Pleasant Valley Basin, ground water in the Fox Canyon aquifer moves eastward from Oxnard Plain Basin into Pleasant Valley Basin, as shown on Plate 16-B.

In the southeast portion of Oxnard Plain Basin there are a few wells which are perforated in both the Oxnard and Fox Canyon aquifers, and water levels appear to be nearly the same in the two aquifers.

Replenishment and Depletion of Ground Water. Oxnard Plain Basin is replenished by subsurface inflow from Oxnard Forebay and from the ocean side of the trough during periods of low water levels. It is possible that a minor amount of water is supplied to the Oxnard aquifer during periods of low water level by compaction of overlying clays. Appreciable leakage may occur through the clay from the semi-perched zone into the Oxnard aquifer, but its amount could not be estimated because of the considerable time and expense required. No hydrologic evidence is available to show that leakage does occur through the clay cap, but well logs consistently indicate that this cap contains irregular interbedded lenses of gravel and sand, and it is therefore conceivable that leakage could occur.

Extractions from Oxnard Plain include pumping and, during periods of high water levels, outflow to the ocean and effluent discharge through uncapped wells. It is probable that some water is lost by leakage through the clay cap when the piezometric surface of the Oxnard aquifer is higher than the water table of the semi-perched ground water body.

It is also possible that an unknown amount of water is transferred between Oxnard Plain Basin and Mount Basin through the San Pedro formation.

Subsurface Inflow and Outflow. Subsurface inflow and outflow is discussed above.

Ground Water Storage Capacity. Since the aquifers in Oxnard Plain Basi are confined, there is essentially no change in storage except that resulting frc compaction of overlying clays. Such change of storage is probably negligible. The base of the clay which caps the Oxnard aquifer in general slopes oceanward as shown on Geologic Section K-K', Plate 12-B, and the diagrammatic sketch on Plate 13. Therefore, the line of intersection of the water table with the base of the clay cap shifts laterally with varying water levels in Oxnard Forebay Basin resulting in change of storage in the area defined as Oxnard Plain Basin. For convenience, such change of storage has been included with that in Oxnard Forebay Basin.

It is estimated that the total storage capacity of that portion of the Oxnard aquifer within Oxnard Plain Basin, if it could be dewatered, would be abou 500,000 acre-feet, and that the capacity of the Fox Canyon aquifer is probably th same.

Yield of Wells. Water wells in Oxnard Plain Basin yield from 300 to 2,300 gallons per minute and have an estimated average yield of about 900 gallons per minute and an average specific capacity of about 70.

Peasant Valley Basin

Pleasant Valley Basin has been divided in prior reports into pressure ad non-pressure areas. It is considered in its entirety as a pressure area in tis report for reasons discussed below. This basin consists of about 23,850 ares and is second only to Oxnard Plain Basin in irrigated acreage. It ranges i elevation from about 15 to over 240 feet above sea level.

Geology. Many aspects of the geology and ground water hydrology in Peasant Valley Basin are not clearly understood; faulting, folding, rapid thinnng of formations, multiple perforations of individual wells, and lack of adequate lgging and inspection of wells during drilling make an interpretation of the eology of the area difficult.

The water-bearing formations in Pleasant Valley Basin include alluvium c Recent and upper Pleistocene age, and the marine San Pedro and Santa Barbara frmations. These formations are underlain by the Pico and "Santa Margarita" frmations, Modelo shale, and volcanics of Miocene age. The volcanic rocks outcop in the Santa Monica Mountains on the southeast side of Pleasant Valley Basin.

In general, there are two areas in Pleasant Valley Basin where aquifers i alluvium of Recent and upper Pleistocene age are utilized. One area is north c the Camarillo fault and south of the Camarillo Hills, the other is south of the marillo fault in the east and southeast portion of the basin. The aquifers in ese areas do not appear to be connected with the Oxnard aquifer in Oxnard Plain sin. Alluvium north of the Camarillo fault reaches a thickness of 400 feet and nsists of grey sand, gravel, and yellow and blue clay deposited in alluvial fans r Arroyo Las Posas and by other smaller creeks. The sands and gravels are ickest to the north and appear to pinch out toward the south. The alluvium uth of the Camarillo fault is about 400 feet thick and is mostly clay with irgular interbedded sands and gravels. Sands and gravels are predominant in e easterly portion of Pleasant Valley Basin and appear to thin out westward from the area south of the town of Camarillo into the west central portion of thi basin.

The San Pedro formation underlies all Pleasant Valley Basin and consist of from 400 to 1,500 feet of gravels, sands and clays. The most important aquife in Pleasant Valley Basin is the basal Fox Canyon member which consists of sand an gravel. Thickness of the Fox Canyon aquifer varies from 100 feet near Santa Rosa Valley to 300 feet in most of the area. The Fox Canyon aquifer can be easily traced by well logs over all but the eastern corner of the basin, where there are few logs of deep wells. It is possible that the Fox Canyon aquifer is connected by interbedded gravels with the shallower sands and gravels of the alluvium in th eastern portion of Pleasant Valley.

The Fox Canyon aquifer is underlain by the Santa Barbara formation, whi consists of sand, clay, and some gravel and varies in thickness from 50 feet near Somis to over 900 feet at the west border of the area. The Santa Barbara formati is reached by few water wells in Pleasant Valley Basin. It is possible that the equivalent of the Grimes Canyon member in East Las Posas Basin is present in Pleasant Valley Basin near the top of the Santa Barbara formation as shown on Geologic Sections L-L' and M-M', Plate 12-B. The Grimes Canyon aquifer consists of up to 300 feet of loose, coarse gravel and sand.

The volcanic rocks which are adjacent to and underlie the southern portion of Pleasant Valley Basin yield water to wells from fractures and from grave interbedded with the volcanic flows. Most wells drilled into the volcanics also obtain water from overlying gravels of the alluvium or San Pedro formation.

Structural features of Pleasant Valley Basin include at least two east west trending faults and associated folds in the northern portion of the area. The faults and folds appear to die out westward into the Oxnard Plain. These structural features are the Camarillo Hills and Springville anticlines, the Spri-ville fault zone, the Camarillo fault, and a snycline and anticline between thes faults.

The Springville fault zone (see Plate B-1B) is up to 1,000 feet wide and consists of two major and probably other minor faults which parallel the south edge of the Camarillo Hills. The major faults of this zone are well exposed in portions of the Camarillo Hills. Several exposures along one of these faults show that it in turn consists of a complex zone up to 100 feet wide with highly folded sediments included between lesser faults. The principal fracture occurs in a zone of crushed sediments varying from a foot to several feet in width.

The Camarillo fault can be detected in water well logs where displacement of aquifers may be noted. It also has effected older alluvium and can be traced by surficial features.

The folds between the Camarillo fault and the Springville fault zone consist of an east-west trending anticline just north of the Camarillo fault, and a syncline farther north. These folds can be traced from well log data and surface outcrops of older alluvium near Camarillo. The gentle synclinal fold between the Camarillo fault and the Santa Monica Mountains can be detected from well logs.

The Fox Canyon aquifer is folded in the Camarillo Hills anticline so that the top of it is exposed near Somis, as shown on Geologic Section L-L', Plate 12-B. The Fox Canyon aquifer is displaced by the Springville fault zone along the south side of the Camarillo Hills and also by the Camarillo fault. Well logs indicate that the Fox Canyon aquifer lies unconformably on the volcanic rocks along the south side of the Pleasant Valley Basin but does not outcrop there. It runs eastward, north of the Camarillo fault, into the Santa Rosa Basin where it pinches out.

<u>Occurrence of Ground Water</u>. Ground water occurs in sands and gravels of the alluvium and of the San Pedro formation, as well as in the fractured volcanics. Ground water in the basin is essentially confined. However, the Fox Canyon member is unconfined in a limited area near Somis. Some of the very shallow sands and

gravels around the north and southeast sides of the area may be unconfined, but available well logs indicate the shallow sands and gravels to be underlain by thick clays which probably prevent appreciable amounts of surface water from reaching the major aquifers.

Movement of Ground Water. Ground water moves toward the center of Pleasant Valley Basin during periods of heavy draft. When water levels are high the ground water generally moves in a southerly direction. Plates 14-B, 15-B, and 16-B show water level elevation contours of the two principal aquifers in this basin.

Replenishment and Depletion of Ground Water. Pleasant Valley Basin is replenished principally by subsurface inflow from East Las Posas Basin near Somis and from Oxnard Plain Basin through the Fox Canyon Aquifer. Replenishment of smaller magnitude also occurs by subsurface inflow from Santa Rosa Basin through the San Pedro formation, from West Las Posas Basin through the Springville fault zone, and from the volcanics to the south and southwest of the basin. Ground water from Pleasant Valley Basin is depleted by pumped extractions and possibly by subsurface outflow toward the ocean during periods of high water level.

Subsurface Inflow and Outflow. Nearly all ground water used in Pleasant Valley Basin is supplied by subsurface inflow from the following sources: (1) From the ocean and Oxnard Forebay Basin through the Fox Canyon aquifer under Oxnard Plain Basin; (2) From East and West Las Posas Basins through the Fox Canyon aquifer near Somis and across the Springville fault zone; (3) From Santa Rosa Valley through the San Pedro formation; (4) From the fractured volcanics into overlying and adjacent shallow aquifers and the Fox Canyon aquifer.

Subsurface outflow toward the ocean may occur during periods of high water level.

Ground Water Storage Capacity. Negligible change of storage occurs in te little used shallow sands and gravels and in the confined aquifers. It is lkely that some change of storage has occurred in the volcanic rocks, but data ae not available to make an estimate of this change. Similarly, data are lacking fr an estimate of total storage capacity of the basin, although it is probably c the order of magnitude of the storage capacity of Oxnard Plain Basin.

Yield of Wells. In general, the wells which are perforated in the Fox Cnyon aquifer yield the greatest amounts of water. The maximum is about 2,400 gllons per minute and the average about 1,000 gallons per minute with a drawdown c about 10 to 50 feet. Wells perforated in both volcanic rocks and shallower aquifers or in shallower aquifers only generally yield up to 1,000 gallons per mnute, the average being about 400 gallons per minute and the drawdown 30 to 70 eet.

Ground Water Basins Within the Calleguas-Conejo Hydrologic Unit

The ground water basins of the Calleguas-Conejo Hydrologic Unit includ Simi, East and West Las Posas, Conejo, Tierra Rejada, and Santa Rosa Basins. Si Basin is the only basin in this hydrologic unit which is essentially a simple al luvial filled type. The others are complex and consist of two or more formation which are folded and faulted. Geologic features of this unit are shown on Plate B-1C, and certain physical characteristics are summarized in Table 16 of Chapter II.

Simi Basin

Simi Basin, comprising an area of about 10,760 acres, underlies the alluvial area of Simi Valley in the extreme east central portion of the Calleguas-Conejo Hydrologic Unit. The floor of Simi Valley is formed by coalescing alluvi fans emanating from Tapo Creek and other canyons. Surface elevation ranges fro 700 feet at the western end of the valley to 1,100 feet near the apex of the Ta Creek cone. A maximum surface elevation of 3,117 feet is attained on the draine divide in the Santa Susana Mountains to the north.

Geology. Geologic formations in the Simi Valley area may be divided into permeable alluvium of Recent and Pleistocene age and older semi-permeable formations. The folded Santa Barbara formation forms a ground water basin in t Tapo Canyon area which is separated from the alluvial filled Simi Valley by sem- permeable older formations. Semi-permeable formations include the volcanics, Sespe, upper and lower Llajas, Santa Susana-Martinez, and sandstones of Cretaceo age. Of these semi-permeable formations, the Sespe, lower Llajas, and Cretaceou formations yield some water to wells in the hills on the south and southeast si of Simi Valley. Ground water in some of these formations appears to be of poor quality, especially at depths of more than 300 or 400 feet.

Alluvium in Simi Basin consists of stream deposited gravel, sand, and clay up to 730 feet thick. The base of the alluvium is bowl-shaped and tapers upward to its edges. It is underlain and flanked by the older formations mentioned above. The alluvium has a high clay content in the west end of the valley, where it locally confines the underlying gravels. Elsewhere in Simi Basin the clays are lenticular and quite irregular.

The older formations in the hills surrounding Simi Valley form a syncline which plunges gently westward. The syncline is cut off on the north side of the valley by the Simi fault.

In the Tapo Canyon area about three miles north of Simi Basin, the Santa Barbara formation of Plio-Pleistocene age is exposed. It consists of marine and continental gravels, sands, and clays, all of which have been folded into a tight syncline by southward thrusting of the Santa Susana fault. The Santa Barbara formation is over 1,000 feet thick in this area. Although some of the deep alluvium in Simi Basin may be equivalent to part of the Santa Barbara formation, the two are not in hydrologic continuity as they are separated by the semi-permeable formations north of Simi Valley.

Occurrence of Ground Water. Ground water occurs in the alluvial fill of Simi Valley and in interstices and fractures of the older formations that flank the valley. The alluvial fill constitutes the principal aquifer and underlies the area of Simi Basin. Second in importance is the isolated area of the Santa Barbara formation which yields water from permeable sand and gravel members in the vicinity of Tapo Canyon.

In cross-section the alluvium of Simi Basin is shown to be shallow near the perimeter of the basin and to increase in thickness toward the center (Sections Q-Q' and R-R', Plate 12-C) where it exceeds 700 feet.

Near the westerly extremity of the valley the alluvium at shallow depth contains considerable clay and silt. These fine materials serve to locally

confine ground water. In periods of high water level, wells that penetrate beneath these materials have flowed. However, unconfined conditions predominate i
Simi Basin.

Movement of Ground Water. Ground water in the alluvium of Simi Valley moves westerly except in dry periods when wells are heavily pumped (see Plates 14-C, 15-C, and 16-C). During such periods a depression forms in the central portion of the basin and the ground water converges on this low area.

Ground water in the older semi-permeable formations moves in general toward the valley fill. In the eastern portion of Simi Valley water levels in wells in alluvium are generally lower than water levels in wells perforated only in the underlying older formations.

Replenishment and Depletion of Ground Water. Ground water in Simi Basi is replenished by percolation of direct precipitation, stream flow, and the unco- sumed portion of water applied for irrigation and other uses. Additional source of replenishment are artificial spreading and a minor amount of subsurface inflo from older formations. Ground water in the older semi-permeable formations and in the Santa Barbara formation in the Tapo Canyon area is replenished by rainfal penetration and stream percolation.

The alluvial basin is depleted by pumped extractions, consumptive use f phreatophytes, effluent discharge and subsurface outflow. The semi-permeable fo- mations are depleted by evapo-transpiration, pumping, by outflow through spring during periods of high water level, and by subsurface outflow into the alluvium The Santa Barbara formation is depleted by spring discharge and by pumping of water for export to Simi Valley.

Subsurface Inflow and Outflow. Subsurface inflow enters the alluvial fill of Simi Basin from adjacent older formations, but no subsurface inflow is known to enter this hydrologic subunit from other subunits. Subsurface outflow aves Simi Valley through the Arroyo Simi where the alluvium appears to be only 6 to 100 feet thick and about 1,000 feet wide, and enters East Las Posas Basin. bsurface flow out of Simi Valley through this alluvium has been estimated by e slope-area method to be about 100 acre-feet per year. During periods of low ter levels, it is possible that subsurface outflow becomes negligible.

Ground Water Storage Capacity and Specific Yield. Estimates of change storage in the alluvium of Simi Basin are discussed in Chapter II. Estimated ighted mean specific yield of alluvial sediments in Simi Basin is 8.6 per cent. tal storage capacity of the alluvium below high water level of 1929 was estimad to be about 180,000 acre-feet. Storage above this level was estimated to be out 40,000 acre-feet.

Yield of Wells. Wells in the alluvium of Simi Valley yield an average about 400 gallons per minute. An exceptional well in Cretaceous sandstone is ported to yield 1,200 gallons per minute, but most of the wells in the older cks yield about 100 gallons per minute. Wells in the Santa Barbara formation in e Tapo Canyon area have an average yield of about 100 gallons per minute.

Artificial Spreading of Water as a Means of Basin Replenishment. Studies of the Soil Conservation Service and the Division of Water Resources indicate e most suitable locations for major spreading works on alluvium are situated ear the mouth of Tapo Canyon, along Chivo Creek, and along Arroyo Simi just west f Santa Susana. The Tapo Creek location provides greater available ground water torage than does the Arroyo Simi location, but infiltration rates at this site are nferior. The Chivo Creek area appears to have least available storage but infiltration rates are suitable. Before any particular site is chosen here or in any ther area for large scale spreading, exploratory test wells should be drilled and ilot spreading operations conducted to insure success.

East Las Posas Basin

East and West Las Posas Basins are geologically similar in some respect but differences are great enough that they can be described separately. East Las Posas Basin comprises about 36,370 acres and is located within the East Las Posas subunit. It is bounded by nonwater-bearing formations which are adjacent to the basin on the south slope of Oak Ridge, in the Happy Camp Canyon area, and in the Las Posas Hills. The western boundary is the surface drainage divide between Eas and West Las Posas Basins. Near Somis the boundary was arbitrarily placed across the narrowest part of the southwesterly-trending valley through that town. Eleva tion of the drainage area ranges from about 250 feet near Somis to about 2,800 ft on Oak Ridge.

Geology. East Las Posas Basin is a broad east-west trending valley be tween Oak Ridge and the hills on the south and is presently undergoing stream di section. The principal water-bearing materials of the basin are Recent and uppe Pleistocene alluvium and the San Pedro and Santa Barbara formations. Semi-perme able older formations adjacent to and underlying the water-bearing formations include the Sespe, Vaqueros, Modelo, and Pico formations, as well as limited area of volcanic rocks. Most of these older formations contain water of poor quality but good water has been obtained from sandstones and conflomerates of the Sespe formation. Late Quaternary alluvium occurs as fill in most of the valleys of th basin. The thickest, most extensive, and most important alluviated area is in the vicinity of Moorpark, where the alluvium consists principally of up to 200 feet of sand and gravel and underlies about 5,100 acres. Near Somis the alluvium is only 40 to 80 feet thick, and consists of silts and clays. In the smaller valleys, alluvium generally varies up to 40 feet in thickness and consists of silt and sand with some clay and gravel.

Previous workers have called the youngest of the pre-alluvial sediments "terrace deposits". Since most of these deposits are folded and since it is extremely difficult to differentiate them from the underlying San Pedro formation they are considered in this report as part of the San Pedro formation. The San Pedro formation is up to 2,000 feet thick in this basin and consists predominantly of yellow, red, and blue silty clay, with lenticular sands and gravels.

The San Pedro formation contains two members notable as aquifers; namely the Epworth gravels and the Fox Canyon aquifer. The Epworth gravels, near the top of the San Pedro formation, are located in a rather limited area lying about two to three miles north and northwest of Moorpark. They consist of up to 200 feet of gravel, gravelly clay, and silt, grading westward and southward into silt and clay. The Epworth gravels are probably remnants of an ancient alluvial fan, which accounts for their limited extent. The gravels have been folded and partially eroded so that they now outcrop in the area shown on the geologic map (Plate B-1C) and they underlie a total area of about six square miles.

The basal Fox Canyon member of the San Pedro formation has been named from its excellent exposure in Fox Canyon, about a mile west of Bradley Road. It consists of from 100 to 400 feet of sand and gravel containing some clay and silt lenses. The outcrop of the Fox Canyon member along the south slope of Oak Ridge is irregularly bedded as a result of facies changes and scour and fill, and varies considerably in total thickness. Fossils found in the member indicate deposition under shallow marine conditions. Sediments of the Fox Canyon member generally are white or gray in color. These sediments can be easily differentiated on the outcrop from the underlying Grimes Canyon sediments because of the distinct brown coloring of the latter. In well logs it is usually difficult to differentiate Fox and Grimes Canyon sediments. From a study of all available logs it is clear that the Fox Canyon aquifer extends under most of East Las Posas Basin. In general, the Fox Canyon aquifer is thickest in the central portion of the basin where it consists principally of coarse sand. On Oak Ridge it is variable in thickness and consists of gravel and sand grading into fine sand near Happy Camp Canyon, where it pinches out entirely. On the Las Posas Hills it consist of sand and gravel, grading into sand near Moorpark.

In East Las Posas Basin, most of the San Pedro formation other than the above mentioned aquifers consists of fine silt and clay with scattered lenses of gravel and sand. Since individual gravel lenses are quite local, and since yield of wells in this material is generally quite low, this portion is here called the semi-permeable portion of the San Pedro formation. These materials overlie the Fox Canyon aquifer, and confine the ground water under pressure in that aquifer.

The Santa Barbara formation underlies the San Pedro formation and in this basin consists of up to 2,000 feet of clay, silt, sand, and gravel. At the west end of Oak Ridge it consists of clay and silt, but east of Bradley Road sand and gravel lenses become more common along the outcrop until in Happy Camp Canyon they predominate. The formation also thins to about 1,000 feet near Happy Camp Canyon. A coarse gravel member near the top of the Santa Barbara formation is exposed east and north of Bradley Road and is called the Grimes Canyon aquifer. This aquifer consists of coarse to fine brown gravel, sand, and lenses of clay and silt. The rusty brown color of the Grimes Canyon is usually distinctive, but occasionally is not evident in exposures or well logs. The aquifer varies in thickness from zero to about 1,000 feet in Happy Camp Canyon where it comprises nearly all the Santa Barbara formation. The Grimes Canyon aquifer underlies most of East Las Posas Basin.

The Grimes Canyon aquifer is overlain by the Fox Canyon aquifer, and several outcrops reveal them to be in direct contact, although a clay member within the Santa Barbara formation separates the two aquifers in other exposed areas. The thickness of the aquifers indicated by some water and oil well logs suggests that the Fox Canyon and Grimes Canyon aquifers are in direct contact under much, if not most, of East Las Posas Basin. It is possible that some of the sediments of the Santa Barbara formation in Tapo Canyon are also the equivalent of the Grimes Canyon member. The detailed field work necessary to make such a discrimination was not undertaken in this investigation. The Santa Barbara formation with exception of the Grimes Canyon aquifer previously described is for the most part composed of materials of low permeability.

The San Pedro formation, Santa Barbara formation, and the underlying Pico, Modelo, Vaqueros, and Sespe formations are all folded and faulted, only alluvium being undisturbed. In general, East Las Posas Basin is a synclinal area, plunging gently westward, and includes several minor en echelon synclines and anticlines. Oak Ridge and the Las Posas Hills are major anticlinal uplifts. The folding of the area has resulted in the Fox Canyon and Grimes Canyon aquifers being buried quite deeply in the central portion of the basin and exposed around the fringes. Structural features and relationships of various aquifers are shown on Geologic Section N-N' and P-P', Plate 12-C.

<u>Occurrence of Ground Water</u>. Ground water occurs in the sands and gravels of the alluvial deposits, in the Epworth gravels, and in the Fox Canyon and Grimes Canyon aquifers. Limited amounts of ground water occur in sands and gravel lenses in the semi-permeable portion of the San Pedro formation which overlies the Fox Canyon member. Limited supplies of water occur in the older semi-permeable formations and may be of poor quality.

Ground water in the alluvial deposits and in the Epworth gravels is essentially unconfined, although water level behavior in some wells indicate locally confined conditions. Ground water in the Fox Canyon and Grimes Canyon aquifers is confined by the overlying silts and clays. Ground water is unconfined in these aquifers, however, near their upturned edges which approximate the outcrop areas as shown on Plate B-1C.

Movement of Ground Water. Ground water in the alluvium near Moorpark generally moves westward toward Somis except during periods of low water level, when a pumping depression forms southwest of Moorpark. Ground water in the Epworth gravels appears to move in a southerly direction, indicating some movemen from the Epworth gravels into the semi-permeable portion of the San Pedro formation.

Ground water in the Fox Canyon aquifer moves in a southwesterly direction from Happy Camp Canyon and the outcrop along the north side of East Las Posa Basin. Subsurface flow in the fall of 1951 as depicted by dashed ground water contours on Plate 16-C converges on the Somis area and moves into Pleasant Valle Basin. Meager historic data suggests that in periods of high water levels groun water in the Fox Canyon aquifer moves westward into West Las Posas Basin as well as into Pleasant Valley Basin. Water levels of fall 1951 indicate a ground wate mound in the piezometric surface of the Fox Canyon aquifer near the west boundar of East Las Posas Basin.

Replenishment and Depletion of Ground Water. Ground water in East Las Posas Basin is replenished by percolation of direct precipitation, stream flow, and the unconsumed portion of water applied for irrigation and other uses in out crop areas of aquifers, and possibly to some extent by subsurface inflow from older formations that surround the basin. Alluvium southwest of Moorpark along Arroyo Las Posas overlies the Fox Canyon aquifer where they are probably in hydr logic continuity. In the vicinity of Somis and Moorpark, studies of water level and the chemical character of ground water have led to the conclusion that groun water moves from the alluvium into the Fox Canyon aquifer.

East Las Posas Basin is depleted by pumped extractions from the Fox Ca yon aquifer and by consumptive use of phreatophytes. Additional depletion is effected by subsurface outflow and export of water into West Las Posas Basin.

Springs are reported to have flowed near Somis in Arroyo Las Posas in the early 1900's which would indicate that in periods of high water levels the basin was to some extent depleted by effluent discharge.

<u>Subsurface Inflow and Outflow</u>. Subsurface inflow into East Las Posas Basin is limited to that coming from older rocks and about 100 acre-feet per year which enters from Simi Basin through alluvium. This latter increment of inflow has been described under the paragraph on inflow and outflow to Simi Basin. Subsurface outflow into Pleasant Valley Basin through the Fox Canyon aquifer is indicated by water level contours (Plates 14-C, 15-C, and 16-C). This outflow has been estimated by the slope area method to be on the order of 3,000 acre-feet per year. As previously mentioned, subsurface outflow to West Las Posas Basin has probably occurred in the past during periods of high ground water level.

<u>Ground Water Storage Capacity and Specific Yield</u>. Changes in ground water storage occurring within East Las Posas Basin during selected study periods were estimated following the procedures described in Chapter B-VI and are discussed in Chapter II. Total storage capacity of aquifers in the basin could not be estimated, but is probably very large.

Depth to water in the outcrop area of the Fox Canyon and Grimes Canyon aquifers on Oak Ridge was approximately 500 or 600 feet in 1951 and 1952, and therefore considerable available storage exists in these aquifers above the water table. The average specific yield of the Fox Canyon and Grimes Canyon aquifers is believed to vary between 10 and 20 per cent. Estimated specific yield of the Epworth gravels is about six per cent; most of the remainder of the San Pedro formation, three per cent, and the alluvium in the Moorpark area, eight per cent.

Yield of Wells. Estimated average yield of wells in East Las Posas Basin is summarized below:

Alluvium	400 gallons per minute
Epworth Gravels	300 " " "
Fox Canyon and Grimes Canyon Aquifers	600 " " "
Semi-permeable portion of San Pedro formation	10 " " "

Artificial Spreading of Water as a Means of Basin Replenishment. Water could be spread artificially on any portion of the outcrop area of the Fox Canyon or Grimes Canyon aquifers and reach the water table. The most desirable spreadin area for these aquifers is in Happy Camp Canyon about three miles north of Arroyo Simi. This locality has available surface area for construction of spreading grounds, high rates of percolation according to the Soil Conservation Service, an free access to the water table of the Grimes Canyon aquifer which is in hydrologi continuity with the Fox Canyon aquifer. In addition, the water table is about 5(feet below the surface in this area so that adequate ground water storage is avai· able. A seismic survey of the spreading area by this Division indicates an absence of clay lenses within 30 to 60 feet of the surface. Most other areas of outcrop have limited surface area available for construction of spreading works.

Spreading into the Epworth gravels may be possible, but this would benefit only the wells in these gravels. A large surface area is available for construction of spreading works near the corner of Broadway and Moorpark Roads, abou two miles north of Moorpark, but spreading rates are probably low.

Spreading into alluvium near Moorpark is feasible from percolation rate and surface area aspects. However, available storage of alluvium is probably smal even when the alluvium is dewatered, and it might be filled by natural stream percolation of Arroyo Simi during wet periods.

Wst Las Posas Basin

West Las Posas Basin is located within the corresponding subunit and cmprises about 11,450 acres. Elevation of the subunit ranges from 200 feet to a nximum of 2,258 feet on South Mountain. Boundaries of West Las Posas Basin are te outcrop of the Fox Canyon aquifer on the north, the surface drainage divide c the east and south, and the limit of the Oxnard zone of Oxnard Plain and (nard Forebay Basins on the west.

Geology. Aquifers of significance in West Las Posas Basin include the ix Canyon and Grimes Canyon. The upper semi-permeable portion of the San Pedro irmation overlies the Fox Canyon aquifer and in turn is overlain by alluvium of icent and upper Pleistocene age. The alluvium is not easily differentiated from ie silts and clays of the underlying San Pedro formation, but it is probably up) 200 or 300 feet thick. The alluvium consists of fine yellow silt and clay with cattered lenticular sands and gravels and has been deposited in alluvial fans by nall streams draining Oak Ridge. The semi-permeable portion of the San Pedro ormation consists of over 1,000 feet of yellow and blue silty clay and clay, with cattered lenticular sands and gravels.

The Fox Canyon aquifer consists of 200 to 300 feet of sand and gravel at ne base of the San Pedro formation. The Fox Canyon aquifer continues into East as Posas Basin, Oxnard Plain and Forebay Basins, and into the Camarillo Hills nd Pleasant Valley Basin. The Fox Canyon aquifer outcrops on the south slope of ak Ridge and in the east end of the Camarillo Hills.

The Fox Canyon aquifer is underlain by the Santa Barbara formation which ontains the Grimes Canyon aquifer near its top. The Grimes Canyon aquifer does ot outcrop in the West Las Posas Basin but underlies it as shown by electric logs nd drillers logs. It consists of up to 300 feet of coarse gravel and sand. Well

logs indicate that a clay bed up to 600 feet thick lies between the Fox Canyon a
Grimes Canyon aquifers in the Camarillo Hills (see Section L-L', Plate 12-B). A
similar clay bed is found on the outcrop in East Las Posas Basin and it is likel
that these two clay beds are of a similar origin. Field inspection of the clay
bed in East Las Posas Basin shows that an erosional unconformity at the base of th
Fox Canyon aquifer has resulted in direct contact of the Fox Canyon and Grimes
Canyon aquifers where the clay has been eroded.

As in East Las Posas Basin, folding of the Fox Canyon has resulted in its being exposed on the edges of the basin and deeply buried in the middle. Th most prominent folds are the Camarillo Hills anticline and the Las Posas synclin

Occurrence of Ground Water. The Fox Canyon and Grimes Canyon aquifers are the principal sources of ground water in West Las Posas Basin. Some water i derived from sand and gravel zones of limited extent contained within the semi-permeable portion of the San Pedro formation. Ground water in the Fox Canyon an Grimes Canyon aquifers is confined except where these aquifers outcrop on the southern slopes of Oak Ridge and where they have been folded in the Camarillo Hills (see Section L-L', Plate 12-B).

Movement of Ground Water. Movement of ground water in 1951, as depict by contours (Plate 16-C), was westerly in the Fox Canyon aquifer toward Oxnard Forebay Basin. Some ground water possibly moves southward across the Camarillo Hills, through the Springville fault zone, and into Pleasant Valley.

Replenishment and Depletion of Ground Water. West Las Posas Basin is replenished by percolation of direct precipitation and stream flow on the outcr area of the Fox Canyon aquifer and possibly to some extent by subsurface inflow from East Las Posas Basin. The silty upper portion of the San Pedro formation nd alluvium may in addition be replenished by percolation of the unconsumed portio of water applied for irrigation and other uses. West Las Posas Basin is deplet by pumping from the Fox Canyon and other aquifers and by subsurface outflow.

Subsurface Inflow and Outflow. Subsurface flow into West Las Posas Basin probably occurs from East Las Posas Basin during periods of high water level. Subsurface outflow occurs into Oxnard Plain and Pleasant Valley Basins through the Fox Canyon aquifer. The outflow has been estimated by the slope area method to be on the order of 600 acre-feet per year into the Oxnard Plain Basin. Subsurface outflow probably occurs across the Springville fault zone into Pleasant Valley Basin, but no data are available to estimate the amount. Since the ground water divide in the piezometric surface of the Fox Canyon aquifer is located close to the surface divide, it is likely that subsurface outflow into East Las Posas Basin through that aquifer is negligible.

Ground Water Storage Capacity and Specific Yield. Change of ground water storage in West Las Posas Basin is discussed in Chapter II. Specific yield of the Fox Canyon aquifer is estimated by inspection to be about 15 to 20 per cent. Specific yield of the overlying San Pedro formation and the alluvium is estimated to be about three per cent.

Yield of Wells. Yield of wells in the Fox Canyon and Grimes Canyon aquifers averages about 600 gallons per minute. Wells in the semi-permeable portion of the San Pedro formation yield about ten gallons per minute.

Artificial Spreading. Artificial spreading on the outcrop area of the Fox Canyon aquifer is physically possible, as in East Las Posas Basin, although the rugged topography limits areas in which spreading works could be constructed.

Conejo Basin

Conejo Basin is located in the southern portion of the Calleguas-Conejo Hydrologic Unit as shown on Plate 11. The basin varies in elevation from about

600 feet to 2,300 feet except on the floor of Conejo Creek Canyon, the elevation of which is about 300 feet. Within the hydrologic unit most of the rocks including volcanics and consolidated sediments absorb and transmit water, but wells in these rocks generally yield small amounts of water. Since there are no areas which can be easily defined as ground water basins, the entire drainage area of about 28,930 acres is considered as the basin.

Geology. Most of Conejo Basin is an upland valley area which has drained eastward in the geologic past, possibly into Triunfo Creek. The ancestral drainage was subsequently captured by headward erosion of Conejo Creek, so that the area now drains into Santa Rosa Basin.

Geologic formations in Conejo Basin include alluvium, Modelo sandstone and shale, volcanic rocks, the Topanga formation, and limited exposures of the lower Llajas and Santa Susana-Martinez formations as well as some consolidated sediments of Cretaceous age. Alluvium of Recent and Pleistocene age occurs as valley fill in the Newbury Park and Thousand Oaks areas, on the floor of Conejo Creek Canyon, and as terrace deposits scattered throughout the basin. The alluvium is generally shallow, probably being only a few feet thich except in the valley fill areas where it attains a thickness of about 60 feet. The volcanic rocks, the Topanga formation, and the Modelo sandstones and shales are drilled by many wells in Conejo Basin. The limited outcrops of other formations are not generally drilled within the basin. All the aforementioned formations are described in Chapter B-III of this Appendix. All the formations with the exception of the alluvium are folded and faulted as shown on the geologic map (Plate B-1C).

Occurrence of Ground Water. Ground water occurs in the alluvium, in the fractures and weathered portions of the volcanic rocks and Modelo shales, and in pervious zones of the Modelo sandstone and Topanga formations. The ground water surface conforms, in general, with the topography as shown on Plate 16-C and is essentially unconfined. Most wells in alluvial areas penetrate the alluvium completely and obtain water from underlying formations as well as from alluvium. At the time of this investigation no water wells were known to have penetrated very deeply into the older rocks. Scattered oil well logs indicate that such previous zones exist in the older rocks, but quality of water in them is uncertain.

Movement of Ground Water. Ground water from the periphery of the basin converges toward Conejo Creek as indicated by ground water contours on Plate 16-C. Perennial springs which are supplied by subsurface flow from Conejo Basin exist in the canyon of Conejo Creek.

Replenishment and Depletion. Ground water is replenished by percolation of direct precipitation and stream flow as is evidenced by a close relationship between water table and topography and fairly rapid recovery of water levels following rains. Replenishment also occurs by percolation of the unconsumed portion of water applied for irrigation and other uses. Ground water is depleted by pumped extractions, by consumptive use of phreatophytes, by effluent discharge, and, most likely, by subsurface outflow.

Subsurface Inflow and Outflow. No subsurface inflow occurs into Conejo Basin. Subsurface outflow probably occurs into Santa Rosa Basin through the alluvial fill in Conejo Creek Canyon and through the volcanics. Subsurface outflow may also occur into Pleasant Valley Basin, through the volcanics. Subsurface outflow through volcanics appears to be possible because: 1. The volcanics dip toward Santa Rosa and Pleasant Valley Basins; 2. Water levels in Conejo Basin are higher than in the other basins; 3. The volcanics are permeable. A ground water divide may exist in the same general location as the drainage divide but water level data are lacking to verify this possibility. If this were the case, subsurface flow into Pleasant Valley and Santa Rosa Basins through the volcanics would be negligible.

Water level measurements in the Thousand Oaks area indicate that a ground water divide exists near the drainage divide so that subsurface flow in or out of the Malibu Hydrologic Unit is probably negligible.

Storage Estimates. Change of storage does occur in Conejo Basin as evidenced by fluctuations of water levels and unconfined ground water conditions. Well log and historic water level data are lacking, however, and specific yield of the various formations in the basin is uncertain. For these reasons estimates of change in storage in Conejo Basin are not considered to be of sufficient accuracy for use in the hydrologic balance.

Yield of Wells. Because of the general low permeability of the formations in Conejo Basin, average yield of wells is low and on the order of 50 gallons per minute. One exceptional well, however, yields 1,000 gallons per minute and several yield about 300 gallons per minute.

Artificial Spreading. Artificial spreading in Conejo Basin does not appear to be feasible because of relatively shallow depths to water and the general low specific yield of the formations.

Tierra Rejada Basin

Tierra Rejada Basin is located between Simi, Conejo, Santa Rosa, and East Las Posas Basins as indicated on Plate 11. Surface elevation ranges from 6] feet in the valley floor to about 1,600 feet on the drainage divide. Nearly all Tierra Rejada Basin is underlain by water-bearing volcanic rocks. For this reas] the drainage divide is taken as the basin boundary. The basin includes an area of about 4,390 acres.

Geology. Although most of Tierra Rejada Basin is underlain by fractured volcanic rocks, a small portion is underlain by the Modelo, Topanga, and Sespe formations. The volcanics consist of about 2,000 feet of basaltic flows, agglomerates, rhyolitic tuffs, and interbedded conglomerates and clays. These materials are intruded by basaltic dikes and sills.

All formations present are folded and faulted. In general the structure of the basin is that of a westward plunging syncline. The volcanic rocks in the southern and eastern parts of the basin dip from 10 to 30 degrees toward the flat irrigated portion of the basin. North of the irrigated area the attitude of the volcanic rocks is nearly vertical. These rocks are terminated near the north boundary of the basin by the east-west trending Simi fault. Another fault trending north-south displaces the volcanic rocks several hundred feet near the western side of the basin.

Occurrence of Ground Water. The volcanic rocks are generally highly fractured but appear to be most intensively fractured beneath the irrigated portion of the basin, as wells in the volcanics have highest yields there. Ground water occurs chiefly within these fractures, and is essentially unconfined.

Movement of Ground Water. Ground water moves through the highly fractured volcanic rocks converging toward the westerly end of the basin. At the west end subsurface flow out of the basin is impeded by the above mentioned north-south fault. That this fault serves as a ground water barrier is evidenced by a pronounced drop in water level. In 1951 the ground water level east of this fault in Tierra Rejada Basin stood about 100 feet above the level observed in a well situated near the fault on its westerly side. Movement of ground water is indicated by ground water elevation contours on Plates 15-C and 16-C.

Replenishment and Depletion of Ground Water. Tierra Rejada Basin is replenished by percolation of direct precipitation, stream flow, and the unconsumed portion of water applied for irrigation and other uses. The basin is depleted by pumped extraction, limited subsurface outflow into Santa Rosa Basin, and possibly effluent discharge and consumptive use of phreatophytes during periods of high water level.

Subsurface Inflow and Outflow. No subsurface flow enters Tierra Rejada Basin from Simi Basin. Water level measurements in the area of the drainage divide separating these basins indicates that a ground water divide exists which would prevent inflow from Simi Basin through the volcanics. If no ground water divide existed there, some inflow might be expected since water level elevations in the west portion of Tierra Rejada Basin are generally lower than in Simi Vall.

As previously discussed, the north-south fault at the west end of Tier Rejada Basin limits subsurface outflow. A producing well situated a short distance west of the fault suggests that this fault is only a partial barrier since the only feasible source of supply is subsurface flow across the fault. It is likely that subsurface flow northward across Simi fault into East Las Posas Basi is negligible.

Ground Water Storage Capacity. As in Conejo Basin, poor geologic and hydrologic data resulted in uncertainties in change of storage estimates; so direct evaluation thereof could not be made.

Yield of Wells. Wells in Tierra Rejada Basin yield from 10 to 700 ga lons per minute with an average yield in the principal pumping area of about 30 gallons per minute.

Santa Rosa Basin

Santa Rosa Basin, comprising about 3,490 acres, is located just east of Pleasant Valley Basin. It is bounded by the volcanics on the south, the limit the San Pedro formation on the north, Tierra Rejada Basin on the east, and the topographic narrows at the west end of the basin. Santa Rosa Basin ranges from 200 to over 400 feet in elevation with a maximum elevation of about 1,200 feet on the drainage divide.

Geology. Principal water-bearing sediments in Santa Rosa Basin include Recent alluvium and the San Pedro formation . Formations underlying and adjacent to the basin include the Santa Barbara, the Topanga and Sespe formations, and volcanic rocks.

Recent alluvium in Santa Rosa Basin consists of up to 200 feet of gravel, sand and clay. Fossil remains in outcrops of alluvium in the stream cut gullies indicate that some of the clays in the west end of the basin have been deposited in a fresh water swamp or shallow lake.

The San Pedro formation consists of up to 700 feet of gravel, sand, silt, and clay. In the western end of the basin a sand and gravel member about 100 feet thick can be traced in well logs at the base of the formation and is probably the equivalent of the Fox Canyon aquifer. This aquifer, however, cannot be traced in well logs into the central and eastern portion of the basin. In general, the sands and gravels of the San Pedro formation are extremely lenticular and with the above mentioned exception cannot be correlated between wells. In the west end of the basin, the Santa Barbara formation is found below the San Pedro, but it contains water of poor quality. Only one or two wells are drilled into it here, so that its nature is poorly known, but it apparently consists of silt and clay with lenticular gravels and sands. The volcanics of Miocene age which underlie the alluvium and San Pedro formation on the south side of the basin are exposed in the hills to the south where they dip ten to twenty-five degrees northward. The volcanics consist of over 2,000 feet of interbedded basaltic agglomerates and flows with scattered andesitic intrusions, all of which are fractured. The great thickness of volcanics on the south of the basin is represented in the Las Posas Hills by a basaltic sill about 15 feet thick. Relationships of the formations are shown on Geologic Sections N-N' and P-P' on Plate 12-C.

All these formations except the alluvium have been folded and faulted. The structure of most significance is the east-west trending Santa Rosa syncline, shown on the geologic map (Plate B-1C), in which the San Pedro formation has been folded. Field inspection of outcrops and well logs indicates that the north dipping flank of the syncline lies beneath the alluvium on the south side of Santa Rosa Basin. The San Pedro formation and alluvium are underlain in part by volcanics and other formations. The north flank of the folded San Pedro formation has been cut off by the Simi-Santa Rosa fault system, exposing the semi-permeable Sespe and Topanga formations in the Las Posas Hills just north of the basin.

Occurrence of Ground Water. Ground water occurs in pervious zones of the Recent alluvium and San Pedro formation and in the fractured volcanics. Water of poor quality occurs in the Santa Barbara formation and possibly in the Sespe and Topanga formations. Ground water in Santa Rosa Basin is essentially unconfined, although the pervious lenses of the San Pedro formation are confined in some areas.

Movement of Ground Water. Ground water in Santa Rosa Basin moves westerly and within the basin appears to move northerly from the volcanics and southerly in the San Pedro formation. Plate 16-C shows the southerly movement in the fall of 1951, but the northern direction of movement at this time was not appreciable. When Conejo Creek flows into Santa Rosa Basin, percolation occurs and a ground water mound is built up near the mouth of Conejo Creek. Past measurements of a well on the extreme south side of the basin as well as the presence of springs in the volcanics indicate that some water probably moves directly from the volcanics into the alluvium.

Replenishment and Depletion of Ground Water. Ground water in Santa Rsa Basin is replenished by percolation of direct precipitation, stream flow, and te unconsumed portion of water applied for irrigation and other uses as well as t subsurface inflow. The basin is depleted by pumped extractions, subsurface ctflow, and by effluent discharge and consumptive use of phreatophytes during priods of high water level.

Subsurface Inflow and Outflow. Subsurface inflow to Santa Rosa Basin ccurs from Tierra Rejada and Conejo Basins. Inflow from both these sources is cfficult to estimate by geologic methods because of the lack of wells and other cta. Subsurface outflow into Pleasant Valley through the San Pedro formation has ben estimated by the slope-area method to be about 200 acre-feet per year.

Ground Water Storage Capacity and Specific Yield. Estimates of change c storage in alluvium and San Pedro formation are discussed in Chapter II. Wighted average specific yield of the alluvium and San Pedro formation is estimted to be five per cent.

Yield of Wells. Water wells in Santa Rosa Basin yield up to 1,200 galons per minute. Their yield averages about 600 gallons per minute, and specific apacities range from 10 to 30. The highest yielding well is in the volcanics, ad wells in the San Pedro formation generally yield slightly less than those in he alluvium. In general, these differences are controlled by permeability, but n some instances are dependent on the method of well construction.

Artificial Spreading. Spreading in Santa Rosa Basin is feasible near he mouth of Conejo Creek, where most stream percolation has occurred. In the ther areas where surface conditions appear suitable for spreading, well log data re poor, and it is not known whether large quantities of water would percolate irectly to the water table.

Miscellaneous Areas In and Near Ventura County

The areas discussed below are those which contain ground water bodies of unknown extent and usefulness within and adjacent to Ventura County, but which are outside the principal developed ground water areas.

Malibu Hydrologic Unit

The Malibu Hydrologic Unit is located in the southeastern portion of the county and includes that portion of the Santa Monica Mountains draining southward to the ocean. Principal geologic features are shown on Plate B-1C.

Formations in this area include alluvium, Modelo sandstone and shale, volcanic rocks, the Topanga formation, and a small area of older sedimentary rock. Ground water is obtained from wells drilled into most of these formations. Principal water-bearing formations, however, are the alluvium and the volcanic rocks.

Alluvium of Recent and Pleistocene age occurs as valley fill up to at least 100 feet thick in the upper drainage areas of Triunfo and Medea Creeks. The alluvial area which has most wells is Hidden Valley, located just west of Lake Sherwood. Water wells here penetrate alluvium and the underlying volcanic rocks. Nearly all the wells in Hidden Valley are used for domestic and limited irrigation purposes. Yield of wells is small in this area, probably averaging 50 gallons per minute. The low yield of the wells suggests that the alluvium and volcanics are fairly impervious and have low specific yield and storage capacity. The direction of movement of ground water is eastward toward Lake Sherwood as shown on Plate 16-C.

Downstream from Lake Sherwood a few irrigation wells obtain a good supply of ground water from the coarse alluvial gravels in the valley floor. In most of the remaining alluvial areas shown on the geologic map few wells have been drilled, bt the alluvium is most likely thin and probably does not contain large quantites of ground water.

Numerous wells have been drilled into the volcanic rocks, the Topanga frmation, and the Modelo formation. Most of these wells yield small amounts of wter, but one well in the volcanics and one in the Topanga formation reportedly yeld 300 gallons per minute. Scattered well measurements and observations of srings in the Malibu Hydrologic Unit indicate that the ground water surface confrms in general with topography, as would be expected with formations of low prmeability.

Rncon Subunit and Rincon Creek Drainage Area

The Rincon subunit is located along the ocean between the Ventura River ad the Santa Barbara-Ventura County line. Ground water bodies are extremely small i this subunit, being restricted to the alluvial filled valley bottoms, the beach posits, and the thin terrace deposits. Older formations probably contain water c poor quality, as do the beach deposits during dry periods. Because of the limied ground water bodies in the subunit only a few small wells are found there, mst of the water being imported.

The geology and occurrence of ground water in the Rincon Creek area has ben discussed by Upson (1951). Since Rincon Creek recharges a ground water basin lcated mostly in Santa Barbara County, the area will not be further discussed here.

Cyama River Drainage Area

The principal development in the Cuyama River drainage area has occurred i Santa Barbara and San Luis Obispo Counties. This area has been described by son and Worts (1951). The following discussion applies principally to the Venura County portion of the drainage area which is utilized by only a few wells.

Formations in the Ventura County portion of the Cuyama River drainage include alluvium, the Morales, Quatal, Simmler, and older sedimentary formations as well as granitic rocks. All of these are described in Chapter B-III of this appendix. The principal water-bearing formation presently utilized is alluvium of Recent and Pleistocene age which appears to be 60 to 100 feet thick in the va ley areas. The morales and portions of the Quatal formations, although not presently utilized by wells, appear from surface lithology to be potentially good sources of ground water. Pronounced lowering of water levels may occur in the area if the ground water is utilized, because of low rainfall and probable limit recharge in the area of outcrop of the formations.

Upper Portions of Piru Creek Drainage

Areas in the upper portion of Piru Creek drainage where a few water wel are found include Lockwood Valley and Hungry and Peace Valleys. The latter two valleys are located in the alluvial areas shown on Plate 10 near the northeast corner of Ventura County.

In Lockwood Valley alluvium is very thin, and the few water wells in th area appear to be obtaining ground water from the continental sediments of Mioce age. One well in these sediments, however, had such a high boron content that a young apple orchard was destroyed by application of the water. The volume of ground water which is available for use is unknown, but is probably small.

In Hungry and Peace Valleys a few water wells obtain a supply from the relatively thin alluvium and from sand and gravel of the underlying Ridge Basin group of sediments of Pliocene age. Two wells in the upper part of the Ridge Basin group reportedly yield large amounts of water for irrigation purposes. It is not known whether ground water storage and recharge is sufficient for potenti future irrigation uses.

BIBLIOGRAPHY

xelrod, D. I.
The Piru Gorge Flora of Southern California. Carnegie Inst. Wash. Pub. 590, pp. 159-214. 1950.

ailey, Thomas L.
Lateral Change of Fauna in the Lower Pleistocene. Bull. Amer. Assoc. Petrol. Geol., Vol. 46, pp. 489-502. 1935.

Origin and Migration of Oil into Sespe Redbeds, California. Bull. Amer. Assoc. Petrol. Geol., Vol. 31, No. 11, pp. 1913-1935. 1937.

Late Pleistocene Coast Range Orogenesis in Southern California. Bull. Amer. Assoc. Petrol. Geol., Vol. 54, pp. 1549-1566. 1943.

Underground Water Supply for Point Mugu Naval Base, Ventura County, California. Unpublished report for Point Mugu Naval Air Missile Test Center. Oct. 1948.

ailey, William C.
South Mountain Oil Field. California Oil Fields, Vol. 29, No. 2. 1943.

Shiells Canyon Area of Bardsdale Field. California Oil Fields, Vol. 31, No. 1. 1945.

uwalda, J. P., Gazin, C. L.,and Sutherland, J. C.
Frazier Mountain, a Crystalline Overthrust Slab, West of Tejon Pass, California. Pan-Amer. Geol., Vol. 54, No. 1, pp. 71-72. 1930.

alifornia Dept. of Public Works, Division of Water Resources
Bulletin No. 45, South Coastal Basin Investigation - Geology and Ground Water Storage Capacity of Valley Fill. 1934.

Bulletin No. 46, Ventura County Investigation. 1933.

arlson, Stanley A.
Stratigraphy of the Cuyama Valley Area, California. Paper given at Amer. Assoc. Petrol. Geol. meeting, Los Angeles, Oct. 31, 1952.

artwright, L. D.
Sedimentation of the Pico Formation in the Ventura Quadrangle, California. Bull. Amer. Assoc. Petrol. Geol., Vol. 12, No. 3, pp. 239-248. 1928.

lements, Thomas
Structure of the Southeastern Part of the Tejon Quadrangle, California. Bull. Amer. Assoc. Petrol, Geol., Vol. 21, No. 1, pp. 212-232. 1937.

rowell, John C.
Geology of Hungry Valley Area, Southern California. Bull. Amer. Assoc. Petrol. Geol., Vol. 34, pp. 1623-1646. 1950.

Geology of the Lebec Quadrangle, California. Calif. Dept. Natural Resources, Div. of Mines, Special Report 24. Aug. 1952.

Probable Large Displacement on the San Gabriel Fault, Southern California. Bull. Amer. Assoc. Petrol. Geol., Vol. 36, No. 10, pp. 2026-2035. Oct. 1952.

Dehlinger, Peter
Geology of the Southern Ridge Basin, Los Angeles County, California. Calif. Dept. Natural Resources, Div. of Mines, Special Report 26. 1952.

Dibblee, T. W. Jr.
Cuyama Valley and Vicinity. Amer. Assoc. Petrol. Geol. Guidebook, pp. 82-84. March 1952.

Driver, H. L.
Foraminiferal Section along Adams Canyon, Ventura County, California. Bull. Amer. Assoc. Petrol. Geol., Vol. 12, No. 7, pp. 753-756. 1928.

Eaton, J. E.
Divisions and Duration of the Pleistocene in Southern California. Bull. Amer Assoc. Petrol. Geol., Vol. 12, pp. 111-141. 1928.

The By-Passing and Discontinuous Deposition of Sedimentary Materials. Bull. Amer. Assoc. Petrol. Geol., Vol. 13, No. 7, p. 750. 1929.

Ridge Basin, California. Bull. Amer. Assoc. Petrol. Geol., Vol. 23, No. 4, pp. 517-558. 1939.

Eldridge, G. H. and Arnold, R.
The Santa Clara Valley, Puente Hills and Los Angeles Oil Districts, Southern California. U. S. Geol. Surv. Bull. 309. 1907.

Emery, K. O. and Rittenberg, S. C.
Early Diagenesis of California Basin Sediments in Relation to Origin of Oil. Bull. Amer. Assoc. Petrol. Geol., Vol. 36, No. 5, pp. 735-806. May 1952.

Emery, K. O. and Shepard, F. P.
Lithology of the Sea Floor Off Southern California. Bull. Amer. Assoc. Petro. Geol., Vol. 56, pp. 431-478. 1945.

Handin, J. W.
The Source, Transportation and Deposition of Beach Sediments in Southern Cal-ornia. Beach Erosion Board, Office of the Chief of Engineers, Technical Mem randum No. 22. 1951.

Hanna, G. D., and Hertlein, L. G.
Characteristic Fossils of California, Calif. Dept. Natural Resources, Div. o Mines, Bull. 118, pp. 165-182, 1943.

Herron, R. F.
Thrust Faults of the Ventura Basin. Paper presented at meeting of the Amer. Assoc. Petrol. Geol., Los Angeles, Oct. 30, 1952.

Hill, M. L. and Dibblee, T. W. Jr.
San Andreas, Garlock, and Big Pine Faults, California. Bull. Geol. Soc. of America, Vol. 64, No. 4, pp. 443-458. 1953.

Hoots, H. W.
Geology of the Eastern Santa Monica Mountains, Los Angeles County, California. U. S. Geol. Surv. Prof. Paper 165-C. 1931.

Excursion in the Los Angeles Basin and the Santa Monica Mountains. 16th Int. Geol. Congr. Guidebook 15, pp. 43-48. 1932.

Inman, D. L.
Report on Beach Study in the Vicinity of Mugu Lagoon, California. Beach Erosion Board, Corps of Engineers, Technical Memorandum No. 14. Mar. 1950.

Submarine Topography and Sedimentation in the Vicinity of Mugu Submarine Canyon, California. Beach Erosion Board, Corps of Engineers, Technical Memorandum No. 19. July 1950.

Jacobs, C. E. and Cooper, H. H. Jr.
A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well Field History. Amer. Geophysical Union Trans., Vol. 27, No. 4, pp. 526-534. 1946.

Jahns, R. H.
Stratigraphy of the Easternmost Ventura Basin, California. Carnegie Inst. Wash., Pub. 514, pp. 145-194. 1940.

Jenkins, O. P.
Geologic Map of California. Calif. Dept. Natural Resources, Div. of Mines. 1938.

Geomorphic Provinces of California. Calif. Dept. Natural Resources, Div. of Mines, Bull. 118, pp. 83-88. 1943.

Kaplow, E. J.
Oxnard Oil Field. California Oil Fields, Vol. 33, No. 2. 1947.

Kew, W. S. W.
Geology and Oil Resources of a Part of Los Angeles and Ventura Counties, California. U. S. Geol. Surv. Bull. 753. 1924.

Kimble, J. C.
Underflow at Whittier Narrows, San Gabriel River Valley, Los Angeles County, California. Amer. Geophysical Union Trans., pp. 521-525. 1936.

Kleinpell, R. M.
Miocene Stratigraphy of California. Amer. Assoc. Petrol. Geol., 1938.

Merrill, William R.
Ojai to Ozena. Amer. Assoc. Petrol. Geol. Guidebook, pp. 77-81. Mar. 1952.

Natland, M. L. and Kuenen, Ph. H.
Sedimentary History of the Ventura Basin, California, and the Action of Turbidity Currents. Soc. of Econ. Paleontologists and Mineralogists, Special Publication No. 2, pp. 76-107. Nov. 1951.

Natland, M. L.
Pleistocene and Pliocene Stratigraphy of Southern California. Unpublished Ph. D. Thesis, Univ. Calif. Los Angeles. 1952.

Poland, J. F., Garrett, A. A., and Mann, J. F. (U. S. Geological Survey)
Progress Report on Water Supply for the Point Mugu Naval Base, Ventura County, California. Typewritten report for the Bureau of Yards and Docks, Dept. of the Navy. August 20, 1948.

Putnam, William C.
Geomorphology of the Ventura Region. Bull. Geol. Soc. Amer., Vol. 53, pp. 691-754. 1942.

Reed, R. D.
Geology of California. Amer. Assoc. Petrol. Geol. 1933.

Reed, R. D. and Hollister, J. S.
Structural Evolution of Southern California. Bull. Amer. Assoc. Petrol. Geol Vol. 20, No. 12, pp. 1533-1704. 1936.

Sheller, J. W. and Bien, M. N.
Thrust Fault Zones in Ventura Basin, Los Angeles and Ventura Counties, California. Bull. Amer. Assoc. Petrol. Geol., Vol. 31, pp. 1505-1509. 1947.

Soper, E. K.
Geology of the Central Santa Monica Mountains, Los Angeles County, California Jour. Mines and Geol., Vol. 34, pp. 131-180. 1938.

Stipp, T. F.
Simi Oil Field. Calif. Dept. Natural Resources, Div. of Mines, Bull. 118, pp. 417-423. 1943.

Stock, Chester
Oreodonts from the Sespe Deposits of South Mountain, Ventura County, Californi Carnegie Inst. Wash., Pub. 404, pp. 27-41. 1930.

Eocene Land Mammals on the Pacific Coast. Proc. Nat. Acad. Sci., Vol. 18, No. 7, pp. 518-523. 1932.

An Upper Oligocene Mammalian Fauna from Southern California. Proc. Nat. Acac Sci., Vol. 18, No. 8, pp. 550-554. 1932.

Tolman, C. F.
Ground Water. McGraw-Hill Book Co. 1937.

Upson, J. E.
Geology and Ground Water Resources of the South-Coast Basins of Santa Barbar County, California. U. S. Geol. Surv. Water Supply Paper 1108. 1951.

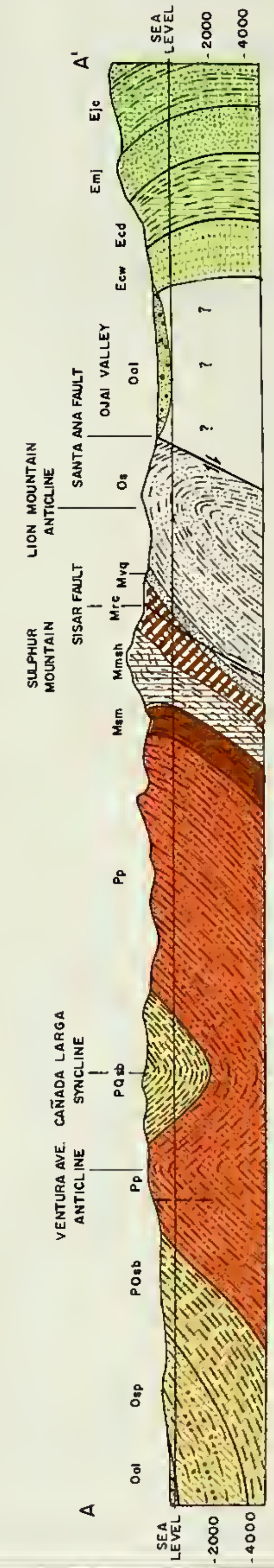
Upson, J. E. and Worts, G. E. Jr.
Ground Water in the Cuyama Valley, California. U. S. Geol. Surv. Water Supp Paper 1110-B. 1951.

Wallace, R. E.
Structure of a Portion of the San Andreas Rift in Southern California. Bull. Geol. Soc. Amer., Vol. 60, pp. 781-806. 1949.

Waterfall, L. N.
A Contribution to the Palentology of the Fernando Group, Ventura County, California. Univ. Calif. Bull. Dept. Geol. Sci., Vol. 18, No. 3, pp. 71-92. 1929.

Wenzel, L. K.
Methods for Determining Permeability of Water-Bearing Materials. U. S. Geol. Surv. Water Supply Paper 887. 1942.

SEE PLATE B-1C FOR GEOLOGIC LEGEND



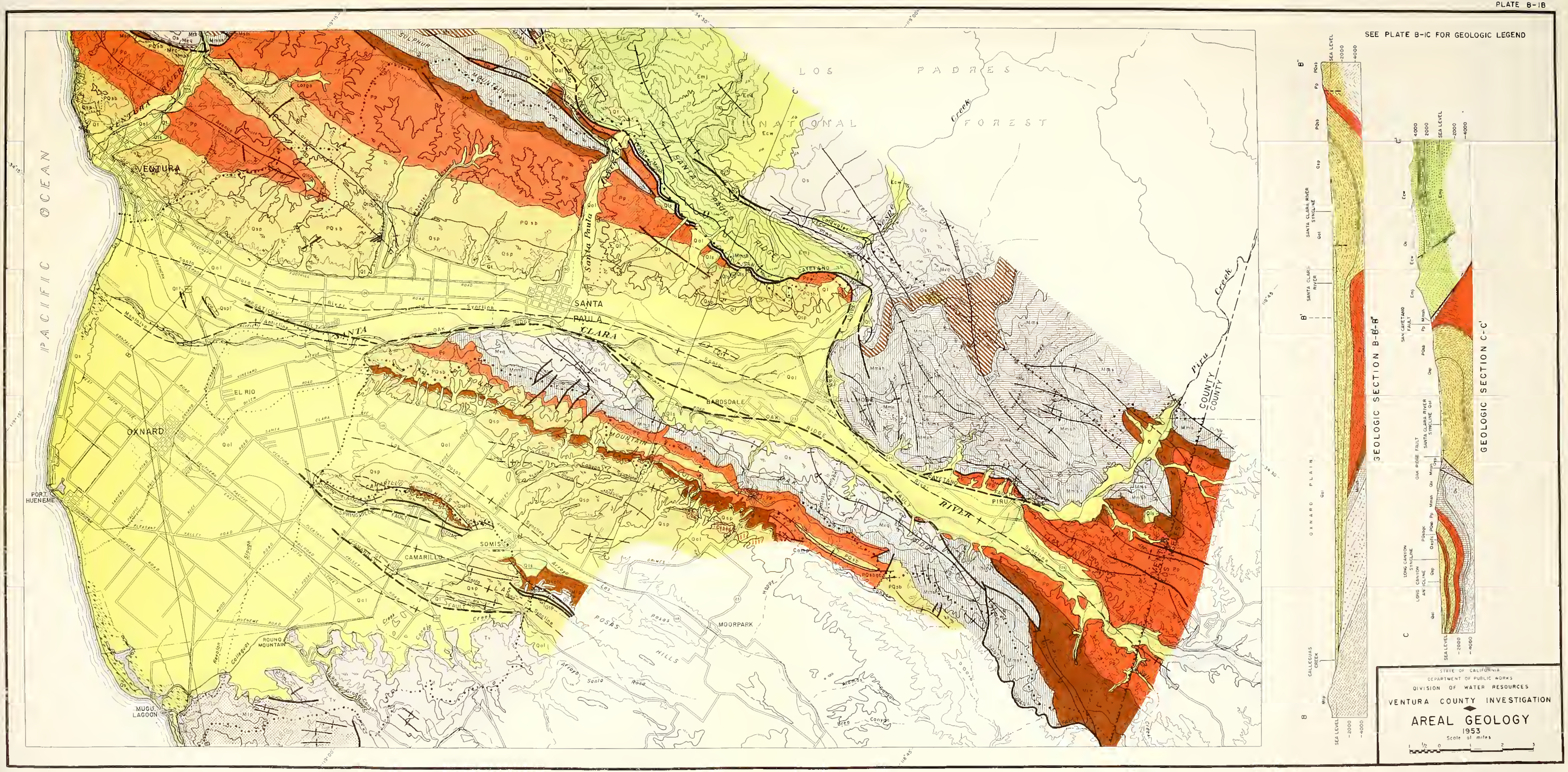
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION

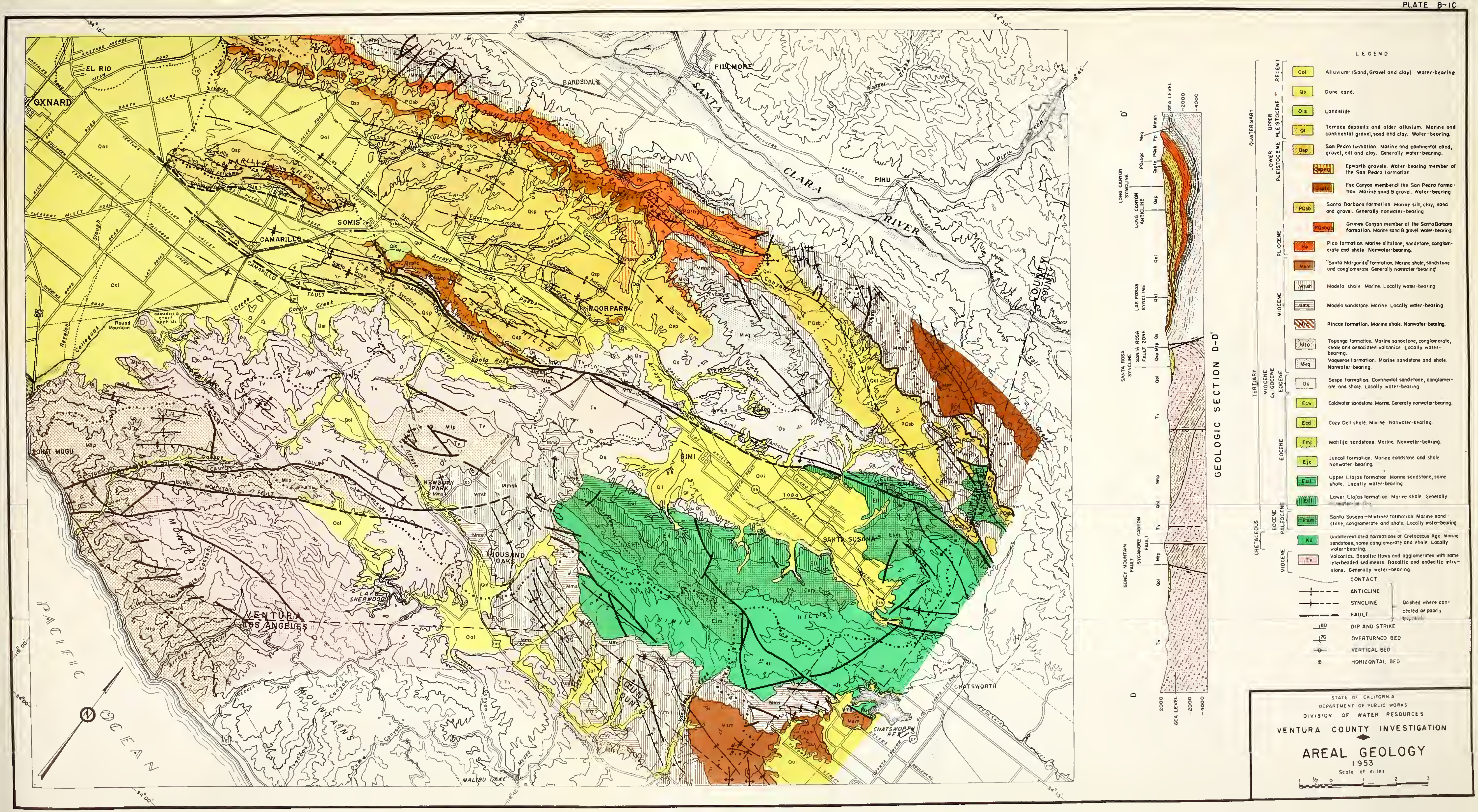
AREAL GEOLOGY

1953

Scale of miles

1 ½ 0 1 2 3

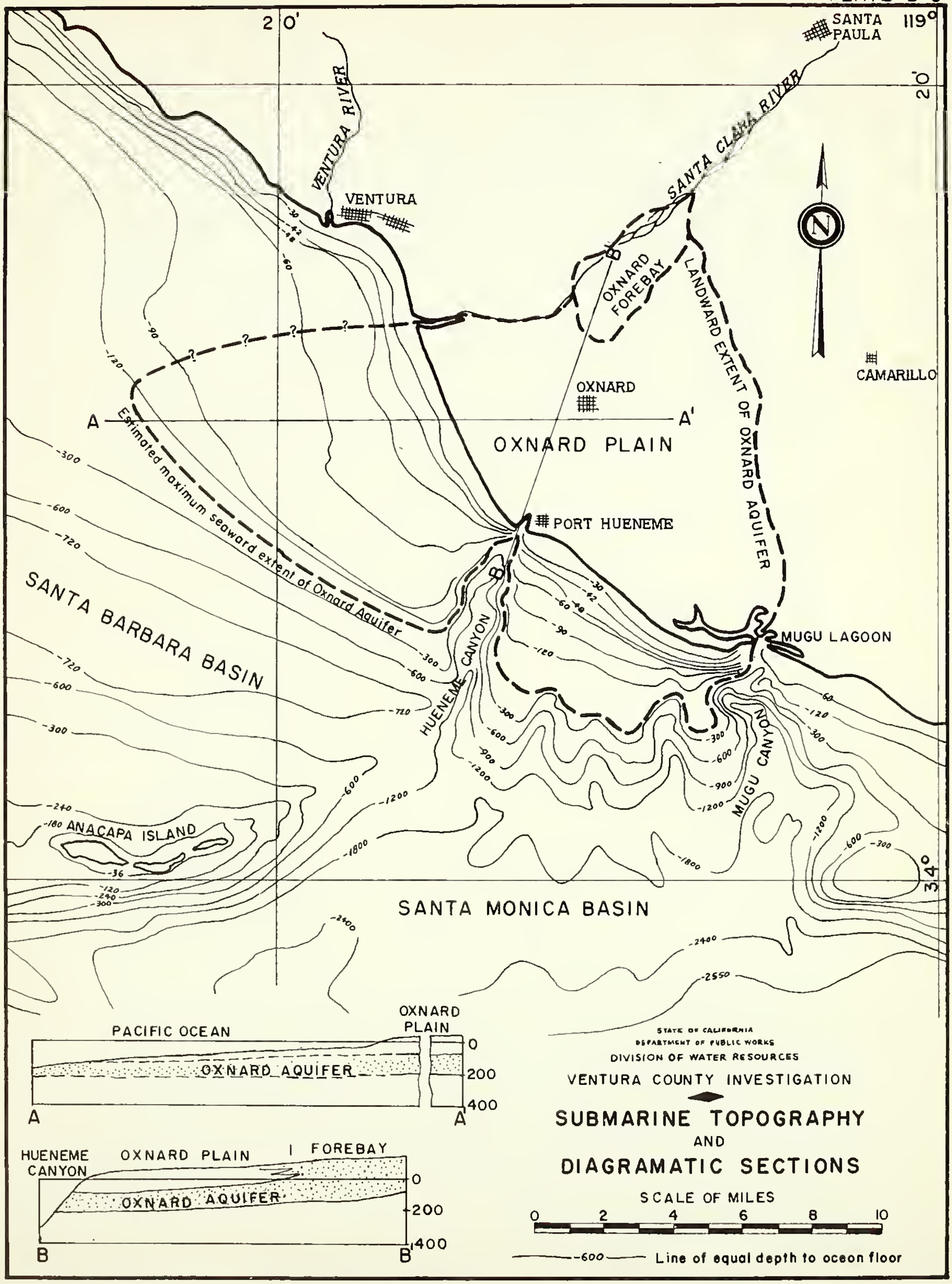

SEE PLATE B-1C FOR GEOLOGIC LEGEND
PACIFIC OCEAN
LOS PADRES NATIONAL FOREST
VENTURA
SANTA PAULA
OXNARD
PORT HUENEME
EL RIO
BARDSDALE
FILLMORE
PIRU
CAMARILLO
SOMIS
MOORPARK
MUGU LAGOON
ROUND MOUNTAIN
SANTA CLARA RIVER
OAK RIDGE
SANTA PAULA RIDGE
SULPHUR MOUNTAIN
POSAS HILLS
Piru Creek
GEOLOGIC SECTION B-B'-B''
GEOLOGIC SECTION C-C'
OXNARD PLAIN
SEA LEVEL
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
AREAL GEOLOGY
1953
Scale of miles


OXNARD
EL RIO
CAMARILLO
SOMIS
MOORPARK
FILLMORE
BARDSDALE
PIRU
SANTA CLARA RIVER
SIMI
SANTA SUSANA
THOUSAND OAKS
NEWBURY PARK
CHATSWORTH
CHATSWORTH RES.
LAKE SHERWOOD
MALIBU LAKE
PT. MUGU
PACIFIC OCEAN
SIMI HILLS
VENTURA
LOS ANGELES
GEOLOGIC SECTION D-D'
SEA LEVEL
LEGEND
QUATERNARY
RECENT
UPPER PLEISTOCENE
LOWER PLEISTOCENE
PLIOCENE
MIOCENE
TERTIARY
OLIGOCENE
EOCENE
PALEOCENE
CRETACEOUS
Qal Alluvium: (Sand, Gravel and clay) Water-bearing.
Qs Dune sand.
Qls Landslide
Qt Terrace deposits and older alluvium. Marine and continental gravel, sand and clay. Water-bearing.
Qsp San Pedro formation. Marine and continental sand, gravel, silt and clay. Generally water-bearing.
Qspeg Epworth gravels. Water-bearing member of the San Pedro formation.
Qspfc Fox Canyon member of the San Pedro formation. Marine sand & gravel. Water-bearing
PQsb Santa Barbara formation. Marine silt, clay, sand and gravel. Generally nonwater-bearing
PQsbgc Grimes Canyon member of the Santa Barbara formation. Marine sand & gravel. Water-bearing.
Pp Pico formation. Marine siltstone, sandstone, conglomerate and shale. Nonwater-bearing.
Msm "Santa Margarita" formation. Marine shale, sandstone and conglomerate. Generally nonwater-bearing.
Mmsh Modelo shale. Marine. Locally water-bearing.
Mms Modelo sandstone. Marine. Locally water-bearing
Mrc Rincon formation. Marine shale. Nonwater-bearing.
Mtp Topanga formation. Marine sandstone, conglomerate, shale and associated volcanics. Locally water-bearing.
Mvq Vaqueros formation. Marine sandstone and shale. Nonwater-bearing.
Os Sespe formation. Continental sandstone, conglomerate and shale. Locally water-bearing
Ecw Coldwater sandstone. Marine. Generally nonwater-bearing.
Ecd Cozy Dell shale. Marine. Nonwater-bearing.
Emj Matilija sandstone. Marine. Nonwater-bearing.
Ejc Juncal formation. Marine sandstone and shale. Nonwater-bearing.
Eul Upper Llajas formation. Marine sandstone, some shale. Locally water-bearing.
Ell Lower Llajas formation. Marine shale. Generally
Esm Santa Susana-Martinez formation. Marine sandstone, conglomerate and shale. Locally water-bearing.
Ku Undifferentiated formations of Cretaceous Age. Marine sandstone, some conglomerate and shale. Locally water-bearing.
Tv Volcanics. Basaltic flows and agglomerates with some interbedded sediments. Basaltic and andesitic intrusions. Generally water-bearing.
CONTACT
ANTICLINE
SYNCLINE
FAULT
Dashed where concealed or poorly
DIP AND STRIKE
OVERTURNED BED
VERTICAL BED
HORIZONTAL BED
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES
VENTURA COUNTY INVESTIGATION
AREAL GEOLOGY
1953
Scale of miles

STRATIGRAPHIC COLUMNS — VENTURA COUNTY REGION

AGE	SANTA MONICA MOUNTAINS CONEJO AND TIERRA REJADA BASINS-MALIBU HYDROLOGIC UNIT	OAK RIDGE-SOUTH MOUNTAIN EAST LAS POSAS, WEST LAS POSAS AND SANTA ROSA BASINS	SIMI HILLS-SANTA SUSANA MOUNTAINS SIMI SUBUNIT	COASTAL PLAIN MOUND, OXNARD FOREBAY, OXNARD PLAIN AND PLEASANT VALLEY BASINS	VENTURA RIVER DRAINAGE AND SANTA PAULA BASIN UPPER AND LOWER VENTURA RIVER BASINS OJAI AND UPPER OJAI BASINS	SESPE-PIRU CREEK AREA FILLMORE-PIRU SUBUNITS NORTH OF THE SANTA CLARA RIVER	CUYAMA RIVER DRAINAGE AREA	EASTERN SANTA CLARA RIVER DRAINAGE AREA EASTERN BASIN
QUATERNARY — RECENT	ALLUVIUM AND TERRACE DEPOSITS: Clay sand and gravel, 0–60' thick.	STREAM AND TERRACE DEPOSITS: Clay and silt with sand and gravel in some areas, 0–200' thick.	SIMI BASIN: Stream, terrace, alluvial fan and swamp deposits, 0–200' thick SANTA SUSANA MOUNTAINS: Clays, sands and gravels, 0–50' thick	OXNARD PLAIN: Stream deposits sand and gravel 20' ELSEWHERE: Clay, silt and sand, 0 – 50' thick.	Stream deposited clay, sand and gravel, 0-700' thick.	Stream deposited sand and gravel with some clay 0 – 250' thick.	Stream and terrace deposits: sand, gravel and some clay, 0 – 100' thick.	Stream and terrace deposits. Sand and gravel, 0–150' thick.
QUATERNARY — PLEISTOCENE — UPPER	Unconformity	Unconformity	Unconformity	Stream, swamp and lagunal deposits of clay, sand and gravel, 200 – 400' thick. Oxnard aquifer [illegible] Unconformity	Unconformity	Unconformity	Unconformity	Unconformity
QUATERNARY — PLEISTOCENE — LOWER	Missing	SAN PEDRO FORMATION: Marine clay, sand and gravel, 500 – 2000' thick Epworth gravels, near top of formation, 0–300'. Fox Canyon member – sand and gravel, 100'–300' thick at base of formation. Unconformity SANTA BARBARA FORMATION: Marine clay, silt sand and gravel, 1000 – 2000' thick. Grimes Canyon member – sand and gravel, 100–1000' thick near top of formation. Unconformity	SIMI BASIN: Continental clays, sands and gravels 0–500' thick. Unconformity SANTA BARBARA FORMATION: Marine sand and gravel with some clay, 1000' thick.	SAN PEDRO FORMATION: Marine and non-marine clay, sand and gravel, 600–4000' thick Fox Canyon member-sand and gravel, 100–300' thick in Oxnard Plain and Pleasant Valley at base of formation. SANTA BARBARA FORMATION Marine clay 600 – 4000' thick Grimes Canyon member-sand and gravel, 0–300' thick in Pleasant Valley at top of formation.	SAN PEDRO FORMATION: Marine and non-marine clay, sand and gravel, 4000' thick. SANTA BARBARA FORMATION: Marine clay and silt, 4000' thick.	SAN PEDRO FORMATION: Marine and non-marine clay, sand and gravel, 4000' thick. SANTA BARBARA FORMATION: Marine clay and silt, 4000' thick.	Missing	Missing or not recognized.
TERTIARY — PLIOCENE		PICO FORMATION: Brown and gray siltstone, sandstone and conglomerate, 0 – 900' thick. Unconformity Missing	Unconformity PICO FORMATION: Brown and gray siltstone, sandstone and conglomerate, 5000' thick.	Unconformity PICO FORMATION: Shale, sandstone and conglomerate 12000' thick. Unconformity	PICO FORMATION. Shale, sandstone and conglomerate, 12000' thick.	PICO FORMATION: Shale, sandstone and conglomerate, 8000' thick. Unconformity	MORALES FORMATION: Continental clay, sand and gravel, 4000' thick. Unconformity	RIDGE BASIN GROUP. Continental shale, sandstone and conglomerate, 18000' thick SAUGUS FORMATION: Continental clay, sand and gravel, 2500' thick. PICO FORMATION: Shale sandstone, and conglomerate, 5500' thick. Unconformity
TERTIARY — MIOCENE — UPPER	"SANTA MARGARITA" FORMATION: Diatomaceous shale and sandstone, 1300' thick. Unconformity Modelo shale and sandstone, 1000' thick. Unconformity	Modelo shale, 1500' thick Unconformity	"SANTA MARGARITA" FORMATION: Siliceous shale, 2000' thick. Unconformity Modelo shale and sandstone volcanic intrusion at base. Unconformity	"SANTA MARGARITA" AND MODELO FORMATIONS: Shale and sandstone. Unconformity	"SANTA MARGARITA" FORMATION Siliceous shale and sandstone, 1800' thick.	"SANTA MARGARITA" FORMATION: Shale and sandstone, 1000' thick. MODELO FORMATION: 2200' to 6500' thick: Shale, 200'-1500' thick. / Sandstone, 900' thick / Shale, 400' – 1600' thick. / Sandstone, 200' – 2000 thick. / Shale, 500' thick.	QUATAL FORMATION: Continental red gypsiferous clay, sandstone and conglomerate, 4500' thick.	Missing "SANTA MARGARITA" FORMATION: Siliceous shale MODELO SANDSTONE AND SHALE: 2000' thick. Unconformity MINT CANYON FORMATION: Continental sandstone, shale and conglomerate, 4000' thick. Unconformity
TERTIARY — MIOCENE — MIDDLE	TOPANGA FORMATION: marine sandstone, conglomerate and brown to black shale 6000–9000' thick. VOLCANICS: basaltic flows and agglomerates & andesitic and basaltic intrusives 13000' thick.	Missing	Missing or included in modelo shale.	TOPANGA FORMATION AND VOLCANICS: 11000' thick.	MODELO SHALE: Brown to white, siliceous shale 1500' thick.			Missing
TERTIARY — MIOCENE — LOWER	VAQUEROS FORMATION: Not exposed	VAQUEROS FORMATION: Brown shale and sandstone, 400' thick	VAQUEROS FORMATION: Brown shale and sandstone, 100 – 1800' thick.		RINCON FORMATION: Gray, brown, nodular marine shale, 2000' thick. VAQUEROS FORMATION Well cemented sandstone, interbedded shale, 300 – 450' thick. Unconformity	RINCON FORMATION: Marine shale, 1000' thick. VAQUEROS FORMATION: Shale and sandstone 250 thick. Unconformity	Unconformity	
TERTIARY — OLIGOCENE	SESPE FORMATION: Not exposed.	SESPE FORMATION: Continental, massive sandstone, conglomerate with red, gray and green shale and siltstone, 7000' thick.	SESPE FORMATION: Continental, massive sandstone, conglomerate with red, gray and green shale and siltstone, 7300' thick.		SESPE FORMATION: Continental, massive sandstone conglomerate and red and green shale, 4500' thick	SESPE FORMATION: Continental massive sandstone, lenticular conglomerate and red gray and black shale, 3800' thick.	SIMMLER FORMATION: Continental shale, red sandstone and conglomerate, 4000' thick. Intrusive andesites near Lockwood valley Unconformity	VASQUEZ FORMATION Continental shale, sandstone and conglomerate, 9000' thick, plus basaltic flows, 4000' thick near base. Unconformity
TERTIARY — EOCENE — UPPER			Unconformity UPPER LLAJAS FORMATION: Sandstone with some shale, 2000' thick.	Older rocks not exposed.	COLDWATER SANDSTONE: Marine 2200' thick. COZY DELL SHALE: Marine, 3800' thick. Large sandstone member north of Ventura river. MATILIJA SANDSTONE: Marine, 2400' thick JUNCAL SHALE AND SANDSTONE: Marine, 5000' thick. Includes basal limestone. Unconformity	COLDWATER SANDSTONE: Marine, 500' thick. COZY DELL SHALE: Marine, missing in some areas, over 5000' thick in others. MATILIJA SANDSTONE: Marine, 4000' thick.	Undivided marine shale and sandstone South of Nocimiento fault PATTIWAY FORMATION: Brackish and continental shale and sandstone 2500' thick Unconformity	Missing or not recognized.
TERTIARY — EOCENE — LOWER	Marine shale and sandstone, not exposed.		LOWER LLAJAS FORMATION: Shale, 2000 – 3000' thick.					
TERTIARY — PALEOCENE		Eocene marine rocks not exposed.	SANTA SUSANA – MARTINEZ FORMATION: Undivided, shale sandstone and conglomerate, 3500 thick.		Missing or not recognized.		Missing or not recognized	MARTINEZ FORMATION: Marine sandstone and conglomerate, 5000' thick. Fault or Unconformity
CRETACEOUS	Marine shale and sandstone, not exposed. Fault		Upper Cretaceous, marine, massive sandstone with some shale, 5500' thick Base not exposed		Marine siltstone, shale and conglomerate, 5000' thick. Base not exposed	Older rocks not exposed or recognized.	Marine shale, sandstone and conglomerate, 5000' thick. Fault	Missing
PRE-CRETACEOUS	Basement complex, not exposed.						BASEMENT COMPLEX: Granitic rocks.	BASEMENT COMPLEX. Granite, granodiorite, quartz diorite, anorthosite, schist and gneiss.

NOTE: Since stratigraphic units do not generally conform with the delineated basin or watershed boundary, the column headings refer only to generalized areas not indicated on any plates. The various subunits or basins are listed beneath the column headings to indicate the stratigraphic relationships therein.



STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

VENTURA COUNTY INVESTIGATION

SUBMARINE TOPOGRAPHY AND DIAGRAMATIC SECTIONS

APPENDIX C

ESTIMATES OF COST

TABLE OF CONTENTS

ESTIMATES OF COST

TABLE OF CONTENTS

ESTIMATES OF COST
(Continued)

TABLE OF CONTENTS

ESTIMATES OF COST
(Continued)

ESTIMATED COST OF CASITAS DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 92,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 523 feet, U.S.G.S. datum
Elevation of crest of spillway: 503 feet
Height of dam to spillway crest, above stream bed: 178 feet

Capacity of reservoir to crest of spillway: 92,000 acre-feet
Capacity of spillway with 10.6-foot freeboard: 17,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Diversion of stream and de-watering of foundation		lump sum	$ 10,000	
Excavation, stripping				
Stream bed, common	780,300 cu.yd.	$ 0.41	319,900	
rock	41,000 cu.yd.	1.10	45,100	
Abutments, random	296,300 cu.yd.	0.88	260,700	
Right abutment, slide area	50,000 cu.yd.	0.82	41,000	
Excavation, from borrow pits	4,319,400 cu.yd.	0.44	1,900,500	
Embankment, compacted	4,715,400 cu.yd.	0.24	1,131,700	
Gravel fill, pervious drain	54,400 cu.yd.	4.60	250,200	
Rock riprap	55,300 cu.yd.	4.00	221,200	
Drilling grout holes	8,750 lin.ft.	3.00	26,300	
Pressure grouting	4,400 cu.ft.	4.00	17,600	
Slope stabilization, planting	17.2 acres	1,000.00	17,200	$4,241,400
Spillway				
Excavation				
Channel	82,600 cu.yd.	2.75	227,200	
Cutoff	690 cu.yd.	6.00	4,100	
Concrete				
Weir and bucket	625 cu.yd.	35.00	21,900	
Walls	520 cu.yd.	40.00	20,800	
Floor	1,400 cu.yd.	30.00	42.000	
Cutoff	690 cu.yd.	35.00	24,200	
Reinforcing steel	323,300 lbs.	0.15	48,500	388,700
Outlet Works				
Excavation				
Stripping for tower	2,000 cu.yd.	1.50	3,000	
Rock, tower foundation	160 cu.yd.	6.00	1,000	
Rock, conduit trench	1,200 cu.yd.	6.00	7,200	
Concrete				
Tower	465 cu.yd.	80.00	37,200	
Pipe encasement	640 cu.yd.	40.00	25,600	
Reinforcing steel	110,000 lbs.	0.15	16,500	
Pipe, reinf. conc. 42-inch dia.	1,000 lin.ft.	21.00	21,000	

ESTIMATED COST OF CASITAS DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 92,000 ACRE-FEET
(continued)

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Outlet Works (continued)				
Gate valves, 30-in. dia.	3 each	$3,000.00	$ 9,000	
Gate valves, 24-in. dia.	6 each	2,000,00	12,000	
Floor stands and stems		lump sum	6,000	
Reducing thimbles, cast iron		lump sum	2,500	
Miscellaneous metal work	15,000 lbs.	0.40	6,000	
Control house		lump sum	2,500	$149,500
Reservoir				
Land and improvements		lump sum	1,500,000	
Highway relocation		lump sum	415,000	
Relocation of utilities		lump sum	60,500	
Clearing reservoir land	800 acres	150.00	120,000	2,095,5
Subtotal				$6,875,1
Administration and engineering, 10%				$ 687,5
Contingencies, 15%				1,031,3
Interest during construction				343,8
TOTAL				$8,937,7
ANNUAL COSTS				
Interest, 4%				$ 357,5
Amortization, 40-year sinking fund at 4%				94,0
Operation and maintenance				15,0
TOTAL				$ 466,5

ESTIMATED COST OF CASITAS DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 105,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 533 feet U.S.G.S. Datum
Elevation of crest of spillway: 513 feet
Height of dam to spillway crest, above stream bed: 188 feet
Capacity of reservoir to crest of spillway: 105,000 acre-feet
Capacity of spillway with 9-foot freeboard: 17,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Diversion of stream and dewatering of foundation		lump sum	$ 10,000	
Excavation, stripping				
Stream bed, common	830,400 cu.yd.	$ 0.41	340,500	
rock	43,800 cu.yd.	1.10	48,200	
Abutments, random	310,400 cu.yd.	0.88	273,200	
Right abutment, slide area	50,000 cu.yd.	0.82	41,000	
Excavation, from borrow pits	5,013,800 cu.yd.	0.44	2,206,100	
Embankment, compacted	5,461,800 cu.yd.	0.24	1,310,800	
Gravel fill, pervious drain	62,700 cu.yd.	4.60	288,400	
Rock riprap	68,000 cu.yd.	4.00	272,000	
Drilling grout holes	10,330 lin.ft.	3.00	31,000	
Pressure grouting	5,170 cu.ft.	4.00	20,700	
Slope stabilization, planting	17.3 acres	1,000.00	17,300	$4,859,200
Spillway				
Excavation				
Channel	55,300 cu.yd.	2.75	152,100	
Cutoff	640 cu.yd.	6.00	3,800	
Concrete				
Weir and bucket	590 cu.yd.	35.00	20,700	
Walls	630 cu.yd.	40.00	25,200	
Floor	1,530 cu.yd.	30.00	45,900	
Cutoff	540 cu.yd.	35.00	18,900	
Reinforcing steel	330,000 lbs.	0.15	49,500	316,100
Outlet Works				
Excavation				
Stripping for tower	2,000 cu.yd.	1.50	3,000	
Rock, tower foundation	390 cu.yd.	6.00	2,300	
Rock, conduit trench	1,320 cu.yd.	6.00	7,900	
Concrete				
Tower	520 cu.yd.	80.00	41,600	
Pipe encasement	700 cu.yd.	40.00	28,000	
Reinforcing steel	121,900 lbs.	0.15	18,300	

ESTIMATED COST OF CASITAS DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 105,000 ACRE-FEET
(Continued)

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Outlet Works (Continued)					
Pipe, reinf. conc. 42-in. dia.	1,100	lin.ft.	$ 21.00	$ 23,100	
Gate valves, 30-in. dia.	4	each	3,000.00	12,000	
Gate valves, 24-in. dia.	5	each	2,000.00	10,000	
Floor stands and stems			lump sum	6,500	
Reducing thimbles, cast iron			lump sum	3,000	
Miscellaneous metal work	20,000	lbs.	0.40	8,000	
Control house			lump sum	2,500	$ 166,20
Reservoir					
Land and improvements			lump sum	1,500,000	
Highway relocation			lump sum	415,000	
Relocation of utilities			lump sum	60,500	
Clearing reservoir land	850	acres	150.00	127,500	2,103,00
Subtotal					$7,444,50
Administration and engineering, 10%					$ 744,40
Contingencies, 15%					1,116,7
Interest during construction					372,20
TOTAL					$9,677,80
ANNUAL COSTS					
Interest, 4%					$ 387,1
Amortization, 40-year sinking fund at 4%					101,8
Operation and maintenance					18,0
TOTAL					$ 506,9

ESTIMATED COST OF CASITAS DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 130,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam:
547 feet, U.S.G.S. datum
Elevation of crest of spillway:
527 feet
Height of dam to spillway crest, above stream bed: 202 feet

Capacity of reservoir to crest of spillway: 130,000 acre-feet
Capacity of spillway with 9-foot freeboard: 17,000 second feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Dam					
Diversion of stream and dewatering of foundation			lump sum	$ 10,000	
Excavation, stripping					
Stream bed, common	986,800	cu.yd.	$ 0.41	404,600	
rock	55,800	cu.yd.	1.10	61,400	
Abutments, random	476,300	cu.yd.	0.88	419,100	
Right abutment, slide area	50,000	cu.yd.	0.82	41,000	
Excavation, from borrow pits	6,390,600	cu.yd.	0.44	2,811,900	
Embankment, compacted	6,934,100	cu.yd.	0.24	1,664,200	
Gravel fill, pervious drain	70,640	cu.yd.	4.60	324,900	
Rock riprap	120,400	cu.yd.	4.00	481,600	
Drilling grout holes	15,500	lin.ft.	3.00	46,500	
Pressure grouting	7,740	cu.ft.	4.00	31,000	
Slope stabilization, planting	19.7	acres	1,000.00	19,700	$6,315,900
Spillway					
Excavation					
Channel	44,950	cu.yd.	2.75	123,600	
Cutoff	610	cu.yd.	6.00	3,700	
Concrete					
Weir and bucket	590	cu.yd.	35.00	20,700	
Walls	610	cu.yd.	40.00	24,400	
Floor	1,170	cu.yd.	30.00	35,100	
Cutoff	510	cu.yd.	35.00	17,900	
Reinforcing steel	287,800	lbs.	0.15	43,200	268,600
Outlet Works					
Excavation					
Stripping for tower	2,000	cu.yd.	1.50	3,000	
Rock, tower foundation	390	cu.yd.	6.00	2,300	
Rock, conduit trench	2,090	cu.yd.	6.00	12,500	
Concrete					
Tower	570	cu.yd.	80.00	45,600	
Pipe encasement	740	cu.yd.	40.00	29,600	
Reinforcing steel	129,000	lbs.	0.15	19,400	
Pipe, reinf. conc. 48-in. dia.	1,150	lin.ft.	24.00	27,600	

ESTIMATED COST OF CASITAS DAM AND RESERVOIR WITH STORAGE CAPACITY OF 130,000 ACRE-FEET (Continued)

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Outlet Works (Continued)				
Gate valves, 30-in. dia.	5 each	$3,000.00	$ 15,000	
Gate valves, 24-in. dia.	4 each	2,000.00	8,000	
Floor stands and stems		lump sum	6,500	
Reducing thimbles, cast iron		lump sum	3,000	
Miscellaneous metal work	20,000 lbs.	0.40	8,000	
Control house		lump sum	2,500	$ 183,00
Reservoir				
Land and improvements		lump sum	1,500,000	
Highway relocation		lump sum	415,000	
Relocation of utilities		lump sum	60,500	
Clearing reservoir land	900 acres	150.00	135,000	2,110,50
Subtotal				$ 8,878,00
Administration and engineering, 10%				$ 887,80
Contingencies, 15%				1,331,70
Interest during construction				665,90
TOTAL				$11,763,40
ANNUAL COSTS				
Interest, 4%				$ 470,50
Amortization, 40-year sinking fund at 4%				123,80
Operation and maintenance				21,00
TOTAL				$ 615,30

ESTIMATED COST OF CASITAS DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 156,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 560 feet, U.S.G.S. datum
Elevation of crest of spillway: 540.5 feet
Height of dam to spillway crest, above stream bed: 215 feet

Capacity of reservoir to crest of spillway: 156,000 acre-feet.
Capacity of spillway with 8.5-foot freeboard: 17,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Diversion of stream and dewatering of foundation		lump sum	$ 10,000	
Excavation, stripping				
Stream bed, common	1,132,700 cu.yd.	$ 0.41	464,400	
rock	59,600 cu.yd.	1.10	65,600	
Abutments, random	1,404,400 cu.yd.	0.88	1,235,900	
Right abutment, slide area	50,000 cu.yd.	0.82	41,000	
Excavation, from borrow pits	11,731,900 cu.yd.	0.44	5,162,000	
Embankment, compacted	12,441,800 cu.yd.	0.24	2,986,000	
Gravel fill, pervious drain	77,600 cu.yd.	4.60	357,000	
Rock riprap	270,800 cu.yd.	4.00	1,083,200	
Drilling grout holes	19,850 lin.ft.	3.00	59,600	
Pressure grouting	9,950 cu.ft.	4.00	39,800	
Slope stabilization, planting	31.9 acres	1,000.00	31,900	$11,536,400
Spillway				
Excavation				
Channel	158,400 cu.yd.	2.75	435,600	
Cutoff	720 cu.yd.	6.00	4,300	
Concrete				
Weir and bucket	395 cu.yd.	35.00	13,800	
Walls	840 cu.yd.	40.00	33,600	
Floor	2,070 cu.yd.	30.00	62,100	
Cutoff	720 cu.yd.	35.00	25,200	
Reinforcing steel	403,000 lbs.	0.15	60,500	635,100
Outlet Works				
Excavation				
Stripping for tower	1,370 cu.yd.	1.50	2,100	
Rock, tower foundation	550 cu.yd.	6.00	3,300	
Rock, conduit trench	3,160 cu.yd.	6.00	19,000	

ESTIMATED COST OF CASITAS DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 156,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Outlet Works (Continued)				
Concrete				
Tower	693 cu.yd.	$ 80.00	$ 55,400	
Pipe encasement	1,110 cu.yd.	40.00	44,400	
Reinforcing steel	182,500 lbs.	0.15	27,400	
Pipe, reinf. con. 48-in. dia.	1,740 lin.ft.	24.00	41,800	
Gate valves, 30-in. dia.	6 each	3,000.00	18,000	
Gate valves, 36-in. dia.	3 each	5,000.00	15,000	
Floor stands and stems		lump sum	6,500	
Reducing thimbles, cast iron		lump sum	3,000	
Miscellaneous metal work	25,000 lbs.	0.40	10,000	
Control house		lump sum	2,500	$ 248,40
Reservoir				
Land and improvements		lump sum	1,500,000	
Highway relocation		lump sum	415,000	
Relocation of utilities		lump sum	60,500	
Clearing reservoir land	1,000 acres	150.00	150,000	2,125,50
Subtotal				$14,545,40
Administration and engineering, 10%				$ 1,454,50
Contingencies, 15%				2,181,80
Interest during construction				1,454,50
TOTAL				$19,636,20
ANNUAL COSTS				
Interest, 4%				$ 785,50
Amortization, 40-year sinking fund at 4%				206,60
Operation and maintenance				25,00
TOTAL				$ 1,017,10

ESTIMATED COST OF VENTURA RIVER DIVERSION TO CASITAS RESERVOIR WITH
CONDUIT OF 100 SECOND-FOOT CAPACITY
AND DIVERSION AT THE MIDDLE SITE
(Based on prices prevailing in spring of 1953)

Elevation at crest of weir:
910 feet, U.S.G.S. datum
Height of weir above stream bed:
10 feet

Total length of pipe line: 17,600 feet
Total length of canal and flume:
14,730 feet

Item	Quantity	Unit Price	Cost	
CAPITAL COSTS				
Diversion Works				
Excavation	200 cu.yd.	$ 4.00	$ 800	
Stripping	870 cu.yd.	3.00	2,600	
Concrete				
Weir and cutoff	750 cu.yd.	35.00	26,300	
Walls	20 cu.yd.	50.00	1,000	
Reinforcing steel	2,500 lbs.	0.15	400	
Trash rack steel	1,000 lbs.	0.20	200	
Outlet gates		lump sum	2,200	$33,500
Pipe Line				
Pipe, reinforced concrete, 42-inch, installed including earthwork	17,600 lin.ft.	23.31	410,300	
Air valves, blowoffs, and structures		lump sum	26,000	
Sand trap		lump sum	9,800	446,100
Canal and Flume				
Excavation	52,690 cu.yd.	0.45	23,700	
Compacted fill	6,870 cu.yd.	0.31	2,100	
Shotcrete lining	21,600 sq.yd.	3.50	75,600	
Flume, semicircular, metal, 6.4 foot diameter, including structures	600 lin.ft.	21.80	13,100	
Flume, semicircular, metal, 7.0 foot diameter including structures	30 lin.ft.	18.20	500	
Special structure		lump sum	17,000	
Farm road bridges	4 each	2,200.00	8,800	140,800
Rights of Way				
Canal	20 acres	1,000.00	20,000	
Pipe line	21 acres	150.00	3,200	23,200
Subtotal				$643,600

ESTIMATED COST OF VENTURA RIVER DIVERSION TO CASITAS RESERVOIR WITH
CONDUIT OF 100 SECOND-FOOT CAPACITY
AND DIVERSION AT THE MIDDLE SITE
(Continued)

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Administration and engineering, 10%			$ 64,400
Contingencies, 15%			96,500
Interest during construction			32,200
TOTAL			$836,700
ANNUAL COSTS			
Interest, 4%			$ 33,500
Amortization, 40-year sinking fund at 4%			8,800
Operation and maintenance			4,000
TOTAL			$ 46,300

ESTIMATED COST OF VENTURA RIVER DIVERSION TO CASITAS RESERVOIR
WITH CONDUIT OF 150 SECOND-FOOT CAPACITY
AND DIVERSION AT THE MIDDLE SITE
(Based on prices prevailing in spring of 1953)

Elevation at crest of weir: 910 feet, U.S.G.S. datum
Height of weir above stream bed: 10 feet

Total length of pipe line: 17,600 feet
Total length of canal and flume: 14,730 feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Diversion Works				
Excavation	200 cu.yd.	$ 4.00	$ 800	
Stripping	870 cu.yd.	3.00	2,600	
Concrete				
Weir and cutoff	750 cu.yd.	35.00	26,300	
Walls	20 cu.yd.	50.00	1,000	
Reinforcing steel	2,500 lbs.	0.15	400	
Trash rack steel	1,000 lbs.	0.20	200	
Outlet gates		lump sum	2,200	$33,500
Pipe Line				
Pipe, reinforced concrete, 48-inch diameter, installed	17,600 lin.ft.	26.62	468,500	
Air valves, blowoffs, and structures		lump sum	28,100	
Sand trap		lump sum	9,800	506,400
Canal and Flume				
Excavation	71,560 cu.yd.	0.45	32,200	
Compacted fill	11,610 cu.yd.	0.31	3,600	
Shotcrete lining	29,328 sq.yd.	3.50	102,600	
Flume, semicircular, metal, 7.6 foot diameter, including structures	600 lin.ft.	29.40	17,600	
Flume, semicircular, metal, 8.3 foot diameter, including structures	30 lin.ft.	25.80	800	
Special structures		lump sum	17,000	
Farm road bridges	4 each	2,200.00	8,800	182,600
Rights of Way				
Canal	34 acres	1,000.00	34,000	
Pipe line	21 acres	150.00	3,200	37,200
Subtotal				$759,700

ESTIMATED COST OF VENTURA RIVER DIVERSION TO CASITAS RESERVOIR
WITH CONDUIT OF 150 SECOND-FOOT CAPACITY
AND DIVERSION AT THE MIDDLE SITE
(Continued)

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Administration and engineering, 10%			$ 76,000
Contingencies, 15%			113,900
Interest during construction			38,000
TOTAL			$ 987,600
ANNUAL COSTS			
Interest, 4%			$ 39,500
Amortization, 40-year sinking fund at 4%			10,400
Operation and maintenance			4,000
TOTAL			$ 53,900

ESTIMATED COST OF VENTURA RIVER DIVERSION TO CASITAS RESERVOIR
WITH CONDUIT OF 200 SECOND-FOOT CAPACITY
AND DIVERSION AT THE MIDDLE SITE

(Based on prices prevailing in spring of 1953)

levation of crest of weir:
910 feet, U.S.G.S. datum
eight of weir above stream bed:
10 feet

Total length of pipe line: 17,600 feet
Total length of canal and flume:
14,730 feet

Item	Quantity		Unit price	Cost	
APITAL COSTS					
iversion Works					
Excavation	200	cu.yd.	$ 4.00	$ 800	
Stripping	870	cu.yd.	3.00	2,600	
Concrete					
Weir and cutoff	750	cu.yd.	35.00	26,300	
Walls	20	cu.yd.	50.00	1,000	
Reinforcing steel	2,500	lbs.	0.15	400	
Trash rack steel	1,000	lbs.	0.20	200	
Outlet gates			lump sum	2,200	$ 33,500
ipe Line					
Pipe, reinforced concrete 54-inch dia., installed	17,600	lin.ft.	30.97	545,100	
Air valves, blowoffs, and structures			lump sum	30,000	
Sand trap			lump sum	12,300	587,400
anal and Flume					
Excavation	76,700	cu.yd.	0.45	34,500	
Compacted fill	11,610	cu.yd.	0.31	3,600	
Shotcrete lining	31,580	sq.yd.	3.50	110,500	
Flume, semicircular, metal, 8.3-foot dia., including structures	600	lin.ft.	34.60	20,800	
Flume, semicircular, metal, 8.9-foot dia., including structures	30	lin.ft.	26.60	800	
Special structures			lump sum	18,100	
Farm road bridges	4	each	2,200.00	8,800	197,100
ight of Way					
Canal	34	acres	1,000.00	34,000	
Pipe line	21	acres	150.00	3,200	37,200
Subtotal					$ 855,200

ESTIMATED COST OF VENTURA RIVER DIVERSION TO CASITAS RESERVOIR
WITH CONDUIT OF 200 SECOND-FOOT CAPACITY
AND DIVERSION AT THE MIDDLE SITE
(Continued)

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Administration and engineering, 10%			$ 85,500
Contingencies, 15%			128,300
Interest during construction			42,800
TOTAL			$1,111,800
ANNUAL COSTS			
Interest, 4%			$ 44,500
Amortization, 40-year sinking fund at 4%			11,700
Operation and maintenance			4,000
TOTAL			$ 60,200

ESTIMATED COST OF FERNDALE DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 12,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,100 feet, U.S.G.S. datum
Elevation of crest of spillway: 1,075 feet
Height of dam to spillway crest, above stream bed: 165 feet

Capacity of reservoir to crest of spillway: 12,000 acre-feet
Capacity of spillway with 5-foot freeboard: 37,000 second-feet

Item	Quality		Unit price	Cost	
CAPITAL COSTS					
Dam					
Exploration			lump sum	$ 30,000	
Diversion of stream and dewatering of foundation			lump sum	10,000	
Stripping topsoil	26,600	cu.yd.	$ 0.60	16,000	
Foundation excavation					
Abutment	208,500	cu.yd.	1.10	229,400	
Channel	20,700	cu.yd.	0.60	12,400	
Embankment					
Impervious	902,900	cu.yd.	0.70	632,000	
Pervious	1,408,500	cu.yd.	0.45	633,800	
Rock riprap	38,000	cu.yd.	4.00	152,000	
Drilling grout holes	5,880	lin.ft.	3.00	17,600	
Pressure grouting	3,920	cu.ft.	4.00	15,700	$1,748,900
Spillway					
Excavation	328,800	cu.yd.	2.00	657,600	
Concrete					
Weir and cutoff	1,440	cu.yd.	35.00	50,400	
Floor	1,340	cu.yd.	30.00	40,200	
Walls	840	cu.yd.	40.00	33,600	
Reinforcing steel	267,800	lbs.	0.15	40,200	822,000
Outlet Works					
Excavation					
Inlet structure	300	cu.yd.	5.00	1,500	
Conduit trench	7,920	cu.yd.	6.00	47,500	
Concrete					
Inlet structure	220	cu.yd.	60.00	13,200	
Conduit encasement	3,590	cu.yd.	40.00	143,600	
Reinforcing steel	183,900	lbs.	0.15	27,600	
Miscellaneous metal work	32,400	lbs.	0.40	13,000	
Steel pipe 42-inch dia.	198,000	lbs.	0.28	55,500	
High pressure slide gate			lump sum	25,000	
Needle valve, 36-inch dia.			lump sum	12,000	
Control house, etc.			lump sum	9,100	348,000

ESTIMATED COST OF FERNDALE DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 12,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Reservoir				
Land acquisition		lump sum	$ 258,800	
Improvements		lump sum	576,700	
State road relocation		lump sum	420,000	
Clearing	270 acres	$ 150.00	40,500	$1,296,000
Subtotal				$4,214,900
Administration and engineering, 10%				$ 421,500
Contingencies, 15%				632,200
Interest during construction				105,400
TOTAL				$5,374,000
ANNUAL COSTS				
Interest, 4%				$ 215,000
Amortization, 40-year sinking fund at 4%				56,500
Operation and maintenance				5,000
TOTAL				$ 276,500

ESTIMATED COST OF FERNDALE DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 24,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,150 feet, U.S.G.S. datum
Elevation of crest of spillway: 1,120 feet
Height of dam to spillway crest, above stream bed: 210 feet

Capacity of reservoir to crest of spillway: 24,000 acre-feet
Capacity of spillway with 5-foot freeboard: 37,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Exploration		lump sum	$ 40,000	
Diversion tunnel				
15-foot diameter	1,250 lin.ft.	$386.00	482,500	
Portal excavation	20,200 cu.yd.	0.80	16,200	
Concrete plug	260 cu.yd.	30.00	7,800	
Diversion of stream and dewatering of foundation		lump sum	10,000	
Stripping topsoil	37,000 cu.yd.	0.60	22,200	
Foundation excavation				
Abutment	349,100 cu.yd.	1.10	384,000	
Channel	25,200 cu.yd.	0.60	15,100	
Embankment				
Impervious	1,757,400 cu.yd.	0.70	1,230,200	
Pervious	2,343,900 cu.yd.	0.45	1,054,800	
Rock riprap	56,830 cu.yd.	4.00	227,300	
Drilling grout holes	7,440 lin.ft.	3.00	22,300	
Pressure grouting	4,960 cu.ft.	4.00	19,800	$3,532,200
Spillway				
Excavation	160,800 cu.yd.	2.00	321,600	
Concrete				
Weir and cutoff	970 cu.yd.	35.00	34,000	
Floor	1,270 cu.yd.	30.00	38,100	
Walls	590 cu.yd.	40.00	23,600	
Reinforcing steel	220,600 lbs.	0.15	33,100	450,400
Outlet Works				
Inlet structure concrete	300 cu.yd.	60.00	18,000	
Inlet structure excavation	400 cu.yd.	6.00	2,400	
Steel pipe 60-inch dia.	326,500 lbs.	0.28	91,400	
Reinforcing steel	41,000 lbs.	0.15	6,200	
High pressure slide gate		lump sum	25,000	
Needle valve 48-inch dia.		lump sum	18,000	
Miscellaneous metal work	35,000 lbs.	0.40	14,000	
Control house, etc.		lump sum	11,000	186,000

ESTIMATED COST OF FERNDALE DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 24,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price		Cost
CAPITAL COSTS				
Reservoir				
Land acquisition		lump sum	294,200	
Improvements		lump sum	641,900	
State road relocation		lump sum	420,000	
Clearing	340 acres	$ 150.00	51,000	$1,407,100
Subtotal				$5,575,700
Administration and engineering, 10%				$ 557,600
Contingencies, 15%				836,400
Interest during construction				278,800
TOTAL				$7,248,500
ANNUAL COSTS				
Interest, 4%				$ 289,90
Amortization, 40-year sinking fund at 4%				76,30
Operation and maintenance				6,50
TOTAL				$ 372,70

ESTIMATED COST OF FERNDALE DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 34,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,180 feet, U.S.G.S. datum
Elevation of crest of spillway: 1,150 feet
Height of dam to spillway crest, above stream bed: 240 feet

Capacity of reservoir to crest of spillway: 34,000 acre-feet
Capacity of spillway with 5-foot freeboard: 37,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Exploration		lump sum	$ 40,000	
Diversion tunnel				
15-foot diameter	1,600 lin.ft.	$ 386.00	617,600	
Portal excavation	12,760 cu.yd.	0.80	10,200	
Concrete plug	260 cu.yd.	30.00	7,800	
Diversion of stream and dewatering of foundation		lump sum	10,000	
Stripping topsoil	68,300 cu.yd.	0.60	41,000	
Foundation excavation				
Abutment	423,000 cu.yd.	1.10	465,300	
Channel	29,600 cu.yd.	0.60	17,800	
Embankment				
Impervious	2,303,000 cu.yd.	0.70	1,612,100	
Pervious	4,031,800 cu.yd.	0.45	1,814,300	
Rock riprap	82,220 cu.yd.	4.00	328,900	
Drilling grout holes	7,920 lin.ft.	3.00	23,800	
Pressure grouting	5,280 cu.ft.	4.00	21,100	$5,009,900
Spillway				
Excavation	363,820 cu.yd.	2.00	727,600	
Concrete				
Weir and cutoff	1,260 cu.yd.	35.00	44,100	
Floor	2,110 cu.yd.	30.00	63,300	
Walls	1,630 cu.yd.	40.00	65,200	
Reinforcing steel	340,500 lbs.	0.15	51,100	951,300
Outlet Works				
Inlet structure concrete	300 cu.yd.	60.00	18,000	
Inlet structure excavation	400 cu.yd.	6.00	2,400	
Steel pipe 60-inch dia.	381,600 lbs.	0.28	106,800	
Reinforcing steel	41,000 lbs.	0.15	6,200	
High pressure slide gate		lump sum	25,000	
Needle valve 48-inch dia.		lump sum	18,000	
Miscellaneous metal work	40,000 lbs.	0.40	16,000	
Control house, etc.		lump sum	11,000	203,400

ESTIMATED COST OF FERNDALE DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 34,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Reservoir				
Land acquisition		lump sum	$ 294,200	
Improvements		lump sum	641,900	
State road relocation		lump sum	420,000	
Clearing	450 acres	$ 150.00	67,500	$1,423,60
Subtotal				$7,588,20
Administration and engineering, 10%				$ 758,80
Contingencies, 15%				1,138,20
Interest during construction				379,40
TOTAL				$9,864,60
ANNUAL COSTS				
Interest, 4%				$ 394,60
Amortization, 40-year sinking fund at 4%				103,80
Operation and maintenance				7,00
TOTAL				$ 505,40

ESTIMATED COST OF COLD SPRING DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 35,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 3,400 feet, Santa Clara Water Conservation District datum, 1932
Elevation of crest of spillway: 3,378 feet
Height of dam to spillway crest, above stream bed: 178 feet

Capacity of reservoir to crest of spillway: 35,000 acre-feet
Capacity of spillway with 5-foot freeboard: 50,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Exploration		lump sum	$ 40,000	
Diversion of stream and dewatering of foundation		lump sum	10,000	
Stripping topsoil	33,150 cu.yd.	$ 0.50	16,600	
Foundation excavation				
Abutment	63,630 cu.yd.	1.60	101,800	
Channel	45,840 cu.yd.	0.60	27,500	
Embankment				
Impervious	655,560 cu.yd.	0.74	485,100	
Random	1,264,070 cu.yd.	0.58	733,200	
Rock riprap	35,200 cu.yd.	4.00	140,800	
Gravel fill, pervious drain	19,100 cu.yd.	5.25	100,300	
Drilling grout holes	4,380 lin.ft.	3.00	13,100	
Pressure grouting	2,920 cu.ft.	4.00	11,700	
Slope stabilization, planting	7.5 acres	1,000.00	7,500	$1,687,600
Spillway				
Excavation, unclassified	343,900 cu.yd.	2.00	687,800	
Concrete				
Weir and cutoff	920 cu.yd.	35.00	32,200	
Floor	1,930 cu.yd.	30.00	57,900	
Walls	690 cu.yd.	40.00	27,600	
Reinforcing steel	341,700 lbs.	0.15	51,300	856,800
Outlet Works				
Excavation				
Inlet structure	300 cu.yd.	5.00	1,500	
Conduit trench	8,890 cu.yd.	6.00	53,300	
Concrete				
Inlet structure	220 cu.yd.	60.00	13,200	
Conduit encasement	2,960 cu.yd.	40.00	118,400	
Reinforcing steel	152,400 lbs.	0.15	22,900	
Miscellaneous metal work	32,000 lbs.	0.40	12,800	

ESTIMATED COST OF COLD SPRING DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 35,000 ACRE-FEET
(Continued)

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Outlet Works (Continued)					
Steel pipe 54-inch dia.	221,000	lbs.	$ 0.28	$ 61,900	
High pressure slide gate			lump sum	25,000	
48" Howell-Bunger valve			lump sum	12,000	
Control house, etc.			lump sum	9,000	$ 330,000
Reservoir					
Land acquisition			lump sum	25,000	
Clearing	760	acres	50.00	38,000	
Access road			lump sum	40,000	103,000
Subtotal					$2,977,400
Administration and engineering, 10%					$ 297,700
Contingencies, 15%					446,600
Interest during construction					74,400
TOTAL					$3,796,100
ANNUAL COSTS					
Interest, 4%					$ 151,800
Amortization, 40-year sinking fund at 4%					39,900
Operation and maintenance					7,500
TOTAL					$ 199,200

ESTIMATED COST OF COLD SPRING DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 43,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 3,410 feet, Santa Clara Water Conservation District datum, 1932
Elevation of crest of spillway: 3,390 feet
Height of dam to spillway crest, above stream bed: 190 feet

Capacity of reservoir to crest of spillway: 43,000 acre-feet
Capacity of spillway with 5-foot freeboard: 50,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Exploration		lump sum	$ 40,000	
Diversion of stream and dewatering of foundation		lump sum	10,000	
Stripping topsoil	35,000 cu.yd.	$ 0.50	17,500	
Foundation excavation				
Abutment	85,800 cu.yd.	1.60	137,300	
Channel	67,600 cu.yd.	0.60	40,600	
Embankment				
Impervious	852,000 cu.yd.	0.74	630,500	
Random	1,394,500 cu.yd.	0.58	808,800	
Rock riprap	39,500 cu.yd.	4.00	158,000	
Gravel fill, pervious drain	19,900 cu.yd.	5.25	104,500	
Drilling grout holes	4,620 lin.ft.	3.00	13,900	
Pressure grouting	3,080 cu.ft.	4.00	12,300	
Slope stabilization, planting	8.0 acres	1,000.00	8,000	$1,981,400
Spillway				
Excavation, unclassified	370,000 cu.yd.	2.00	740,000	
Concrete				
Weir and cutoff	1,100 cu.yd.	35.00	38,500	
Floor	1,900 cu.yd.	30.00	57,000	
Walls	610 cu.yd.	40.00	24,400	
Reinforcing steel	371,200 lbs.	0.15	55,700	915,600
Outlet Works				
Excavation				
Inlet structure	300 cu.yd.	5.00	1,500	
Conduit trench	9,030 cu.yd.	6.00	54,200	
Concrete				
Inlet structure	220 cu.yd.	60.00	13,200	
Conduit encasement	3,010 cu.yd.	40.00	120,400	
Reinforcing steel	154,300 lbs.	0.15	23,100	

ESTIMATED COST OF COLD SPRING DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 43,000 ACRE-FEET
(Continued)

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Outlet Works (Continued)					
Miscellaneous metal work	32,000	lbs.	$ 0.40	$ 12,800	
Steel pipe 60-inch dia.	273,500	lbs.	0.28	76,600	
High pressure slide gate			lump sum	25,000	
48" Howell-Bunger valve			lump sum	12,000	
Control house, etc.			lump sum	9,000	$ 347,800
Reservoir					
Land acquisition			lump sum	25,000	
Clearing	850	acres	50.00	42,500	
State road relocation			lump sum	1,050,000	
Access road			lump sum	40,000	1,157,500
Subtotal					$4,402,300
Administration and engineering, 10%					$ 440,200
Contingencies, 15%					660,300
Interest during construction					110,000
TOTAL					$5,612,800
ANNUAL COSTS					
Interest, 4%					$ 224,500
Amortization, 40-year sinking fund at 4%					59,000
Operation and maintenance					8,000
TOTAL					$ 291,500

ESTIMATED COST OF COLD SPRING DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 77,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 3,450 feet, Santa Clara Water Conservation District datum, 1932
Elevation of crest of spillway: 3,430
Height of dam to spillway crest, above stream bed: 230 feet

Capacity of reservoir to crest of spillway: 77,000 acre-feet
Capacity of spillway with 5-foot freeboard: 50,000 second feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Exploration		lump sum	$ 45,000	
Diversion tunnel				
16-foot diameter	1,520 lin.ft.	$ 460.00	699,200	
Portal excavation	3,550 cu.yd.	1.50	5,300	
Concrete plug	370 cu.yd.	30.00	11,100	
Diversion of stream and dewatering of foundation		lump sum	20,000	
Stripping topsoil	37,400 cu.yd.	0.50	18,700	
Foundation excavation				
Abutment	98,100 cu.yd.	1.60	157,000	
Channel	80,100 cu.yd.	0.60	48,100	
Embankment				
Impervious	1,281,200 cu.yd.	0.80	1,025,000	
Random	2,121,800 cu.yd.	0.58	1,230,600	
Rock riprap	50,640 cu.yd.	4.00	202,600	
Gravel fill, pervious drain	29,400 cu.yd.	5.25	154,400	
Drilling grout holes	5,160 lin.ft.	3.00	15,500	
Pressure grouting	3,440 cu.ft.	4.00	13,800	
Slope stabilization, planting	10.7 acres	1,000.00	10,700	$3,657,000
Spillway				
Excavation, unclassified	213,100 cu.yd.	2.00	426,200	
Concrete				
Weir and cutoff	1,210 cu.yd.	35.00	42,400	
Floor	1,850 cu.yd.	30.00	55,500	
Walls	550 cu.yd.	40.00	22,000	
Reinforcing steel	281,900 lbs.	0.15	42,300	588,400
Outlet Works				
Inlet structure concrete	300 cu.yd.	60.00	18,000	
Inlet structure excavation	400 cu.yd.	5.00	2,000	
Steel pipe 60-inch dia.	322,200 lbs.	0.28	90,200	
Reinforcing steel	41,000 lbs.	0.15	6,200	
High pressure slide gate		lump sum	25,000	

ESTIMATED COST OF COLD SPRING DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 77,COO ACRE-FEET
(Continued)

Item	Quantity		Unit price		Cost
CAPITAL COSTS					
Outlet Works (Continued)					
54" Howell-Bunger valve			lump sum	$ 18,000	
Miscellaneous metal work	35,000	lbs.	$ 0.40	14,000	
Control house, etc.			lump sum	11,300	$ 184,700
Reservoir					
Land acquisition			lump sum	25,000	
Clearing	1,140	acres	50.00	57,000	
State road relocation			lump sum	1,050,000	
Access road			lump sum	40,000	1,172,000
Subtotal					$5,602,100
Administration and engineering, 10%					$ 560,200
Contingencies, 15%					840,300
Interest during construction					280,100
TOTAL					$7,282,700
ANNUAL COSTS					
Interest, 4%					$ 291,300
Amortization, 40-year sinking fund at 4%					76,600
Operation and maintenance					10,000
TOTAL					$ 377,900

ESTIMATED COST OF COLD SPRING DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 100,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 3,472 feet, Santa Clara Water Conservation District datum, 1932
Elevation of crest of spillway: 3,452 feet
Height of dam to spillway crest, above stream bed: 252 feet

Capacity of reservoir to crest of spillway: 100,000 acre-feet
Capacity of spillway with 5-foot freeboard: 50,000 second-feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Dam					
Exploration			lump sum	$ 50,000	
Diversion tunnel					
16-foot diameter	1,520	lin.ft.	$ 460.00	699,200	
Portal excavation	3,600	cu.yd.	1.50	5,400	
Concrete plug	370	cu.yd.	30.00	11,100	
Diversion of stream and dewatering of foundation			lump sum	22,000	
Stripping topsoil	48,860	cu.yd.	0.50	24,400	
Foundation excavation					
Abutment	132,600	cu.yd.	1.60	212,200	
Channel	119,200	cu.yd.	0.60	71,500	
Embankment					
Impervious	1,534,700	cu.yd.	0.83	1,273,800	
Random	3,034,400	cu.yd.	0.60	1,820,600	
Rock riprap	64,140	cu.yd.	4.00	256,600	
Gravel fill, pervious drain	38,800	cu.yd.	5.25	203,700	
Drilling grout holes	5,520	lin.ft.	3.00	16,600	
Pressure grouting	3,680	cu.ft.	4.00	14,700	
Slope stabilization, planting	13.3	acres	1,000.00	13,300	$4,695,100
Spillway					
Excavation, unclassified	185,800	cu.yd.	2.00	371,600	
Concrete					
Weir and cutoff	1,230	cu.yd.	35.00	43,100	
Floor	1,800	cu.yd.	30.00	54,000	
Walls	570	cu.yd.	40.00	22,800	
Reinforcing steel	281,400	lbs.	0.15	42,200	533,700
Outlet Works					
Inlet structure concrete	300	cu.yd.	60.00	18,000	
Inlet structure excavation	400	cu.yd.	5.00	2,000	
Steel pipe 60-inch dia.	322,200	lbs.	0.28	90,200	

ESTIMATED COST OF COLD SPRING DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 100,000 ACRE-FEET
(Continued

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Outlet Works (Continued)				
Reinforcing steel	41,000 lbs.	$ 0.15	$ 6,200	
High pressure slide gate		lump sum	25,000	
54" Howell-Bunger valve		lump sum	18,000	
Miscellaneous metal work	35,000 lbs.	0.40	14,000	
Control house, etc.		lump sum	11,300	$ 184,70
Reservoir				
Land acquisition		lump sum	25,000	
Clearing	1,290 acres	50.00	64,500	
State road relocation		lump sum	1,050,000	
Access road		lump sum	40,000	1,179,50
Subtotal				$6,593,00
Administration and engineering, 10%				$ 659,30
Contingencies, 15%				989,00
Interest during construction				329,70
TOTAL				$8,571,00
ANNUAL COSTS				
Interest, 4%				$ 342,80
Amortization, 40-year sinking fund at 4%				90,20
Operation and maintenance				12,50
TOTAL				$ 445,50

ESTIMATED COST OF TOPATOPA DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 50,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 2,395 feet, U.S.G.S. datum
Elevation of crest of chute spillway: 2,360 feet
Elevation of crest of overpour spillway: 2,380 feet
Elevation of top of gates, chute spillway: 2,380 feet
Height of dam to top of gates, above stream bed: 280 feet
Capacity of reservoir to top of gates: 50,000 acre-feet
Capacity of spillways with 5-foot freeboard: 82,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Concrete	287,000 cu.yd.	$ 18.00	$5,166,000	
Excavation	100,000 cu.yd.	3.00	300,000	
Drilling grout holes	9,000 lin.ft.	3.00	27,000	
Pressure grouting	7,000 cu.ft.	4.00	28,000	
Diversion of stream		lump sum	50,000	
Exploration		lump sum	35,000	$5,606,000
Chute spillway				
Concrete	4,500 cu.yd.	40.00	180,000	
Excavation	155,000 cu.yd.	4.00	620,000	
Reinforcing steel	380,000 lbs.	0.15	57,000	
Gates and hoists	3 each	25,000.00	75,000	932,000
Outlet Works		lump sum		60,000
Reservoir				
Land acquisition		lump sum	25,000	
Roads to dam		lump sum	400,000	
Clearing		lump sum	20,000	445,000
Subtotal				$7,043,000
Administration and engineering, 10%				$ 704,000
Contingencies, 15%				1,056,000
Interest during construction				352,000
TOTAL				$9,155,000
ANNUAL COSTS				
Interest, 4%				$ 366,200
Amortization, 40-year sinking fund at 4%				96,300
Operation and maintenance				20,000
TOTAL				$ 482,500

ESTIMATED COST OF TOPATOPA DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 75,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 2,437 feet, U.S.G.S. datum
Elevation of crest of chute spillway: 2,400 feet
Elevation of crest of overpour spillway: 2,420 feet
Elevation of top of gates, chute spillway: 2,420 feet

Height of dam to top of gates, above stream bed: 322 feet
Capacity of reservoir to top of gates: 75,000 acre-feet
Capacity of spillways with 5-foot freeboard: 82,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Concrete	412,000 cu.yd.	$ 18.00	$7,416,000	
Excavation	190,000 cu.yd.	3.00	570,000	
Drilling grout holes	11,000 lin.ft.	3.00	33,000	
Pressure grouting	9,000 cu.ft.	4.00	36,000	
Diversion of stream		lump sum	50,000	
Exploration		lump sum	35,000	$8,140,00(
Chute spillway				
Concrete	4,300 cu.yd.	40.00	172,000	
Excavation	146,000 cu.yd.	4.00	584,000	
Reinforcing steel	360,000 lbs.	0.15	54,000	
Gates and hoists	3 each	25,000.00	75,000	885,00(
Outlet Works		lump sum		60,00(
Reservoir				
Land acquisition		lump sum	25,000	
Roads to dam		lump sum	400,000	
Clearing		lump sum	30,000	455,00(
Subtotal				$9,540,00(
Administration and engineering, 10%				$ 954,00(
Contingencies, 15%				1,431,00(
Interest during construction				596,00(
TOTAL				$12,521,00(
ANNUAL COSTS				
Interest, 4%				$ 500,800
Amortization, 40-year sinking fund at 4%				131,700
Operating and maintenance				20,000
TOTAL				$ 652,500

ESTIMATED COST OF TOPATOPA DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 100,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 2,470 feet, U.S.G.S. datum
Elevation of crest of chute spillway: 2,435 feet
Elevation of crest of overpour spillway: 2,455 feet
Elevation of top of gates, chute spillway: 2,455 feet
Height of dam to top of gates, above stream bed: 355 feet
Capacity of reservoir to top of gates: 100,000 acre-feet
Capacity of spillways with 5-foot freeboard: 82,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Concrete	522,000 cu.yd.	$ 18.00	$9,396,000	
Excavation	275,000 cu.yd.	3.00	825,000	
Drilling grout holes	13,000 lin ft.	3.00	39,000	
Pressure grouting	11,000 cu.ft.	4.00	44,000	
Diversion of stream		lump sum	50,000	
Exploration		lump sum	35,000	$10,389,000
Chute spillway				
Concrete	4,100 cu.yd.	40.00	164,000	
Excavation	122,000 cu.yd.	4.00	488,000	
Reinforcing steel	350,000 lbs.	0.15	52,500	
Gates and hoists	3 each	25,000.00	75,000	779,500
Outlet Works		lump sum		60,000
Reservoir				
Land acquisition		lump sum	62,500	
Roads to dam		lump sum	400,000	
Clearing		lump sum	40,000	502,500
Subtotal				$11,731,000
Administration and engineering, 10%				$ 1,173,000
Contingencies, 15%				1,760,000
Interest during construction				880,000
TOTAL				$15,544,000
ANNUAL COSTS				
Interest, 4%				$ 621,800
Amortization, 40-year sinking fund at 4%				163,500
Operation and maintenance				20,000
TOTAL				$ 805,300

ESTIMATED COST OF HAMMEL DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 25,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,125 feet, U.S.G.S. datum
Elevation of top of gates: 1,120 feet
Height of dam to top of gates, above stream bed: 330 feet

Capacity of reservoir to top of gates: 25,000 acre-feet
Capacity of spillway with 5-foot freeboard: 90,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Exploration		lump sum	$ 90,000	
Diversion tunnel				
7-foot diameter	490 lin.ft.	$ 140.00	68,600	
Portal excavation	2,000 cu.yd.	2.00	4,000	
Concrete plug	40 cu.yd.	30.00	1,200	
Diversion of stream and dewatering of foundation		lump sum	40,000	
Stripping	179,400 cu.yd.	3.00	538,200	
Mass concrete	530,700 cu.yd.	15.00	7,960,500	
Cooling concrete	530,700 cu.yd.	0.50	265,300	
Parapet wall concrete	180 cu.yd.	50.00	9,000	
Drilling grout holes	3,300 lin.ft.	4.00	13,200	
Pressure grouting	2,200 cu.ft.	3.00	6,600	$8,996,600
Spillway				
Reinforced concrete				
Walls	1,490 cu.yd.	40.00	59,600	
Piers	740 cu.yd.	50.00	37,000	
Gates and hoists	928,000 lbs.	0.32	297,000	
Reinforcing steel	549,000 lbs.	0.15	82,300	
Bridge		lump sum	20,000	495,900
Outlet Works				
Ring seal gates	120,000 lbs.	0.45	54,000	
Needle valve 48-inch dia.	32,000 lbs.	0.55	17,600	
Steel pipe 54-inch dia.	75,000 lbs.	0.28	21,000	
Trashrack steel	90,000 lbs.	0.40	36,000	
Miscellaneous metal work	371,000 lbs.	0.40	148,400	277,000
Reservoir				
Access road	2 miles	50,000.00	100,000	
Clearing	210 acres	150.00	31,500	
Land and improvements		lump sum	12,500	144,000
Subtotal				$9,913,500
Administration and engineering, 10%				$ 991,300
Contingencies, 15%				1,487,000
Interest during construction				495,700
TOTAL				$12,887,500

ESTIMATED COST OF HAMMEL DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 25,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price	Cost
ANNUAL COSTS			
Interest, 4%			$ 515,500
Amortization, 40-year sinking fund at 4%			135,600
Operation and maintenance			15,000
TOTAL			$ 666,100

ESTIMATED COST OF HAMMEL DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 50,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,223 feet, U.S.G.S. datum
Elevation of top of gates: 1,218 feet
Height to top of gates, above stream bed: 428 feet

Capacity of reservoir to top of gates: 50,000 acre-feet
Capacity of spillway with 5-foot freeboard: 90,000 second-feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Dam					
Exploration			lump sum	$ 110,000	
Diversion tunnel					
7-foot diameter	560	lin.ft.	$ 140.00	78,400	
Portal excavation	2,000	cu.yd.	2.00	4,000	
Concrete plug	40	cu.yd.	30.00	1,200	
Diversion of stream and de-watering of foundation			lump sum	40,000	
Stripping	286,100	cu.yd.	3.00	858,300	
Mass concrete	1,067,900	cu.yd.	15.00	16,018,500	
Cooling concrete	1,067,900	cu.yd.	0.50	533,900	
Parapet wall concrete	320	cu.yd.	50.00	16,000	
Drilling grout holes	4,920	lin.ft.	4.00	19,700	
Pressure grouting	3,280	cu.ft.	3.00	9,800	$17,689,80
Spillway					
Reinforced concrete					
Walls	2,120	cu.yd.	40.00	84,800	
Piers	740	cu.yd.	50.00	37,000	
Gates and hoist	928,000	lbs.	0.32	297,000	
Reinforcing steel	725,000	lbs.	0.15	108,700	
Bridge			lump sum	20,000	547,50
Outlet Works					
Ring seal gates	120,000	lbs.	0.45	54,000	
Needle valve 48-inch dia.	32,000	lbs.	0.55	17,600	
Steel pipe 54-inch dia.	124,000	lbs.	0.28	34,700	
Trashrack steel	90,000	lbs.	0.40	36,000	
Miscellaneous metal work	747,500	lbs.	0.40	299,000	441,30
Reservoir					
Access road	2	miles	50,000.00	100,000	
Clearing	320	acres	150.00	48,000	
Land and improvements			lump sum	12,500	160,50
Subtotal					$18,839,10

ESTIMATED COST OF HAMMEL DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 50,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price	Cost
PITAL COSTS			
ministration and engineering, 10%			$ 1,883,900
ntingencies, 15%			2,825,900
terest during construction			942,000
TOTAL			$24,490,900
NUAL COSTS			
terest, 4%			$ 979,600
ortization, 40-year sinking fund at 4%			257,600
eration and maintenance			15,000
TOTAL			$ 1,252,200

ESTIMATED COST OF UPPER BLUE POINT DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 50,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,320 feet, U.S.G.S. datum
Elevation of crest of spillway: 1,295 feet
Height of dam to spillway crest, above stream bed: 205 feet

Capacity of reservoir to crest of spillway: 50,000 acre-feet
Capacity of spillway with 5-foot freeboard: 100,000 second-feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Dam					
Exploration			lump sum	$ 50,000	
Diversion tunnel					
20-foot diameter	1,250	lin.ft.	$ 500.00	625,000	
Portal excavation	4,000	cu.yd.	0.70	2,800	
Concrete plug	730	cu.yd.	30.00	21,900	
Diversion of stream and dewatering of foundation			lump sum	20,000	
Stripping topsoil	53,000	cu.yd.	0.40	21,200	
Foundation excavation	679,500	cu.yd.	0.90	611,600	
Embankment					
Impervious	1,867,500	cu.yd.	0.70	1,307,300	
Pervious	3,118,900	cu.yd.	0.50	1,559,500	
Rock riprap	77,000	cu.yd.	4.00	308,000	
Drilling grout holes	6,660	lin.ft.	3.00	20,000	
Pressure grouting	4,440	cu.ft.	4.00	17,800	$4,565,10
Spillway					
Excavation	599,900	cu.yd.	2.25	1,349,800	
Concrete					
Weir and cutoff	1,860	cu.yd.	30.00	55,800	
Floor	4,080	cu.yd.	25.00	102,000	
Walls	1,840	cu.yd.	40.00	73,600	
Reinforcing steel	624,100	lbs.	0.15	93,600	1,674,80
Outlet Works					
Tower concrete	660	cu.yd.	80.00	52,800	
Tower excavation	400	cu.yd.	5.00	2,000	
Steel pipe 72-in. dia.	336,600	lbs.	0.28	94,200	
Tower inlet valve 36-in. dia.	4	each	3,600.00	14,400	
Howell-Bunger valve 48-in. dia.	1	each	12,000.00	12,000	
Needle valve 48-in. dia.	1	each	18,000.00	18,000	
Sluice gate			lump sum	25,000	
Miscellaneous metal work	32,000	lbs.	0.40	12,800	
Control house, etc.			lump sum	10,000	241,20

ESTIMATED COST OF UPPER BLUE POINT DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 50,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Reservoir				
Land acquisition		lump sum $	33,300	
Clearing	640 acres	$ 50.00	32,000	
Access Road		lump sum	15,000	$ 80,300
Subtotal				$6,561,400
Administration and engineering, 10%				$ 656,200
Contingencies, 15%				984,200
Interest during construction				328,000
TOTAL				$8,529,800
ANNUAL COSTS				
Interest, 4%				$ 341,200
Amortization, 40-year sinking fund at 4%				89,700
Operation and maintenance				7,500
TOTAL				$ 438,400

ESTIMATED COST OF BLUE POINT DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 50,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,305 feet, U.S.G.S. Datum
Elevation of crest of spillway: 1,280 feet
Height of dam to spillway crest, above stream bed: 215 feet

Capacity of reservoir to crest of spillway: 50,000 acre-feet
Capacity of spillway with 5-foot freeboard: 100,000 second-feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Dam					
Exploration			lump sum	$ 50,000	
Diversion of stream and dewatering of foundation			lump sum	40,000	
Stripping topsoil	33,200	cu.yd.	$ 0.40	13,300	
Foundation excavation	733,100	cu.yd.	0.90	659,800	
Embankment					
Impervious	1,435,800	cu.yd.	0.70	1,005,100	
Pervious	2,061,900	cu.yd.	0.50	1,031,000	
Rock riprap	55,400	cu.yd.	4.00	221,600	
Drilling grout holes	4,830	lin.ft.	3.00	14,500	
Pressure grouting	3,220	cu.ft.	4.00	12,900	$3,048,200
Spillway					
Portal excavation	300,000	cu.yd.	2.25	675,000	
Tunnel excavation	60,000	cu.yd.	15.00	900,000	
Concrete					
Weir	4,500	cu.yd.	30.00	135,000	
Walls and paving	2,500	cu.yd.	40.00	100,000	
Tunnel lining	12,000	cu.yd.	50.00	600,000	
Reinforcing steel	2,000,000	lbs.	0.15	300,000	2,710,000
Outlet Works					
Excavation					
Tower foundation	380	cu.yd.	5.00	1,900	
Conduit trench	5,080	cu.yd.	6.00	30,500	
Concrete					
Tower	660	cu.yd.	80.00	52,800	
Pipe encasement	3,340	cu.yd.	40.00	133,600	
Reinforcing steel	283,400	lbs.	0.15	42,500	
Steel pipe, 72-inch dia.	359,600	lbs.	0.28	100,700	
Gate valve 36-inch dia.	4	each	3,600.00	14,400	
Howell-Bunger valve 48-inch dia.	1	each	12,000.00	12,000	
Needle valve 48-inch dia.	1	each	18,000.00	18,000	
Sluice gate	1	each	20,000.00	20,000	
Miscellaneous metal work	33,000	lbs.	0.40	13,200	
Control house, etc.			lump sum	10,000	449,600

ESTIMATED COST OF BLUE POINT DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 50,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price		Cost
CAPITAL COSTS				
Reservoir				
Land acquisition		lump sum	$ 33,300	
Clearing	640 acres	$ 50.00	32,000	
Access Road		lump sum	12,200	$ 77,500
Subtotal				$6,285,300
Administration and engineering, 10%				$ 628,500
Contingencies, 15%				942,800
Interest during construction				314,300
TOTAL				$8,170,900
ANNUAL COSTS				
Interest, 4%				$ 326,800
Amortization, 40-year sinking fund at 4%				86,000
Operation and maintenance				7,500
TOTAL				$ 420,300

ESTIMATED COST OF DEVIL CANYON DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 100,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,245 feet, U.S.G.S. datum
Elevation of crest of spillway: 1,220 feet
Height of dam to spillway crest, above stream bed: 240 feet

Capacity of reservoir to crest of spillway: 100,000 acre-feet
Capacity of spillway with 5-foot freeboard: 102,00 second-feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Dam					
Exploration			lump sum	$ 40,000	
Diversion tunnel					
21-foot diameter	1,750	lin.ft.	$ 510.00	892,500	
Portal excavation	13,300	cu.yd.	1.50	19,900	
Concrete plug	730	cu.yd.	30.00	21,900	
Diversion of stream and dewatering of foundation			lump sum	50,000	
Stripping topsoil	57,200	cu.yd.	0.40	22,900	
Foundation excavation					
Abutment	105,300	cu.yd.	1.40	147,400	
Channel	905,000	cu.yd.	0.60	543,000	
Embankment					
Impervious	2,599,400	cu.yd.	0.65	1,689,600	
Pervious	3,764,100	cu.yd.	0.45	1,693,800	
Rock riprap	80,000	cu.yd.	4.00	320,000	
Drilling grout holes	6,360	lin.ft.	3.00	19,100	
Pressure grouting	4,240	cu.ft.	4.00	17,000	$5,477,10
Spillway					
Excavation	1,288,300	cu.yd.	2.00	2,576,600	
Concrete					
Weir and cutoff	5,220	cu.yd.	35.00	182,700	
Floor	8,460	cu.yd.	30.00	253,800	
Walls	5,180	cu.yd.	40.00	207,200	
Reinforcing steel	1,573,700	lbs.	0.15	236,100	3,456,40
Outlet Works					
Inlet structure concrete	300	cu.yd.	60.00	18,000	
Inlet structure excavation	400	cu.yd.	5.00	2,000	
Steel pipe 72-in. dia.	450,100	lbs.	0.28	126,000	
Reinforcing steel	30,000	lbs.	0.15	4,500	
High pressure slide gate			lump sum	25,000	
Needle valve 60-in. dia.		1 each	27,500.00	27,500	
Miscellaneous metal work	32,000	lbs.	0.40	12,800	
Control house, etc.			lump sum	10,000	225,80

ESTIMATED COST OF DEVIL CANYON DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 100,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price		Cost
CAPITAL COSTS				
Reservoir				
Land acquisition		lump sum	$ 110,300	
Clearing	1,050 acres	$ 50.00	52,500	$ 162,800
Subtotal				$9,322,100
Administration and engineering, 10%				$ 932,200
Contingencies, 15%				1,398,300
Interest during construction				466,100
TOTAL				$12,118,700
ANNUAL COSTS				
Interest, 4%				$ 484,700
Amortization, 40-year sinking fund at 4%				127,500
Operation and maintenance				12,500
TOTAL				$ 624,700

ESTIMATED COST OF DEVIL CANYON DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 150,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,290 feet, U.S.G.S. datum
Elevation of crest of spillway: 1,265 feet
Height of dam to spillway crest, above stream bed: 285 feet

Capacity of reservoir to crest of spillway: 150,000 acre-feet
Capacity of spillway with 5-foot freeboard: 102,000 second-feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Dam					
Exploration			lump sum	$ 40,000	
Diversion tunnel					
21-foot diameter	2,130	lin.ft.	$ 510.00	1,086,300	
Portal excavation	12,000	cu.yd.	1.50	18,000	
Concrete plug	730	cu.yd.	30.00	21,900	
Diversion of stream and dewatering of foundation			lump sum	50,000	
Stripping topsoil	91,860	cu.yd.	0.40	36,700	
Foundation excavation					
Abutment	104,400	cu.yd.	1.40	146,200	
Channel	1,036,300	cu.yd.	0.60	621,800	
Embankment					
Impervious	3,421,500	cu.yd.	0.65	2,224,000	
Pervious	6,467,400	cu.yd.	0.45	2,910,300	
Rock riprap	112,840	cu.yd.	4.00	451,400	
Drilling grout holes	7,080	lin.ft.	3.00	21,200	
Pressure grouting	4,720	cu.ft.	4.00	18,900	$7,646,700
Spillway					
Excavation	1,280,100	cu.yd.	2.00	2,560,200	
Concrete					
Weir and cutoff	4,250	cu.yd.	35.00	148,800	
Floor	10,520	cu.yd.	30.00	315,600	
Walls	5,490	cu.yd.	40.00	219,600	
Reinforcing steel	1,727,800	lbs.	0.15	259,200	3,503,400
Outlet Works					
Tower concrete	850	cu.yd.	80.00	68,000	
Tower excavation	400	cu.yd.	5.00	2,000	
Steel pipe 72-inch dia.	673,200	lbs.	0.28	188,500	
Tower inlet valves 36-in. dia.	5	each	3,600.00	18,000	
Howell-Bunger valve, 48-in. dia.	1	each	12,000.00	12,000	
Needle valve, 48-in. dia.	1	each	18,000.00	18,000	
Sluice gate			lump sum	20,000	
Miscellaneous metal work	40,000	lbs.	0.40	16,000	
Control house, etc.			lump sum	10,000	352,500

ESTIMATED COST OF DEVIL CANYON DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 150,000 ACRF-FEET
(Continued)

Item	Quantity	Unit price		Cost
CAPITAL COSTS				
Reservoir				
Land acquisition		lump sum	$ 110,300	
Clearing	1,500 acres	$ 50.00	75,000	$ 185,300
Subtotal				$11,687,900
Administration and engineering, 10%				$ 1,168,800
Contingencies, 15%				1,753,200
Interest during construction				876,600
TOTAL				$15,486,500
ANNUAL COSTS				
Interest, 4%				$ 619,500
Amortization, 40-year sinking fund at 4%				162,900
Operation and maintenance				15,700
TOTAL				$ 798,100

ESTIMATED COST OF SANTA FELICIA DAM AND RESERVOIR WITH STORAGE CAPACITY OF 50,000 ACRE-FEET
(Based on prices prevailing in spring 1953)

Elevation of crest of dam: 1,030 feet
Elevation of crest of spillway: 1,010 feet
Height of dam to spillway crest, above stream bed: 140 feet

Capacity of reservoir to crest of spillway: 50,000 acre-feet
Capacity of spillway with 5-foot freeboard: 103,000 second-feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Dam					
Exploration			lump sum	$ 50,000	
Diversion of stream and dewatering of foundation			lump sum	50,000	
Stripping topsoil	30,700	cu.yd.	$ 0.40	12,300	
Foundation excavation					
Abutment	29,400	cu.yd.	1.40	41,200	
Channel	886,400	cu.yd.	0.55	487,500	
Excavation for embankment					
From borrow pits	1,686,600	cu.yd.	0.47	792,700	
From stream bed	838,700	cu.yd.	0.36	301,900	
Embankment					
Impervious	1,466,600	cu.yd.	0.18	264,000	
Pervious	1,571,300	cu.yd.	0.12	188,600	
Rock riprap	41,100	cu.yd.	4.00	164,400	
Drilling grout holes	6,240	lin.ft.	3.00	18,700	
Pressure grouting	4,160	cu. ft.	4.00	16,600	$2,387,900
Spillway					
Excavation	1,598,100	cu.yd.	0.90	1,438,300	
Concrete					
Weir and cutoff	3,290	cu.yd.	35.00	115,200	
Floor	8,590	cu.yd.	30.00	257,700	
Walls	3,010	cu.yd.	40.00	120,400	
Reinforcing steel	1,199,800	lbs.	0.15	180,000	2,111,600
Outlet Works					
Excavation					
Inlet Structure	300	cu.yd.	5.00	1,500	
Conduit Trench	5,250	cu.yd.	6.00	31,500	
Concrete					
Inlet structure	220	cu.yd.	60.00	13,200	
Conduit encasement	1,750	cu.yd.	40.00	70,000	
Reinforcing steel	91,200	lbs.	0.15	13,700	
Steel pipe 60-inch dia.	159,000	lbs.	0.28	44,500	
Miscellaneous metal work	32,000	lbs.	0.40	12,800	
High pressure slide gate			lump sum	25,000	
Needle valve 54-inch dia.			lump sum	20,000	
Control house, etc.			lump sum	10,000	242,200

ESTIMATED COST OF SANTA FELICIA DAM AND RESERVOIR WITH STORAGE CAPACITY OF 50,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Reservoir				
Land acquisition		lump sum	$ 447,000	
Clearing	1,030 acres	$ 50.00	51,500	
Road relocation and oil well damage		lump sum	350,000	$848,500
Subtotal				$5,590,200
Administration and engineering, 10%				$ 559,000
Contingencies, 15%				838,500
Interest during construction				139,800
TOTAL				$7,127,500
ANNUAL COSTS				
Interest, 4%				$285,100
Amortization, 40-year sinking fund at 4%				75,000
Operation and maintenance				9,000
TOTAL				$369,100

ESTIMATED COST OF SANTA FELICIA DAM AND RESERVOIR WITH
STORAGE CAPACITY OF 75,000 ACRE-FEET
(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,055 feet
Elevation of crest of spillway: 1,035 feet
Height of dam to spillway crest, above stream bed: 165 feet

Capacity of reservoir to crest of spillway: 75,000 acre-feet
Capacity of spillway with 5-foot freeboard: 103,000 second-feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Dam					
Exploration			lump sum	$ 50,000	
Diversion tunnel					
22-foot diameter	1,080	lin.ft.	$ 530.00	572,400	
Portal excavation	18,000	cu.yd.	1.50	27,000	
Concrete plug	800	cu.yd.	30.00	24,000	
Diversion of stream and dewatering of foundation			lump sum	60,000	
Stripping topsoil	42,600	cu.yd.	0.40	17,000	
Foundation excavation					
Abutment	37,100	cu.yd.	1.40	51,900	
Channel	989,300	cu.yd.	0.55	544,100	
Excavation for embankment					
From borrow pits	2,198,200	cu.yd.	0.47	1,033,200	
From streambed	1,794,400	cu.yd.	0.36	646,000	
Embankment					
Impervious	1,911,500	cu.yd.	0.18	344,100	
Pervious	2,615,500	cu.yd.	0.12	313,900	
Rock riprap	59,700	cu.yd.	4.00	238,800	
Drilling grout holes	6,960	lin.ft.	3.00	20,900	
Pressure grouting	4,640	cu.ft.	4.00	18,600	$3,961,90
Spillway					
Excavation	1,034,100	cu.yd.	0.80	827,300	
Concrete					
Weir and cutoff	3,290	cu.yd.	35.00	115,200	
Floor	8,230	cu.yd.	30.00	246,900	
Walls	2,820	cu.yd.	40.00	112,800	
Reinforcing steel	1,153,100	lbs.	0.15	173,000	1,475,20
Outlet Works					
Inlet structure concrete	290	cu.yd.	60.00	17,400	
Inlet structure excavation	390	cu.yd.	5.00	2,000	
Steel pipe 72-inch dia.	280,500	lbs.	0.28	78,500	
Reinforcing steel	27,300	lbs.	0.15	4,100	
High pressure slide gate			lump sum	25,000	
Needle valve 60-inch dia.	1	each	27,500.00	27,500	
Miscellaneous metal work	32,000	lbs.	0.40	12,800	
Control house, etc.			lump sum	10,000	177,30

ESTIMATED COST OF SANTA FELICIA DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 75,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price	Cost	
APITAL COSTS				
eservoir				
Land acquisition		lump sum	$ 447,000	
Clearing	1,270 acres	$ 50.00	63,500	
Road relocation and oil well damage		lump sum	350,000	$860,500
Subtotal				$6,474,900
dministration and engineering, 10%				$ 647,500
ontingencies, 15%				971,200
nterest during construction				323,700
TOTAL				$8,417,300

NNUAL COSTS	
nterest, 4%	$336,700
mortization, 40-year sinking fund at 4%	88,500
peration and maintenance	10,000
TOTAL	$435,200

ESTIMATED COST OF SANTA FELICIA DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 100,000 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,077 feet, U.S.G.S. datum
Elevation of crest of spillway: 1,057 feet
Height of dam to spillway crest, above stream bed: 187 feet

Capacity of reservoir to crest of spillway: 100,000 acre-feet
Capacity of spillway with 5-foot freeboard: 103,000 second-feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Dam					
Exploration			lump sum	$ 50,000	
Diversion tunnel					
22-foot diameter	1,270	lin.ft.	$ 530.00	673,100	
Portal excavation	19,800	cu.yd.	1.50	29,700	
Concrete plug	890	cu.yd.	30.00	26,700	
Diversion of stream and dewatering of foundation			lump sum	70,000	
Stripping topsoil	92,300	cu.yd.	0.40	36,900	
Foundation excavation					
Abutment	57,700	cu.yd.	1.40	80,800	
Channel	1,018,600	cu.yd.	0.55	560,200	
Excavation for embankment					
From borrow pits	2,458,200	cu.yd.	0.47	1,155,400	
From stream bed	2,492,500	cu.yd.	0.36	897,300	
Embankment					
Impervious	2,137,600	cu.yd.	0.18	384,800	
Pervious	3,290,500	cu.yd.	0.12	394,900	
Rock riprap	75,740	cu.yd.	4.00	303,000	
Drilling grout holes	7,260	lin.ft.	3.00	21,800	
Pressure grouting	4,840	cu.ft.	4.00	19,400	$4,704,000
Spillway					
Excavation	699,100	cu.yd.	0.70	489,400	
Concrete					
Weir and cutoff	3,290	cu.yd.	35.00	115,200	
Floor	8,950	cu.yd.	30.00	268,500	
Walls	3,190	cu.yd.	40.00	127,600	
Reinforcing steel	1,245,700	lbs.	0.15	186,900	1,187,600
Outlet Works					
Inlet structure concrete	290	cu.yd.	60.00	17,400	
Inlet structure excavation	390	cu.yd.	5.00	2,000	
Steel pipe 72-inch dia.	295,800	lbs.	0.28	82,800	
Reinforcing steel	30,000	lbs.	0.15	4,500	
High pressure slide gate			lump sum	25,000	
Needle valve 60-inch dia.	1	each	27,500.00	27,500	
Miscellaneous metal work	32,000	lbs.	0.40	12,800	
Control house, etc.			lump sum	10,000	182,000

ESTIMATED COST OF SANTA FELICIA DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 100,000 ACRE-FEET
(Continued)

Item	Quantity	Unit price		Cost
CAPITAL COSTS				
Reservoir				
Land acquisition		lump sum	$ 447,000	
Clearing	1,490 acres	$ 50.00	74,500	
Road relocation and oil well damage		lump sum	350,000	$ 871,500
Subtotal				$6,945,100
Administration and engineering, 10%				$ 694,500
Contingencies, 15%				1,041,800
Interest during construction				347,300
TOTAL				$9,028,700
ANNUAL COSTS				
Interest, 4%				$ 361,100
Amortization, 40-year sinking fund at 4%				95,000
Operation and maintenance				12,500
TOTAL				$ 468,600

ESTIMATED COST OF DISTRIBUTION SYSTEM
FROM CASITAS RESERVOIR

(Based on prices prevailing in spring of 1953)

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Main Feeder - Casitas Reservoir to Foster Park				
Excavation and backfill	12,900 lin.ft.	$ 2.80	$ 36,100	
Furnish and install 36-inch diameter reinforced concrete pipe	12,900 lin.ft.	16.25	209,600	
Ventura River crossing	1,100 lin.ft.	26.75	29,400	
Gate valves		lump sum	4,000	
Line meters	2 each	4,000.00	8,000	
Blowoff valves	2 each	500.00	1,000	
Air valves	2 each	400.00	800	
Chlorinator structure		lump sum	10,000	
Chlorinator equipment		lump sum	10,500	
Road surfacing	12,900 lin.ft.	1.00	12,900	
Concrete in structures	220 cu.yd.	65.00	14,300	
Miscellaneous metal	2,500 lbs.	0.65	1,600	
Fire hydrants	4 each	150.00	600	
Right of way		lump sum	5,000	$ 343,800
Eastside Conduit - Foster Park to Lacrosse				
Excavation and backfill	8,700 lin.ft.	2.15	18,700	
Furnish and install 27-inch diameter concrete cylinder pipe	8,700 lin.ft.	11.85	103,100	
Creek crossing	300 lin.ft.	20.75	6,200	
Gate valve - 18-inch dia.	1 each	1,000.00	1,000	
Blowoff valves		lump sum	400	
Air valves	2 each	300.00	600	
Service outlets	5 each	150.00	800	
Concrete structures	50 cu.yd.	65.00	3,300	
Miscellaneous metal	1,000 lbs.	0.65	700	
Road surfacing	8,700 lin.ft.	0.85	7,400	
Fire hydrants	2 each	150.00	300	
Right of way		lump sum	1,000	143,500
Eastside Conduit - Lacrosse to Baldwin Road				
Excavation and backfill	18,000 lin.ft.	1.86	33,500	
Furnish and install 24-inch diameter concrete cylinder pipe	18,000 lin.ft.	10.25	184,500	
Gate valves - 18-inch dia.	3 each	1,000.00	3,000	
Line meter		lump sum	2,900	
Blowoff valves	2 each	400.00	800	
Air valves	2 each	300.00	600	
Service outlets	5 each	150.00	800	
Concrete structures	80 cu.yd.	65.00	5,200	
Miscellaneous metal	2,000 lbs.	0.65	1,300	

ESTIMATED COST OF DISTRIBUTION SYSTEM
FROM CASITAS RESERVOIR
(Continued)

Item	Quantity		Unit price	Cost	
(PITAL COSTS					
(stside Conduit - Lacrosse to Baldwin Road (Continued)					
Road surfacing	7,500	lin.ft.	$ 0.80	$ 6,000	
Fire hydrants	8	each	150.00	1,200	
Reservoir			lump sum	35,000	
Pumping plant			lump sum	32,200	
Right of way			lump sum	15,000	$ 322,000
(stside Conduit - Baldwin Road to Fairview Wye					
Excavation and backfill	11,400	lin.ft.	1.00	11,400	
Furnish and install 16-inch diameter concrete cylinder pipe	11,400	lin.ft.	6.25	71,200	
Gate valves - 12-inch dia.	2	each	450.00	900	
Blowoff valves	3	each	200.00	600	
Air valves	2	each	300.00	600	
Service outlets	5	each	150.00	800	
Concrete structures	80	cu.yd.	65.00	5,200	
Miscellaneous metal	1,000	lbs.	0.65	600	
Road surfacing	9,000	lin.ft.	0.60	5,400	
Fire hydrants	7	each	150.00	1,000	
Pumping plant			lump sum	27,000	
Right of way			lump sum	4,000	128,700
(reek Road Conduit - Lacrosse to Terminal Reservoir					
Excavation and backfill	42,800	lin.ft.	1.00	42,800	
Furnish and install 16-inch diameter concrete cylinder pipe	42,800	lin.ft.	6.25	267,500	
Gate valves - 12-inch dia.	8	each	450.00	3,600	
Line meter			lump sum	2,000	
Blowoff valves	4	each	200.00	800	
Air valves	8	each	300.00	2,400	
Service outlets	14	each	150.00	2,100	
Concrete structures	150	cu.yd.	65.00	9,800	
Miscellaneous metal	3,300	lbs.	0.65	2,100	
Road surfacing	24,400	lin.ft.	0.60	14,600	
Fire hydrants	10	each	150.00	1,500	
Highway crossing			lump sum	2,500	
Reservoir			lump sum	35,000	
Pumping plant			lump sum	34,200	
Right of way			lump sum	7,000	427,900
(per Ojai Conduit					
Excavation and backfill	10,200	lin.ft.	0.80	8,200	
Furnish and install 12-inch diameter concrete cylinder pipe	10,200	lin.ft.	4.85	49,500	

ESTIMATED COST OF DISTRIBUTION SYSTEM
FROM CASITAS RESERVOIR
(Continued)

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Upper Ojai Conduit (Continued)					
Gate valves - 10-inch dia.	2	each	$ 350.00	$ 700	
Line meter			lump sum	1,800	
Blowoff valves	2	each	200.00	400	
Air valves	2	each	300.00	600	
Service outlets	5	each	150.00	800	
Concrete structures	75	cu.yd.	65.00	4,900	
Miscellaneous metal	1,000	lbs.	0.65	600	
Road surfacing	4,200	lin.ft.	0.55	2,300	
Fire hydrants	3	each	150.00	400	
Pumping plant			lump sum	15,700	
Right of way			lump sum	2,500	$ 88,400
Cross Tie to Grand Avenue					
Excavation and backfill	4,500	lin.ft.	0.80	3,600	
Furnish and install 12-inch diameter concrete cylinder pipe	4,500	lin.ft.	4.85	21,800	
Gate valves - 10-inch dia.	2	each	350.00	700	
Line meter			lump sum	1,800	
Blowoff valves			lump sum	200	
Air valves	2	each	300.00	600	
Service outlets	3	each	150.00	400	
Concrete structures	20	cu.yd.	65.00	1,300	
Concrete pipe anchors	20	cu.yd.	30.00	600	
Miscellaneous metal	1,000	lbs.	0.65	600	
Road surfacing	4,500	lin.ft.	0.55	2,500	
Fire hydrants	3	each	150.00	400	
Right of way			lump sum	500	35,000
Baldwin Road - Santa Ana Conduit					
Excavation and backfill	11,800	lin.ft.	1.00	11,800	
Furnish and install 14-inch diameter concrete cylinder pipe	11,800	lin.ft.	5.45	64,300	
Ventura River crossing	1,600	lin.ft.	10.70	17,100	
Gate valves - 12-inch dia.	3	each	450.00	1,400	
Line meter			lump sum	1,800	
Blowoff valves	2	each	200.00	400	
Air valves	3	each	300.00	900	
Service connections	4	each	150.00	600	
Concrete structures	60	cu.yd.	65.00	3,900	
Miscellaneous metal	1,500	lbs.	0.65	1,000	
Road surfacing	8,800	lin.ft.	0.60	5,300	
Fire Hydrants	3	each	150.00	400	

ESTIMATED COST OF DISTRIBUTION SYSTEM
FROM CASITAS RESERVOIR
(Continued)

Item	Quantity		Unit price	Cost	
PITAL COSTS					
ldwin Road - Santa Ana Conduit (Continued)					
Highway crossing			lump sum	$ 2,500	
Reservoir			lump sum	35,000	
Right of way			lump sum	5,000	$ 151,400
nor Canyon Extension					
Excavation and backfill	9,000	lin.ft.	$ 0.80	7,200	
Furnish and install 10-inch diameter welded steel pipe	9,000	lin.ft.	2.65	23,900	
Gate valves - 6-inch dia.	2	each	300.00	600	
Line meter			lump sum	1,000	
Blowoff valves	2	each	200.00	400	
Air valves	2	each	300.00	600	
Service outlets	3	each	150.00	400	
Concrete structures	40	cu.yd.	65.00	2,600	
Miscellaneous metal	1,000	lbs.	0.65	600	
Road surfacing	2,000	lin.ft.	0.60	1,200	
Fire hydrants	3	each	150.00	400	
Pumping plant			lump sum	13,700	
Right of way			lump sum	2,500	55,100
nada Larga Conduit					
Excavation and backfill	29,200	lin.ft.	0.80	23,400	
Furnish and install 6-inch diameter welded steel pipe	29,200	lin.ft.	1.80	52,600	
Gate valves - 4-inch dia.	4	each	170.00	700	
Line meter			lump sum	400	
Blowoff valves	3	each	100.00	300	
Air valves	4	each	200.00	800	
Service outlets	5	each	150.00	800	
Concrete structures	50	cu.yd.	65.00	3,300	
Miscellaneous metal	1,000	lbs.	0.65	600	
Road surfacing	10,000	lin.ft.	0.55	5,500	
Fire hydrants	6	each	150.00	900	
Highway crossing			lump sum	1,000	
Pumping plant			lump sum	8,500	
Right of way			lump sum	2,500	101,300
ncon Conduit					
Excavation and backfill	99,000	lin.ft.	0.75	74,200	
Furnish and install welded steel pipe					
10-inch diameter	79,000	lin.ft.	2.75	217,300	
8-inch diameter	20,000	lin.ft.	2.25	45,000	
Gate valves - 6-inch dia.	6	each	300.00	1,800	

ESTIMATED COST OF DISTRIBUTION SYSTEM
FROM CASITAS RESERVOIR
(Continued)

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Rincon Conduit (Continued)					
Line meter			lump sum	$ 1,000	
Blowoff valves	10	each	$ 200.00	2,000	
Air valves	10	each	300.00	3,000	
Service outlets	10	each	150.00	1,500	
Concrete structures	80	cu.yd.	65.00	5,200	
Miscellaneous metal	5,000	lbs.	0.65	3,200	
Road surfacing	20,000	lin.ft.	0.60	12,000	
Fire hydrants	10	each	150.00	1,500	
Reservoir			lump sum	35,000	
Pumping plant			lump sum	30,900	
Right of way			lump sum	5,000	$ 438,600
Conduit from Matilija Line to Proposed Reservoir					
Excavation and backfill	5,000	lin.ft.	1.00	5,000	
Furnish and install 14-inch diameter concrete cylinder pipe	5,000	lin.ft.	5.45	27,200	
Gate valves - 12-inch dia.	2	each	450.00	900	
Blowoff valves	2	each	200.00	400	
Air valves	3	each	300.00	900	
Service outlets	3	each	150.00	400	
Concrete structures	40	cu.yd.	65.00	2,600	
Miscellaneous metal	1,000	lbs.	0.65	600	
Road surfacing	4,000	lin.ft.	0.60	2,400	
Fire hydrants	4	each	150.00	600	
Reservoir			lump sum	35,000	
Right of way			lump sum	5,000	81,000
Subtotal					$2,316,700
Administration and engineering, 10%					$ 231,700
Contingencies, 15%					347,500
Interest during construction					57,900
TOTAL					$2,953,800
ANNUAL COSTS					
Interest, 4%					$ 118,200
Amortization, 40-year sinking fund at 4%					31,200
Replacement, 30-year sinking fund at 3.5%					9,700
Operation and maintenance					14,500
Electrical energy					78,400
TOTAL					$ 252,000

ESTIMATED COST OF CASITAS - OXNARD PLAIN DIVERSION

(Based on prices prevailing in spring of 1953)

Capacity of conduit: 25 second-feet   Length of conduit: 96,300 lineal feet

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Excavation	115,000 cu.yd	$ 1.29	$ 148,400
Backfill	94,800 cu.yd.	0.53	50,200
Pipe, reinforced concrete cylinder, furnish and install,			
30-inch diameter	49,000 lin.ft.	10.10	494,900
27-inch diameter	47,300 lin.ft.	8.93	422,400
Fittings		lump sum	41,800
Valves			
Air release, 3-inch dia.	6 each	300.00	1,800
Blowoff, 5-inch dia.	6 each	1,000.00	6,000
Gate, 24-inch dia.	3 each	1,300.00	3,900
Venturi meter	1 each	5,000.00	5,000
River crossings		lump sum	85,000
Road resurfacing and crossings		lump sum	21,000
Right of way		lump sum	29,800
Subtotal			$1,310,200
Administration and engineering, 10%			$ 131,000
Contingencies, 15%			196,500
Interest during construction			32,800
TOTAL			$1,670,500
ANNUAL COSTS			
Interest, 4%			$66,800
Amortization, 20-year sinking fund at 4%			56,100
Operation and Maintenance			4,200
TOTAL			$127,100

ESTIMATED COST OF SANTA CLARA RIVER CONDUIT
DEVIL CANYON DAM TO SESPE CREEK

(Based on prices prevailing in spring of 1953)

Capacity of conduit: 65 second-feet Length of conduit: 90,200 lineal feet

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Excavation	142,000 cu.yd.	$ 0.90	$ 127,800
Backfill	114,800 cu.yd.	0.45	51,700
Pipe, reinforced concrete, furnish and install			
42-inch diameter	26,600 lin.ft.	16.19	430,700
36-inch diameter	63,600 lin.ft.	12.13	771,500
Fittings		lump sum	55,200
Valves			
Air release, 4-inch diameter	7 each	400.00	2,800
Blowoff, 6-inch diameter	8 each	1,300.00	10,400
Gate, 36-inch diameter	2 each	3,600.00	7,200
Venturi meter	1 each	5,000.00	5,000
River crossings		lump sum	65,000
Road resurfacing		lump sum	35,000
Right of way		lump sum	16,000
Subtotal			$1,578,300
Administration and engineering, 10%			$ 157,800
Contingencies, 15%			236,700
Interest during construction			39,500
TOTAL			$2,012,300
ANNUAL COSTS			
Interest, 4%			$ 80,500
Amortization, 40-year sinking fund at 4%			21,200
Operation and maintenance			5,000
TOTAL			$ 106,700

ESTIMATED COST OF SANTA CLARA RIVER CONDUIT
SANTA FELICIA DAM TO SESPE CREEK

(Based on prices prevailing in spring of 1953)

apacity of conduit: 65 second-feet   Length of conduit: 77,100 lineal feet

Item	Quantity	Unit price	Cost
APITAL COSTS			
xcavation	129,200 cu.yd.	$ 0.90	$ 116,300
ackfill	103,700 cu.yd.	0.45	46,700
ipe, reinforced concrete, furnish and install			
42-inch diameter	54,200 lin.ft.	16.02	868,300
36-inch diameter	22,900 lin.ft.	11.65	266,800
ittings		lump sum	56,800
alves			
Air release, 4-inch dia.	7 each	400.00	2,800
Blowoff, 6-inch dia.	8 each	1,300.00	10,400
Gate, 36-inch dia.	2 each	3,600.00	7,200
enturi meter	1 each	5,000.00	5,000
iver crossings		lump sum	65,000
oad resurfacing		lump sum	35,000
ight of way		lump sum	16,000
Subtotal			$1,496,300
dministration and engineering, 10%			$ 149,600
ontingencies, 15%			224,400
nterest during construction			37,400
TOTAL			$1,907,700
NUAL COSTS			
terest, 4%			$ 76,300
ortization, 40-year sinking fund at 4%			20,100
eration and maintenance			4,800
TOTAL			$ 101,200

ESTIMATED COST OF SANTA CLARA RIVER CONDUIT
SESPE CREEK TO OXNARD RESERVOIR

(Based on prices prevailing in spring of 1953)

Capacity of conduit: 120 second-feet   Length of conduit: 92,500 lineal feet

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Excavation	211,000 cu.yd.	$ 0.90	$ 189,900
Backfill	159,700 cu.yd.	0.45	71,900
Pipe, reinforced concrete, furnish and install			
54-inch diameter	67,500 lin.ft.	20.10	1,356,800
48-inch diameter	15,000 lin.ft.	16.95	254,300
42-inch diameter	10,000 lin.ft.	14.25	142,500
Fittings		lump sum	81,700
Valves			
Air release, 4-inch dia.	4 each	400.00	1,600
Blowoff, 8-inch dia.	3 each	1,600.00	4,800
Gate, 48-inch dia.	3 each	8,700.00	26,100
Venturi meter	1 each	10,000.00	10,000
River crossings		lump sum	120,000
Road resurfacing		lump sum	10,000
Right of way		lump sum	10,600
Subtotal			$2,280,200
Administration and engineering, 10%			$ 228,000
Contingencies, 15%			342,000
Interest during construction			57,000
TOTAL			$2,907,200
ANNUAL COSTS			
Interest, 4%			$ 116,300
Amortization, 40-year sinking fund at 4%			30,600
Operation and maintenance			7,300
TOTAL			$ 154,200

ESTIMATED COST OF SANTA CLARA RIVER CONDUIT
SESPE FEEDER

(Based on prices prevailing in spring of 1953)

Capacity of conduit: 55 second-feet   Length of conduit: 28,800 lineal feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Diversion works					
Excavation	9,770	cu.yd.	$ 4.00	$ 39,100	
Concrete					
Weir and cutoff	3,620	cu.yd.	35.00	126,700	
Walls	490	cu.yd.	50.00	24,500	
Reinforcing steel	109,900	lbs.	0.15	16,500	
Trashrack steel	16,700	lbs.	0.20	3,300	
Outlet gates			lump sum	4,200	
Sand trap			lump sum	9,800	$ 224,100
Pipe line					
Excavation	43,200	cu.yd.	0.95	41,000	
Backfill	35,140	cu.yd.	0.45	15,800	
Pipe, reinforced concrete, furnish and install, 36-inch dia.	28,800	lin.ft.	11.65	335,500	
Fittings			lump sum	16,800	
Valves, furnish and install					
Air release, 4-inch dia.	2	each	400.00	800	
Blowoff, 8-inch dia.	2	each	1,500.00	3,000	
Gate, 30-inch dia.	2	each	3,000.00	6,000	
Meter and junction			lump sum	7,500	
Road and railroad crossing			lump sum	3,000	
Right of way			lump sum	8,500	437,900
Subtotal					$662,000
Administration and engineering, 10%					$ 66,200
Contingencies, 15%					99,300
Interest during construction					16,500
TOTAL					$844,000
ANNUAL COSTS					
Interest, 4%					$ 33,800
Amortization, 40-year sinking fund at 4%					8,900
Operation and maintenance					4,200
TOTAL					$ 46,900

ESTIMATED COST OF OXNARD PLAIN-PLEASANT VALLEY
DISTRIBUTION SYSTEM

(Based on prices prevailing in spring of 1953)

Capacity of conduit: 120 second-feet   Length of conduit: 174,500 lineal feet

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Excavation	219,000 cu.yd.	$ 0.90	$ 197,100
Backfill	178,400 cu.yd.	0.45	80,300
Pipe, reinforced concrete, furnish and install	174,500 lin.ft.	9.49	1,656,000
Fittings		lump sum	82,800
Valves		lump sum	35,700
Line meters	3 each	4,000.00	12,000
Service outlets	191 each	150.00	28,700
Road and stream crossings		lump sum	5,000
Road resurfacing		lump sum	10,000
Regulating reservoirs		lump sum	250,000
Right of way		lump sum	25,000
Subtotal			$2,382,600
Administration and engineering, 10%			$ 238,300
Contingencies, 15%			357,400
Interest during construction			59,400
TOTAL			$3,037,700
ANNUAL COSTS			
Interest, 4%			$ 121,500
Amortization, 40-year sinking fund at 4%			32,000
Operation and maintenance			15,200
TOTAL			$ 168,700

ESTIMATED COST OF OXNARD-PORT HUENEME
CONVEYANCE AND PUMPING SYSTEM

(Based on prices prevailing in spring of 1953)

Capacity of conduit: 40 second-feet   Length of conduit: 50,700 lineal feet

Item	Quantity		Unit price	Cost	
CAPITAL COSTS					
Pipe line					
Excavation	79,400	cu.yd.	$ 0.95	$ 75,400	
Backfill	65,900	cu.yd.	0.45	29,700	
Pipe--furnish and install, reinforced concrete cylinder					
42-inch dia.	18,550	lin.ft.	14.25	264,300	
36-inch dia.	4,250	lin.ft.	11.65	49,500	
30-inch dia.	15,600	lin.ft.	9.30	145,100	
24-inch dia.	12,300	lin.ft.	7.15	87,900	
Fittings (elbows, reducers, enlargers, etc.)			lump sum	15,400	
Valves--furnish and install					
Gate 36-inch dia.	1	each	1,800.00	1,800	
Gate 30-inch dia.	3	each	1,200.00	3,600	
Gate 24-inch dia.	1	each	800.00	800	
Air release	3	each	400.00	1,200	
Blowoff	3	each	500.00	1,500	
Line meters	2	each	2,900.00	5,800	
Road surfacing	9,500	lin.ft.	0.80	7,600	
Railroad crossings	4	each	200.00	800	
Right of way			lump sum	10,000	$ 700,400
Pumping system					
Well, gravel packed, drilled and cased, 18-inch dia.	16	each	3,750.00	60,000	
Pump and motor installed	16	each	4,330.00	69,300	
Pipe--furnish and install reinforced concrete cylinder					
42-inch dia.	1,500	lin.ft.	14.25	21,400	
30-inch dia.	2,880	lin.ft.	9.30	26,800	
18-inch dia.	3,220	lin.ft.	5.25	16,900	
Valves--furnish and install					
Gate 18-inch dia.	7	each	600.00	4,200	
Check 18-inch dia.	16	each	300.00	4,800	
Land acquisition	40	acres	3,000.00	120,000	
Fencing	9,600	lin.ft.	1.00	9,600	333,000
Subtotal					$1,033,400

ESTIMATED COST OF OXNARD-PORT HUENEME
CONVEYANCE AND PUMPING SYSTEM
(Continued)

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Administration and engineering, 10%			$ 103,300
Contingencies, 15%			155,000
Interest during construction			25,800
TOTAL			$1,317,500
ANNUAL COSTS			
Interest, 4%			$ 52,700
Amortization, 40-year sinking fund at 4%			13,900
Replacement, 30-year sinking fund at 3.5%			1,300
Electrical energy			20,400
Operation and maintenance			6,000
TOTAL			$ 94,300

ESTIMATED COST OF PIRU-LAS POSAS DIVERSION CONDUIT

(Based on prices prevailing in spring of 1953)

apacity of conduit: 80 second-feet   Length of conduit: 67,500 lineal feet

Item	Quantity		Unit price	Cost
APITAL COSTS				
xcavation	167,840	cu.yd.	$ 0.95	$ 159,400
ackfill	123,820	cu.yd.	0.45	55,700
ipe, lock joint concrete cylinder, furnish and install				
60-inch diameter	54,800	lin.ft.	39.53	2,166,200
54-inch diameter	12,700	lin.ft.	32.17	408,600
alves				
Air release, 4-inch dia.	9	each	490.00	4,400
Blowoff, 8-inch dia.	9	each	1,650.00	14,900
Gate, 42-inch dia.	4	each	7,200.00	28,800
ittings			lump sum	128,700
ine meters			lump sum	15,000
tructural concrete	220	cu.yd.	90.00	19,800
iscellaneous metal	14,600	lbs.	0.55	8,000
oad resurfacing	25,000	lin.ft.	1.55	38,800
iver crossings	700	lin.ft.	40.65	28,500
appy Camp Canyon Tunnel	13,500	lin.ft.	165.00	2,227,500
ight of way			lump sum	50,000
Subtotal				$5,354,300
dministration and engineering, 10%				$ 535,400
ontingencies, 15%				803,100
nterest during construction				267,700
TOTAL				$6,960,500
NNUAL COSTS				
nterest, 4%				$ 278,400
mortization, 40-year sinking fund at 4%				73,200
peration and maintenance				17,400
TOTAL				$ 369,000

ESTIMATED COST OF SPREADING WORKS
IN EAST LAS POSAS, AND SIMI BASINS

(Based on prices prevailing in spring of 1953)

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Happy Camp Spreading Works - Capacity 50 second-feet				
Levees	89,220 cu.yd.	0.35	$ 31,200	
Strip checking grounds	50 acres	$300.00	15,000	
Riprap	1,200 cu.yd.	4.00	4,800	
Feeder system to basins	2,600 lin.ft.	7.60	19,800	
Stilling wells	3 each	700.00	2,100	
Corrugated metal culverts, in place, including end sections, and toe-plates	15 each	240.00	3,600	
Right of Way	50 acres	500.00	25,000	$ 101,500
Happy Camp - Simi Lateral - Capacity 30 second-feet				
Excavation	96,000 cu.yd.	0.95	91,200	
Backfill	67,200 cu.yd.	0.45	30,200	
Pipe--furnish and install 42-inch diameter concrete	48,000 lin.ft.	23.77	1,141,000	
Valves		lump sum	7,400	1,269,800
Dry Canyon Spreading Works - Capacity 30 second-feet				
Levees	121,200 cu.yd.	0.35	42,400	
Strip checking ground	70 acres	300.00	21,000	
Stilling well	1 each	700.00	700	
Corrugated metal culverts, in place, including end sections, and toe-plates	18 each	240.00	4,300	
Right of Way	70 acres	2,000.00	140,000	208,400
Subtotal				$1,579,700
Administration and engineering, 10%				$ 158,000
Contingencies, 15%				237,000
Interest during construction				39,500
TOTAL				$2,014,200
ANNUAL COSTS				
Interest, 4%				$ 80,600
Amortization, 40-year sinking fund at 4%				21,200
Operation and maintenance				5,000
TOTAL				$ 106,800

ESTIMATED COST OF FILLMORE WELL FIELD

(Based on prices prevailing in spring of 1953)

'apacity of pumps: 55 second-feet
ross seasonal pumpage: 22,000 acre-feet

Item	Quantity		Unit price	Cost
'APITAL COSTS				
'ell, gravel packed, drilled and cased, 18-inch diameter	18	each	$3,080.00	$ 55,400
'ump, motor and equipment, installed	18	each	4,330.00	77,900
'ipe, welded steel				
18-inch diameter	3,600	lin.ft.	5.25	18,900
30-inch diameter	3,800	lin.ft.	10.10	38,400
'alves			lump sum	5,000
ence	7,200	lin.ft.	1.00	7,200
egulating reservoir			lump sum	20,000
ight of way	30	acres	1,500.00	45,000
Subtotal				$267,800
dministration and engineering, 10%				$ 26,800
ontingencies, 15%				40,200
nterest during construction				3,300
TOTAL				$338,100
NNUAL COSTS				
nterest, 4%				$ 13,500
mortization, 40-year sinking fund at 4%				3,600
eplacement, 30-year sinking fund at 3.5%				2,600
lectric energy				30,800
peration and maintenance				5,000
TOTAL				$ 55,500

ESTIMATED COST OF VENTURA COUNTY AQUEDUCT
TO CONNECT WITH FACILITIES OF METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA
(Based on prices prevailing in spring of 1953)

Capacity of conduit: 25 second-feet Length of conduit: 438,800 lineal feet

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Excavation	625,100 cu.yd.	$ 1.70	$ 1,062,700
Backfill	516,500 cu.yd.	0.76	392,500
Pipe, lock joint concrete cylinder furnish and install,			
36-inch diameter	414,800 lin.ft.	17.30	7,176,000
24-inch diameter	5,000 lin.ft.	8.50	42,500
18-inch diameter	3,800 lin.ft.	6.50	24,700
Valves-furnish and install			
Air release - 3-inch diameter	49 each	325.00	15,900
Blowoff - 6-inch diameter	46 each	1,250.00	57,500
Gate	6 each	2,200.00	13,200
Venturi meter and equipment	2 each	18,000.00	36,000
Fittings (Elbows, reducers, enlargers, manholes, passholes, etc.)		lump sum	334,900
Road surfacing			
Temporary	16,600 tons	4.50	74,700
Permanent	23,700 tons	6.00	142,200
River crossings	3,450 lin.ft.	36.70	126,600
Railroad crossings	620 lin.ft.	38.00	23,600
Santa Susana tunnel	15,200 lin.ft.	165.00	2,508,000
Pumping plant and equipment	2 each	145,500.00	291,000
Right of way		lump sum	76,000
Subtotal			$12,398,000
Administration and engineering, 10%			$ 1,239,800
Contingencies, 15%			1,859,700
Interest during construction			929,800
TOTAL			$16,427,300

ESTIMATED COST OF VENTURA COUNTY AQUEDUCT
TO CONNECT WITH FACILITIES OF METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

(Based on prices prevailing in spring of 1953)

Capacity of conduit: 50 second-feet. Length of conduit: 438,800 lineal feet.

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Excavation	883,600 cu.yd.	$ 1.70	$ 1,502,100
Backfill	675,200 cu.yd.	0.76	513,200
Pipe, lock joint concrete cylinder, furnish and install,			
48-inch diameter	414,800 lin.ft.	32.65	13,543,200
28-inch diameter	5,000 lin.ft.	9.60	48,000
24-inch diameter	3,800 lin.ft.	8.50	32,300
Valves-furnish and install			
Air release - 4-inch diameter	49 each	360.00	17,600
Blowoff - 8-inch diameter	46 each	1,550.00	71,300
Gate	6 each	6,450.00	38,700
Venturi meter and equipment	2 each	18,000.00	36,000
Fittings (Elbows, reducers, enlargers, manholes, passholes, etc.)		lump sum	645,300
Road surfacing			
Temporary	30,300 tons	4.50	136,400
Permanent	42,400 tons	6.00	254,400
River crossings	3,450 lin.ft.	39.90	137,700
Railroad crossings	620 lin.ft.	58.00	36,000
Santa Susana tunnel	15,200 lin.ft.	165.00	2,508,000
Pumping plant and equipment	2 each	244,900.00	489,800
Right of way		lump sum	76,000
Subtotal			$20,086,000
Administration and engineering, 10%			$ 2,008,600
Contingencies, 15%			3,012,900
Interest during construction			1,506,400
TOTAL			$26,613,900

ESTIMATED COST OF VENTURA COUNTY AQUEDUCT
TO CONNECT WITH FACILITIES OF METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA
(Based on prices prevailing in spring of 1953)

Capacity of conduit: 75 second-feet   Length of conduit: 438,800 lineal feet

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Excavation	1,008,900 cu.yd.	$ 1.70	$ 1,715,100
Backfill	763,000 cu.yd.	0.76	579,900
Pipe, lock joint concrete cylinder, furnish and install,			
54-inch diameter	414,800 lin.ft.	38.90	16,135,700
30-inch diameter	5,000 lin.ft.	10.10	50,500
28-inch diameter	3,800 lin.ft.	9.60	36,500
Valves-furnish and install			
Air release - 5-inch diameter	49 each	425.00	20,800
Blowoff - 10-inch diameter	46 each	1,650.00	75,900
Gate	6 each	6,450.00	38,700
Venturi meter and equipment	2 each	20,000.00	40,000
Fittings (elbows, reducers, enlargers, manholes, passholes, etc.)		lump sum	771,300
Road surfacing			
Temporary	30,100 ton	4.50	135,400
Permanent	48,500 ton	6.00	291,000
River crossings	3,450 lin.ft.	43.47	150,000
Railroad crossings	620 lin.ft.	67.00	41,500
Santa Susana tunnel	15,200 lin.ft.	165.00	2,508,000
Pumping plant and equipment	2 each	331,900.00	663,800
Right of way		lump sum	76,000
Subtotal			$23,330,100
Administration and engineering, 10%			$ 2,333,000
Contingencies, 15%			3,499,500
Interest during construction			1,749,800
TOTAL			$30,912,400

ESTIMATED COST OF VENTURA COUNTY AQUEDUCT
TO CONNECT WITH FACILITIES OF METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA
(Based on prices prevailing in spring of 1953)

Capacity of conduit: 100 second-feet Length of conduit: 438,800 lineal feet

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Excavation	1,151,200 cu.yd.	$ 1.70	$ 1,957,000
Backfill	851,000 cu.yd.	0.76	646,800
Pipe, lock joint concrete cylinder, furnish and install,			
60-inch diameter	414,800 lin.ft.	45.60	18,914,900
36-inch diameter	5,000 lin.ft.	13.00	65,000
30-inch diameter	3,800 lin.ft.	10.10	38,400
Valves-furnish and install			
Air release - 5-inch diameter	49 each	425.00	20,800
Blowoff - 10-inch diameter	46 each	1,650.00	75,900
Gate	6 each	14,680.00	88,100
Venturi meter and equipment	2 each	27,000.00	54,000
Fittings (elbows, reducers, enlargers, manholes, passholes, etc.)		lump sum	906,800
Road surfacing			
Temporary	37,000 ton	4.50	166,500
Permanent	54,250 ton	6.00	325,500
River crossings	3,450 lin.ft.	47.11	162,500
Railroad crossings	620 lin.ft.	75.00	46,500
Santa Susana tunnel	15,200 lin.ft.	165.00	2,508,000
Pumping plant and equipment	2 each	411,600.00	823,200
Right of way		lump sum	76,000
Subtotal			$26,875,900
Administration and engineering, 10%			$ 2,687,600
Contingencies, 15%			4,031,400
Interest during construction			2,015,700
TOTAL			$35,610,600

ESTIMATED COST OF VENTURA COUNTY AQUEDUCT TO CONNECT
WITH FACILITIES OF METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

(Based on prices prevailing in spring of 1953)

Capacity of conduit: 150 second-feet   Length of conduit: 438,800 lineal feet

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Excavation	1,464,300 cu.yd.	$ 1.70	$ 2,489,300
Backfill	1,035,000 cu.yd.	0.76	786,600
Pipe, lock joint concrete cylinder, furnish and install			
72-inch diameter	414,800 lin.ft.	60.40	25,053,900
42-inch diameter	5,000 lin.ft.	21.10	105,500
36-inch diameter	3,800 lin.ft.	13.00	49,400
Valves-furnish and install			
Air release - 6-inch dia.	49 each	490.00	24,000
Blowoff - 12-inch dia.	46 each	1,750.00	80,500
Gate	6 each	14,680.00	88,100
Venturi meter and equipment	2 each	27,000.00	54,000
Fittings (elbows, reducers, enlargers, manholes, pass-holes, etc.)		lump sum	1,200,400
Road surfacing			
Temporary	44,300 tons	4.50	199,400
Permanent	66,400 tons	6.00	398,400
River crossings	3,450 lin.ft.	50.70	174,900
Railroad crossings	620 lin.ft.	90.00	55,800
Santa Susana tunnel	15,200 lin.ft.	165.00	2,508,000
Pumping plant and equipment	2 each	501,650.00	1,003,300
Right of way		lump sum	76,000
Subtotal			$34,347,500
Administration and engineering, 10%			$ 3,434,800
Contingencies, 15%			5,152,100
Interest during construction			3,434,800
TOTAL			$46,369,200

ESTIMATED COST OF OAK CANYON LATERAL

(Based on prices prevailing in the spring of 1953)

Capacity of conduit: 40 second-feet

Length of conduit: 4,010 lineal feet

Item	Quantity	Unit price	Cost
CAPITAL COSTS			
Excavation	7,100 cu.yd.	$ 0.90	$ 6,400
Backfill	5,700 cu.yd.	0.45	2,600
Pipe, lock joint concrete cylinder, furnish and install, 42-inch diameter	4,010 lin.ft.	22.30	89,400
Valves - furnish and install			
Air release, 4-inch diameter	2 each	350.00	700
Blowoff, 8-inch diameter	2 each	1,550.00	3,100
Gate, 36-inch diameter	1 each	6,500.00	6,500
Fittings (elbows, reducers, enlargers, etc.)		lump sum	9,200
Right of way		lump sum	4,000
Pumping plant and equipment		lump sum	38,500
Subtotal			$160,400
Administration and engineering, 10%			$ 16,000
Contingencies, 15%			24,100
Interest during construction, none			---
TOTAL			$200,500

ESTIMATED COST OF OAK CANYON DAM AND RESERVOIR
WITH STORAGE CAPACITY OF 7,500 ACRE-FEET

(Based on prices prevailing in spring of 1953)

Elevation of crest of dam: 1,110 feet
Elevation of crest of spillway: 1,100 feet
Height of dam to spillway crest, above stream bed: 170 feet

Capacity of reservoir to crest of spillway: 7,500 acre-feet
Capacity of spillway with 5-foot freeboard: 2,000 second-feet

Item	Quantity	Unit price	Cost	
CAPITAL COSTS				
Dam				
Exploration		lump sum	$ 10,000	
Diversion of stream and dewatering of foundation		lump sum	1,000	
Stripping topsoil	25,000 cu.yd.	$ 0.60	15,000	
Foundation excavation				
Abutment	22,000 cu.yd.	1.50	33,000	
Channel	91,000 cu.yd.	0.60	54,600	
Embankment				
Impervious	586,400 cu.yd.	0.65	381,200	
Random	1,000,300 cu.yd.	0.55	550,200	
Rock riprap	39,400 cu.yd.	4.00	157,600	
Drilling grout holes	6,400 lin.ft.	3.00	19,200	
Pressure grouting	4,200 cu.ft.	4.00	16,800	$1,238,600
Spillway				
Excavation	900 cu.yd.	1.50	1,400	
Concrete				
Weir and cutoff	230 cu.yd.	35.00	8,000	
Floor	420 cu.yd.	30.00	12,600	
Walls	420 cu.yd.	40.00	16,800	
Reinforcing steel	75,600 lbs.	0.15	11,300	50,100
Outlet Works				
Tower concrete	580 cu.yd.	80.00	46,400	
Concrete encasement	470 cu.yd.	40.00	18,800	
Steel pipe, 48-inch dia.	1,020 lin.ft.	25.00	25,500	
Tower inlet valve, 30-inch dia.	4 each	3,000.00	12,000	
Needle valve, 42-inch dia.	1 each	12,000.00	12,000	
Miscellaneous metal work	17,500 lbs.	0.40	7,000	121,700
Reservoir				
Land acquisition		lump sum	48,000	
Clearing	160 acres	10.00	1,600	49,600
Subtotal				$1,460,000
Administration and engineering, 10%				$ 146,000
Contingencies, 15%				219,000
Interest during construction				36,000
TOTAL				$1,861,000