STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

EARL WARREN, Governor
C. H. PURCELL, Director of Public Works
EDWARD HYATT, State Engineer

Bulletin No. 52-B

SALINAS BASIN INVESTIGATION

SUMMARY REPORT

1946

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DIVISION OF WATER RESOURCES

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Oliver P. Bardin*	Roy Gleason
Henry Clausen	Arnold Tottini

*Deceased

THE BOARD OF SUPERVISORS

COUNTY OF MONTEREY

SALINAS, CALIFORNIA

August 27, 1946

Mr. Edward Hyatt
State Engineer
Division of Water Resources
Department of Public Works
Sacramento, California

Dear Mr. Hyatt:

Reference is made to the report on the Salinas Basin Investigation which has been carried on under joint agreement between the State Department of Water Resources and the County of Monterey for the past eighteen months.

The undersigned have both been in close touch with the work as carried on by Mr. Russel Simpson of your staff, and on Friday, August 16th, Mr. Zander and Mr. Simpson met with the Water Conservation and Flood Control Committee of Monterey County, and discussed the matters covered by the report.

It was the opinion of the said committee that the report adequately covers conditions in the basin and presents conclusions in which the committee concurs, and which will form the basis of the ultimate design of a plan for the correction of the conditions existing in the basin.

Yours very truly,

Chas. L. Pioda.

Chas. L. Pioda, Chairman
Salinas Valley Flood Control and
Water Conservation Committee of
Monterey County.

H. F. Cozzens

H. F. Cozzens, Secretary.

ACKNOWLEDGMENTS

The Flood Control and Water Conservation Committee of the County of Monterey aided the investigation in an advisory capacity. Special mention is made of the close and helpful cooperation of Mr. Charles L. Pioda, Chairman of the Committee, who contributed to the report an historical account of the development of water utilization in the Salinas Basin.

Acknowledgment is made of the valuable assistance and technical advice given in the conduct of the investigation by Mr. Howard F. Cozzens, in charge of the Engineering Department of the County of Monterey and member of the California Water Resources Board. The records collected under his supervision by the county on water levels at wells in the Salinas Basin from 1933 to 1944 have been included in the basic data submitted in Bulletin 52A.

Mr. A. A. Tavernetti, Monterey County Farm Advisor, gave valuable assistance and cooperation during the course of the investigation. He made available the information on irrigation practices in the Salinas Basin collected by his office and by the University of California Extension Service under the direction of Dr. F. J. Veihmeyer. All water samples collected during the investigation were submitted through the Monterey County Farm Advisor to the Division of Plant Nutrition, Agricultural Experiment Station, University of California College of Agriculture for analysis by Mr. J. C. Martin, Associate Chemist. Comments by Mr. Martin on the qualities of water in the basin were especially helpful.

As a concurrent study in cooperation with this investigation, the Division of Irrigation, Soil Conservation Service, United States Department of Agriculture, Mr. W. W. McLaughlin, Chief of Division, (retired) and Mr. George D. Clyde, his successor, made a survey of irrigation practices and determination of consumptive uses of water in the Salinas Basin. Under the direction of Mr. A. T. Mitchelson, Senior Irrigation Engineer, Messrs. Paul A. Ewing, Senior Irrigation Economist, and Harry F. Blaney, Senior Irrigation Engineer, prepared a report on "Irrigation Practices and Consumptive Uses of Water in the Salinas Basin".

The field work on the survey of irrigation practices in the Salinas Basin was done by Messrs. Lew E. Hanks, S. Burkett Johnson, Clinton W. Renny, and C. Warren Hink under the direction of Mr. Clyde Seibert of the Watsonville branch office of the Soil Conservation Service, United States Department of Agriculture. Information on soils in the basin was submitted by Messrs. Seibert and Johnson.

CHAPTER I

INTRODUCTION

The Board of Supervisors and the Flood Control and Water Conservation Committee of the County of Monterey became concerned in April 1944, over the intrusion of saline water in the ground water supply utilized for irrigation, domestic and industrial purposes in the lower reaches of the Salinas Basin near Monterey Bay. The entire agricultural and urban development in the basin depends on an adequate supply of ground water of good quality.

There had been some abandonment of wells in the Salinas Basin near the bay shore due to excessive salinity as early as 1938. Accelerated encroachment of the contamination occurred in 1943, and the matter was brought to public attention in 1944. The County of Monterey and the Department of Public Works, State of California, executed a contract on July 10, 1944, providing for maintenance in cooperation an investigation of the water resources of the Salinas Valley in Monterey County and conditions relative thereto which obtain in the valley or affect the water supplies available therefor. It further provides that the Department shall prepare a report based on the investigation setting forth the physical facts pertinent to water supply and to salt water intrusion, and if possible, incorporate findings as to a method or methods of solving the problems involved.

Field work by the Division of Water Resources on the Salinas Basin Investigation was begun on July 17, 1944. Collection of data for this report was interrupted in December, 1945, and resumed for general measurement of water levels prevailing at wells in March, 1946. The work accomplished was financed as follows:

State of California (Division of Water Resources)	$13,700
County of Monterey	13,700
Total	$27,400

Development of Water Utilization in Salinas Basin

Mr. Charles L. Pioda, Chairman of the Flood Control and Water Conservation Committee of Monterey County, an agency of the board of supervisors, has been, during the past half century, intimately associated with the development of the utilization of the water resources in the Salinas Basin. Mr. Pioda, who is an authority on this subject, has submitted the following historical account:

"In reviewing the agricultural development of the Salinas Valley, particularly the phenomenal records of production and returns for the recent war years, it is difficult to understand why the pioneer cartographers of California designated it on their maps as the 'Salinas Desert' unless we realize that the factors that have made the transformation possible have been water and irrigation.

"Water first for the Missions, when the Padres with their Indian neophytes and crude tools led it through hand made ditches from nearby streams, was used to irrigate the fields surrounding those of San Antonio (1771) and Soledad (1791). They produced fresh vegetables, fruit, and wine and had reasonable assurance of cereal crops even in dry years.

"The vagaries of California's rainfall were as unpredictable and extreme then as now. Detailed studies, made by H. B. Lynch, Engineer of the Metropolitan Water District of Southern California, of all available information obtainable concerning the rainfall and climate of Southern California from 1769 on, convinced him of the existence of cycles of dry years eclipsing in length and intensity any that have occurred since actual rainfall records have been kept. The same conclusion was reached by Mr. C. E. Grunsky, C. E., who made a study of water conditions in the Southern San Joaquin Valley and the Tulare Lake Basin after the drought of 1896.

"No doubt such a dry cycle made it necessary to resort to irrigation to provide sufficient food for the hungry Indians that would gravitate to the Missions at such times. Secularization of the California Missions occurred in 1833 and abandonment of all irrigation followed.

"The census of 1850 reported the total California population as 92,597 and that of Monterey County as 1872. This was after the State's population had been increased and Monterey County's reduced as a result of the discovery of gold. The population of Monterey City was reported as 1,092, thus leaving only 780 in the remainder of the County, which at that time included all of the present San Benito County.

"The agricultural population of 780 persons was scattered over the County on land grants that had been made by the Mexican Governor. There were 65 grants, including 648,730 acres in Monterey County and 16 grants, covering 233,046 acres in San Benito County, which were eventually patented by the Federal land office. These grants covered practically all of the valley areas. Land had little value and cattle ranching, the chief enterprise, required relatively large areas. The result was a very sparse settlement.

"Cultivated crops were very limited and methods of tillage primitive. In the gold rush days even such crops as grew were left unharvested because of lack of labor. In 1850 beef cattle sold in San Francisco at $20 to $30 per head.

"The period from 1849 to 1858 was a prosperous one for the ranchers, but in 1859 a decline in their fortunes began, principally because of the competition of better quality beef from other nearby states. The dry seasons of 1862-63 and 1863-64 almost put the original cattle raisers out of business. Streams dried up, feed was short or non-existent, stock died by the thousands or were killed for their hides and tallow, and the best land in the vicinity of Salinas was offered for sale at 50 cents per acre.

"No actual records of precipitation in Monterey County exist for this period. At San Francisco 13.74 inches of rain fell during the winter of 1862-63 and 10.08 during the following winter as compared with a 72 year mean of 22.32 inches. The precipitation at this station for the season of 1850-51 was only 7.42 inches, the shortest of record, but very little has been written about this earlier drought, while the latter has received much prominence in connection with the shift from cattle raising to grain farming. However this actually only served to precipitate a change from a type of agriculture which was becoming unprofitable, to one which was developing possibilities of favorable returns to an increasing number of people. Thus the change could not have been long delayed had the dry years not occurred.

"The exact year when grain was first grown commercially in Monterey County has not been determined, but one of the earliest attempts was by J. B. Hill, who grew 95 acres of barley near Salinas. The returns were such that in 1854 Mr. Hill had 'fenced in 400 acres of plowed land and was making preparations to enclose as many more'. This fencing was necessary to prevent the trespassing of cattle and the expense was prohibitive for the isolated farmer. In 1867 the County Recorder reported that 7,000 acres of land had been enclosed in two years and that 11,000 acres had been improved and put under cultivation.

"The Eleventh Census, the first to take irrigation into consideration, summarizes the status in Monterey County in 1890 as follows:

> 'Irrigation where practiced is conducted on a small scale, the water of springs and rivulets being utilized by individuals having land conveniently situated. On the low ground near the mouth of the Salinas River there were reported to be 60 flowing wells upon farms in 1890, most of them being not far from Castroville. They range in depth from 60 to 189 feet, the average being 136 feet, and they discharge only about 3 gallons per minute. They are reported to fluctuate with the season, many of them ceasing to flow in summer, and in winter barely discharging at the surface of the ground. At Salinas about 10 miles from the coast, most of the deep wells are pumped by windmills.'

"Diversion of water from the Salinas River for irrigation was the first phase of irrigation to assume considerable importance in the American period.

Two claims for small amounts of water were filed in 1877; the first large claim was that of Mr. Brandenstein for 50,000 miner's inches, filed in 1882. The use which was made under this later claim was described in 1890 as follows:

> 'The Canal - takes water from Salinas River in the Southern part of the Country....It is built on the east side of the river for a distance of 6 miles. The average width is 10 feet and the cost was $25,000. The canal, owned by a corporation, was begun in 1884 and first used about 1888. The principal crop irrigated at present is alfalfa. The water supply is fairly good, although the river is dry at times, the water sinking into the bed of the stream.'

"Seventy claims to water from the Salinas River and its tributaries were filed prior to 1901. Only a fraction of them were consummated by the actual use of water. The important ones actually built were one from the San Lorenzo Creek near King City, - two from the Salinas River, one at King City and one at Gonzales, and three from the Arroyo Seco. One, the original Arroyo Seco canal, is still in use at Greenfield, the others had varying and unsatisfactory periods of use and have long since been abandoned.

"The torrential nature of the streams from which water was diverted by these canals, particularly the Salinas, made it extremely difficult to operate and maintain headgates during flood periods, while the small flow of water after the winter's flood subsided made them inadequate for summer irrigation.

"The second important phase of irrigation development was that of pumping directly from the river. In 1897 the Spreckels Sugar Company built steam powered pumping plants to supply its ranches near King City and Soledad with water from the Salinas River. In later years a number of other large steam plants were installed along the river as far north as Salinas. This method of pumping from the river was subject to the same seasonal limitations as was gravity irrigation.

"The third phase, of vastly greater importance than preceding attempts at irrigation, was entered when large scale use began to be made of the water in the underlying gravels of the Salinas Valley. While in the early days of grain farming, limited use had been made of the wells heretofore mentioned for irrigation by installing centrifugal pumps operated by steam threshing engines to raise the water, it was not until the building of the Spreckels factory, near Salinas, in 1897 that the capacity of the underground gravel was demonstrated. In that year in order to obtain satisfactory water for its operations, the Spreckels Sugar Company dug six wells four feet in diameter and 190 feet deep and connected them to central centrifugal pumps with a combined capacity of 5,500 gallons per minute. In addition about 10,000 gallons per minute of water was pumped from the surface flow of water in the Salinas River. All surplus water was used to irrigate adjacent land largely owned by the Spreckels Sugar Company.

"In 1904 at the King City Ranch of the Spreckels Sugar Company, a similar installation was made of six 20-inch wells 70 feet deep and one of the pumps previously pumping from the river was connected with them. This pump had a capacity of about 6,000 gallons per minute and about 400 acres of alfalfa were irrigated therefrom.

"Driven by the necessity of growing the greater part of the beets for the operation of its factory, the Spreckels Sugar Company arranged to lease a number of large ranches, install pumping plants, and prepare them for irrigation. By 1919 there were 11 such pumping plants in operation with a combined capacity of 80,000 gallons per minute, not including the factory plants.

"By 1915 it was found that the fall flow of water in the Salinas River was insufficient to supply the needs of the factory and an additional installation of wells with 8,000 gallons per minute pumping capacity had to be made. By 1919 a further increase in the supply from wells was required and by 1924 when deep well pumps came into general use, resort was had to that type of pump to provide the necessary supply of water. Finally all old installations had to be abandoned and the full supply needed obtained from new wells and deep well pumps.

"There have been three important steps in the development of the existing pumping situation. First was the extension of electric power lines in 1911 to King City, thus making power available throughout the area.

"Second was the perfection of a reasonably efficient motor driven deep well pump, which could be installed in a single well and operated with a minimum of attention.

"Third was the introduction of vegetable growing in the Salinas Valley on a broad scale in 1924, which gave impetus to the extensive agricultural improvement of the area.

"The financial success that followed this pioneer work caused rapid development of land suitable for vegetable growing. Large pumping plants were abandoned and individual wells and pumps provided in their stead. This development has been continued during the passing years until at the present time little first class land remains undeveloped.

Pumping From Wells and Total Irrigation in Salinas Valley
Monterey County 1889 - 1929

Year	Pumped Wells Number	Pumped Wells Capacity Gal. per Min.	Farms Irrigated	Total Acreage Irrigated
1889	*		21	891
1899	*		88	6,675
1909	102	196,235	258	15,056
1919	606	407,310	451	47,336
1929	1,176	1,012,242	803	80,981

U. S. Department of Commerce - Bureau of Census - Reports of Agriculture 1890-1930
*No Report

"In the report on the study of the water conservation problems of the Valley made by the State Department of Public Works, Division of Water Resources in 1931 and 1932 (financed jointly by the State of California and the counties of Monterey and San Luis Obispo) casual mention is made of salt water encroachment in one or two wells at the lower end of the valley near the shore of Monterey Bay.

"The report also voiced the opinion that little apprehension need be felt concerning the sufficiency of the supply of water for all needed purposes including irrigation, within a stated limit of variation of water levels.

"Fortunately from that time up to the present there has been ah average of more than normal rainfall. During this period a large additional acreage in the Valley has been brought under irrigation together with more double cropping, a number of additional irrigation wells have been bored near the Monterey Bay Shore and elsewhere, a large industrial plant using continuously about 1,000 gallons of water per minute has been established there, and some water has been diverted for use on non-overlying lands.

"As a consequence, during recent years an increasing number of wells in that vicinity have become so salty that their use had to be abandoned or at least greatly restricted. In the Spring of 1944 conditions became so bad that a number of farmers and land owners from this area appealed to the Board of Supervisors for help. Under instructions from the Board, County Engineer Howard Cozzens arranged with the State Department of Public Works, Division of Water Resources to make a study of the situation; the cost to be borne equally by the State and Monterey County. In accordance with this understanding, an investigation was commenced by the Division in July, 1944.

"The report which follows gives factual data acquired in 18 months of field work. It also analyzes the present water situation in the Valley from

San Ardo to Monterey Bay as far as available data will permit. Such conclusions as are contained herein should be accepted as coming from the most authoritative source available, namely the office of the State Engineer of the State of California."

Prior Investigations by State and County

The Water Conservation Committee of Salinas Chamber of Commerce became concerned over the apparent depletion of the ground water supplies in the Salinas Basin in 1930 during the last dry period. The committee requested the Division of Water Resources to make an investigation referred to above by Mr. Pioda and if necessary lay out a plan for conservation of a portion of the runoff normally wasting into Monterey Bay. After a preliminary examination it was decided at that time that an investigation should be limited to an effort to determine (1) whether the natural replenishment of the underground basin was adequate to supply the draft, (2) the water requirements of the then unirrigated lands, and (3) the amount of water which could be made available by conservation works. The 1931 legislature appropriated funds for such an investigation, the appropriation to become available as matched by funds locally and deposited in the State Treasury.

The County of Monterey appropriated $5,000 and the County of San Luis Obispo $500 of matching funds toward the conduct of an investigation of the Salinas Basin by the Division of Water Resources in 1931 and 1932. The Division published a report in 1933 entitled, "Report on Salinas Basin Preliminary Investigation", and a supplement entitled "Record of Water Levels at Wells in Salinas Basin".

The 1933 report of the Division summarizes hydrologic information on the Salinas Basin. It refers to and contains a summary of an unpublished report by Geologist Chester Marliave on the geology of all known dam sites in the Salinas River stream system. A conclusion is set forth in the report that the average long time natural replenishment of the underground basin was probably sufficient for a water demand based on use in 1932, but if the draft from 1928 to 1931 was to recur continuously there would exist a permanent overdraft which must in time be remedied. It will be hereafter set forth that the previous peak demand in 1931 was exceeded in 1939, and from 1943 to 1945, inclusive.

It is set forth in the 1933 report by the Division that the quality of water in the Salinas Basin as a whole is excellent, and there appeared at that time no intrusion of salt water from the bay to the pumping strata. It is further stated: "Two things might happen which would impair the quality in the northern end of the valley and more particularly near the ocean: (1) the water plane might be so lowered that ocean water would penetrate the pumping strata. (2) Since pumping draft has been substituted for natural disposal of water a tendency may be found for the salt content of the underground water to increase. It will be noted that it does increase to the northward." The occurrence of both of these predictions are hereafter set forth.

It was recommended in the 1933 report by the Division in view of the narrow margin of surplus over demand that local interests should continue measurements of water elevations at representative wells in the Salinas Basin. County Engineer Howard F. Cozzens of the County of Monterey has since maintained records of water levels at 116 selected wells in the basin at the commencement and at the close of each irrigation season.

Previous Reports

Six early reports have been published on conditions in Salinas Valley. These are:

(1) Charles D. Marx - Report on Irrigation Problems in the Salinas Valley. This report covers problems incident to gravity diversion systems in Salinas Valley in 1901. Pumping from ground waters was unimportant at that time.

(2) Homer Hamlin - (1904) Water Resources of the Salinas Valley - Water Supply Paper 89. Good information on a few possible reservoir sites are set forth. These were considered from the standpoint of water conservation.

(3) W. O. Clark - (1916) Measurements of Depth to Water in Wells in the Salinas Valley (unpublished). These records were obtained from the U. S. Bureau of Soils and included in the supplement of the Division of Water Resources' report in 1933.

(4) M. H. Lapham and W. H. Heileman - (1901) Soil Survey of the Lower Salinas Valley. This early soil survey covered the area from King City to Monterey Bay in Salinas Valley.

(5) E. J. Carpenter, A. E. Kocher and F. O. Youngs - (1924) Soil Survey of the King City Area. This is a resurvey of the area from Soledad to King City and new survey from King City to Wunpost.

(6) E. J. Carpenter, and Stanley W. Cosby - (1925) Soil Survey of the Salinas Area. This is a resurvey of the area from Soledad to Monterey Bay.

Investigation by Corps of Engineers, U. S. Army

A survey of the entire drainage basin of the Salinas River for flood control and related matters was ordered by the Chief of Engineers, U. S. Army on July 11, 1939. Completion of the comprehensive flood control survey report is awaiting availability of information developed in the concurrent hydrologic investigation of the Salinas Basin by the Division of Water Resources, Department of Public Works, State of California.

In connection with the flood control survey studies, possibilities of channel training and bank protection works were developed that appeared to fit into any general plan of flood control and water conservation, separate consideration of which was warranted. A proposed interim report of the Chief of Engineers, U. S. Army, which gave separate consideration to such works, was referred by the Governor of California through the Director of Public Works to the State Engineer on February 8, 1946 for review and report thereon. The review and report by the State Engineer was included in the views and recommendations of the State of California on the proposed interim report. It was recommended that the project be approved and be authorized by Congress for immediate construction. The Rivers and Harbors Act, enacted in 1946, included the Salinas River channel improvement project, as set forth in the interim report.

Scope of Investigation

The general scope of the Salinas Basin Investigation is set forth in the contract entered into by the State and County. The contract provides for investigation of the water resources of the Salinas Valley in Monterey County and conditions relative thereto which obtain in the valley or affect the water supplies available therefor. It is further provided that the Department shall prepare a report based on the investigation setting forth the physical facts pertinent to water supply and to salt water intrusion, and if possible, incorporating findings as to a method or methods of solving the problems involved.

It was the expressed desire of the county officials that the investigation include a review of the hydrologic conditions in the Salinas Basin since the time of the previous investigation by the Division of Water Resources in 1931 and 1932. Such a review appeared to be necessary in view of probability of current overdrafts on ground waters.

The scope of the investigation was further crystallized by the Division after the completion of the preliminary phase of the work in September, 1944.

There would be no duplication of work done in the previous investigation by the State and County. The scope of the investigation was limited to water conservation problems, since a comprehensive flood control survey was being conducted concurrently by the United States Engineering Department. There appeared to be but little irrigable land in the Salinas Basin in the County, which, when brought under irrigation, would not detract from the source of supply common to the lands presently irrigated. The investigation was limited to a determination and solution of problems involved in maintenance of a water supply adequate both in quantity and quality for all present beneficial uses in the basin and for future uses that offered a threat to further depletion of the common supply.

The first consideration in the Salinas Basin Investigation was ascertainment of whether water problems requiring water conservation actually existed. This involved a determination of overdrafts, if any, on the ground water supplies. After discovery of necessity for water conservation, the investigation was pointed to find the following:

1. Where additional water is needed.
2. How much supplemental water is presently and will ultimately be required.
3. Where the sources of surplus water that waste from the basin are located.
4. What feasible methods are available for capture of a portion of the waste to the bay.
5. How the captured water can be made available for use in areas of overdraft.

A detailed knowledge of the physical situation is necessary in order to appreciate the problems and grasp the solutions that appear.

CHAPTER II

SUMMARY AND CONCLUSIONS

Information collected in the Salinas Basin Investigation, analyses of basic data, and results are set forth in Bulletins 52, 52A and 52B of the Division of Water Resources. Bulletin 52 contains an introductory statement, summary and conclusions, and detailed technical analyses. The introductory statement includes an account of water resources development in the basin, information leading up to the investigation, a list of prior investigations and reports, and statement as to scope of the present investigation. The results of analyses free of technical discussion, and a concise statement of possible solutions of water conservation problems are set forth in the summary and conclusions. All basic data used in the analyses are published in Bulletin 52A. The Introduction, Summary and Conclusions of Bulletin 52 have been reprinted as Bulletin 52B.

Description of Salinas Basin

Knowledge of general physical conditions in the Salinas Basin, reasons for division of the valley floor into five areas, composition of the valley fill, and present development in the area is necessary to appreciate the problems revealed in results of analyses and to grasp the solutions that appear. A brief description of these features follows.

(1) General

The Salinas River system drains a mountain and foothill area of about 3,950 square miles, exclusive of the Soda Lake watershed, which is a closed interior valley with an area of about 660 square miles. The tributary watersheds are grouped for analytical purposes in accordance with runoff characteristics. The main thread of the Salinas River is about 170 miles long and has a general northwesterly course somewhat parallel to the coast to its mouth in Monterey Bay near Castroville.

The lower 93 miles of the Salinas River meanders through the valley floor from near Wunpost to the Bay. The gross area of the valley floor is about 239,000 acres, all in Monterey County. This area is classified into four general groups based on a cultural survey in 1944 as follows:

Group	Area in Acres
Irrigated land	125,423
Irrigable dry-farm and grass land	51,981
Native vegetation	30,419
Miscellaneous	31,195
Total	239,018

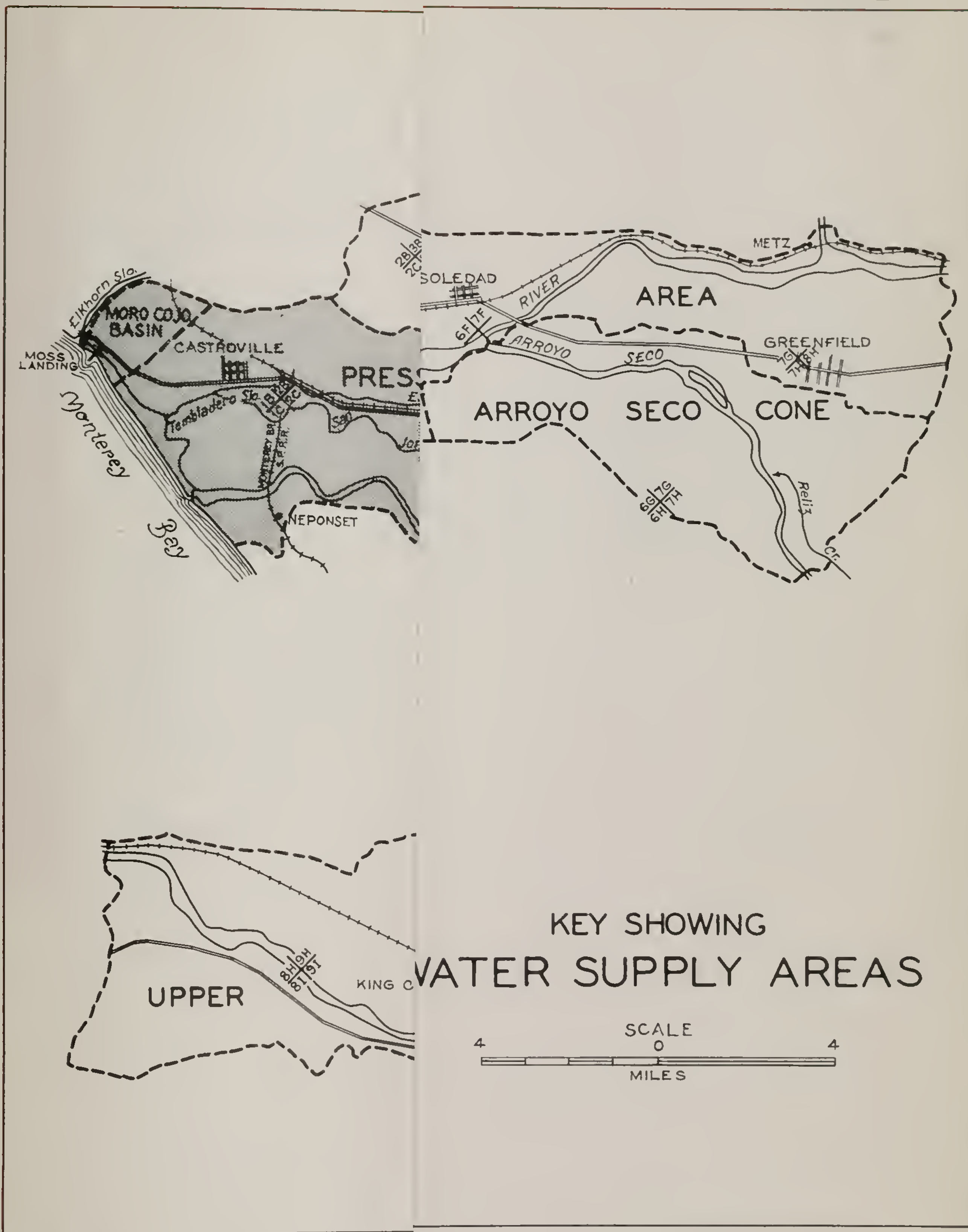
All water requirements in the basin for irrigation, domestic, municipal and industrial purposes are supplied from ground water with the exception of a limited acreage near Greenfield, which receives supplemental early season gravity water from the Arroyo Seco, a tributary of the Salinas River. The principal source of replenishment of the ground water is percolation of stream flow in the channels of the Salinas River and its tributaries. There is probably some contribution directly from precipitation on portions of the valley floor in wet years.

(2) Division of Valley Floor into Five Areas

The valley floor was divided into five areas for analytical purposes. The division is in accordance with sources of replenishment of ground water for the respective areas served as indicated by direction of flow of ground water after the close of the 1944 irrigation season. The areas are designated as Pressure, East Side, Forebay, Arroyo Seco Cone, and Upper Valley. The boundaries of the areas are shown on the key map submitted as Plate 1. These areas are not in any way to be confused with sub-basins. All information collected during the investigation indicates the ground waters therein are interconnected with the exception of possible instances of closed lenses in the East Side Area and a more or less effective ground water barrier immediately south of Moro Oojo Slough. The acreages embraced in the respective areas into which the valley floor is divided, as shown on Plate 1, are as follows:

Area	Acreage
Pressure	80,980
East Side	36,477
Forebay	40,373
Arroyo Seco Cone	22,115
Upper Valley	59,073
Total	239,018

The Pressure Area embraces a strip with an average width of about 4-3/4 miles extending southerly from Monterey Bay to Gonzales. The pumping zones in this area are largely supplied by ground water flow from the upstream Forebay Area. With the exception of a pocket of free ground water in the vicinity of Quail Creek, the aquifers in the Pressure Area are partially confined. The confinement appears to effectively prevent percolation to the pumping zone directly from precipitation and from the river channel between Gonzales and the bay. A deep ocean canyon, a short distance offshore in the bay and at right angles to the main axis of the Pressure Area, is probably the northern boundary of the partially confined waters in the area. The confined waters appear to be generally interconnected with the free ground water to the east, which permits inflow and outflow from and to the East Side Area.


Elkhorn Slo.
MORO COJO BASIN
MOSS LANDING
CASTROVILLE
Monterey Bay
Tembladero Slo.
PRES
NEPONSET
SOLEDAD
RIVER
METZ
AREA
ARROYO
SECO
GREENFIELD
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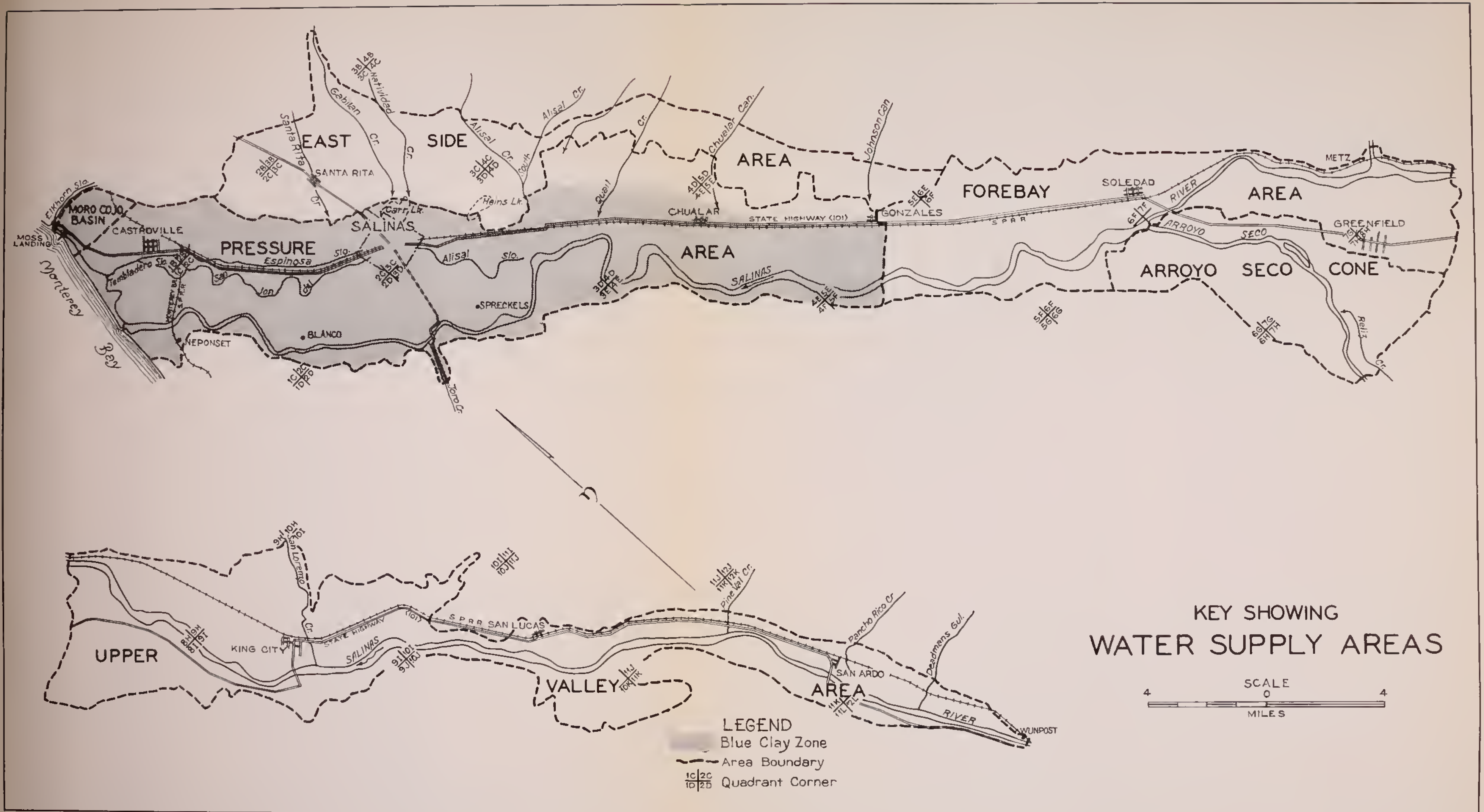

EAST SIDE AREA
PRESSURE AREA
FOREBAY AREA
ARROYO SECO CONE
UPPER VALLEY AREA
MORO COJO BASIN
MOSS LANDING
CASTROVILLE
SALINAS
SANTA RITA
CHUALAR
GONZALES
SOLEDAD
METZ
GREENFIELD
SPRECKELS
BLANCO
NEPONSET
KING CITY
SAN LUCAS
SAN ARDO
WUNPOST
Monterey Bay
STATE HIGHWAY (101)
S P R R
Elkhorn Slo.
Santa Rita Cr.
Gabilan Cr.
Natividad Cr.
Alisal Cr.
South Alisal Cr.
Quail Cr.
Chualar Can.
Johnson Can.
Carr Lk.
Heins Lk.
Espinosa Slo.
Tembladero Slo.
San Jon Gul.
Alisal Slo.
SALINAS RIVER
ARROYO SECO
Reliz Cr.
Toro Cr.
San Lorenzo Cr.
Pine Val. Cr.
Pancho Rico Cr.
Deadmans Gul.
KEY SHOWING
WATER SUPPLY AREAS
SCALE
4 0 4
MILES
LEGEND
Blue Clay Zone
Area Boundary
1C 2C 1D 2D Quadrant Corner

The principal source of ground water replenishment in the East Side Area is percolation from the channels of streams that head on the west slope of the Gabilan Range between Santa Rita Creek and Johnson Canyon. There may be some contribution to ground water directly from precipitation in the wetter years. There has been surface outflow from the East Side Area in only five of the past 16 years. The entire water crop on the area, under average conditions of rainfall and runoff, is retained there and locally disposed of through evapo-transpiration and percolation. In years when the consumption of ground water in this area exceeds replenishment, the boundary line between the Pressure and East Side Areas tends to move easterly; and conversely, whenever the replenishment exceeds consumption of ground water in the East Side Area, the west boundary thereof tends to shift westerly.

The principal source of ground water replenishment in the Forebay Area is ground water outflow from the Upper Valley Area and the Arroyo Seco Cone. Percolation from the channel of the Salinas River is also important. There is probably no contribution to ground water direct from precipitation on the area, except in very wet years such as 1940-41.

The principal source of ground water replenishment in the Arroyo Seco Cone is percolation from the channels of the Arroyo Seco and its tributary Reliz Creek. A major portion of the water diverted from the Arroyo Seco through the Clark Canal to the Greenfield district percolates to the water table in the cone. Since the average annual precipitation over this area is about nine inches, there is probably no contribution to ground water direct from precipitation on the cone except in very wet years.

The principal source of replenishment of ground water in the Upper Valley Area is stream channel percolation from the Salinas River and its tributaries between Metz and San Ardo. There may be some percolation to the water table from precipitation over the area in wet years. There is no opportunity for any appreciable ground water inflow from the south because the alluvial fill of the main valley terminates at the south end of San Ardo Valley.

(3) Valley Fill

Knowledge of the composition of the valley fill is based on observations of ground water behavior and a study of well logs and well driller information. Logs of 420 wells distributed over the valley floor were identified as to well locations. Several lines of logs plotted along the main axis of the valley and at right angles thereto show the valley fill to be complex with numerous lenses from the side tributaries interspersed within the principal influence of the Salinas River.

The only consistent strata in the fill appear to be two continuous layers of blue clay between Gonzales and Monterey Bay. The blue clay zone appears to average more than $4\frac{1}{2}$ miles in width and abuts the easterly base of the Santa Lucia Range on the westerly edge of the valley floor. There are two aquifers with partially confined waters throughout the blue clay zone. The average depth to near the center of the upper aquifer is about 180 feet and it is referred to as the 180-foot aquifer. There is a stratum of impervious blue clay over-lying the 180-foot aquifer. Another stratum of blue clay separates the 180-foot aquifer from the deeper water-bearing formation, designated the 400-foot aquifer. There were 660 wells operating in 1945, that were perforated exclusively in the 180-foot aquifer, and 37 that tapped only the 400-foot aquifer. There were two wells known to be perforated in both aquifers. The 180-foot aquifer supplies more than 95 per cent of the current total demand for water in the Pressure Area. There may be deeper water-bearing formations below the 400-foot aquifer that have not been explored. The 400-foot aquifer extends farther to the east than the 180-foot aquifer between Carr Lake and Santa Rita. There are inadequate well logs through the 400-foot aquifer in the southerly portion of the Pressure Area to support a conclusion that both aquifers have a common forebay.

The ground waters generally through the East Side, Forebay and Upper Valley Areas and the Arroyo Seco Cone are unconfined. The gravels, sands and silts since deposition in these areas have been in process of change through decomposition to clay. All shades of material are indicated by the logs. Any stratum may range from coarse open gravel to fine sand, sandy and gravelly clays, and clays with varying arrangements in succeeding strata. The clays in these areas of free ground water are yellow or red in color and are in unconnected lenses. Some pockets of water-bearing gravels are under slight pressure due to partial local confinement. Heavy yielding wells with slight drawdowns are generally obtained in these areas. Yields in excess of 200 gallons per minute per foot of drawdown are quite common. However, there are instances of wells of low yield, inadequate to support irrigation draft, which are largely confined to strips of overlap in the outwash of deltas of various tributaries on the east side of the valley.

(4) Present Development

The character and boundary lines of all types of culture on the alluvial fill in the Salinas Basin were mapped in 1944 and again in 1945. The locations of all operating wells and such of the non-operating wells on which well logs were available or which were used as measuring wells were also mapped during the cultural surveys. Aerial photographic reproductions were used as a base for the surveys.

(a) Crops

Cultural classification of the entire valley floor was made in accordance with estimated normal water consumption. Water-consuming vegetation that has substantially the same consumptive uses was placed in the same class. The grouping included 10 classes of irrigated culture, one of irrigable land, four of native vegetation and five in miscellaneous. A summary of irrigated culture and of potential irrigable land in 1944 follows:

	Acres in Valley Floor Area					
Culture	Pressure	East Side	Forebay	Arroyo Seco	Upper Valley	Total
Alfalfa	2,201	1,978	5,208	2,997	2,018	14,402
Lettuce	19,457	1,952	2,551	353	---	24,313
Truck	9,097	1,414	5,146	1,178	1,515	18,350
Beans	8,926	7,048	5,247	8,374	6,480	36,075
Sugar Beets	3,595	537	1,563	173	9,893	15,761
Artichokes	2,942	---	---	---	---	2,942
Guayule	2,927	1,599	3,102	1,057	98	8,783
Seeds	544	109	---	---	107	760
Orchard	250	281	710	424	1,322	2,987
Grain	151	236	109	45	509	1,050
Irrigated Sub-total	50,090	15,154	23,636	14,601	21,942	125,423
Irrigable dry-farm and grass	12,540	18,815	4,182	2,289	14,155	51,981
Irrigated and Irrigable Total	62,630	33,969	27,818	16,890	36,097	177,404

A total area of approximately 126,700 acres was irrigated in 1945. This represents an irrigation development of about 71 per cent of the total irrigable area in the valley.

Soil surveys were made in 1924 and 1925 in the Salinas Valley by the United States Department of Agriculture, Bureau of Chemistry and Soils. Extensive changes have been made in land uses and irrigation practices in the basin since the time of these surveys. Additional information is now available through more than 20 years of demonstration of the adaptability of the lands to a wide range of crops, of proper irrigation systems to prevent damage from erosion, of necessity for drainage in certain areas, and other improvements.

(b) Wells

Since most of the area in the Salinas Valley lies in Spanish land grants, the valley floor was divided into quadrants to facilitate description of well locations. The same quadrant system shown on the 1933 map of the Division of Water Resources was used on the cultural maps. The location of quadrant corners is indicated on Plate 1. The first number and letter of a well designation indicates the quadrant within which the well is located. The following number indicates the well number within that quadrant. If there is no final letter in the well designation, an operating irrigation well is indicated. Final letters n, m, i, d and p in the well designation respectively indicate "non-operating", "municipal", "industrial", "domestic", and "plugged".

There were 636 operating irrigation wells and 61 industrial and municipal wells in the Pressure Area in 1945. This represented approximately half of the irrigation, municipal and industrial wells in Salinas Valley at that time. There are also numerous non-operating and domestic wells of negligible draft throughout the valley.

Inflow and Outflow

An ascertainment of overdraft involves a determination of the total inflow and outflow to and from the valley floor. The inflow embraces the total water crop, which is made up of surface tributaries and ground water inflow to the valley floor and rainfall directly thereon. There is no importation of water to the valley. The outflow is made up of the total disposition of water on the valley floor and comprises surface and ground water outflow to the bay, all evaporation and plant transpiration within the valley and exportation from the basin. For purposes of hydrologic analyses, a 16-year base period from 1929-30 to 1944-45, inclusive, was used. This 16-year period was used as a base because the average runoff and precipitation were close to the mean of the long time record. Further reasons for using this period are that within it the hydraulic data on inflow, outflow and ground waters are more complete and the current problems have arisen within that time. The Arroyo Seco, on which continuous records of discharge are available during the past 44 years, has been used as guide stream in supplying a runoff index to reproduce the records for the unmeasured tributaries. The average rainfall at Salinas during the past 44 years is almost equal to the 72-year mean. The precipitation at Salinas has been used as an index for determination of the average seasonal precipitation on the valley floor each year during the 16-year base period.

(1) Water Crop

The average annual total water crop received by the valley floor during the 16-year base period has been determined to be approximately 946,000 acre-feet. This amount has been derived from sources directly tributary to the five areas in the valley floor approximately as follows:

Water Crop in Acre-Feet

Area	Surface Tributary Inflow	Rainfall on Valley Floor	Marine Intrusion	Lateral Percolation
Upper Valley	516,000	52,000	0	Negligible
Arroyo Seco Cone	133,000	18,000	0	Negligible
Forebay	14,000	32,000	0	Slight
East Side	6,000	43,000	0	Negligible
Pressure	32,000	94,000	6,000	Slight
Total	701,000	239,000	6,000	Negligible

That portion of the water crop directly tributary to the Upper Valley Area and Arroyo Seco Cone, which was not retained in those areas, flowed into the Forebay Area. Also that portion of the water crop tributary to the Forebay and East Side Areas, which was not retained in these areas, flowed into the Pressure Area.

(2) Outflow

The average annual total outflow from the basin during the 16-year base period was determined to be approximately 533,000 acre-feet. This is made up as follows:

Source	Average Outflow Acre-feet
Salinas River at Spreckels (measured)	476,000
Toro Creek and foothills to the northwest	6,000
East Side Area via Tembladero Slough	1,000
Rainfall runoff from valley floor below Spreckels	7,000
Irrigation Return and sewage effluent	13,000
Ground water	30,000
Exportation	Negligible
Total	533,000

The single item of measured surface outflow of the Salinas River near Spreckels makes up approximately 90 per cent of the total outflow from the basin.

(3) Retention and Consumption

The difference between the average total water crop and the outflow indicates an average annual retention in the valley floor of about 413,000 acre-feet during the 16-year base period, which figure includes the estimated average marine intrusion of 6,000 acre-feet per annum and precipitation on the valley floor.

The average annual retention of water plus or minus the average change in ground water storage during the 16-year base period is a measure of the average annual water consumption on the valley floor for the period. There was no appreciable change in ground water storage during the base period except a decrement in the East Side Area and in the fringe of free ground water in the easterly portion of the Pressure Area, which approximated 30,000 acre-feet. The average annual decrement in ground water storage was about 2,000 acre-feet for the period, which added to the average annual retention, by this method of approach indicates an average annual consumption of 415,000 acre-feet. Use of the integration method as an independent approach to determine the average consumption of water during the period closely checked the inflow-outflow method.

The retention of water in the valley floor in 1944-45 was approximately 383,000 acre-feet and decrease in ground water storage was about 50,000 acre-feet, which indicates a total consumption in that year of 433,000 acre-feet. The average acreage under irrigation during the 16-year base period was about 107,000 acres as compared with 126,700 acres irrigated in 1945.

Percolation

Observations of retention of surface inflow from the Arroyo Seco within the Arroyo Seco Cone during the period from October 1, 1944 to September 30, 1945, were used as a basis for a formula to calculate the annual percolation from that stream in the cone during the 16-year period. The average annual percolation was calculated to be approximately 51,000 acre-feet, which represents about 40 per cent of the average inflow from the Arroyo Seco. A portion of the surface outflow from the Arroyo Seco Cone into the Salinas River also percolates in the Forebay Area. The natural regulation of the inflow through percolation from the Arroyo Seco in 1944-45 was about 60,000 acre-feet, which represents 58 per cent of the total inflow during that year.

The combined stream flow percolation during the 16-year base period in the Upper Valley and Forebay Areas was calculated as a differential. A summary of the calculated average stream flow percolation that has occurred in various portions of the valley during the 16-year base period follows:

Area	Average Percolation Acre-Feet
Arroyo Seco Cone	51,000
Upper Valley and Forebay (combined)	163,000
East Side	5,000
Pressure	1,000
Total	220,000

(1) Ground Water Movement

The average ground water movement from all areas in the valley, except the Upper Valley, during the 16-year base period was calculated as follows:

Area	Acre-feet
Arroyo Seco Cone	31,000
Forebay	91,000
East Side (net)	0
Pressure (net)	30,000

Ground water may move either from the East Side to the Pressure Area, or from the Pressure to the East Side Area depending on the time of the year and the degree of wetness of the year. The net effect during the period has probably been an average annual ground water outflow from the Pressure Area to the East Side Area in the order of 1,000 acre-feet.

(2) Sources of Surplus Water

An average annual discharge of approximately 444,000 acre-feet, or about five-sixths of the total outflow from the Salinas Basin, has during the 16-year base period flowed from the Forebay Area in the form of surface waste. About one-third of the remaining one-sixth has occurred as ground water outflow to the bay largely during the winter season when irrigation demand was light. The remaining estimated average annual waste has the following sources:

Source	Waste in Acre-Feet
Tributaries North of Arroyo Seco	36,000
Outflow from rainfall on valley floor	10,000
Irrigation return and sewage	13,000

Surface wastes from tributaries to the valley north of the Arroyo Seco and from precipitation on the valley floor are unreliable. The outflow from these two sources is negligible in years that are slightly subnormal in precipitation. The irrigation return and sewage outflow, which occur in the blue clay zone of the Pressure Area, are comparatively steady under prevailing irrigation practices. This latter source might provide some firm water in the Pressure Area.

Approximately 80 per cent of the total surface inflow from watersheds tributary to the East Side Area during the 16-year period has been retained in that area. There was 100 per cent natural regulation through percolation of the flows of these streams in 11 out of 16 years. The small average surplus water in these streams occurs so infrequently that consideration of enhancement of the supply through local development in the area is unwarranted. A complete solution of the problems of overdraft must include salvage of a portion of the large surface outflow from the Forebay Area.

Underground storage within the 60-foot zone below ground surface in the order of 100,000 acre-feet, on which draft has never been made, exists in the Forebay Area and the lower portion of the Arroyo Seco Cone.

Underground Hydrology

The study of the underground reservoir of the Salinas Valley includes a determination of rates of safe yield and overdraft in the Pressure Area with contamination from marine intrusion as the controlling factor. The study also embraces consideration of unconfined waters in the valley fill to define areas where present draft exceeds average annual recharge, and to ascertain the location and extent of surplus underground storage.

(1) Fluctuations in Water Levels

There was a fluctuation in water levels at wells in the 180-foot aquifer in the Pressure Area of about 15 feet during the irrigation seasons of 1944 and 1945. All but less than one foot of the average recovery in water levels at wells in the aquifer after the close of the irrigation season in 1944 occurred prior to any replenishment of ground water in the basin from percolation of stream flow and precipitation. The small average recovery of less than one foot after the Salinas River commenced to flow during the winter of 1944-45 indicates little seasonal depletion in the supply to the aquifer from the Forebay Area in 1944. The seasonal depletion was slightly greater in 1945 than during the previous year. It is concluded that fluctuations in water levels and hydraulic gradient in the 180-foot aquifer are largely governed by pressure relief induced by draft. Seasonal depletion of ground water storage in the Forebay Area above the blue clay zone has a minor effect in years close to normal, such as 1944 and 1945.

There has been no important change in storage of unconfined ground waters in Salinas Valley during the past 16 years, except in the East Side Area and in the Quail Creek section of free ground water included in the Pressure Area. The aquifers in the blue clay zone in the Pressure Area remain saturated at all times. Water levels in the Upper Valley and Forebay Areas have had a narrow range of fluctuation of about six feet between the low in 1931 and the high in 1941. The estimated average recession in water levels during the past 16 years in the East Side Area was about five feet and in the free ground water in the Quail Creek section of the Pressure Area was about 10 feet.

(2) Draft

The consumption of water, expressed in unit values of feet in depth per acre, has been determined by the Division of Irrigation of the Soil Conservation service for various cultural classifications under irrigation practices prevailing during 1944-45 in the different areas in the valley. The unit values were determined for normal climatic conditions and also under the conditions prevailing during the years 1943-44 and 1944-45. A summary of average unit values of normal consumptive uses, expressed in feet in depth per acre follows:

Consumption of Ground Water and Precipitation on Valley Floor

Area	Irrigated	Irrigable Dry-Farm and Grass*	Native Vegetation	Miscellaneous
Pressure	1.69	1.10	3.81	1.73
East Side	1.86	1.10	4.51	1.10
Forebay	2.17	.75	2.68	1.53
Arroyo Seco Cone	2.12	.75	3.10	.73
Upper Valley	2.13	.83	2.47	1.88
Entire Valley	1.93	.99	2.94	1.59

*Average annual precipitation on valley floor is approximately equal to consumption by irrigable dry-farm and grass.

The determined unit values of consumptive uses in 1943-44 and 1944-45 expressed as percentages of the above normal unit values follow:

Area	Per Cent of Normal	
	1943-44	1944-45
Pressure	99.0	100.5
East Side	99.0	100.5
Forebay	98.3	99.6
Arroyo Seco Cone	98.3	99.6
Upper Valley	97.8	100.0

The unit values of normal consumptive uses were applied to the estimated average acreages in the various cultural groups during the 16-year base period to obtain the approximate average consumption in each area in the valley during the period. The 1944-45 unit values were applied to the acreage irrigated in 1945 to obtain the consumption in that year. The comparative results follow:

Area	Consumption in Acre-Feet	
	16-year Average	1944-45
Pressure	141,000	149,000
East Side	48,000	53,000
Forebay	78,000	81,000
Arroyo Seco Cone	38,000	40,000
Upper Valley	109,000	110,000
Total Valley	414,000	433,000

It may be noted that the above 16-year average consumption in the entire valley of 414,000 acre-feet obtained by this method closely checks that previously calculated by the inflow-outflow method.

The estimated amount of pumping from ground water in 1944-45 to supply a portion of the above consumption was about 353,000 acre-feet for irrigation purposes and 14,000 acre-feet for domestic, municipal and industrial uses.

The pumping in 1943-44 was estimated to be about 348,000 acre-feet for irrigation purposes and 13,000 acre-feet for domestic, municipal and industrial uses. It is estimated that more than 90 per cent of the domestic, municipal and industrial pumping was in the Pressure Area. The estimated pumping for irrigation use in the various areas during each of the two years follows:

Area	Ground Water Pumped in Acre-feet	
	1943-44	1944-45
Pressure	104,000	107,000
East Side	33,000	34,000
Forebay	77,000	77,000
Arroyo Seco Cone	47,000	48,000
Upper Valley	87,000	87,000

The domestic, municipal and industrial pumping in the Pressure Area was about 12,000 acre-feet in 1943-44, and 13,000 acre-feet in 1944-45.

(3) Overdrafts

The only overdrafts on ground water in the Salinas Valley are in the East Side and Pressure Areas. There is no present shortage of ground water in the remainder of the basin and no threat of deficiency under probable ultimate development.

(a) East Side Area

The total consumption of water within the East Side Area was about 52,000 acre-feet in 1943-44 and 53,000 acre-feet in 1944-45. Direct precipitation on the area respectively supplied about 38,000 and 39,000 acre-feet in 1943-44 and 1944-45. Consumption of ground water within the East Side Area approximated 14,000 acre-feet during each of the two years. Excluding consideration of the net difference in ground water inflow and outflow (which is believed to be small), consumption of ground water within the East Side Area during the 2-year period exceeded replenishment by approximately 23,000 acre-feet. Under normal conditions of consumption and replenishment and with demand based on cultural classifications prevailing during the 2-year period, the overdraft would be in the order of 7,000 acre-feet per annum. The normal consumption of ground water in the adjoining area of 5,000 acres overlying free ground water in the Pressure Area is about 3,000 acre-feet per annum. The only ground water replenishment during the 2-year period for this latter area was escape of water from the partially confined aquifers in the Pressure Area.

An approximate area of 18,000 acres of dry-farm and grass land in the East Side Area offers the greatest possibility for expansion of irrigated lands in the Salinas Basin. The possibility for increased annual consumption of ground water in this area is in the order of 14,000 acre-feet under maximum development.

The ultimate overdraft, including that estimated to presently exist, may approach 21,000 acre-feet per annum.

(b) Pressure Area

A direct method of determination in 1944-45 of rate of flow through the 180-foot aquifer in the Pressure Area was used. This involved collection of the following information:

1. Periods of lag in stabilization of water levels in the aquifer after changes in rates of draft;
2. Positions of trough in pressure surface elevations; and
3. Draft above and below the trough in the pressure surface.

The determined rates of flow through the 180-foot aquifer showed wide variations under different conditions of draft. Under an average minimum draft of 17 cubic feet per second for three weeks the rate of flow appeared to be about 85 cubic feet per second with an approximate rate of outflow to the bay of 68 cubic feet per second. An average maximum rate of draft of about 330 cubic feet per second prevailing for three weeks appeared to induce a rate of flow down the valley of about 275 cubic feet per second and a rate of infiltration of sea water from the bay of about 55 cubic feet per second. Under conditions of draft generally dispersed throughout the Pressure Area, the safe yield rate of draft on the 180-foot aquifer was calculated by this direct method to be about 230 cubic feet per second. Varying conditions of draft concentrations may cause variations in the rate of safe yield. The combined rate of draft from the 180-foot aquifer in 1945 exceeded the rate of safe yield for a period of more than six months during the irrigation season. The rate of excess draft varied from about 15 to 100 cubic feet per second between April 8 and October 13, in 1945. The overdraft was made up by movement of water through the aquifer toward the inland from Monterey Bay. The cumulative amount of marine intrusion during this period in 1945 was about 12,000 acre-feet. However, the cumulative amount of the excess in rate of total draft over and above the rate of safe yield in 1945 was about 20,000 acre-feet. This latter quantity represents the approximate amount of water that must be substituted for present draft on the aquifer in order to eliminate actual overdraft. Actual overdraft is equal to the cumulative difference between downstream flow of water through the aquifer, and safe yield, plus marine intrusion. Substitute water to eliminate actual overdraft should be available over a 6-month period at rates up to a maximum of 100 cubic feet per second to prevent marine intrusion.

The ultimate overdraft on the 180-foot aquifer, including that estimated to presently exist, may approach 55,000 acre-feet per annum less such additional water as may be extracted from the 400-foot aquifer under safe yield conditions. The annual outflow from the 400-foot aquifer and other water bearing formations, if any, in addition to the 180-foot aquifer and surface water zone was estimated as 8,000 acre-feet in 1944-45. This comparatively small waste, a substantial portion of which occurs during the winter season, makes it unsafe to assume that the deeper water-bearing formations offer much toward a solution of the problems other than temporary relief.

Quality of Water

Approximately 97 per cent of the estimated total percolation from stream flow, during the 16-year base period, occurred in the area south of Gonzales. In this area about 70 per cent of the runoff normally comes from the Santa Lucia Range below Paso Robles. Waters emanating from the Santa Lucia Range are of good quality, whereas those coming from the Diablo Range have comparatively high concentration of solubles.

The quality of the waters in the Salinas River above Gonzales is most important during two different periods of the year when greatest contribution to water occurs. A rapid rate of percolation occurs from the first river flow during the runoff season following cessation of fall irrigation when water levels in the free ground water areas are near the low point for the year. A rapid rate of percolation from the river also occurs after the commencement of the irrigation season on or about the first of April and continues until the river flow fails. Fortunately the early and late flows in the Salinas River are usually supplied entirely from tributaries heading on the Santa Lucia Range where the precipitation is approximately twice that on the Diablo Range. The east side streams coming from the Diablo Range ordinarily do not commence to flow during the winter season until substantially full recharge of ground water has occurred in the areas supplied by river percolation. Only that portion of ground water formations lying east of the Salinas River influence between Metz and San Ardo usually receives replenishment from surface waters containing high concentrations of salte. The contaminated ground waters in the easterly portions of the San Lorenzo and Pancho Rico deltas may be accounted for by the salinity in the sources of replenishment.

There is a general increase in salinity in the Salinas River during the course of its flow from San Ardo toward Monterey Bay. The quality of water during periods of low flow is largely influenced by the ground water inflow. The summer flow below Blanco is too saline for irrigation use. Likewise the dry weather season flows in tributaries to Tembladero Slough are unsafe for irrigation use with the exception of Espinosa Slough, which is largely made up of industrial wastes of fair quality.

(1) <u>Contamination in Forebay Area</u>

The amount of water pumped for irrigation use in the Forebay Area in 1944 has been estimated as about 77,000 acre-feet. The consumption of water on the irrigated land during the irrigation season in 1944 was about 35,000 acre-feet. The precipitation during the summer season in 1944 on the irrigated land in that area supplied about 2,000 acre-feet of consumptive uses. The unconsumed irrigation water in the amount of approximately 44,000 acre-feet largely returned to the pumping zone. This represents nearly half of the estimated ground water movement from the Forebay Area. A large part of the replenishment in the Forebay Area is made up of ground water flow from the Upper Valley Area and Arroyo Seco Cone. The Forebay Area thus ultimately receives unconsumed irrigation water applied to all irrigated lands in the valley south of Gonzales. The unconsumed irrigation water becomes charged with natural soil solubles and applied fertilizers, which are carried to the pumping zone. The ground water flow from the area is limited by the bottleneck at the head of the adjacent Pressure Area. The quality of water throughout the Forebay Area is quite spotted, ranging from excellent to fair. The type of ground water solubles apparently accumulating in various portions of the Forebay Area is similar in character to the contamination from surface water (perched water) in the vicinity of Salinas in the Pressure Area.

(2) <u>Normal Good Water in Pressure Area</u>

The normal good water in the 180-foot aquifer is restricted to a belt between a line about two miles inland from the bay and a short distance south of Blanco. Analyses of samples from six control wells in this belt show substantially no change in quality of water between 1932 and 1944. The average of analyses of samples from 35 wells in this belt in 1944 with mineral concentrations ranging from about 350 to 450 parts per million has been taken as indicative of normal good water in the 180-foot aquifer.

A reconnaissance of quality of water in the 400-foot aquifer in 1944-45 failed to reveal any contamination in this water-bearing formation. Total solubles run quite uniform between about 275 and 325 parts per million. Laboratory analyses of samples from three wells indicate excellent quality of water in this aquifer for irrigation, municipal and industrial uses.

(3) 180-Foot Aquifer South of Blanco

All samples of water collected from wells in the 180-foot aquifer in 1944-45 south of Blanco showed extra solubles as compared with normal good water in that aquifer. Samples from 25 wells showed total salinity ranging from about 1200 to 1900 parts per million. The character of contaminated waters in this belt is quite similar to that in the Forebay Area for comparable degrees of concentration of solubles. The upper limit for safe use for irrigation as to total solubles for this type of contamination appears to be about 1700 parts per million. Heavy soils with slow drainage predominate in this area and the rainfall is normally inadequate to cause leaching of salt concentrations from the top-soil.

(4) Marine Intrusion

Marine intrusion has occurred in the 180-foot aquifer in recent years as a result of overdraft. There was no evidence of such contamination in October, 1945 at any well more than 1-3/4 miles from the bay shore. The average distance of the fringe of contamination from the bay shore at that time was about 1½ miles. The total length of the contaminated strip, including the Moro Cojo sub-basin in the Moss Landing Area, was about 6½ miles. The gross area embraced within the zone of contamination was approximately 6,000 acres, about 25 per cent of which was in the Moss Landing Area. The wells within about half of the contaminated zone contain waters that are presently either unusable for irrigation, or are near the upper limit in salinity for safe use.

The inland rate of encroachment of the fringe of contamination was slow between August 1944 and August 1945. The average movement during this period of one year was about 600 feet. Although the rate of encroachment was slow during that time, the concentration of salts rapidly increased in wells of heavy draft within the zone of contamination. Chlorides more than doubled in the water solubles in many of the wells during the year. Pumps of low draft for domestic purposes may skim off water of good quality from the top of the aquifer where there are no nearby wells of heavy draft to surge the salinity to the upper waters.

The maximum distance that marine intrusion may encroach in the 180-foot aquifer is the most inland position of the trough in the pressure surface under conditions of heaviest draft. If water supply and draft conditions in 1945 were maintained indefinitely, salinity encroachment might approach, but not extend beyond a line, which would embrace between it and the bay shore an area of about 9200 acres irrigated in 1945. The small difference in head due to difference in specific gravity of water on both sides of the fringe of contamination would have negligible effect on the distance of encroachment.

Evaluation of Water Problems

The average annual total water crop received by the valley floor in the Salinas Basin, exclusive of marine intrusion, is approximately 940,000 acre-feet. The normal annual total consumption of water on the valley floor under present stage of development is about 433,000 acre-feet. This may approach 509,000 acre-feet under ultimate development. The average amount of unconsumed water under present and ultimate development shows availability of large local water supplies to solve the water conservation problems. Total consumption, as herein used, includes all evapo-transpiration on the valley floor from precipitation and from surface and ground water supplies, as distinguished from draft, which is limited solely to consumption of ground water. It is necessary to consider safe yields of ground water supplies under existing conditions in the various areas and drafts thereon to evaluate the problems.

Primary sources of ground water troubles are overdrafts. Deterioration in quality of water and receding water levels are manifestations of overdraft. Present and estimated ultimate irrigated acreages and annual drafts, and safe yield of ground water supplies under existing conditions in the various areas on the valley floor are summarized in the following tabulation:

Area	Irrigated Acreage		Draft in Acre-feet		Safe Yield
	Present	Ultimate	Present	Ultimate	Acre-feet
Upper Valley	22,000	36,000	58,000	76,000)	190,000
Forebay	23,800	27,800	49,000	55,000)	
Arroyo Seco Cone	14,800	16,800	22,000	25,000	51,000
East Side	15,900	33,900	12,000	26,000	5,000
Pressure	50,200	62,600	103,000	138,000	83,000
Total	126,700	177,100	244,000	320,000	------

The foregoing tabulation shows safe yield in excess of estimated ultimate drafts in the Upper Valley, Forebay and Arroyo Seco Cone Areas. However, such excess in safe yield, under existing conditions, is not available to make up the deficiency in the East Side and Pressure Areas due to the bottleneck at the lower edge of the Forebay Area, which limits the rate of ground water outflow therefrom. The safe yield in the Forebay Area may be materially increased through establishment of greater ground water movement from that area, as hereafter discussed.

Present and estimated ultimate overdrafts in the East Side and Pressure Areas and wastes that occur from the basin are summarized as follows:

Item	Acre-feet
Present combined overdrafts	27,000
Ultimate combined overdrafts	76,000
Average annual surface outflow	503,000
Average annual ground water outflow	30,000

A salvage in the order of five per cent of the average total outflow would eleminate present overdrafts. Ultimate demand may necessitate salvage which would approach 15 per cent of the average total outflow.

Methods of Conservation

Methods of conservation that appear possible of incorporation in a solution of water problems in the Salinas Basin are hereafter briefly discussed. The methods deal both with salvage of wastes to relieve overdrafts and protection of quality of ground waters.

Surface reservoir sites on the Arroyo Seco, San Antonio River, Nacimiento River, and the Salinas River south of San Ardo are receiving attention in the current flood control survey by the Corps of Engineers, U. S. Army. Development of surface storage for water conservation hinges on the suitability of the site for flood control. When and if surface storage is developed in the Salinas Basin south of Soledad for flood control purposes, consideration should be given to benefits that may be received from participation therein for purposes of water conservation.

(1) General Available Methods of Salvage

Salvage of applied irrigation water unconsumed on crop land in the Pressure Area can best be accomplished by increasing the irrigation efficiency so as to eliminate all pumping in excess of beneficial requirement. Outflow from irrigation return is limited to the blue clay zone in the Pressure Area. Drainage from the blue clay zone is not susceptible of re-use due to the generally prevailing high concentration of solubles. The indicated method of salvage is elimination of unnecessary pumping, which would reduce the occurrence of waste by a corresponding amount. The total amount of applied irrigation water unconsumed on irrigated crop land in the blue clay zone was in excess of 50,000 acre-feet in each of the two years 1943-44 and 1944-45. The portion of such water unconsumed on irrigated crop land, which may properly be included in beneficial requirement, has not been determined.

The effluent from the sewage disposal plant of the City of Salinas is near the borderline of safety for irrigation use. Dilution of the effluent with water pumped from the 400-foot aquifer would probably make it safe for irrigation use. The amount available for use in 1945 during the irrigation season was in the order of 2,000 acre-feet. Annual carrying charges on the combined effluent and dilution water were estimated at $2,500. The combined flow during the irrigation season of about 3,000 acre-feet, while small, would have low unit cost.

Packing shed washwater and ice plant cooling water in and near Salinas is mostly discharged into Espinosa Slough. About half the total average discharge of approximately 12 cubic feet per second during 1945 was pumped from the slough for irrigation re-use. The water is of fair quality. Due to probability of further deterioration in quality and a liklihood of eventual abandonment of water cooling at ice plants in the area, the salvage may be classed as a temporary supply providing about 1,000 acre-feet during the irrigation season. Cost of salvage for use on abutting lands would be nominal.

Some attention was given to the matter of inducing increased percolation in the Arroyo Seco Cone in the 1933 report by the Division of Water Resources. Further consideration was given in the recent investigation to increased percolation in other areas of free ground water. In any event a complete solution of the problems of overdraft must include salvage of some of the surface waste from the Forebay Area. There was almost complete failure of surface outflow from the Salinas Basin during five years of record since 1912. (1913, 1924, 1931, 1933 and 1939.) Additional water for use in critical dry years obviously is dependent on cyclic storage either in surface reservoirs or underground. Cyclic storage underground is generally preferable where empty storage capacity exists, or where space for additional natural percolation may be created by draft on unused underground storage.

Underground storage exists in the Forebay Area and in the lower portion of the Arroyo Seco Cone in the order of 100,000 acre-feet within the 60-foot zone below ground surface on which no draft has ever been made. Empty capacity for underground storage existed in the East Side Area in 1945 between the water table and the 60-foot zone below ground surface in the order of 200,000 acre-feet. A comparable additional capacity then existed in the East Side Area between 60 and 12 feet below ground surface.

The Forebay Area and lower portion of the Arroyo Seco Cone are favorably situated in respect to areas of overdraft in the basin for utilization of unused underground storage to eliminate the deficiencies. The underground reservoir also has a strategic location for flexible operation in conjunction with direct diversion from the Salinas River and released surface storage from any important reservoir site in the stream system with the exception of those on the Arroyo Seco. Diversion from underground storage should be restricted to territory south of the head of the 180-foot aquifer a sufficient distance to prevent drawdown from having any material effect on the existing ground water flow through the Pressure Area.

(2) Conservation of Quality of Water

Further protective measures pointed toward conservation and improvement of quality of water supplies in the Salinas Basin deserve equal consideration with those designed to maintain adequacy in quantity. Slow movement of ground water operates against rehabilitation after contamination has occurred. Many "defective wells" in the older irrigated sections in the basin are either still in operation, or have been abandoned without being properly plugged. The term "defective well", as here used, means any well drilled, dug or excavated, which encounters unpotable water, or water containing substances toxic to crop plants, and which is so constructed as to permit the commingling of such contaminated water with waters of better quality, or a flowing well which lacks the necessary devices to control waste of water therefrom.

There are acceptable methods for preventing construction of defective wells and also for repair of defective wells if they are to be continued in use. The construction of defective wells as above defined should of course be prohibited. Any existing defective wells, which are to be continued in use, should be repaired. Whenever a defective well is abandoned it should be plugged under competent supervision.

In order to enable intelligent action under the foregoing protective measures, standards for uniform logging of wells should be adopted. All well logs should be filed with a central governmental agency within a limited time after completion.

As far as is known there are no defective wells in the 400-foot aquifer. There are doubtless many defective wells in the 180-foot aquifer, long since abandoned, that either cannot be found, or which it would be impractical to clean and effectively plug. However, establishment of protective measures would tend to retard contamination from surface water.

Proposed Solution

Irrespective of the method of salvage employed to capture some of the surface outflow from the Forebay Area, a complete solution must embrace a plan of delivery of water impounded, either in surface or underground reservoirs, to locations where additional water is required. Released surface storage and increasad percolation in the stream beds south of Gonzales, without artificial means of conveyance, would be ineffective to relieve overdrafts in the East Side and Pressure Areas. No site was found for gravity diversion from the Salinas River between San Ardo and Monterey Bay. Diversion from the lower 93 miles of the river appears to be limited to pumping installations. Pumping plants so located that direct diversion of surplus spring flow from the river, released surface storage, and unused underground storage could be diverted for conveyance to locations of overdraft, would offer ideal flexibility.

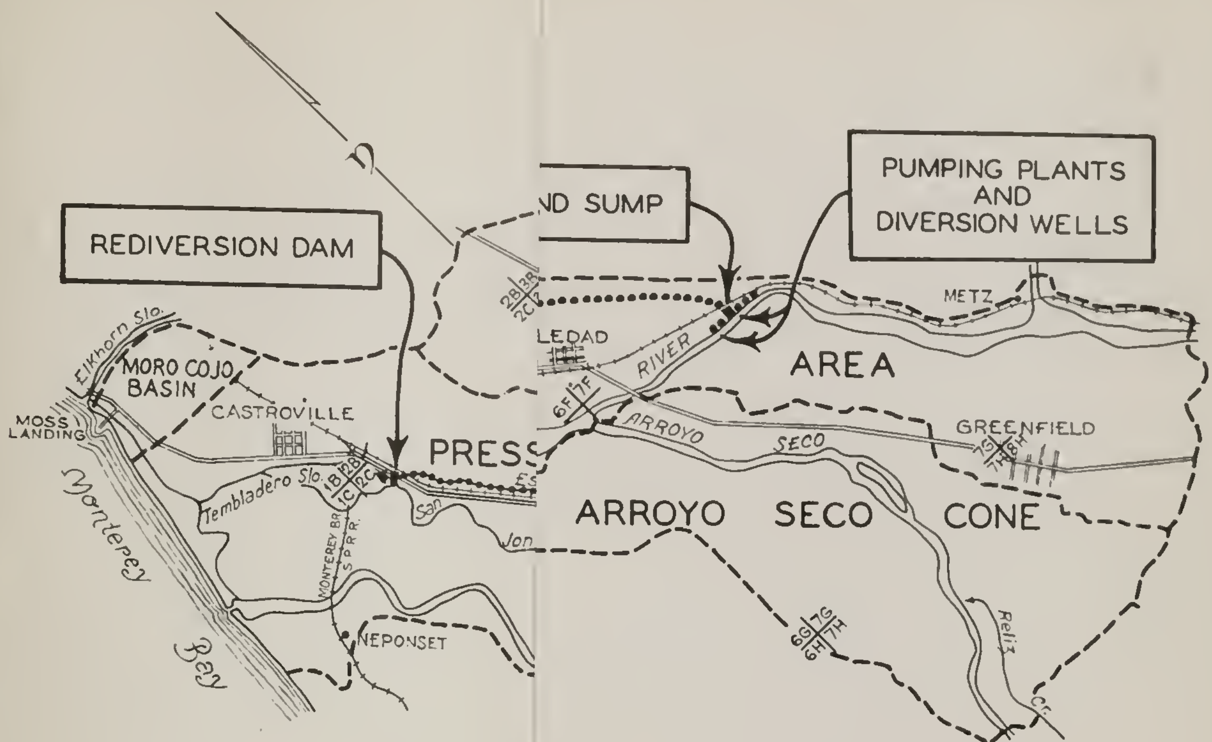
Favorable sites for diversion wells appear to be situated in the vicinity where the course of the Salinas River changes from the east toward the west side of the valley about three miles southeast of Soledad. The yields of wells with 16-inch casings near the river in this location range from 100 to 300 gallons per minute per foot of drawdown with capacities up to about 2,800 gallons per minute. Water diverted in this location and raised to elevation about 265 feet on the bench north of the river could be conveyed by gravity to a major portion of the East Side Area and to any point in the Pressure Area. The estimated average gross pumping lift at this site would be about 100 feet.

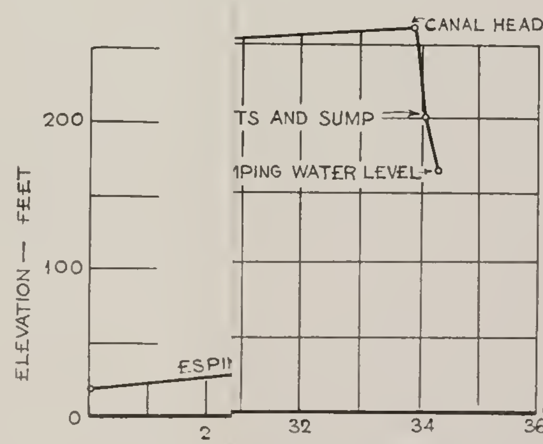
A diversion system heading at this location was selected for a reconnaissance to calculate approximate costs of construction as of the end of the year 1945. More detailed surveys might demonstrate other possible routes to be more feasible.

(1) Description of Diversion System

The layout of the proposed diversion system is indicated on Plate 1A. The estimated initial headworks would embrace 36 diversion wells with 16-inch casings drilled to an average depth of 200 feet. Each would be equipped with a deep well turbine type pump with a 60-foot column to deliver water to a centrally located sump. Each pumping plant would have a capacity between 1800 and 2000 gallons per minute for a range in total pumping lift from 20 to 45 feet. Estimated average total lift is 35 feet. There would be six initial booster units installed, each with a capacity of 25 cubic feet per second, to elevate water from the sump to the head of the diversion conduit. The total booster lift would be fairly constant at about 65 feet.

The diversion conduit from its head for a distance of 23 miles to the South Branch of Alisal Creek would consist of a concrete lined canal with a capacity of 250 cubic feet per second for 12 miles and then would have a gradual reduction in capacity to 150 cubic feet per second in the next 11 miles. The flow would be conveyed down the South Branch of Alisal Creek to a rediversion dam where a portion would be diverted and conveyed northerly six miles to Natividad Creek through an unlined canal with capacity of 80 cubic feet per second. The remaining water would be conveyed down natural and canalized channel to a regulating reservoir in





:D DIVERSION SYSTEM

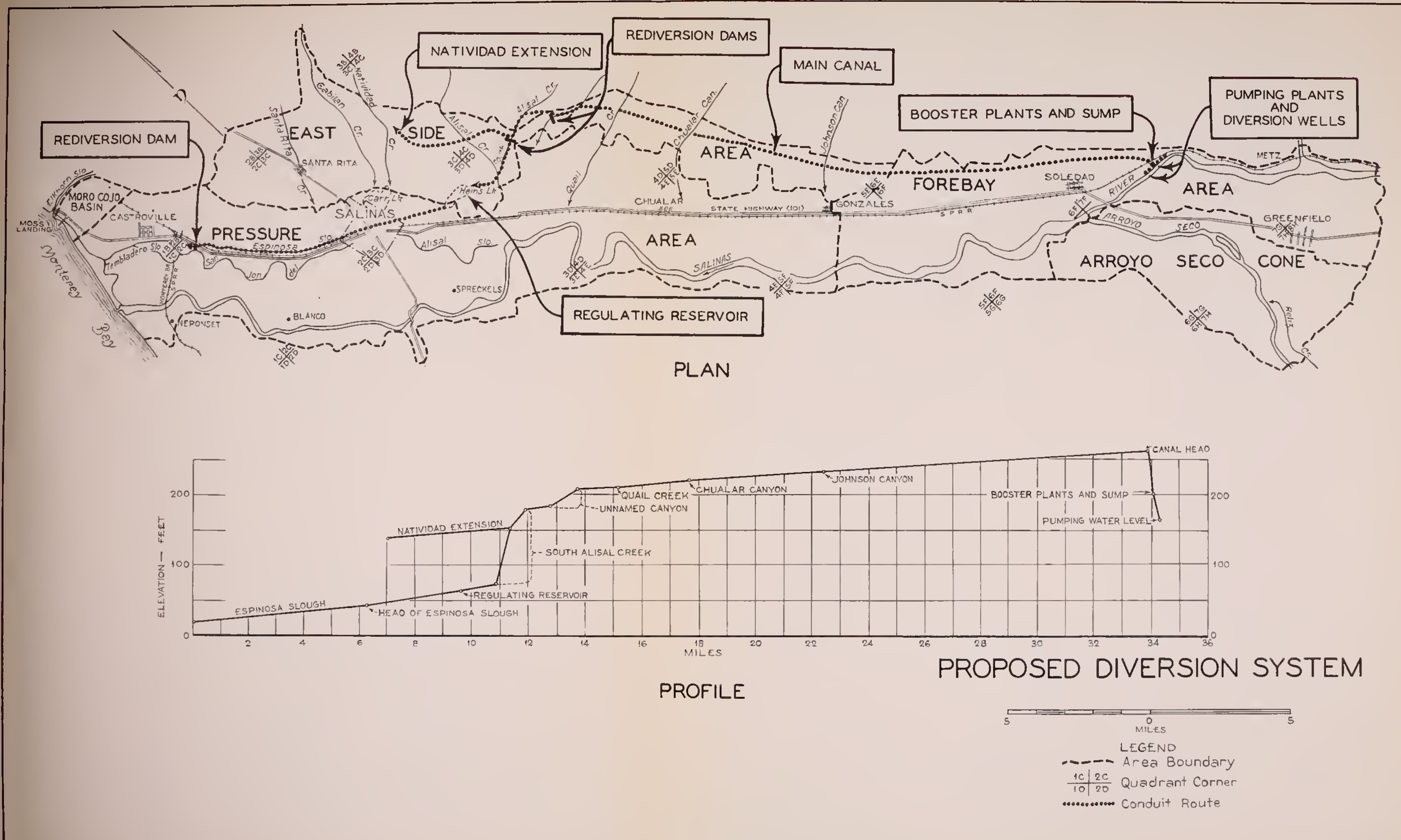
0 5
MILES

LEGEND

Area Boundary

1C | 2C / 1D | 2D Quadrant Corner

Conduit Route



PROPOSED DIVERSION SYSTEM

Heins Lake with a capacity of 300 acre-feet. A portion of the water would be conveyed from the regulating reservoir through concrete pipe for tie-in and service through existing distribution systems in the Salinas area and the remainder would be conveyed to the head of Espinosa Slough at Highway 101 crossing. Espinosa Slough would be used to convey water to the Salinas-Castroville Highway crossing where water would be rediverted and delivered through concrete pipes for tie-in to and service through existing distribution systems in the area of marine intrusion.

The main canal between Johnson Canyon and the South Branch of Alisal Creek and the Natividad Extension would be equipped with checks, take-outs, distribution pipe lines and valves to effect tie-in to and service through existing distribution systems below the conduit in the East Side Area. Thirty county and farm road bridges and flumes for crossing 10 creeks would be included in the system.

The foregoing initial development would utilize in average years under current demand approximatly 17,000 acre-feet of direct diversion from the Salinas River prior to June 15. Average annual draft on underground storage through the proposed diversion system under current demand would be about 28,000 acre-feet after the river ceased to flow through the Forebay Area.

(2) Diversion System Offers Solution

The primary purpose of such a diversion system, as above suggested, would be for direct use through existing distribution systems in areas of overdraft in lieu of draft on local supplies. An initial diversion of 45,000 acre-feet during the irrigation season would provide about 25,000 acre-feet of substituted supply for the East Side Area and 20,000 acre-feet in the Pressure Area where serious contamination from perched water and marine intrusion has occurred, and in the section of free ground water supplied by escape from confined waters. Normal annual consumption of ground water in the East Side Area for acreage presently irrigated is about 12,000 acre-feet compared with annual replenishment from local tributaries of about 5,000 acre-feet. Unconsumed irrigation water largely returns to the pumping zone in the East Side Area. The combined local and substituted supplies would provide an estimated annual contribution to cyclic underground storage of 16,000 acre-feet. Such cyclic storage would be available for emergency use within the area and no physical difficulty would be encountered in recapture and transfer for use in the Pressure Area in years of extreme drouth.

An accumulation of cyclic underground storage in the East Side Area would reverse the present direction of ground water movement from the Pressure to the East Side Area. The East Side Area may eventually assume its former capacity of serving as a lateral forebay to the Pressure Area thereby causing an increase in present flow of water through the partially confined aquifers. This would result in escape of some cyclic underground storage but such outflow would not be wasted.

Draft on unused underground storage from the Forebay Area would establish more movement of ground water therefrom, a highly desirable condition. It would tend to improve the quality of water therein by inducing greater percolation of surface flows of the Salinas River and the Arroyo Seco. About 88 per cent of the total surface outflow from the basin would be available for natural recharge of the underground reservoir.

Adequate unused underground storage is immediately available to meet all present requirements for additional water in areas of overdraft. Continued observations of general effect on ground water as a result of increased draft from the Forebay Area would allow a more accurate evaluation of the amount of surface storage required under ultimate development in the Salinas Basin. The foregoing estimates of necessary salvage are to be taken as approximations subject to more accurate determination during the course of development of the solution of the problems.

(3) Estimated Cost of Diversion System

Estimated costs were based on unit costs as of the end of the year, 1945. Unsettled labor conditions and unstable prices of materials may cause substantial and rapid changes in construction costs during the post-war period.

The initial construction of the diversion system, on which a cost analysis was made, would have a pumping capacity of 150 cubic feet per second. Additional units would be installed as demand for water increased. The lined canal would be constructed with a capacity of 250 cubic feet per second. The cost analysis includes diversion wells, pumping plants, regulating reservoir, supplemental distribution systems, rediversion dams from natural channels, clearing natural channel, and construction of main canal and crossings. The estimated cost includes rights of way, 25 per cent for engineering and contingencies, and interest during construction at 3 per cent. The total cost for initial development, based on prices at the end of the year 1945, is estimated at $2,117,000.

Annual carrying charge on initial costs was computed with interest at 3 per cent and amortization in 40 years. Power costs for pumping, including additional cost of pumping under existing plants in the Forebay Area, were computed on the basis of rates effective in 1945 for electric power service in the Salinas Valley. Annual charges on clearing natural channel were based on one complete clearing per 10-year period. Annual maintenance on pumps, motors and diversion wells were calculated on the basis of 3 per cent of initial cost of installation. Depreciation on pumps and motors is based on replacement in 25 years. Allowance for general maintenance each year was made on the basis of one per cent of the balance of construction costs. Demand for water under the initial installation was based on substitution of 25,000 acre-feet in the East Side Area and 20,000 acre-feet in the Pressure Area during each irrigation season, where present average power costs for water were estimated to be about $2.90 per acre-foot.

Based on prices at the end of the year 1945, the total annual costs of the substituted supply are estimated at $226,400 for 45,000 acre-feet under the proposed initial installation. The cost per acre-foot of substituted supply is estimated at $5.00. No effort is made in this report to apportion among the various water users in the basin the difference in cost of water to users, who would receive direct service from substitute water. It is estimated that approximately 35 per cent of the substitute water would go to cyclic underground storage, which would benefit all water users in the East Side and Pressure Areas.

When and if surface storage under a dual-purpose project becomes available for release to maintain recharge of ground water in the Forebay Area, the item in carrying charges of increased cost of pumping to overlying lands in the Forebay Area, estimated at $15,000 per annum, would be eliminated. Such released storage would also decrease annual power costs for pumping under the proposed diversion system in an amount estimated at $9,000.

Legal Considerations

The foregoing analyses have been based strictly on engineering principles. Successful consummation of plans embracing a complete solution of water conservation problems involves more than engineering. The existence of numerous overlying landowners and appropriators in the basin creates legal obstacles to development designed to salvage waste.

The development of the ground waters in the Salinas Basin has been typical of that by individual effort in many other areas. It has proceeded without supervision or adequate information of results on the part of those using the water. Such information usually comes after alarm is caused by deterioration in quality of water and receding water levels, and frequently after a series of lawsuits, which may be inconclusive.

Underground water is presumed to be percolating water and the burden of proof is upon the party claiming to the contrary. Ground water flowing through definite underground streams are subject to the same laws as streams with surface flow. The English common law rule of absolute ownership of percolating waters on the part of the overlying owner was abrogated in 1903 by the California Supreme Court. Katz v. Walkinshaw, 141 Cal. 116. The principles therein declared, and as developed in subsequent decisions, have come to be known as the California doctrine of correlative rights. The correlative doctrine of rights of landowners overlying percolating waters is comparable in many respects to the doctrine of riparian rights of owners of lands contiguous to water courses. The two doctrines became more closely analogous after adoption of the Constitutional amendment in 1928, Calif. Const. Art. XIV, Sec. 3, which imposed reasonable use upon riparian as well as ground water uses. Knowledge of the fundamental principles of the correlative doctrine is essential to an appreciation of the legal obligations imposed by law on users of percolating waters under overdraft conditions.

(1) Rights of Way and Financing

As previously stated, any complete solution of overdraft problems in the basin will necessitate an extensive diversion system from the Salinas River. This will involve rights of way through several holdings. It may be anticipated that some of the rights of way cannot be obtained without condemnation proceedings. It will also be necessary to raise funds to finance construction, operation and maintenance of works.

(2) Comprehensive Adjudication Under Water Code

Increase in irrigation efficiency by elimination of extractions for non-beneficial uses would give direct relief to overdraft on the 180-foot aquifer and would retard current marine intrusion. This is also a vital step toward conservation of quality of ground water throughout the basin, which is threatened by excessive leaching of top soil. The expeditious and certain method of increasing irrigation efficiency is through a comprehensive determination of rights to extract ground water under the court reference procedure. (Sections 2000 to 2050, inclusive, of the Water Code). Through this adjudication procedure, which is comparatively inexpensive, elimination of extractions of water in excess of quantities required for beneficial use can be secured as well as uniform observance of the rule of reasonable use as enjoined by Section 3, Article XIV of the Constitution.

The court reference procedure permits the reference of any water right case to the Department of Public Works, acting through the State Engineer, for investigation and report to the court upon any or all of the issues. This procedure has been recommended to the superior courts in many recent water law decisions of the California Supreme Court. The details of the procedure were reviewed and approved in Fleming v. Bennett, 18 Cal. (2d) 518.

Several benefits would be derived from a comprehensive determination of rights to pump ground water in the basin other than elimination of extractions in excess of beneficial requirement. It would afford a basis for assessment, pro rata in accord with benefits received, of costs of providing a water supply necessary to enable a complete solution of water conservation problems. It would also stop the running of the statute of limitations and prevent impairment of legal rights of claimants to water whose rights may be in the process of being adversed by prescription. A comprehensive adjudication would give stability to water right titles and establish a basis for orderly progress of development of a complete solution of the water problems.

(3) Use of Underground Reservoirs

A complete solution of water conservation problems in the Salinas Basin, as previously explained, may include utilization of two natural underground reservoirs. One of these situated in the Forebay Area has a large surplus of unused underground storage and the other in the East Side Area has empty capacity for storage. In regards the right to use underground reservoirs where storage capacity already exists and can readily be made available, a case in point is Los Angeles v. Glendale, 142 Pac. (2d) 289 (1943). It is stated at page 294 in that decision as follows:

> "It would be as harsh to compel plaintiff to build reservoirs when natural ones were available as to compel the construction of an artificial ditch beside a streambed."

The proposed plan, involving utilization of unused underground storage, includes compensation of overlying owners in the Forebay Area for increased costs of operation, although estimated ultimate demand would require use only within the 60-foot zone below ground surface. It was stated in Peabody v. Vallejo at page 496, 40 Pac. (2d) as follows:

> "....The correct rule is stated with its appropriate limitations in the italicized words in the following language of the District Court of Appeal in Waterford I. Dist. v. Turlock I. Dist., 50 Cal. App. 213, at page 221, 194 P. 757, 761: 'The mere inconvenience, or even the matter of extra expense, within limits which are not unreasonable, to which a prior user may be subjected, will not avail to prevent a subsequent appropriator from utilizing his right.'" (Note underlined portion was italicized).

Prior users are subject to extra expense within reasonable limits and it might be ruled by a court that the item of additional cost of pumping under existing plants in the Forebay Area should be borne in whole or in part by the users in that area rather than by users who would receive direct service from substitute water.

Conclusions

The conclusions in this report with reference to the future conditions are based on the following general assumptions:

(a) That all irrigable land in the Salinas Valley will ultimately be brought under irrigation, (b) the net change in types of irrigated crops and irrigation practices will not materially alter the average annual water consumption per acre of irrigated land in the areas of free ground water, (c) the average amount of water pumped per acre of irrigated land in 1944 in the blue clay zone will remain constant and that increased pumping for new irrigation will not increase return to the pumping zone, but will be disposed of by evapotranspiration and outflow to the bay, (d) water utilization on town and farm lots is substantially the same as the average on irrigated land in the area, and (e) rainfall and water supply will have annual and cyclic variations as in the past.

It has been concluded from analyses of available data as follows:

1. The average annual total water supply, including rainfall but exclusive of marine intrusion, received by the valley floor in the Salinas Basin approximates 940,000 acre-feet.

2. Normal annual total consumption of water on the valley floor under present stage of development is about 433,000 acre-feet. This may approach 509,000 acre-feet under ultimate development.

3. There are no present or prospective overdrafts on ground water supplies in the Arroyo Seco Cone, Forebay and Upper Valley areas.

4. Present and estimated ultimate normal annual drafts on ground water, safe yield of ground water supplies under existing conditions and annual overdraft in the East Side and Pressure Areas approximate the following amounts:

Area	Draft in Acre-feet		Safe Yield	Overdraft in Acre-feet	
	Present	Ultimate	Acre-Feet	Present	Ultimate
East Side	12,000	26,000	5,000	7,000	21,000
Pressure	103,000	138,000	83,000	20,000	55,000
Total	115,000	164,000	88,000	27,000	76,000

5. Average annual surface outflow from the Salinas Basin of about 503,000 acre-feet provides a large local water supply to solve the water conservation problems. A major portion of the average annual ground water outflow of about 30,000 acre-feet occurs during the winter season and is not susceptible of salvage.

6. Surface storage in the Salinas River stream system south of Gonzales, or increased percolation in the Arroyo Seco Cone, with no supplemental works to recapture respectively released surface storage or the percolate for use in areas with deficient supplies, would be ineffective. Such development would probably be offset by a comparable increase in surface outflow and natural disposal of other inflow to the Forebay Area with a net result of little or no salvage of wastes for beneficial uses.

7. Any complete solution of the water conservation problems must embody utilization of a portion of the average annual surface outflow from the Forebay Area of about 444,000 acre-feet. Any complete solution must also embrace a diversion system from the Salinas River to the East Side and Pressure Areas. (The layout of a proposed diversion system is indicated on Plate 1A.) The outflow from the East Side Area is not worthy of consideration in a plan of conservation due to infrequency of occurrence and inadequacy in total amount.

8. Cyclic storage is necessary to provide additional water for use in the Salinas Basin in critical dry years. Empty underground reservoir capacity in the order of 400,000 acre-feet, which is usable for cyclic storage, exists in the East Side Area. Any ground water outflow during the irrigation season from underground storage in the East Side Area would be available for use in the Pressure Area where a current deficiency prevails. This would result in comparatively high efficiency in recapture of cyclic underground storage for use.

9. Undergrouhd storage within the 60-foot zone below ground surface in the order of 100,000 acre-feet, on which draft has not been made, exists in the Forebay Area and the lower portion of the Arroyo Seco Cone.

10. A proposed diversion system designed to annually divert and convey under initial installations 45,000 acre-feet of unused underground storage from the Forebay Area for direct use in areas of overdraft in lieu of draft on local supplies in the East Side and Pressure Areas offers a solution of present water conservation problems. Total cost per acre-foot, including operation, maintenance, interest and amortization based on prices at the end of year 1945, of such substitute water is estimated at $5.00. Estimated average cost of power alone for

water from existing supplies in areas of overdraft is $2.90 per acre-foot. Approximately 16,000 acre-feet of such substitute water would, after direct use, annually go to cyclic underground storage.

11. After completion of the current flood control survey by the Corps of Engineers, U. S. Army, a feasible plan of dual-purpose surface storage may be developed, which would permit diversion of released surface storage for direct use and provide a greater amount of cyclic underground storage for emergency use in critical dry periods. The above proposed diversion system, which would be necessary in any event to provide a complete solution of water conservation problems, would fit in with and be an integral part of such dual-purpose surface storage.

12. Excessive leaching of top soil in the valley south of Gonzales because of low irrigation efficiency is resulting in an accumulation of salinity in the ground water in the Forebay Area. A large part of the replenishment in the Forebay Area is made up of ground water inflow from the Upper Valley Area and Arroyo Seco Cone which contains leachings from irrigation waters unconsumed in those areas. Increase in irrigation efficiency is a vital step toward conservation of quality of water throughout the basin. The above proposed diversion system would also tend to improve quality of water in the Forebay Area.

13. Conservation measures for protection of quality of ground waters should be preventive rather than corrective because of semi-permanent nature of damage after contamination has occurred. Protective provisions may be established by law and enforced through legal measures prescribing uniform standards for logging of wells, recordation of well logs, repair of operating defective wells and plugging of abandoned defective wells under competent supervision.

14. Salvage of wastes resulting from extractions in excess of beneficial requirement, general conservation of quality of ground water through elimination of excessive leaching of top soil, stabilization of water right titles, and orderly progress in development of a complete solution of water conservation problems would require a comprehensive adjudication of rights to pump in the basin.

15. Problems of overdraft are not necessarily the sole concern of those being damaged by deterioration in quality of ground water, recession in water levels, and operation of prescription. The California doctrine of correlative rights applicable to percolating waters imposes obligations on users of percolating waters to share the burdens when there is not enough water for all.

16. Plans to meet present and ultimate requirements for water in the Salinas Basin can and should be accomplished by an orderly progression of phases of development. Successive steps in a comprehensive plan call first for salvage of available wastes with lowest unit cost, and thence in order of expense for recourse to methods of greater unit cost. The more expensive water may in this manner be held to a minimum in the final phase of development.

17. In order to supply the mechanics for solution of the problems involved, it would be necessary to create a local water authority or public district endowed with appropriate powers.

PUBLICATIONS

DIVISION OF WATER RESOURCES

PUBLICATIONS OF THE

DIVISION OF WATER RESOURCES

DEPARTMENT OF PUBLIC WORKS

STATE OF CALIFORNIA

When the Department of Public Works was created in July, 1921, the State Water Commission was succeeded by the Division of Water Rights, and the Department of Engineering was succeeded by the Division of Engineering and Irrigation in all duties except those pertaining to State Architect. Both the Division of Water Rights and the Division of Engineering and Irrigation functioned until August, 1929, when they were consolidated to form the Division of Water Resources. The Water Project Authority was created by the Central Valley Project Act of 1933.

STATE WATER COMMISSION

*First Report, State Water Commission, March 24 to November 1, 1912.
*Second Report, State Water Commission, November 1, 1912, to April 1, 1914.
*Biennial Report, State Water Commission, March 1, 1915, to December 1, 1916.
*Biennial Report, State Water Commission, December 1, 1916, to September 1, 1918.
*Biennial Report, State Water Commission, September 1, 1918, to September 1, 1920.

DIVISION OF WATER RIGHTS

*Bulletin No. 1—Hydrographic Investigation of San Joaquin River, 1920-1923.
*Bulletin No. 2—Kings River Investigation, Water Master's Report, 1918-1923.
*Bulletin No. 3—Proceedings First Sacramento-San Joaquin River Problems Conference, 1924.
*Bulletin No. 4—Proceedings Second Sacramento-San Joaquin River Problems Conference, and Water Supervisors' Report, 1924.
*Bulletin No. 5—San Gabriel Investigation—Basic Data, 1923-1926.
Bulletin No. 6—San Gabriel Investigation—Basic Data, 1926-1928.
Bulletin No. 7—San Gabriel Investigation—Analysis and Conclusions, 1929.
*Biennial Report, Division of Water Rights, 1920-1922.
*Biennial Report, Division of Water Rights, 1922-1924.
Biennial Report, Division of Water Rights, 1924-1926.
Biennial Report, Division of Water Rights, 1926-1928.

DEPARTMENT OF ENGINEERING

*Bulletin No. 1—Cooperative Irrigation Investigations in California, 1912-1914.
*Bulletin No. 2—Irrigation Districts in California, 1887-1915.
Bulletin No. 3—Investigations of Economic Duty of Water for Alfalfa in Sacramento Valley, California, 1915
*Bulletin No. 4—Preliminary Report on Conservation and Control of Flood Waters in Coachella Valley, California, 1917.
*Bulletin No. 5—Report on the Utilization of Mojave River for Irrigation in Victor Valley, California, 1918.
*Bulletin No. 6—California Irrigation District Laws, 1919 (now obsolete).
Bulletin No. 7—Use of Water from Kings River, California, 1918.
*Bulletin No. 8—Flood Problems of the Calaveras River, 1919.
Bulletin No. 9—Water Resources of Kern River and Adjacent Streams and Their Utilization, 1920.
*Biennial Report, Department of Engineering, 1907-1908.
*Biennial Report, Department of Engineering, 1908-1910.
*Biennial Report, Department of Engineering, 1910-1912.
*Biennial Report, Department of Engineering, 1912-1914.
*Biennial Report, Department of Engineering, 1914-1916.
*Biennial Report, Department of Engineering, 1916-1918.
*Biennial Report, Department of Engineering, 1918-1920.

DIVISION OF WATER RESOURCES

Including Reports of the Former Division of Engineering and Irrigation

*Bulletin No. 1—California Irrigation District Laws, 1921 (now obsolete).
*Bulletin No. 2—Formation of Irrigation Districts, Issuance of Bonds, etc., 1922.
Bulletin No. 3—Water Resources of Tulare County and Their Utilization, 1922.
Bulletin No. 4—Water Resources of California, 1923.
Bulletin No. 5—Flow in California Streams, 1923.
Bulletin No. 6—Irrigation Requirements of California Lands, 1923.
*Bulletin No. 7—California Irrigation District Laws, 1923 (now obsolete).
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