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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

WATER RESOURCES
OF THE
SALINAS VALLEY, CALIFORNIA

BY

HOMER HAMLIN



WASHINGTON
GOVERNMENT PRINTING OFFICE
1904

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

The publications of the United States Geological Survey consist of (1) Annual Reports; (2) Monographs; (3) Professional Papers; (4) Bulletins; (5) Mineral Resources; (6) Water-Supply and Irrigation Papers; (7) Topographic Atlas of United States, folios and separate sheets thereof; (8) Geologic Atlas of United States, folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

The Bulletins, Professional Papers, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports.

The following Water-Supply Papers are out of stock, and can no longer be supplied: Nos. 1-16, 19-20, 22, 29-34, 33, 39-40, 43, 46, 57-65, 75. Complete lists of papers relating to water supply and allied subjects follow. (PP=Professional Paper; B=Bulletin; WS=Water-Supply Paper.)

SERIES I—IRRIGATION.

- WS 2. Irrigation near Phoenix, Ariz., by A. P. Davis. 1897. 98 pp., 31 pls. and maps.
 - WS 5. Irrigation practice on the Great Plains, by E. B. Cowgill. 1897. 39 pp., 11 pls.
 - WS 9. Irrigation near Greeley, Colo., by David Boyd. 1897. 90 pp., 21 pls.
 - WS 10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker. 1898. 51 pp., 11 pls.
 - WS 13. Irrigation systems in Texas, by W. F. Hutson. 1898. 68 pp., 10 pls.
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 - WS 18. Irrigation near Fresno, Cal., by C. E. Grunsky. 1898. 94 pp., 14 pls.
 - WS 19. Irrigation near Merced, Cal., by C. E. Grunsky. 1899. 59 pp., 11 pls.
 - WS 23. Water-right problems of Bighorn Mountains, by Elwood Mead. 1899. 62 pp., 7 pls.
 - WS 32. Water resources of Porto Rico, by H. M. Wilson. 1899. 48 pp., 17 pls. and maps.
 - WS 43. Conveyance of water in irrigation canals, flumes, and pipes, by Samuel Fortier. 1901. 86 pp., 15 pls.
 - WS 70. Geology and water resources of the Patrick and Goshen Hole quadrangles, Wyoming, by G. I. Adams. 1902. 50 pp., 11 pls.
 - WS 71. Irrigation systems of Texas, by T. U. Taylor. 1902. 137 pp., 9 pls.
 - WS 74. Water resources of the State of Colorado, by A. L. Fellows. 1903. 151 pp., 14 pls.
 - WS 87. Irrigation in India, by H. M. Wilson. 1903. 233 pp., 27 pls.
- The following papers also relate especially to irrigation: Irrigation in India, by H. M. Wilson, in Twelfth Annual, Pt. II; two papers on irrigation engineering, by H. M. Wilson, in Thirteenth Annual, Part III.

SERIES J—WATER STORAGE.

- WS 33. Storage of water on Gila River, Arizona, by J. B. Lippincott. 1900. 98 pp., 33 pls.
- WS 40. The Austin dam, by Thomas U. Taylor. 1900. 51 pp., 16 pls.
- WS 45. Water storage on Cache Creek, California, by A. E. Chandler. 1901. 48 pp., 10 pls.
- WS 46. Physical characteristics of Kern River, California, by F. H. Olmsted, and Reconnaissance of Yuba River, California, by Marsden Manson. 1901. 57 pp., 8 pls.
- WS 53. Storage of water on Kings River, California, by J. B. Lippincott. 1902. 100 pp., 33 pls.
- WS 68. Water storage in Truckee Basin, California-Nevada, by L. H. Taylor. 1902. 90 pp., 8 pls.
- WS 73. Water storage on Salt River, Arizona, by A. P. Davis. 1902. 54 pp., 25 pls.
- WS 86. Storage reservoirs on Stony Creek, California, by Burt Cole. 1903. 62 pp., 16 pls.
- WS 89. Water resources of the Salinas Valley, California, by Homer Hamlin. 1903. — pp., 12 pls.

The following paper also should be noted under this heading: Reservoirs for irrigation, by J. D. Schuyler, in Eighteenth Annual, Pt. IV.

[Continued on third page of cover.]

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,

Washington, D. C., July 22, 1903.

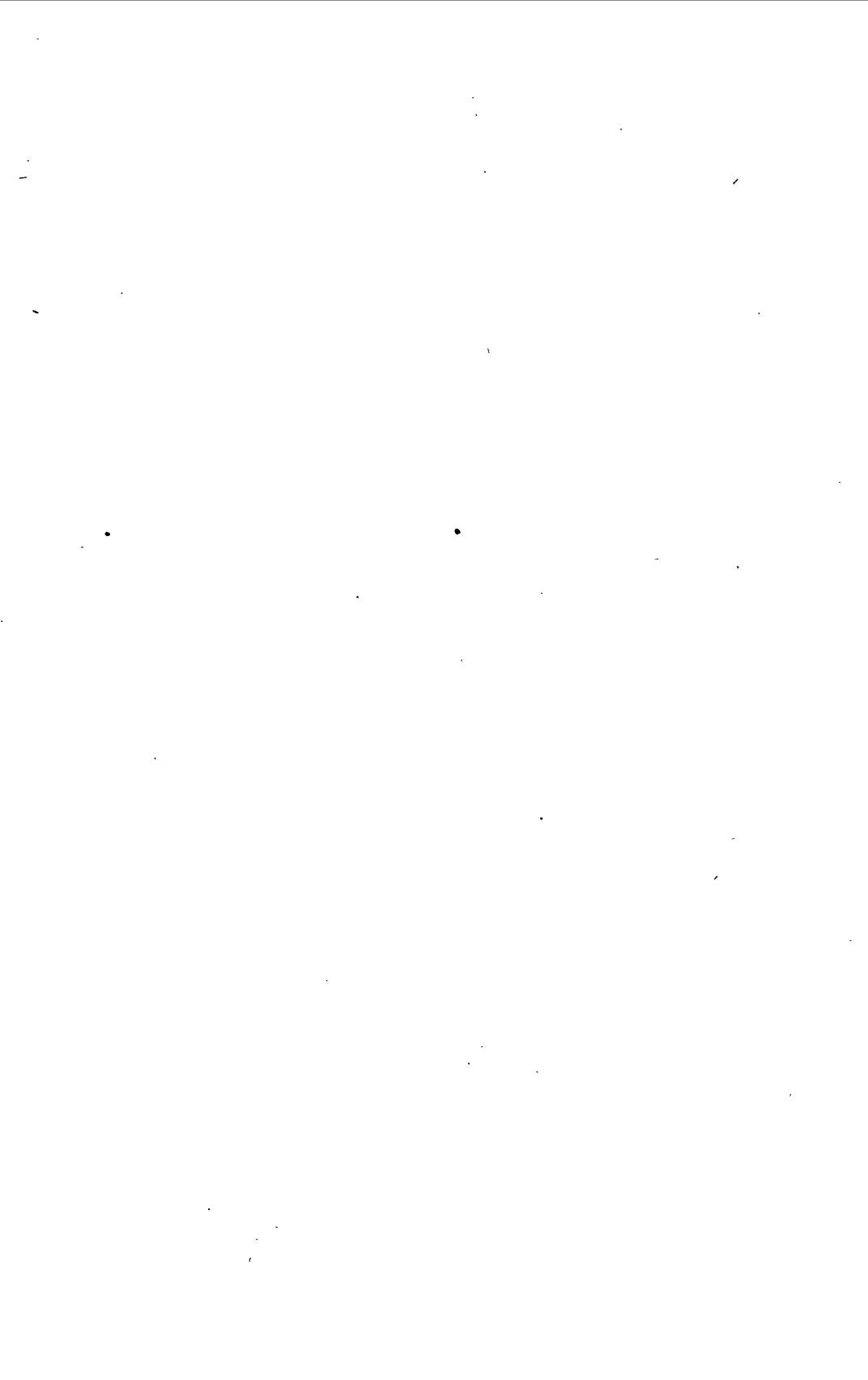
SIR: I have the honor to transmit herewith, for publication in the Water-Supply and Irrigation series, a report on the water resources of the Salinas Valley, California, by Mr. Homer Hamlin.

The report relates particularly to that portion of the Salinas Valley which lies within the boundaries of Monterey County. It describes the topography, hydrography, and economic geology of a portion of the region and discusses the methods of irrigation and the irrigation systems, the extent of underground waters, and the possibility of extending irrigation by the utilization of surface streams and the impounding of flood waters.

Very respectfully,

F. H. NEWELL,
Chief Engineer

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.



WATER RESOURCES OF THE SALINAS VALLEY, CALIFORNIA.

By HOMER HAMLIN.

INTRODUCTION.

This report is based on investigations made by the United States Geological Survey, cooperating with the board of supervisors of Monterey County and the California Water and Forest Association, in Monterey County, Cal., during 1900, 1901, and 1902. The work was done under the supervision of Mr. J. B. Lippincott, resident hydrographer of the United States Geological Survey.

The report relates particularly to that portion of the Salinas Valley that lies within the boundaries of Monterey County, and describes the topography, hydrography, and economic geology of a portion of the region. It also discusses the extent of the underground water, the methods of irrigation, the irrigation systems, and the possibility of extending irrigation by the utilization of surface streams and by impounding flood waters.

The first investigation made in this region was a reconnaissance conducted under the direction of Prof. Charles D. Marx in the summer of 1900. During this reconnaissance, which was made for the purpose of locating and examining the reservoir sites in the drainage basin of Salinas River, Professor Marx's party explored the drainage basins of the Arroyo Seco, of San Antonio and Nacimiento rivers, and a portion of the drainage basin of San Lorenzo Creek. Six reservoir sites were discovered, and preliminary surveys and estimates were made to determine the capacity of each and the cost of storing water. Five of these reservoir sites are in the drainage basin of the Arroyo Seco, viz, the Pettitt, Leigh, Currier, Foster, and The Pools sites. One reservoir site, the Pinkerton, was discovered on the San Antonio, and one, the Mathews, on San Lorenzo Creek.

In October, 1900, Mr. W. W. Cockins, jr., was put in charge of the study of underground waters in the vicinity of Salinas, and during the winter of 1900-1901 was also in charge of stream measurements on Salinas River and its tributaries. In December, 1900, he established

a gaging station on San Antonio Creek near Jolon, one on San Lorenzo Creek at the Hollenbeck ranch, and one on Arroyo Seco at Pettitt's ranch. A gaging station had been established on Salinas River prior to 1900.

In March, 1901, the writer was detailed to study the hydrography and geology of a portion of this region. The field work extended over a period of six months.

In the Salinas Valley, as in many parts of California, pumping water for irrigation is expensive on account of the high price of fuel. The object of the geologic investigation was to discover, if possible, cheap fuel in the form of coal or oil. A reconnaissance was made of the region and detailed examinations were made of certain localities. The result was disappointing, as no territory that will yield oil in commercial quantities was found, and the one coal field is of small extent and almost inaccessible.

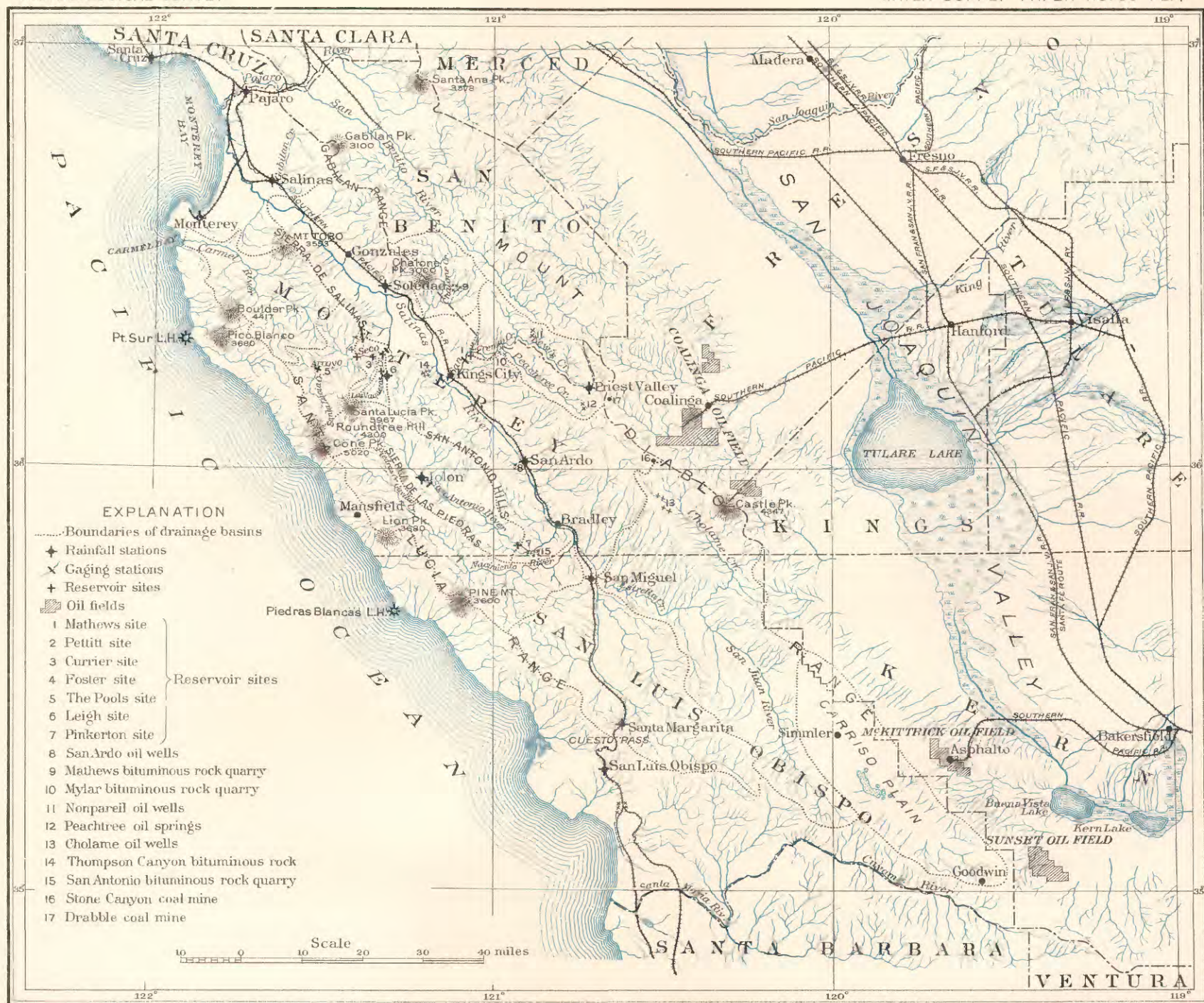
In presenting the report on the economic geology of the region the writer wishes to disclaim any idea of its being more than a preliminary description of the conditions observed during the reconnaissance. At no place were the investigations exhaustive, and facts relating to the oil-producing rocks, coal beds, and water supply only were noted. Much yet remains to be done in the study of the general geology of the region and the correlation of the various formations with equivalent strata in other regions.

In October, 1901, Mr. H. E. Green was detailed to make topographic surveys of the Mathews reservoir and dam site. He also designed the dam and made estimates of the cost of construction and of the capacity of the reservoir. In August and September, 1902, the writer made a topographic survey of the Currier and Foster reservoir and dam sites, and later designed the dams and made estimates of the cost of construction and of the capacity of the reservoirs.

General acknowledgment is due a large number of persons who have rendered assistance. Thanks are particularly due Dr. William H. Dall for the identification of fossils; to the United States Department of Agriculture for well records and maps of a portion of the Salinas Valley; to the Spreckels Sugar Company for statistics on irrigation; to Mr. Lou G. Hare, county surveyor, for use of county maps, and to Messrs. T. T. Tidball, J. W. Leigh, A. J. Meyers, A. Hubbard, J. M. Krenkel, C. H. Royse, and Mrs. M. Griffin, who have furnished rainfall records.

GEOGRAPHY.

The total area of the Salinas Valley is 4,780 square miles. Its length is 150 miles and its maximum width about 45 miles. (See Pl. I.) It extends from the high mountain region in southeastern San Luis Obispo County to the Bay of Monterey, 80 miles south of San Francisco. The Salinas Valley, in common with the other Coast Range



MAP OF THE DRAINAGE BASIN OF THE SALINAS RIVER
SHOWING HYDROGRAPHIC FEATURES

valleys, has a northwest-southeast trend. On the southwest it is separated from the Pacific Ocean by the Santa Lucia Range and from Carmel River by the Sierra de Salinas. On the northeast it is separated from the San Joaquin Valley by the Mount Diablo Range and from the San Benito Valley by the Gabilan Range.

This region is entirely included in the rectangle bounded by parallels $35^{\circ} 10'$ and $36^{\circ} 50'$ north latitude, and meridian $119^{\circ} 30'$ and $121^{\circ} 50'$ west longitude. The Salinas Valley lies entirely within the boundaries of Monterey and San Luis Obispo counties.

TOPOGRAPHY.

The Coast Range of California southeast of San Francisco consists of a series of parallel mountain ridges extending in a general northwest-southeast direction.

This system of ranges has received the general and comprehensive name of Coast Range, but the subordinate ranges have also been designated by local names, some of which are not yet well established. Of these ranges the most northeasterly is the Mount Diablo Range (Pl. I), which as a system of parallel mountain ridges extends from Mount Diablo, in Contra Costa County, to Mount Pinos, in Ventura County, where it merges into the complex mountain region west of Tejon Pass. The length of this range is 270 miles, and for this entire distance it is the barrier between the San Joaquin Valley on the northeast and the Cuyama Valley, the Salinas Valley, and San Francisco Bay, with its adjacent valleys, on the southwest. The highest peaks in the central portion of this range are Santa Ana Peak, altitude, 3,578 feet, and Castle Peak, altitude, 4,347 feet. The average altitude of the crest of the range is not known definitely, but it must be at least 3,000 feet.

The Santa Cruz-Gabilan Range (Pl. I) extends, with one break, from the Golden Gate southeastward 120 miles to Chalone Peak, beyond which it ceases to be a prominent topographic feature. Pajaro River breaks through this range, dividing it into the two portions known locally as the Santa Cruz and the Gabilan ranges. In the southern range the highest peaks are Gabilan Peak, altitude 3,100 feet, and Chalone Peak, altitude about 3,000 feet. This portion of the range has an average altitude of about 2,500 feet, and a length of 40 miles. It is the barrier between the lower Salinas Valley on the southwest and the San Benito Valley on the northeast.

The Santa Lucia Range rises abruptly from the ocean south of Carmel Bay and extends southeastward along the coast as an unbroken chain to Cuesta Pass, in San Luis Obispo County, a distance of 100 miles. The seaward slope of this range is exceedingly precipitous, and is scored by deep rugged canyons, down which small torrential streams find their way to the ocean. The average width of this slope in Monterey County is about 5 miles. At one place it is but

3 miles from the crest of the range to the ocean, and the greatest width is but 9 miles. The highest peaks in this range are Santa Lucia, altitude 5,967 feet; Boulder Peak, altitude 4,417 feet; Pico Blanco, altitude 3,680 feet; Roundtree Hill, altitude 4,300 feet, and Pine Mountain, altitude 3,600 feet. The average altitude of the crest can not be less than 3,500 feet, and is probably nearer 4,000 feet.

Between the Salinas Valley and the high Santa Lucia Range are other mountain ranges, the most northern of which is known as the Sierra de Salinas (Pl. I). This is a long mountain ridge extending from the mouth of the canyon of Arroyo Seco, in Monterey County, northwestward about 25 miles to the mesa lands lying southwest of Salinas. It presents steep slopes toward the Salinas Valley, shutting out from view the higher and more rugged ranges nearer the coast. The highest point, Mount Toro, altitude 3,553 feet, is a broad, rounded ridge. This range probably has an average altitude of nearly 2,500 feet throughout its entire length.

The mountain range known as the San Antonio Hills (Pl. I) is a divergent ridge sent off from the most elevated portion of the Santa Lucia Range. It terminates rather suddenly near Bradley, where San Antonio River turns northeastward and joins the Salinas. Although not conspicuous as a topographic feature it can be traced for several miles beyond this point in the low rolling ridge northeast of San Miguel, in San Luis Obispo County. The range has been deeply eroded and many canyons extend far back toward the rounded crest, the average altitude of which is from 2,000 to 2,500 feet.

Between the San Antonio Hills and the main Santa Lucia Range is the range known as the Sierra de las Piedras (see Pl. I). It lies between San Antonio and Nacimiento rivers and, like the San Antonio Hills to the northeast, is a divergent ridge from the main range. It extends southeastward to the point where the Nacimiento turns northeastward to join Salinas River, but can be traced geologically to the San Jose Mountains east of the Santa Margarita Valley, in San Luis Obispo County. Its average altitude is 2,000 to 2,500 feet, and it is an inconspicuous feature in the general topography of the region, lying as it does just northeast of the main mountain ridge. In the past there has been much confusion regarding the names of these different ranges.

The Salinas Valley is the largest of the intermontane valleys of the Coast Range region. Along the coast it is a broad, fertile valley ranging from 6 to 10 miles wide, gradually narrowing to about 5 miles at Soledad, 30 miles inland. For 25 miles of this distance the valley is walled in by the steep slopes of the Sierra de Salinas and the Gabilan Range, but both drop down near Soledad and the valley widens on the northeast side into a broad mesa, or elevated plain, lying between the Santa Lucia and Mount Diablo ranges. This mesa extends far to the southeast and ends in the arid Carriso Plain, lying east of San

Juan River. The mesa has an average width of about 20 miles and rises gently from Salinas River far up the slopes of the Mount Diablo Range. It has been greatly dissected by numerous canyons, which traverse it in a general southwesterly direction. This mesa was traced to the east and northeast of Chalone Peak, where it appears to extend across the ridge between San Benito and Salinas rivers.

GEOLOGY.

GENERAL GEOLOGY.

STRUCTURE.

The upper Salinas Valley is a synclinal fold which extends in a northwest-southeast direction between the Mount Diablo and Santa Lucia ranges. The characteristic structure of this fold may be seen by one crossing the valley in a northeasterly direction from the Sierra de las Piedras to the Mount Diablo Range along a line passing through the town of Bradley. The different formations are seen to dip from both sides toward the axis of the fold, in the valley below. In both of the above-mentioned ranges sedimentary rocks fill the troughs of subordinate folds parallel with the main syncline. In general, in and near the mountains, the formations have been compressed into sharp folds, while in the broad Salinas Valley they are practically undisturbed.

STRATIGRAPHY.

Basement complex.—The Basement complex on which all the unaltered sedimentary rocks of the region rest consists of (1) a series of metamorphic rocks—gneiss, schist, marble, etc.; (2) granitic rocks, chiefly granite, often coarsely porphyritic. The granite has been described by Prof. A. C. Lawson as the Santa Lucia granite.^a

The rocks of the Basement complex form the axes or cores of the Santa Lucia, Gabilan, and Mount Diablo ranges, and evidently extend to a great depth. The age of the metamorphic series is not definitely known, but it is probably as old as the Carboniferous.^b

San Luis formation.—The name San Luis formation has been applied by Dr. H. W. Fairbanks^c to a group of sedimentary and associated rocks in the San Luis quadrangle. The formation consists of conglomerates, sandstones, shales, jasper, and altered eruptives. These rocks outcrop along the southwestern slope of the Mount Diablo Range in a long, narrow belt, extending the entire length of Monterey County. They here probably rest unconformably on the Basement complex. Dr. Fairbanks has also described rocks belonging to this formation in the Santa Lucia Range, extending along the coast

^a Bull. Dept. Geology, Univ. California, vol. 1, 1893, p. 9.

^b Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 1, 1901, p. 369.

^c Geologic Atlas U. S., folio 101, U. S. Geol. Survey, 1903.

from Sur River southeastward to San Luis Obispo County.^a The San Luis formation is considered to be the equivalent of the Franciscan series and is probably of Jurassic age.

Vaquero sandstone.—In the Salinas Valley the Vaquero sandstone is a well-defined formation. So far as observed in this region it rests unconformably on the Basement complex and on stratified terranes older than the Neocene, being thus in this locality the oldest known member of the Neocene; in other localities Neocene formations are found below the Vaquero sandstone, indicating that it is not the basal member of the Neocene.

The Vaquero formation is a rather coarse, uniformly gray, white or light-yellow quartzose sandstone, with an occasional stratum of granitic pebbles. It is of great thickness along the eastern slope of the Santa Lucia Range, especially in Los Vaqueros Valley; hence the designation proposed by the writer for this series of sandstones. In the Mount Diablo Range it appears at a few points beneath later formations. On the summit of the Mount Diablo Range, around the headwaters of Stone Canyon, there is a series of beds beneath the Monterey shale which may be a portion of the Vaquero or may be older. The Stone Canyon coal beds are in this series. The following fossils have been found in the Vaquero sandstone: *Balanus* sp.?, *Mytilus* sp., probably *matthewsonii* Gabb; *Ostrea tayloriana* Gabb (Young)?; *Ostrea tilan* Conrad?; *Pecten magnolia* Conrad; *Turritella hoffmanni* Gabb?; *Chione matthewsonii* Gabb; *Chione* n. sp. (large, characteristic of this horizon); *Mactra* aff. *catilliformis* Conrad; *Pecten estrellanus* Conrad; *Pecten* (*Chlamys*) n. sp., S.; *Pecten* (*Plagioctenium*) n. sp., A.

Monterey shale.—Above the Vaquero sandstone is found the Monterey shale, which, by reason of its peculiar lithologic characteristics, is conspicuous among the rocks of the Coast Range. In Monterey County it is found in a broad belt along the northeastern slope of the Santa Lucia Range and at frequent intervals along the southwestern slope of the Mount Diablo Range. In both ranges it extends southward far beyond Monterey County. It is usually found resting on the Vaquero sandstone, but is also in contact with older formations at several points.

This formation consists of an enormous thickness of thin-bedded siliceous shales, with a small amount of limestone and cherts, especially near the base. The shale beds vary in thickness from a fraction of an inch up to 2 feet, and in color from white, through brown and chocolate color, to black. The more porous shales tend to weather white, while the cherts remain brown or black, and the limestone weathers a rusty brown.

When first exposed these shales and limestones are dark, often black, with disseminated bituminous and carbonaceous matter. If closely examined under a microscope or with a magnifying glass, they

^aJour. Geol., vol. 3, 1895, pp. 416-425.

are seen to contain vast numbers of minute fossil shells and fish scales. These fossils are the remains of marine animals, and show that the shales were deposited in the ocean. It appears probable that the organic remains buried in the Monterey shale are in part, at least, the primary source of the oil and bitumen found in Neocene rocks in California.

At the base of the Mount Diablo Range, in Cholame Valley, is found a thick series of sandstones and shales, resting on the Monterey shale. Conspicuous in this series are beds of bluish-gray sandstone and shale much resembling the Monterey shale below. There are many alternations of the sandstone and shale beds, both of which contain certain well-marked fossil forms. In Priest Valley there is a thick series of sandstone and shale very similar in appearance to the series in Cholame Valley, but it contains, in addition to the sandstone and shale beds noted above, two thin beds of impure lignite. Some of the fossils in the Priest Valley region are identical with those in Cholame Valley. The field work was not done in enough detail to determine the stratigraphic relations of these beds. Our present knowledge only warrants us in saying that both belong to the Neocene and are probably a portion of what is known as the Miocene.

Santa Margarita formation.—Above the Monterey shale on the southwest side of the Salinas Valley is found a series of rocks to which Mr. H. W. Fairbanks^a has given the name Santa Margarita formation. It has a most characteristic fauna, and is probably the equivalent of the San Pablo formation, described by Dr. J. C. Merriam.^b In the Santa Lucia Range, where it outcrops at frequent intervals northeast of the Monterey shale belt, it consists of soft gray sandstone. On the northeast side of the Salinas Valley the formation is sandstone at the base, grading upward into soft chalk-like shale and clay shale. It outcrops over a large area in the Salinas Valley near Kings City, where the most characteristic fossil is the large barnacle *Tamiosomia gregaria* Conr. The sandstone beds of this formation, in many localities in California, are saturated with bitumen and asphaltum. The occurrence of such beds in Monterey County is described on page 18. From the incomplete data at hand it seems probable that the Santa Margarita formation is more recent than the sandstones and shales noted in Cholame Valley and in Priest Valley.

Paso Robles formation.—In the upper Salinas Valley is found a series of rocks known as the Paso Robles formation, which has been described by Mr. H. W. Fairbanks.^c The basal beds of this formation are conglomerates, above which lie alternating beds of reddish clay and conglomerates composed of pebbles of shale, jasper, and granitic rocks. The conglomerates seem to be of local origin and

^aGeologic Atlas U. S., folio 101, U. S. Geol. Survey, 1903.

^bBull. Dept. Geology, Univ. California, vol. 2, 1898, pp. 113-116.

^cJour. Geol., vol. 6, 1898, p. 565.

contain a large percentage of Monterey shale pebbles. In the Salinas Valley the rocks of this formation are practically undisturbed, but they are sharply folded in both the Mount Diablo and Santa Lucia ranges. The marked unconformity in bedding between the Paso Robles and all the formations below serves as one of the most satisfactory datum planes in the stratigraphy of the Coast Range. The formation was traced from the upper Salinas into Monterey County, where it covers a large area in the vicinity of Bradley. It is greatly developed in the mesa region on the east side of Salinas River and is found between Monterey and Toro Creek, southwest of Salinas.

Later sandstones.—East of Monterey Bay is found a soft, quartzose sandstone of considerable thickness, yellow or reddish brown in color, and on weathered surfaces often containing small nodules of sand cemented by iron oxide. It disintegrates into the soft sand beds which form the sand hills north and west of Salinas. It appears to have once extended up the Salinas Valley as far as San Lucas, probably as a stream deposit, but most of it has been removed by erosion. This formation is more recent than those that have been described, and rests unconformably on the older rocks.

Stream deposits.—The stream deposits in the lower Salinas Valley consist of unconsolidated beds of clay, sand, gravel, and shale pebbles. In the vicinity of Salinas these river deposits yield large quantities of ground water. The wells penetrate alluvial sands and clays, reaching the water supply in beds of gravel 150 to 200 feet below the surface. A further description of these underground waters is given on page 21.

ECONOMIC GEOLOGY.

OIL AND BITUMINOUS ROCK DEPOSITS.

In Monterey County bituminous sandstone and shale are found at several points. Near San Ardo (Pl. I) the Monterey shale has a total thickness of about 2,200 feet. Both the Monterey shale and the Vaquero sandstone below have been sharply flexed into a secondary anticlinal fold on the northeast limb of the San Antonio Hills anticline. The shale is here very different from the typical Monterey shale in the Santa Lucia Range. Some beds are soft and chalk-like; others contain an unusual percentage of fine sand and mica flakes, interstratified with beds of quartzose sandstone. The whole series is bituminous, but the sand beds are much richer in bitumen than the others. The soft shales weather white, but when broken are seen to be colored black or brown with bitumen. The upper 770 feet of this formation consists of alternating beds of chalk-like shale and sandstone. Between these beds and the basal sandstones of the Santa Margarita formation is from 3 to 5 feet of cherty shale, characteristic of the Monterey. Small tar springs are found in this series at several points, and also in the typical Monterey shale to the southwest.

Above this series to the northeast are found beds of sandstone with shale inclusions and fossils characteristic of the Santa Margarita formation.

The amount of liquid bitumen at this locality is exceedingly small. Both the shales and sandstones are close-textured rocks and would yield oil very slowly even if it should be present in large quantities. The strata are steeply inclined, dipping northeastward at an angle of from 65° to 90° . Oil wells drilled here simply pass down into one or two beds of sand instead of piercing several, the chance of reaching any productive oil sand being proportionately reduced. The rocks bituminized are also without an impervious cover, the crest of the antiline having been removed by erosion.

Several prospect wells have been drilled here, but all have thus far proved unproductive. The Tomboy Oil and Improvement Company drilled one well in sec. 19, T. 22 S., R. 10 E., Mount Diablo meridian. The San Antonio Oil Company drilled on their property in secs. 20, 29, and 30, T. 22 S., R. 10 E., M. D. M., about 2 miles west of San Ardo, and the San Antonio Consolidated Oil Company drilled one well on its property in sec. 12, T. 22 S., R. 9 E., and sec. 7, T. 22 S., R. 10 E., M. D. M.

The Mathews bituminous rock quarry is situated in sec. 29, T. 17 S., R. 8 E., M. D. M., in San Benito County, about 7 miles northeast of Metz. (See Pl. I.) The bituminous rock consists of a bed of coarse sand and boulders, resting directly upon the eroded surface of the granitic axis of the Gabilan Range, and above this are finer sands, the whole having a considerable but variable thickness. Three prospect holes have been opened and a considerable quantity of bituminous sand rock, which seems to be of excellent quality, has been hauled away. The bituminous sand is covered by thick beds of soft, chalky shale, probably a part of the Monterey shale, resembling that at San Ardo. The shale has a low dip, 3° to 5° , toward the east.

The Mylar bituminous rock quarry is situated in secs. 14 and 15, T. 19 S., R. 9 E., M. D. M., 10 miles northeast of Kings City. The quarry is owned by the City Street Improvement Company, of San Francisco. The bituminous rock is here of considerable thickness and consists of coarse granitic gravels which rest directly upon the worn surface of the granitic axis of the Gabilan Range, followed upward by beds of coarse granitic sand, the whole evidently derived from the wear of the adjacent granite rocks. The gravels and sandstones are bituminous throughout their entire thickness. Resting on the bituminous sandstone are beds of soft chalky shale, probably a portion of the Monterey shale series. The sandstone dips westerly at a low angle, 3° to 5° . Considerable rock has been quarried here and shipped to various localities.

No oil wells have been drilled either at this point or at the Mathews quarry, and it is not probable that wells would be successful, as the

bituminous rock which rests on the eroded surface of the granite is of uncertain thickness and small extent at either locality. There are also beds of similar sandstone, not bituminous, however, at other points along the buried granitic axis of the Gabilan Range. The exact relation of these sands to the shales above is not clearly understood, and they may be beds older than the Monterey shale, which have been impregnated with bitumen by downward infiltration.

About 6 miles northeast of the Mylar quarry the Nonpareil Consolidated Oil Company has drilled several prospect wells in sec. 32, T. 18 S., R. 10 E., M. D. M. These wells were drilled in the Monterey shale east of a great fault which has brought that formation up into contact with the Paso Robles formation. The shales here have a dip of 50° to the northeast and are succeeded above by beds of sandstone. There is a small amount of brea and bituminous sand in the Paso Robles formation along the line of the fault. These wells were not successful and have been abandoned. At several points between this locality and the Peachtree ranch there are indications of oil, but none to justify exploitation. Near the eastern corner of the Peach Tree ranch there is another outcrop of bituminous sandstone and conglomerate, apparently a part of the Paso Robles formation. These bituminous beds rest on crumpled strata of the Monterey shales which are also impregnated with bitumen. The deposit is of no value as bituminous rock, being dry and friable, and there is no probability that a productive oil sand will be reached at this place.

In the East Fork of Little Cholame Creek, northwest of Parkfield (Pl. I), there are many seepages of heavy brea or maltha. These are from the Monterey shale, from the sandstone directly above, and at one point from the Paso Robles formation. The seepages are from thin beds of bituminous sandstone and sandy shale. All of the formations examined here, except the Paso Robles, are close-textured rocks; no open porous sandstones were seen. The strata are greatly disturbed and are in close proximity to the granitic rocks below. The amount of bitumen is small and the conditions are not favorable for its storage.

Several oil wells have been drilled in this region, none of which was successful. The Cholame Valley Oil and Development Company drilled in sec. 31, T. 22 S., R. 14 E.; the Parkfield Oil Company in sec. 16, T. 23 S., R. 14 E., and the Waverly Oil Company in sec. 32, T. 22 S., R. 14 E., M. D. M.

At several points in Monterey and San Luis Obispo counties the basal sandstones of the Santa Margarita formation are bituminous. This sandstone is impregnated with bitumen at the mouth of Thompson Canyon, 4 miles west of Kings City (Pl. I), where it outcrops for some distance in a northwest-southeast direction along the northeast side of the Monterey shale area. Both the sandstone and shale are tilted at a high angle, dipping about 50° NE. This sandstone is now

dry and friable on the surface and there are no oil springs in this vicinity.

There are bituminous sandstones on San Antonio River, 8 miles southwest of Bradley, near the Monterey-San Luis Obispo County line (Pl. I). They are the basal beds of the Santa Margarita formation and outcrop at intervals along the northeast side of the Monterey shale area for several miles. The Monterey shale here contains beds of hard chert, typical of the shale in the Santa Lucia Range, and just below the base of the Santa Margarita formation it contains thin beds of bituminous sandstone. The Santa Margarita formation here consists of a considerable thickness of soft quartzose sandstone, containing many pebbles of Monterey shale, granitic and metamorphic rocks. Both the shale and sandstone are sharply tilted on the south side of San Antonio River, where the dip is northeastward at an angle of 40° to 85° . Toward the northeast the dip is less and the bituminous sandstone is covered by the basal conglomerates of the Paso Robles formation.

Two oil wells have been drilled at this locality, both near the southwest corner of sec. 35, T. 24 S., R. 10 E., M. D. M. One was drilled by the White Oaks Oil Company and another by the Great American Oil Company, which drilled entirely through the bituminous rock into the Monterey shale below without reaching productive oil sand. An oil well was drilled by the Monterey Oil Company in sec. 27, T. 24 S., R. 10 E., M. D. M. It was drilled in the Monterey shale, and was a failure.

Erroneous theories are entertained by some oil men and investors regarding the oil-producing formations in California. It is supposed that because the Monterey shales are bituminous they must of necessity contain commercially valuable quantities of oil, and on this supposition hundreds of thousands of dollars have been wasted in useless exploitation of barren territory throughout the State. At a few localities in California the Monterey shale contains interstratified beds of sand. When these beds of sand are thick enough, of considerable horizontal extent, of porous texture, and have been folded into favorable attitudes, they may contain valuable deposits of petroleum, provided, of course, that the adjacent shale is bituminous.

In the Salinas Valley the Monterey shale, although containing a great amount of bitumen, is far less bituminized than it is in other parts of the State where oil is found. It is here practically without interstratified beds of sand which might be oil producing, and when, in prospecting for oil in this region, the drill enters into a considerable thickness of hard, flinty shale, containing a little oil, gas, and sulphurous water, it is very probable that the drill has reached the Monterey shale, and further exploitation will doubtless result in disappointment.

COAL.

There are two localities in Monterey County where coal beds have been exploited, Stone Canyon and Priest Valley. (See Pl. I.) At the Stone Canyon mine (formerly known as Slack Canyon coal mine) the thickness of the coal bed is from 12 to 14 feet. The entire thickness is clean coal without shale partings. This coal bed has been traced, by means of tunnels, pits, and borings, for 4,300 feet along the strike, and to a depth of 526 feet at the incline of the Stone Canyon mine.^a The analyses made (see table on p. 21) indicate that the coal is a lignite and that it contains a large percentage of volatile matter. The roof of this mine is a hard, yellowish sandstone, which outcrops above the coal bed in massive strata several hundred feet thick. The floor is of soft, friable clay shale, much crushed and full of slickensides. It is of considerable thickness, and west of the mine appears to rest directly upon the San Luis formation, but to the east it rests on sandstone similar to that above the coal bed. The whole series of sandstone, shale, and coal is tilted up at high angles, with northward dips ranging from 80° to 90° along the outcrop. A very large amount of sulphureted hydrogen escapes from the coal bed below the water plane, making it difficult for men to work in the incline.^b

This mine is in an isolated region on the summit of Mount Diablo Range, 2,600 feet above sea level, and 20 miles from a railroad. The construction of a branch railroad will be expensive and difficult, although a line could be built to within 3 or 4 miles of the mine at a reasonable cost, and the coal delivered to this point by a cable incline operated by gravity.

In Priest Valley and on Wartham Creek there are coal beds which have been prospected at various times (see Pl. I), especially those at the Drabble mine, on Wartham Creek.^c These mines are now idle, and it is evident from an examination of the mine and region that the coal is of poor quality and too far from market to be of value at present (see table of analyses on next page). The coal beds exposed in the Drabble mine extend northwestward under Priest Valley, where they are folded into a synclinal trough. The same series of beds appears on the southwest side of the valley, dipping northeastward, and also on the northeast side of the valley, dipping southwestward. The coal here is not so good as that at the Drabble mine.

Coal beds are also reported to occur at intervals northwest of Priest Valley, in the Mount Diablo Range,^d but from reports none of these deposits seemed to be of any economic value and they were not visited.

^a Information given by F. J. Horswell, Superintendent.

^b Eighth Ann. Rept. California State Mining Bureau, 1888, p. 404.

^c Twelfth Ann. Rept. California State Mining Bureau, 1894, p. 51.

^d *Ibid.*, p. 61.

Table of analyses of coal from Drabble and Stone Canyon mines.

Locality.	Coking qualities.	Water.	Volatile matter.	Fixed carbon.	Ash.	Authority.
Drabble mine:						
Upper tunnel—						
Upper vein.....	None	11.25	38.25	38.50	12.0	Mathyas. ^a
Lower vein.....	do	13.25	37.65	36.60	12.5	Do. ^a
Lower tunnel—						
Upper vein.....	do	13.25	33.90	38.60	14.25	Do. ^a
Lower vein.....	do	13.00	37.25	31.50	13.25	Do. ^a
Stone Canyon mine:						
From dump.....	Slight	5.25	39.75	49.25	5.75	Do. ^a
Heading tunnel No.1	do	4.15	50.55	41.04	4.26	Hillebrand. ^b

^aTwelfth Ann. Rept. California State Mining Bureau, 1894, p. 64.^bU. S. Geological Survey.

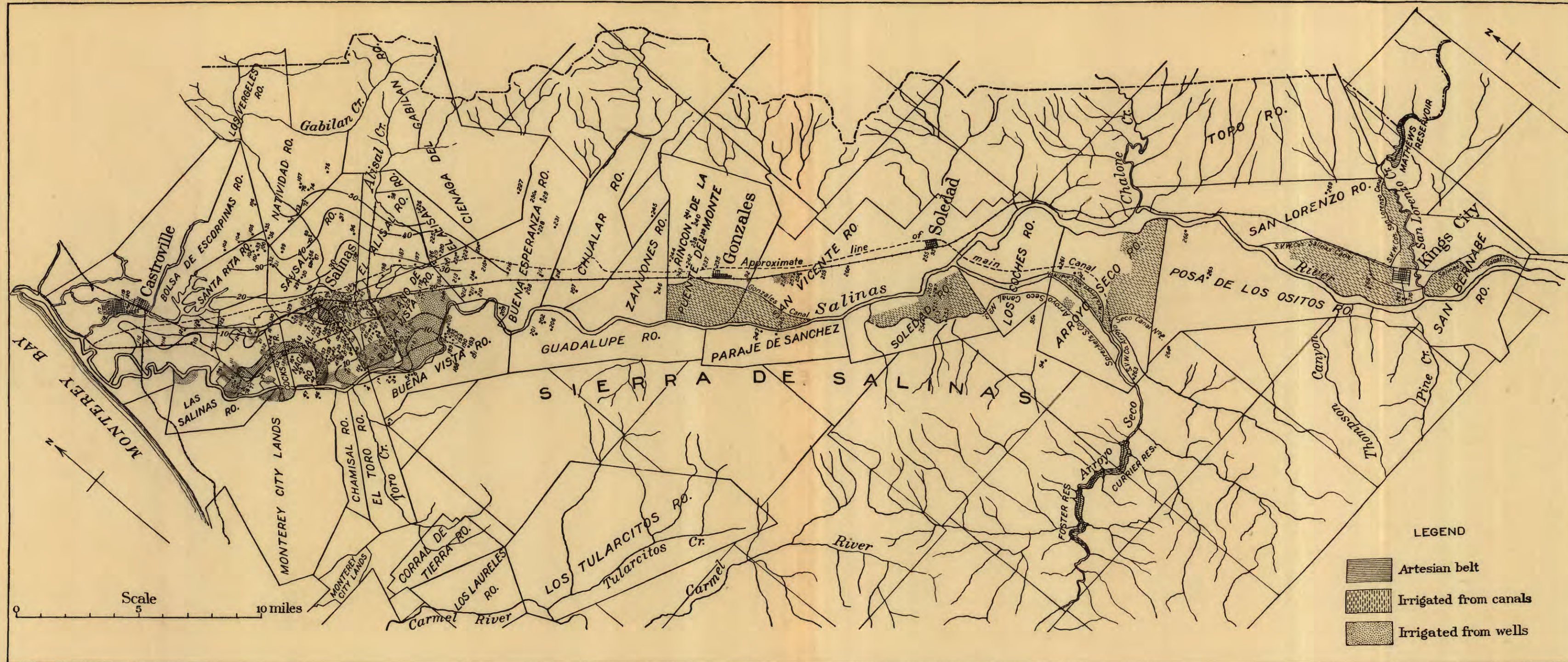
UNDERGROUND WATER.

In October, 1901, Mr. W. W. Cockins, jr., was detailed to study the ground water of the lower Salinas Valley. Data were collected regarding the depth of wells, amount of water, cost, etc. From his observations, supplemented by the work of the Bureau of Soils of the United States Department of Agriculture, the table on pages 22-30 has been compiled.

The location of the wells is shown on Pl. II. In a small bow-shaped area west of Salinas the wells formerly flowed slightly; the boundaries of this artesian tract are indicated on the map. Some of these wells flow at present when not drawn down by pumping. The artesian water is struck in a bed of coarse gravel that lies about 150 feet below the surface. In passing northeastward up the valley this stratum is found at a greater depth and the artesian water rises, but fails to reach the surface. The distance from the surface to the water from the artesian stratum is shown on the map by heavy lines, the line numbered 10 indicating that the ground water will rise to within 10 feet of the surface, but in order to reach the gravel bed it will be necessary to sink 150 to 160 feet plus 10 feet, or 160 to 170 feet, etc. There are not enough deep wells to trace the entire outline of this basin, but the direction taken by the various curves of depth indicate that the gravel bed may thin out in passing up the valley and that they probably extend northwestward beyond Castroville to the Bay of Monterey.

Wells in Salinas Valley.

No. of well.	Owner of well.	Location.	Class of well.	Depth of well.	Strata.	Depth to water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.
1	H. Corey	Buena Vista Rancho	Driven, 7-inch	Feet. 333		12	Wind	\$1,000	\$100	Domestic.
2	do	do	Bored, two 10-inch	168		8	8-inch centrifugal.	200	1,300	Irrigation.
3	do	do	Driven, 7-inch	182		5	Wind	235	100	Stock.
4	D. Jacks	El Toro Rancho	Bored, 7-inch	155	Sand, clay, gravel	10	do	140	100	Domestic.
5	H. Siegleton	Buena Vista Rancho	Dug, 4 by 4 feet	47	Gravel, clay, shale, clay.	.40	Hand	40	37	Do.
6	R. Wetjens	do		17	Loam, clay, gravel	10	do			Stock.
7	B. J. Marks	T. 15 S., R. 3 E., sec. 30		159	Rock, clay, gravel	60	Wind	500	200	Domestic.
8	W. Robson	Nacional Rancho		166		14	do	200		Do.
9	L. E. Fenton	Confederate Corner	Bored, 10-inch	174	Clay, sand, gravel	9	Gas engine	200	750	Irrigation.
10	do	do	Bored, 7-inch	177			Wind	250	150	Domestic.
11	P. Thompson	Salinas	do	164		14	do		50	Do.
12	N. C. Grant	do	Bored, 2-inch	130	Clay, sand, gravel		do	65	50	Do.
13	C. Graves	Nacional Rancho	Bored, 7-inch	170		1	do	160	60	Do.
14	do	do	Bored, two 10-inch	{ 184 180		1	Steam	600		Irrigation.
15	H. Bardin	do	Bored, 7-inch	133		0	Wind			Domestic.
16	do	do	Bored, two 10-inch	{ 194 186		8	Gas engine	410	1,000	Irrigation.
17	Mrs. H. C. Tollet	do	Bored, 2-inch	138			Wind			Domestic.
18	P. Vaughan	Cocks tract	Bored, 2-inch	180		15	do			Do.
19	J. Borondo	Rincon del San Jon	Bored, 7-inch	85			do	250	100	Do.
20	A. S. Borges	do	Bored, 8-inch	186		12	do			Do.
21	J. Dersepa	T. 14 S., R. 2 E., sec. 25	Bored, 2-inch	152		8	do			Do.
22	J. G. Armstrong	T. 14 S., R. 2 E., sec. 26				2.5	Gas engine			Irrigation.
23	R. Porter	Cocks tract	Bored, 7-inch	152		0	Wind	200	750	Domestic.
24	do	do	Bored, 2-inch			0	do			Stock.
25	F. Kopman	do	do	160		.5	do			Domestic.
26	W. Crow	T. 14 S., R. 2 E., sec. 35	Bored			.5	Hand			Do.



MAP OF THE SALINAS VALLEY, SHOWING IRRIGATED LANDS, CANALS, PROPOSED RESERVOIRS, AND LOCATION OF WELLS.

Contour lines indicate distance from surface to water. Small numbers indicate location of wells listed on pages 22-30.

UNDERGROUND WATER

[illegible]

Wells in Salinas Valley—Continued.

No. of well.	Owner of well.	Location.	Class of well.	Depth of well.	Strata.	Depth to water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.
				<i>Feet.</i>		<i>Feet.</i>				
58	Mr. Dedimi.	Nacional Rancho.	Bored, 2-inch.	86		18	Wind			Domestic.
59	A. Abbott	do.	Bored, 7-inch.	135		20	do			Do.
60	J. Dill	do.	Bored, 2-inch.	91	Sand, gravel.	22	do			Do.
61	Mrs. Jeffery	do.	Bored, 7-inch.	125		26	do			Do.
62	J. Gran	do.	Bored, 2-inch.	180			Hand			Do.
63	Mr. Garside	do.	Bored, 4-inch.	150		25	do			Do.
64	do	do.	Bored, 10-inch.	25		10	Wind			Domestic and irrigation.
65	Salinas City W. Co.	Salinas	Bored, ten 20-inch	{ 200 165 }		2	Steam			City supply.
66	Monterey Co.	County hospital	Dug, 7 by 7	10		2	Wind and horse			Domestic.
67	do	do	Dug, 5 by 5	10		6	Wind			Irrigation.
68	do	do	do	12		10	do			Do.
69	E. Sherwood	Sausal Rancho	Bored, 7-inch.	525		45	do	\$2,000		Domestic.
70	do	do	Dug, 4 by 4	8		6				Stock and domestic.
71	C. P. Cooper	Natividad Rancho	Bored, 7-inch.	165		46	Wind			Do.
72	E. W. Sheely	do	Bored, 2-inch.	180		50	do			Do.
73	H. Mayn.	do	do	180		50	do			Do.
74	Mr. Patton	do	Dug, 4 by 4	26		23	do			Stock.
75	J. W. Patton	Natividad	do	10		6	do			
76	G. Mosca	do	Dug, 3 by 3	40		36	Hand			
77	J. Breschini	Blanco	Bored, three 10-inch	{ 135 164 }		8	Wind			Domestic and irrigation.
78	Mrs. C. Clausen	do	Bored, 7-inch.	152		7	do	200	\$1,700	Domestic.
79	F. McFadden	El Trucho Rancho	Bored, 2-inch.	163		7	do			Do.
80	do	do	Bored, two 10-inch.	{ 187 198 }		6.5	Steam	400	2,000	Irrigation.
81	Spreckels Sugar Co.	Llano de Buena Vista	Bored, 5-inch.	177		20	Hand			Domestic.
82	do	do	Bored, 6-inch.			20	Wind			Do.

83	M. Harkens	do	do	106	Clay	20	do	Do.
84	M. T. Martin	do	Bored, 2-inch	142		20	do	Stock and irrigation.
85	J. Gran	do	do	142		17	do	Domestic.
86	do	do	Bored, 10-inch	165		15.5	do	Irrigation.
87	J. Davila	do	do	154		16	do	Domestic.
88	Mr. Tavernetti	do	Bored, 10-inch	150		15	Wind and gas engine	Domestic and irrigation.
89	M. Winn	El Tucho Rancho	Bored, 2-inch	149		7	Wind	Domestic.
90	T. Campbell	do	Bored, 10-inch	178		6	Gas engine	Irrigation.
91	F. Vierra	T. 14 S., R. 2 E., sec. 22	Bored, 2-inch	165		7	Wind	Domestic.
92	Dr. Gonzales	Punta del Monte	Bored, two 10-inch	177		29		
93	Southern Pacific R. Co.	Soledad	Dug, 4 by 4	32		31	Wind	Boilers.
94	O. Olsen	T. 18 S., R. 6 E., sec. 29	Dug	230	Sand, clay and gravel			
95	Wiley Bros.	T. 18 S., R. 6 E., sec. 21	Dug, 4 by 4	141		137	Wind	Domestic.
96	M. Williams	El Alisal Rancho		90		68	do	Do.
97	J. Duncan	do	Bored, 7-inch	106		36	do	Do.
98	P. Zabala	El Alisal Rancho	do	200	Gravel, clay, quicksand, sand.	80	do	Do.
99	D. McKinnon	Sausal Rancho	Bored, 10-inch	240	Sand and clay	50	do	Do.
100		Santa Rita Rancho	Bored	132	Gravel	20		
101		do	Dug	22	do	16		
102		do	Bored	71	do	23		
103		Escarpines Rancho	Dug	80	do	30		
104		do	Bored	160	do	40		
105		do	Dug	70	do	22		
106		do	Bored, 10-inch	105	do	25		
107		Natividad	Dug	42	do	8		
108		Sausal Rancho	Dug, 4 by 4	51		47	Wind	Domestic and stock.
109		Salinas	Bored	180	Gravel	18		
110		do	do	138	do	8		
111		T. 14 S., R. 2 E., sec. 27	do	150	do	12		
112		Morocojo Rancho	do	20	do	15		
113		do	do	205	do	5		
114		do	do	125	do	31		

Wells in Salinas Valley—Continued.

No. of well.	Owner of well.	Location.	Class of well.	Depth of well.	Strata.	Depth to water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.
				<i>Feet.</i>		<i>Feet.</i>				
115		Morocoyo Rancho	Bored	180		0				
116		do	Dug	12		6				
117		Castroville	do	18		13				
118		do	do	18		15				
119		do	Bored	80	Gravel	12				
120		do	Bored, 10-inch	107		8				
121		Morocoyo Rancho	Dug	15		10				
122		do	Bored	127		12				
123		Coopers	do	112	Gravel	2				
124		San Jon Rancho	do	100	do	6				
125		Salinas	do	101	do	11				
126		do	do	130	do	12				
127		Nacional Rancho	do	90		7				
128		Sausal Rancho	do	100		8				
129		do	do	140		9				
130		San Jon Rancho	do	187	Gravel	8				
131		Cocks Tract	do	180	do	10				
132		do	do	184	do	2				
133		Salinas	do	135	do	15				
134		Nacional Rancho	do	158	do	9				
135		do	do	190	do	9				
136		Salinas	do	105	do	14				
137		do	do	107	do	14				
138		do	do	130	do	11				
139		Nacional Rancho	do	134	do	20				
140		do	Bored, 10-inch	160	do	11				
141		do	Bored	134	do	12				
142		do	do	134	Gravel	12				

143	do	do	do	120	Gravel	12	
144	do	do	do	140	do	8	
145	do	do	do	140	do	11	
146	Sausal Rancho	Dug	50	50		20	
147	Nacional Rancho	Bored	90	Gravel		9	
148	do	do	127	do		11	
149	do	do	150			10	
150	do	do	90	Gravel		7	
151	do	do	165	do		7	
152	do	do	160	do		5	
153	do	do	160	do		3	
154	do	do	150	do		2	
155	do	do	140	do		1	
156	do	do	120	do		2	
157	do	do	158	do		0.5	
158	do	do	168	do		8	
159	do	do	148	do		9	
160	do	do	162	do		8	
161	do	do	150	do		15	
162	do	do	150	do		12	
163	do	do	65	do		15	
164	Riverside	do	156	do		8	
165	do	do	164	do		18	
166	Llano de Buena Vista	do	150	do		13	
167	do	do	151	do		13	
168	do	do	141	do		13	
169	do	do	137	do		8	
170	do	do	128	do		9	
171	do	do	130	do		15	
172	do	do	126	do		10	
173	do	do	170	do		10	
174	do	do	140	do		25	
175	do	do	165	do		13	
176	do	do	130	do		18	
177	do	do	300	do		14	

Irrigation.

Wells in Salinas Valley—Continued.

No. of well.	Owner of well.	Location.	Class of well.	Depth of well.	Strata.	Depth to water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.
178		Llano de Buena Vista	Bored	Feet. 110	Gravel	10				
179		do	do	160	do	18				
180		do	do	158	do	20				
181		do	do	140	do	18				
182		do	do	120	Sand	8				
183		do	do	70	Gravel	8				
184	Spreckels Sugar Co.	Ranch No. 1	do	150	do	12				
185		Llano de Buena Vista	do	150	do	20				
186		Buena Esperanza	Dug	26	do	8				
187		El Alisal Rancho	do	20	do	16				
188		Buena Vista Rancho	Bored, 7 inch	178	do	50				
189		do	Bored	130	do	22				
190		do	do	65	do	10				
191		do	do	180	do	100				
192		do	do	200	Pebbles	60				
193		do	do	120	do	8				
194		do	do	138	Gravel	0				
195		do	do	100	do	12				
196		do	do	108	Gravel, sand	8				
197		El Alisal Rancho	Dug	23	do	20				
198		do	do	22	do	18				
199		Buena Vista Rancho	Bored	130	Gravel	10				
200		do	do	136	do	6				
201		Guadalupe Rancho	do	90	do	30				
202		do	do	100	do	8				
203		Nacional Rancho	Bored, 10-inch	180	do	10				
204		Salinas	Bored	778	Clay, sand, gravel, bowlders.					
205		Sec. 30, T. 18 S., R. 6 E.	Springs							

206	Guadalupe Rancho.	Dug	45	Gravel	40
207	Chualar Rancho	do	50	do	45
208	Buena Esperanza.	do	35	do	33
209	do	Bored	35	do	30
210	do	Dug	25	do	19
211	do	Bored	125	do	20
212	do	Dug	30	do	27
213	do	do	30	do	23
214	do	do	20	do	15
215	do	do	47	do	45
216	do	Bored	187	do	40
217	do	do	160	do	30
218	Chualar Rancho	Dug	50	do	40
219	Buena Esperanza.	do	20	do	15
220	Alisal Rancho	do	10	do	7
221	Buena Esperanza.	do	20	do	17
222	do	do	28	Gravel	22
223	do	do	60	do	57
224	do	do	72	do	70
225	Alisal Rancho.	Bored	125	Gravel, clay	40
226	do	do	163	do	80
227	Gabilan Rancho	Dug	40	do	16
228	Buena Esperanza.	Bored	130	Gravel, loam	123
229	do	do	246	do	146
230	do	Dug	62	Gravel, sand	47
231	do	Bored	295	Gravel	165
232	Gonzales	Dug	35	do	31
233	do	do	30	do	23
234	do	Bored	47	do	26
235	do	Dug	137	Blue mud	160
236	do	do	65	Gravel	30
237	Punta del Monte	do	60	do	32
238	do	do	100	do	90
239	do	do	100	do	95
240	do	do	182	Gravel	175

Wells in Salinas Valley—Continued.

No. of well.	Owner of well.	Location.	Class of well.	Depth of well.	Strata.	Depth to water.	Method of lift.	Cost of well.	Cost of machinery.	Use of water.
				<i>Feet.</i>		<i>Feet.</i>				
241		Punta del Monte	Dug	178	Gravel	170				
242		do	do	32	do	28				
243		do	do	28	do	21				
244		do	do	60		30				
245		Sec. 2, T. 16 S., R. 5 E	do	20	Gravel	10				
246		Zanjoncs Rancho	do	40		10				
247		Pajaro de Sanchez	do	120	Gravel	4				
248		do		80		78				
249		Soledad Rancho		66	Gravel	60				
250		do		67	do	60				
251		do	Dug			15				
252		do	Bored		Gravel	45				
253		do	do	131		20				
254		do	Dug			15				
255		Soledad		30		27				
256		San Vicente Rancho	Bored	250		50				
257		do		50		42				
258		do		44		40				
259		do		30	Gravel, bowlders	24				
260		do		25	Gravel	23				
261		Arroyo Seco Rancho				25				
262		do		100	Gravel, clay	40				
263		do				21				
264		T. 19 S., R. 6 E., sec. 13		59	Clay	40				
265		Posa de los Ositos		70	Sand	30				
266		do				30				
267		San Lorenzo Rancho			Gravel, quicksand	16				
268		do				14				
269		do		200		170				
270		do		40		20				

NOTE.—Well records Nos. 1 to 99, inclusive, obtained by W. W. Cockins, jr.; well records Nos. 100 to 270, inclusive, obtained by Bureau of Soils, Agricultural Department.

The character of the strata filling the lower portion of the valley is shown by a well (No. 204 in table) drilled near the court-house at Salinas, at an altitude of about 33 feet above sea level.

Record of Salinas well.

Character of strata.	Thickness.	Depth of bottom of formation.
	<i>Ft. In.</i>	<i>Ft. In.</i>
Alluvium	4 0	4 0
Yellow clay	6 0	10 0
Yellow sand	8 0	18 0
Yellow clay	5 0	23 0
Yellow quicksand	18 0	41 0
Yellow clay	16 0	57 0
Blue sand	5 0	62 0
Blue clay	10 0	72 0
Yellow clay (small flow of gas)	10 0	82 0
Brown vegetable mold (strong flow of gas, but well soon filled with water)	3 0	85 0
Sand and coarse gravel	10 0	95 0
Blue clay	5 0	100 0
Yellow clay	25 0	125 0
Sand and gravel alternating	57 0	182 0
Quicksand	10 0	192 0
Decomposed coarse gravel	10 0	202 0
Tough yellow clay	2 0	204 0
Blue clay	28 0	232 0
Black sand and mud	3 0	235 0
Rotten gravel	2 0	237 0
Bluish sand	10 0	247 0
Blue clay	17 0	264 0
Yellow sand and coarse gravel	43 0	307 0
Tough yellow clay	1 0	308 0
Yellow sand and coarse gravel	50 0	358 0
Tough yellow clay	10 0	368 0
Yellow sand	9 0	377 0
Coarse gravel and sand	95 0	472 0
Tough whitish clay	7 0	479 0
Gray sand and gravel	15 0	494 0
Seam of limestone	0 4	494 4
Tough yellow clay	51 0	545 4
Mud	0 8	546 0
Sand and gravel	156 0	702 0
Yellow clay	5 0	707 0
Sand and coarse gravel	15 0	722 0

Record of Salinas well—Continued.

Character of strata.	Thickness.	Depth of bottom of formation.
	<i>Ft. In.</i>	<i>Ft. In.</i>
Yellow clay	6 0	728 0
Gravel and bowlders	15 0	743 0
Tough clay and limestone	10 0	753 0
Yellow sand	8 0	761 0
Clay, gravel, and cement	4 0	765 0
Cement sand	10 0	775 0
Dry yellow sand	2 0	777 0
Gray clay with limestone	1 0	778 0

The gravel brought to the surface consists of small waterworn pebbles from half an inch to 2 or 3 inches in diameter; many of the coarser pebbles were broken in the well.^a

It is probable that the abundant supply of ground water is struck in the beds of sand and gravel from 125 to 202 feet in depth. The well appears to have pierced the clays and limestone of the older formation at a depth of 472 feet, or about 440 feet below sea level. This is then an approximate measure of the depth of the detritus filling this portion of the valley.

In 1880 a well was drilled at Castroville to a depth of 178 feet, producing a volume of fresh water, which at high tide flowed in large quantity over the casing and at low tide ceased flowing. This well is near the mouth of Salinas River, and the surface of the ground is 20 feet above the river.^a

The gathering ground for this body of underground water is unknown, but the close agreement of the basin with the outcrops of the sand hills on both sides of the valley suggests that this formation may be the source from which the water is indirectly derived by seepage. This idea is strengthened by the fact that the water from the deep wells is of about the same purity as that found in the sand hills, being far purer than the river water, the surface water in this portion of the valley, or the water derived from the older formations. This water may possibly be derived by percolation through deeply buried gravel beds, from the Arroyo Seco or the upper Salinas, but deep borings have not proved that conditions are favorable to this origin.

Southeast of Salinas, as far as Kings-City, there are a few pumping plants used for irrigation, some of which draw water from the river. They are described on page 80. The wells in this portion of the valley do not furnish sufficient data on which to base an opinion as to

^a Tenth Ann. Rept. California State Mining Bureau, 1890, p. 346.

the underground conditions other than that the supply of ground water is limited except along the river.

The only artesian well noted in Monterey County, except in the vicinity of Salinas, is on the Pleyto ranch (Pl. I), at Mr. Pinkerton's place, one-half mile southeast of Pleyto. The total depth of this well is 145 feet. At depths between 70 and 100 feet the drill was in hard, black rock, and at 100 feet water rose 9 feet. At 145 feet a bed of hard rock was penetrated and the water then flowed over the top of a 7-inch casing.^a This well is situated in the lower end of a synclinal basin, at a point where one would expect to secure an artesian flow if there is one in that locality. This basin extends northwestward about 20 miles, and there is a possibility that a small artesian flow may be struck in the southeast part of it, between Jolon and Pleyto. At no other point in Monterey County were conditions favorable for artesian wells observed.

It seems probable to the writer that deep wells in the mesa region on the east side of the valley, southeast of Kings City, may yield sufficient water for stock-raising purposes if pumped. This can be proved only by experiment, however.

CLIMATE.

CLIMATIC FACTORS.

In an appendix to a report on the climatology of the arid regions of the United States with reference to irrigation Mr. A. W. Glassford makes the following statements:^b

Two influences dominate the climate of California, radically dissimilar in every particular, combining in ever-varying forces to produce the resultant which is recorded by observers of the weather. One is the sea, tending always to charge the air with moisture, the other the mountain mass, tending always to discharge the moisture from the air. The combination of these two activities in varying proportions is responsible for the variation in the amount of precipitation, including months of drought. It is necessary to consider these two active and determining forces not merely in their resultant, but, so far as is possible, by resolution into their component forces as well. In the present state of knowledge the resolution can not be complete, yet the extent to which it can be made affords interesting results.

The mountain factor.—The States of California and Nevada abut upon the maximum extension in latitude of the Cordilleran system, by which designation is inclusively implied all those ranges, basins, and valleys which in a looser description are often spoken of as the backbone of the continent and considered to include everything from the eastern ranges of the Rocky Mountains to the Pacific Ocean. Between the parallels of 35° and 40° this system attains not only its greatest breadth, but its greatest general elevation. It extends from eastern Colorado across four States and into the ocean, where but a few miles from the California coast it breaks short off from the continental shelf and plunges to abyssal depths.

^a Information furnished by W. Pinkerton.

^b Irrigation and water storage in the arid region: House Ex. Doc. 287, Fifty-first Congress, second session, pp. 334-337.

Not only is its width greatest between these parallels, and therefore productive of its maximum influence upon the general circulation of the atmosphere, but also by the massing of many of its extreme heights within these same limits it exerts such violent influence of perturbation as is due to sudden uplifting of air bodies to great altitudes. Thus in Colorado there is a chain of peaks all rising to a height of more than 14,000 feet, of which Pikes Peak is the eastern outpost; Utah and Nevada form the Great Basin, on a general level of 5,000 feet; in California the Sierra Nevada has its peaks of 14,000 feet, as well as Colorado, and at the very edge of the sea is another range of mountains lower than the Sierras, yet of marked influence upon the climate and the rainfall in particular. These systems within the limits of the two States now under examination may properly claim more detailed investigation.

The characteristic orographic feature of this region is the Sierra Nevada, and it is as well the predominant climatic instrument both for California, to which it gives the rain, and for Nevada, from which it withholds it. The geographer and the geologist unite in considering this the most interesting and important link in the Cordilleran system, and the climatologist must unhesitatingly and without reserve give adhesion to their judgment. In brief description it is a long and elevated mountain chain, on the whole the most conspicuous on the continent. It displays its greatest prominence when viewed from the west, because on this side it falls almost to sea level, while upon its eastern slope it merges into the general high altitudes of the interior plateau. But it does not, however, border immediately on the ocean, since for all its course there lies between its foothills and the sea beach a chain of lower mountains, known as the Coast Ranges. * * *

These, the Coast Ranges, are sufficiently important in their relations to precipitation to merit more close consideration. The most important part of the Coast Ranges is that which fences off the great valley of the Sacramento and San Joaquin rivers from the sea. In this portion of their length, where they may be clearly distinguished from all series of inosculating elevation, they have a length of fully 400 miles, and in width vary from 40 to 70 miles; in this particular it is to be noted that their eastern limit is fixed with considerable precision of definition at a practically constant distance from the western limit of the Sierras; the expansions are uniformly made by encroachments upon the sea. The system comprises a multitude of subordinate ranges, some large, some small, but almost all distinguished by names bestowed upon them during the former Spanish occupation of the country, with a few Indian names yet preserved for characteristic peaks. The general trend of the subranges, as of the system at large, is with a tendency toward parallelism with the coast. In proportion to distance from San Francisco, where the system is broken through at sea level by a gap but a mile in width, the summits and the general elevation are found to be higher, and this is true both north and south. * * * From Mount Hamilton the ridge of 3,000 feet elevation continues without interruption and almost in a right line to the Tehachapi country and its coalescence with the same level of the Sierra system. * * *

Having thus indicated the orographic skeleton of the country, it comes next in order to examine the valleys infolded between these mountains.

As it is the greatest, so is the Great Valley of California the most important; it frequently takes the names of the rivers which traverse it and is known in its northern portion as the Sacramento Valley, and in its southern half as the San Joaquin Valley. It is fenced on the east by the Sierra Nevada, on the west by the Coast Ranges, and at north and south by the coalescence of its side walls. Between these walls it has a length of about 450 miles and maintains the average breadth of 40 miles. * * *

In the Coast Ranges are many fertile valleys, which vary greatly in size and conditions, according to position. * * * North of the [San Francisco] bay the

valleys uniformly open into the Sacramento Valley, and each has a name which has nearly the value of a trade-mark in the markets for farm, orchard, and vineyard produce. * * * South of the bay, on the dry eastern slope of the Coast Ranges, not a valley is to be found of any moment. West of the summits are to be found several fertile valleys. Of these the valley of Santa Clara and Alameda open on the Bay of San Francisco, and the valleys of the San Benito and the Salinas open on the Pacific at the Bay of Monterey. * * *

The oceanic factor.—This presentation of the mountain masses of the region under study has been made for the purpose of showing what influences may be counted on as constantly exerted to discharge the moisture from the atmosphere. Another influence is constantly exerted to charge the atmosphere with moisture, and this influence should be examined in turn. It is found in the Pacific Ocean, which washes the entire coast of California. * * *

The largest of all the oceans, the Pacific, is least subject to perturbing influences of a local character. Its conditions are constant over large areas; its currents, both of wind and water, are drawn in broad, sweeping curves, in which extent of space and time of passage serve to override all mere local or temporary modifications. Thus it is enabled to present almost the ideal problem of oceanic circulation and to array upon the climate of California, and in a modified degree that of Nevada, a few masses of simple influence which become involved and difficult of study only through the continental disturbances.

Without interruption that part of the North Pacific Ocean which may be considered as modifying the climate of California stretches away over nearly 100 degrees of longitude. To the west it is bounded by the extreme Orient. * * * The northern limit is drawn by the Aleutian Islands, and the eastern border is the shore of North America. To the south no consistent mass of land appears to hem this ocean in, yet the barrier is none the less strong because it may be measured only with the instruments of the meteorologist. It exists at the thirtieth parallel of north latitude. Below this bounding line is the region of northeast trade winds and the westward drift of the equatorial current, and these two serve sufficiently to bound in wind and water the great basin above. * * *

The winds upon this basin are of the system of the passage winds which are developed upon the surface of the earth by the descent from high altitudes of upper currents. In general these winds vary with the latitude from southwest, westerly, to northwest. * * *

The Californian parallels lie entirely within the northern zone of the passage or antitrade winds, and are therefore under an atmosphere with a uniformly eastern progression as a part of the general system of atmospheric circulation of the globe. * * *

The wind drawn in from sea by the general circulation of the atmosphere may be taken to have in suspension the maximum amount of moisture, and, other things being equal, to approximate the saturation amount theoretically to be expected in air of a given pressure and at a given temperature.

WINDS.

Throughout California the general drift or movement of the atmosphere is to the southeast. Over the land, however, the direction and velocity of the wind are much modified by the trend of the mountain ranges and intervening valleys, as well as by diurnal and seasonal changes in temperature. Along the coast the northwest passage winds blow with remarkable regularity during the summer, and more or less constantly during the entire year. The diurnal changes in

temperature over the land cause the daily fluctuation in these winds. Ordinarily the wind from the ocean begins to blow inland during the forenoon and increases in force until late in the afternoon, when it gradually subsides. This is known as the sea breeze. During the night there is often a light breeze seaward, known as the land breeze. The sea and land breezes are but local modifications of the general drift of the atmosphere, and depend principally upon the difference in temperature between the land and the sea. In valleys that open toward the northwest and extend far inland between high mountain ranges, as the Salinas Valley, the sea winds are usually strong, and during the summer season often violent.

In the accompanying tables are given anemometer records of the total wind movement in miles per day at Salinas from January 1, 1902, to March 13, 1903, and at Kings City from January 1, 1902, to March 14, 1903. The greater part of this wind movement is up the Salinas Valley and takes place during the afternoon.

Total daily wind movement, in miles, at Salinas.

Date.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1902.											
January							59	134	91	130	140
February	115	111	113	107	114	128	199	215	139	103	181
March			159	127	161	217	161	228	197	201	144
April	206	183	201	160	122	104	308	131	151	147	180
May	207	174	174	156	125	242	172	157	169	124	211
June	247	281	213	203	184	180	180	174	170	204	---
July									104	145	133
August	192	242	197	186	166	186	176	195	191	191	190
September	142	169	171	236	132	173	151	172	157	143	146
October	202	185	161	172	92	139	181	120	130	167	162
November	125	131	163	120	133	112	133	225	462	355	104
December	134	115	148	167	96	109	66	149	131	214	146
1903.											
January	97	125	109	158	200	214	145	94	98	132	107
February	150	161	131	220	148	130	140	230	119	96	197
March	221	163	152	166	193	129	133	170	325	101	180

Total daily wind movement, in miles, at Kings City.

Date.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1902.											
January											
February	126	110	122	136	159	153	170	190	141	125	124
March	160	312	180	151	137	295	90	355	178	207	221
April	271	181	109	166	60	220	304	199	283	262	262
May	228	299	264	197	98	197	183	332	253	578	00
June	302	331	348	344	267	301	312	209	231	238	324
July	300	243	240	417	244	296	243	229	239	308	214
August	306	289	234	271	245	262	242	282	294	326	367
September	189	210	257	216	255	229	244	208	248	237	206
October	490	482	86								
November	178	63	228	222	169	140	131	264	341	370	136
December	147	162	222	86	123	145	94	147	202	441	187
1903.											
January	134	136	128	177	158	140	149	102	122	102	140
February	128	124	236	79	118	91	80	267	163	141	162
March	151	150	299	123	167	121	99	258	241	121	192

Date.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.
1902.										
January										
February	214	162	224	299	200	331	250	230	154	213
March	192	292	240	282	208	95	282	194	162	322
April	337	237	208	169	219	285	233	324	313	128
May	247	184	225	240	291	430	395	464	289	234
June	306	330	396	359	284	280	216	271	258	267
July	210	270	259	381	279	350	181	283	307	253
August	287	175	167	235	321	244	216	246	206	212
September	216	246	255	243	203	177	192	184	264	169
October		100	118	204	115	225	119	161	131	227
November	156	123	107	165	112	180	190	146	127	162
December	76	103	140	132	194	69	53	99	64	77
1903.										
January	95	111	107	186	135	155	128	172	243	132
February	193	198	127	91	123	119	122	147	145	124
March	180	307	266							

Total daily wind movement, in miles, at Kings City—Continued.

Date.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
1902.										
January					374	118	101	105	157	124
February	323	143	397	240	320	192	146			
March	257	311	163	215	152	173	156	197	128	190
April	213	157	198	217	322	160	204	156	214	
May	173	207	254	262	200	243	323	367	349	335
June	243	250	360	273	253	405	338	238	288	
July	228	210	236	283	210	305	323	304	286	337
August	239	277	268	214	231	204	213	225	237	219
September	140	163	276	314	270	142	289	189	148	
October	210	276	280	132	112	103	171	203	175	270
November	88	115	91	78	110	126	153	204	198	
December	99	98	98	150	195	111	209	113	100	125
1903.										
January	147	109	130	163	187	312	320	175	197	56
February	124	106	236	214	149	109	153			
March										

RAINFALL.

When the passage winds reach the coast they sometimes, under proper conditions, precipitate a portion of their moisture. One of these conditions is cooling of the air by contact with a cool land area or by being forced to a great altitude in passing over mountain ranges, for the cold summits of mountains are effective condensers of moisture. Such conditions do not, however, occur along the coast of Monterey County, for the general movement of the air currents there is from the northwest to the southeast, parallel with and not across the mountain ranges. In addition to this the air currents in their southeastward drift are continually passing into a warmer region, where the temperature of the air is raised and its capacity for absorbing moisture increased. Thus the passage winds, although moist and cool on the coast, become dry in the interior and abstract moisture by evaporation from every stream and lake, from the soil, and from all vegetation. These northwest winds bring no moisture to the land along the coast south of San Francisco.

The above-described climatic conditions are practically constant, recurring from day to day throughout the year unless modified by general atmospheric disturbances accompanying regional storms. As is well known, in cyclonic storms of vast extent the storm center is an area of low barometer toward which the winds blow from every

direction. The path of these storms shifts with the seasons, moving southward during the autumn and reaching the coast of Washington and Oregon in October or November. Many pass eastward without bringing rain to central or southern California; others, however, are deflected southward by atmospheric conditions east of the Cascade Mountains and the Sierra Nevada and pass over California, Nevada, and Arizona. These storms are preceded by southeast, south, or southwest winds along the coast regions of California, or toward the storm center in the northern part of the State. The general direction of these storm winds is nearly at right angles to the general drift of the passage winds and across the trend of the mountain ranges of the State. This marked change in the direction of the wind is an important factor in the rainfall on the Pacific coast. These moist southerly winds pass from a warm to a cooler region and are cooled sufficiently to cause precipitation, thus giving rain over sea and land.

These moisture-laden storm winds from the Pacific, on encountering the mountain ranges along the coast and in the interior, are forced to rise to a considerable altitude, where they are still further cooled and precipitate a large part of their moisture, leaving the regions to the east of the mountain ranges dry and barren.

Aridity, or rather the unequal distribution of moisture, is largely the result of topography or inequalities of land surface. If the land were perfectly flat, it is probable that the winds, meeting with no obstructions, would distribute the rains with considerable uniformity in broad bands approximately parallel to the equator; but the relatively thin layer of dense atmosphere surrounding the globe is disturbed in its uniform flow by the lofty mountain masses which traverse the continents. The atmosphere surrounding the earth extends outward many miles, but it is the layer, a mile or two in thickness, resting immediately upon the surface, and relatively dense, within which occur the changes or disturbances that make up what we know as "weather." The movements of the air above this thin layer concern us little, but the behavior of the clouds and winds near the surface of the ground brings success or failure to the farmer, and affects more or less directly other industries, and even health.^a

The marked influence of topography on the distribution of rainfall is strikingly shown in fig. 1. This diagram shows graphically the increase in rainfall due to difference in altitude on the west side of the Sierra Nevada and the no less pronounced decrease on the east side, indicating how completely the moisture-laden winds have been robbed of their moisture by the cold mountain range. This diagram consists of a profile or section drawn along a line from Farallon Islands through San Francisco, across the Sacramento Valley and Sierra Nevada, and out on the Great Basin as far as Wadsworth. The various stations along this profile and their altitude above sea level are shown. The height of the small black columns represents the average annual rainfall in inches at each station.

^aNewell, F. H., *Irrigation*, p. 16.

At the Farallon light-house on Farallon Island, 30 miles west of San Francisco, the average rainfall is 18.44 inches. This may be taken as the probable average along the coast at this latitude, where the precipitation is not influenced by adjacent mountain masses. At San Francisco the annual rainfall is 22.77 inches, the increase being due to the influence of the Coast Range. Toward the east, in the Sacramento Valley, the annual rainfall is about the same as over the ocean, being 19.78 inches at Fairfield and 19.60 inches at Sacramento. Folsom is at the foot of the Sierra Nevada, at an altitude of 180 feet, and has an annual rainfall of 23.81 inches. On the western slope the rainfall increases with increase in altitude, but not uniformly. The rainfall at Auburn is 33.06 inches, at Colfax, 47.02 inches, and at Cisco, a short distance west of the summit, 51.18 inches. The increase from Folsom to Colfax is at the rate of some-

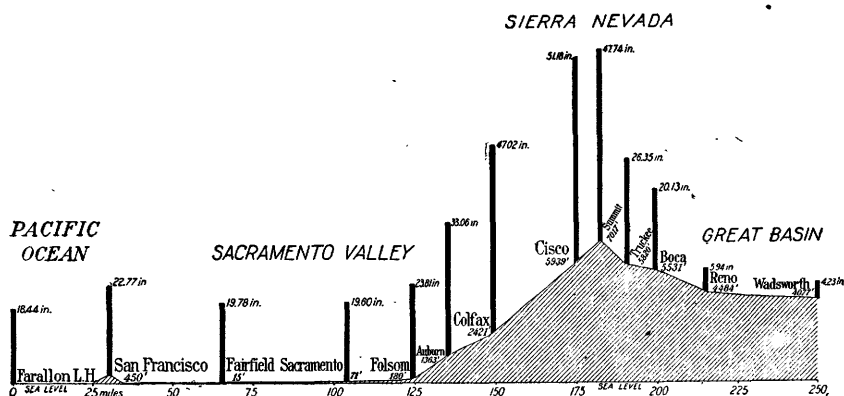


FIG. 1.—Diagram showing unequal distribution of rainfall in California and Nevada, the result of topographic features.

what more than 1 inch per 100 feet rise in elevation, while from Colfax to Cisco the increase is at the rate of but a little more than 0.1 inch per 100 feet rise in elevation, or about one-tenth of the increase below. At Summit, on the crest of the range, the rainfall is 47.74 inches, or 3.44 inches less than at Cisco, although Summit is 1,028 feet higher. The sudden decrease in rainfall on the lee side of the range is strikingly shown in this diagram. At Summit the rainfall is 47.74 inches and at Truckee 26.35 inches. The difference in altitude of these two points is 1,197 feet and the actual decrease in rainfall is 21.39 inches, a trifle over $1\frac{1}{4}$ inches decrease per 100 feet drop in altitude. This rate of decrease is many times greater than the rate of increase on the opposite side of the range at the same altitude.

It is believed that the following general conclusions can be justly drawn from a study of this section:

(1) The average rainfall over the sea in the latitude of San Francisco is about 18.50 inches.

(2) On the southwest slopes of mountain ranges exposed to the storm winds the increase in rainfall is at the rate of approximately 1 inch per 100 feet rise up to an altitude of 2,500 feet.

(3) Between about 2,500 and 6,000 feet there is still an increase in the amount of rainfall, but at a much lower rate.

(4) Above 6,000 feet there is a slight decrease in the rainfall.

(5) The first high cold land passed over by the winds cools the atmosphere and condenses a large part of the moisture, leaving less or little for the land beyond.

The available rainfall records in the Salinas Valley and adjacent regions are given in the accompanying table. When these records are examined it is seen that there is a great difference in the amount of rainfall at different points—as at Mansfield and at San Ardo, for example. Fig. 2 is a graphic illustration of these variations. The section is similar to the one in fig. 1, and extends from the Pacific Ocean across the Santa Lucia Range, the Salinas Valley, and the

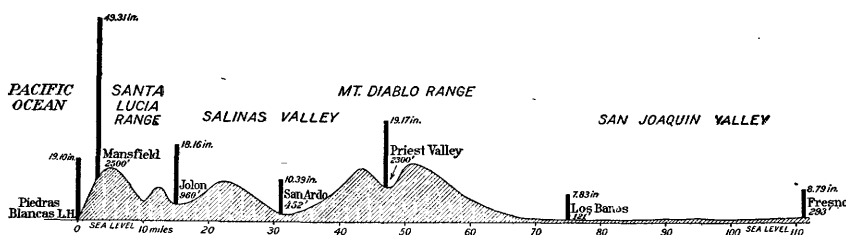


FIG. 2.—Diagram showing unequal distribution of rainfall in the Coast Range of California, the result of topography.

Mount Diablo Range to Fresno, on the east side of the San Joaquin Valley. The Santa Lucia Range, the most elevated land mass on the coast of central California, fronts the Pacific Ocean for more than 100 miles, exposing a bold, rugged system of peaks and ridges to the full force of the storm winds that sweep up from the southwest. Over this range these moisture-laden winds, in their passage inland, are forced to rise in altitude from 3,500 to 6,000 feet. This range, from its position and altitude, should be one of the dominant factors in the distribution of rainfall in this region, and an examination of the rainfall diagram given in fig. 2 shows that this is the case.

At Piedras Blancas light-house, near sea level, the average annual rainfall is 19.10 inches. At Point Sur light-house it is 18.11 inches. The rainfall at sea level here is apparently about the same as at Farallon light-house. In passing eastward along the line of this profile the next station is Mansfield, at an altitude of about 2,500 feet, and but 3 or 4 miles from the ocean. The average rainfall here is 49.31 inches, or more than two and one-half times greater than at sea level. The rate of increase with rise in elevation is somewhat greater here

Seasonal rainfall, in inches, in the Salinas Valley and the adjacent coast region.

[This table shows the total rainfall for twelve months, beginning September 1 and ending August 31.]

Elevation in feet	Stations.																		
	Santa Cruz, ^a	Pajaro, ^a	Salinas, ^a	Soledad, ^a	San Ardo, ^a	San Miguel, ^a	Paso Robles, ^a	Santa Margarita, ^a	Jolon, ^b	Los Vaqueros, ^c	Monterey, ^a	Point Sur Light-house, ^d	Piedras Blancas Light-house, ^d	San Luis Obispo, ^a	Priest Valley, ^e	Stimmer, ^f	Goodwin, ^g	Mansfield, ^h	Parkfield, ⁱ
Season—	25	23	44	183	432	616	723	966	960	950	0	0	0	270	2,300			2,500	
1868-69.....											<i>j</i> 18.15								
1869-70.....											13.59				12.03				
1870-71.....											<i>j</i> 10.45				12.97				
1871-72.....											<i>j</i> 21.56				26.02				
1872-73.....			13.45												12.79				
1873-74.....	18.49		13.61	6.35											20.52				
1874-75.....	12.41		8.05	5.01											19.69				
1875-76.....	26.17		19.16	15.94											30.12				
1876-77.....		5.53	3.90	2.65											8.15				
1877-78.....	36.41	28.01	23.75	12.22							32.02				30.60				
1878-79.....	22.06	17.37	9.32	4.15							11.89				11.66				
1879-80.....	18.22	16.54	13.33	7.38							<i>j</i> 16.78				25.81				
1880-81.....	20.34	19.91	12.43	6.78							13.91				23.69				
1881-82.....	22.83	18.89	12.86	9.74							15.16				17.03				
1882-83.....	19.62	16.88	11.21	8.64					15.90		16.64				16.83				
1883-84.....	30.74	23.37	19.44	16.36					23.65		21.38				42.40				
1884-85.....	16.40	12.91	9.30	5.79					11.75		11.11				17.59				

^f A. Hubbard^g [Name of observer not known.]^h J. M. Krenkel.ⁱ C. H. Royce.^j Broken record.^a U. S. Weather Bureau and Southern Pacific Railway Company.^b T. T. T. T. T.^c T. T. T. T. T.^d U. S. Weather Bureau.^e A. J. Meyers and Mrs. M. Griffin.

Seasonal rainfall, in inches, in the Salinas Valley and the adjacent coast region—Continued.

Stations.																			
Santa Cruz.	Pajaro.	Salinas.	Soledad.	San Ardo.	San Miguel.	Paso Robles.	Santa Margarita.	Jolon.	Los Vaqueros.	Monterey.	Point Sur Light-house.	Piedras Blancas Light-house.	San Luis Obispo.	Priest Valley.	Simmler.	Goodwin.	Mansfield.	Parkfield.	
25	23	44	133	452	616	723	996	980	950	0	0	0	270	2,300			2,500		
Season—																			
1885-86	27.65	20.56	14.45					31.42		18.50			23.30						
1886-87	17.17	9.88	6.74	7.92	<i>a</i> 9.86	<i>a</i> 10.72		12.42		9.16			16.56						
1887-88	22.91	15.71	6.15	9.91	11.03	14.30		16.77		12.78			19.33						
1888-89	23.35	15.76	10.63	14.10	11.89	15.84		24.74		12.86			19.54						
1889-90	54.68	39.88	28.44	23.27	20.13	29.35	49.79	36.94		29.32									
1890-91	19.46	18.98	12.57	7.50	7.33	16.42	23.77	14.97	<i>a</i> 5.00	12.30									
1891-92	24.22	17.97	12.93	8.15	5.83	7.42	11.98	10.66	<i>a</i> 5.00	11.90									
1892-93	33.42	28.93	18.03	12.02	12.92	13.63	22.65	27.23	26.76		20.98	20.89	<i>a</i> 30.85		12.19	6.75	8.87	11.36	
1893-94	26.98	<i>a</i> 17.46	13.70	5.20	3.85	4.03	6.83	12.95	7.27	<i>a</i> 6.00		14.71	17.35		5.17				
1894-95	36.85	26.10	17.04	10.84	10.92	12.79	17.09	34.52	19.58	17.88		23.49	19.91	25.10	12.94				
1895-96	21.44	18.45	12.78	9.98	14.59	11.12	17.94	26.55	17.96	7.10	18.79	18.26	13.64	<i>a</i> 17.74	9.37		<i>a</i> 57.69	11.17	
1896-97	27.95	19.90	14.93	9.60	<i>a</i> 9.22	10.82	16.83	25.58	16.85	<i>a</i> 16.18	14.79	18.00	24.36	20.59	10.83		<i>a</i> 56.94	11.26	
1897-98	12.49	10.15	8.50	3.47	3.65	3.47	4.75	8.44	5.30	8.57	6.95	9.54	8.24	7.20	1.44		<i>a</i> 19.75	4.12	
1898-99	25.00	22.60	10.55	5.89	7.40	8.15	11.53	19.19	12.00	12.98	10.42	20.14	26.02	17.33	2.70		<i>a</i> 48.75	6.95	
1899-1900	28.38	21.50	11.68	6.68	7.73	8.73	11.66	19.62	11.90	10.38	12.38	16.61	19.27	17.21	5.70		<i>a</i> 42.75	10.96	
1900-1901	26.27	24.92	15.63	12.29	15.70	13.18	22.80	48.82	26.12	24.46	16.00	23.19	22.21	31.40	31.73		<i>a</i> 69.45	14.49	
1901-2	29.35	18.98	10.58	8.74	10.37	9.08	12.75	29.80	14.77	20.61	14.98	21.47	19.23	21.78	17.11		49.81		
Mean	26.31	19.61	13.70	8.93	10.89	10.54	15.25	27.78	18.16	16.09	15.53	18.11	19.10	20.64	19.17	8.01	5.00	49.31	11.29

Broken record.

than in the Sierra Nevada. There are no records at a greater elevation in this range, but the precipitation undoubtedly increases with the altitude.

The next station on this section is at Jolon, 960 feet above sea level, where the average rainfall is 18.16 inches. To the northeast, in the broad, low Salinas Valley at San Ardo, the rainfall is still less, being but 10.39 inches. On the northeast side of the Salinas Valley the Mount Diablo Range rises to an average altitude of 3,500 to 4,000 feet, and there is a noticeable increase in the rainfall over this region. At Priest Valley, altitude 2,300 feet, the annual rainfall is 19.17 inches. This is, however, but a four years' record. In passing northeastward to the San Joaquin Valley, the rainfall diminishes, being 7.83 inches at Los Banos and 8.79 inches at Fresno. If similar sections should be drawn either to the north or south of this the same distribution of rainfall would be noted.

At Salinas the average annual rainfall is 13.70 inches, and there is a material increase to the northwest, there being 19.61 inches at Pajaro and 26.31 inches at Santa Cruz, these two stations being beyond the influence of the Santa Lucia Range. At Monterey the average rainfall is 15.53 inches.

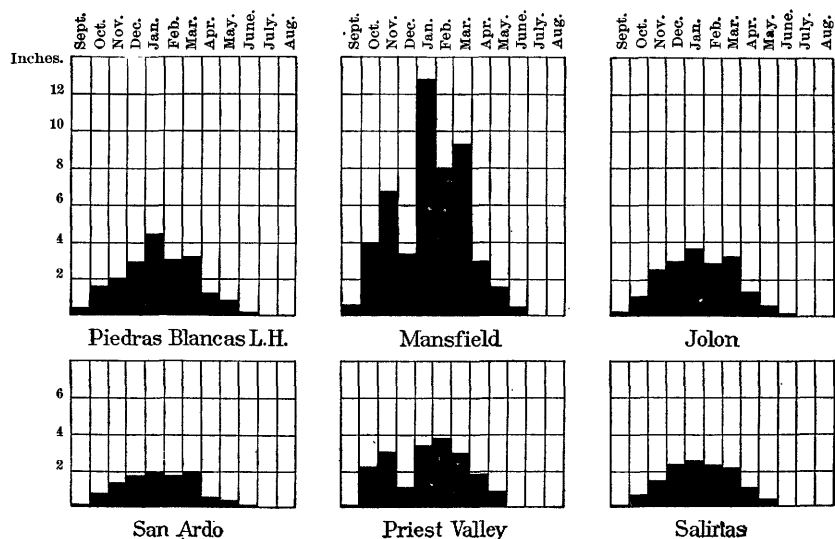


FIG. 3.—Diagram showing monthly distribution of rainfall in the Salinas Valley.

In passing up the Salinas Valley the rainfall is found to decrease as far as Soledad, where it is but 8.94 inches. To the southeast there is a steady increase, the records showing 10.39 inches at San Ardo, 10.54 inches at San Miguel, 15.25 inches at Paso Robles, and 27.78 inches at Santa Margarita.

In the southeast corner of Monterey County, at Parkfield, the rainfall is 11.29 inches. Over the Carriso Plain, probably the most arid region in the Coast Range, the rainfall is light, being but 8.01 inches at Simmler and about 5 inches at Goodwin.

The average monthly precipitation at six stations in the Salinas Valley is shown in fig. 3. The height of each of the small black columns represents the average amount of rain for the corresponding month. This diagram shows graphically the contrast between the distribution of the rainfall in summer and winter.

To summarize, it may be said that the distribution of rainfall in Monterey County depends upon the topography. The region may be divided into three topographic zones or belts in which rainfall conditions are similar. The most western belt is the Santa Lucia Range, the central is the Salinas Valley, with the mesa lands on the north-east side, and the eastern is the Mount Diablo Range.

In the Santa Lucia Range the rainfall varies from about 18 inches at sea level to 50 inches along the summit of the range, decreasing on the northeastern slope to about 18 inches at an altitude of 1,000 feet. In the upper Salinas Valley the rainfall is about 10 inches, decreasing gradually toward the southeast. From the incomplete records in the Mount Diablo Range it seems probable that the average rainfall is from 20 to 25 inches in Monterey County.

HYDROGRAPHY.

SALINAS RIVER.

The main trunk stream of the Salinas Valley is Salinas River, which, with its tributaries, drains an area of 4,780 square miles. (See Pl. I.) The drainage basin is 150 miles long, extending from southern San Luis Obispo County to the Bay of Monterey, in Monterey County. The western tributaries of the Salinas have their sources in the elevated, well-watered Santa Lucia Range, while its eastern tributaries drain the low mesa lands and the western slopes of the Mount Diablo Range. The river drains all the area lying between the Santa Lucia Range on the southwest and the Gabilan and Mount Diablo ranges on the northeast except the inclosed basin east of San Juan Creek known as the Carriso Plain.

The following table shows the areas of the drainage basins of the river and its tributaries:

Areas of drainage basins of Salinas River and its tributaries.

	Sq. miles.
Total drainage of the Salinas River	4,780
Drainage of Salinas River above gaging station near Salinas	4,084
Drainage of Salinas River above Estrella Creek	591
Total drainage of Nacimiento River	380
Drainage of Nacimiento River above gaging station near Bryson	171
Total drainage of San Antonio River	342
Drainage of San Antonio River above Pinkerton dam site	322
Drainage of San Antonio River above gaging station near Jolon	161
Total drainage area of Arroyo Seco above Arroyo Seco canal No. 3	218
Drainage area of Arroyo Seco above gaging station at Pettitt ranch	215
Drainage area of Arroyo Seco above Currier dam site	184
Drainage area of Arroyo Seco above Foster dam site	161
Total drainage area of Los Vaqueros Creek above Pettitt dam site	28
Drainage area of Los Vaqueros Creek above Leigh dam site	22
Drainage area of Estrella Creek	924
Drainage area of Carriso Plain	470
Total drainage area of San Lorenzo Creek above Mathews dam site	235
Drainage area of Chalone Creek	128

These areas were determined by planimeter measurements from the Monterey and San Luis Obispo atlas sheets.

From San Miguel, in San Luis Obispo County, northwest to Wunpost, in Monterey County, the Salinas flows in a deep, wide canyon, which it has eroded several hundred feet below the level of the surrounding mesas. At Wunpost the mesa recedes on the northeast side and the river valley widens out somewhat into a long, narrow, terraced alluvial plain, with a width ranging from 1 mile at the upper end to 4 or 5 miles at Soledad. From Soledad to the Bay of Monterey the alluvial plain and bordering detritus slopes are from 6 to 10 miles wide, with terraces far less pronounced than those in the upper portions of the valley. Each of the terraces is an ancient flood plain of the stream. For this distance the stream flows in a broad, sandy channel from 500 to 1,500 feet wide, into which the waters sink in summer to reappear again at some point below. From Soledad to the ocean the stream is perennial, being fed by these underground waters. When wet the fine sand in the river bed becomes quicksand, making the stream dangerous to ford, especially in winter. The photographic views reproduced in Pl. III, and Pl. IV, A, show the general character of the stream during the dry season.

The large volume of water discharged by this stream during the rainy season has enabled it to trench its channel to a depth considerably below the alluvial plains on both sides of the river. For the same reason the grade of the stream is very slight, being but 1.33 feet per mile from the ocean to the gaging station at the Monterey road bridge; 5.5 feet per mile from the Monterey road bridge to Soledad and 6.5 feet per mile from Soledad to Bradley, where the bed of the stream is at an altitude of about 500 feet. These grades are approxi-

mate and are given merely to show the low gradient of this, the main drainage line of the region.

This stream is torrential in character, having very large flood discharge during the rainy season and being practically dry during the summer except in its lower portion. The winter flow is probably at all times sufficient for the needs of winter and spring irrigation.

That portion of the drainage basin of the Salinas that lies south of San Miguel, comprising 591 square miles, is on the northeast slope of the Santa Lucia Range, in the region of heaviest rainfall, and the run-off here is undoubtedly large.

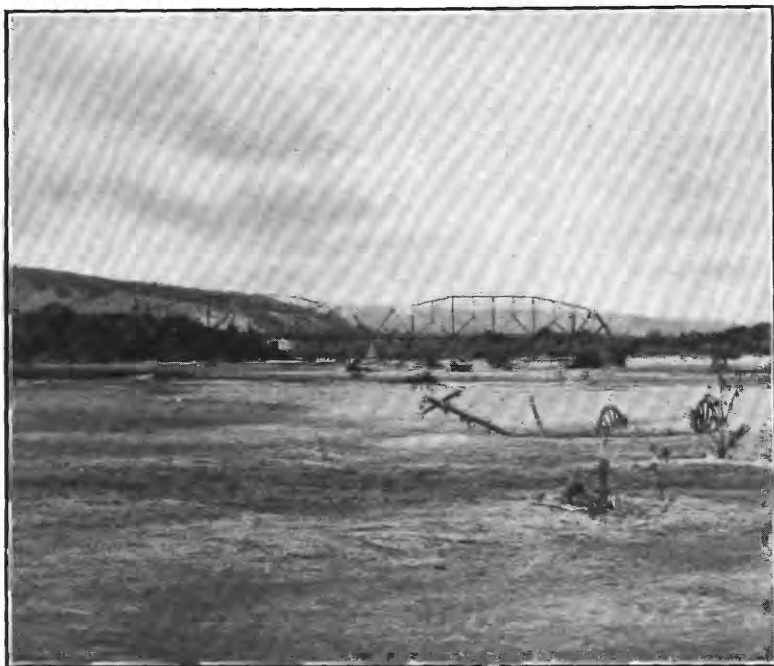
A record of the discharge of the main stream was kept at the Monterey road bridge from January 8, 1900, to July 31, 1901. From these observations the following table has been prepared.

Estimated monthly discharge of Salinas River 4 miles south of Salinas.

[Drainage area, 4,084 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1900.						
January 8-31	2,700	223	848	40,368	0.21	0.19
February	223	40	105	5,831	.03	.03
March	223	25	73	4,489	.02	.02
April	32	19	22	1,309	.01	.01
May	19	17	17	1,045	.00	.00
June	17	15	16	952	.00	.00
July	10	6	8	492	.00	.00
August	8	6	7	430	.00	.00
September	8	2	6	357	.00	.00
October	4	1	2	123	.00	.00
November	33,600	0	2,413	143,583	.59	.66
December	1,050	82	295	18,139	.07	.08
1901.						
January	35,162	380	4,921	302,580	1.21	1.39
February	20,927	540	4,131	231,701	1.02	1.06
March	1,772	430	1,063	65,361	.26	.30
April	405	160	270	16,066	.07	.07
May	2,012	160	533	32,773	.13	.15
June	160	30	56	3,332	.01	.01
July	30	25	27	1,660	.01	.01

NOTE.—Gage heights and discharge measurements for 1901 are given in Water-Supply Paper No. 66, page 154.



A. SALINAS RIVER ABOVE GAGING STATION AT MONTEREY ROAD BRIDGE,
NEAR SALINAS.

Shows quicksand in bed of stream.



B. SALINAS RIVER NEAR KINGS CITY.

Shows drifted sand blown upstream by the prevailing northwest wind.

ESTRELLA CREEK.

The most eastern branch of Salinas River is Estrella Creek (see Pl. I). At a point 20 miles southeast of its junction with the Salinas the two branches of the Estrella are known as San Juan River and Cholame Creek. The San Juan drains the northeastern slopes of the San Jose Range and Cholame Creek drains the southwestern slope of the Mount Diablo Range. Between these two mountain ranges lie the elevated mesa lands of the upper Salinas Valley. This mesa region passes over into the Carriso Plain, the waters of which, however, do not flow to the sea, but toward a salt flat or salt lake which fills the lower portion of the plain. Nothing very definite is known regarding the average rainfall in this region (see table on p. 43), but it is certain that it is very light, probably less than 10 inches, over the mesa regions, which are cut off from the storm winds by the intervening Santa Lucia and San Jose ranges. It is probable that the greater portion of the water in this stream is derived from rainfall in the surrounding mountains. The area of the drainage basin of Estrella Creek is 924 square miles, and the area of the Carriso Plain is 470 square miles.

NACIMIENTO RIVER.

The Nacimiento is one of the large western tributaries of the Salinas, entering that stream between San Miguel and Bradley (see Pl. I). It has its sources among the highest peaks of the Santa Lucia Range, only 3 miles from the Pacific Ocean. It flows southeastward about 35 miles, receiving many small tributaries from the southwest, and emerges from the mountains after rounding the declining ridge of the Sierra de las Piedras. From this point to the Salinas it flows in a broad, sandy channel eroded in the mesa. This stream flows for 25 miles parallel with and but a few miles northeast of the crest of the range, in the belt of maximum precipitation (see fig. 2), where the average rainfall must be from 30 to 50 inches per annum. The fact that the precipitation here is great is shown by the character of the stream and the vegetation over this portion of the range. The total area of this watershed is 380 square miles, of which 300 square miles are mountainous, the remainder being rolling hills and river valley.

The Nacimiento watershed decreases in width from 7 miles near its head to 2 at its lower end. It is 40 miles long. The upper 7 miles is mountainous, as is all that portion lying between the river and the coast divide. The valley floor averages 1 mile in width, and extends downstream 10 miles from a point 7 miles below the head. The eastern wall of the valley is the western wall of the San Antonio. The lower 25 miles of the river lies in a narrow V-shaped canyon whose sides rise 300 to 1,500 feet. The mountain slopes are covered with brush and trees. The valley floor is shaded with white oaks of great size. For the most part the bed of the river is sandy and crosswise flat, and varies in width from 50 to 400 feet. In the open valley the banks range from 15 to 40 feet in height. There are good

dam sites at the mouth of Gabilan Creek, Piedras Altas, and Pebblestone Gorge, 7 miles below the Monterey County line, but there are no corresponding storage sites of value.^a

The following table of discharge of Nacimiento River in March and April, 1901, has been prepared:

Estimated monthly discharge of Nacimiento River at Bryson post-office.

[Drainage area, 171 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1901.						
February 17 to 28-----	3,300	295	855	20,350	5.00	5.21
March -----	365	110	184	11,314	1.08	1.24
April -----	670	87	99	5,891	.58	.65

NOTE.—Gage heights and discharge measurements for 1901 are given in Water-Supply Paper No. 66, page 154.

This stream is torrential, with a great run-off during the rainy season, but it dwindles to a small creek by early summer. The character of the stream in June, 1902, is shown in Pl. IV, B.

SAN ANTONIO RIVER.

The drainage basin of San Antonio River joins that of the Nacimiento on the northeast, and the upper 120 square miles is in a similar mountain region (Pl. I). The area of the watershed above the Pinkerton reservoir site is 322 square miles. Of this area the mountain portion, 120 square miles, probably receives an average annual rainfall of 30 to 50 inches and the elevated valleys near Jolon as much as 18 inches. This stream leaves the mountains about 6 miles above Jolon, and from there to the Salinas flows in a broad, sandy channel through wide valleys. These valleys have an altitude of from 800 to 1,200 feet and are covered with scattering oak timber (see Pl. V).

The San Antonio drainage basin is 6 miles wide from the head for a distance of 24 miles, then for 5 miles it widens to 10 miles; in the next 5 miles it narrows to 3 miles, and this width continues for 15 miles to its mouth. The valley floor averages $1\frac{1}{2}$ to 2 miles wide. The southwestern wall of the valley is 5,000 feet high at the upper end, and this height falls to a few hundred feet toward the mouth. The north wall of the valley, the Santa Lucia Range, is 3,000 to 6,000 feet high. The eastern wall decreases from north to south from 2,500 feet to a few hundred feet in elevation.

The valley floor extends to the San Antonio-Arroyo Seco divide, and the main stream has a comparatively light slope. The tributaries are short, and each for

^aMS. report of Prof. Charles D. Marx.



A. SALINAS RIVER AT BRADLEY.

Shows broad-topped terrace on which the town is built, and the flat-topped hills of the mesa beyond.



B. NACIMIENTO RIVER AT GAGING STATION NEAR BRYSON POST-OFFICE.



A OAK GROVE IN SAN ANTONIO RIVER VALLEY, NORTH OF JOLON.



B. SAN ANTONIO RIVER VALLEY SOUTHEAST OF JOLON.



the greater part of its course has a rapid fall. The upper part of the drainage basin is brush covered on steep slopes, and the valley floor is shaded by oaks. The slopes are bare on the east wall of the lower half of the basin. The valley furnishes no combination of large storage basin followed just downstream by a good dam site.^a

A gaging station was established on this stream 1 mile south of Jolon, and a record of the discharge was kept from December 15, 1900, to April 30, 1901. From these observations the following table of discharge of San Antonio River has been prepared:

Estimated monthly discharge of San Antonio River at Jolon.

[Drainage area, 161 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second- feet per square mile.	Depth in inches.
1900.						
December 15 to 28 ----	200	170	184	5, 109	1. 14	0. 59
1901.						
January -----	3, 700	64	523	32, 158	3. 25	3. 75
February -----	1, 700	110	509	28, 268	3. 17	3. 31
March -----	400	84	171	10, 514	1. 06	1. 22
April -----	740	39	83	4, 939	. 52	. 58

NOTE.—Gage heights and discharge measurements for 1901 are given in Water-Supply Paper No. 66, page 154. Rating table on page 178 of same paper.

During the summer of 1900 this drainage basin was explored under the direction of Prof. Charles D. Marx to discover and survey any possible reservoirs. The only one discovered on this stream is on the Pleyto ranch, 6 miles southeast of Pleyto post-office, the dam site being in sec. 30, T. 24 S., R. 10 E. (see Pl. I), and about 12 miles above the junction of San Antonio River with Salinas River.

PINKERTON RESERVOIR.

A reconnaissance survey was made of this reservoir, known as the Pinkerton site, by Prof. Charles D. Marx. The contour map of the reservoir is shown in fig. 4, and a cross section of the canyon of San Antonio River at the dam site is shown in fig. 5. The highest contour of the reservoir is at an altitude of 950 feet, as determined by aneroid observations. The area of the drainage basin tributary to the reservoir is 322 square miles. The dam as designed was to be of sandstone rubble 50 feet high, 900 feet long on top, and 500 feet long at

^aMS. report of Prof. Charles D. Marx.

the surface of the stream. The bed rock is sandstone and it is estimated to be 25 feet below the bed of the stream. Rock suitable for the construction of the dam can be quarried within 1,000 feet of the dam.

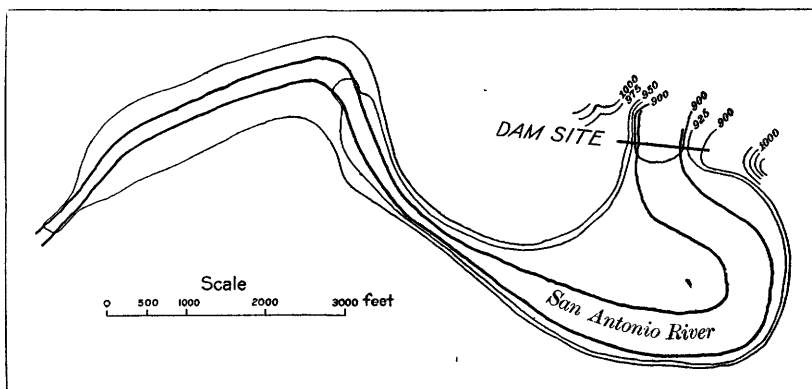


FIG. 4.—Reconnaissance map of Pinkerton reservoir site.

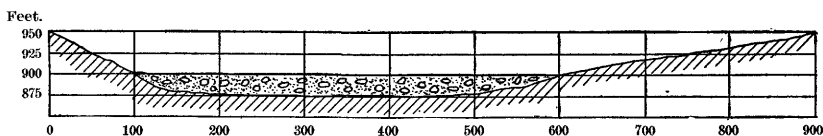


FIG. 5.—Cross section of canyon of San Antonio River at the Pinkerton dam site.

The following table shows the estimated storage capacity and the cost of storage at this location:

Estimated storage capacity and cost of storage at Pinkerton reservoir.^a

Height of dam.	Total storage acre-feet.	Total cost of storage.	Cost per acre-foot.
25 feet.....	2,300	\$92,000	\$40.00
50 feet.....	8,200	210,500	26.00

ARROYO SECO.

The most northern tributary of Salinas River is the Arroyo Seco, which rises on the slopes of the highest portion of the Santa Lucia Range (Pl. I). The upper valleys of this stream are far back in the range, surrounded by high mountains. This portion of the range undoubtedly receives as great a rainfall as any other locality in this region. It does not seem unreasonable to suppose that the average annual rainfall is from 30 to 50 inches.

The drainage basin of the Arroyo Seco is almost entirely made up of sharp ridges and V-shaped canyons. The western portion is well covered with brush and trees of medium size. Toward the east this growth decreases, until at the

^a MS. report of Prof. Charles D. Marx.



A. CANYON OF ARROYO SECO AT FOSTER DAM SITE, SHOWING STREAM TERRACE.



B. CANYON OF ARROYO SECO, 20 MILES WEST OF SOLEDAD, SHOWING STREAM TERRACES AND SANTA LUCIA MOUNTAINS.

Salinas the country is bare. The stream beds of this area fall rapidly, the Arroyo Seco rising at nearly 6,000 feet and emptying into the Salinas at an elevation of 170 feet.^a

For 10 miles above its junction with the Salinas the channel of this stream is a broad wash of gravel and sand across the flat plain, into which the stream sinks in the dry season and from which it receives its name "Arroyo Seco." For the next 11 miles the stream flows in a deep terraced valley eroded into bituminous shales. The terraces form a most conspicuous feature (see Pl. VI and Pl. IX, A) and mark successive periods of uplift. They were cut into the bituminous shale or sandstone by the stream.

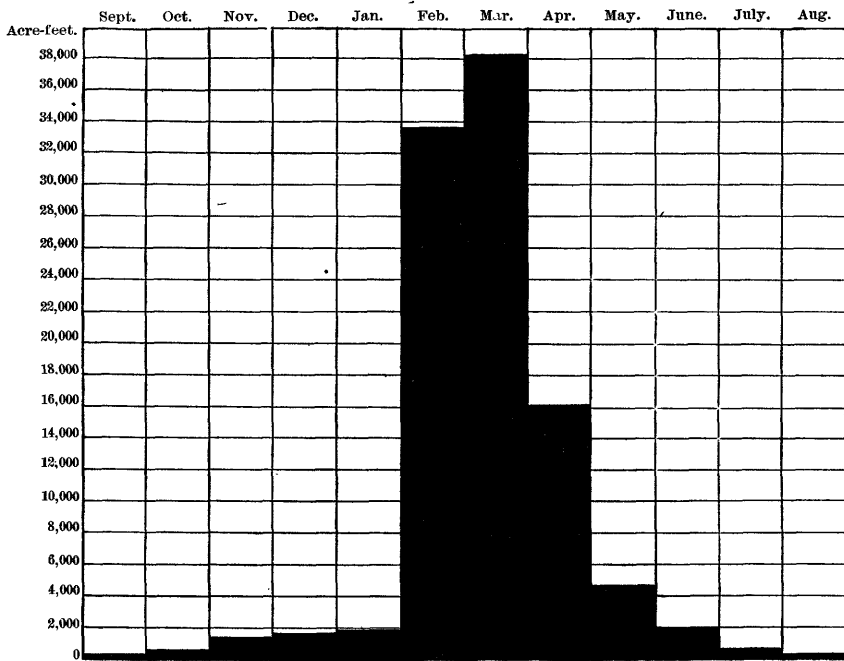


FIG. 6.—Discharge of Arroyo Seco, Pettitt ranch, from September 1, 1901, to August 30, 1902.

The present channel of Arroyo Seco in this 11-mile section is a deep trench or canyon, from 100 to 200 feet deep and 250 to 1,000 feet wide, sunk below the floor of the valley. The bottom of this canyon is covered with great washes of granite boulders and sand. (See Pl. VII, A.) This débris conjoins with the floods of water that rush down from the mountains above to form the agencies that are now actively eroding the channel of this stream.

A record of the discharge of this stream was kept at Pettitt ranch during 1902 and a portion of 1901. From these observations the table on page 54 has been prepared. Fig. 6 is a graphic illustration of the discharge during the season of 1901-2.

^a MS. report of Prof. Charles D. Marx.

Estimated monthly discharge of Arroyo Seco at Pettitt ranch.

[Drainage area, 215 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second- feet per square mile.	Depth in inches.
1901.						
January	4,500	105	888	54,601	4.13	4.76
February	2,860	160	931	51,705	4.33	4.51
March	610	105	246	15,126	1.14	1.32
April	2,500	95	195	11,608	.91	1.01
May			95	5,841	.44	.51
June			58	3,451	.27	.30
July			22	1,353	.10	.12
August			15	922	.07	.08
September			8	476	.04	.04
October			10	615	.05	.05
November	50	9	22	1,309	.10	.11
December	40	23	26	1,599	.12	.14
1902.						
January	40	25	28	1,722	.13	.15
February	2,860	25	605	33,600	2.81	2.93
March	2,320	185	620	38,122	2.88	2.32
April	1,650	145	270	16,066	1.26	1.41
May	105	55	74	4,550	.34	.39
June	55	15	32	1,904	.15	.17
July	15	7	12	738	.06	.07
August	7	3	4	246	.02	.02
September	3	0	0	0	0.00	0.00
October	55	0	9	553	.04	.05
November	750	11	57	3,392	.27	.30
December	145	25	54	3,320	.25	.29
1903.						
January	1,790	22	188	11,560	.87	1.00
February	970	120	313	17,383	1.46	1.52
March	3,080	92	471	28,961	2.19	2.52
April	3,210	120	483	28,740	2.25	2.51
May	120	56	85	5,226	.40	.46
June	56	32	46	2,737	.21	.23
July	32	13	25	1,537	.12	.14
August	22	6	10	615	.05	.06

NOTE.—Gage heights and discharge measurements for 1901 are given in Water-Supply Paper No. 66, page 156. Rating table on page 178, same paper.

During the summer of 1900 the drainage area of Arroyo Seco was explored by Prof. Charles D. Marx. Three reservoir sites were discovered on Arroyo Seco—The Pools site, the Foster site, and the Currier site (Pl. I). Two sites were also discovered on Los Vaqueros Creek, a tributary of Arroyo Seco—the Pettitt site and the Leigh site. The Foster and Currier reservoir sites were resurveyed by the writer in the summer of 1902. These reservoir sites will be described in detail.

THE POOLS RESERVOIR.

The Pools reservoir site is far back in the Santa Lucia Mountains, just below the junction of Arroyo Seco and Santa Lucia Creek (Pl. I).

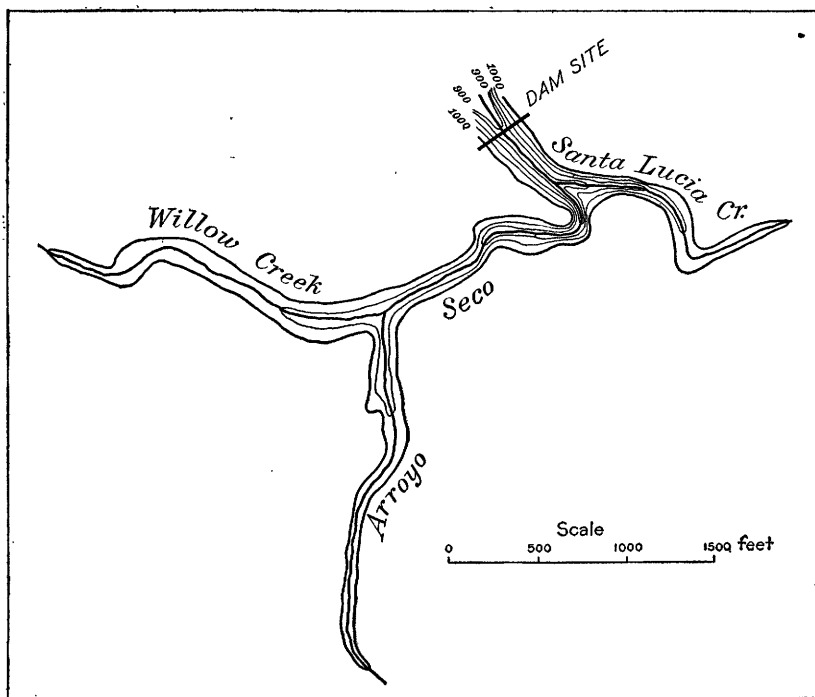


FIG. 7.—Reconnaissance map of The Pools reservoir site.

It is about 20 miles west of Soledad. A reconnaissance survey was made of this reservoir site by Prof. Charles D. Marx in the summer of 1900. A contour map of the reservoir forms fig. 7, and a cross section of the canyon of Arroyo Seco at the dam site is given in fig. 8. The highest contour of the reservoir is at an altitude of 1,000 feet, as determined by aneroid observations. The drainage area tributary to the reservoir is 74 square miles of steep mountain slopes covered with thick brush and trees.

The dam as designed was to be of granite rubble, with a maximum

height of 100 feet and 250 feet long on top. The bed rock is granite and the estimated depth to solid rock is 5 feet. The following table shows the storage capacity and cost of storage at this location.

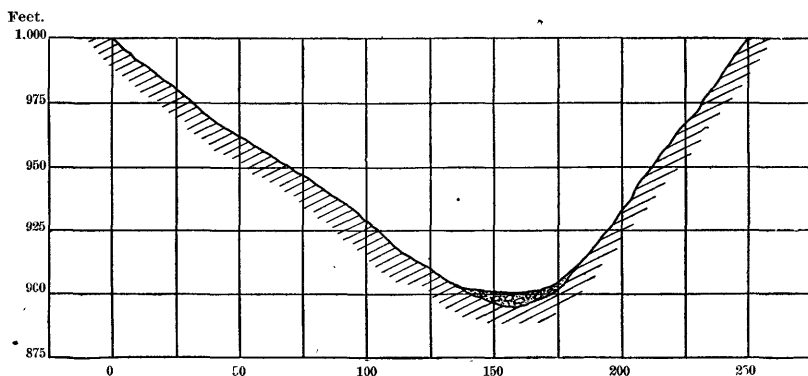


FIG. 8.—Cross section of canyon of Arroyo Seco at The Pools dam site.

Estimated storage capacity and cost of storage at The Pools reservoir.^a

Height of dam.	Total storage in acre-feet.	Total cost.	Cost per acre-foot.
25 feet -----	30	\$10,200	\$340
50 feet -----	130	28,800	222
75 feet -----	310	61,800	195
100 feet -----	660	115,800	175

The reservoir is merely a steep, V-shaped canyon. The cost of storage, \$175 per acre-foot, is prohibitive, and with the great distance, 20 miles from irrigable land, serves to condemn this location.

PETTITT RESERVOIR.

The Pettitt reservoir is in sec. 20, T. 19 S., R. 6 E., M. D. M., at the mouth of Los Vaqueros Creek. It is about 11 miles south of Sole-

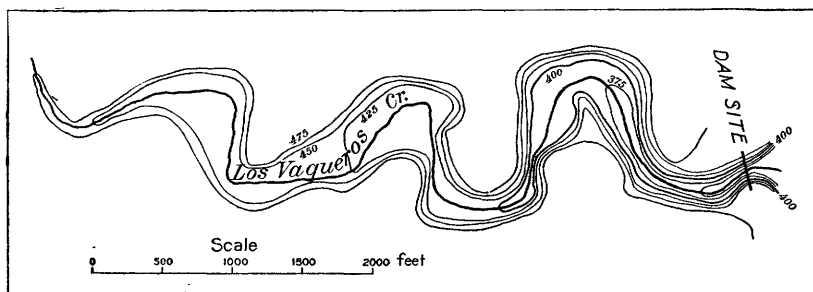


FIG. 9.—Reconnaissance map of Pettitt reservoir site.

dad. (See Pl. I.) A reconnaissance survey was made of this reservoir site by Prof. Charles D. Marx in the summer of 1900. A contour

^a MS. report of Prof. Charles D. Marx.

map of the reservoir forms fig. 9, and a cross section of the canyon of Los Vaqueros Creek at the dam site is given in fig. 10.

The highest contour of the reservoir has an altitude of 450 feet, as determined by aneroid observations. The area of the drainage basin tributary to the reservoir is 28 square miles. The dam as designed

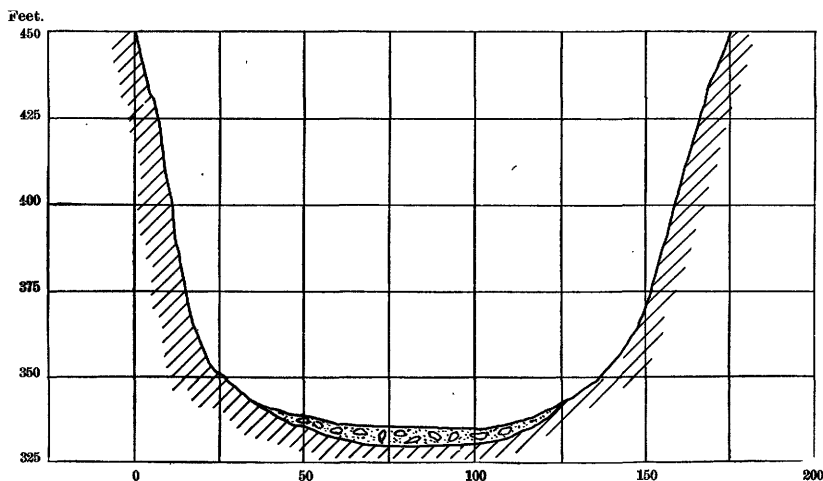


FIG. 10.—Cross section of Los Vaqueros Creek at Pettitt dam site.

was to be a concrete masonry structure 115 feet high and 175 feet long on top. The bed rock is shale, and the estimated depth to solid rock is 5 feet.

The following table shows the estimated storage capacity and cost of storage at this location.

Estimated storage capacity and cost of storage at Pettitt reservoir.^a

Height of dam.	Total storage in acre-feet.	Total cost.	Cost per acre-foot.
25 feet.....	15	\$9,000	\$635
50 feet.....	110	27,000	245
75 feet.....	420	54,000	130
100 feet.....	1,040	99,000	95
115 feet.....	1,650	139,000	84

^aMS. report of Prof. Charles D. Marx.

LEIGH RESERVOIR.

The Leigh reservoir site is in sec. 9, T. 20 S., R. 6 E., M. D. M., in Los Vaqueros Valley, 4 miles south of the Pettitt site (Pl. I).

A reconnaissance survey was made of this reservoir site by Prof. Charles D. Marx in the summer of 1900. A contour map of the reservoir forms fig. 11, and a cross section of the canyon of Los Vaqueros Creek at the dam site is given in fig. 12.

The highest contour of the reservoir is at an altitude of 975 feet, as determined by aneroid observations. The drainage area tributary to the reservoir is 22 square miles of steep mountain slopes covered with brush. The altitude of the area ranges from 900 feet at the dam site to almost 6,000 feet on the slopes of Santa Lucia Peak.

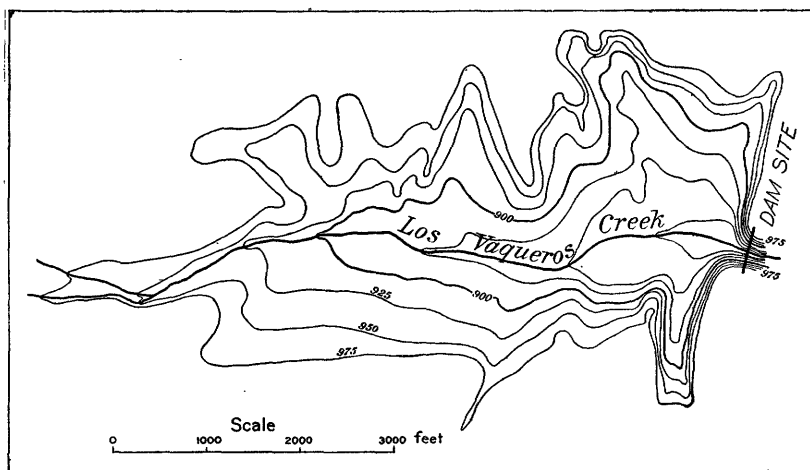


FIG. 11.—Reconnaissance map of Leigh reservoir site.

The dam as designed was to be of sandstone rubble, with a maximum height of 175 feet and a length of 400 feet on top. The bed rock is hard sandstone, and the estimated depth below the bed of the stream to solid rock is 15 feet. Sandstone suitable for the construc-

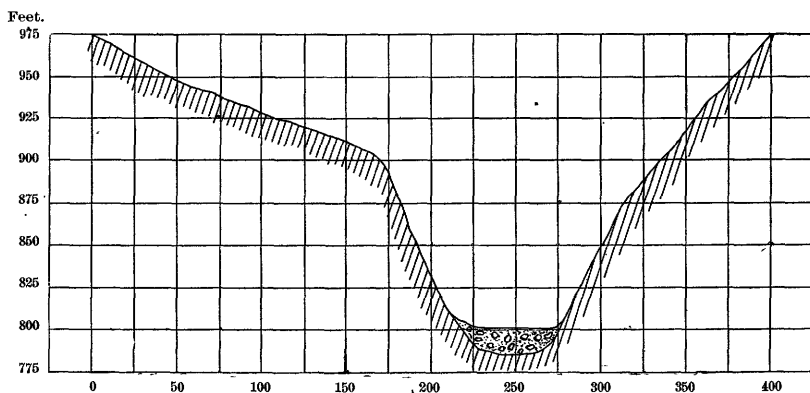


FIG. 12.—Cross section of Los Vaqueros Creek at Leigh dam site.

tion of the dam is available in the cliffs above, at both ends of the dam. The character of the canyon at the dam site is shown in Pl. VII, *B*. The irrigable lands are in the Salinas Valley, 10 miles below. The following table shows the estimated storage capacity and cost of storage at this location.



A. CHANNEL OF ARROYO SECO AT ABBOTTS, 20 MILES WEST OF SOLEDAD,
SHOWING GRANITIC DETRITUS IN BED OF STREAM.



B. LEIGH DAM SITE ON LOS VAQUEROS CREEK, LOOKING DOWNSTREAM.

Estimated storage capacity and cost of storage at Leigh reservoir.^a

Height of dam.	Total storage in acre-feet.	Total cost.	Cost per acre-foot.
25 feet -----	70	\$8,600	\$122.00
50 feet -----	600	21,600	36.00
75 feet -----	2,000	43,200	21.60
100 feet -----	4,600	77,000	16.60
125 feet -----	8,800	127,000	14.40
150 feet -----	14,800	194,000	13.00
175 feet -----	23,000	292,000	12.70

No measurements of the run-off from this drainage basin have been made. An examination of the discharge of Arroyo Seco, of which this stream is a tributary, shows that in 1901-2, a season of about average rainfall, the run-off was 0.78 second-foot per square mile (see table on p. 54). When this factor is used for computing the run-off of Los Vaqueros Creek a total run-off of approximately 10,000 acre-feet is given. As the rainfall at Los Vaqueros Valley is somewhat below the supposed average for this altitude, it is assumed that the run-off will be but 75 per cent of the amount computed as above, or approximately 7,500 acre-feet.

This will fill the reservoir to about the 925-foot contour. It seems probable that the drainage basin will supply this amount in a season of average rainfall, much more in a wet season, and but little in a dry season. It is believed that this will eventually be a valuable adjunct to the irrigation systems taking water from Arroyo Seco.

The dam should be built high enough to impound all the flood waters, the excess over 7,500 acre-feet being held over, if desirable, for the next year. The impounded water can be dropped into the channel of the creek and picked up again in Arroyo Seco at the head works of the canals without serious loss of water, so the only expense will be that of storage.

A cheaper dam, of the rock-fill type, could be constructed here, which would reduce the cost to probably one-third of the above estimate.

FOSTER RESERVOIR.

The proposed Foster reservoir is on Arroyo Seco, 12 miles southwest of Soledad in an air line and about 17 miles by the wagon road (Pl. II). The dam site is in the NW. $\frac{1}{4}$ sec. 23, T. 19 S., R. 5 E., M. D. M., and the reservoir site extends southwestward about $2\frac{1}{2}$ miles. A survey of this location was made by the writer in the summer of 1902. A topographic map of the reservoir is given as fig. 13. The altitude of the stream at the dam site is 490 feet by aneroid observations.

^aMS. report of Prof. Charles D. Marx.

The survey was made for a dam which would raise the water 110 feet above the bed of the stream, or to the 600-foot contour. Such a dam will impound 16,710 acre-feet of water. The table below shows the area and capacity of this reservoir at the various contours. Fig. 14

T. 19 S. R. 5 E

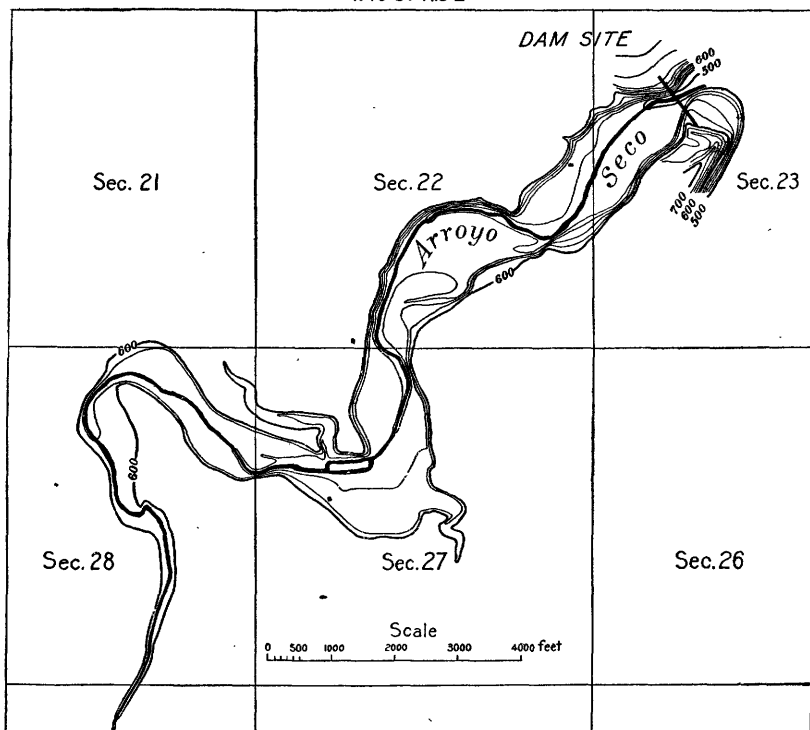


FIG. 13.—Foster reservoir site on Arroyo Seco.

Area and capacity of proposed Foster reservoir, Arroyo Seco.

Contour.	Area.	Capacity.
	<i>Acres.</i>	<i>Acre-feet.</i>
500	2.3	
510	22.2	122.6
520	50.6	486.6
530	80.1	1,140.1
540	117.8	2,129.1
550	149.6	3,466.1
560	192.8	5,178.1
570	252.1	7,402.1
580	292.5	10,125.1
590	329.0	13,232.1
600	366.6	16,710.1

shows the capacity curve of the reservoir, by means of which the amount of water stored can be ascertained for any depth. The drainage area tributary to this reservoir is 161 square miles. The table on page 54 shows the estimated monthly discharge of Arroyo Seco at the Pettitt ranch, 4 miles below. The discharge here will be practically the same as at the gaging station.

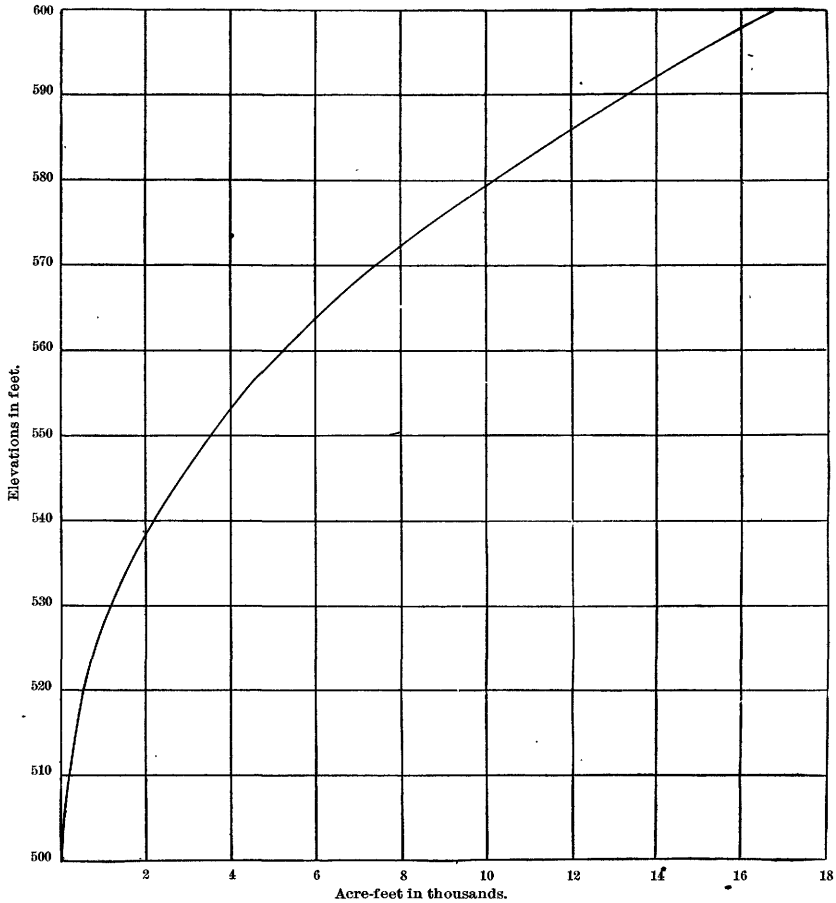


FIG. 14.—Capacity curve of Foster reservoir site, showing capacity, in thousands of acre-feet, with the water surface at various levels.

The reservoir site is situated in the terraced valley of Arroyo Seco, and is a long, narrow, steep-sided stream channel, the bottom of which is covered with washes of granitic boulders and sand. Pl. VI, A, shows the general character of this channel looking upstream from below the dam site.

At the dam site the canyon has a width of 250 feet at the level of the stream and about 900 feet at the 615-foot contour, the top of the

dam. The rock at the dam site is the Monterey shale. The specific gravity of an ordinary specimen of the shale is 2 and the weight per cubic foot is about 125 pounds. These shales are hard and close textured where not weathered. In weathering they do not crumble into dust or sand as do ordinary rocks, but simply break into smaller fragments. At this point the shales are evenly stratified in thin beds which strike N. 75° W. and dip 40° SW. Rock is exposed in the bed of the stream at several places at the dam site, and it is probable that it is but a few feet to bed rock at any point. No borings have been made to bed rock, however. Pl. VIII, *A*, is a view of the north side of the canyon at the dam site, and Pl. VIII, *B*, is a view of the south side.

PROPOSED FOSTER DAM.

The dam at this point, as designed, is to be of the rock-fill type. Three different classes of material are available for the construction

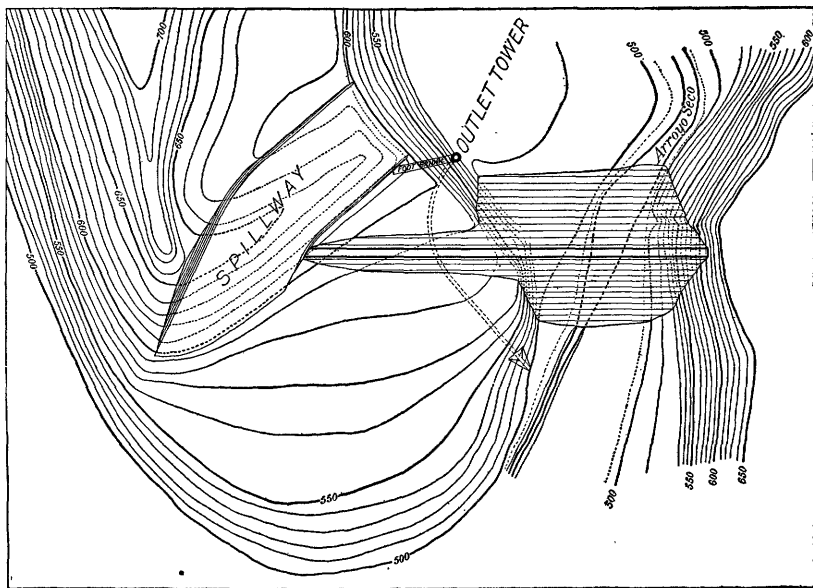
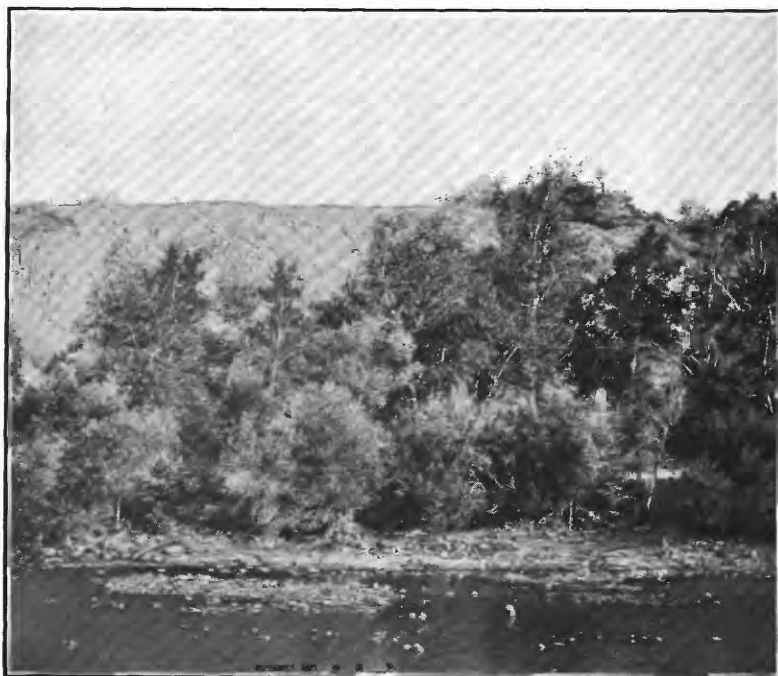


FIG. 15.—Foster dam site and spillway on Arroyo Seco.

of a dam here—(1) the Monterey shale on the south side of canyon; (2) the granitic boulders and sand in the bed of the stream both above and below the dam site; (3) gravel, sand, and soil on the north side of the canyon. It was not considered safe to build an earthen or sand and gravel dam in the main channel of a torrential stream of this character, so the loose rock-fill type was chosen. It will be necessary to excavate a spillway in any case, and as located the excavation for the spillway will about make the fill for the dam. The relative position of the dam and spillway is shown in fig. 15.



A. NORTH ABUTMENT AT FOSTER DAM SITE.



B. SOUTH ABUTMENT AT FOSTER DAM SITE.

The dam will have a maximum height of 125 feet above the stream at the lower toe of the dam, as shown in fig. 16. The upstream slope is to be $1\frac{1}{2}$ horizontal to 1 vertical and the downstream slope $1\frac{1}{4}$ horizontal to 1 vertical. The top width is to be 20 feet and the extreme length about 900 feet. The crest of the dam is to be 15 feet above the level of the spillway. This may seem excessive, but so little is known of the floods on this stream that it was not considered wise to make it less. In the future, if observations show that it is advisable, the level of the spillway can be easily raised.

The dam is to be made water-tight by a $1\frac{1}{2}$ -foot layer of asphaltic concrete laid on the upstream slope of the dam. This concrete is to be covered with $3\frac{1}{2}$ feet of hand-laid rubble to protect it from the heat of the sun and weathering. The asphaltic concrete is to be made of sharp, angular broken rock and sharp sand, cemented with refined asphalt, properly tempered. The amount of asphalt should be reduced to the smallest amount that is required to secure a water-tight layer.

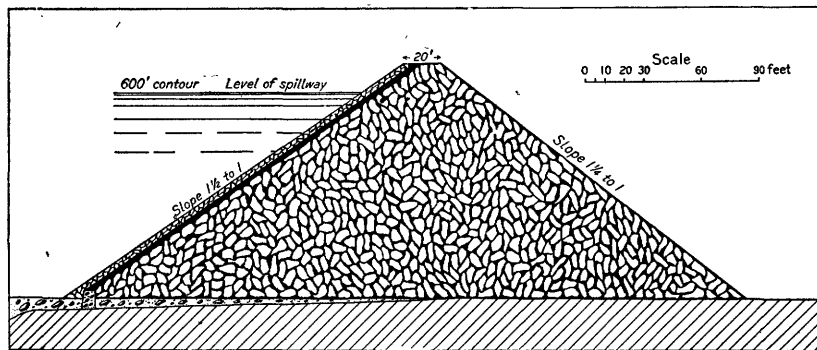


FIG. 16.—Maximum cross section of proposed Foster dam.

Concrete of this character, if laid on a $1\frac{1}{2}$ horizontal to 1 vertical slope and protected, will certainly be permanent.

A cut-off wall of concrete is to be carried down to bed rock at the upstream toe of the dam. The asphaltic concrete is to join this wall, making the entire upstream slope of the dam water-tight.

The spillway channel is to be excavated in the Monterey shale at the south end of the dam. It is to be 200 feet wide on the bottom and will discharge approximately 29,000 second-feet with the water 12 $\frac{1}{2}$ feet above the level of the crest. It is believed that this spillway will be permanent without a protective pavement. It should be deepened somewhat on the convex side to throw the current away from the south end of the dam.

The outlet from the reservoir is to be through a tower and tunnel near the south end of the dam, as shown in fig. 17. The tower is to be of concrete, is circular in plan, and will contain the valves for controlling the flow of the water from the reservoir. Four intake pipes 3 feet in diameter will be placed in this tower. The valves will be

the ordinary disks or covers, which will be lifted by a rod and geared wheels. The outlet gates from the tower are to be ordinary slide gates on steel rollers, with a clear opening of 2 by 4 feet. They will be operated by means of a rod and geared wheels, like the inlet valves. These outlet gates will normally remain open, but may be closed or partly closed in case the inlet valves should fail to close or break. They will also serve to regulate the pressure in the tower in case it is difficult to operate the inlet valves. As the water will be used solely for irrigation, all the inlet valves were placed near the bottom of the tower. If desirable, however, others can be placed at different levels at any time. The outlet tunnel is to be driven through the shale rock and lined with concrete to prevent erosion.

The location of the spillway and dam is favorable for cheap and rapid handling of rock by means of two overhead cableways. The rock when blasted will doubtless shatter into sizes easily handled, probably small enough to be loaded into skips with a steam shovel.

The following is a summary of the estimated cost of the Foster dam and reservoir:

Estimated cost of Foster dam and reservoir.

Loose rock fill in dam	\$141,920
Asphaltic concrete	51,240
Hand-laid rubble	14,738
Cut-off wall	7,173
Outlet tunnel	10,918
Outlet tower	9,630
Inlet valves	3,640
Outlet valves	3,900
Tower house and footbridge	500
Engineering and contingencies, 5 per cent	12,182
Reservoir and dam site	5,000
Total	260,841

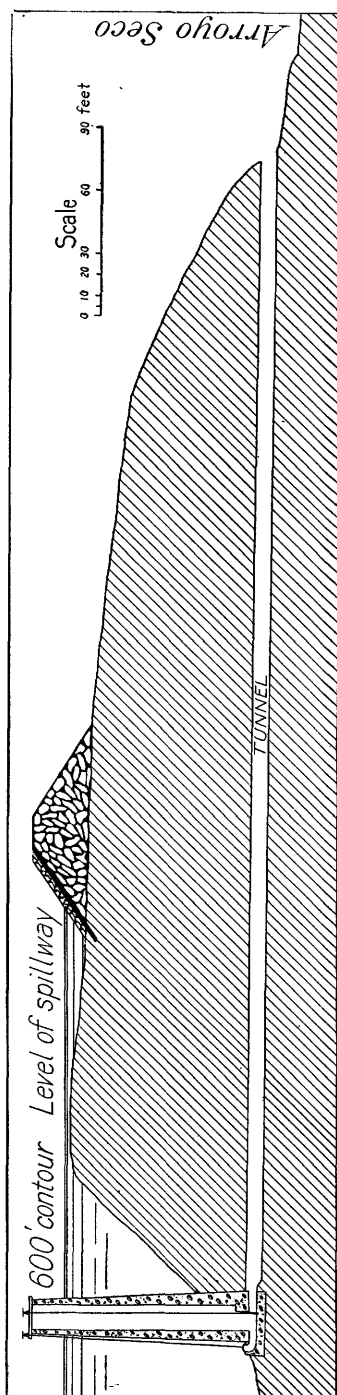


FIG. 17.—Profile of outlet tower and tunnel of proposed Foster reservoir.

The estimated cost of storage at this locality is \$15.61 per acre-foot if the reservoir is filled once during the winter, or \$7.80 per acre-foot if filled twice.

CURRIER RESERVOIR.

The proposed Currier reservoir is on Arroyo Seco, 11 miles south of Soledad in an air line and about 12 miles by the wagon road (Pl. II). The dam site lies in the NE. $\frac{1}{4}$ of sec. 19 and the NW. $\frac{1}{4}$ of sec. 20, T. 19 S., R. 6 E., M. D. M., and the reservoir site extends westward about 3 miles to the Foster dam site. A survey was made of this loca-

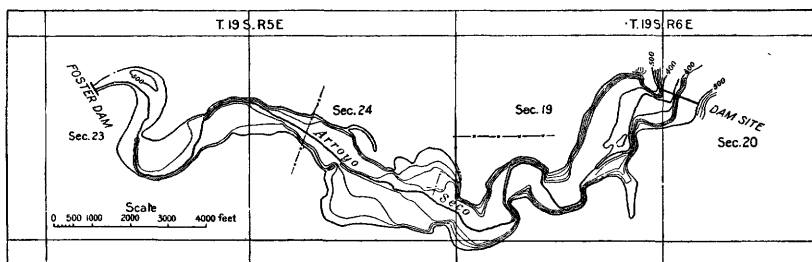


FIG. 18.—Currier reservoir site on Arroyo Seco.

tion by the writer in the summer of 1902. The topographic map of the reservoir is shown in fig. 18. The altitude of the stream at the dam site is 380 feet by aneroid observations. The survey was made for a dam which would raise the water 120 feet above the bed of the stream, or to the 500-foot contour. Such a dam will impound 24,657 acre-feet of water. The accompanying table shows the area and capacity of this reservoir at the various contours.

Area and capacity of proposed Currier reservoir, Arroyo Seco, California.

Contour.	Area.	Capacity.
	<i>Acres.</i>	<i>Acre-feet.</i>
380	0	0
390	7.8	39
400	30.2	229
410	79.5	777
420	112.8	1,738
430	139	2,997
440	186	4,622
450	231	6,707
460	282	9,272
470	329	12,327
480	375	15,847
490	441	19,927
500	505	24,657

Fig. 19 shows the capacity curve of the reservoir, by means of which the amount of water stored can be ascertained for any depth. The drainage area tributary to this reservoir is 189 square miles. The table on page 54 shows the estimated monthly discharge of Arroyo Seco at the Pettitt ranch, 1 mile below. The discharge here will be practically the same as at the gaging station. The reservoir is a portion of the terraced valley of Arroyo Seco. Pl. IX, A, shows the character of this valley looking upstream from below the dam site. The canyon has a width of about 340 feet at the bottom and

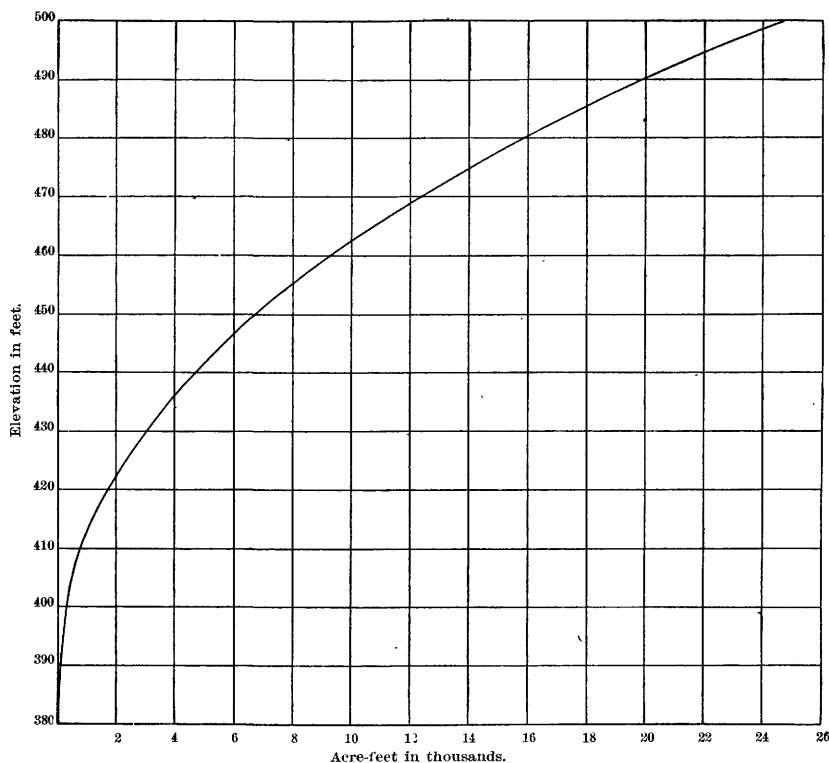
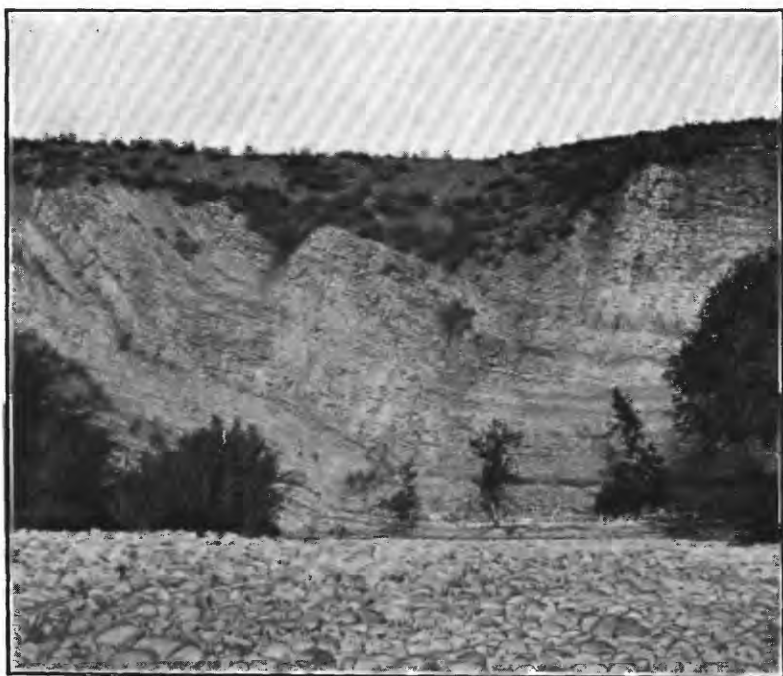


FIG. 19.—Capacity curve of proposed Currier reservoir, showing capacity in thousands of acre-feet, with the water surface at various levels.

of about 550 feet at the level of the first terrace, 125 feet above the stream. The rock at the dam site is the Monterey shale. This formation has been described on page 62. At this point the shales are evenly stratified in thin beds, which are sharply folded and somewhat faulted just below the axis of the dam. Pl. IX, B, shows this fold on the south side of the canyon and Pl. X, A, shows the nearly horizontal beds of shale in the north side of the dam site. The shale east of the axis of the fold strikes N. 70° W., and dips south-westward at an angle of from 40° to 45°. Rock is exposed in the sides



A. CURRIER DAM SITE ON ARROYO SECO, LOOKING UPSTREAM FROM
BELOW THE DAM.



B. SOUTH ABUTMENT AT CURRIER DAM SITE.

of the canyon, but the bottom is covered with boulders and sand. It seems probable that it is at least 20 to 25 feet to solid rock, but no borings have been made to test this locality.

PROPOSED CURRIER DAM.

The dam at this point as designed is to be of the rock-fill type. The location of the dam and spillway are shown in fig. 20. It is necessary either to excavate a spillway or to build a long wing wall to prevent the flood water from flowing around the end of the dam and over the cliff onto the lower slope. It was decided to excavate a spillway and use the rock in the dam. The dam will have a maximum height of 135 feet above the surface of the stream and will probably extend 20 to 25 feet below to bed rock, as shown in fig. 21. The upstream slope is to be $1\frac{1}{2}$ horizontal to 1 vertical, and the downstream

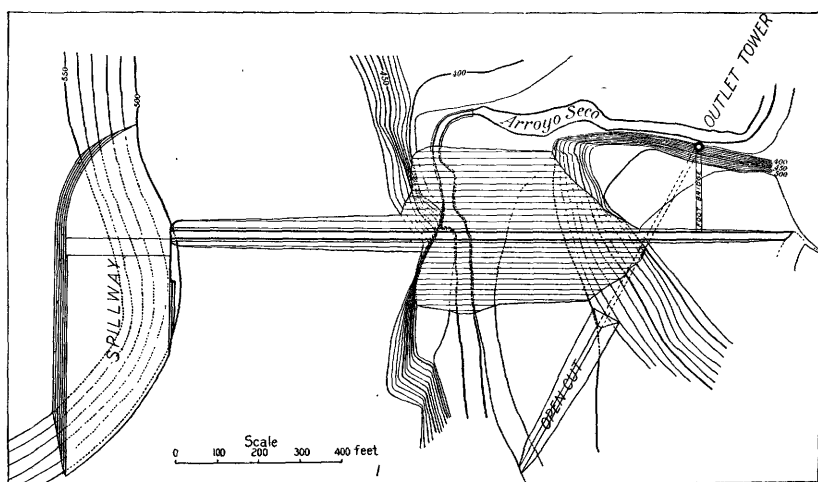


FIG. 20.—Currier dam site and spillway on Arroyo Seco.

slope $1\frac{1}{2}$ horizontal to 1 vertical. The top width is to be 20 feet. The extreme length of the dam will be 1,460 feet, but only the upper 20 feet of the dam will have this length, the balance being less than 500 feet long. The crest of the dam is to be 15 feet above the level of the spillway. In the future, if observations show that it is advisable, the level of the spillway can be easily raised. If raised 5 feet it would increase the capacity of the reservoir about 3,000 acre-feet. The dam is to be made water-tight by a $1\frac{1}{2}$ -foot layer of asphaltic concrete, laid on the upstream slope of the dam. This concrete is to be covered with $3\frac{1}{2}$ feet of hand-laid rubble to protect it from the heat of the sun and weathering, and is to be of the same composition as that described on page 63 for use at the Foster dam. A cut-off wall of Portland-cement concrete is to be carried down to bed rock at the upstream toe of the dam. The asphaltic concrete is to join this wall, making the entire upstream slope of the dam water-tight.

The proposed spillway will have a breadth of 250 feet and ample capacity to handle any flood. It will discharge on a broad terrace several hundred feet from the edge of the cliff, and even if the shale does wear somewhat it is believed that the spillway will be permanent over the terrace. It is proposed to pave the spillway with asphalt-

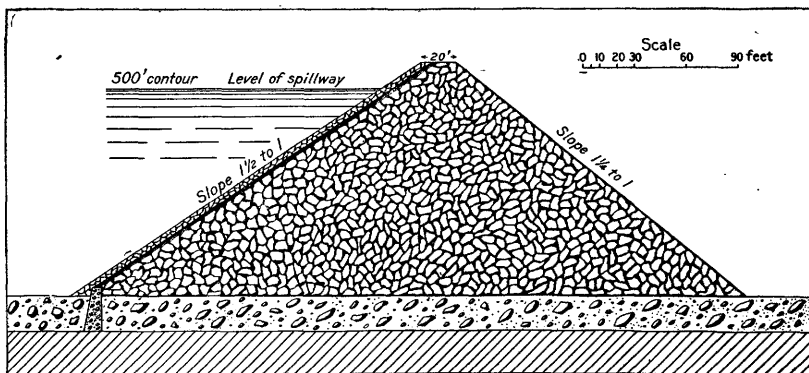


FIG. 21.—Maximum cross section of Currier dam.

tic concrete for 300 feet below the crest on account of the folded and fractured condition of the shale.

The outlet from the reservoir is to be through a tower and tunnel near the north end of the dam, as shown in fig. 22. The tower is to be of concrete, is circular in plan, and will contain the valves for controlling the flow from the reservoirs. Five intake pipes 3 feet in diameter will be placed in this tower. The valves will be the ordinary disks

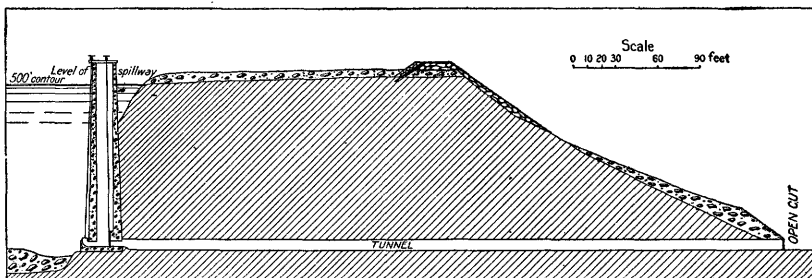
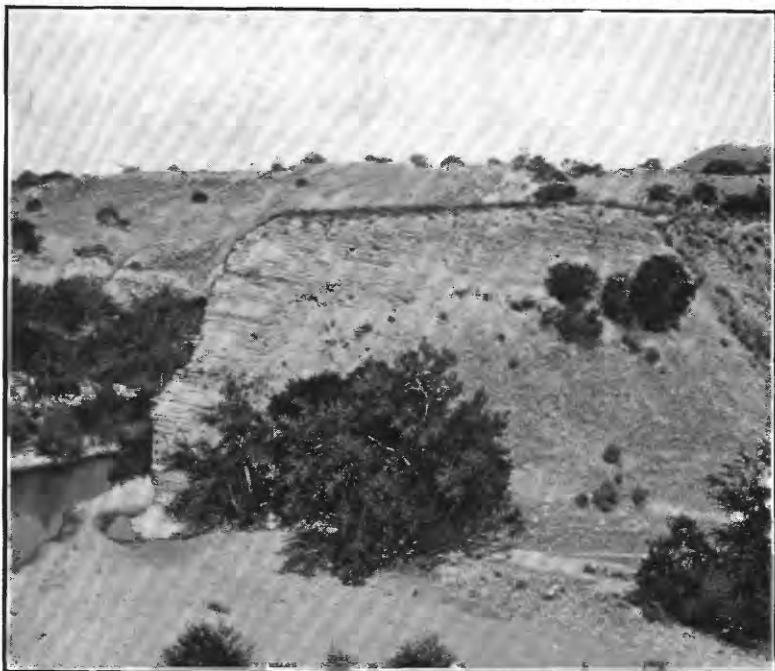


FIG. 22.—Profile of outlet tower and tunnel of Currier reservoir.

or covers, which will be lifted by a rod and geared wheels. The outlet gates from the tower are to be ordinary slide gates on rollers, with a clear opening of 2 by 4 feet. They will be operated by means of a rod and geared wheels, like the inlet valves. These outlet valves will normally remain open, but may be closed or partly closed in case the inlet valves should fail to close or break. They will also serve to regulate the pressure in the tower in case it is difficult to operate the inlet valves. As the water will be used solely for irrigation, the



A. NORTH ABUTMENT AT CURRIER DAM SITE.



B. SUMMIT REGION OF MOUNT DIABLO RANGE AT HEAD OF GAVIOTA CREEK.

Shows scattered growth of timber and brush.

valves were placed near the bottom of the tower. If desirable, however, others can be placed at different levels at any time. The outlet tunnel is to be driven through shale rock and lined with concrete. As at the Foster site, the location of the spillway and dam is favorable for cheap and rapid handling of rock by means of two overhead cableways. The rock when blasted will doubtless shatter into sizes easily handled, probably into sizes small enough to be loaded into skips with a steam shovel.

The following is a summary of the estimated cost of the dam and reservoir:

Estimated cost of Currier dam and reservoir.

Loose rock fill in dam	\$184,130
Asphaltic concrete	69,491
Hand-laid rubble	19,936
Cut-off wall	36,016
Wing wall north of spillway	7,704
Pavement on spillway	6,445
Outlet tunnel	11,895
Outlet tower	11,610
Inlet valves	4,550
Outlet valves	3,900
Tower house and footbridge	500
Engineering and contingencies, 5 per cent	17,809
Reservoir and dam site	7,500
Total	381,486

The estimated cost of storage at this locality is \$15.47 per acre-foot if the reservoir is filled once during the winter, or \$7.74 per acre-foot if filled twice, as described on page 85.

As the discharge of this stream is always sufficient to fill both the Foster and Currier reservoirs at least twice during the wet season, the outlet gates and tunnels were designed to discharge the contents of the reservoirs in thirty days. This amount of water can easily be handled in the valley below for winter irrigation. The impounded water can be released in the stream channel below the Currier dam and picked up by the existing and proposed canals at the mouth of the canyon, as shown on Pl. II.

SAN LORENZO CREEK.

The only stream of any importance entering the Salinas from the east, except Estrella Creek, is San Lorenzo Creek. (See Pls. I and II.) This stream leaves the Mount Diablo Range about 15 miles above its junction with the Salinas. Its easterly tributary, Lewis Creek, rises in the most elevated portion of the Mount Diablo Range, in Priest Valley, and flows northwestward in a deep valley in this range to within about 5 miles of its junction with Peachtree Creek, a stream that drains the southwestern slope of the long, narrow ridge between Priest Valley and the low-lying mesa lands to the southwest. This

ridge has an altitude ranging from 3,300 to 3,800 feet, and runs in a general northwest-southeast direction for many miles, being one of the main ridges of the Mount Diablo Range. These elevated ridges of this portion of the Mount Diablo Range are generally without forest covering, and often without even brush, bearing only scattered pine and oak trees. (See Pl. X, B.) Many large areas are covered only with a growth of grass or wild oats. In some of the valleys, as Priest Valley, there are large scattered oak trees. These ridges and elevated valleys, which embrace an area of 150 square miles, are in the region of greatest precipitation in the Mount Diablo Range, and the greater part of the run-off from San Lorenzo Creek in ordinary years is from this portion of the drainage basin, the mesa to the west yielding little or no run-off.

All of the streams that rise along the southwest slope of the Mount Diablo Range in Monterey County have eroded deep channels into the soft, sedimentary rocks of the mesa, the erosion being favored by the folded and broken condition of the strata in a narrow zone along the southwest slope of the Mount Diablo Range. The tendency of these streams—Peachtree, Gaviota, and Chalone creeks—to follow this folded zone is apparent on inspection of the drainage lines shown on Pl. I. The contour of the country is such that these streams receive but little drainage from the mesa which slopes southwestward to Salinas River. Peachtree Creek has recently been robbed of a portion of its drainage basin by Gaviota Creek, formerly one of the small mesa streams. This change of drainage was accomplished by the progressive erosion upstream of the canyon of Gaviota Creek until it finally cut through the dividing ridge and diverted the water from 40 square miles of the upper drainage area of Peachtree Creek. The comparative recency of this change is shown by the fact that Gaviota Creek is now rapidly cutting a deep gorge through the upper part of its course in the mesa, having already sunk its bed several hundred feet below the former bed of Peachtree Creek, and by the additional fact that the valley of Peachtree Creek below the diversion is fast filling with débris brought down by small lateral streams.

Below Lonoak San Lorenzo Creek has eroded a valley 500 to 800 feet deep, and has reached granite bed rock below the soft sedimentary rocks of the mesa (see Pl. XI, A).

From the scant information at hand it seems probable that the upper portion of this drainage area in the Mount Diablo Range receives an average annual precipitation of at least 20 inches, with a probable maximum for wet years of 40 inches, and a minimum of 10 inches for very dry years (see table on p. 43). During December, 1900, and from January 1 to April 30, 1901, and during 1902, a record was kept of the discharge of this stream at the Mathews ranch. From these observations the table below of discharge of San Lorenzo Creek has been prepared. The diagram shown in fig. 23 is a graphic illustration of the discharge of this stream during the season of 1901-2.



A. MATHEWS DAM SITE, LOOKING DOWNSTREAM, SHOWING GRANITE BED ROCK BELOW SOFT SHALES OF MESA REGION.



B. SPRECKELS SUGAR COMPANY'S PUMPING PLANT ON SOLEDAD RANCHO AT RANCH NO. 2.

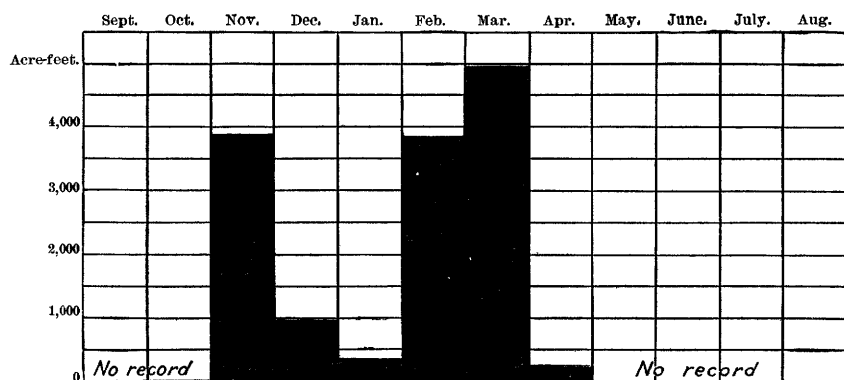


FIG. 23.—Discharge of San Lorenzo Creek at Mathews ranch from September 1, 1901, to August 30, 1902.

Estimated monthly discharge of San Lorenzo Creek at Mathews dam site, 5 miles east of Kings City.

[Drainage area, 235 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Second-feet per square mile.	Depth in inches.
1900.						
December 16 to 31	13	9	9	286	0.04	0.02
1901.						
January	2,540	9	171	10,514	.73	.84
February	9,200	9	725	40,264	3.09	3.21
March	27	9	17	1,045	.07	.08
April	27	6	8	476	.03	.03
November	720	15	65	3,868	.28	.31
December	50	5	16	984	.07	.08
1902.						
January	15	5	6	369	.03	.03
February	795	5	69	3,832	.29	.30
March	875	5	81	4,980	.34	.39
April	5	5	4	238	.02	.02
November	200	15	85	5,057	.36	.40
December	15	5	7	430	.03	.03
1903.						
January	274	5	34	2,091	.14	.16
February	200	5	52	2,888	.22	.23
March	470	5	89	5,472	.38	.44
April	470	5	69	4,106	.29	.32
May	5	3	4	246	.02	.02

NOTE.—Gage heights and discharge measurement for 1901 are given in Water-Supply Paper No. 66, page 155; rating table on page 178, same paper.

During the summer of 1900 the lower part of this drainage basin was explored by Prof. Charles D. Marx. The Mathews site was discovered and a reconnaissance survey was made. During the summer of 1901 Mr. H. E. Green resurveyed the reservoir and dam site, designed the dam, and made estimates of the cost.

MATHEWS RESERVOIR.

The Mathews reservoir site is in the canyon of San Lorenzo Creek, about 6 miles northeast of Kings City. The dam site is in the NW. $\frac{1}{4}$ sec. 24, T. 19 S., R. 8 E., M. D. M., and the reservoir site extends eastward about 2 miles. The topographic map of the reservoir is shown in fig. 24. The altitude of the stream at the dam site is 440 feet. The survey was made for a dam that would raise the water 100 feet, to the 540-foot contour. Such a dam will impound 16,131 acre-feet of water.

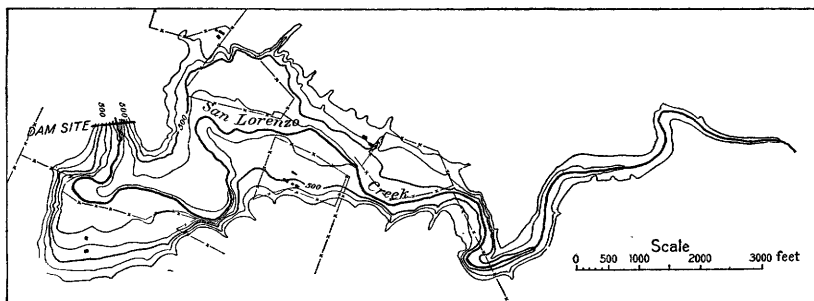


FIG. 24.—Mathews reservoir site on San Lorenzo Creek.

Area and capacity of proposed Mathews reservoir on San Lorenzo Creek.

Contour.	Area.	Capacity.
	<i>Acres.</i>	<i>Acre-feet.</i>
440	0.5	0
450	5.6	30.5
460	35.2	234.5
470	59.5	708
480	113	1,570.5
490	153.9	2,905
500	219	4,769.5
510	254.5	7,137
520	286.8	9,843.5
530	326	12,911.5
540	364	16,365.5

The accompanying table shows the area and capacity of this reservoir at the various contours. Fig. 25 shows the capacity curve of the

reservoir, by means of which the amount of water stored for any height can be ascertained. The area of the watershed tributary to this reservoir is 235 square miles. The table on page 71 shows the estimated monthly discharge from this stream at the dam site, and the table on page 43 shows the rainfall in the upper portion of the

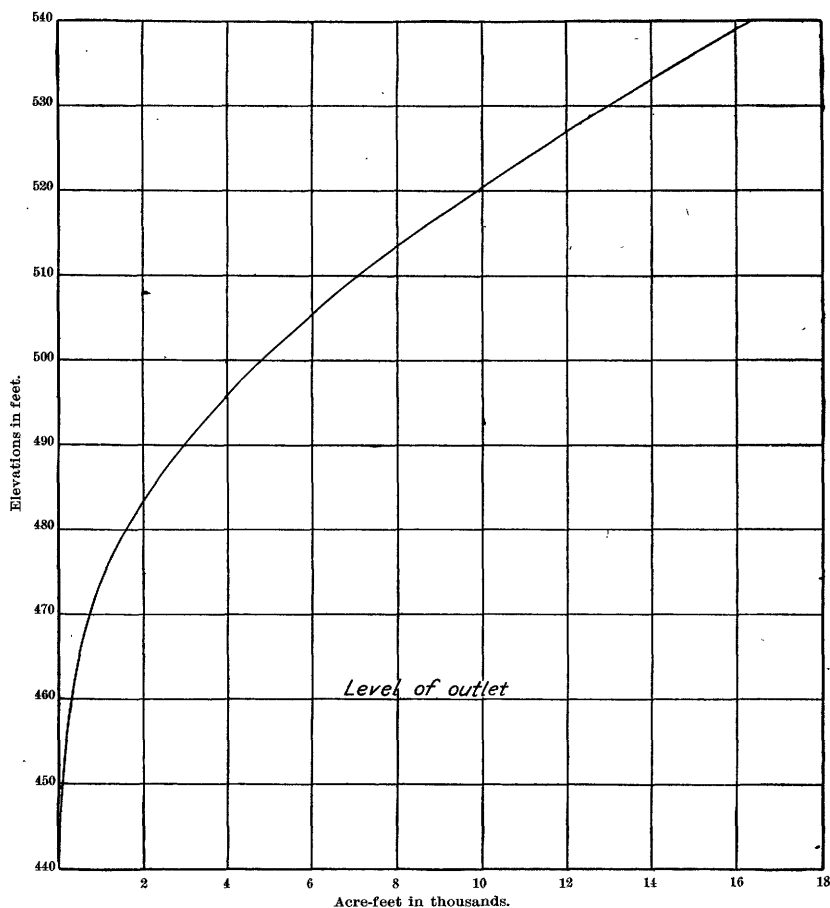


FIG. 25.—Capacity curve of proposed Mathews reservoir, showing capacity in thousands of acre-feet with the water surface at various levels.

drainage basin in Priest Valley. The reservoir is a portion of the canyon of San Lorenzo Creek, where it has cut down through the soft sedimentary formation of the mesa into the granite below. PL. XI, A, shows the character of this canyon at the dam site. At the dam site the canyon has a width of 120 feet at the level of the stream and 590 feet at the top of the dam.

PROPOSED MATHEWS DAM.

The dam at this point as designed is to be an earth fill. The positions of the dam and spillway are shown in fig. 26. The dam will have a maximum height of 110 feet above the bed of the stream on

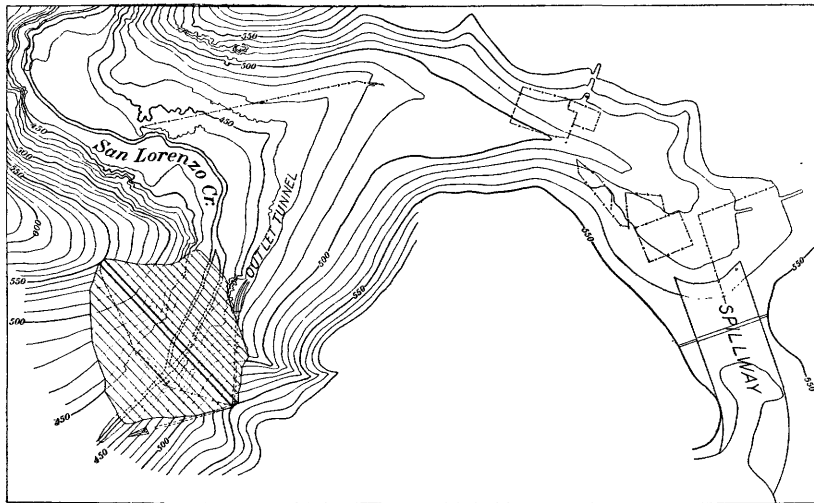


FIG. 26.—Mathews dam site and spillway on San Lorenzo Creek.

the axis of the dam, as shown in fig. 27. The upstream slope is to be $2\frac{1}{2}$ horizontal to 1 vertical, and the downstream slope is to be 2 horizontal to 1 vertical. The top width will be 20 feet and the extreme length about 590 feet. The crest of the dam is to be 10 feet above the

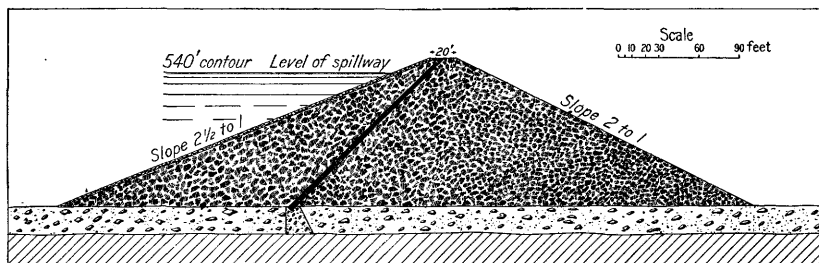


FIG. 27.—Maximum cross section of Mathews dam.

level of the spillway. The dam will be made water-tight by a layer of natural bituminous sandstone embedded in the dam, as shown in fig. 27. This bituminous rock can be obtained at the Mylar mine, $6\frac{1}{2}$ miles upstream. It is of excellent quality and can be had in large

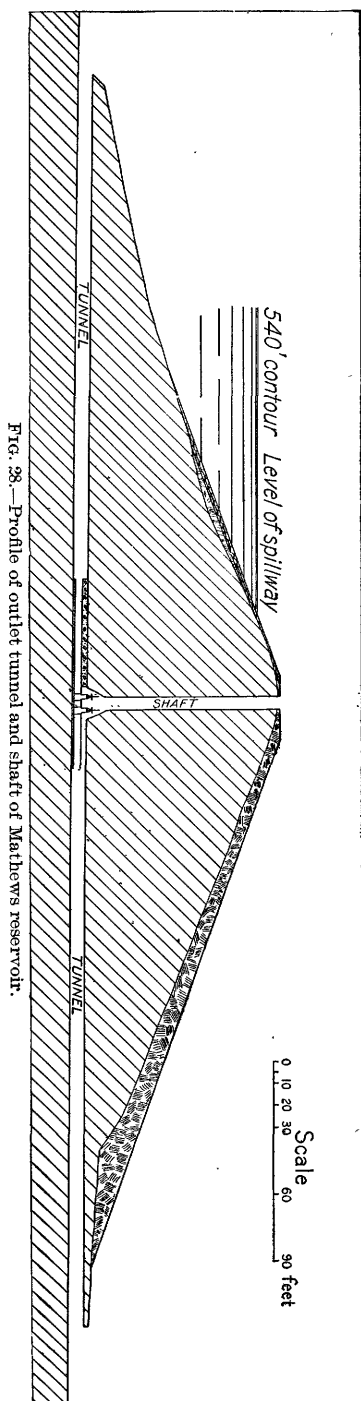
quantities. A cut-off wall of concrete is to be carried down to bed rock at the upstream toe of the bituminous layer. The depth to bed rock was estimated at 20 feet, but no test borings have been made here. The upstream slope of the dam will be protected from wave action by a 2-foot thick pavement of bowlders and coarse gravel.

The spillway will be excavated through a low saddle northeast of the dam site, as shown in fig. 26. It is to be 200 feet wide and 10 feet deep, lined with concrete for a short distance below the crest, if necessary. This spillway will discharge into a lateral canyon which reaches the main stream 500 feet below the dam site.

The outlet from the reservoir is to be through a tunnel in the granite bed rock and two 36-inch cast-iron pipes, as shown in fig. 28. The flow from the reservoir will be controlled by ordinary straight waygates or valves in this pipe, as shown in figs. 29 and 30. The flow will ordinarily be controlled by the lower gate; the other will be normally open, but can be closed in case of accident to the lower gates, or for repairs. The shaft is to give easy access to the gates. As the water will be used solely for irrigation, the outlet pipe was placed near the bottom of the reservoir, and no provision has been made for drawing off water at different levels.

Earth for the construction of a dam lies above the granite bed rock to the west of the dam. It can be delivered at the dam site either by a tramway or by overhead cableways.

The following is a summary of the estimated cost of the dam and reservoir:



Estimated cost of Mathews dam and reservoir.

Earth embankment	\$72,750.00
Bituminous rock core wall	44,240.00
Cut-off wall	12,112.00
Riprap	3,750.00
Outlet tunnel, shaft, and pipes	16,235.00
Overflow weir	4,800.00
Plant and material	25,000.00
Reservoir site and right of way	4,000.00
Engineering and contingencies	18,288.70
Total	201,175.70

Cost of storage per acre-foot, \$12.29+.

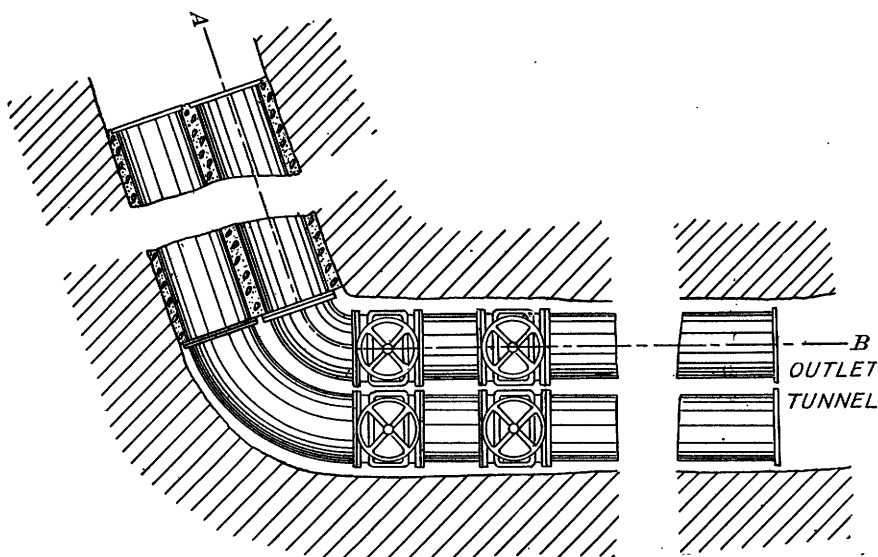


FIG. 29.—Plan of outlet gates of Mathews reservoir.

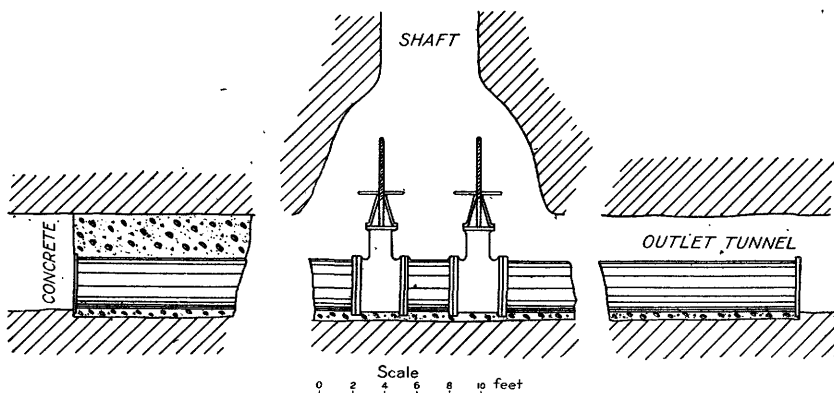


FIG. 30.—Vertical section on line A-B through outlet gates of proposed Mathews reservoir.

CHALONE CREEK.

Chalone Creek, which enters Salinas River near Metz (Pl. I), is a torrential stream flowing from the southeastern slopes of the Gabilan Range and Chalone Peak, draining an area of 128 square miles. It also has cut a deep canyon across the mesa lands. The discharge of this stream is large at times, as shown by the character of the channel. There are no reservoir sites in this watershed, and it is of small importance for irrigation purposes.

MESA STREAMS.

All the streams along the east side of Salinas River which rise in the mesa region, being without mountain drainage areas, are dry gulches during the dry season and flow but a few hours after storms in the wet season.

CARMEL RIVER.

Carmel River, although not a tributary of the Salinas, is one of the important streams of the region and merits a short description. It rises in a very rough mountain country on the northeastern slopes of the Santa Lucia Range and on the northwestern slopes of the Sierra de Salinas and flows northwestward, reaching Carmel Bay at the northwest extremity of the Santa Lucia Range (Pl. I). The valley is wide between the bounding hills and mountains for 10 miles from the coast, above which the stream flows in a canyon similar to that on the middle section of Arroyo Seco. Above Tularcitos Creek the stream flows in a canyon that reaches far back into the mountain region. Nothing very definite is known about the altitudes in this drainage area, but the average must be between 3,000 and 3,500 feet. The divide between Carmel River and Arroyo Seco is at an altitude of 2,500 feet where it is crossed by the trail. This portion of the Santa Lucia Range is covered with a very thick growth of brush and some areas are well forested by pines.

The Pacific Improvement Company diverts water from this stream by pipe system to reservoirs near Pacific Grove. The diversion dam is 15 miles from the mouth of the stream, at an elevation of 428 feet above sea level. The water is used for domestic supply at Pacific Grove and Monterey, and also for a small amount of irrigation.

The total area of the drainage basin of Carmel River is 275 square miles.

IRRIGATION.

CROPS IRRIGATED.

Only a comparatively small portion of the fertile lands of the Salinas Valley is now irrigated. The residents of this region have apparently not until lately realized the need of irrigation, but have placed entire dependence on the rainfall, while vast floods annually

run to waste. The cycle of dry years just past and the introduction of new crops have called public attention to the urgent need of supplementing the scant rainfall by irrigation. The present report is based on investigations undertaken to aid in the development of the water supply of this region. In early days all the upper Salinas Valley was given over to stock raising, the upper valley and mesa lands supporting vast herds. In the early seventies, when the railroad was built south to Soledad, a gradual change took place and wheat farming was begun in the valley. At the present time practically all the high valley land is used for raising wheat and barley, while the uplands or mesas, with the mountain slopes and small valleys, are still given over to stock raising. Grazing is and always will be an important industry. Pl. II shows the location of the irrigated and irrigable lands and the proposed storage reservoirs and canals in the Salinas Valley. It is estimated that there are 65,000 acres of irrigable land lying between the headworks of the Salinas canal and the ocean. Of this amount about 20,300 acres are irrigated by various ditches and pumping plants, leaving a balance of 44,700 acres of irrigable land to be provided for.

The principal crops irrigated are sugar beets, alfalfa, vegetables, and grain. Land on which sugar beets are raised is irrigated during the winter or early spring, usually but once, about $1\frac{1}{2}$ acre-feet being run over the field. The amount of water used of course varies with difference in the porosity of soil, but $1\frac{1}{2}$ acre-feet is a close average. This is in addition to the rainfall. Sugar beets are not irrigated after planting, but depend entirely upon one irrigation and the rainfall. Alfalfa is usually irrigated twice during the summer, about $1\frac{1}{2}$ acre-feet being used for each irrigation, or a total of 3 acre-feet a year. Alfalfa is ordinarily cut four and sometimes five times a year. Land on which potatoes are raised is irrigated once, in early spring, before planting, about $1\frac{1}{2}$ acre-feet being used. Grain is irrigated once, in April or May, about $1\frac{1}{2}$ acre-feet being used.

The cost of irrigation from canals is about \$1.50 per acre-foot, including profits to the canal companies. Irrigation by pumping is necessarily more expensive, the average cost, not including profits, being about \$2.50 per irrigation, or \$1.67 per acre-foot.

CANALS.

The following is a brief description of the irrigation works now in operation in the Salinas Valley.

The Salinas canal was constructed in 1896 and 1897. Water is diverted from Salinas River to this canal by means of a temporary dam near the north line of San Benito rancho, south of Kings City (Pl. II). The canal is 30 feet wide on the bottom, 40 feet wide on top, and was constructed to carry 5 feet of water. The grade is very light, 6 inches per mile, and the total length of the canal is about

9 miles. This canal was designed to divert water for winter and spring irrigation only, and now irrigates about 3,500 acres of land near Kings City, the principal crop being sugar beets and barley.

The San Lorenzo canal was constructed in 1896. Water is diverted from San Lorenzo Creek by means of a temporary dam of gravel at the mouth of the canyon, one-half mile below the Mathews dam site. (Pl. II). The canal is 20 feet wide on the bottom, 30 feet wide on top, and was designed to carry 5 feet of water. The grade is 5 feet per mile, and the total length of the canal about $8\frac{1}{2}$ miles. This canal was designed for winter use only, and takes the flood water and winter flow from San Lorenzo Creek, which is practically a dry stream in the summer. The land irrigated is what is termed the San Lorenzo Creek bottom, and the amount irrigated each year has varied greatly, for since the construction of the canal there have been years of very scant rainfall. Perhaps 800 acres a year would cover the service of this canal.

Arroyo Seco canal No. 1 diverts flood water from the Arroyo Seco at the south line of lot 1 of the Arroyo Seco rancho (Pl. II). It was constructed in 1897. The canal is 25 feet wide on the bottom, 35 feet wide on top, and was designed to carry 5 feet of water. The grade is 5 feet per mile and the length is about 4 miles. This canal irrigates about 300 acres of land a year on the north half of the Arroyo Seco rancho.

Arroyo Seco canal No. 2 is owned by the Arroyo Seco Improvement Company. It was constructed in 1898. Water is diverted to this canal by a temporary dam of gravel at the mouth of the canyon of the Arroyo Seco, at the south line of the Arroyo Seco rancho (Pl. II). The canal is 17 feet wide on the bottom, 27 feet wide on top, and was constructed to carry 5 feet of water. The grade is 1 foot per mile and the total length about 4 miles. This canal irrigates about 4,000 acres of land each year on the south half of the Arroyo Seco rancho and on the Espinosa tract.

Arroyo Seco canal No. 3 was constructed by the Spreckels Sugar Company in 1901 and 1902. Water is diverted to this canal from the Arroyo Seco by a temporary dam about one-half mile below the head of canal No. 2 (Pl. II). The canal is 20 feet wide on the bottom, 38 feet wide on top, and was constructed to carry 4 feet of water. The grade is 5 feet per mile, and the length is 14 miles. It irrigates 2,000 acres of land on the Soledad rancho."

The Gonzales Water Company's canal was constructed in 1899 at a cost of \$18,375 for construction of canal and right of way. The main canal is $7\frac{1}{2}$ miles long and diverts water from Salinas River by a wing dam of sand and brush about 4 miles south of the town of Gonzales (Pl. II). The river at this point flows throughout the year. The canal is 16 feet wide on the bottom, 32 feet wide on top,

^aInformation furnished by the Spreckels Sugar Company.

and has a grade of 1 foot per mile. About 2,700 acres of land are irrigated from this canal, principally grain land, but during the last summer somewhat over 500 acres have been irrigated for alfalfa, beets, and beans. The land has proved to be well adapted to irrigation, being well drained and fertile. Good crops have been obtained when all else around was a failure.^a

The Brandenstein ditch (now abandoned) diverted water from Salinas River in sec. 10, T. 23 S., R. 10 E., M. D. M., and irrigated land on the San Bernardino rancho, southeast of San Ardo. The survey was made for a canal 50 feet wide with a depth of 3 feet of water, and with a grade of 2 feet per mile. The main canal is about 6 miles long, and from 8 to 10 miles of lateral ditches have been constructed. No information is available as to the amount of water actually used or the exact location of the canals, so no attempt has been made to delineate them on the maps.^b

PUMPING PLANTS.

Considerable water is pumped for irrigation at several points in the Salinas Valley. At the Spreckels Sugar Company's ranch No. 1, at the sugar factory, 4 miles south of Salinas (Pl. II), about 3,000 acres are irrigated, the waste water from the factory being utilized. The pump is an 18-inch Byron-Jackson centrifugal, directly connected with a General Electric 400-horsepower motor, driven from the factory generator. The average lift is 25 feet; the total average lift, including friction in pipe, 50 feet. The length of pipe is 4 miles; the diameters, 30, 32, and 34 inches. The general requirements of irrigation demand 20 inches in depth of water per annum. The pump can also take water directly from Salinas River for irrigation at any time. Water is spread by a system of permanent checks. The average size of the ditches is 3 feet on bottom, 12 feet on top, and 3½ feet deep.

The Spreckels Sugar Company also has a pumping plant on the Willoughby tract, near Spence station, on the right bank of Salinas River (Pl. II). The plant consists of one 20-inch Krugh centrifugal pump, belted to an Atlas compound engine. The pump takes water from Salinas River to irrigate 500 acres. The capacity of pump is 6,000 to 10,000 gallons per minute, with an average lift of 23 feet. The average area irrigated is 350 acres on alternate years. The average cost of pumping water is \$2 per acre, or \$1.20 per acre-foot, running daytime only. The consumption of fuel is one-third cord of wood per acre irrigated.

At the Spreckels Sugar Company's ranch No. 2—the Soledad rancho (Pl. II), opposite Soledad—about 500 acres are irrigated by water pumped from Salinas River. The pumping plant consists of one 20-inch Krugh centrifugal pump, belted to an 18 by 24 inch Atlas

^aInformation furnished by Dr. A. Gonzales, president Gonzales Water Company.

^bInformation furnished by Mr. Meyer Brandenstein.



SPRECKELS SUGAR COMPANY'S PUMPING PLANT NEAR KINGS CITY, AT RANCH NO. 3.

simple engine. The average lift is 22 feet, and the capacity of the pump is 6,000 to 10,000 gallons per minute. The consumption of fuel is at the rate of one-half cord of wood per acre irrigated. The cost of irrigation is \$2.50 per acre, or \$1.36 per acre-foot, running day-time only. The general requirements of irrigation demand 22 inches in depth in winter and spring. A general view of this pumping plant is shown in Pl. XI, *B*.

At the Spreckels Sugar Company's ranch No. 3 there is a pumping plant on Salinas River, near Kings City (Pl. II). It consists of three 20-inch Krugh centrifugal pumps, each belted to an 18 by 24 inch Atlas simple engine. Originally all the pumps took water from a sump fed from Salinas River and discharged into a 60-inch wood-stave pipe, 3,300 feet in length. Lately one pump has been connected with six wells, 20 inches in diameter and 70 feet deep, furnishing 6,000 gallons of water per minute. The capacity of each pump, when pumping from sump, is 8,000 to 10,000 gallons per minute. The lift is from 20 to 35 feet. The fuel used consists of willow and cottonwood. The total area susceptible of irrigation is 2,000 acres, partly controlled by the Salinas canal. About 400 acres of alfalfa are irrigated from the deep wells. Pl. XII is a general view of this plant, showing discharge pipes and 60-inch wood-stave pipe.^a

The Salvation Army Colony tract on the Soledad rancho plant pumps water to a tract of land on the south side of Salinas River near Soledad (Pl. II). The source of supply is Salinas River, from which the water is diverted by an open cut.

The Soledad Land and Water Company has a pumping plant on the Soledad rancho, on the south side of Salinas River, where water is pumped for irrigating 800 acres of land near the old Soledad Mission. The soil is sandy loam, without hardpan, and requires about 1 acre-foot during the irrigating season, which extends from April 1 to November 1.

The pump is a centrifugal pump of 10,000 gallons' capacity per minute, with a lift of 20 feet. The plant is so arranged that water may be pumped to a height of 14, 20, 22, 27, or 31 feet, as required. The power is furnished by an 85-horsepower tandem, compound, Corliss engine, belted to the centrifugal pump. This plant cost \$10,000 exclusive of the ditches. The actual running expense per hour, without taking into account the depreciation of the plant, is about as follows:

Engineer	\$0.30
Superintendent25
Fuel25
Oil10
Incidentals10
Total	1.00

^aInformation furnished by the Spreckels Sugar Company.

The fuel used is willow and cottonwood, of rather poor quality, which is burned at the rate of about 1 cord every six hours. The cost of cutting and delivering wood on the company's land is \$1.50 per cord. This plant is operated very economically and gives satisfaction.^a

In the lower Salinas Valley there are many small pumping plants that pump from deep wells. The pumps are usually of the centrifugal type, operated by gasoline engines or occasionally by threshing engines, which are moved from place to place. Many of these wells will yield a second-foot, and it seems certain that there is a large supply of underground water in the vicinity of Salinas. These wells are used to irrigate fields of alfalfa, potatoes, and vegetables. The aggregate area thus irrigated was estimated to be approximately 2,600 acres. The underground water is discussed on pages 21-33.

EXTENSION OF IRRIGATION.

There are four sources of water supply available in this region for the extension of irrigation, viz: (1) Salinas River, (2) San Antonio River, (3) San Lorenzo Creek, and (4) Arroyo Seco. The location of these streams is shown on Pl. I, and the location of the most important reservoirs on Pl. II.

EXTENSION OF IRRIGATION FROM SALINAS RIVER.

The waters of Salinas River sink into the broad, sandy channel described on page 47, leaving but little surface flow in the dry season, when water is most needed. The winter floods are large, sweeping everything before them and converting the broad, sandy channel into a bed of shifting quicksand and silt. The estimated discharge of this stream from January 1 to July 31, 1901, is shown in the tables on page 48. The grade of this stream is very light, as noted on page 47, and the channel lies far below the general level of the valley. Any canals diverting water from this stream to the irrigable lands would of necessity have a very flat gradient and large cross section to deliver a sufficient amount of water. This adds greatly to the cost of construction. These features and the shifting channel of quicksand make it very difficult to divert the winter flow from the river. So serious are these obstacles that no large canals have been constructed to utilize the winter flow of the stream. Future investigation will, without doubt, show that it will be possible to divert Salinas River for winter irrigation, so as to conserve a portion of the water stored on the tributaries for summer use. There is an abundance of flood water for all the valley land that can be reached. Diversion from this stream will probably be most easily made by means of low, light weirs, such as are used on Kern River. They are inexpensive and in such a stream are very effective.

^a Information by Mr. Ben Gould, Soledad, Cal.

Although the grade of Salinas River is very flat, the grades of its principal tributaries are much steeper, and a point is soon reached in ascending these streams where the flow may be diverted to the valley lands below.

EXTENSION OF IRRIGATION FROM SAN ANTONIO RIVER.

The most southern tributary of Salinas River from which it is practicable to divert water for the Salinas Valley is San Antonio River. The Pinkerton reservoir on this stream has been described on page 51.

By reference to the table on page 52 the cost of storage is seen to be excessive, but if a dam could be constructed to a height of 75 or 100 feet the storage capacity of the reservoir would be enormously increased. There is no probability of a shortage of water, as the run-off from San Antonio River is certainly large. There is not enough irrigable land along this stream for many miles below to justify the expense of a dam here. The only other land within reach of this reservoir is the Salinas Valley between Wunpost and Kings City. It is approximately 22 miles from the reservoir to Wunpost. The canal would be on steep sidehills for a large part of the way unless it could be run through Hames Valley, in which case the distance would be considerably shortened. It would be necessary to cross Salinas River with an expensive flume to reach the northeast side of the valley.

For these reasons no further investigations were made of this project. It is possible, however, that in the future this site may become a valuable adjunct to the irrigation systems in the Salinas Valley. A cheaper dam, of the rock-fill type, could be substituted for the masonry structure, and this would greatly reduce the cost of storage.

EXTENSION OF IRRIGATION FROM SAN LORENZO CREEK.

The proposed Mathews reservoir and dam have been described on page 72. From December 16, 1900, to April 30, 1901, inclusive, the estimated discharge of this stream was 52,585 acre-feet (see table on p. 71), or nearly three and one-fourth times the capacity of the reservoir. From November 1, 1901, to April 30, 1902, inclusive, the estimated discharge of this stream was but 14,271 acre-feet (see table on p. 71), or but nine-tenths the capacity of the reservoir. As the rainfall this season was undoubtedly somewhat below the normal, it is probable that the reservoir will be filled in a season of average rainfall, while much water would go to waste in a wet season. From November 1, 1902, to May 30, 1903, inclusive, the estimated discharge of this stream was 20,290 acre-feet (see table on p. 71), or one and one-fourth times the capacity of the reservoir. Residents along the stream are authority for the statement that in some very dry seasons the stream flows little or none in the lower portion. During the summer the water is very alkaline. A sample collected one-fourth

mile above the head-gate of the San Lorenzo canal in the summer of 1901 and analyzed shows that when the stream is at the summer stage, discharging about 1 second-foot, the water may be expected to contain about 480 parts of solids in 100,000 parts of water. The complete analysis is shown below, expressed in parts per 100,000, the elements being calculated as compounds.

Analysis of water from San Lorenzo Creek during summer flow.^a

	Parts in 100,000.
Calcium sulphate (CaSO_4)	80.15
Magnesium sulphate (MgSO_4)	57.40
Sodium sulphate (Na_2SO_4)	175.22
Potassium chloride (KCl)	10.68
Sodium chloride (NaCl)	119.35
Sodium bicarbonate (NaHCO_3)	34.11
Sodium carbonate (Na_2CO_3)	4.19
Total	481.10

Samples of water were also collected from the first rises at the beginning of the wet season, No. 1 when the stream had risen 1 foot and No. 2, when it had risen approximately 2 feet. The proportion of solids is still seen to be very large.

Analyses of water from San Lorenzo Creek at beginning of wet season.^b

	No. 1.	No. 2.
	Parts in 100,000.	Parts in 100,000.
Calcium sulphate (CaSO_4)	53.3	114.9
Magnesium sulphate (MgSO_4)	74.1	85.8
Sodium sulphate (Na_2SO_4)	37.9	40.4
Potassium chloride (KCl)	15.6	22.5
Sodium chloride (NaCl)	40.1	17.1
Sodium bicarbonate (NaHCO_3)	43.7	74.9
Total	264.7	355.6

No samples have been collected from this stream after prolonged floods, but no doubt the amount of alkali is much less in time of flood. Provision should be made for drawing off the summer flow and the first flood waters before filling the reservoir. The total mineral content of the low-water flow and first floods is so large as to produce an appreciable and ultimately deleterious deposit in irrigated soil. The stream carries a large amount of silt in floods, but no determinations have been made of the percentages or the time it will take to fill the reservoir.

As no run-off records were kept on this stream prior to 1900, there are few data on which to base a reliable estimate of the discharge. It

^a U. S. Department of Agriculture, Bureau of Soils. Atherton Seidell, analyst.

^b U. S. Department of Agriculture, Bureau of Soils. Bailey E. Brown, analyst.

seems probable, however, that dry seasons may occur once in from six to ten years, when little water will be stored, and a supply must be held over from the preceding season. It is estimated that 4,000 acre-feet should be held over to maintain crops that require a continuous supply of water, as alfalfa, etc. By this estimate the effective capacity of the reservoir is reduced from about 16,000 acre-feet to about 12,000 acre-feet in ordinary seasons. Assuming the duty of water at 2 acre-feet per season, this reservoir should provide water for 6,000 acres in ordinary seasons with a hold-over supply of 4,000 acre-feet.

During seasons of more than average rainfall if the water for winter irrigation is drawn from the reservoir it will serve as a regulator of the flood discharge, and more land can be irrigated if crops requiring winter irrigation only are raised.

Canals are already constructed from the mouth of the canyon to and beyond Kings City, but it will be necessary to extend the system if the reservoir is built; however, no expensive works will be necessary.

EXTENSION OF IRRIGATION FROM ARROYO SECO.

The proposed Foster and Currier reservoirs have been described on pages 59 and 65. The table on page 54 shows that the total estimated discharge of Arroyo Seco from January 1 to August 31, 1901, was 144,602 acre-feet, approximately 3.5 times the combined capacity of both reservoirs. One large flood occurred in November, 1900, of which there is no record, as the gaging station had not yet been established, but it is certain that a great amount of water was discharged.

The table on page 54 shows that from September 1, 1901, to August 31, 1902, the total estimated discharge of this stream was 100,947 acre-feet, or approximately 2.4 times the capacity of both reservoirs. The rainfall throughout the Salinas Valley was somewhat below the average this season. The table on page 54 shows that from September 1, 1902, to August 31, 1903, the total estimated discharge of the stream was 104,024 acre-feet, $2\frac{1}{2}$ times the combined capacity of both reservoirs. No other records of the discharge of this stream have been kept, and no estimate can be made of the discharge for a very dry season, such as that of 1897-98, but from the testimony of residents in this region it seems probable that both reservoirs can be filled once even in seasons of very scant rainfall, and no hold-over storage will be necessary.

In seasons of ordinary rainfall the discharge of the stream is sufficient to fill both reservoirs twice and in wet years three or more times. As noted on page 78, it is desirable to irrigate for certain crops during the winter and early spring, say from January 1 to March 31. This ordinarily is the season of greatest discharge from the Arroyo Seco.

It seems probable that by proper management both reservoirs can be filled and emptied and filled again in this period in seasons of ordinary rainfall and filled and emptied twice and filled again in wet sea-

sons. As noted above, they can probably be filled once even in the driest years. The combined capacity of the reservoirs is 41,367 acre-feet. By this estimate it is seen that it will be possible to start at the beginning of the dry season with full reservoirs, which, with the duty of water at 2 acre-feet, will provide irrigation for about 20,000 acres in very dry seasons. This is sufficient to carry through a dry year such crops as alfalfa, as well as orchards, etc. In seasons of ordinary rainfall the reservoirs should provide water for irrigating 40,000 acres, and in wet seasons 60,000 acres or more. It is believed that this estimate is conservative.

The reservoirs are thus seen to serve as regulators of the flood discharge as well as storage reservoirs.

To carry this water to the lands below it will be necessary to construct a canal approximately as located on Pl. II. This canal can be so located as to divert flood water from Salinas River between Kings City and Soledad, and the canals from the San Lorenzo and Arroyo Seco could discharge into it during the latter part of the season, supplementing the winter flow, if necessary. It is believed that such a canal, in connection with the reservoirs, will supply water to all the best irrigable land from Soledad to the Bay of Monterey. No surveys for such a canal and no estimates of its cost have been made by the United States Geological Survey.

The stream carries but a small percentage of silt, and the water is very pure, in every way suited for irrigation and domestic use.

The following table of analysis shows the character of this water at the gaging station the first of the season after a slight rise:

Analysis of water from Arroyo Seco.^a

	Parts in 100,000.
Calcium sulphate (CaSO_4)	4.0
Magnesium sulphate (MgSO_4)	2.9
Potassium chloride (KCl)	1.0
Sodium bicarbonate (NaHCO_3)	13.8
Potassium bicarbonate (KHCO_3)8
Total	22.5

Other analyses show that the flood water contains slightly less mineral matter.

EXTENSION OF IRRIGATION BY PUMPING WATER.

If the above-described reservoirs and canals are constructed it is probable that pumping water for irrigation will decrease rather than increase in the lower Salinas Valley. The high price of fuel makes pumping expensive and in the future it will undoubtedly be limited to procuring water for domestic supplies and for the irrigation of small garden patches. The underground water conditions of the

^aCalculated as compounds. U. S. Department of Agriculture, Bureau of Soils. Bailey E. Brown, analyst.

lower Salinas Valley have been described on page 21. In the upper Salinas Valley and the mesa regions it is not improbable that sufficient water for stock-raising purposes could be reached by deep wells. Deep-well pumps driven by powerful windmills would raise the water to the surface and make available range lands now unused. For a detailed description of pumps and windmills used for such purposes the reader is referred to Water-Supply and Irrigation Papers Nos. 1, 8, 14, 29, 41, and 42 of the United States Geological Survey, and for a description of the methods of irrigation from wells to Water-Supply and Irrigation Paper No. 20.

SUMMARY.

The important results of the hydrographic investigations are summarized in the following table:

Summary of results of investigations.

• Improvement.	Capacity in acre- feet.	Cost of installation.		Annual charge for interest, taxes, and mainte- nance.	Annual charges per acre-foot stored.
		Total.	Per acre- foot stored.		
Foster reservoir, 125-foot dam:					
In dry years	16,710	\$260,841.00	\$15.61	\$41,237.00	\$1.28
In ordinary years	33,420	260,841.00	7.80	41,237.00	.64
In wet years	50,130	260,841.00	5.20	41,237.00	.43
Currier reservoir, 135-foot dam:					
In dry years	24,657	381,486.00	15.47	29,441.00	1.19
In ordinary years	49,300	381,486.00	7.74	29,441.00	.60
In wet years	73,971	381,486.00	5.16	29,441.00	.40
Mathews reservoir, 110-foot dam:					
In dry years	4,000	201,175.70	50.29	17,180.00	4.30
In ordinary years	12,000	201,175.70	16.76	17,180.00	1.43
In wet years	16,131	201,175.70	12.29	17,180.00	1.07

In the above estimate interest was calculated at 6 per cent and taxes at 0.8 of 1 per cent on the total cost of the dams and reservoirs. In each case an additional charge of \$3,500 per annum was made for maintenance and supervision.

The last column of the foregoing table gives the cost per acre-foot per annum of water stored at the above-mentioned reservoirs. Data are not available to estimate the loss by seepage in canals and by evaporation, but in estimating the amount of land that can be irrigated a liberal allowance has been made of the duty of water. It is assumed that for each 1.5 acre-feet of water put on the land 0.5 of an acre-foot will be lost in the canals. About 1.5 acre-feet per annum is the average amount of water actually used on the land. The Leigh reservoir and Pinkerton reservoir are not of special value at present, but may be valuable adjuncts to the water supply of the Salinas Valley in the future.



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- WS 4. A reconnaissance in southeastern Washington, by I. C. Russell. 1897. 96 pp., 7 pls.
 WS 6. Underground waters of southwestern Kansas, by Erasmus Haworth. 1897. 65 pp., 12 pls.
 WS 7. Seepage waters of northern Utah, by Samuel Fortier. 1897. 50 pp., 3 pls.
 WS 12. Underground waters of southeastern Nebraska, by N. H. Darton. 1898. 56 pp., 21 pls.
 WS 21. Wells of northern Indiana, by Frank Leverett. 1899. 82 pp., 2 pls.
 WS 26. Wells of southern Indiana (continuation of No. 21), by Frank Leverett. 1899. 64 pp.
 WS 30. Water resources of the Lower Peninsula of Michigan, by A. C. Lane. 1899. 97 pp., 7 pls.
 WS 31. Lower Michigan mineral waters, by A. C. Lane. 1899. 97 pp., 4 pls.
 WS 34. Geology and water resources of a portion of southeastern South Dakota, by J. E. Todd. 1900. 34 pp., 19 pls.
 WS 53. Geology and water resources of Nez Perces County, Idaho, Pt. I, by I. C. Russell. 1901. 86 pp., 10 pls.
 WS 54. Geology and water resources of Nez Perces County, Idaho, Pt. II, by I. C. Russell. 1901. 87-141 pp.
 WS 55. Geology and water resources of a portion of Yakima County, Wash., by G. O. Smith. 1901. 68 pp., 7 pls.
 WS 57. Preliminary list of deep borings in the United States, Pt. I, by N. H. Darton. 1902. 60 pp.
 WS 59. Development and application of water in southern California, Pt. I, by J. B. Lippincott. 1902. 95 pp., 11 pls.
 WS 60. Development and application of water in southern California, Pt. II, by J. B. Lippincott. 1902. 96-140 pp.
 WS 61. Preliminary list of deep borings in the United States, Pt. II, by N. H. Darton. 1902. 61 pp.
 WS 67. The motions of underground waters, by C. S. Slichter. 1902. 106 pp., 8 pls.
 B 199. Geology and water resources of the Snake River Plains of Idaho, by I. C. Russell. 1902. 192 pp., 25 pls.
 WS 77. Water resources of Molokai, Hawaiian Islands, by Waldemar Lindgren. 1903. 62 pp., 4 pls.
 WS 78. Preliminary report on artesian basins in southwestern Idaho and southeastern Oregon, by I. C. Russell. 1903. 53 pp., 2 pls.
 PP 17. Preliminary report on the geology and water resources of Nebraska west of the one hundredth and third meridian, by N. H. Darton. 1903. 69 pp., 43 pls.

The following papers also relate to this subject: Underground waters of Arkansas Valley in eastern Colorado, by G. K. Gilbert, in Seventeenth Annual, Pt. II; Preliminary report on artesian waters of a portion of the Dakotas, by N. H. Darton, in Seventeenth Annual, Pt. II; Water resources of Illinois, by Frank Leverett, in Seventeenth Annual, Pt. II; Water resources of Indiana and Ohio, by Frank Leverett, in Eighteenth Annual, Pt. IV; New developments in well boring and irrigation in eastern South Dakota, by N. H. Darton, in Eighteenth Annual, Pt. IV; Rock waters of Ohio, by Edward Orton, in Nineteenth Annual, Pt. IV; Artesian well prospects in the Atlantic Coastal Plain region, by N. H. Darton, Bulletin No. 138.

SERIES P—HYDROGRAPHIC PROGRESS REPORTS.

Progress reports may be found in the following publications: For 1888-89, Tenth Annual, Pt. II; for 1889-90, Eleventh Annual, Pt. II; for 1890-91, Twelfth Annual, Pt. II; for 1891-92, Thirteenth Annual, Pt. III; for 1893-94, B 131; for 1895, B 140; for 1896, Eighteenth Annual, Pt. IV, WS 11; for 1897, Nineteenth Annual, Pt. IV, WS 15, 16; for 1898, Twentieth Annual, Pt. IV, WS 27, 28; for 1899, Twenty-first Annual, Pt. IV, WS 35-38; for 1901, Twenty-second Annual, Pt. IV, WS 47-52; for 1901, WS 65, 66, 75; for 1902, WS 82-85.

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