STATE OF CALIFORNIA

DEPARTMENT OF ENGINEERING

BULLETIN No. 5

REPORT ON THE

Utilization of Mojave River for Irrigation in Victor Valley, California

By MOJAVE RIVER COMMISSION: W. F. McCLURE, State Engineer, Chairman; J. A. SOURWINE, Engineer for San Bernardino County; and C. E. TAIT, Senior Irrigation Engineer, Office of Public Roads and Rural Engineering, United States Department of Agriculture.

(Based in part on data gathered under cooperative agreement between the Office of Public Roads and Rural Engineering, Irrigation Division, of the United States Department of Agriculture, and the California State Department of Engineering.)

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PREFACE.

In December, 1916, a petition was presented to the Board of Supervisors of San Bernardino County praying for the formation of an irrigation district in Victor Valley, east of the Mojave River. Under the provisions of the law, the State Engineer was called on to report upon the feasibility of the project, and he caused an examination to be made therefor.

It was found that many conflicting claims exist to the water intended to be taken for the proposed district, by lands which seem to have an equally good right to the water to those lands embraced in the proposed district.

The State Engineer, finding that in the one month allowed by law in which to make his investigation it would be impossible to ascertain whether sufficient water was available to the district for its proper development, recommended that the matter be held in abeyance until the whole question of the utilization of the waters of Mojave River could be analyzed and studied, and he suggested that a fund be provided to defray the cost of making a thorough examination.

The Board of Supervisors placed funds at the disposal of the County Engineer to pay the expenses of such an investigation to be made jointly by the San Bernardino County Engineer, the Office of Public Roads and Rural Engineering of the United States Department of Agriculture, and the State Department of Engineering.

This report is the result of the investigation and studies of the subject made under the co-operative direction of the agencies named.

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LETTER OF TRANSMITTAL.

April 30, 1918.

To the Honorable Board of Supervisors, County of San Bernardino, San Bernardino, California.

GENTLEMEN: In accordance with the instructions of your Honorable Board, we are submitting herewith a report, embodying the summary of the studies made by this commission.

Your instructions read, "This commission shall have power to make such engineering investigations as may be necessary to show the water available, the proper duty of water, the sufficiency of proposed reservoir and dam sites, and the general feasibility of the required engineering works."

It has not been deemed necessary or expedient to encumber the report with all the detail data acquired in making the investigations.

Respectfully submitted.

THE MOJAVE RIVER COMMISSION.

W. F. MCCLURE,
State Engineer, Chairman.

J. A. SOURWINE,
Engineer for San Bernardino County.

C. E. TAIT,
Senior Irrigation Engineer, Office of Public Roads and Rural Engineering, United States Department of Agriculture.

REPORT ON THE

UTILIZATION OF MOJAVE RIVER FOR IRRIGATION IN VICTOR VALLEY, CALIFORNIA.

BY

MOJAVE RIVER COMMISSION.

W. F. McCLURE, State Engineer, Chairman; J. A. SOURWINE, Engineer for San Bernardino County; and C. E. TAIT, Senior Irrigation Engineer, Office of Public Roads and Rural Engineering, United States Department of Agriculture.

INTRODUCTION.

The investigations for this report related to the following subjects: The economic problems confronting the land entrymen and settlers; the history; constructed works and future plans of the corporate enterprises; the water rights for which allowance must be made; the amount and movement of the underground water; the extent to which pumping from wells can be depended upon for irrigation; the amount of the annual surface water supply; the possible sites for storage; the possibilities of hydroelectric power development; the proper duty of water; the area for which reclamation can be safely undertaken; and the most efficient and economical plan of irrigation works.

The investigations of riparian lands are not as complete as it was desired to make them, but, considering the time and funds available, it was necessary to limit the studies in this direction.

Data were secured on all the wells in the region and the elevations of the ground surface and water surface for many of the wells were obtained by leveling from the government bench marks. This enabled hydrographic contours to be located and permitted the formulating of conclusions regarding the movement of underground water.

All records of stream discharge and of precipitation in the watershed were reviewed and correlated in arriving at the amount of water available for use.

Data on duty of water for the crops suited to the region were secured throughout Victor Valley, also from other sections of southern California with similar conditions.

Complete contour surveys were made of two possible reservoir sites which, together with private surveys of other sites, give data on all the available sites for storage.

It has not been practical to present a detailed review of the plans previously proposed for the utilization of the waters of Mojave River.

The map has been prepared from official and authentic private sources and from original surveys by the commission.

Acknowledgments.

Space does not permit acknowledgment of all the courtesies extended to the authors of this report by the many owners of wells and ditches in Victor Valley, but the commission desires to acknowledge special aid as follows: Victor H. Smith, President, Arrowhead Reservoir and Power Company, for valuable discharge measurements of Mojave River and tributaries; F. C. Finkle, Consulting Engineer for the same company, for description of the company's works; H. Hawgood, Consulting Engineer for the Mojave Water and Power Company, for useful discharge measurements of Mojave River; J. B. Lippincott, Consulting Engineer for the Victor Valley Mutual Water Association, for much data on the subject matter; John S. Thayer and Louis Evans, of the Appleton Land, Water, and Power Company, for information on the company's lands and irrigation system; F. E. Trask, Consulting Engineer for the Mojave River Irrigation District, for information as to the plans of the district; F. M. Walton, Manager of the Victor Valley Irrigation District, for information as to the plans of this district; and to Byron Waters, Attorney for ditch owners on Mojave River, for historical facts.

W. A. Johnstone and A. E. Chandler, of the California State Water Commission, visited the territory being investigated and made suggestions regarding water rights; O. E. Meinzer, of the United States Geological Survey, gave access to a report by G. A. Waring on the geology and ground waters; Charles A. Jensen, of the Bureau of Plant Industry, United States Department of Agriculture, allowed the use of apparatus for determining the wilting percentages of the soils; and C. G. Haskell, Irrigation Engineer, Office of Public Roads and Rural Engineering, United States Department of Agriculture, co-operated in the investigation of the wells.

The commission was assisted by the following: P. M. Norboe, Assistant State Engineer, assisted in organizing the field work; Robert T. Hill, Consulting Geologist, advised as to the character of some of the dam sites; F. J. Veihmeyer, Irrigation Engineer, Office of Public Roads and Rural Engineering, United States Department of Agriculture, conducted the examination of the soils and assisted in the canvass of the wells; Fred D. Bowlus, Irrigation Engineer of the same department, made the contour survey of the Mirage Valley and collected data on water rights; Porter V. Hanf, of the County Surveyor's office, San Bernardino County, had charge of the topographic surveys of the West Fork reservoir sites; H. L. Way, of the same office, collected most of the data on duty of water; Wilber D. Cook assisted in the compilation of the map; and Williams M. Humans prepared the map for publication.

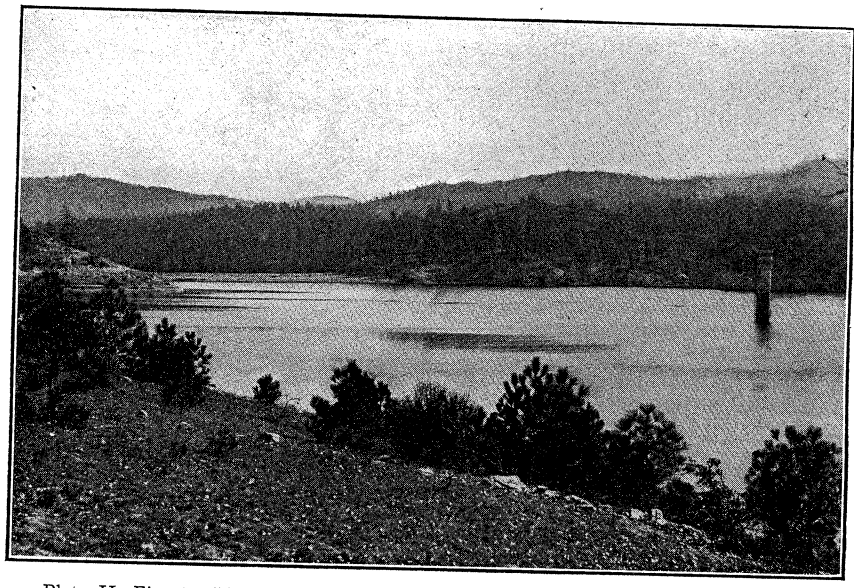


Plate II, Fig. 1.—Little Bear Valley Reservoir, November, 1917, showing dam at left and gate tower at right.

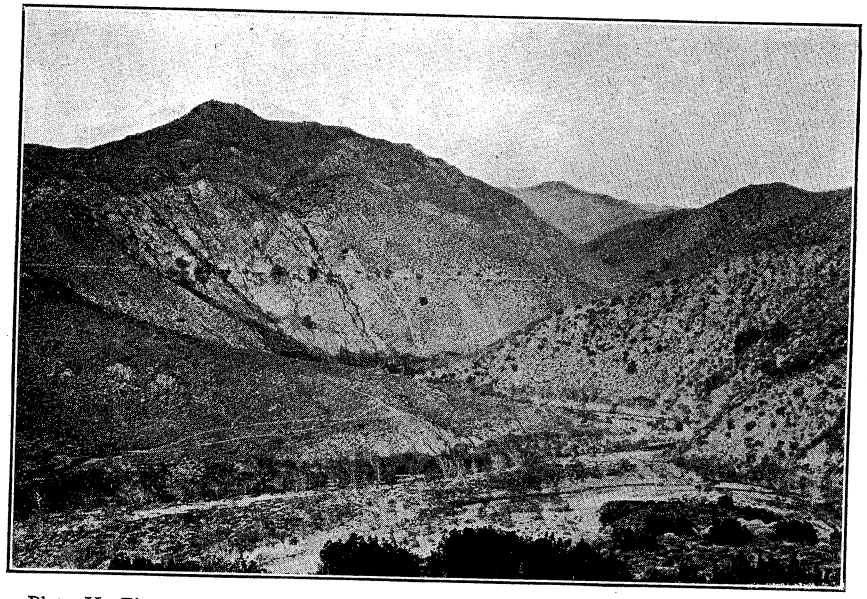


Plate II, Fig. 2.—Forks of Mojave River and Mouth of Deep Creek, showing Hesperia Ditch on Side of Mountain.

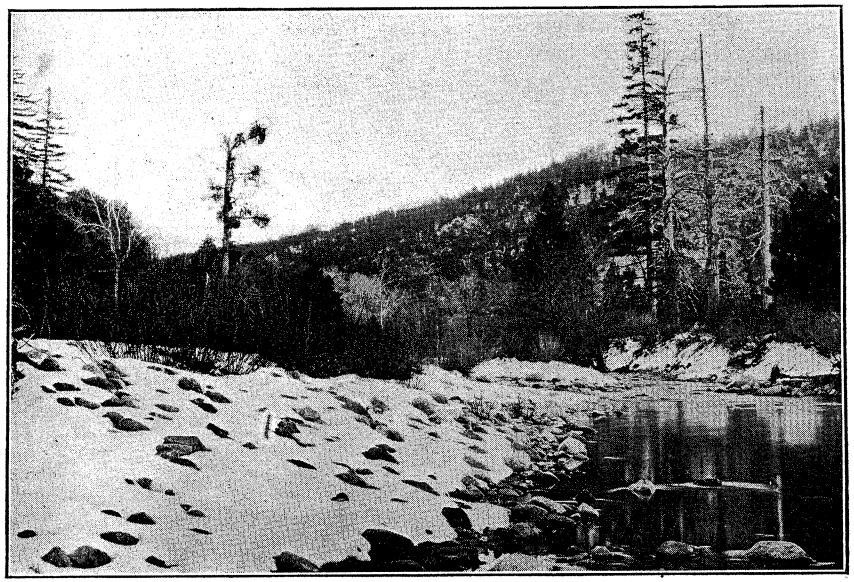


Plate III, Fig. 1.—East Fork of West Fork of Mojave River above Dam Site No. 3.

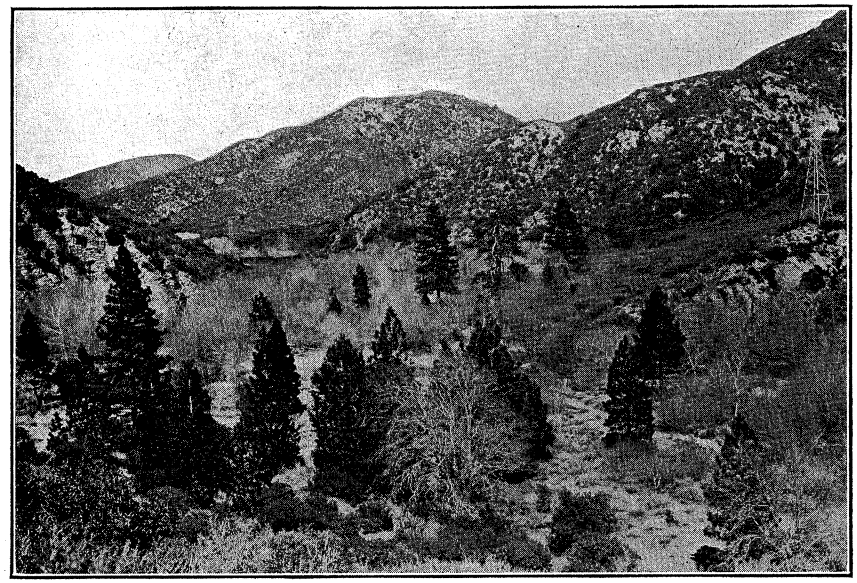


Plate III, Fig. 2.—Dam Site No. 3-B, West Fork, Mojave River, looking down stream.

DESCRIPTION.

Mojave River is situated in San Bernardino County, California, and constitutes the chief drainage system of the northern slopes of the San Bernardino Mountains. The mountain headwaters comprise two distinct branches, East Fork, or Deep Creek, and West Fork, which unite at the base of the mountains to form the main river. This junction is known as the Forks. (Plate II, Fig. 2.) Below it the river, in its course 90 miles across the desert plain, receives not a surface tributary of consequence. The course of the river is first northward 30 miles, then northeastward 20 miles, and finally eastward 40 miles. The river sinks at Soda Lake at an elevation between 900 and 1,000 feet above sea level. The mountain watershed of the river, 217 square miles in area, extends from an elevation of 8,000 feet at the summit of the range to 3,000 feet at the Forks. The upper portion has heavy precipitation and the main tributaries are never dry. In summer the water sinks in the river a short distance below the Forks but appears again several miles below, reaching the Upper Narrows (Plate V, Fig. 1) at Victorville, 14 miles below the Forks. The surface flow continues through the Lower Narrows (Plate V, Fig. 2) 4 miles farther down stream and again sinks several miles below Oro Grande. The water is then brought to the surface for short distances at a number of other points, these points being farther apart and the flow of diminishing quantity toward the lower end of the stream. At places in the dry channel water may be had by digging to shallow depths. The water is generally seen at Helen 10 miles below Oro Grande and again at Hicks. The valley is confined between bluffs from the mountain to this point, but between Hicks and Barstow it widens on the northwest side. The channel is again between bluffs from Barstow to Daggett and the water is at the surface at Barstow and at Nebo, 4 miles above Daggett. Below Daggett the river crosses a broad plain. The stream is twice more between bluffs, at Camp Cady and at the Caves, and at both places the water is at the surface. The Caves are remarkable for the columnar appearance and the variegated coloring which nature has given the clay bluffs of the canyon walls. Below the Caves the channel is dry in summer.

The late winter flood water resulting from the melting of the snow always reaches to Barstow and generally to Camp Cady as an unbroken stream. Some years it reaches entirely to the broad basins of Soda and Silver lakes, which it fills to a shallow depth and in which the water gradually disappears by sinking and evaporating. The flood water generally flows to Barstow from December to April or May.

This report is concerned chiefly with the upper part of the river, including the mountain watershed and the adjacent mesas known as Victor Valley, and with the ditches having rights to water. The east

mesa is known as Apple Valley and the lower portion of this mesa bordering the river bottom is called the First Bench. The upper portion of the west mesa (Plate VI, Fig. 1) above Hesperia and stretching westward along the foothills beyond Cajon Pass is known as Baldy Mesa, the name being derived from Mount San Antonio, generally called Baldy. The lower and northern portion of the west mesa about the settlement of Adelanto is called Sunrise Valley and the section around the dry lake bed at Grey Mountain (Plate VI, Fig. 2) is called Mirage Valley.

EARLY HISTORY.

Although the history of the Mojave River country after the beginning of irrigation is more essential to this report, a few facts relating to the early period may be of interest and not out of place.

Until about the time of the Civil War the territory along the river was dominated by the Piute Indians and it was not a place of safe habitation.

Aside from the native Indians, probably among the first to explore this part of the desert were Jedediah Smith and his party of trappers from Salt Lake City, who in 1827 crossed Colorado River at the Mojave Indian villages (now Fort Mojave) and traveled westward to the course of a river, undoubtedly the Mojave, which was thereafter followed toward a pass, the Cajon, in the Coast Range en route to Los Angeles.[1] The trip was repeated the following year, but while crossing the Colorado River on a raft this party was attacked in midstream by the Indians, who had been friendly on the first trip but who had then been excited to hostility by the Spanish, and eight of the twelve members were killed. The survivors, as had the party of the previous year, crossed the desert and arrived in Los Angeles after much hardship.

Again, in 1829, Ewing Young, at the head of another party of trappers, a youthful member of which was later to be General Kit Carson, made a similar journey.[2] A member of this party has described the stream as a dry river rising in the Coast Range and leading northeast into the Great Basin, which was followed several days before water was found; also as a singular stream running southeast 200 miles and emptying into Colorado River, not two miles of its entire length in which it does not disappear, and in part resembling a line of shallow lakes. In four days after leaving the river the party arrived at San Gabriel Mission, where they were much refreshed. The river could have been none other than the Mojave, and the pass was undoubtedly the Cajon.

[1]History of the American Fur Trade of the Far West, by Capt. H. M. Chittenden.
[2]Kit Carson Days, by E. L. Sabin.

Evidently these early travelers were unaware of the sinking of the river at Soda Lake, 100 miles westward from Colorado River, and believed its course could be traced to a junction with the larger stream. Whether the emigrants who later, but prior to the fifties, traveled the Spanish or extension of the Santa Fe trail from Colorado River to Cajon Pass discovered this error is not known. Certain it is that the early official maps show a junction with the Colorado, and that the Army engineers believed them to be correct until 1853, when reconnaissance surveys were made by the War Department for a railroad from the Mississippi River to the Pacific Ocean.

That part of the survey in California was in charge of Lieutenant R. S. Williamson, who had with him William P. Blake, geologist, and 25 soldiers in command of Lieutenant George Stoneman as a military escort to guard against attack by the Piute and Mojave Indians. Lieutenant Williamson, after deciding on Tehachapi Pass as the most practical entry from the Tulare to the Great Basin, set about to locate the best route from there to the mouth of the Gila River, where his survey was, according to instructions, to join that of another party working from the east.[1]

It was reasoned that to cross the Sierra Madres to Los Angeles by the Soledad and Newhall passes would but necessitate another crossing of the Coast Range to reach the Gila. Not only was Warners Pass believed to be the only gateway from the southern California coast to the Colorado Desert, but it was also believed that by running eastward from the Tehachapi to Mojave River and then following that stream to its supposed junction with the Colorado and finally along the Colorado to the mouth of the Gila, that excellent grades would be offered. An alternate or second possible route in order of preference was to go up instead of down the Mojave River in the hope of finding a pass through the San Bernardino Mountains at the headwaters of the river which would lead to Colorado Desert with but a single crossing of the range. A route southward through Cajon Pass was not considered because it would, like a route through Los Angeles, require a second crossing at Warners Pass, understood to be impractical for a railroad.

The surveying party traveled along the north side of the Sierra Madres and arrived where the Spanish Trail from Cajon Pass reached Mojave River (probably below the Lower Narrows), October 19, 1853. Here the river is described as a broad shallow stream with valley abundantly wooded between terraced banks from one to three miles apart. The water soon sank to reappear at some point of rocks below. A detachment was sent up the river, who soon returned with the informa-

[1]Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean, Vol. V. War Department.

tion that it would be impossible to reach the Gila by the ascent of the Mojave.

Being now more confident of the preference for the river route, Lieutenant Williamson started down the river, and as he progressed found it more difficult to procure sufficient water for his mules at some of the camps, it being necessary to dig in the sands of moist places in the channel.

Finally, a canyon between clay bluffs 100 feet high, with a running stream for seven miles, evidently the Caves, was reached. Below this canyon was a sandy plain on which the channel was entirely lost, but a lake bed (Soda Lake) was observed to the north, which on examination was found to be 15 miles long and covered with an incrustation of salt and moist in places. Camp was located at springs (Soda Lake Spring), at the base of mountains near the lake bed, for headquarters for further exploration. The first lake bed was found to be connected to another (Silver Lake) two or three miles to the north of it by a ditch about 20 feet wide and 2 feet deep. This second basin, reached November 16, 1853, had a smooth floor of hard dry clay, and it, like the first, was found to have no outlet. Thereupon it was concluded that the river sank in the first basin and that the accumulating flood water when high overflowed into the second basin.

Having determined the maps showing a channel for 100 miles farther east to the Colorado River to be erroneous, Lieutenant Williamson abandoned the idea of a railroad over this route and retraced his steps to Soledad Pass, through which they went to Los Angeles and on to San Bernardino, and from which latter settlement he expected to go to Warners Pass by way of Temecula. But at San Bernardino he was informed of the existence of San Gorgonio Pass and as a second surprise found excellent grades for a railroad through this pass situated between the two highest peaks in southern California, Mount San Gorgonio and Mount San Jacinto. It is of interest to note that the Southern Pacific from Tehachapi to Yuma was constructed practically on the route finally recommended by Williamson, also that portions of the Santa Fe and Salt Lake follow in part the general route he first attempted to survey.

Emigrants, including gold seekers in '49, came to southern California through the thirties and forties from New Mexico and the East[1] over the Spanish Trail, striking Mojave River at Soda Lake Spring and following it to the Lower Narrows, thence diverging toward Cajon Pass. After the Mormons blazed the Salt Lake Trail and settled the new San Bernardino in 1851, their wagon trains increased the traffic. The freighters carried supplies from Los Angeles and San Bernardino to the mines both northward and eastward. The northward route

[1]Century Annals of San Bernardino County, by L. A. Ingersol.

branched off from the older trail at the "Forks of the Road" near where Daggett has been located. A toll road was instituted in 1862 and during the sixties regular stage service was in operation along the river.

By the late sixties stockmen, who at first only ranged their cattle in the region, risked danger of depredations by the Indians and began to live along the river. The first settlements were the stations on the trail located where the lands were moist or where the flow of the river was sufficient for the growing of hay to feed cattle and supply the freighters. Settlements were made near the Lower Narrows and at other points down the river. Although not immediately on the trail, other choice locations settled early were just above the Upper Narrows where the Brown Ranch was started and in the valley of the West Fork, called Dunlap Valley.

The report of Lieutenant Eric Bergland, on his expedition in 1875,[1] records conditions on the river at the time. He had been instructed to examine the feasibility of diverting the Colorado River of the West from its channel for purposes of irrigation.

Starting with his party from Los Angeles, he made his outward journey to the Colorado along Mojave River, arriving at Lane's Upper Crossing, the highest station on the stream and located just below the Lower Narrows, June 29, 1875. Here the river was found to be 100 feet wide and 3 feet deep. Bergland's map shows the successive stations going down the river to have been: Point of Rocks, now Helen; Cottonwood, now Hicks; Grapevine, now Barstow; Forks of the Road, located eight miles below the site of Daggett; Camp Cady, then an abandoned military post; the Caves, and Soda Lake Spring. The eastward trail continued by way of Marl Spring and Piute Hill to Fort Mojave. The Mormon trail branched northward from the Forks of the Road. At a later time the stages, instead of following the bend of the river past Grapevine, traveled a more direct route from Cottonwood to the "Fish Ponds," located on the river between Grapevine and Forks of the Road. Another shorter but less traveled route was from Huntingtons, between the Upper and Lower narrows by way of Stoddard's Well, to Forks of the Road.

Bergland found Soda Lake nearly dry and to give mirages of perfect illusion. He states that the drainage from these saline flats is supposed to connect with Death Valley to the north, but that this had not been proven. It may now be stated that this is as much in error as the once supposed junction with Colorado River. Although some ditches were in use on the upper part of the river at the time, he makes no mention

[1]Geographical Surveys West of the One Hundredth Meridian, War Department Documents, 1876-77.

of irrigation; however, he notes having observed vegetation at Point of Rocks, Cottonwood and Camp Cady. Some of the moist lands at the stations produced hay without irrigation.

A few small ditches are believed to have been used prior to 1870 and more permanent conduits were constructed from 1873 to 1880. Some of the early settlers had no title other than possession to the lands which they occupied and they herded cattle for miles away from the river wherever feed could be found. Aside from pre-empted land in the river bottom, one of the first titles was that granted to Max Stroebel, who, in 1870, acting for an organization known as the Thirty-fifth Parallel Association, purchased from the government, under a statute then in force, about 30,000 acres on the upper part of the river. It is understood that it was the intention to establish a German colony on the land, but no such plan was carried out, and the land, although later transferred, still remains in a single corporate ownership.

ENTERPRISES.

Appleton Land, Water and Power Company.

The Appleton Land, Water and Power Company is the successor of the Hesperia Land and Water Company. The older company was organized in 1886 with an authorized capital stock of $300,000, for the purpose of supplying water to and selling the Stroebel lands which were acquired at the time of organization. The lands had originally been purchased from the government about 1870 when the public lands were, under certain conditions, sold in unlimited quantities at $1.25 per acre. The Stroebel holdings consisted of about 30,000 acres situated in the Mojave River bottom and on the west mesa, and comprised township 4 north and most of the even-numbered section of township 5 north, range 4 west. About 20,000 acres of the lands had been acquired under a single patent.

Soon about 2,000 acres, including the dam site at the Upper Narrows (Plate V, Fig. 1), were sold and the towns of Victorville and Hesperia were started. A tract of 160 acres at the forks of Mojave River, together with the water right appurtenant to it, also the claim to the surplus waters of the West Fork, were purchased. A conduit was constructed to divert water from Deep Creek at a point above the forks and convey it across the main Mojave River for the irrigation of lands in the vicinity of Hesperia on the west mesa. From the intake to the Mojave River the conduit consisted of four miles of concrete lined ditch (Plate II, Fig. 2). The water was then carried under the river by inverted siphon which, together with the extension to Hesperia, consisted of five miles of 14-inch steel riveted pipe. The pipe terminated in an earthen reservoir of 58 acre-feet capacity. Some apple orchards

were planted and these, together with other crops, made a total of about 1,000 acres which were irrigated from the system at one time. The project had been launched toward the end of a period of unusual activity in the exploitation of lands throughout southern California, and as a reaction there followed a period of general depression among private corporate colonization enterprises accompanied by the complete failure of numerous state irrigation districts. During this era of litigation with its disastrous effect on irrigation securities, the Hesperia company made no further progress and was unable to finance the development of more water for the reclamation of additional land. What was most needed to make the system efficient for the lands sold and adequate for a larger area was storage of winter flood water for use in the late summer when the flow of Deep Creek was at the lowest stage. The area irrigated became smaller, and Hesperia, which had given promise of becoming a prosperous settlement, declined. The water system was operated at a loss. The steel siphon under Mojave River was washed out by flood several times, but was each time replaced, although for two years prior to the reorganization in 1911 no water was delivered at Hesperia. The cost of the irrigation works was estimated at $100,000 in 1910.

In 1911 the system was transferred to a new corporation, the Appleton Land, Water and Power Company, with an authorized capital of $300,000, of which $250,250 is issued. At the time of appraisal by the California Railroad Commission the company stated its assets to be $575,000, and liabilities $448,273. Improvements were begun, including the relining of the intake ditch, the construction of four miles of 30-inch steel riveted pipe, including the inverted siphon under Mojave River which was placed in a new location. Two miles of the old 14-inch pipe connecting the main line with Hesperia remain in place. The diversion works consist of a low concrete dam 20 feet long across Deep Creek and headgates. The capacity of the main conduit is probably 40 second-feet.

The Hesperia Water Company was organized in 1915 with a capital stock of $40,000, of which $10,500 is issued, to distribute and serve water to the town of Hesperia and to the users for irrigation under the system. The Victorville water system is still owned by the Appleton company. The Hesperia Water Company obtains the water from the Appleton company under lease and is classed as a public utility, and as such is regulated by the California State Railroad Commission. The water rate approved by the comission is 1.5 cents per hour-inch. The handling of the water sales under this subsidiary organization divorces the public service from the land colonization enterprise. In 1916 only 90 acres of apple orchard and 220 of alfalfa and corn were irrigated.

Of the Appleton Land, Water and Power Company's lands 20,000 acres are in one tract, 18,000 acres of which are commanded by the main

pipe line. Laterals would have to be extended to irrigate this area. The lands are not now being offered for sale.

The land in the Lower Narrows of Mojave River (Plate V, Fig. 2), between Victorville and Oro Grande, which has possibilities as a dam site, was at one time acquired by the predecessor of this company, but it was sold and no storage at the Lower Narrows has been seriously contemplated by these companies or others.

The company claims riparian rights to about 20,000 acres acquired from the government under one patent, also appropriation rights, one relating back to the filing for the ditch purchased, another to the filing for the Deep Creek diversion and conduit to Hesperia, another on the surplus water of the West Fork and the control of other filings made in 1911.

Arrowhead Reservoir and Power Company.

The predecessor of the present Arrowhead Reservoir and Power Company was the Arrowhead Reservoir Company, organized in 1891, the principal stockholders being Cincinnati capitalists. The original plan was a colossal undertaking. It was proposed to construct a main reservoir in Little Bear Valley which would impound the natural drainage of Little Bear Creek, a tributary of Deep Creek. An inlet tunnel, now partly constructed, was to be made from the reservoir eastward to Deep Creek and extended from this stream to Crab and Holcomb creeks to collect all drainage above the tunnel and carry it into the reservoir. Diversion dams and regulating reservoirs were to be located at Deep, Crab and Holcomb creeks and the flow of the smaller streams was to enter the tunnel through shafts. All of these works would be in the Deep Creek watershed. Another reservoir was to be constructed in Grass Valley, westward of the main reservoir and on a tributary of the West Fork of the Mojave River, and this supplemental basin was to be connected with the main basin by a tunnel. Two other reservoirs were to be located in mountain flats, the sites for which were later abandoned. Water was to be taken from the main reservoir by an outlet tunnel through the San Bernardino Range and delivered for the irrigation of lands south of the mountains. The company had no lands for sale and made no contracts for the delivery of water.

A masonry dam, to form the main reservoir, was begun on Little Bear Creek, but by the time the foundation was constructed it was found that suitable rock in sufficient quantity to construct a masonry dam was not to be had near the site. This caused a suspension of construction which was prolonged for a number of years. Data on the amount of water for storage had been meagre and the supply had been overestimated. In 1892 a series of precipitation and run-off measurements was begun throughout the watershed which was continued for 13 years before construction was resumed.

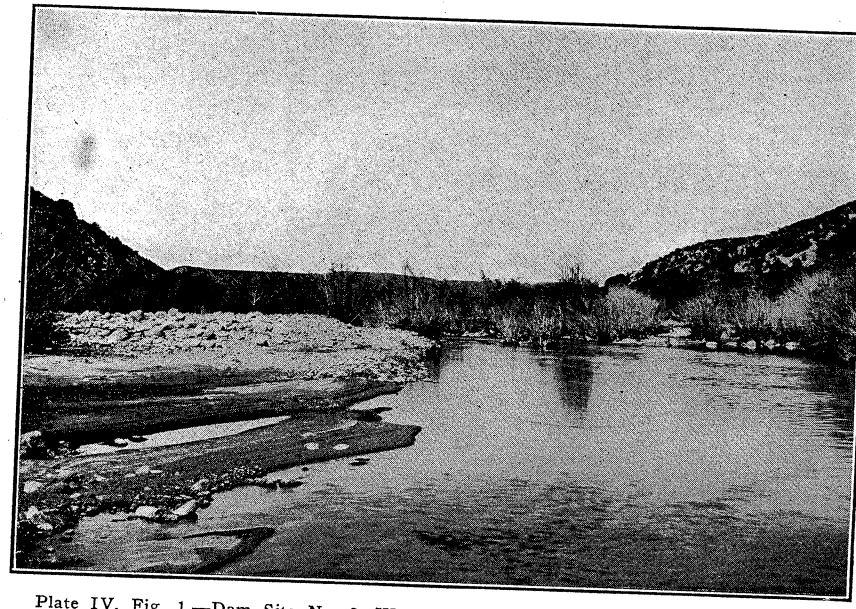


Plate IV, Fig. 1.—Dam Site No. 2, West Fork, Mojave River, looking down stream.

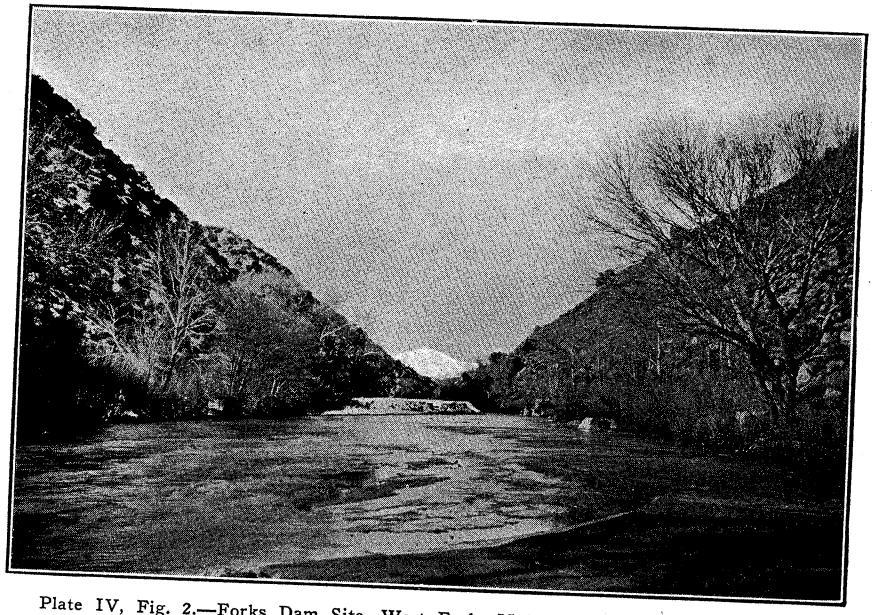


Plate IV, Fig. 2.—Forks Dam Site, West Fork, Mojave River, looking up stream.

Until 1895 the development of power had not been considered in connection with the project. About that time, when it became known that long transmission of electrical power was practicable, it was planned to utilize the energy of the water in its descent on the southern slope of the mountains.

In 1905 the property was transferred to a new corporation, the Arrowhead Reservoir and Power Company, capitalized at $6,500,000 with nonassessable stock of which $500,000 was 5 per cent preferred and the remainder common stock. Shares representing about $600,000 par value were issued and placed in the hands of a trustee, no payments having been made on these shares. Some of the stockholders have taken notes of the company for other obligations, but the company has no indebtedness outside of the stockholders.

The type of dam for the Arrowhead site was changed to a semi-hydraulic fill with concrete core. The plan of outlet works was also modified. The Burcham ranch, now called Rancho Las Flores, containing 5,240 acres and including the Forks reservoir site (Plate IV, Fig. 2) on the West Fork of Mojave River near the Forks, also two dam sites farther upstream on the West Fork and known as the West Fork sites numbers 2 and 3 (Plate III, Fig. 2, and Plate IV, Fig. 1), were acquired. It was proposed to convey the water in Little Bear Valley reservoir to the Forks reservoir, using the intervening drop for power development. The water would be combined in the forks reservoir with that received from the natural drainage of the West Fork. This lower reservoir was then to be drained by a tunnel through the mountain range to the south side, where another power drop would be located and below which the water would, as under the former plan, be delivered for irrigation in San Bernardino Valley.

About 1909 some of the owners of riparian lands on Mojave River, including the Hesperia Land and Water Company, filed suits to prevent the company diverting water from the watershed, but the cases have not been brought to trial. In 1912 application was made to the California Railroad Commission for permission to issue $4,000,000 in bonds when riparian land owners again opposed the plans of the company by protesting against the granting of the application. The application was denied, without prejudice, for the stated reason that the company's title to water was uncertain until the cases were decided by the courts. The record of the hearings conducted by the commission on the application shows the following:

Valuation put on property at time of reorganization	$1,191,000
Spent by new company since reorganization	923,204
Principal owed by new company	793,796
Interest owed by new company	126,589
Total	3,034,589

About this time the company, or a trustee of some of the stockholders, began to purchase riparian lands on Mojave River mainly for the purpose of quieting opposition from adverse water right claimants, and 1,000 acres just below the Forks and 3,200 acres, together with most of older and more useful ditches between Victorville and Barstow, were acquired. This property included the Westwater lands below Victorville.

It had been the intention to purchase more riparian lands, but owing to the decision of the State Supreme Court about this time to the effect that flood waters of a stream could not legally be diverted from the natural drainage basin,[1] a radical change in plan was adopted which made this no longer necessary. It was now decided to use the water for the development of power and irrigation on the north side instead of the south side of the mountains. In 1914 an offer, which was not accepted, was made to the city of San Diego to sell the water from the system, the diversion from the watershed for domestic use not being illegal.

In addition to agricultural lands below the Forks, the company holds about 12,000 acres in the mountains, mainly in the Little Bear Valley, Grass Valley and Forks reservoir basins. The company claims riparian rights appertaining to the extensive lands above and below the Forks, also appropriation rights on all streams above the Little Bear Valley reservoir inlet dating from 1890 and on the West Fork and Deep Creek dating from 1905.

The company claims that the measurements show that enough water can be stored to enable the delivery of 40 second-feet continuously from the Little Bear Valley reservoir, or 100 second-feet continuously from this reservoir and the Forks reservoir combined.

The Little Bear Valley dam (Plate II, Fig. 1) is now built to a height of 160 feet above stream bed and is 80 per cent completed. It is to have a maximum height of 200 feet above stream bed and 220 feet above bedrock, a length on top of 830 feet and a top width of 20 feet. The fill will contain 1,562,329 cubic yards of earth and the core will contain 27,999 cubic yards of concrete. The original slopes were, inside 2½ to 1 and outside 2 to 1, but an addition is now being made to the lower fill to change the outside slope to 3 to 1. The core wall is 20 feet thick at the base and tapers to 3 feet thick at the top. That part above a thickness of 4 feet is reinforced. In the winter of 1909 cracks occurred in the top of the core wall which had then been built up 38 feet above the earth fill. The cracking was believed to be due to the effect of temperature on this exposed portion of the concrete. The cracks were repaired. The spillway is over the natural rim of the basin and is 5 feet deep, 100 feet wide and is to be lined with concrete.

[1]Miller & Lux *vs.* Madera Canal and Irrigation Company, 155 Cal. 60.

The Deep Creek inlet tunnel is under construction, it now being driven and partly lined from the reservoir to a point beyond Shake Creek, a length of nearly two miles. A siphon of 1,284 feet and shafts at Fern, Shake and Sheep creeks are finished. The completed tunnel will be over 14,316 feet long. The tunnel from Deep Creek to Crab Creek is to be 5,000 feet long and the Holcomb Creek extension is to add 12,100 feet. The Deep Creek dam is to be 150 feet high above stream bed, of which height 30 feet would be below the tunnel portal. The Deep Creek reservoir is to have a capacity of 2,000 acre-feet and is to act as a regulator to the inlet tunnel. The tunnel has a capacity of 600 to 1,000 second-feet, depending on the head above the intake. The Holcomb Creek dam is to be 70 feet high, giving a capacity of 1,000 acre-feet to the basin above the tunnel.

The tunnel connecting Grass Valley, 4,172 feet long, is driven and lined, but the Grass Valley dam has not been constructed. The dam as proposed is to be 90 feet high, which would give a storage capacity of 7,632 acre-feet. Water is now diverted from Grass Valley by ditch to and through the connecting tunnel into the main reservoir.

The outlet tunnel of the main reservoir, 5,102 feet long, is constructed and lined, and through it water can now be discharged into Guernsey Creek, a tributary of Deep Creek, above the intake of the Appleton Land, Water and Power Company's canal. The gate tower (Plate II, Fig. 1) is a reinforced concrete structure 185 feet high located in the reservoir basin at the upper end of the outlet. Besides the gate valves in this tower additional valves are placed in a shaft 220 feet deep extending down to the outlet in the rock rim of the reservoir. The maximum head on the outlet will be 175 feet. The maximum depth of water at the dam will be 185 feet. The capacity of the completed reservoir below the floor of the spillway will be 60,179 acre-feet when the area of the water surface will be 883 acres. About 35,000 acre-feet is now stored in the reservoir with the dam partially completed.

The fall from Little Bear Valley reservoir to the Forks is 2,000 feet, a drop sufficient to develop about 7,000 horsepower with 40 second-feet of water. The Forks reservoir site is in a position to receive, naturally, the entire flow of the West Fork, also the water from Little Bear Valley reservoir through the proposed power conduit and the flood water from the lower part of Deep Creek, provided about one mile of inlet ditch or tunnel be constructed from that stream. A dam 150 feet high across the West Fork would give a capacity of 102,000 acre-feet and a reservoir area of 2,000 acres. In addition to the main dam a saddle in the rim of the basin on the north side would have to be raised with an embankment to give this capacity.

Mojave Water and Power Company.

The project now undertaken by the Mojave Water and Power Company was first attempted by the Columbia Colonization Company, organized about 1895. It was proposed to dam Mojave River at the Upper Narrows (Plate V, Fig. 1) to impound water which would be used to irrigate the desert along the river below Victorville. An option was procured to purchase from the Hesperia Land and Water Company the dam site and the lands of the latter company that would be flooded by the reservoir to be formed.

The company failed to carry out the plan and the option, also about 16,000 acres of land along the river below Victorville, were acquired by James Westwater, who proposed to construct a tunnel from the reservoir underneath the mesa and through the San Bernardino Mountains, a distance of 22 miles, to convey part of the stored water to the southern side of the range where it would be used for the development of power and for irrigation, while some of the water was to be used to irrigate the mesa and valley lands along the river below Victorville.

The dam site and the reservoir lands of the Hesperia Company, 2,060 acres, were then purchased by I. R. Wilbur, who, together with Mr. Westwater, obtained also an option to purchase the lands of Rancho Verde that would be flooded. Mr. Wilbur then, together with Eugene de Sabla and others, in about 1908 organized the Mojave Water and Power Company, to which the property was assigned. The option on the Verde lands has been allowed to expire. A right of way was secured from the government to use the unentered land at the rocky points of the dam site for reservoir purposes.

The Victor dam site (Plate V, Fig. 1) is good, the gorge having walls of granite, and the reservoir is open to criticism only for its large area which would probably produce a heavy evaporation loss. The possibility of seepage water detouring around the west end of the dam site is not a serious objection, for some water must of necessity be allowed to flow down the river to satisfy lower riparian owners.

Tests of the underflow[1] in the narrows were made in 1894 by the United States Geological Survey. Velocities of 10 to 96 feet per day were found in the different parts of the cross section. The amount of underflow for the section of 4,160 square feet at an average velocity of 50 feet per day, and assuming the porosity of the sands at 33⅓ per cent was found to be .8 second-foot.

The elevation of the river channel at the dam site is 2,709. The United States Geological Survey made borings[2] in 1899 to determine the position of bedrock and found the maximum depth to the rock to

[1]Water Supply Paper No. 140, U. S. Geological Survey.
[2]Eighteenth Annual Report of the United States Geological Survey; Twenty-first Annual Report of the United States Geological Survey.

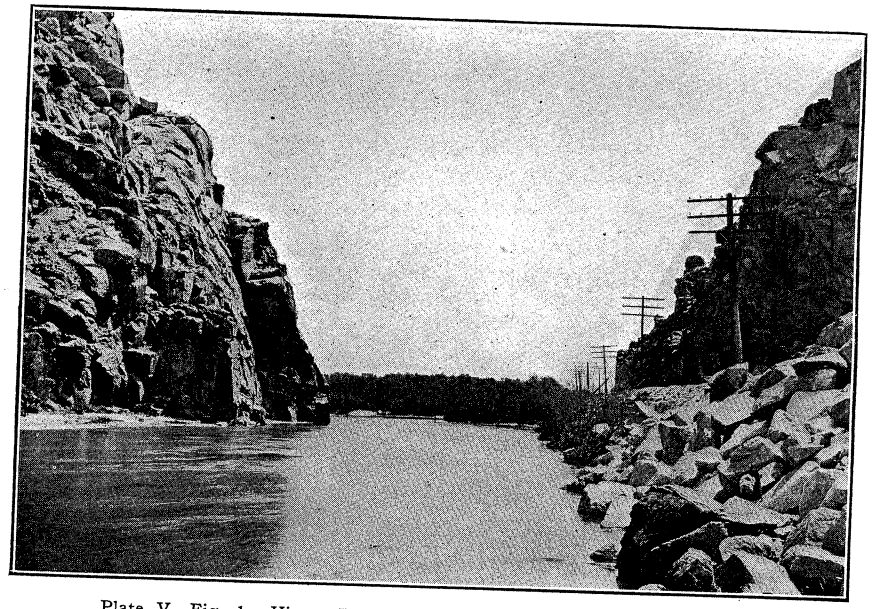


Plate V, Fig. 1.—Victor Dam Site, Upper Narrows of Mojave River.

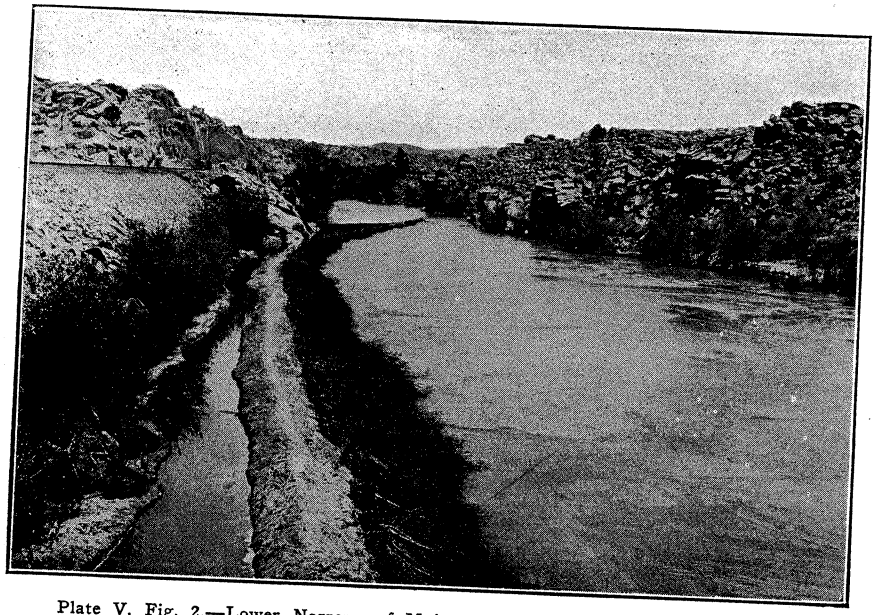


Plate V, Fig. 2.—Lower Narrows of Mojave River and intake of Driscoll Ditch.

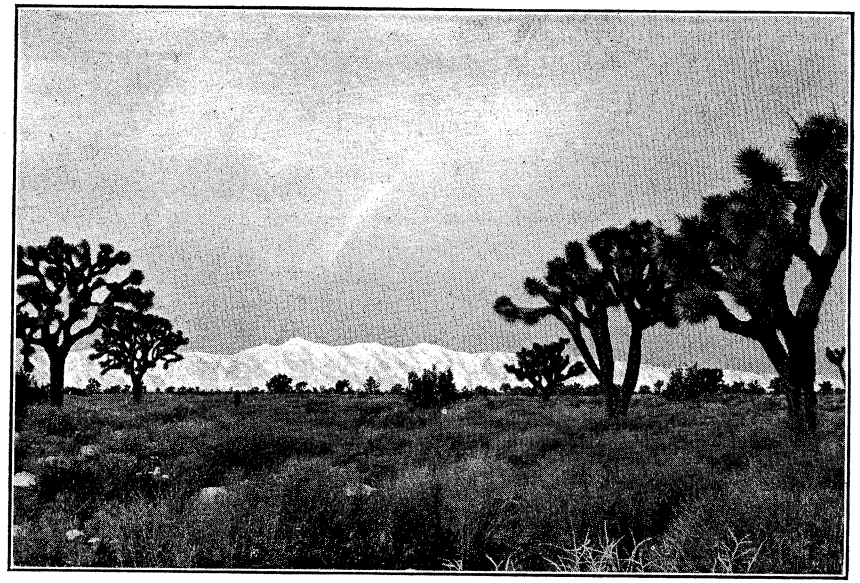


Plate VI, Fig. 1.—West Mesa of Victor Valley, showing yucca and San Gabriel mountains.

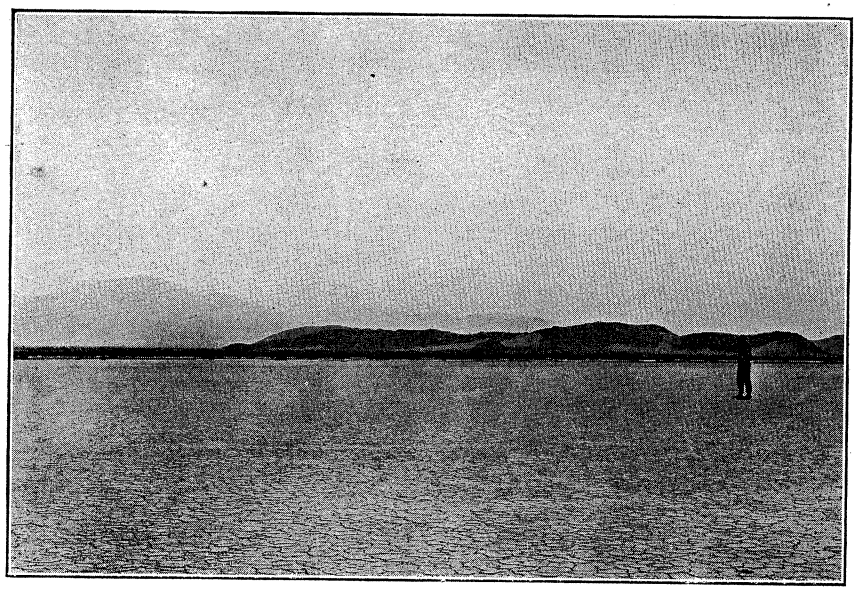


Plate VI, Fig. 2.—Mirage Playa and Grey Mountain.

be 46 feet. The width of the gorge at stream bed is 140 feet and at 145 feet above the stream it is 350 feet. Complete detailed surveys have been made of the dam site and reservoir basin by Mr. Hawgood for the company, from which the following capacities are taken:

80 ft. contour	75,000 acre feet
100 ft. contour	134,000 acre feet
120 ft. contour	218,000 acre feet
130 ft. contour	271,000 acre feet
140 ft. contour	350,000 acre feet

For the site to be utilized several miles of the Santa Fe Railroad would have to be moved to a new location. The railroad company has agreed to move the track to permit the building of the dam and has surveyed an acceptable route entering Victorville farther to the west by way of the arroyo.

The gigantic plan for a tunnel from the reservoir to San Bernardino Valley has been abandoned and it is now contemplated to use all the stored water on the lands on both sides of the river below the reservoir. A canal from the base of the dam would reach the mesa west of the river in a distance of about 12 miles. It is now the intention to construct the dam to about the 130-foot contour which would give an area to the full reservoir of 5,800 acres and a capacity of 271,000 acre-feet. The dam would be 345 feet long on top. According to the discharge measurements of the company and provided the water be not impounded above, also allowing 5 feet for evaporation, enough water can be stored to deliver from 100 to 140 second-feet continuously for 300 days.

Rancho Verde Company.

Rancho Verde includes 3,800 acres in the Mojave River bottom just above the Upper Narows. The first occupation was about 1867 by James Brown, a cattleman who pre-empted land and by 1874 had 1,500 acres fenced and a ditch from the river. Cole and Harris, who acquired the property about 1894, added more land by purchase, constructed another ditch, drilled wells, and started a dairy. They also incorporated Rancho Verde Company and about 1902 sold to the present owners. Until 1912 cattle had been grazed on the surrounding public range as well as on the ranch, but by this time the range was so well occupied by entrymen that the cattle were sold and the ranch has since been producing alfalfa and sugar beets. The owners claim that taxes have been paid on 1,000 miner's inches of water diverted by the ditches since 1869, and to obtain 880 miner's inches from the seven pumped wells and 350 miner's inches from the twelve flowing wells on the ranch. About 1,000 acres are now being irrigated and the ditches cover 1,500

acres, all of which has been irrigated. A portion of the land is riparian. This ranch is the most extensive of the producing properties and the company is the largest user of water on Mojave River.

Daggett Ditch.

The headworks of the Daggett Ditch were begun by the Silver Valley Land and Water Company about 1890. It was then the intention to collect the underflow of the Mojave River and convey it to the Calico mining district north of the river, near Otis (Yermo P. O.). After constructing some works at the "Fish Ponds," near Nebo, the promoters were unable to finance the completion of the enterprise and the work was resumed by the Southern California Improvement Company in 1893, who changed the plan to a ditch on the south side of the river for the purpose of irrigating land near Daggett and Minneola. A submerged dam of sheet piling driven down through the sands of the channel and into the subsurface clay was placed across the river and a tunnel or gathering flume was excavated above this dam to receive the water and deliver it to the ditch. The ditch was constructed from the intake to the Daggett ranch, a distance of four miles, and from there to the town site of Minneola, an additional six miles. The company's activities terminated with bankruptcy. In 1901 a copartnership of four persons undertook the improvement and completion of the works. The headworks which had been damaged by flood were improved, 30-inch concrete pipe was laid in the first mile of the ditch and covered with earth, and the remaining three miles of ditch leading to the Daggett ranch was lined with concrete and covered with boards. The ditch from Daggett to Minneola was abandoned.

The gathering tunnel at the intake is about one-half mile long and is timbered on top and sides. The ditch is claimed to have a capacity of 1,600 miner's inches. By agreement among the owners the Daggett ranch is entitled to the first 200 miner's inches of water secured and only this amount has been developed. An area of 250 acres on the ranch is all that is irrigated regularly under this system. Surface flood water in the river reaching the intake can be turned into the ditch and occasionally some additional land has been irrigated in this manner. The present owners claim to have spent $75,000 and each of the two companies preceding them is said to have spent a larger amount.

Yermo Mutual Water Company.

This system was initiated in 1910 by the Mojave River, Land and Water Company to supply water to about 8,000 acres of land located north of Mojave River and along the Los Angeles and Salt Lake Railroad below Yermo. The land had been acquired by the promoters and was to be sold by them, but in constructing a part of the system they became too heavily burdened with indebtedness to continue. The Yermo Mutual Water Company, a reorganization of the first company, was incorporated in 1916, with $160,000 capital stock, to continue the work. It is claimed that a total of about $200,000 has been spent, of which the greater part was under the first company. The works constructed consist of five 16-inch wells over 400 feet deep, of which two are equipped with 12-inch centrifugal pumps and 50-horsepower engines, three miles of concrete-lined ditch of 1,300 miner's inches capacity below the wells, then four miles of ditch of 3,300 miner's inches capacity, and two lateral ditches. It is the intention to collect underflow from the river channel and to convey it by pipe 4,400 feet to the point of enlargement in the ditch, where it is to be raised to the grade of the ditch by pumping. The company claims that 250 miner's inches can now be delivered from the two pumped wells and that more can be delivered when the settlement demands it by supplying the other wells with pumps. The water is lifted from 50 to 60 feet. Only about 200 acres are being irrigated. It is expected that alfalfa and deciduous fruits will be grown mainly. The enterprise is making but slow growth owing to lack of settlers.

Proposed Enterprises for the Use of Underflow.

Several enterprises for the development of underflow of Mojave River for irrigation have been proposed which have not progressed further than the formality of a stock incorporation and the filing of a claim on water to be appropriated, with possibly the doing of a nominal amount of work with the intention of technically establishing a right to use water relating to the date of the claim. The amount of underground water that can be diverted by gravity is largely a matter of speculation. Success in pumping from wells sunk in or near the channel at favorable locations is more certainly demonstrated. Numerous plants are operating near Hicks, Barstow, Daggett and Minneola, some of which produce good streams of water for irrigating. Several land owners pump from a trench near the river at Helen and they claim to obtain 100 miner's inches with which they irrigate 160 acres of young orchard.

LAND OWNERSHIP AND SETTLEMENT.

The territory considered in this report and shown by the map (Plate I) includes gross agricultural areas as follows:

	Acres	Acres
Mojave River bottom above Victorville		12,000
East Mesa—		
Apple Valley	32,000	
First Bench	4,000	
East of Deadman's Point	8,000	
		44,000
West Mesa—		
Baldy Mesa and Hesperia	100,000	
Sunrise Valley	70,000	
Mirage Valley	64,000	
Along river below Victorville	35,000	
		269,000
Total		325,000

Of this total 12,000 acres are patented unsold railroad grant lands, 47,000 are selected unpatented railroad indemnity lands; 17,000 acres are, or were, state school lands, and 37,000 acres are in control of the Appleton Land, Water and Power Company, the Arrowhead Reservoir and Power Company, and Rancho Verde Company, leaving 212,000 acres of public land, nearly all of which has been applied for under the Homestead and Desert Land Acts.

The railroad lands are owned by the Southern Pacific and the grant relates to the road from Mojave through Barstow to Colorado River, now controlled and operated by the Santa Fe, but which was built by the Southern Pacific about 1884. The line through Cajon Pass and Victor Valley, built by the Santa Fe in 1885, was not a land grant road. The original grant included the Southern Pacific and the Atlantic and Pacific, but the latter did not build across Mojave Desert as was contemplated. The portion of the land that should go to the Southern Pacific was in controversy until 1898 when it was decided that the railroad company was entitled to sections numbered 1, 5, 9, 13, 17, 21, 25, 27, 31 and 33 within the grant limits. The southern limit of the 20-mile strip of the grant crosses Mojave River between Oro Grande and Victorville. The southern edge of the indemnity strip, 10 miles wide outside the grant limits in which the railroad company has selected some of the odd-numbered sections, crosses the river between Victorville and Hesperia. The railroad lands have not been on the market.

Of the land applied for under the national laws, the greater area has been under the Homestead Act and a much larger proportion of the homestead entries have been patented than of the desert land entries.

The Hesperia Land and Water Company, soon after its organization, cleared some of its land of brush and timber and sold the juniper and yucca for wood. About this time many homestead filings were made and the entrymen cut the timber (Plate VI, Fig. 1) and sold wood, hauling it to Hesperia. Soon the government enforced restrictions on the cutting of timber on homestead entries which curtailed this practice and some of the entries were allowed to revert to the government.

Then came years of little activity until the present decade which brought a period of much land filing. The stimulus of the national movement for arid land reclamation, the demonstration of the feasibility of pumping south of the mountains, a better established market for apples and pears, and the activities of speculators were all influences in the rush for the public lands. Although the orchard was generally regarded as the future chief industry of the region, land entries were made for the maximum area allowed under the law and 320-acre desert entries were located where the water furnished by wells is inadequate and where pumping is too expensive for reclamation and the making of final proof.

In 1913 many of the settlers and land entrymen on both sides of the river formed the Victor Valley Mutual Water and Power District Association to secure beneficial measures, the chief one being a government irrigation project. This association was unincorporated and membership was voluntary. The members were assessed on the acre basis to provide funds to carry out the purpose of organization. The association made an urgent appeal to the government for a project to include lands on both sides of the river, but the government, although in sympathy with the end sought, was, owing to the depleted condition of the reclamation fund, unable to render financial aid. The association was instrumental in securing extensions of time for the making of final proof on land entries pending arrangements for an irrigation project to use water from Mojave River, but this offered temporary relief only.

The condition confronting many land entrymen in 1915 was discouraging. Besides the final proofs to be made, numerous small tracts had been planted to orchard on which the trees would, in a few years, need more water than could be supplied by the irrigation facilities. The total area irrigated in Victor Valley is about 7,740 acres, of which only about 2,185 acres are on the mesas.

Table No. 1 gives the areas irrigated in Victor Valley and on Mojave River. The areas irrigated from the river are close approximations and the area irrigated from wells are estimated from partial data. All ditches down to and including the Haws and Robinson are considered as being in Victor Valley.

TABLE No. 1.

Area Irrigated on Mojave River and in Victor Valley.

Division	Area irrigated from river (Acres)	Area irrigated from wells (Acres)	Total acres
River Bottom and First Bench of East Mesa	1,655	3,900	5,555
East Mesa and Lucerne Valley Pass	----------	975	975
West Mesa, including Mirage Valley	310	900	1,210
Totals, Victor Valley	1,965	5,775	7,740
Lowlands	1,130	1,000	2,130
Totals, Mojave River	3,095	6,775	9,870

The Smith Act, which passed congress August 11, 1916, making possible the inclusion of government land in irrigation districts organized under the laws of the states provided such districts do not include a majority acreage of unentered land, opened the way for state irrigation districts in Victor Valley. A district to include 55,000 acres on both the east and west mesas was proposed by the association, but the land entrymen on the east mesa, believing that an independent system for their lands would be cheaper per acre than the more general project, proceeded to secure the organization of the Mojave River Irrigation District for the east side only. Soon the entrymen on the west mesa petitioned for the formation of the Victor Valley Irrigation District for the west side.

One of the main obstacles to progress is the large size of the land holdings. A majority of the entrymen can not finance the improvement of 160 and 320 acres and but few of the irrigated tracts on the mesas exceed 20 acres. If the entries were limited to 40 acres the chances for successful reclamation would be better. Small tracts planted to orchard would give more profit and more value to the land and justify more expense for water than larger tracts for other purposes. At the same time they would require less water per acre, allow a larger district to be irrigated with the water supply and make the cost of the works less burdensome. No disadvantage would be imposed on the actual settler.

MOJAVE RIVER IRRIGATION DISTRICT.

The first petition for the organization of the Mojave River Irrigation District was filed with the board of supervisors of San Bernardino County, November 20, 1916. The board, acting on the advice of the state engineer and being uncertain as to the feasibility of the proposed works and the security that could be offered for a bond issue, denied the petition without prejudice and arranged for an investigation of the conditions to be made in thirty days, intending to take final action after

being in possession of facts to enable a more intelligent decision. The petitioners could not, according to law, present a new petition until thirty days had elapsed, but it was not possible for the commission to make the necessary investigations in that time and the petitioners were unwilling to wait for the results. A new petition was then filed February 2, 1917, bearing the signatures of over 75 per cent of the landowners in the proposed district which, under the law, made it obligatory on the part of the supervisors to provide for the organization of the district. When submitted to the voters the proposal for a district carried by a vote of 40 for and none against. The organization was completed April 9, 1917.

The district embraces 27,655 acres, of which 26,874 acres are irrigable. On November 23, 1917, 11,930 acres were patented, 7,120 acres were railroad selected land and the remaining 8,615 acres were practically all entered, 75 per cent of the entered land being under the Homestead Act. It was originally the purpose of this district to purchase the Forks reservoir site of the Arrowhead Reservoir and Power Company, improve the site and construct a conduit 12 miles long of siphon, tunnel and canal to irrigate the greater portion of the district by gravity. Water would then have to be lifted 100 feet to cover the upper or southern portion of the district. Later the plans were changed and the district is now making an endeavor to combine with the Appleton Land, Water and Power Company and other landowners on the west mesa to secure the use of water from Little Bear Valley reservoir. Toward this end the district filed suit October 5, 1917, against the Arrowhead Reservoir and Power Company, and a trustee of stockholders in the company and the holders of options on their property, to condemn their entire properties and water rights.

VICTOR VALLEY IRRIGATION DISTRICT.

The first petition for the Victor Valley Irrigation District was filed May 28, 1917. The action and the reasons for the action taken by the supervisors were exactly the same as with the district for the east side, the petition being denied without prejudice. In compliance with the law a second petition was presented August 3, 1917, with a sufficient number of signatures to make it mandatory for the supervisors to provide for the organization. At the election 44 ballots were cast for and none against the organization, and the district was declared organized October 22, 1917.

The district has a total area of 71,517 acres, of which 65,000 are believed to be irrigable. About the time the organization was completed the boundary included the following classes of land: patented 34,281 acres, railroad selected land 9,417 acres, homestead entries 9,456 acres,

and desert entries 18,363 acres. No land of the Appleton Land, Water and Power Company is included.

The district controls three options to purchase all or parts of the properties of the Arrowhead Reservoir and Power Company and of a trustee of stockholders in the company. The options were obtained October 6, 1916, by C. F. Guthridge and held by him for the district to be organized. It was provided that if a district should be organized in four months of the date of the options and that if the district should take steps to exercise the right of purchase, the options were to extend for one year, or to October 6, 1917. The options were made assignable to the district only and were not to be further assigned by the district. By agreement of October 3, 1917, the options were extended to July 1, 1918, and on October 22, 1917, they were assigned by Mr. Guthridge to the district. The options are as follows:

1. For Rancho Las Flores and the agricultural lands below Victorville owned by the trustee of stockholders of the company, $750,000.

2. For all properties, including lands, constructed works, water rights, and rights of way of the company, also the right to construct a dam at the Forks site and to flood the reservoir basin on Rancho Las Flores owned by the trustee, $2,000,000.

3. For all properties of the company without the flooding privilege on Rancho Las Flores, $1,750.000.

It is proposed to exercise both the first and third options and under them to purchase for a total of $2,500,000 all the properties of the company and the trustee. The district proposes to follow one of two plans or a combination of them to carry water to the west mesa. One is for the completion of the Little Bear Valley reservoir (Plate II, Fig. 1) and the inlet works, and the construction of a conduit from the outlet of the reservoir westward across the West Fork of Mojave River and to the west mesa which would cover all land in the district by gravity. This conduit would be 27 miles long and would consist in part of tunnel at the upper end, of inverted siphon across the West Fork and of concrete pipe towards the lower end. A power drop of 810 feet would be utilized at the approach to the siphon.

The other plan is to complete Little Bear Valley reservoir, construct the power conduit to the Forks, improve the Forks reservoir site and provide for lifting the water discharged from this reservoir to the lands above the gravity conduit.

Under a combination of these plans only a part of the water in the Little Bear reservoir would be carried directly to the mesa as under the first plan, and the remainder would be dropped to the Forks reservoir. Power would then be developed on both outlets of the Little Bear reservoir and the water from the Forks reservoir would be used on the lower lands by gravity.

SOILS.

The soils of Victor Valley consist of the materials eroded from the mountains and redistributed in the valley, consequently they do not differ widely in composition but vary more in their relative proportions of sand and clay. The records of wells drilled indicate that an enormous quantity of material has been transported to the plain. The general arrangement of coarse material near the mountains outward to fine in the lower plain is not so noticeable in the surface soils as on many alluvial fans. The migratory character of the stream channels has no doubt disturbed this gradual order to some extent and the winds have also added to the complexity by transporting fine sand and dust.

In general, the higher lands are superior to the lower. That part of the west mesa known as Baldy Mesa, situated above contour 3,400, has more rain, less wind, more even temperature, more vegetation and better agricultural soil than other portions of either mesa. The foothills are covered with a thick growth consisting principally of scrub oak, manzanita and juniper, the latter extending out on the plain two or three miles. Creosote, commonly called greasewood, and sage, desert shrubs, and bunch grass, interpersed with giant yucca (*Clistoyucca arborescens*), are distributed over the entire plain. The yucca, sometimes called the Joshua tree, is peculiar to this desert and to southern Nevada, and its fantastic appearance lends a weird picturesqueness to the region (Plate VI, Fig. 1). The yucca has commercial value for the manufacture of paper, of which it makes a good grade of the manilla kind.

No comprehensive soil survey has been made of Victor Valley, but the reconnaissance for a complete survey is being made by the Bureau of Soils, United States Department of Agriculture. The soils of both mesas are well adapted to agricultural purposes.

For the purpose of studying the moisture requirements of the soils, borings were made on selected parts of the mesas to depths of 6 feet or more and soil samples were taken at each foot in depth. The samples were also used to test some other properties of the soils.

Analyses for alkali content were made of the first foot of soil from different parts of the mesas. All indicated freedom from injurious amounts of salts. No analyses were made of the subsoils, but owing to the fact that the limited amount of water for irrigation in proportion to the irrigable land will operate to make the use of water economical, it is probable that the ground water level will never be raised sufficiently to bring salts in solution to an accumulation at the surface.

Occurring on the surface and in the substrata at different points in the valley are soils containing some carbonate of lime which cements together the materials into a hardpan. It is probable that this hardpan will be softened when there is irrigation.

Soil was encountered in a number of test holes which was coarse yet hard and seemingly impervious. This appeared to consist of angular grains closely packed and held by clay particles. This soil is easily crushed and melts or softens in water without becoming plastic. This type of soil is found in rather large areas on the east mesa, but to a less extent on the west mesa, and this probably accounts for a prevailing exaggerated idea that the soils on the east mesa are much heavier than those on the west mesa. They are in general some heavier but the effect of this characteristic should be to some degree overcome by the application of water.

Table No. 2 shows the amount of organic matter in the surface soil from the different parts of the valley. The organic matter was calculated at 58 per cent of the total carbon which was quantitatively determined.

TABLE No. 2.

Carbon and Organic Content in First Foot of Soil in Victor Valley.

Number of test hole	Kind of field	Location	Per cent of total carbon	Per cent of organic matter
1	2-year orchard	SW. cor., NW. ¼, Sec. 6, T. 4 N., R. 2 W.	.1260	.2172
2	5-year orchard	SW. ¼, NW. ¼, SW. ¼, Sec. 9, T. 4 N., R. 3 W.	.1266	.2172
6	12-year orchard	SW. ¼, SW. ¼, Sec. 30, T. 5 N., R. 3 W.	.1290	.2224
7	12-year alfalfa	NW. ¼, SE. ¼, SW. ¼, Sec. 30, T. 5 N., R. 3 W.	.1455	.2508
12	3-year orchard	NE. cor., SW. ¼, NW. ¼, Sec. 8, T. 5 N., R. 3 W.	.1365	.2353
15	5-year orchard	Center, SE. ¼, Sec. 23, T. 5 N., R. 3 W.	1.6380	2.8270
16	3-year orchard	NE. ¼, NE. ¼, Sec. 24, T. 4 N., R. 6 W.	.3075	.5301
18	1-year orchard	SE. cor., NE. ¼, Sec. 22, T. 4 N., R. 5 W.	.1500	.2586
21	11-year orchard	NE. cor., SE. ¼, Sec. 21, T. 5 N., R. 5 W.	.0795	.1370
22	3-year orchard	NE. cor., NW. ¼, SE. ¼, Sec. 22, T. 5 N., R. 6 W.	.1005	.1733

Excepting the sample from test hole No. 15, which was on subirrigated river bottom land, the soils are deficient in organic matter. This lack may be overcome to some extent by the growing of cover crops which supply humus to the soil, but such crops require some water for their irrigation in addition to that required by the main crop.

No mechanical analyses were made of the soils, but the wilting percentage was determined, and it is a measure of the texture or fineness of particle, the perviousness or degree to which it facilitates the passage of moisture and the porosity or the capacity to hold water. The finer the soil particles the "heavier" the soil, the higher the wilting percentage, the greater the quantity of water the soil must contain to support plant growth, the greater the capacity to hold water and the slower the movement of water in the soil. Although the rate of movement is slower, the final reach of capillarity is farther in the heavy soils than in the lighter soils. The loss of moisture by evaporation should be greater from the finer textured soils.

The tests to determine the amount of moisture that should be maintained in the soils to sustain plant growth are useful in comparing the two mesas as to their relative requirements of water. This study was made according to the method developed and used by the Bureau of Plant Industry of the United States Department of Agriculture. The purpose was to determine what is designated as the wilting percentage of the soils. This term is expressed in percentage by weight on the basis of the weight of the dry soil and it may be defined as the percentage of moisture in the soil below which, if the moisture drops, the plants will wilt. It has been determined by experiment that the finer the texture of the soil the greater the percentage of this unavailable moisture. It is apparent that for good plant growth and profitable crop production the moisture should not be allowed to fall below the wilting percentage during the growing season. The wilting percentage, if multiplied by 1.84, gives what is known as the moisture equivalent. The percentage of moisture which corresponds to this is that usually found in the soil after an irrigation and probably may be considered an optimum.

Tables No. 3 and No. 4 give the wilting percentages and the moisture equivalents for soils tested from the east and west mesas. The amounts of water necessary in the soil to prevent wilting of plants and to satisfy the moisture equivalent shown in the two last columns were calculated on the basis of an assumed volume weight of soil of 90 pounds per cubic foot.

TABLE No. 3.

Wilting Percentages and Moisture Equivalents for Six Feet of Soil on East Mesa.

Number of test hole	Location	Average wilting percentage	Average moisture equivalent in per cent	Acre feet per acre to prevent wilting	Acre feet per acre for moisture equivalent
1	SW. cor., NW. ¼, Sec. 6, T. 4 N., R. 2 W.	5.4	9.8	.462	.846
2	SW. ¼, NW. ¼, SW. ¼, Sec. 9, T. 4 N., R. 3 W.	6.1	11.1	.521	.959
3	SW. ¼, NW. ¼, SW. ¼, Sec. 9, T. 4 N., R. 3 W.	3.6	6.6	.309	.570
6	SW. ¼, SW. ¼, Sec. 30, T. 5 N., R. 3 W.	8.6	15.8	.743	1.145
11	SE. cor., Sec. 22, T. 5 N., R. 3 W.	3.0	5.5	.258	.474
12	NE. cor., SW. ¼, NW. ¼ Sec. 8, T. 5 N., R. 3 W.	7.2	13.0	.617	1.124
13	SE. cor., SW. ¼, NW. ¼, Sec. 8, T. 5 N., R. 3 W.	9.6	17.7	.838	1.529
14	SW. ¼, SW. ¼, Sec. 33, T. 5 N., R. 3 W.	4.3	8.0	.374	.691
	Average	6.0	10.9	.515	.917

TABLE No. 4.

Wilting Percentages and Moisture Equivalents for Six Feet of Soil on West Mesa.

Number of test hole	Location	Average wilting percentage	Average moisture equivalent in per cent	Acre feet per acre to prevent wilting	Acre feet per acre for moisture equivalent
16	NE. ¼, NE. ¼, Sec. 24, T. 4 N., R. 6 W.	6.1	11.1	.522	.959
17	SW. cor., SW. ¼, Sec. 18, T. 4 N., R. 5 W.	4.4	8.0	.377	.691
18	SE. cor., NE. ¼, Sec. 22, T. 4 N., R. 5 W.	5.8	10.6	.497	.914
19	SE. cor., NW. ¼, Sec. 22, T. 5 N., R. 5 W.	6.3	11.5	.542	.994
21	NE. cor., SE. ¼, Sec. 21, T. 5 N., R. 5 W.	3.1	5.8	.272	.497
22	NE. cor., NW. ¼, SE. ¼, Sec. 22, T. 5 N., R. 6 W.	8.1	15.3	.710	1.322
24	SW. cor., NW. ¼, Sec. 4, T. 5 N., R. 6 W.	5.2	9.6	.464	.838
25	SE. cor., NE. ¼, Sec. 23, T. 6 N., R. 7 W.	3.0	5.5	.261	.474
	Average	5.3	9.6	.456	.836

In sampling it was noticed that in all except No. 14, which was in an unirrigated orchard on Baldy Mesa, the soil was dry below the third or fourth foot.

The test for the first 6 feet of soil in eight holes on the east mesa gave wilting percentages ranging from 3.0 to 9.6 per cent, with an average of 6.0 per cent. Similar tests for eight holes on the west mesa gave wilting percentages ranging from 3.0 to 8.1 per cent with an average of 5.3 per cent. The number of acre-feet of water per acre that would have to be put into the upper 6 feet of soil on the east mesa to produce a moisture percentage above the wilting point is .52, and the number of acre-feet to produce the same result on the west mesa is .46. It is assumed that a depth of 6 feet of soil is sufficient for the penetration of roots of deciduous fruit trees. The surface soil on the east mesa in considerable areas is "heavier" than that on the west mesa where the "heavier" textured soil is more in spots. This theoretical comparison indicates that the soils of the east mesa would require but slightly more water than those of the west mesa.

These results do not show the duty of water nor give data from which the duty of water may be determined. They merely compare the soils as to moisture requirements. They do not show how rapidly the moisture, if once supplied, would be depleted by the action of nature nor how frequently and in what amounts water would have to be supplied to maintain the required moisture percentages. These studies take account of soils only and do not give consideration to other important factors affecting duty of water.

CLIMATE.

In a study of duty of water due consideration must be given to elevation and topograhpy as affecting precipitation, temperature and wind as affecting evaporation, and to the possibility of deep percolation.

Table No. 5 gives the maximum and minimum temperatures recorded at the ranch of Dr. G. W. Dobie, centrally located on the west mesa.

TABLE No. 5.

Temperatures in Degrees Fahrenheit at Dobie Ranch, Victor Valley.

	1909		1910		1911		1912		1913		1914		1915		1916	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
January	70	26	68	12	60	16	68	14	64	12	66	22	58	24	65	18
February	66	26	69	12	58	19	68	18	67	21	64	26	62	28	75	19
March	72	25	84	30	84	24	67	29	85	20	76	30	74	34	88	30
April	89	38	94	34	84	24	78	29	93	32	82	33	86	30	91	39
May	98	40	109	33	86	35	92	38	97	28	97	38	98	40	96	36
June	106	47	105	42	106	42	106	42	100	40	106	----	105	42	109	40
July	111	49	108	46	106	52	106	46	108	50	106	----	----	----	103	47
August	102	52	106	54	107	50	103	50	106	50	110	----	106	61	----	----
September	102	40	100	50	102	43	98	40	98	38	96	----	102	42	----	----
October	83	44	91	34	78	36	----	----	86	28	86	----	94	40	----	----
November	76	30	78	26	74	16	70	30	74	22	72	22	89	18	----	----
December	67	12	68	24	64	14	58	14	60	20	50	16	70	18	66	16

The highest temperature in the foregoing table is 111° which occurred in July. The lowest, 12°, occurred several times in the months of December, January and February. The lower parts of the valley have greater and the higher parts less extremes of temperature. The minimum winter temperature at Victorville has fallen below zero on occasions.

The annual rainfall in Victor Valley varies from about 15 inches at the foothills to about 5 inches at Victorville. The clouds come from the south or southwest and they enter the valley through Cajon Pass and by crossing over the mountains on either side of the pass. They are sometimes turned westward from Cajon Pass and this probably accounts for a precipitation on Baldy Mesa that is greater than would be accounted for by elevation alone. Generally an annual rainfall of 8 or 9 inches is required to satisfy the immediate surface run-off and the evaporation from the soil and the precipitation must generally exceed this amount for any considerable quantity of moisture to be retained in the soil long enough to produce other than characteristic desert vegetation. This appears to hold true for this locality where the greater precipitation on Baldy Mesa produces the heavier and more varied plant forms of the Juniper belt.

Table No. 6 gives the only measurements of precipitation that have been kept long enough to be of value.

TABLE No. 6.

Precipitation in Victor Valley.

Season	Forks, elevation 3,000 feet (Inches)	Hesperia, elevation 3,190 feet (Inches)	Dobie Ranch, elevation 3,130 feet (Inches)	Rancho Verde, elevation 2,760 feet (Inches)	Victorville, elevation 2,726 feet (Inches)	Barstow, elevation 2,150 feet (Inches)
1904–1905	----------	12.42	----------	----------	6.70	5.90
1905–1906	14.94	4.78	----------	6.71	5.89	1.80
1906–1907	25.77	13.44	----------	10.72	8.61	----------
1907–1908	9.14	9.33	----------	6.28	5.75	7.03
1908–1909	9.94	5.21	3.35	5.19	4.94	4.81
1909–1910	17.14	8.99	2.85	6.16	4.47	4.16
1910–1911	11.75	8.21	3.84	5.72	3.25	2.90
1911–1912	----------	----------	3.77	5.82	----------	3.31
1912–1913	----------	----------	3.50	2.72	----------	----------
1913–1914	----------	----------	6.76	7.27	----------	----------
1914–1915	----------	----------	6.91	----------	----------	----------
1915–1916	----------	----------	3.40	----------	----------	----------
Average	14.75	8.91	4.30	6.29	5.66	4.27
Number of seasons	6	7	8	9	7	7

The variation in annual precipitation at the several stations is graphically shown by the diagram Fig. 1.

Unfortunately no records of rainfall have been kept for periods of several years on the east mesa but such meagre records as are available indicate the rainfall to be less than on the west mesa. This difference has been observed by residents of the valley and it is also shown by the vegetation.

Almost no rain falls in June and July and about 75 per cent of the total annual precipitation occurs in December to April, inclusive. Some snow falls in winter, especially on the upper slopes of the plain. The monthly distribution of the annual precipitation at the Dobie Ranch is shown by Table No. 7, also by the diagram Fig. 2.

TABLE No. 7.

Monthly Precipitation at Dobie Ranch.

Month	1912-13 (Inches)	1913-14 (Inches)	1914-15 (Inches)	1915-16 (Inches)	Mean 1908-09	(Inches) 1909-10	(Inches) 1910-11	(Inches) 1911-12	Mean (Inches)
July	-------	0	0	0	0	.30	0	-------	.04
August	-------	.90	.05	0	0	.13	0	0	.13
September	.40	0	0	1.74	1.01	0	0	0	.39
October	.76	0	0	.10	-------	0	.36	0	.15
November	0	.15	.10	0	.18	.67	.22	.10	.18
December	.38	1.18	.03	.15	0	.08	2.23	.22	.53
January	.60	.32	1.38	0	.87	3.17	1.19	2.56	1.26
February	.20	0	1.48	0	1.26	1.03	2.18	.36	.81
March	1.01	.30	.61	1.48	.08	.05	.07	.05	.46
April	0	0	.18	.30	0	1.23	.40	0	.26
May	0	0	.01	0	0	.10	.26	.11	.06
June	0	0	0	0	.10	0	0	0	.01
Season	3.35	2.85	3.84	3.77	3.50	6.76	6.91	3.40	4.27

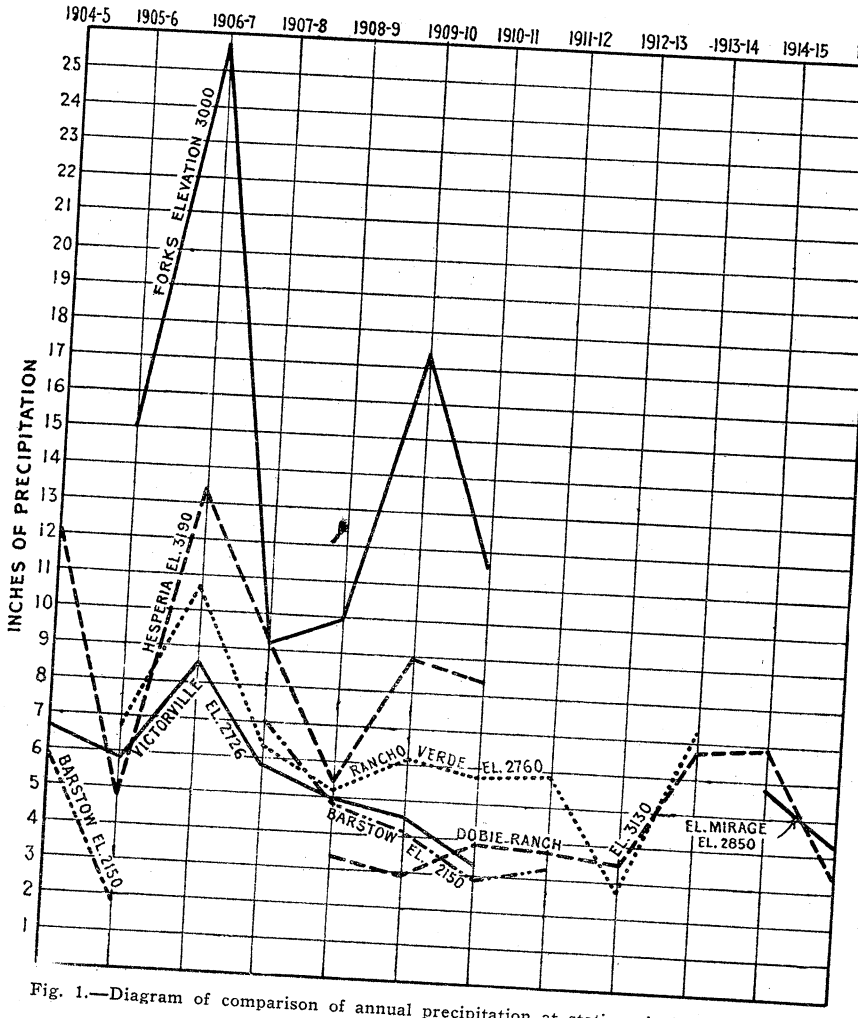


Fig. 1.—Diagram of comparison of annual precipitation at stations in Victor Valley.

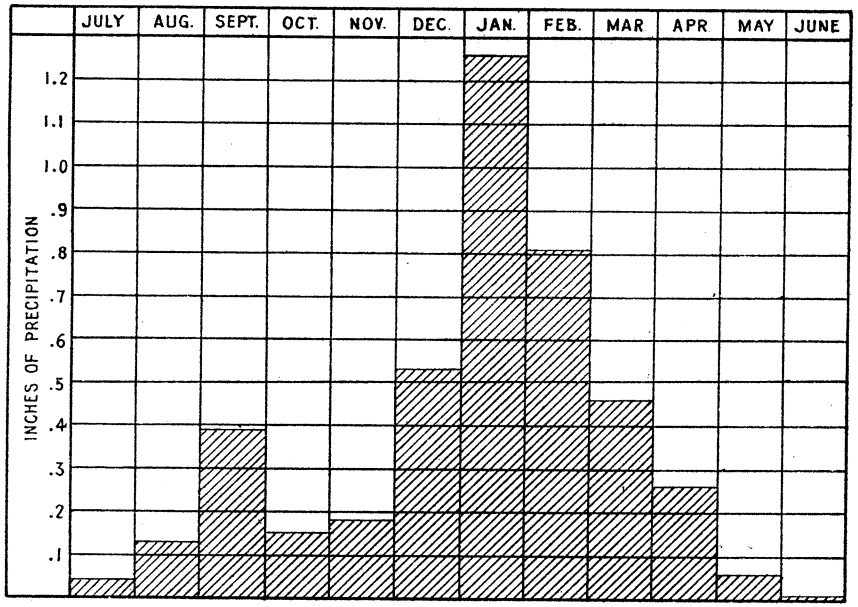


Fig. 2.—Diagram of mean monthly precipitation at Dobie Ranch.

This is a region of much wind. The prevailing direction is from south of west. The Baldy Mesa is most free from wind. The stronger air currents occur more frequently in the spring. The winds, together with the dry atmosphere, should produce high evaporation losses from either water surfaces or wetted soils. The Fourth Annual Report of the Los Angeles Board of Water Commissioners gives the evaporation from a water surface in this section at 56.40 inches for June to December, inclusive, 1898, and an estimate of 86.55 inches is given for the entire year. The Arrowhead Reservoir and Power Company has found the evaporation from Little Bear Valley Reservoir in the mountains to be from 30 to 36 inches per annum. A comparison of these records shows the effect of the desert atmosphere, temperatures and winds on evaporation.

DUTY OF WATER.

An advantage is to be gained by selecting crops such as apples and pears that are not only suited to soil and climate of Victor Valley, but which also have high commercial value and require little water. It is, in fact, imperative that the greater part of the land to be under any irrigation system on either mesa grow crops that permit both a high duty of water and a high cost of irrigation per acre in order that the project be financially feasible. It is assumed that a small portion of the land would produce alfalfa and vegetables but the proportion of these should

not be large. Alfalfa in this region would require more than double the amount of water required by deciduous fruits and the area served by the water available if planted to alfalfa would then be less than half the area that could be served if planted to orchard. Finally, the cost per acre of the works for alfalfa would practically be double that for orchard for the cost of the distributing system on the mesa would be small in proportion to that of the mountain works which latter cost would be the same in either case.

No attempt was made to systematically collect information on the duty of water for alfalfa for this report as was done for duty for deciduous fruits, but opportunity was given in the course of the investigation to obtain some miscellaneous data which are presented for what they are worth in Table No. 8.

TABLE No. 8.

Duty of Water for Alfalfa.

Number of tract	Locality	Acres	Acre feet	Acre feet per acre
1	Mojave River bottom	60	960.00	16.00
2	Mojave River bottom	66	1,040.82	15.77
3	East Mesa	40	274.40	6.89
4	West Mesa	5	6.20	1.24
5	West Mesa	25	100.00	4.07
6	Lucerne Valley	18	39.60	2.20
7	Lucerne Valley	40	109.20	2.73
8	Lucerne Valley	17	46.24	2.72
9	Perris Valley	75	421.50	5.62
10	Perris Valley	50	303.50	6.07
11	Perris Valley	30	191.70	6.39
12	Perris Valley	50	275.00	5.50
	Totals and average	476	3,768.16	7.92

The average 7.92 acre feet per acre is obtained by dividing the total number of acre feet, 3,768.16, by the total number of acres, 476, which gives weight in the average to the several tracts according to area. Eliminating tracts numbers 1 and 2, which are in the river bottom where the soil is sandy and the water plentiful and cheaply applied, the average is 5.72 acre feet per acre which amount is believed more than is necessary for alfalfa in Victor Valley.

A better idea of the amount of water required for irrigating alfalfa may be had from consideration of two of the larger alfalfa growing sections of southern California, Imperial Valley and Chino, the one more arid and the other less arid than Victor Valley. The water used in Imperial Valley flows by gravity from Colorado River and is plentiful and cheap. That used at Chino is pumped from wells with lifts up

to 125 feet and is expensive. The fields in Imperial Valley are flooded by the border check method and those at Chino are flooded by surface pipe. The duty of water for alfalfa in these localities is shown by Table No. 9.

TABLE No. 9.

Duty of Water for Alfalfa in Imperial Valley and at Chino.

Locality	Number of crops	Rainfall in acre feet per acre	Irrigation in acre feet per acre	Total water in acre feet per acre	Irrigation per crop in acre feet per acre	Total water per crop in acre feet per acre
Imperial Valley	8	.25	4.00	4.25	.50	.53
Chino	6	1.25	2.50	3.75	[1].50	.62
			3.25	4.00	.50	.57

[1]The first crop at Chino is unirrigated.

Four crops and sometimes a light or partial fifth crop of alfalfa are cut per annum in Victor Valley. If .5 foot in depth of water be applied to produce each crop the total amount that would be required is 2 or 2.5 acre feet per acre.

Apple and pear orchards in Victor Valley have generally been irrigated four times per annum, the first being in April or May and the last in October. In some cases a fifth irrigation has been given in November. Most of the orchards appear to have had insufficient water and it is probable that under an efficient irrigation system the practice would be to give five irrigations, unless rain is plentiful in the first half of the winter.

In order to arrive at a proper duty of water for deciduous fruits data were obtained on the use of water on all orchards in Victor Valley where the amount applied was measured or where records of value were kept. Data were also secured on orchards in other sections of southern California where somewhat similar conditions obtain. The elevation and climate of the settlements on the north side of the Sierra Madre range, including Victor Valley, closely resemble. Some of those on the south side differ more from Victor Valley in certain respects as with reference to precipitation at Beaumont and Yucaipa and to plentiful water supply at Banning, but they are in general comparable. Other things being equal, records from Victor Valley should be given more weight than records from other sections, and data on mature orchards more truly indicate the amount of water that would eventually be required on the mesa, but, unfortunately, there are as yet only a few producing orchards in Victor Valley, so that the records from the greater number of older orchards in the other deciduous fruit sections must be relied upon to a large extent.

The results for each of the localities investigated are given in the following tables. The average duty of water in acre-feet per acre for each locality is determined from the total number of acres and the total amount of water applied, thereby giving weight according to acreage in making the average.

TABLE No. 10.

Mojave River Bottom.

Duty of Water for Deciduous Orchards. Mojave River Bottom.

Number of tract	Kind of orchard	Age of trees	Acres	Acre feet	Acre feet per acre
1	Apples	20	15	38.25	2.55
2	Pears	1	6	11.88	1.98
	Totals and average		21	50.13	2.39

East Mesa.

Number of tract	Kind of orchard	Age of trees	Acres	Acre feet	Acre feet per acre
3	Apples	12	30	171.60	5.72
4	Apples	3	140	61.60	.44
5	Apples and pears	3–5	75	62.25	.83
6	Apples and pears	4	75	123.75	1.65
7	Apples and pears	4	40	28.00	.70
8	Apples and pears	1–2	54	71.80	1.23
9	Apples and pears	1–2	40	39.60	.99
10	Apples and cherries	3	56	39.76	.71
	Totals and average		510	598.36	1.17

West Mesa.

Number of tract	Kind of orchard	Age of trees	Acres	Acre feet	Acre feet per acre
11	Apples	20	10	8.10	.81
12	Apples	20	8	2.88	.36
13	Apples	20	12	12.36	1.03
14	Apples	20	20	18.20	.91
15	Apples	20	20	29.80	1.49
16	Apples	4	30	6.90	.23
17	Apples	1–6	10	2.00	.20
18	Apples and pears	3	55	28.60	.52
19	Apples	4	40	8.80	.22
20	Apples	2	20	4.40	.22
21	Pears	3	40	8.80	.22
	Totals and average		265	130.84	.49

Lucerne Valley.

Number of tract	Kind of orchard	Age of trees	Acres	Acre feet	Acre feet per acre
22	Apples	3	8	2.48	.31
23	Apples and pears	3	20	16.60	.83
24	Pears	2	40	40.80	1.02
	Totals and average		68	59.88	.88

Yucaipa.

Number of tract	Kind of orchard	Age of trees	Acres	Acre feet	Acre feet per acre
25	Peaches	10	6	17.34	2.89
26	Apples	8–12	3	8.67	2.89
27	Apples	4	10	3.60	.36
28	Apples, cherries, pears	4–20	20	35.60	1.78
	Totals and average		39	65.21	1.67

San Timeteo Canyon.

Number of tract	Kind of orchard	Age of trees	Acres	Acre feet	Acre feet per acre
29	Peaches	6	20	7.20	.36
30	Apricots	20	15	7.20	.48
	Totals and average		35	14.40	.41

Perris Valley.

Number of tract	Kind of orchard	Age of trees	Acres	Acre feet	Acre feet per acre
31	Apricots	1	10	4.20	.42
32	Apricots	3	10	6.80	.68
33	Apricots	1	10	9.40	.94
	Totals and average		30	20.40	.68

Beaumont.

Number of tract	Kind of orchard	Age of trees	Acres	Acre feet	Acre feet per acre
34	Apples	4–7	100	42.00	.42
35	Apples	3–6	10	3.60	.36
36	Apples, peaches, pears	5–8	8	2.88	.36
37	Apples	5	5	2.40	.48
38	Apples, pears, cherries	5	5	1.20	.24
39	Apples	7	5	1.80	.36
40	Apples and cherries	5	11	2.42	.22
41	Cherries, pears, apples, peaches	5	5	1.20	.24
42	Apples	5	5	1.80	.36
43	Apples	5	5	1.80	.36
44	Apples, pears, peaches, cherries	7	5	.85	.17
45	Apples	3	8	3.60	.45
	Totals and average		172	65.55	.38

Banning.

Number of tract	Kind of orchard	Age of trees	Acres	Acre feet	Acre feet per acre
46	Apricots and almonds	Over 5	15	16.05	1.07
47	Apricots, peaches, almonds	25	20	31.80	1.59
48	Apricots and peaches	8	15	29.70	1.98
49	Apricots, peaches, almonds	6–9	20	12.00	.60
50	Apricots	5	8	19.68	2.46
51	Apricots	20	10	19.80	1.98
52	Peaches, prunes, apricots, almonds	15	10	23.80	2.38
52	Peaches and almonds	8–20	40	95.20	2.38
	Totals and average		138	248.03	1.80

Summary.

Locality	Number of orchards	Total acres	Total acre feet	Acre feet per acre
Mojave River bottom	2	21	50.13	2.39
East Mesa	8	510	598.36	1.17
West Mesa	11	265	130.84	.49
Lucerne Valley	3	68	59.88	.88
Yucaipa	4	39	65.21	1.67
San Timeteo Canyon	2	35	14.40	.41
Perris Valley	3	30	20.40	.68
Beaumont	12	172	65.55	.38
Banning	8	138	248.03	1.80
Totals and average	53	1,278	1,252.80	.98

The average amount of water applied to the 53 orchards representing a combined area of 1,278 acres giving proper weight to the area of each orchard is .98 acre-foot per acre. This summary includes orchards of all ages. The results when segregated for trees under 5 years of age and over 5 years of age are shown by Tables No. 11 and No. 12.

TABLE No. 11.

Summary for Orchards Under Five Years of Age.

Locality	Number of orchards	Total acres	Total acre feet	Acre feet per acre
Mojave River bottom	1	6	11.88	1.98
East Mesa	7	480	426.76	.89
West Mesa	6	195	59.50	.31
Lucerne Valley	3	68	59.88	.88
Yucaipa	1	10	3.60	.36
San Timeteo Canyon	0	0	0	
Perris Valley	3	30	20.40	.68
Beaumont	2	18	7.20	.40
Banning	0	0	0	
Totals and average	23	807	589.22	.73

TABLE No. 12.

Summary for Orchards Over Five Years of Age.

Locality	Number of orchards	Total acres	Total acre feet	Acre feet per acre
Mojave River bottom	1	15	38.25	2.55
East Mesa	1	30	171.60	5.72
West Mesa	5	70	71.34	1.02
Lucerne Valley	0	0	0	
Yucaipa	3	29	61.61	2.12
San Timeteo Canyon	2	35	14.40	.41
Perris Valley	0	0	0	
Beaumont	10	154	58.35	.38
Banning	8	138	248.03	1.80
Totals and averages	30	471	663.58	1.41

The average used on 23 orchards representing 807 acres of trees under 5 years is .73 acre-foot per acre and the average for 30 orchards representing 471 acres in trees over 5 years is 1.41 acre-feet per acre. This latter group includes an orchard in the river bottom at Oro Grande, tract No. 1, and the Victor Ranch on the first bench, tract No. 3, which are not representative of conditions on the mesas and for which the duty of water is excessively low. Eliminating these the average for the orchards over 5 years of age with a combined area of 426 acres is 1.07 acre-feet per acre. Most of the orchards in Victor Valley appear to have had insufficient water for vigorous growth and production.

The results for the individually owned orchards are supplemented by figures on the gross duty of water for the areas served by several irrigation systems delivering water principally for deciduous fruit trees as given by Table No. 13. The figures, except for the Banning Water Company, are from measurements. The duty for the Beaumont Land and Water Company is for 1913 and that for the Lake Hemet Water Company is an average of several seasons. The duty for the other systems is for 1916.

TABLE No. 13.

Duty of Water for Deciduous Orchards Under Irrigation Systems.

Irrigation system	Kind of trees	Acres	Rainfall in feet	Irrigation in feet	Total water in feet
Yucaipa Water Co. No. 1	Apples, cherries, etc.	2051	1.50	.53	2.03
Beaumont Land & Water Co.	Miscellaneous deciduous	1065	1.66	.12	1.78
Banning Water Co.	Miscellaneous deciduous	2700	1.10	1.47	2.57
Lake Hemet Water Co.	Deciduous and citrus	5600	1.00	1.10	2.10
Palmdale Water Co.	Pears	200	.50	.75	1.25
Little Rock Creek Irri. Dist.	Pears	1500	.60	.85	1.45
Average				.80	1.86

The Yucaipa Company delivers to orchards of all ages and the water supply has been adequate. Although the precipitation at Beaumont is high the amount given for the system is considered insufficient for the locality. The duty for the Banning Company is based on the amount of water available for use, 11 second-feet, for six months. The amount actually used may have been less. This company has a plentiful supply and it is probable that more water is used than is necessary. Most of the Hemet orchards are decidous but some are in citrus fruits. The trees at Palmdale are young and more water should be used when they become mature. Only about 200 acres of the total area given for the Little Rock district were of full bearing age in 1916 and the amount used in this district should increase in the future.

The average amount of water applied under these irrigation systems is .80 acre-foot per acre and the average total, including rainfall, is 1.86 acre-feet per acre. To give the equivalent of this latter amount in Victor Valley it would be necessary to apply 1.36 feet of irrigation water assuming an average rainfall of .5 foot per annum.

The only records of rainfall on the east mesa are for such short periods as to be of little value for comparison. However, it is believed that the east mesa, being on the average about 200 feet lower than the west mesa, has less rainfall and that the amount of water should be from 10 to 20 per cent greater than for the west mesa. It is recommended that the duty of water be estimated at 1.25 acre-feet per acre for the

west mesa and 1.50 acre-feet per acre for the east mesa. No allowance is made for loss in distribution, but neither is any account taken of the land that would be devoted to buildings and which would not require irrigation.

One miner's inch flowing continuously for a season of 200 days is equivalent to a depth of 1.25 feet on 6.40 acres, and a depth of 1.50 feet on 5.33 acres.

WATER RIGHTS.

The first irrigation ditches on Mojave River were constructed in the early seventies below and near the Lower Narrows. In a few years others were constructed on the West Fork and near the Upper Narrows. It appears that the early irrigators relied mainly on the use of the water to establish their priorities and for some of the ditches did not accompany their appropriations with the formality of filing until after the ditches had been used, while for other ditches they never filed. On the other hand, as with most streams of the arid country, many claims have been recorded which did not materialize by the construction of ditches and use of water. It is estimated from a review of the county water records that several hundred such filings have been made on the Mojave. Probably the one of most liberal conception was a promoter's claim for 1,000,000 miner's inches to be diverted from the river near Hicks by a canal to be 400 feet wide on top, 250 feet wide on the bottom, 10 feet deep, and to have a grade of 3 feet per mile, for irrigating 10 townships (230,400 acres) of land below Daggett.

The earliest claim recorded is dated April 21, 1861, and is for the entire river down to bedrock for 3 miles near the mill-site at Flat Salt Springs. This and other claims filed in the sixties were for mining purposes. The first recorded claim for an irrigation ditch that was constructed and used was for the Lane & Riley Ditch in 1872. Next came the Houlton filing on the West Fork and the Pearl filing on the main river in 1873. These are followed by the filing for the Rogers Ditch in 1876. The filings for most of the other ditches so located as to have a sufficient supply of water every year had been made by 1885.

Table No. 14 associates the filings as identified from the records and other essential data with the original and present names of the ditches, the list being in order of location downstream. Several of the older ditches were abandoned, in some cases the water right being exercised through other ditches. Others have been changed as to location of intake with the shifting of the river channel and a few have been relocated throughout.

Under an act of the legislature of 1864 and applying to San Bernardino County only, the county maintained a board of water commissioners for a number of years to administer the waters of the streams, an institution fashioned after that of the early Mormon communities in Utah. The commissioners were to "locate" ditches and to apportion the water in them annually. They annually selected a water master for each ditch to make the apportionment and the reports of the water masters to the board are a matter of record. The main activities of the commissioners related to the more populous settlements on the Santa Ana River and tributaries, but in 1879, acting on petition of residents, they gave attention to irrigation on Mojave River. On January 15th of that year they met on the banks of the river and located six ditches near the Lower Narrows, assigning to them names and numbers and alloting to them amounts as shown by the table. The basis of the numbering is not made clear and the order is probably arbitrary. The numbers are not according to location and they are not understood to represent priorities. Several other ditches were in use on other parts of the river at this time.

TABLE

Data on Ditches

No. 14

in Victor Valley

Original or former name of ditch	Allotment by county water commissioners: Number of ditch	Allotment: Date	Allotment: Amount miner's inch	Claim of appropriation: Claimants	Claim: Date	Claim: Amount miner's inch	Decreed rights: Name under which decreed	Decreed: Date	Decreed: Amount miner's inch	Present ownership: Name of ditch	Present: Names of owners	Present: Area irrigated	Remarks
Upper West Fork				Amos Houlton	May 30, '73	800							
				C. A. Burcham	Jan. 27, '83	2,000							
Lower West Fork				J. F. Houghton	Jan. 9, '82	10,000							
				C. A. Burcham	Jan. 16, '92	10,000							
Grass Valley Creek				C. A. Burcham	Jan. 6, '85	5,000				Los Flores No. 1	Victor C. Smith	200	
Lang				Wm. R. Lang	Mar. 18, '11	500				Los Flores No. 2	Victor C. Smith		
Hesperia				Hesperia Land & Water Co.	Aug. 13, '85	5,000				Los Flores No. 3	Victor C. Smith		
East Fork				C. A. Burcham	June 27, '83	10,000				Lang	Wm. R. Lang	50	
Laughlin				Sanford C. Laughlin	Jan. 2, '09	1,500				Hesperia	Appleton L., W. & P. Co.	310	
Cole				A. W. Cole	(No filing)					Lower Deep Creek	Appleton L., W. & P. Co.	45	
Cory				E. L. Horton and J. C. Cory.	Feb. 20, '07	1,000				Laughlin	Laughlin & Laufer.	95	
Carden				H. G. Carden	May 7, '07	500				Cole	A. W. Cole	30	
Upper Brown				Jas. Waters Jr, and Jas. Brown.	Oct. 28, '82	1,000				Lewis	C. C. Lewis and I. B. Miller.	40	
Lower Brown				John Brown	(No filing)					Carden	H. G. Carden	75	
Rogers				Samuel Rogers and Wm. Ross.	Jan. 31, '76	1,000				Upper Verde	Rancho Verde Co.	400	
Allison				A. J. Spencer	Jan. 10, '80	2,000				Lower Verde	Rancho Verde Co.		
Atwood					(No filing)		Rogers	Dec. 24, '88	800	Rogers	Heirs of Samuel Rogers.	80	Hesperia L. & W. Co. vs. Rogers.
Mill				Hallock, Congar, Clancey and Goldsworthy.	Oct. 15, '80	4,000				Driscoll	Victor C. Smith	75	Allison and Atwood combined. For ore mill.
Hulday Pearl	2	Jan. 15, '79	100	Hulday Pearl	(No filing)								Abandoned.
Foote	4	Jan. 15, '79	500	Geo. E. Foote	(No filing)								Abandoned.
Pioneer	1	Jan. 15, '79	300	Atkinson, Lane, Swarthout and Bemis.	April 17, '85	800	Meyer	May 18, '97	175	Bennette	J. T. Bennette	50	Bledsoe vs. Decrow.
Wild Goose	6	Jan. 15, '79	300	Riley, Decrow and Snodderly.	(No filing)		Davidson, Bemis & Lane.	May 18, '97	230	Pioneer	Victor C. Smith	110	Bledsoe vs. Decrow. Combined, 1879.
A. H. Pearl				A. H. Pearl	July 25, '73	whole river				Downey & Robinson.	Victor C. Smith		Combined. Water used through Pioneer 1916-7.
Lane & Riley	3	Jan. 15, '79	100	A. G. Lane	Oct. 22, '72	400	Decrow & Van Horn.	May 18, '97	400	Decrow	Victor C. Smith	80	Bledsoe vs. Decrow.
Snodderly & Decrow	5	Jan. 15, '79		E. Snodderly and Geo. Decrow.	(No filing)								
Bledsoe & Robinson				J. B. Bledsoe and J. D. Clark.	April 30, '83		Bledsoe & Robinson.	May 18, '97	600	Haws & Robinson.	Victor C. Smith, W. H. Robinson, P. Huerlick.	200	Bledsoe vs. Decrow.
				Bledsoe, Clark, Robinson and Boren.	Oct. 6, '83	600							
				Francis A. Haws	Dec. 15, '83	600							
McNew				Jerry McNew	(No filing)					McNew	Carl McNew	50	
Boren & Schneidewidt				M. J. Tiney and F. S. Schneidewidt.	Jan. 20, '95	150				Schneidewidt	F. Schneidewidt	25	
Wilson				J. A. Wilson	Oct. 13, '09	500				Ingraham	W. W. Ingraham	80	
Hartman				H. Hartman	Dec. 23, '84	1,000				Hartman	Victor C. Smith	80	
Swarthout				G. M. Swarthout and J. T. Bennette.	Dec. 18, '07	800				Swarthout	George M. Swarthout.	40	Area estimated.
Richardson				Richardson and Talmadge.	Jan. 16, '03	1,000				Richardson	—— Richardson	80	
Decrow & Scoble				Durell, Decrow and Scoble.	Oct. 28, '09	1,500				Decrow & Scoble	Decrow, Durell & Scoble.	200	
Anchiniachie				J. T. Anchiniachie	Aug. 28, '06	600				McLean	McLean	80	Area estimated.
Cobb				Chapman, Cobb and Chilson.	Oct. 17, '07	4,000							Abandoned.
Stonical					(No filing)					Stonical	—— Stonical	20	Area estimated.
Harland				R. A. Harland and D. T. Chilson.	Mar. 22, '15	200				Harland	R. A. Harland	20	Area estimated.
Minneola				Wm. Deterle	Sept. 28, '93	100,000				Daggett	B. A. Funk and T. S. Vandyke.	250	
Elmholt				Mojave River Land and Water Co.	Sept. 27, '10	20,000				Yermo	Yermo Mutual Water Co.	200	Water pumped from wells.

On January 27, 1879, also on January 23, 1880, water masters were appointed for these ditches for the seasons. The report of W. H. Robinson, water master on the Pioneer Ditch (No. 1), dated March 5, 1879, is the only one recorded. It shows the water in the ditch to have been apportioned by rotation among seven users, a complete round being made every 15 days and 7 hours.

Of the ditches located in 1879 only one, the Lane & Riley (No. 3), had a filing. Afterwards in 1885 several landowners filed on water to be used through the Pioneer Ditch (No. 1). This ditch and the Foote (No. 4), later the Meyer and now the Bennette, and the Snodderly & Decrow (No. 5) are still in use. The latter two were at first on the west side of the river but were moved to the east side following a change in the river's course in 1884. The Hulday Pearl Ditch (No. 2) which was later abandoned is not to be confused with the A. H. Pearl Ditch which was combined with the Lane & Riley into the Downey & Robinson Ditch of the present time. The Wild Goose (No. 6) was combined with the Pioneer (No. 1) October 24, 1879, the contract signed by the seven water users concerned and recorded providing that the owners of Ditch No. 1 "agree to make Ditch No. 1 as many rods long as Ditch No. 6 now is." A further memorandum is attached to the record of these transactions stating that, "_____ _____ sells his right in Pioneer Ditch (No. 1) to _____ for 500 pounds of corn, $5.35 and 25 days work on the ditch." Another agreement dated January 7, 1889, provided that eight users under the Pioneer Ditch give to three landowners a one-fifth interest in the ditch for a right of way through their lands.

The original Houlton Ditch on the West Fork is said to have been abandoned and to have been in a different location from any of the ditches used at a later time for the Burcham Ranch, now Rancho Las Flores. The relation of the present West Fork ditches to the Houlton filing would be affected not so much by a change in location as by any lapse of use for 5 years or more that may have occurred.

From the best evidence available the original Brown Ditch, constructed about 1873, was the lower of the two now on Rancho Verde. The only filing by any of the original or subsequent owners of the Brown Ranch is that of Waters and Brown in 1882, which is believed to have been for the second and Upper Brown Ditch.

The Allison and the Atwood were combined as to water right into the present Driscoll Ditch (Plate V, Fig. 2). The Mill Ditch, used for a time for an ore mill at Oro Grande, was abandoned when the mill ceased to operate and was never used for irrigation. The Hesperia Ditch, now owned by the Appleton Land, Water and Power Company, is the only one diverting water away from the lands in the immediate river bottom.

The early settlers took advantage of the locations where the surface flow of the river is constant and the later appropriators had to depend mainly on flood waters. The ditches now diverting at favorable locations are those that were constructed prior to 1886 and they include the Las Flores No. 1, Las Flores No. 2, Hesperia, Lower Deep Creek, Upper Verde, Lower Verde, Rogers, Driscoll, Bennette, Pioneer, Downey & Robinson, Decrow, Haws and Hartman. The others constructed since 1885 are flood water ditches which receive an adequate supply only during the first part of the irrigating season. Some of these on the lower part of the river receive no water in dry years. The Daggett Ditch diverts the underflow and the Yermo Ditch is supplied by pumping from wells.

The table shows the claims for the ditches to be ridiculously extravagant in amount as was usually the case under the old California law. The filings are of little significance except as they may have protected the appropriators for a reasonable time while initiating construction and carrying it to completion and except as the appropriations may relate back to the filings where the construction was prosecuted diligently. The amounts allotted to ditches by the county water commissioners in 1879 are somewhat more moderate. The rights of the ditches if determined under the present law would be based on beneficial use. No applications to divert water from Mojave River have been received by the State Water Commission since it has had jurisdiction over appropriations under the new law effective January 1, 1914. One filing for a flood water ditch near Barstow was recorded at the county seat in the manner prescribed by the old law, since the new has been in effect.

No complete adjudication of rights on Mojave River has been made and the few priorities and decreed amounts are fixed only as regards certain other ditches or as regards certain users under other ditches involved in the litigation. The Rogers Ditch was decreed a capacity of 800 miner's inches December 24, 1888, by the Superior Court and the judgment was affirmed by the Supreme Court in *Hesperia Land and Water Company* vs. *Rogers* (83 Cal. 11). The amount is extremely liberal in consideration of the area irrigated.

Bledsoe et al. vs. *Decrow et al.* (132 Cal. 312) involved, on the part of the plaintiffs: the Bledsoe, now the Haws and Robinson Ditch, and on the part of the defendants: the Pioneer, the Meyer, formerly the Foote and now the Bennette, and the Snodderly and Decrow ditches. The plaintiffs sought to be adjulged the owners of 600 miner's inches independent of any rights of the defendants, but the Superior Court on

May 18, 1879, found that the defendants had prior rights as against the plaintiffs to divert water at their respective intakes as follows: Meyer, 175 miner's inches; Davidson, Bemis and Lane, users under the Pioneer Ditch, 230 miner's inches; and Decrow and Van Horn, 400 miner's inches. The plaintiff accepted the decree to the defendants Meyer but asked for a new trial as regards the other defendants which was ordered by the court provisional on the parties being unable to agree on certain specified terms different from those of the decree. The defendants appealed from this order and the Supreme Court on March 22, 1901, affirmed the order for a new trial but gave an opinion that the lower court should not state the terms of compromise different from the rights found to belong to the several parties. As there is no further record of this case it appears that there was no second trial or compromise and that the original decision stands. The plaintiffs were decreed the water remaining to the extent of 600 miner's inches as against the defendants after satisfying the prior rights of the defendants but this case considers only a few of the ditches on the river. The rights of both the plaintiffs and the defendants are now to a large extent in one ownership.

At a later time several suits relating to water rights were filed making the Arrowhead Reservoir and Power Company, the Appleton Land, Water and Power Company, Rancho Verde Company and other riparian landowners parties, but no action has been brought on these and by stipulation of the attorneys no action is to be brought by either party unless the other be given ten days' notice.

Most of the appropriation rights for the ditches have been used long enough to become prescriptive. So far as is known the only lack of continuous use in the sense of using water when needed for a part of each year, has been confined to the flood water ditches which can not divert water in seasons of deficient supply.

Nearly all, if not all, of the ditch owners have riparian rights which under the old law had preference over appropriation rights and were not lost by nonuse. Under the present law all water not beneficially used by 1924 will then become subject to appropriation and the preference of the riparian proprietor is reduced to the opportunity to establish his right by using the water on his land before that time.

Owing to uncertain legal definition of riparian land it has not been considered advisable to undertake any exact determination of the extent of such lands. The estimate of the area here given is based on the assumption that the riparian land is limited to the smallest subdivisions that have existed at any time touching the high-water banks of the river and its tributaries and lying within the drainage.

Excepting the lands of the Appleton Land, Water and Power Company, probably few, if any, of the original units exceeded 320 acres, and some were only 160 acres. Some of the original tracts have been subdivided. Therefore it seems sufficient to assume as an average that the riparian land does not extend back from the river more than one-half mile on either side. Considering only irrigable land and land where the flow is regular enough for crops to be matured, an estimate of 20,000 acres of riparian land is given. Adding to this another 20,000 acres for the Appleton company lands, the total estimated area of riparian lands that should be taken account of is about 40,000 acres.

Table No. 14 shows the area of land claimed by the owners to be irrigated under each ditch, the total for all ditches being 3,095 acres of which 2,785 acres are in the river bottom and 310 acres on the mesa at Hesperia. In addition to the 20,000 acres of riparian land owned by the Appleton company other large holdings are estimated not to exceed as follows: Victor C. Smith 5,300 acres, of which 1,500 acres are on Rancho Las Flores, 600 acres are between the Forks and Victorville and 3,200 acres are below Victorville; Rancho Verde Company 1,500 acres; and Arrowhead Reservoir and Power Company 400 acres. The other riparian lands are distributed among numerous owners. The Appleton, Arrowhead and Verde companies control about 27,000 acres of the riparian land.

UNDERGROUND WATERS.

Victor Valley is part of a great alluvial plain sloping northward from the granite mountains of the Sierra Madre Range. The swell of the debris indicates that this portion of the desert was formed in previous geological time by the northward drainage of the San Gabriel Mountains and when much more water flowed in this direction than is now carried by Sheep Creek and the other small streams of the present. Oro Grande and Antelope washes appear to have belonged to this older drainage. In the earlier time, probably that portion of the north slope of the mountains now drained southward by Lytle and Lone Pine creeks was drained northward, the flow being turned southward later by the faulting through Cajon Pass.

The more rounded peaks and more numerous flats of the San Bernardino Mountains in contrast to the sharper outlines and deeper cut canyons resulting from long continued erosion of the San Gabriel Mountains, show the former to have been uplifted in later time than the latter.[1] The great series of faults running diagonally through the range and dividing the two groups of mountains occurred with this movement in relatively recent geological time and formed Cajon Pass.[2] Appar-

[1]United States Geological Survey, Water Supply Paper No. 219, by W. C. Mendenhall.
[2]United States Geological Survey, Bulletin 613.

ently the elevation of the San Bernardino group produced the drainage of Mojave River which has eroded its channel across the old alluvium separating what was formerly a continuous plain into the east and west mesas.

Mojave River flows through a valley .5 to 2 miles wide and from 100 to 150 feet deep between the east and west mesas as far as the Lower Narrows, and the terrace of the mesa continues on the west side of the channel as far as Hicks.

The east mesa is limited on the north by mountains and buttes and is open to the east only through the constricted pass between Granite Mountain and the San Bernardinos. The west mesa (Plate VI, Fig. 1) is of much broader extent and is only indefinitely bounded on the north by the Shadow Mountains while to the west it continues as the vast plain of Mojave Desert for many miles beyond Victor Valley which may be considered as reaching only to the San Bernardino and Los Angeles County line.

The west mesa slopes from an elevation of 4,000 feet near the foothills to 2,700 feet in a distance of 15 miles out on the plain. The slope is about 100 feet per mile west of Hesperia and it gradually becomes flatter towards the north. The east mesa is in general lower than the west mesa and it has much less slope.

The materials of these mesas, where exposed by the banks of the streams, are shown to have the character of rudely stratified stream detritus. The logs of wells show the same materials to extend throughout the plain. Some of the hills to the north of Victor Valley are of volcanic origin and consist of tuff, rhyolite, and lava.[1]

A survey was made of the wells and pumping plants to determine location, depth to water, and the extent to which pumping can be relied upon for the reclamation of the land. Levels were run to establish the elevation of the water in the wells and for the platting of hydrographic contours from which to make deductions concerning the slope and direction of movement of the underground water. The elevation of the water along lines from east to west is in general above the river on the west side and nearly level with the river on the east side. The slope of the water is less than that of the land, the difference being more marked on the west, than on the east side. In the center of the west mesa it is 15 feet per mile and to the north and northeast. On the east mesa it is to the north but it becomes nearly level over a large area. The ground water east of the river appears to have much more direct connection with the stream than that on the west side. On the east the main source is the river underflow and but minor additions are made to the basin by the foothill drainage to the southeast. The water is

[1]United States Geological Survey, Bulletin 613.

held up and forced to return to the stream above the Upper Narrows by the rocky barrier limiting Apple Valley on the north. The West Fork probably contributes to the water in the west mesa and apparently other waters move through the mesa from the foothills west of Cajon Pass in a direction towards Victorville and Oro Grande. The subterranean basin in Mirage Valley no doubt received waters percolating from the region of Sheep Creek. The Shadow Mountains and buttes arrest these waters and divert them eastward or westward from the Mirage dry lake or "Playa" (Plate VI, Fig. 2).

Numerous springs occur along the west bank of the river from a point 2 miles above, to a point 4.5 miles below, the Upper Narrows. None are found on the east bank. The water seeps from the sandy strata confined between alternating clay strata. The strongest flowing are situated at the Turner ranch below the narrows and about midway between Victorville and Oro Grande. Some of the springs have been developed by tunneling into the sandy layers from which the water outcrops and the flow is used for domestic purposes and for the irrigation of gardens. Those at the Turner ranch fill a small reservoir from which the water is taken to irrigate a field of considerable size. The several groups of springs vary in elevation but 40 feet throughout the 6.5 miles along the river bank and their positions coincide with the water plane of the mesa as shown by the wells. Those upstream and most of those downstream from the Upper Narrows are above the level of the river at that point and those at the Turner ranch, 3.5 miles below Victorville, are but little lower than those near the town while the river falls 67 feet in the same distance. The water in the test well just northwest of the narrows stands 8 feet above the water in the river at the narrows. This seems to show that the seepage water is not from the river immediately above the narrows but, if from the river, rather from some point farther upstream, or from the West Fork, by an indirect route through the mesa. Other observations indicate that the river underflow does not detour around the west side of the rock at the Upper Narrows. The artesian flow from the wells above the narrows is confined to the river bottom and it comes from strata below bedrock in the narrows. The artesian head should not be produced if the passage of the water around the narrows were not obstructed. The same conclusion is reached from the stream flow. The measurements show a loss in the West Fork from the mouth of Horsethief Creek to the Forks, about the same in the main river at the Forks and at the Upper Narrows and a gain from the upper, to the Lower Narrows.

In the event of water being impounded during a part of each season by a dam at the upper narrows, it is probable that the head produced by the stored water would reverse the movement of the seepage and

cause water to flow out of instead of into the basin above the west end of the dam. It is also possible that such a reservoir would resist the escape of seepage from the east mesa sufficiently to raise the level of the ground water and lessen the pumping lift for wells on the First Bench and the western portion of Apple Valley.

The ground water on being encountered in drilling has generally risen above the first water bearing stratum in wells piercing more than one such stratum. This artesian action is understood to have been as much as 12 feet in parts of the east mesa and as much as 20 feet in parts of the west mesa but it has not been sufficient to cause any wells outside the river bottom to flow. The water level is approximately shown by the hydrographic contours and the depth to water is represented by the difference between the topographic and hydrographic contours on the map. Theoretically the water level is above the ground surface in the artesian area.

Comparison of the elevations of the water level in 1917 with the elevation when the wells were completed in cases where the records are available from well owners and drillers shows that the water level has receded throughout Victor Valley, in most wells not to exceed 10 feet. The drop may, in part at least, be attributed to recent dry years occurring in the declining portion of the supposed cycle of precipitation. Observations have not covered a period of long enough duration to determine whether or not pumping is depleting the underground basins in excess of the average annual contribution to them. The well waters are of good quality for irrigation.

Fig. 3 shows diagrams of the logs of some of the typical deeper wells in the different parts of Victor Valley.

WELLS AND PUMPING.

The data obtained on wells is tabulated as an appendix to this report. The information on wells 302 to 333 was furnished by the United States Geological Survey. The numbering of the wells in the table corresponds to the numbering on the accompanying map. In some cases it was not practicable to obtain all of the data to make the table complete and only such information as seems to be reasonably reliable has been included. Some of the wells are owned by nonresidents who could not be reached. The depth to water was measured wherever practicable. In other cases the statement of the owner or driller was taken. The date of measurement is given only for the wells in which depth to water was measured for this investigation. The elevations of ground and water are those determined for the mapping of the hydrographic contours. In the column showing kind of pumps the terms "single deep well" and "double deep well" refer to the single and double acting plunger

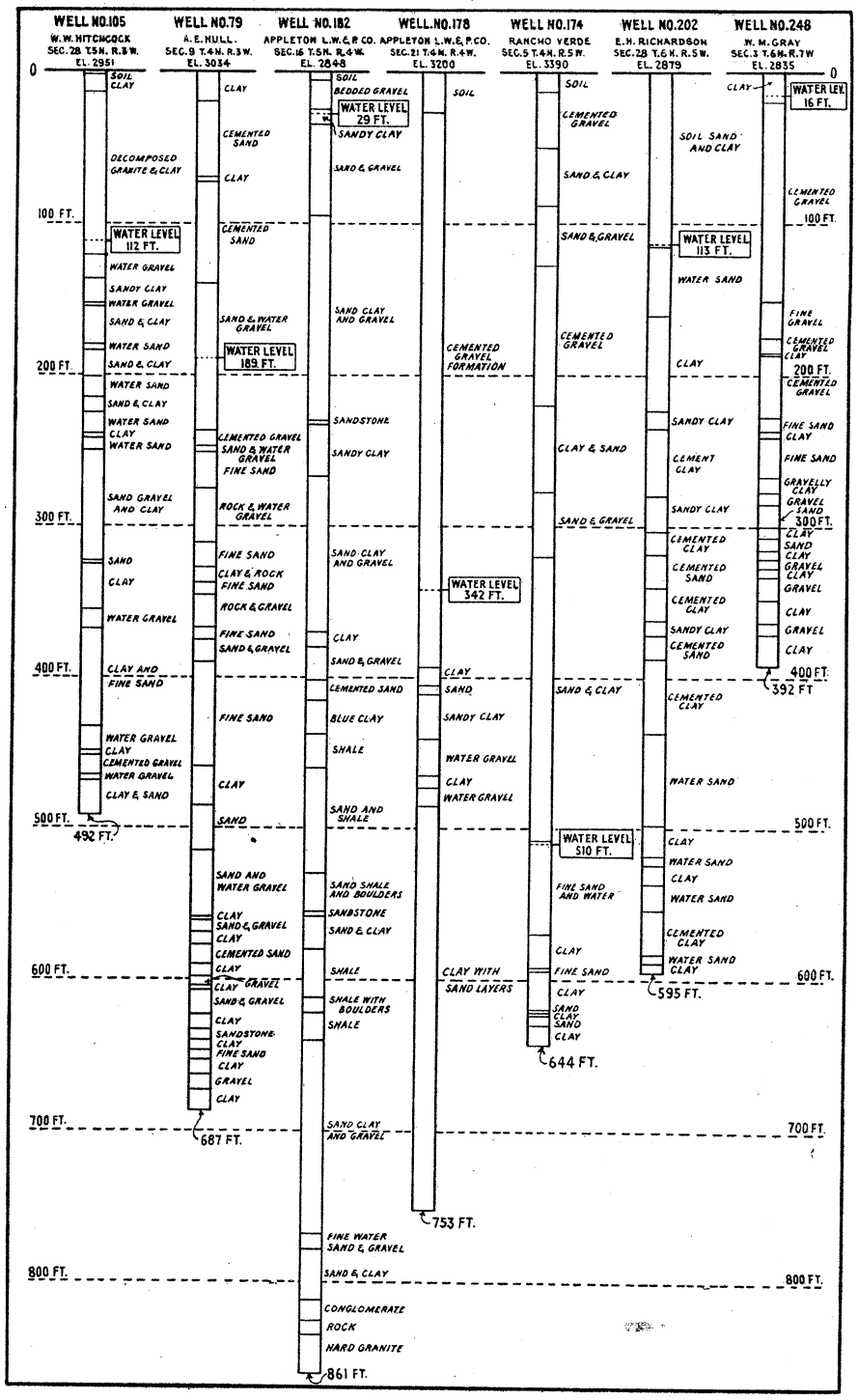


Fig. 3.—Diagrams of wells in Victor Valley.

pumps of large size developed in southern California for irrigating plants with high lifts. These pumps have become known commercially as here designated and they are distinguished from the smaller cylinder pumps used with windmills and domestic water plants.

In few cases only were the plants in operation and the discharge measured on being visited. Most of the discharges are those claimed by the owners or their representatives. Many have never been measured and they are probably overestimated. The miner's inch here used is equal to one-fiftieth part of a second-foot. Other columns in the table require no explanation.

The total number of wells between the mountains on the south and the north line of township 6 on the north and between Lucerne Valley on the east and Los Angeles County line on the west is 333. Of these 214 are drilled and steel-cased and the remainder are dug-shafts. A total of 125 wells, the most of which are drilled, are equipped with pumping machinery, the power being gasoline or oil engines with but four exceptions, and 43 wells are pumped with windmills. Although the main transmission line of the Southern Sierras Power Company crosses Victor Valley, electric power is not distributed generally to pumping plants. Thirteen wells, all located in the river bottom just above the Upper Narrows on Rancho Verde, flow.

An abundance of ground water and low lifts make pumping economical and efficient in the river bottom and on the first bench of the east mesa. This area embraces 48 pumping plants, the most of which have lifts ranging from 50 to 100 feet and discharges from 50 to 200 miner's inches.

The second or main bench of the east mesa, including the pass east of Deadman Point, has 31 pumping plants. The highest discharge for any of these is 70 miner's inches and the most are under 50 miner's inches. Excluding the plants in the pass the lifts range from 72 to 242 feet.

The west mesa includes 40 pumping plants. The lift at Hesperia is 300 feet and at one well on Baldy Mesa it is 869 feet. Such lifts are economically prohibitive for this region and but small streams of water have been pumped from these wells. The lifts are lower and the wells better near the settlement of Adelanto in Sunrise Valley and still better conditions for pumping are found in Mirage Valley. The depth to water is only about 20 feet in wells near the dry lake bed and some good producing wells are located there.

Excluding the river bottom and first bench and considering the mesa lands, it appears that the only sections in which pumping underground water can be relied upon as the sole source of supply to irrigate large solid areas are the north central portion of the east mesa, the lower

portion of Mirage Valley and possibly that in the vicinity of Adelanto. A great majority of the west mesa and a portion of the east mesa can be reclaimed only by stream flood waters, stored and conveyed by gravity.

About one-half million dollars has been invested in wells and pumping machinery in Victor Valley. In addition to the plants within the territory of the map, numerous others are pumping from wells along the lower part of the river the most being near Hicks, Barstow, Daggett and Minneola. The plain about Hinckley, 6 miles northwest of the river between Hicks and Barstow and where the underground water is no doubt in part from the river, is also the scene of pumping activity.

Included herewith are estimates of the cost of pumping intended to represent three sets of conditions found in Victor Valley. Case No. 1 is for the river bottom where the wells are comparatively shallow and good producers, the pumping lifts low, the soil sandy, the crop alfalfa, and the amount of water required high. Case No. 2 is typical of orchard irrigation in portions of Apple Valley. Here the wells are deeper, the lifts greater, the discharges less, the soil tighter and the duty of water higher. This case would apply also to a limited portion of Mirage Valey. Case No. 3 is suggested by conditions of the west mesa, particularly those of the central portion. Here the water must be used for orchards, sparingly on account of the small streams produced by the wells and the expense of pumping against high heads. Case No. 4 is a duplicate of No. 3 except that an electric motor is substituted for the engine to compare the cost of the two modes of power.

Depreciation is not counted on well and building. The percentages are selected for the several combinations of types of pumps and motive power, considering the deep well pump more durable than the centrifugal or the turbine, and the electric motor more durable than the gasoline or semi-Diesel engine. The plant efficiency is also a combination of that for the power and the pump and in fixing the percentages, preference is given slightly to motors over engines and more decidedly to deep well pumps over the types with speedily moving parts. Although deep well pumps have higher mechanical efficiency and longer life than centrifugals and turbines they generally require more expense for repairs under which is included the cost of renewing plunger leathers and the pulling of the rods. The costs of machinery on which computations of fixed charges are based are slightly less than those of the present time (1917) and they approximate the prices that obtained in 1915 which year is believed to better represent the normal.

Case No. 1.

Crop to be irrigated, alfalfa.

Depth of water on land required, 5 ft. Amount of water furnished by well, 150 mi. in. (3 sec. ft.). Season, 150 days (3,600 hrs.).

Area plant will irrigate 180 acres. Lift, 50 ft. Work done, 17 h. p.

Power required at 40 per cent efficiency, 43 h. p.

Cost of plant:

Well, 200 ft. deep, drilling at $2.00 per ft.	$400 00	
Casing, 12 in., double stove pipe, 12 gage, 180 ft. at $2.25 per ft.	405 00	
Starter, 20 ft., 3 ply, and ring	80 00	
Pit, 6 ft. x 6 ft. x 40 ft., redwood curbing at $2.00 per ft.	80 00	
		$965 00
Pump, 7 in., single stage, vertical, centrifugal, wooden frame, shafting pipe, pulley, installed complete		1,250 00
Engine, oil, 50 h. p. freight, concrete foundation, installed complete		1,850 00
Belt, 64 ft.		85 00
Building, 10 ft. x 48 ft. and derrick		500 00
Total,		$4,650 00

Cost of plant per mi. in., $31.00.

Cost of plant per acre, $25.83.

Cost of operation:

Interest, $4,650.00 at 6 per cent	$279 00	
Taxes and insurance, $4,650 at 1 per cent	46 00	
Depreciation on machinery, $3,185 at 12 per cent	382 20	
		$707 70
Fuel, 40 degree (Baumé) oil, 43 h. p., 3,600 hrs., ⅛ gal. per h. p. hr., 19,350 gal. at $.07 per gal. delivered		1,354 50
Attendance, 150 days at $2.00 per day		300 00
Repairs, lubricating oil, etc.		50 00
Total		$2,412 20

Amount of water pumped, 150 mi. in. for 3,600 hrs., 900 acre ft.

Cost of water per acre ft., $2,68.

Cost of water per mi. in. per hr., $.0045.

Cost of water per acre per annum, $13.40.

Case No. 2.

Crop to be irrigated, apples.

Depth of water on land 1.5 ft. Amount of water furnished by well, 50 mi. in. (1 sec. ft.). Season, 150 days (3600 hrs.).

Area plant will irrigate 200 acres. Lift, 100 ft. Work done, 11.4 h. p.

Power required at 35 per cent efficiency, 32.5.

Cost of plant:

Well, 400 ft. deep, drilling at $2.00 per ft.	$800 00	
Casing, 12 in. double stove pipe, 12 gage, 380 ft. at $2.25 per ft.	855 00	
Starter, 20 ft., 3 ply, and ring	90 00	
		$1,745 00
Pump, 9½ in., 8 stage, turbine, installed complete		2,150 00
Engine, oil, 35 h. p., freight, concrete foundation, installed complete		1,400 00
Belt, 60 ft.		70 00
Building 10 ft. x 48 ft. and derrick		500 00
Total		$5,865 00

Cost of plant per mi. in., $117.30.

Cost of plant per acre, $29.32.

Cost of operation:

Interest, $5,865 at 6 per cent	$351 90	
Taxes and insurance, $5,865 at 1 per cent	58 65	
Depreciation on machinery, $3,620 at 13 per cent	470 60	
		$881 15
Fuel, 40 degree (Baumé) oil, 32.5 h. p., 3,600 hrs., ⅛ gal. per h. p. hr., 14,625 gal. at $.07 per gal. delivered		1,023 75
Attendance, 150 days at $2.00 per day		300 00
Repairs, lubricating oil, etc.		50 00
Total		$2,254 90

Amount of water pumped, 50 mi. in. for 3,600 hrs., 300 acre ft.

Cost of water per acre ft., $7.52.

Cost of water per mi. in. per hr., $.0125.

Cost of water per acre per annum, $11.27.

Case No. 3.

Crop to be irrigated, apples.

Depth of water on land, 1.25 ft. Amount of water furnished by well, 25 mi. in. (.5 sec. ft.). Season, 150 days (3,600 hrs.)

Area plant will irrigate 120 acres. Lift, 250 ft. Work done, 14.2 h. p.

Power required at 50 per cent efficiency, 28.4 h. p.

Cost of plant:

Well, 500 ft. deep, drilling at $2.00 per ft.	$1,000 00	
Casing, 12 in., double stove pipe, 12 gage, 480 ft. at $2.25 per ft.	1,080 00	
Starter, 20 ft., 3 ply, and ring	90 00	
		$2,170 00
Pump, double acting, deep well, plunger, 20 h. p. 8 in. cyl., 56 in. double stroke, 20 strokes per min., concrete foundation, derrick and hoist, installed complete		2,400 00
Engine, oil, 30 h. p., concrete foundation, installed complete, including freight		1,250 00
Belt, 60 ft.		50 00
Building, 10 ft. x 48 ft.		400 00
Total		$6,270 00

Cost of plant per mi. in., $250.80.

Cost of plant per acre, $52.25.

Cost of operation:

Interest, $6,270 at 6 per cent	$376 20	
Taxes and insurance, $6,270 at 1 per cent	62 70	
Depreciation on machinery, $3,700 at 10 per cent	370 00	
		$808 90
Fuel, 40 degree (Baumé) oil, 28.4 h. p., 3,600 hrs., ⅛ gal. per h. p. hr., 12,780 gal. at $.07 per gal. delivered		894 60
Attendance, 150 days at $1.50 per day		225 00
Repairs, lubricating oil, etc.		100 00
Total		$2,028 50

Amount of water pumped, 25 mi. in. for 3,600 hrs., 150 acre feet.

Cost of water per acre foot, $13.52.

Cost of water per mi. in. per hr., $.0225.

Cost of water per acre per annum, $16.90.

Case No. 4.

Crop to be irrigated, apples.

Depth of water on land 1.25 ft. Amount of water furnished by well, 25 mi. in. (.5 sec. ft.). Season, 150 days (3,600 hrs.).

Area plant will irrigate, 120 acres. Lift, 250 ft. Work done, 14.2 h. p.

Power required at 55 per cent efficiency, 25.8 h. p.

Cost of plant:

Well, 500 ft. deep, drilling at $2.00 per ft.	$1,000 00	
Casing, 12 in., double stove pipe, 12 gage, 480 ft. at $2.25 per ft.	1,080 00	
Starter, 20 ft., 3 ply, and ring	90 00	
		$2,170 00
Pump, double acting, deep well, plunger, 20 h. p., 8 in. cyl., 56 in. double stroke, 20 strokes per min., concrete foundation, derrick and hoist, installed complete		2,400 00
Motor, 30 h. p., induction, 550 volt, 60 cycle, 3 phase, 1,800 r. p. m., concrete foundation, installed complete, including freight		520 00
Belt, 60 ft.		50 00
Building, 10 ft. x 48 ft.		400 00
Total		$5,540 00

Cost of plant per mi. in., $221.60.

Cost of plant per acre, $46.18.

Cost of operation:

Interest, $5,540 at 6 per cent	$332 40	
Taxes and insurance, $5,540 at 1 per cent	55 40	
Depreciation on machinery, $2,970 at 8 per cent	237 60	
		$625 40
Electrical power 19.25 k.w. (25.8 h.p.) 3,600 hrs., 69,300 k.w. hrs., at $.0175 per k.w. hr.		1,212 75
Attendance, 150 days at $1.00 per day		150 00
Repairs and lubricating oil		75 00
Total		$2,063 15

Amount of water pumped, 25 mi. in. for 3,600 hrs., 150 acre ft.

Cost of water per acre ft., $13.74.

Cost of water per mi. in. per hr., $.0229.

Cost of water per acre per annum, $17.19.

For orchard irrigation, especially with expensive water as under cases No. 3 and No. 4, it would be economical and desirable to use concrete pipe underground to convey and distribute the water to the furrows and trees. Such a system for a 10 acre tract is estimated to cost as follows:

630 ft. of 8 in. concrete pipe at $.18 per ft. laid	$113 40
21 stands, 30 ft. apart, with iron valves at $2.00 each	42 00
1 gate basin with iron slide gate	8 00
	$163 40

Cost per acre, $16.34.

STREAM DISCHARGE.

The mountain watershed of Mojave River has an area of 217 square miles of which 142 square miles are drained by Deep Creek or the East Fork and 75 square miles are drained by the West Fork. The watershed varies from an elevation of 8,000 feet at its highest point to 3,000 feet at the Forks where the entire drainage is brought together in the

main river. The northern slopes (Plate III, Fig. 1) of the Sierra Madre Range receive less precipitation than the southern slopes but they are less steep, less subject to direct rays of the sun, better timbered and they hold the snows longer and have slower runoff in proportion to precipitation than southern slopes.

The comprehensive metereological observations made throughout the watershed by the Arrowhead Reservoir and Power Company for over 20 years show the precipitation to vary from about 15 inches at the Forks to about 50 inches near the summit, the maximum occurring in the flats situated just north of the crest of the range, and flanked by peaks. The precipitation falls off rapidly towards the desert on the northeast. The more elevated portions of the watershed are in heavy timber of pine and fir without much undergrowth and the lower portions are covered with thick brush. Table No. 14 shows the areas drained by the branches grouped according to the reservoir sites into which they are tributary. The drainage of Deep Creek below the upper storage works can be made tributary to the Forks site by diversion.

TABLE No. 15.

Mountain Drainage Areas of Mojave River.

	Square miles	Square miles	Square miles
Deep Creek (East Fork).			
Above Little Bear Valley reservoir and tunnel—			
Little Bear Creek	6.64		
Hooks, Fern, Shake, Cedar and Sheep creeks	3.61		
Deep Creek	16.10		
Crab Creek	3.70		
Holbrook Creek and tributaries	33.76		
Cox Creek	9.39		
Grass Valley Creek[1]	2.72		
Total, Little Bear Valley reservoir		75.92	
Below Little Bear Valley reservoir and tunnel		65.88	
Total, Deep Creek			141.80
West Fork.			
Above dam site No. 2—			
East Fork of West Fork	18.82		
West Fork of West Fork	11.05		
Between dam sites Nos. 2 and 3	4.95		
Total, reservoir sites No. 2 and No. 3		34.82	
Below dam site No. 2 and Grass Valley dam site		39.96	
Total, West Fork (Forks reservoir site)			74.78
Total, Mojave River			216.58

[1]Naturally tributary to West Fork.

An examination of the precipitation records for southern California suggests the selection of a period of about 17 years as a proper one on which to base the average runoff. Tables No. 16 to No. 20 show the precipitation at several stations; the first for 65 seasons at San Diego, the longest record in southern California; the next for 45 seasons at San Bernardino, the second longest record, and the others for Glen Ranch, Bear Valley Dam and Gate House, the latter being at Little Bear Valley Dam, and the only one in the Mojave River watershed. The table for San Diego shows the average for periods of different lengths terminating with 1914-15, also the ratios of these averages to the average for the longest period. It is noticed that 17 seasons must be included to obtain a period terminating with 1914-15 to give an average equal to the average for the longest period.

The tables for the other stations show the ratios of averages for the different periods to the average for the longest period equated to the longer 65 season record at San Diego. The average for the last 17 seasons at the several stations agree remarkably well and it seems that this represents a cycle from which safe deductions of runoff can be made. However, from a study of the precipitation records of this immediate late period and from common knowledge of several seasons of low flood discharges about this time, it seems advisable, in order to consider the most unfavorable conditions which may arise, to extend the period back one additional season to include the low seasonal discharge for 1897-98, making the period 18 seasons.

TABLE No. 16.

Precipitation at San Diego.

Elevation, 93 feet.

Season	Precipitation, inches	Period	Average precipitation for period, inches	Ratio to 65 season average, per cent	Number of seasons in period
1850-51	8.41	1850-1915	9.70	100.00	65
1851-52	9.48	1851-1915	9.72	100.21	64
1852-53	11.03	1852-1915	9.72	100.21	63
1853-54	9.77	1853-1915	9.70	100.00	62
1854-55	13.56	1854-1915	9.70	100.00	61
1855-56	9.89	1855-1915	9.64	99.37	60
1856-57	4.76	1856-1915	9.63	99.27	59
1857-58	7.54	1857-1915	9.72	100.21	58
1858-59	6.61	1858-1915	9.76	100.62	57
1859-60	6.58	1859-1915	9.81	101.13	56
1860-61	7.90	1860-1915	9.87	101.75	55
1861-62	15.64	1861-1915	9.90	102.06	54
1862-63	3.87	1862-1915	9.80	101.03	53
1863-64	5.14	1863-1915	9.91	102.16	52
1864-65	8.45	1864-1915	10.00	103.09	51
1865-66	12.82	1865-1915	10.04	103.51	50
1866-67	13.73	1866-1915	9.98	102.89	49

TABLE No. 16—Continued.

Precipitation at San Diego.

Season	Precipitation, inches	Period	Average precipitation for period, inches	Ratio to 65 season average, per cent	Number of seasons in period
1867-68	11.23	1867-1915	9.90	102.06	48
1868-69	11.68	1868-1915	9.87	101.75	47
1869-70	5.48	1869-1915	9.83	101.34	46
1870-71	5.17	1870-1915	9.93	102.37	45
1871-72	7.18	1871-1915	10.04	103.51	44
1872-73	6.50	1872-1915	10.11	104.23	43
1873-74	16.88	1873-1915	10.19	105.05	42
1874-75	5.73	1874-1915	10.02	103.30	41
1875-76	10.11	1875-1915	10.14	104.54	40
1876-77	3.75	1876-1915	10.13	104.43	39
1877-78	16.10	1877-1915	10.30	106.18	38
1878-79	7.88	1878-1915	10.15	104.64	37
1879-80	14.36	1879-1915	10.21	105.25	36
1880-81	9.66	1880-1915	10.09	104.02	35
1881-82	9.51	1881-1915	10.11	104.22	34
1882-83	4.92	1882-1915	10.12	104.33	33
1883-84	25.97	1883-1915	10.29	106.08	32
1884-85	8.67	1884-1915	9.78	100.82	31
1885-86	16.96	1885-1915	9.82	101.24	30
1886-87	8.32	1886-1915	9.57	98.66	29
1887-88	9.82	1887-1915	9.62	99.17	28
1888-89	11.02	1888-1915	9.61	99.07	27
1889-90	15.02	1889-1915	9.55	98.45	26
1890-91	10.47	1890-1915	9.33	96.18	25
1891-92	8.70	1891-1915	9.29	95.77	24
1892-93	9.26	1892-1915	9.31	95.88	23
1893-94	4.97	1893-1915	9.32	96.08	22
1894-95	11.90	1894-1915	9.52	98.14	21
1895-96	6.21	1895-1915	9.40	96.91	20
1896-97	11.78	1896-1915	9.57	98.66	19
1897-98	4.99	1897-1915	9.45	97.42	18
1898-99	5.24	1898-1915	9.71	100.10	17
1899-00	5.97	1899-1915	9.99	102.99	16
1900-01	10.45	1900-1915	10.26	105.77	15
1901-02	6.17	1901-1915	10.24	105.57	14
1902-03	11.76	1902-1915	10.56	108.87	13
1903-04	4.40	1903-1915	10.46	107.83	12
1904-05	14.32	1904-1915	11.01	113.50	11
1905-06	14.68	1905-1915	10.68	110.10	10
1906-07	10.62	1906-1915	10.23	105.46	9
1907-08	8.55	1907-1915	10.19	105.05	8
1908-09	10.23	1908-1915	10.42	107.42	7
1909-10	9.79	1909-1915	10.45	107.73	6
1910-11	11.99	1910-1915	10.58	109.07	5
1911-12	10.72	1911-1915	10.23	105.46	4
1912-13	5.97	1912-1915	10.07	103.81	3
1913-14	9.83	1913-1915	12.12	124.95	2
1914-15	14.41	1914-1915	14.41	148.55	1

TABLE No. 17.

Precipitation at San Bernardino.

Elevation, 1,054 feet.

Season	Precipitation, inches	Period	Average precipitation for period, inches	Ratio to 45 season average, per cent	Ratio to equated 65 season average, per cent	Number of seasons in period
1870–71	13.94	1870–1915	16.01	100.00	102.37	45
1871–72	8.98	1871–1915	16.05	100.25	102.62	44
1872–73	15.10	1872–1915	16.22	101.31	103.71	43
1873–74	23.81	1873–1915	16.24	101.43	103.84	42
1874–75	13.65	1874–1915	16.06	100.31	102.69	41
1875–76	19.90	1875–1915	16.12	100.69	103.07	40
1876–77	9.52	1876–1915	16.02	100.06	102.43	39
1877–78	20.33	1877–1915	16.19	101.12	103.52	38
1878–79	11.54	1878–1915	16.08	100.43	102.82	37
1879–80	20.36	1879–1915	16.21	101.24	103.64	36
1880–81	13.50	1880–1915	16.09	100.50	102.88	35
1881–82	11.54	1881–1915	16.17	100.99	103.39	34
1882–83	9.17	1882–1915	16.31	101.87	102.60	33
1883–84	37.51	1883–1915	16.53	103.25	105.69	32
1884–85	10.81	1884–1915	15.85	99.00	101.34	31
1885–86	21.93	1885–1915	16.02	100.06	102.63	30
1886–87	14.50	1886–1915	15.82	98.81	101.15	29
1887–88	17.76	1887–1915	15.86	99.06	101.41	28
1888–89	20.97	1888–1915	15.79	98.62	100.96	27
1889–90	25.45	1889–1915	15.68	97.94	100.02	26
1890–91	18.08	1890–1915	15.20	94.94	97.19	25
1891–92	14.35	1891–1915	15.08	94.19	96.42	24
1892–93	19.82	1892–1915	15.11	94.37	96.61	23
1893–94	8.13	1893–1915	14.90	93.06	95.27	22
1894–95	20.98	1894–1915	15.22	95.06	97.32	21
1895–96	8.11	1895–1915	14.94	93.31	95.52	20
1896–97	16.74	1896–1915	15.29	95.50	97.76	19
1897–98	8.24	1897–1915	15.21	95.03	97.25	18
1898–99	7.49	1898–1915	15.62	97.56	99.87	17
1899–00	8.64	1899–1915	16.13	100.74	103.13	16
1900–01	17.36	1900–1915	16.63	103.87	106.33	15
1901–02	11.15	1901–1915	16.58	103.56	106.01	14
1902–03	17.42	1902–1915	16.99	106.12	108.63	13
1903–04	9.37	1903–1915	16.96	105.93	108.44	12
1904–05	20.78	1904–1915	17.65	110.24	112.85	11
1905–06	19.88	1905–1915	17.34	108.31	110.87	10
1906–07	23.17	1906–1915	17.06	106.56	109.08	9
1907–08	15.62	1907–1915	16.29	101.12	104.16	8
1908–09	17.36	1908–1915	16.39	102.37	104.80	7
1909–10	15.02	1909–1915	16.23	101.37	103.77	6
1910–11	16.34	1910–1915	16.47	102.87	103.06	5
1911–12	13.84	1911–1915	16.50	103.06	105.50	4
1912–13	11.08	1912–1915	17.39	108.62	111.19	3
1913–14	21.45	1913–1915	20.55	128.36	131.39	2
1914–15	19.64	1914–1915	19.64	122.67	125.58	1

TABLE No. 18.

Precipitation at Glen Ranch, San Bernardino Mountains.

Elevation, 3,256 feet.

Season	Precipitation, inches	Period	Average precipitation for period, inches	Ratio to 15 season average, per cent	Ratio to equated 65 season average, per cent	Number of seasons in period
1900–01	29.27	1900–1915	33.76	100.00	106.33	15
1901–02	15.00	1901–1915	34.08	100.94	107.33	14
1902–03	29.75	1902–1915	35.55	105.30	111.97	13
1903–04	18.53	1903–1915	36.04	106.75	113.51	12
1904–05	38.41	1904–1915	37.63	111.46	118.51	11
1905–06	37.63	1905–1915	37.55	111.22	118.26	10
1906–07	49.69	1906–1915	37.54	111.19	118.23	9
1907–08	25.95	1907–1915	36.02	106.69	113.44	8
1908–09	33.88	1908–1915	37.46	110.96	117.98	7
1909–10	34.67	1909–1915	38.06	112.73	119.87	6
1910–11	45.86	1910–1915	38.75	114.78	122.05	5
1911–12	36.45	1911–1915	36.95	109.44	116.37	4
1912–13	20.13	1912–1915	37.12	109.95	116.91	3
1913–14	53.61	1913–1915	45.62	135.13	143.68	2
1914–15	37.63	1914–1915	37.63	111.46	118.51	1

TABLE No. 19.

Precipitation at Bear Valley Dam.

Elevation, 6,500 feet.

Season	Precipitation, inches	Period	Average precipitation for period, inches	Ratio to 23 season average, per cent	Ratio to equated 65 season average, per cent	Number of seasons in period
1892–93	44.31	1892–1915	34.37	100.00	96.35	23
1893–94	24.86	1893–1915	33.92	98.69	95.09	22
1894–95	50.29	1894–1915	34.35	99.94	96.30	21
1895–96	11.29	1895–1915	33.56	97.64	94.83	20
1896–97	33.25	1896–1915	34.73	101.04	97.35	19
1897–98	20.22	1897–1915	34.81	101.28	97.59	18
1898–99	13.93	1898–1915	35.67	103.78	100.00	17
1899–00	20.47	1899–1915	37.03	107.74	103.81	16
1900–01	31.52	1900–1915	38.13	110.93	106.88	15
1901–02	26.68	1901–1915	38.61	112.33	108.23	14
1902–03	40.42	1902–1915	39.52	114.98	110.79	13
1903–04	25.15	1903–1915	39.45	114.78	110.60	12
1904–05	44.36	1904–1915	40.75	118.56	114.24	11
1905–06	48.25	1905–1915	40.39	117.51	113.23	10
1906–07	48.38	1906–1915	39.51	114.95	110.26	9
1907–08	30.12	1907–1915	38.41	111.75	107.68	8
1908–09	38.20	1908–1915	39.59	115.18	110.84	7
1909–10	34.15	1909–1915	39.82	115.85	111.63	6
1910–11	49.21	1910–1915	40.96	119.17	114.83	5
1911–12	25.60	1911–1915	38.89	113.15	109.02	4
1912–13	22.00	1912–1915	43.32	126.04	121.45	3
1913–14	53.05	1913–1915	53.90	156.82	151.11	2
1914–15	54.93	1914–1915	54.93	159.82	154.00	1

TABLE No. 20.

Precipitation at Gate House, Little Bear Valley.

Elevation. 5,200 feet.

Season	Precipitation, inches	Period	Average precipitation for period, inches	Ratio to 22 season average, per cent	Ratio to equated 65 season average, per cent	Number of seasons in period
1893-94	23.60	1893-1915	31.36	100.00	96.79	22
1894-95	48.66	1894-1915	31.73	101.18	97.93	21
1895-96	13.84	1895-1915	30.88	98.46	95.30	20
1896-97	33.65	1896-1915	31.78	101.34	98.09	19
1897-98	19.40	1897-1915	31.68	101.02	97.78	18
1898-99	13.66	1898-1915	32.40	103.31	100.00	17
1899-00	22.77	1899-1915	33.57	102.05	98.78	16
1900-01	36.73	1900-1915	34.09	108.71	105.22	15
1901-02	20.70	1901-1915	34.12	108.80	105.31	14
1902-03	30.13	1902-1915	35.15	112.08	108.48	13
1903-04	24.32	1903-1915	35.57	113.42	109.78	12
1904-05	36.68	1904-1915	36.59	116.68	112.94	11
1905-06	42.95	1905-1915	36.59	116.68	112.94	10
1906-07	57.48	1906-1915	35.88	114.41	110.74	9
1907-08	26.29	1907-1915	33.18	105.80	102.41	8
1908-09	40.66	1908-1915	34.16	109.28	105.77	7
1909-10	33.23	1909-1915	33.06	105.42	102.04	6
1910-11	44.63	1910-1915	33.05	105.38	102.00	5
1911-12	23.18	1911-1915	30.16	96.17	93.08	4
1912-13	21.99	1912-1915	32.48	103.57	100.25	3
1913-14	43.88	1913-1915	37.73	120.31	116.46	2
1914-15	31.59	1914-1915	31.59	100.73	97.50	1

Several sets of measurements have been used to determine the mean annual discharge of Mojave River in the preparation of this report. The Arrowhead Reservoir and Power Company measured the streams in the upper watershed now tributary or to be tributary to Little Bear Valley reservoir beginning with 1891-2, except the seasons 1900-1 to 1903-4, inclusive, also the East and West Forks at the Forks (Plate II, Fig. 2) and the main river at the Lower Narrows (Plate V, Fig. 2) continuously beginning with 1905-6. The United States Geological Survey maintained a gaging station on the river at the Upper Narrows (Plate V, Fig. 1) 1899-1900 to 1905-6, inclusive, and the Mojave Water and Power Company continued the measurements to and including 1913-14, also measured the East and West Forks at the Forks 1906-7 to 1913-14, inclusive. Thus both the Arrowhead and Mojave companies gaged the flow at the Forks from 1908-9 to 1913-14, inclusive, so that these measurements, being for the same seasons at the same point are directly comparable. The several measurements were compared and correlated in the following manner: All apparent conflicts between the several series were subjected to detailed study, the computations being

checked from the original daily records. It was found that the only material differences occurred in the records of the heavier winter floods. In one instance of considerable conflict, the Forks records for 1911-12, regarding which no other method of weighing the value of the records suggested itself, recourse was had to the precipitation record which definitely indicated that preference should be given the Arrowhead company's measurement.

In general, the precipitation records were not of as much value in checking the discharge as the comparison of the discharge measurements themselves. A study of the precipitation is, however, not without interest. In only two seasons were any errors of consequence found in the Forks measurements of the Arrowhead company. Both appeared to have occurred in plotting the larger flood records and to be due to infrequency of measurements, probably caused by the difficulty of obtaining them during the period of excessive flow. In only one instance was the error of enough magnitude to affect appreciably the average for a period of years. This was for the heavy flood of 1909-10 where the measurement of Deep Creek was 130,000 acre-feet while that of the Mojave Water and Power Company was 76,000 acre-feet. Fortunately measurements were made at both the Upper and Lower Narrows for this season. By plotting these with allowance for the difference in time of the peak of the flood at the different points and with an interpolation of the curve of the declining flood as obtained from the more frequent measurements at the Narrows during the same time a corrected curve was obtained for the Forks which reduced the Arrowhead company's measurement about 31,000, but still left a difference of about 23,000 acre-feet between the measurement of this company and that of the Mojave company. As these could not be further reconciled an average of them was taken. The same method was applied for the seasons 1908-9 to 1913-14, inclusive, during which the two measurements were made at the Forks. The Arrowhead company made the only measurements at the Forks for 1906-7 and 1907-8. The records agree so well with those of the Mojave company at the Upper Narrows that they are assumed to be correct.

A marked discrepancy occurs for the season 1905-6 between the measurements of the Arrowhead company at the Forks and those of the Geological Survey at the Upper Narrows as shown by Table No. 21. The published government records[1] are incomplete for the latter part of the season and the data were supplied by the Mojave Water and Power Company.

[1]United States Geological Survey, Water Supply Paper No. 300.

TABLE No. 21.

Discharge of Mojave River at Forks and Upper and Lower Narrows—1905-1906.

Month	Discharge at Forks (A. R. & P. Co.) Acre feet	Discharge at Upper Narrows (U. S. G. S.) Acre feet	Discharge at Lower Narrows (A. R. & P. Co.) Acre feet
July	449	1,986	1,318
August	82	1,943	1,602
September	43	2,380	1,659
October	102	2,859	2,383
November	360	3,808	2,761
December	659	4,120	2,841
January	3,703	4,205	2,888
February	4,376	3,637	2,493
March	84,406	126,153	56,790
April	21,771	23,766	17,753
May	12,994	6,800	8,357
June	6,305	3,909	3,135
Season	135,220	185,596	103,970

The Forks measurement for this season is approximately 135,000 acre-feet while that at the Upper Narrows is approximately 185,000 acre-feet. This increase is too large to be explained as inflow from the underground basin above the Narrows or as local runoff from the valley below the Forks. The flow at the Lower Narrows for this season was measured by the Arrowhead company to be approximately 104,000 acre-feet. The records for this season at the three points of measurement show reasonable agreement except for the month of March. The records for this month at the Forks and Lower Narrows are within the limits of what might be expected as difference between these points. The flow recorded for the Upper Narrows is manifestly incorrect if the other records are relied upon. It was therefore decided to regard the Forks record as being correct.

Disregarding 1905-6, and taking the average for 1906-7 to 1913-14, inclusive, as shown by Table No. 22, the average for these 7 years at the Forks varies less than 2 per cent from the average for the same period at the Upper Narrows.

TABLE No. 22.

Discharge of Mojave River at Forks and Upper Narrows.

Season	East Fork at Forks (Acre feet)	West Fork at Forks (Acre feet)	Mojave River at Forks (Acre feet)	Mojave River at Upper Narrows (Acre feet)	Per cent of discharge at Forks to discharge at Upper Narrows
1905–06	87,633	47,587	135,220	185,596	73.2
1906–07	136,052	118,265	254,317	259,906	98.2
1907–08	40,920	19,856	60,776	56,057	108.1
1908–09	54,257	35,483	89,740	97,781	91.8
1909–10	87,656	48,049	135,705	118,084	114.8
1910–11	86,627	61,311	147,938	135,903	108.9
1911–12	29,037	17,927	46,964	50,519	93.2
1912–13	14,900	11,460	26,360	35,297	74.6
1913–14	105,130	64,805			
1914–15	77,331	45,305			

In general, there is a loss from the Forks to the Upper Narrows in years of heavy flood and a gain in years of relatively small flood. This may be explained on the theory that water in this part of the river is lost from the surface flow to the underflow in the heavy floods and returned by the charged gravels to the surface stream above the Narrows in seasons of light discharge. It appears from the measurements that practically all of the water which enters the underground basin below the Forks is re-collected above the Narrows and flows out through them. The observations on underground water serve to confirm this belief.

The close relation shown to exist between the flow at the Forks and that at the Upper Narrows suggests an interpolation of discharge for 1899-1900 to 1904-5, inclusive, during which period no gagings were made at the Forks. Table No. 22 shows the relation between the discharge at the Forks and that at the Upper Narrows from 1905-6 to 1912-13, inclusive.

From these percentages and from the recorded discharges at the Upper Narrows from 1899-1900 to 1904-5, inclusive, the probable percentage of discharge at the Forks to that at the Upper Narrows for each season was obtained and used to compute discharges at the Forks. These results vary less than 5 per cent from the measurements at the Upper Narrows by the Geological Survey.

A report of J. B. Lippincott gives some discharges interpolated from the ratio of flow at the Forks to that of the upper tributaries for seasons where the records are available for comparison. Table No. 23 shows these interpolated results and those based on the flow at the Upper Narrows, although obtained in widely different manner, to be in reasonably close agreement. There are no complete measurements for the Forks or

either the Upper or Lower Narrows for 1897-8 and 1898-9 and the interpolated values deduced by Mr. Lippincott are assumed to be correct.

TABLE No. 23.

Interpolated Discharge of Mojave River.

Season	Discharge at Forks interpolated from discharge of upper tributaries (Acre feet)	Discharge at Forks interpolated from discharge at Upper Narrows (Acre feet)
1897–1898	27,040	27,040
1898–1899	7,710	13,898
1899–1900	20,000	18,132
1900–1901	108,100	96,598
1901–1902	33,610	33,789
1902–1903	111,800	107,315
1903–1904	35,210	28,232
1904–1905	103,294	95,016

In this manner Table No. 24 of discharges of Mojave River at the Forks has been compiled for the 18 seasons 1897-8 to 1914-15, inclusive. The average annual discharge of the river where it enters the Victor Valley basin is shown to be approximately 90,000 acre-feet.

TABLE No. 24.

Discharge of Mojave River at Forks—1897-1915, Inclusive.

Season	Discharge (Acre feet)
1897–1898	27,040
1898–1899	13,878
1899–1900	18,132
1900–1901	96,598
1901–1902	33,789
1902–1903	107,315
1903–1904	28,232
1904–1905	95,016
1905–1906	135,220
1906–1907	254,317
1907–1908	60,776
1908–1909	69,740
1909–1910	135,705
1910–1911	147,938
1911–1912	46,964
1912–1913	26,360
1913–1914	169,935
1914–1915	122,636
Average	89,416

FORKS RESERVOIR SITE.

The reservoir site on the West Fork of Mojave River just above the Forks may be designated West Fork reservoir site No. 1, or as it is generally know, the Forks reservoir site. The land in this basin, or nearly all of it including the dam site, is controlled by the Arrowhead Reservoir and Power Company. It was the original plan of the Mojave River Irrigation District to acquire and develop this site to impound the flood discharge of the West Fork and to store, by diversion, that in the lower part of the East Fork and to convey the water by gravity to the east mesa. The district, however, did not make known definite design, if any was decided upon, for the imporvement of the site.

The Arrowhead company has proposed a dam at the Fork site (Plate IV, Fig. 2) 150 feet high which would give a capacity of 102,000 acre-feet for storing both East and West Fork flood waters. Borings made by the company at the dam site show bedrock to be at a maximum depth of 18 feet below stream bed. The natural rim of the basin at one point is only 110 feet above the stream channel at the dam site and the plans include the necesary raising of this bank 50 feet to give the desired capacity. The bank is here merely a narrow remnant of detrital deposit between the channel of the West Fork and the channel of the main river at a lower elevation than the West Fork. The peculiar topography of this locality can be best understood by reference to the map. The only foundation for a dam to raise the bank, as shown by excavations made by the company, is a layer of hardpan at a depth of 75 feet below the crest of the rim.

Moderate leakage, provided the water reappeared as surface flow in the river, might not be a sufficient reason for condemning the site, for the water lost would help satisfy the owners of riparian lands and the appropriators on the stream below, but excessive leakage would impair the value of the reservoir. Robert T. Hill reported to the commission on the geology of the site as follows:

"The Forks reservoir site is an elongated basin which has been developed by erosion at the junction of the north side of the San Bernardino Range and the southern margin of the so-called Mojave Desert. It is triangular in shape and about five miles long, in a northeast-southwest direction, and about two miles in width at its widest place. It is bordered on the southeast and southwest sides by the high, and somewhat precipitous north front of the San Bernardino Range, and on the north by the even topped escarpment of the south side of the Mojave plain, which slopes away therefrom to the northeast. The floor of this basin, which is some 250 feet beneath the summit of this escarpment, shows several old levels and terraces of alluvial material,

below which the river has cut to its present level close to the northern wall.

"The northeast end of the basin is closed by a natural dam which has only recently in geological time been cut through by a deep gorge at its southern end through which the river now finds an outlet. The eastern end of this dam is a low conical granitic peak, which sets out from the edge of the main escarpment of the mountain, while the western half is a low residual embankment which represents the former continuation of the north wall to a junction with the granite outlier above mentioned. The top of this natural embankment is perhaps a hundred feet lower than that of the main northern escarpment.

"The Mojave River now escapes from the basin at the east end of this natural barrier by a deep and narrow canyon in the granite, in which it is proposed to construct a dam for the retention of the water in the reservoir. In my opinion this granite is an excellent site for a dam (Plate IV, Fig. 2), and there are no geological reasons why one should not be constructed here.

"The southern or mountain side of the basin is composed almost exclusively of a granitic rock characterized by large phenocrysts of pink orthoclase feldspar associated with a finer ground mass of plagioclase and biotite, and which may be termed a biotite quartz mononite porphyry in contradistinction from the gray granite in the Victorville hills which is a granodiorite. Like all the granite masses of the desert side whose surfaces are exposed to the weather, this rock is much jointed and broken at the surface by the expansion and contraction due to the diurnal variations of temperature, but the joints will be found closed at slight depths. In general, it may be considered a highly impervious material, well adapted for retaining water when the latter is impounded against it, and also excellent material upon which to construct dams.

"The north escarpment of the basin consists of a steeply sloping cliff of the so-called Hesperia formation, which at one place affords a fresh exposure in a vertical cliff nearly 200 feet in height. Here it is seen to consist of alternating beds of varying thickness of coarse unconsolidated gray angular sands and slightly reddish colored sands containing a very small amount of clay. These beds dip slightly to the north. They are very porous, much more so than is desirable, and the question of leakage through them is a subject which deserves serious consideration before reaching final conclusions as to the availability of this basin for a reservoir site.

"That portion of the northeast barrier of the basin which is composed of the Hesperia formation is the weakest link in the valley wall. It is not only porous like the main north wall, but it is narrow and bordered by lower land on its downstream side. Also I doubt if it will afford a

suitable foundation for constructing a higher dam at this point. Serious study should be given to the capacity of this section for the inhibition and transmission of water."

UPPER WEST FORK RESERVOIR SITES.

Two sites for reservoirs shown by the map, Plate VII, are located on the upper part of the West Fork of Mojave River. For the purpose of reference, these reservoir sites have been designated as West Fork Reservoir No. 2, and West Fork Reservoir No. 3, in order of location looking upstream. The commission made surveys of these for the plotting of ten-foot contours, but the scale of the map, Plate VII, does not permit showing more than each 20-foot contour. Area and capacity curves for these sites are shown by Fig. 4 and Fig. 5.

Three locations for the dam were considered for Reservoir No. 3. The first, designated as Dam Site No. 3, was abandoned in favor of another further down stream, which appeared more advantageous, and which was designated as Dam Site No. 3-A. The cost for the reservoir was worked up on the basis of using this site No. 3-A. Later it was discovered that saving could be made by shifting still further downstream to a point which has been designated as Dam Site No. 3-B, and it is this location which would be recommended, subject to satisfactory examination by test borings, as the place for a dam.

The report of Robert T. Hill, consulting geologist, on Dam Sites Nos. 2, 3-A and 3-B is as follows:

"I examined the geological conditions of the proposed dam sites within the northern edge of the mountain area along the course of the West Fork of the Mojave River. These sites are three in number, and consist of narrow constrictions of the canyon walls which are to be the dam sites, alternating with wide expansions of the valley which are to constitute the reservoir sites. These dam sites (Plate III, Fig. 2, and Plate IV, Fig. 1) are strongly entrenched ridges of the same granitic rock as that which we have previously described, and there are no geological reasons why they should not be considered excellent locations for the contemplated works.

"Some fear has been expressed regarding the proximity of the dam sites to the fault lines which seem to dominate the physiography of this district. It is my opinion that no serious trouble need necessarily be anticipated from these conditions. The displacements seem to be ancient in comparison to those now taking place on the southwest side of the range. There are no large or open fault fissures which would be conducive to leakage. The only danger would be that of earthquake jars to masonry dams, and so far as is ascertained, this particular area

is about as free from seismic disturbances as any part of southern California.''

To obtain some standard for ready comparison a safe section of gravity dam is assumed, all dimensions of which are expressed in terms of the height. The top width is .15h and this continues down for a depth of .20h from whence the section widens in the form of a trapezoid to .65h at the base. The area of cross section thus provided is $.33h^2$. While not the most effective or economical dam it is sufficiently strong and it offers a section for preliminary comparison of one dam with another. Cross sections of the dam sites as shown by Plate VII were taken and as careful examinations as could be made for dams for varying dimensions.

In order to present the results in the form of cost curves rather than yardage curves a cost of $6.00 per cubic yard was assumed for all concrete. The cost of the dams was then computed for heights from 10 to 150 feet and the unit cost was determined for the different capacities. The unit costs for different capacities when plotted give a fairly uniform curve. Fig. 4 shows area, capacity, and cost curves for the reservoirs, area being plotted against depth, capacity against depth, and unit cost against capacity. The unit cost curves are then used to make Fig. 5 in which the several curves represent different combined capacities for the reservoirs and in which the diagrams show the capacity that should be given each reservoir for the most economic combination together with the corresponding unit cost. The curve at the bottom of Fig. 5 is a summary of those above, and shows the unit cost in dollars per acre-foot for the most economic combined capacities in acre-feet. It is found that the most economic combinations within the range of total storage which would be desirable require that the greater part of the capacity be in Reservoir No. 3-A, also that the ratio between the capacities of the two basins is not constant for varying total capacity.

The maximum economic capacity for Reservoir No. 3-A is approximately 35,000 acre-feet which is shown to correspond to the minimum unit cost of $34.50 per acre-foot. Using the same figure as the maximum allowable unit cost for Reservoir No. 2 the maximum economic capacity for this reservoir is 34,000 acre-feet. Again considering the same unit cost as the limit of expense the minimum economic capacity for Reservoir No. 3-A is 28,000 acre-feet and for Reservoir No. 2, 9,400 acre-feet.

Either of these sites is suitable to serve as the reservoir for the first unit in the development of a project and it is gratifying to find such possibilities for economic storage based on such small units. It is in these units that hope for a successful project in Victor Valley must lie.

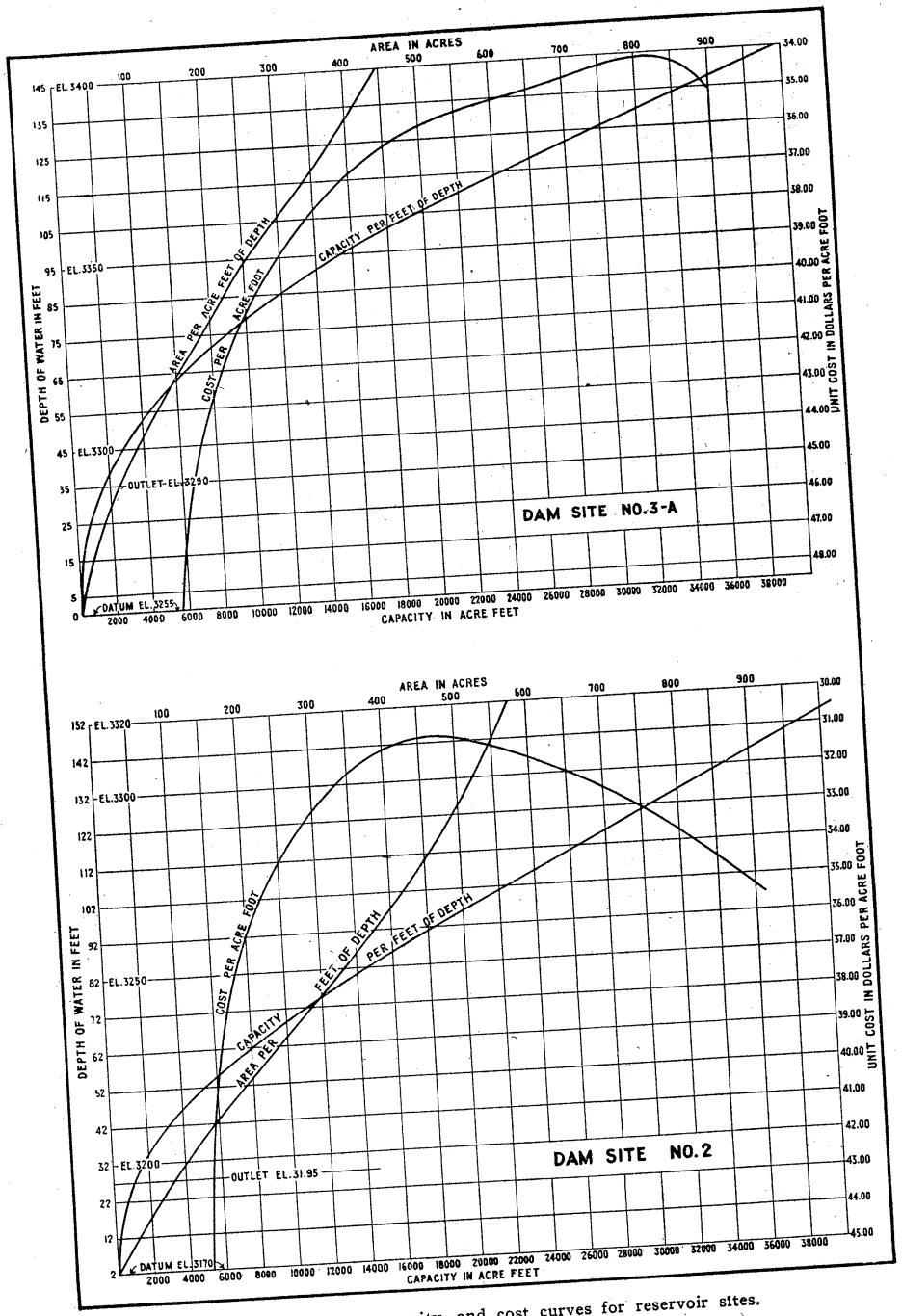


Fig. 4.—Area, capacity, and cost curves for reservoir sites.

For the complete and most economic utilization of the West Fork waters a much larger storage is needed and a combination of these reservoirs offers the means to this end. The curve, Fig. 5, shows a wide range of capacity to be possible through advantageous combinations of the two reservoirs without much variation in unit cost. For example, by proper combination a total capacity of 60,000 acre-feet can be obtained for approximately $33.25 per acre-foot while a total capacity of only 31,000 acre-feet can be had for $34.00 per acre-foot, with an optimum economic total capacity between these two of 52,000 acre-feet for $32.85 per acre-foot. This indicates a possible flexibility of design which is very desirable and which is seldom obtained.

If the area to be first put under cultivation is too large it may become unwieldy with nonproductive acreage and difficult to carry through the development period while if it be too small the first cost may be too high and the overhead charges proportionately too large. Where a project offers such nearly equal unit cost for varying sizes, the first unit may be conveniently given the most desirable size. In the present case an initial or nucleus project should comprise from 15,000 to 18,000 acres.

With a gross duty of 1.25 acre-feet the water supply required for a district of 16,500 acres, or assuming that 15 per cent of the land is unirrigated, a net area of 14,000 acres is 17,500 acre-feet annually.

The mean annual discharge of the West Fork of Mojave River at the Forks including Grass Valley Creek is about 39,200 acre-feet. The mean annual discharge at the upper dam sites as determined by comparing the measurements at the upper sites with those at the Forks, is about 30,000 acre-feet. It appears from the discharge records that for an annual storage of approximately 30,000 acre-feet, a draft of 60 per cent of the total storage or approximately 18,000 acre-feet per year may safely be made. This is sufficient for a net area of 14,000 acres or allowing for 15 per cent of the district being unirrigated a gross area of 16,500 acres.

If, however, Reservoir No. 3-A only should be used for this initial project some study should be made of the most economic use of this reservoir and of the form of unit development that would be consistent with the full development of the combined reservoirs. Ultimate development would use the full 60,000 acre-feet capacity which should give an annual draft of approximately 30,000 acre-feet or practically the entire average flow of the West Fork.

Fig. 5 shows the economic division of this capacity to be 33,000 acre-feet in Reservoir No. 3-A and 27,000 acre-feet in Reservoir No. 2. Therefore, as a tentative plan it is suggested that Reservoir No. 3-A be constructed to a capacity of 33,000 acre-feet for the first unit. This

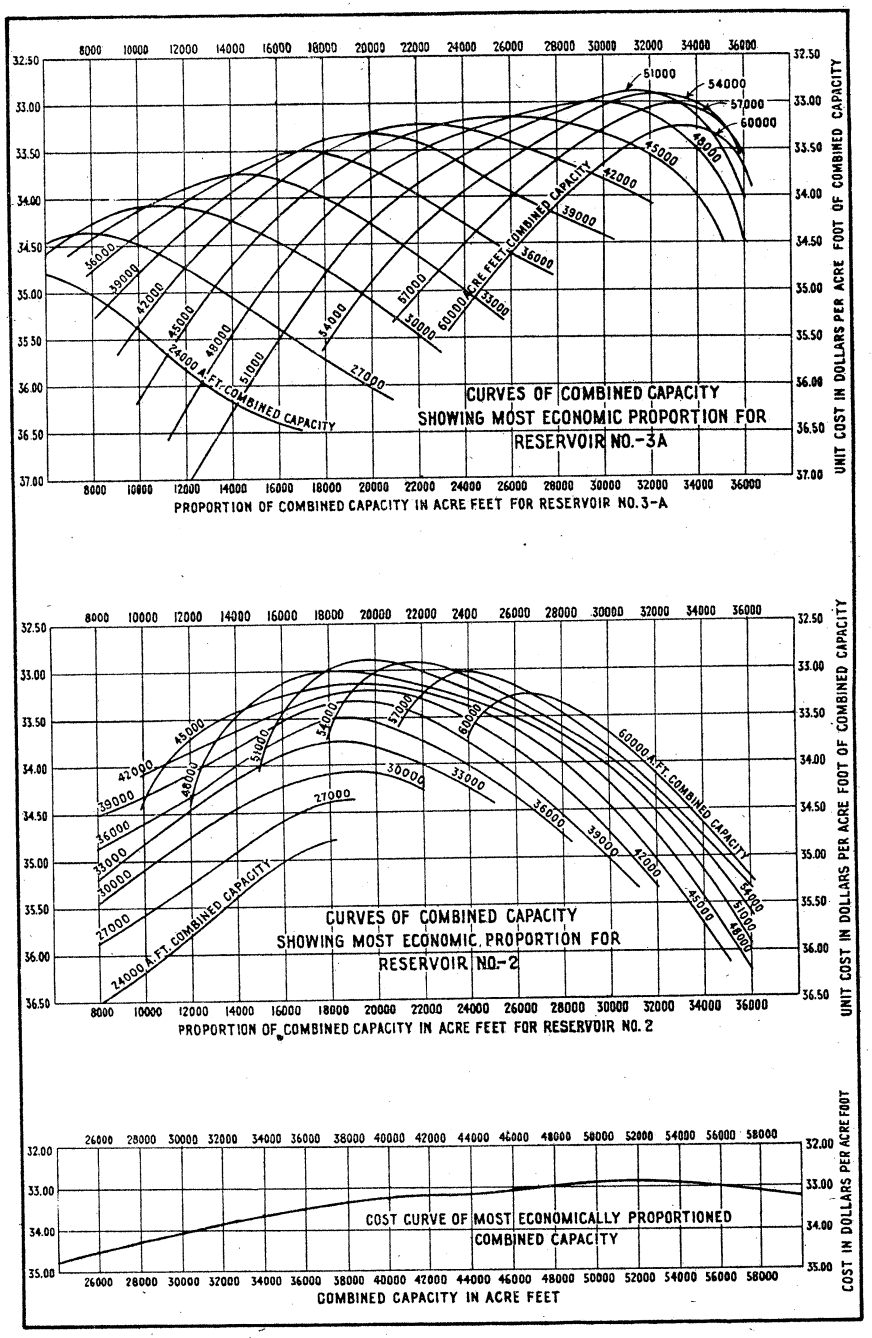


Fig. 5.—Curves for reservoir sites on West Fork of Mojave River.

should allow a safe annual draft of about 20,000 acre-feet or on the basis of 1.25 acre-feet duty should irrigate a net area of the west mesa of 16,000 acres, or allowing 15 per cent for lands not cultivated, should supply a district of approximately 19,000 acres. The following is an estimate of the cost of such a project:

Dam	$1,125,300 00
Spillway	20,000 00
Land, 400 acres at $100 per acre	40,000 00
Main conduits	198,000 00
Distribution system	322,000 00
Total	$1,705,300 00

The foregoing makes no allowance for interest during construction which would require two years. During the first six months of this period it is probable that the work would be of a preliminary character including the making of the necessary surveys and designs and the acquisition of the lands and water rights pertaining to the project. The cost of this preliminary work is estimated at $100,000. For a tentative scheme of financing therefore it is estimated that interest would be paid on sums as follows:

$100,000 at 5 per cent for 2 years	$10,000 00
500,000 at 5 per cent for 1½ years	37,500 00
600,000 at 5 per cent for 1 year	30,000 00
600,000 at 5 per cent for ½ year	15,000 00
Total	$92,500 00

Adding interest to construction cost gives a total estimated cost of $1,797,800, or a cost of $94.62 per acre. A careful design of the dam should reduce the estimated cost 10 or 15 per cent below the estimate based on the arbitrary section of dam assumed for this preliminary study and comparison. Such a reduction would lower the estimated unit cost of the project to approximately $90.00 per acre including interest.

CONCLUSIONS AND SUGGESTIONS.

No plan for the utilization of Mojave River would be complete without considering the Little Bear Valley Reservoir. The Arrowhead Reservoir and Power Company has invested a large amount in this system for impounding and using the water supply of the upper watershed of the East Fork and is in possession of valuable data on the runoff from the entire watershed. This company controls a large amount of riparian land along the river and has acquired additional appropriation rights. Options on the company's properties are held by the Victor Valley Irrigation District. It is not evident that this

district can be properly supplied with water from Little Bear Valley reservoir at reasonable cost. The length of conduit and the expensive nature of construction required, the limited quantity of water available and the comparatively small amount of power which may be developed point to such a large unit cost as to render the project impracticable. The report of J. B. Lippincott points out that the project is feasible only on the basis of a high duty of water such as one acre-foot and indicates uncertainty as to the sufficiency of this duty. We are of the opinion that a duty of one acre-foot is insufficient for the area included in the district.

We deem it unwise to give special consideration to any particular body of land and hold that the broad problem is not how to deliver the water to some particular lands but how to devise the most economical plan to properly irrigate part of the valley. There is a large area of land but a limited quantity of water.

The flood waters may also be stored at the Victor reservoir site controlled by the Mojave Water and Power Company and although this site is too low to be of service to either of the irrigation districts, plenty of good land on which the water may be used is situated below the site.

In the pursuit of practical means for the utilization of Little Bear Valley Reservoir we suggest that some land of the east mesa may be irrigated with this supply at less expense than may the lands of the west mesa and that such a distribution would also permit the development of more electrical energy. The West Fork reservoir sites may be used to store water for the west mesa lands.

The Appleton Land, Water and Power Company owns extensive lands having riparian rights and some appropriation rights and the pipe lines of this company are in a position to receive the discharge from Little Bear Valley reservoir. For the nucleus of development on the east side and near the river on the west side it would seem that this company's ditch and pipe lines might have a very definite value if used with the Arrowhead Reservoir and Power Company's properties.

The following is a summary of the suggestions and findings.

(1) The proper duty of water is approximately 1.50 acre-feet per acre per annum for the east mesa and 1.25 acre-feet per acre per annum for the west mesa.

(2) The total annual average discharge of Mojave River is approximately 90,000 acre-feet, of which about one-third is available for storage in Little Bear Valley reservoir now partially constructed, about one-third is available for storage in proposed upper West Fork reservoirs, and about one-third should be allowed for the riparian lands along the river.

(3) We suggest the use of the water supply under two projects; one for the west mesa to make use of the upper West Fork reservoirs with an initial unit having storage in Reservoir No. 3-A of 33,000 acre-feet and a district of 18,400 acres and an ultimate project with storage in both reservoirs of 60,000 acre-feet and a district of 29,000 acres; the other to use Little Bear Valley reservoir water from which may be delivered by the shortest route to the lands of the east mesa, utilizing the greater inherent power en route and irrigating approximately 20,000 acres net, or allowing for 15 per cent of the total being unirrigated, a total project area of 23,000 acres. The total net area under the two systems would be about 45,000 acres and allowing 15 per cent for lands unirrigated within the exterior boundaries a total gross area of about 52,000 acres.

APPENDIX

TABLE OF DATA ON WELLS AND PUMPING PLANTS IN VICTOR VALLEY.

Number	Owner	Location			Well						Elevations		Pump			Power	
		Section	Township	Range	Year made	Class	Size, inches	Depth, feet	Depth to water, feet	Date measured	Ground, feet	Water, feet	Kind	Size, inches	Discharge claimed, ml. in.	Kind	Horsepower
1	Martin McInnis	7	3	3	-----	Dug	----	22	7.5	Feb. 26, '17	2,945.8	2,938.3	Cylinder	------	------	Windmill	----
2	Martin McInnis	7	3	3	1913	Dug	----	30	10.4	Feb. 26, '17	------	------	Cylinder	------	------	Windmill	----
3	A. Dewitt	7	3	3	-----	Dug	------	11	8.3	Feb. 26, '17	2,944.4	2,936.1	None	------	------	None	----
4	— Vlodek	6	3	3	-----	Dug	------	20	2.8	Feb. 26, '17	2,931.4	2,928.6	None	------	------	None	----
5	C. F. Hedrick	1	3	4	1916	Drilled	10	216	11.0	Feb. 16, '17	2,935.1	2,924.1	Centrifugal	6	80	Gasoline engine	20
6	F. Spencer	1	3	4	1916	Drilled	12	250	11.0	Feb. 16, '17	2,927.4	2,916.4	Centrifugal	7	100	Gasoline engine	25
7	—— ——	1	3	4	-----	Dug	------	------	------	------	2,922.9	------	Cylinder	------	------	Windmill	----
8	M. J. Springer	6	3	3	-----	Dug	------	------	5.7	Feb. 26, '17	------	------	None	------	------	None	----
9	Appleton L. W. P. Co.	36	4	4	-----	Drilled	14	113	3.5	Feb. 17, '17	------	------	None	------	------	None	----
10	Appleton L. W. P. Co.	36	4	4	-----	Drilled	14	202	------	Feb. 17, '17	------	------	None	------	------	None	----
11	Appleton L. W. P. Co.	36	4	4	-----	Drilled	14	280	6.2	Feb. 17, '17	2,927.0	2,920.8	None	------	------	None	----
12	I. C. McLaughlin	31	4	3	1905	Drilled	14	34	34.0	Feb. 26, '17	2,910.0	2,876.0	Cylinder	------	------	Windmill	----
13	I. C. McLaughlin	31	4	3	1911	Drilled	8	52	20.9	Feb. 26, '17	2,913.5	2,892.6	Centrifugal	4	52	Gasoline engine	8
14	A. O'Neil	30	4	3	1911	Drilled	12	225	16.4	Feb. 26, '17	2,897.7	2,881.3	Centrifugal	------	140	Gasoline engine	25
15	A. W. Cole	30	4	3	1914	Dug	------	36	31.7	Mar. 6, '17	2,897.7	2,866.0	Cylinder	5x24	7	Gasoline engine	3
16	A. W. Cole	30	4	3	1913	Drilled	12	162	32.8	Mar. 6, '17	2,898.0	2,865.2	Centrifugal	5	80	Gasoline engine	25
17	County Well	19	4	3	-----	Dug	------	------	12.6	Mar. 6, '17	2,899.9	2,887.3	None	------	------	None	----
18	G. W. McLester	19	4	3	-----	Drilled	10	6	22.7	Feb. 26, '17	------	------	None	------	------	None	----
19	G. W. McLester	19	4	3	-----	Drilled	12	------	22.7	Feb. 26, '17	------	------	None	------	------	None	----
20	H. A. Jock	30	4	4	-----	Drilled	10	54	18.0	------	2,905.2	2.887.2	Cylinder	3	35	Gasoline engine	6
21	O. A. Minister	29	4	3	-----	Dug	------	------	30.0	------	2,896.3	2.866.3	Cylinder	------	9	Gasoline engine	1.5
22	O. A. Minister	29	4	3	1913	Drilled	12	120	24.3	Feb. 25, '17	2,891.2	2,866.9	Centrifugal	6	150	Gasoline engine	22
23	Sidney O'Neil	20	4	3	-----	Drilled	12	------	24.5	Feb. 26. '17	2,882.1	2,867.6	None	------	------	None	----
24	J. M. Allison	20	4	3	-----	Drilled	10	70	30.0	------	2,880.1	2,850.1	None	------	------	None	----
25	J. M. Allison	20	4	3	-----	Drilled	10	70	25.0	------	2,883.4	2,858.4	None	------	------	None	----
26	W. C. Roberts	17	4	3	1915	Drilled	12	155	20.0	------	2,868.5	2,848.5	Centrifugal	6	125	Gasoline engine	20
27	D. W. McPherson	17	4	3	-----	Drilled	7	------	20.4	Feb. 25, '17	2,862.4	2.842.0	Cylinder	------	------	Windmill	----
28	D. W. McPherson	17	4	3	1914	Drilled	12	------	20.6	Feb. 25, '17	2,866.8	2,846.2	None	------	------	None	----
29	I. K. Miller	7	4	3	-----	Drilled	10	150	19.5	Feb. 25, '17	2,861.9	2,842.4	Centrifugal	8	------	Gasoline engine	----
30	C. G. Lewis	7	4	3	1910	Drilled	12	146	12.0	------	2,854.6	2,842.6	Centrifugal	4	55	Gasoline engine	8
31	H. A. Carden	7	4	3	-----	Drilled	10	225	15.1	Feb. 25, '17	2,853.7	2,838.6	Centrifugal	7	------	Gasoline engine	20
32	Harris Garcelon	6	4	3	1909	Drilled	12	133	16.0	------	2,842.9	2,826.9	Centrifugal	6	130	Gasoline engine	16
33	E. Garcelon	7	4	3	1912	Drilled	12	166	10.0	------	2,848.8	2,838.8	Centrifugal	7	150	Gasoline engine	25
34	A. H. Hohman	6	4	3	-----	Dug	------	25	11.8	Feb. 24, '17	2,833.7	2,821.9	Centrifugal	3	24	Gasoline engine	4
35	A. W. Phillips	6	4	3	-----	Drilled	12	94	8.0	------	2,830.5	2,822.5	Centrifugal	6	216	Gasoline engine	35
36	Orr & Pullar	36	5	4	1909	Drilled	12	110	7.0	Feb. 17, '17	2,825.2	2,818.2	Centrifugal	5	75	Gasoline engine	45
37	Verde Ranch	23	5	4	-----	Drilled	10	260	0.0	April 12, '17	2,751.5	2,751.5	Flowing	------	------	None	----
38	Verde Ranch	23	5	4	-----	Drilled	10	350	0.0	April 12, '17	2,748.6	2,751.3	Flowing	------	33	None	----
39	Verde Ranch	23	5	4	-----	Drilled	10	92	0.0	April 12, '17	2,750.2	2,751.8	Flowing	------	------	None	----
40	Verde Ranch	15	5	4	-----	Drilled	10	------	0.0	April 12, '17	2,765.0	2,776.9	Auxiliary pump	------	------	Gasoline engine	----
41	Verde Ranch	26	5	4	-----	Drilled	10	552	0.0	April 12, '17	2,782.1	2,783.5	Flowing	------	------	None	----
42	Verde Ranch	26	5	4	-----	Drilled	10	------	0.0	April 12, '17	2,782.1	2,783.3	Flowing	------	------	None	----
43	Verde Ranch	26	5	4	-----	Drilled	10	106	0.0	April 12, '17	2,783.3	2,784.4	Flowing	------	------	None	----
44	Verde Ranch	26	5	4	-----	Drilled	10	------	0.0	April 12, '17	2,798.4	2,799.6	Flowing	------	------	None	----
45	Verde Ranch	26	5	4	-----	Drilled	10	------	0.0	April 12, '17	------	------	Flowing	------	------	None	----
46	Verde Ranch	35	5	4	-----	Drilled	10	------	0.0	April 12, '17	2,800.4	2,804.3	Flowing	------	------	None	----
47	Verde Ranch	35	5	4	-----	Drilled	10	895	0.0	April 12, '17	2,799.1	2,800.4	Flowing	------	------	None	----
48	Verde Ranch	35	5	4	-----	Drilled	10	------	0.0	April 12, '17	2,800.2	2,800.7	Flowing	------	------	None	----
49	Verde Ranch	35	5	4	-----	Drilled	12	270	4.0	April 12, '17	2,811.0	2,807.0	Centrifugal	------	350	Gasoline engine	60
50	Verde Ranch	35	5	4	-----	Drilled	12	270	4.0	April 12, '17	2,811.0	2,807.0	Centrifugal	------	350	Gasoline engine	60
51	Verde Ranch	35	5	4	-----	Drilled	12	270	4.0	April 12, '17	2,811.0	2,807.0	Centrifugal	------	350	Gasoline engine	60
52	Verde Ranch	35	5	4	-----	Drilled	12	306	4.0	April 12, '17	------	------	Centrifugal	8	------	Gasoline engine	25
53	Verde Ranch	36	5	4	-----	Drilled	12	270	12.8	Mar. 5, '17	2,824.0	2,811.2	Centrifugal	12	400	Gasoline engine	60
54	Verde Ranch	36	5	4	-----	Drilled	12	270	12.8	Mar. 5, '17	2,824.0	2,811.2	Centrifugal	12	400	Gasoline engine	60
55	Verde Ranch	36	5	4	-----	Drilled	12	270	12.8	Mar. 5, '17	2,824.0	2,811.2	Centrifugal	12	400	Gasoline engine	60
56	W. and C. H. Shaw	24	5	4	-----	Drilled	14	72	53.0	Feb. 17, '17	2,815.7	2,762.7	Cylinder	------	------	Windmill	----
57	W. and G. Weldon	24	5	4	-----	Drilled	12	300	50.0	------	2,801.7	2.751.7	Centrifugal	------	------	Gasoline engine	32
58	W. A. Foster	25	5	4	1907	Drilled	10	100	48.0	------	2,833.0	2,785.0	Centrifugal	6	100	Gasoline engine	35
59	M. L. Foster	19	5	4	-----	Drilled	------	160	48.0	------	2,835.0	2,787.0	Double dp. w.	------	40	Gasoline engine	15
60	E. P. Dewey	31	5	3	1903	Drilled	8	545	23.5	Feb. 24, '17	2,850.0	2,826.5	Centrifugal	6	125	Gasoline engine	----
61	Victor Ranch	30	5	3	1905	Drilled	12	500	55.3	Feb. 24, '17	2,845.8	2,789.5	Centrifugal	7	125	Gasoline engine	40
62	W. B. Ames	30	5	3	-----	Drilled	12	------	47.6	Feb. 24, '17	2,845.8	2,797.2	Centrifugal	7	------	Gasoline engine	40
63	W. B. Ames	30	5	3	-----	Drilled	12	------	47.6	Feb. 24, '17	2,848.0	2,800.4	Centrifugal	7	------	Gasoline engine	32
64	W. C. Smith	31	5	3	-----	Drilled	12	------	------	------	------	------	None	------	------	None	----
65	S. L. Wheatley	31	5	3	-----	Drilled	12	------	45.3	Feb. 24, '17	2,863.8	2,818.5	Centrifugal	------	------	Gasoline engine	35
66	L. C. Bailey	31	5	3	-----	Drilled	------	------	------	------	2,865.0	------	Centrifugal	------	------	Gasoline engine	18
67	A. W. Phillips	6	4	3	-----	Drilled	10	100	50.0	Feb. 24, '17	2,866.5	2,816.5	Cylinder	------	6	Gasoline engine	----
68	G. L. Smith	6	4	3	-----	Drilled	12	100	50.0	------	2,878.7	2,828.7	Centrifugal	7	------	Gasoline engine	40
69	W. A. Westphal	5	4	3	1910	Drilled	12	370	80.0	------	2,923.4	2,843.4	Centrifugal	6	80	Gasoline engine	40
70	Apple Valley School	5	4	3	-----	Drilled	7	160	100.0	------	2,923.8	2,823.8	Cylinder	------	------	Windmill	----
71	Edwin Rhodes	8	4	3	1914	Drilled	14	164	71.0	------	2,904.1	2,833.1	Turbine	10	100	Gasoline engine	35
72	—— Cozard	7	4	3	-----	Dug	------	48	46.8	Feb. 25, '17	2,880.4	2,833.6	Cylinder	------	------	Windmill	----
73	—— Keplinger	8	4	3	-----	Dug	------	------	66.0	Feb. 25, '17	2,904.3	2.838.3	Cylinder	------	------	Windmill	---

TABLE OF DATA ON WELLS AND PUMPING PLANTS IN VICTOR VALLEY—Continued.

Number	Owner	Location			Well						Elevations		Pump			Power	
		Section	Township	Range	Year made	Class	Size, inches	Depth, feet	Depth to water feet	Date measured	Ground, feet	Water, feet	Kind	Size, inches	Discharge claimed, mi. in.	Kind	Horsepower
74	C. F. Ten Eyck	8	4	3	1915	Drilled	14	225	132.0				Turbine	12	45	Gasoline engine	42
75	F. E. Harrison	17	4	3	1912	Dug		81	78.2	Feb. 26, '17			Cylinder			Windmill	
76	N. F. Marsh	20	4	3	1915	Drilled	12	180	100.0		2,969.0	2,869.0	Screw	5	32	Gasoline engine	30
77	W. O. Wade	21	4	3	1916	Drilled	12	650	242.0	Mar. 1, '17	3,090.0	2,848.0	Cylinder			Gasoline engine	2
78	W. C. Harris	8	4	3	1912	Drilled	14	345	186.2	Mar. 1, '17	3,030.9	2,844.7	Single dp. w.	9x30	30	Gasoline engine	30
79	A. E. Hull	9	4	3	1912	Drilled	14	687	188.9	Mar. 1, '17	3,033.9	2,845.6	Centrifugal	5	55	Gasoline engine	60
80	W. M. Hunt, Jr.	10	4	3		Drilled	14	300	212.0	Mar. 1, '17	3,060.4	2,848.4	Double dp. w.	38	42	Gasoline engine	40
81	W. E. Tussing	10	4	3	1917	Drilled	12	385	138.0		3,090.0	2,852.0	Double dp. w.	28	27	Gasoline engine	30
82	R. M. Ferguson	5	4	3	1911	Drilled		272	166.0				None			None	
83	O. L. Morgan	4	4	3	1913	Dug			170.0				Cylinder			Windmill	
84	H. W. Fitzpatrick	4	4	3	1912	Dug			5.0		2,992.9	2,837.9	None			None	
85	J. Billingsley	3	4	3		Dug			149.0	Mar. 3, '17	2,978.9	2,829.9	None			None	
86	C. A. Bonadiman	3	4	3		Drilled		241	190.0		3,030.8	2,840.8	Cylinder			Windmill	
87	T. E. Dennison	2	4	3	1909	Drilled	6	180	159.0		2,997.6	2,838.6	Cylinder			Windmill	
88	J. F. Olsen	2	4	3	1911	Dug		167	159.0		2,995.6	2,836.6	Cylinder			Windmill	
89	W. J. Fifield	2	4	3		Drilled	10		213.0	Mar. 2, '17	3,053.0	2,840.0	Cylinder			Windmill	
90	E. D. S. Pope	1	4	3	1913	Drilled	12	730	196.0		3,037.0	2,841.0	Double dp. w.		10	Gasoline engine	12
91	D. D. Spaid	1	4	3	1914	Drilled	12	250	163.0				Screw	6	30	Gasoline engine	40
92	H. E. Walsh	6	4	2	1914	Drilled	12	340	200.0		3,125.0	2,844.0	Double dp. w.	38	33	Gasoline engine	40
93	A. J. Lintner	6	4	2		Drilled	8		200.0	Mar. 4, '17	3,030.0	2,832.0	None			None	
94	B. Peaks	26	5	3		Dug		150	100.0		2,946.8	2,846.8	Cylinder			Gasoline engine	
95	A. M. Byron	34	5	3	1912	Dug		148	128.5	Feb. 28, '17	2,967.0	2,838.5	Cylinder			Windmill	
96	L. H. Clock	33	5	3	1913	Drilled	12	512	155.2		2,985.2	2,830.0	None			None	
97	C. H. White	5	4	3	1915	Drilled	12	204	166.0		3,002.1	2,836.1	Deep well	6	8	Gasoline engine	7
98	T. J. Anderson	33	5	3		Dug		167	157.4	Feb. 17, '17	2,987.3	2,829.9	None			None	
99	W. Paine	32	5	3		Dug		167	160.0		2,994.5	2,834.5	Cylinder			Windmill	
100	M. F. Ihmsen	32	5	3	1912	Drilled	14	300	164.0		2,994.7	2,830.7	Turbine	12	70	Gasoline engine	60
101	Theresa Smith	32	5	3	1915	Drilled	12	269	151.8	Feb. 27, '17	2,986.8	2,835.0	None			None	
102	A. S. Kibbey	28	5	3	1910	Drilled	10	400	130.0		2,975.9	2,845.9	Turbine	9⅝	53	Gasoline engine	35
103	K. Evans	29	5	3	1915	Drilled	12	207	155.0		2,968.0	2,818.0	Deep well		15	Gasoline engine	4
104	A. G. Kent	27	5	3	1916	Drilled	12	253	127.0				None			None	
105	W. W. Hitchcock	28	5	3	1912	Drilled	14	492	112.0	May 15, '12	2,951.5	2,839.5	Turbine	8	50	Gasoline engine	40
106	H. C. Decker	22	5	3	1909	Drilled	10	722	107.7	Feb. 28, '17	2,944.7	2,837.0	Air lift			Gasoline engine	
107	N. Elmer	22	5	3		Dug		119	101.9	Mar. 2, '17	2,939.0	2,837.1	None			None	
108	L. L. Lytle	26	5	3		Dug		101	98.3	Mar. 2, '17	2,939.0	2,840.7	None			None	
109	R. D. Sperry	26	5	3		Dug		111	97.8	Mar. 2, '17	2,938.4	2,840.6	None			None	
110	H. Meacham	30	5	2		Drilled	10		109.0	Mar. 3, '17	2,960.0	2,851.0	None			None	
111	—— Rau	24	5	3	1917	Drilled	12	183	87.1	Mar. 2, '17			Cylinder			None	
112	—— Harlan	24	5	3		Drilled	12	155	81.8	Mar. 4, '17			None			Gasoline engine	
113	Verde Ranch	24	5	3		Drilled	12	300	80.0				Cylinder			Windmill	
114	N. A. Graffin	14	5	3		Dug		92	80.0	Mar. 3, '17	2,916.0	2,836.0	Cylinder			None	
115	S. Miller	14	5	3		Dug			87.3	Mar. 3, '17	2,926.0	2,838.7	None			None	
116	E. D. S. Pope	14	5	3	1913	Drilled	12	160	78.3	April 4, '17	2,913.0	2,834.7	None			Windmill	
117	—— Hatch	14	5	3		Dug			Dry		2,906.6		Cylinder			None	
118	M. E. Gibson	20	5	3		Dug		138					Cylinder			None	
119	M. W. Minor	20	5	3		Dug		147	Dry				None			Windmill	
120	A. E. Dennis	18	5	3		Drilled	12	184	125.8	Feb. 27, '17	2,929.4	2,803.6	Cylinder			None	
121	—— Cochran	18	5	3		Dug		144	143.0	Feb. 27, '17	2,933.5	2,790.5	None			None	
122	—— Cochran	18	5	3		Dug		142	138.0	Feb. 27, '17	2,933.5	2,795.5	Deep well	2		None	
123	J. D. Humiston	18	5	3	1913	Drilled	14	464	97.0	Feb. 27, '17	2,908.0	2,811.0	None			Windmill	
124	J. M. Raphael	18	5	3		Dug					2,925.0		Cylinder			None	
125	Robert Cook	8	5	3		Dug							None			Gasoline engine	10
126	Robert Cook	8	5	3		Drilled		170	106.0		2,918.0	2,812.0	Cylinder			Windmill	
127	Robert Cook	8	5	3		Drilled	10	125	109.2		2,925.0	2,815.8	Cylinder			Windmill	
128	C. E. Van Horn	22	5	3		Drilled	12	185	107.7	Feb. 28, '17	2,941.5	2,833.8	Cylinder			None	
129	M. M. White	8	5	3		Dug		90	88.0	Mar. 5, '17			None			Gasoline engine	
130	J. J. Hill	8	5	3		Dug			72.0		2,950.9	2,878.9	Centrifugal		2	None	
131	F. A. Fletcher	9	5	3		Drilled		458	89.1	Mar. 5, '17	2,910.0	2,820.9	None			Gasoline engine	2
132	F. A. Fletcher	9	5	3		Drilled	7	213	77.4	Feb. 28, '17	2,905.5	2,828.1	Deep well		15	Gasoline engine	18
133	O. S. Overholt	10	5	3	1902	Dug		85	77.5		2,905.5	2,828.0	Screw			None	
134	J. W. Kyle	10	5	3	1915	Drilled	12	218	72.0		2,903.6	2,831.6	None			None	
135	J. F. Fitzsimmons	10	5	3		Dug		80	77.6	Mar. 5, '17			None			None	
136	E. D. Mitchell	12	5	3		Drilled			126.0	Mar. 4, '17	2,965.9	2,839.9	None			None	
137	W. H. Bronson	18	5	2		Dug			132.0				None			None	
138	C. M. Abbeys	12	5	3		Dug		127			2,947.3		None			None	
139	M. Liebold	12	5	3		Dug					2,950.9		None			Gasoline engine	
140	E. H. Keller	2	5	3		Dug			116.7	Mar. 4, '17			Cylinder			Windmill	
141	J. S. Nation	2	5	3		Drilled	6		108.0				Cylinder			Windmill	
142	G. Green	2	5	3		Dug		165	157.6	Mar. 4, '17			Cylinder			Windmill	
143	G. B. Holbrook	4	5	3	1909	Dug		97	72.8	Mar. 5, '17			Cylinder		3	Gasoline engine	18
144	G. B. Holbrook	4	5	3	1910	Drilled	7	94	80.0				Single dp. w.	6		Gasoline engine	35
145	E. H. Corwin	34	6	3	1915	Dug		110	101.2	Mar. 4, '17			Screw				
146	Byron Buneman	28	6	3	1915	Drilled	12	193	117.0								
147	Byron Buneman	28	6	3		Drilled	12	190	120.6	Mar. 4, '17							

TABLE OF DATA ON WELLS AND PUMPING PLANTS IN VICTOR VALLEY—Continued.

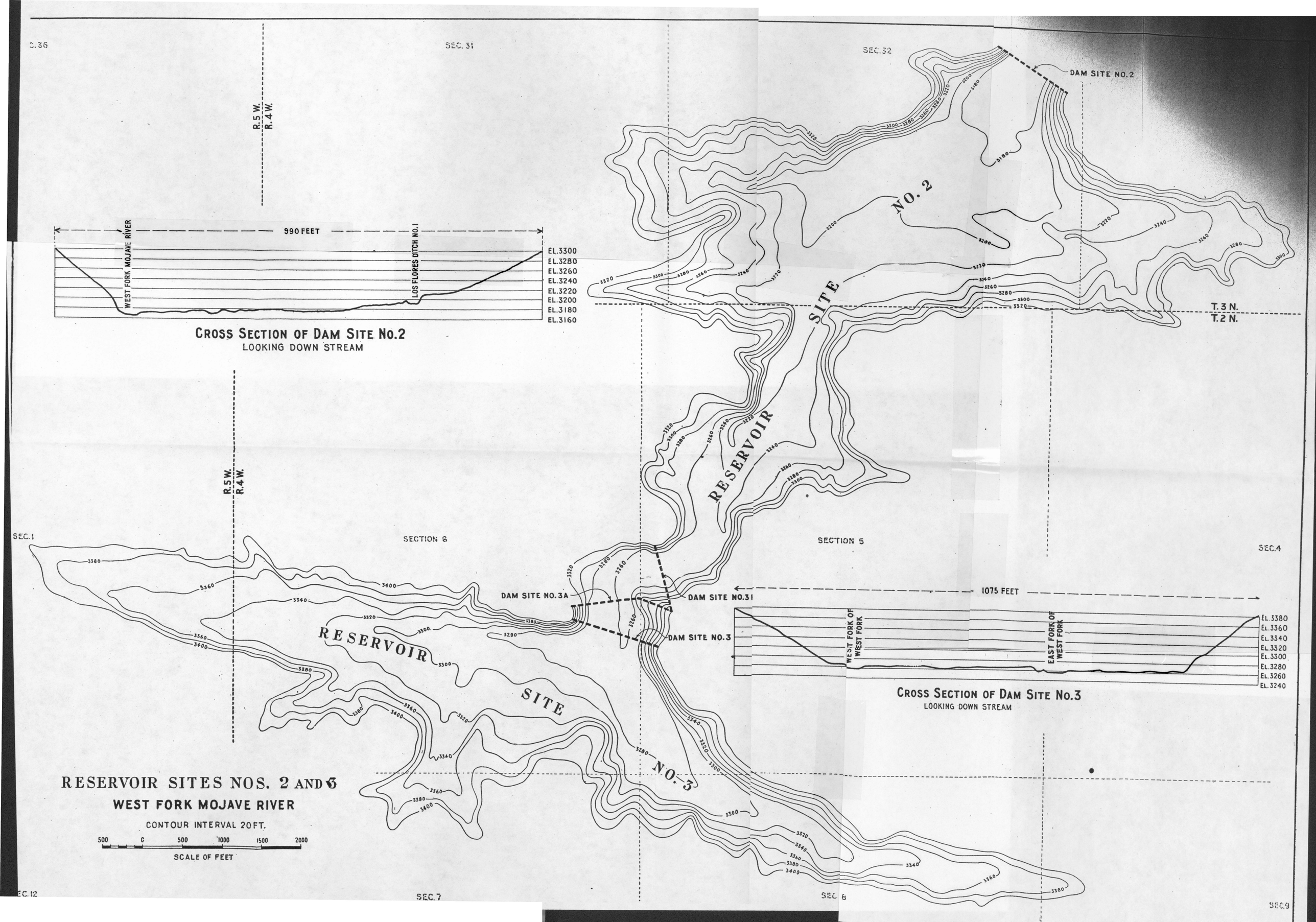
Number	Owner	Location			Well						Elevations		Pump			Power	
		Section	Township	Range	Year made	Class	Size, inches	Depth, feet	Depth to water feet	Date measured	Ground, feet	Water, feet	Kind	Size inches	Discharge claimed, mi. in.	Kind	Horsepower
148	G. A. Ground	7	5	3	1917	Dug	------	133	130.0	------	------	------	None	------	------	None	----
149	A. B. Edmonds	6	5	3	------	Dug	------	------	------	------	------	------	None	------	------	None	----
150	A. B. Sheridan	5	4	2	1915	Drilled	12	311	221.0	------	3,100.0	2,879.0	None	------	------	None	----
151	John McDonald	8	4	2	1915	Drilled	------	418	255.0	------	------	------	None	------	------	None	----
152	A. L. Martin	5	4	2	------	Drilled	12	280	187.0	------	3,041.0	2,854.0	Screw	7	60	Gasoline engine	90
153	E. C. Vessey	4	4	2	1915	Drilled	12	450	177.0	Mar. 1, '17	3,027.0	2,850.0	Air lift	------	60	Gasoline engine	60
154	E. Beasley	32	5	2	------	Drilled	12	307	170.0	Mar. 3, '17	3,025.7	2,855.7	None	------	------	None	----
155	J. B. Davis	32	5	2	------	Drilled	10	200	160.7	Mar. 3, '17	3,011.5	2,850.8	Cylinder	------	------	Windmill	----
156	E. R. Wheatley	4	4	2	------	Drilled	7	195	168.0	------	3,024.9	2,856.9	Cylinder	------	------	Windmill	----
157	E. R. Wheatley	4	4	2	1917	Drilled	------	------	------	------	3,036.0	------	None	------	------	None	----
158	D. W. Hurlihy	4	4	2	1915	Drilled	12	500	222.9	Mar. 1, '17	3,075.6	2,852.7	Air lift	------	40	Gasoline engine	----
159	D. W. Hurlihy	10	4	2	1915	Drilled	12	550	220.3	Mar. 1, '17	3,073.2	2,852.9	Air lift	------	40	Gasoline engine	----
160	J. W. Beasley	10	4	2	1915	Drilled	12	501	183.7	Mar. 1, '17	3,058.2	2,874.5	Air lift	------	------	Gasoline engine	----
161	F. Liebold	14	4	2	------	Dug	------	147	144.2	Mar. 2, '17	------	------	Cylinder	------	------	Windmill	----
162	W. S. Cherry	12	4	2	------	Drilled	12	270	63.0	------	------	------	Double dp. w.	------	------	Gasoline engine	25
163	W. S. Cherry	12	4	2	------	Drilled	12	70	62.0	------	------	------	Cylinder	------	------	Windmill	----
164	John McPherson	1	4	2	------	Dug	------	24	19.0	------	------	------	Cylinder	------	------	Windmill	----
165	—— Lockhart	6	4	1	------	Dug	------	------	------	------	------	------	None	------	------	None	----
166	—— Lockhart	6	4	1	------	Dug	------	30	24.3	Mar. 2, '17	------	------	Centrifugal	------	------	Gasoline engine	----
167	—— Lockhart	6	4	1	------	Dug	------	30	26.4	Mar. 2, '17	------	------	Cylinder	------	------	Windmill	----
168	C. P. Summers	5	4	1	------	Dug	------	26	23.4	Mar. 2, '17	------	------	Cylinder	------	------	Windmill	----
169	C. P. Summers	5	4	1	------	Dug	------	26	23.4	Mar. 2, '17	------	------	Cylinder	------	------	Windmill	----
170	F. H. Hunt	35	4	5	1913	Drilled	12	816	750.0	------	3,613.9	2,863.9	Cylinder	------	------	None	----
171	S. Zacsek	15	4	6	1912	Drilled	12	909	869.5	------	3,800.0	2,930.5	Cylinder	3x4	1	Gasoline engine	14
172	L. J. Hampton	22	4	5	1914	Drilled	12	802	650.0	------	3,551.9	2,901.9	Deep well	5	5	Gasoline engine	15
173	F. W. Lang	35	5	6	------	Drilled	12	598	505.3	April 6, '17	3,405.9	2,900.6	None	------	------	None	----
174	Verde Ranch	5	4	5	------	Drilled	12	644	510.0	April 11, '18	3,390.0	2,880.0	None	------	------	None	----
175	F. C. Lang	22	5	6	1914	Drilled	12	536	330.0	------	3,254.5	2,924.5	Double dp. w.	7	33	Gasoline engine	40
176	Julia Lang	22	5	6	------	Drilled	12	475	328.5	April 6, '17	3,250.1	2,921.6	None	------	------	None	----
177	Secord & Black	12	4	5	1914	Drilled	12	572	490.0	April 12, '18	3,351.5	2,861.5	Cylinder	------	------	None	----
178	Appleton L. W. & P. Co.	21	5	4	------	Drilled	8	753	342.0	------	3,200.0	2,858.0	None	------	------	None	----
179	W. W. Yeager	18	5	5	1915	Dug	------	305	298.6	April 6, '17	3,142.8	2,844.2	None	------	------	None	----
180	C. R. Smyth	15	5	5	1902	Drilled	8	323	292.5	April 6, '17	3,090.3	2,817.8	Cylinder	------	------	Windmill	----
181	S. V. Benson	20	5	5	------	Drilled	7	365	323.0	Mar. 8, '17	3,165.3	2,842.3	None	------	------	None	----
182	Appleton L. W. & P. Co.	16	5	4	------	Drilled	14	861	29.0	Feb. 24, '17	2,848.3	2,819.3	Turbine	------	35	Gasoline engine	----
183	W. G. Dobie	22	5	5	1912	Drilled	10	340	305.0	------	3,125.9	2,820.9	Double dp. w.	5x18	------	None	----
184	W. G. Dobie	22	5	5	1903	Drilled	5	325	300.0	------	3,125.9	2,825.9	Single dp. w.	3¼x4x8	------	Gasoline engine	----
185	H. T. Woods	22	5	5	1908	Drilled	8	340	297.5	------	3,121.0	2,823.5	Double dp. w.	5x30	12	Gasoline engine	----
186	P. S. Carl	12	5	5	1909	Dug	------	------	143.1	Mar. 8, '17	2,938.3	2,794.2	None	------	------	None	----
187	A. M. Corder	12	5	5	------	Drilled	8	80	70.0	------	------	------	None	------	------	None	----
188	A. T. & S. F. R. R.	13	5	5	------	Drilled	8	300	70.0	------	2,967.1	2,897.1	None	------	------	None	----
189	C. H. Smith	2	5	5	1909	Dug	------	156	153.0	------	2,949.6	2,796.6	Cylinder	------	------	Windmill	----
190	C. H. Smith	2	5	5	1913	Dug	------	------	120.9	Mar. 8, '17	2,902.2	2,781.3	None	------	------	None	----
191	E. L. De Bolt	8	5	5	1912	Drilled	12	285	238.6	Mar. 8, '17	3,050.0	2,811.4	Deep well	------	------	Gasoline engine	12
192	L.W. De Bolt	12	5	6	1913	Dug	------	------	211.0	April 6, '17	3,065.0	2,854.0	Cylinder	------	------	Windmill	----
193	J. D. Caldwell	6	5	5	1912	Drilled	10	650	174.6	Mar. 8, '17	------	------	Deep well	------	25	Gasoline engine	16
194	J. Biescar	32	6	5	1912	Drilled	12	243	112.0	------	------	------	Double dp. w.	18	20	Gasoline engine	15
195	E. S. Fisk	34	6	5	------	Dug	------	------	150.0	Feb. 13, '18	2,925.0	2,775.0	Cylinder	------	3	Gasoline engine	----
196	J. M. Scott	34	6	5	------	Drilled	------	157	137.0	------	------	------	Cylinder	3	------	Gasoline engine	1
197	H. Martin	33	6	5	------	Drilled	------	------	------	------	------	------	Cylinder	5	------	Gasoline engine	----
198	J. L. Trummond	26	6	5	------	Drilled	6	500	153.2	April 5, '17	------	------	None	------	------	None	----
199	H. K. Hedges	14	6	5	------	Dug	------	------	119.0	Feb. 13, '18	2,841.1	2,722.1	Cylinder	5	------	None	----
200	H. K. Hedges	14	6	5	------	Dug	------	------	120.0	Feb. 13, '18	2,836.7	2,716.7	None	------	------	None	----
201	E. K. Isaacs	16	6	5	------	Drilled	12	158	102.0	Feb. 13, '18	2,838.3	2,736.3	Cylinder	5x20	12	Gasoline engine	15
202	E. H. Richardson	28	6	5	------	Drilled	12	595	113.0	Feb. 13, '18	2,879.5	2,766.5	Air lift	7¼x12	40	Gasoline engine	80
203	E. H. Richardson	28	6	5	1916	Drilled	14	------	124.3	April 5, '17	------	------	Air lift	7¼x12	40	Gasoline engine	80
204	E. H. Richardson	20	6	5	------	Drilled	12	------	88.0	Feb. 14, '18	2,857.6	2,769.6	Cylinder	------	------	Windmill	----
205	E. H. Richardson	20	6	5	------	Drilled	12	------	89.0	Feb. 14, '18	2,857.0	2,768.0	None	------	------	None	----
206	E. H. Richardson	20	6	5	------	Drilled	------	------	------	------	------	------	None	------	------	None	----
207	W. S. Lehman	27	6	5	------	Drilled	7	709	100.0	------	------	------	None	------	------	None	----
208	—— Campbell	8	6	5	------	Drilled	------	295	------	------	------	------	None	------	------	None	----
209	A. M. Steele	5	5	7	------	Drilled	6	390	232.0	------	3,155.1	2,923.1	Cylinder	------	------	Gasoline engine	----
210	O. W. Jessup	9	5	7	------	Drilled	8	350	280.0	------	3,211.1	2,931.1	Cylinder	------	------	Gasoline engine	3
211	T. O. Ford	4	5	7	------	Drilled	12	300	238.3	April 7, '17	3,157.4	2,919.1	Cylinder	4	------	Gasoline engine	6
212	G. S. Pownald	2	5	7	1913	Drilled	6	380	235.0	------	3,157.8	2,922.8	Cylinder	------	------	Windmill	----
213	De Meville-Rowley	12	5	7	------	Drilled	12	415	315.0	------	------	------	None	------	------	None	----
214	W. Sly	6	5	6	1911	Drilled	12	------	251.0	Feb. 19, '18	3,149.3	2,898.3	None	------	------	None	----
215	G. W. Phenice	31	6	7	1915	Drilled	12	410	153.4	April 7, '17	------	------	None	------	------	None	----
216	Paul Showers	30	6	7	1915	Drilled	12	295	80.0	------	------	------	Deep well	------	------	Gasoline engine	1½
217	H. M. Engebritson	27	6	7	1915	Dug	------	150	135.0	------	------	------	Deep well	------	1	Gasoline engine	3
218	W. Campbell	27	6	7	1916	Drilled	12	400	125.0	------	------	------	Centrifugal	3	25	Gasoline engine	6
219	C. B. Hawks	21	6	7	------	Dug	------	97	------	------	------	------	Deep well	------	1	Gasoline engine	3
220	J. R. Palmer	22	6	7	1912	Drilled	12	330	76.0	------	------	------	None	------	------	None	----
221	C. Williams	22	6	7	------	Drilled	12	425	73.0	April 6, '17	------	------	Air lift	------	13	Gasoline engine	35

TABLE OF DATA ON WELLS AND PUMPING PLANTS IN VICTOR VALLEY—Continued.

Number	Owner	Location			Well						Elevations		Pump			Power	
		Section	Township	Range	Year made	Class	Size, inches	Depth, feet	Depth to water feet	Date measured	Ground, feet	Water, feet	Kind	Size, inches	Discharge claimed, mi. in.	Kind	Horsepower
222	D. Anderson	24	6	7	------	Dug	------	61	57.0	Feb. 21, '18	2,922.0	2,865.0	None	------	------	None	----
223	H. Braden	24	6	7	------	Drilled	------	------	88.6	Mar. 7, '17	------	------	None	------	------	None	----
224	C. H. Sampson	30	6	6	1915	Drilled	12	250	133.2	Mar. 7, '17	------	------	None	------	------	None	----
225	C. H. Sampson	30	6	6	1911	Drilled	12	136	133.2	Mar. 7, '17	------	------	None	------	------	None	----
226	F. Reinke	32	6	6	1910	Drilled	12	380	131.0	Feb. 20, '18	------	------	None	------	------	None	----
227	J. W. Walker	28	6	6	------	Drilled	12	136	102.0	------	3,047.8	2,916.8	None	------	------	None	----
228	L. M. Cotton	28	6	6	1915	Drilled	12	150	105.0	Feb. 20, '18	2,948.3	2,846.3	Cylinder	------	------	Gasoline engine	----
229	W. B. Phillips	18	6	6	1911	Drilled	12	76	45.0	------	2,948.9	2,843.9	Deep well	------	------	Gasoline engine	3
230	F. P. Williams	18	6	6	------	Drilled	12	------	48.9	April 7, '17	------	------	None	------	------	None	----
231	F. P. Williams	18	6	6	------	Drilled	12	205	32.0	------	------	------	None	------	------	None	----
232	R. Atz	14	6	7	1912	Dug	------	------	------	------	------	------	Deep well	------	------	Gasoline engine	4
233	Ed White	15	6	7	------	Drilled	8	58	49.0	------	------	------	Cylinder	------	------	Gasoline engine	3
234	W. Huston	20	6	7	------	Dug	------	67	65.3	April 7, '17	------	------	Deep well	------	------	Gasoline engine	3
235	Etta McKelvey	17	6	7	1916	Drilled	12	300	73.5	April 7, '17	------	------	None	------	------	None	----
236	W. J. Shaw	18	6	7	------	Dug	------	------	55.5	Feb. 17, '18	2,920.8	2,865.3	None	------	------	None	----
237	E. Bonino	18	6	7	------	Dug	------	------	50.0	Feb. 17, '18	2,897.8	2,847.8	None	------	------	None	----
238	W. E. Anderson	18	6	7	------	Dug	------	------	52.0	------	------	------	None	------	------	None	----
239	F. A. Forsyth	7	6	7	1914	Drilled	8	50	37.5	Feb. 16, '18	2,870.4	2,832.9	None	------	------	None	----
240	J. Dobersch	7	6	7	------	Drilled	12	------	------	------	------	------	None	------	------	None	----
241	G. B. Flock	8	6	7	------	Drilled	8	42	37.0	------	------	------	None	------	------	None	----
242	I. S. Lindley	9	6	7	1914	Drilled	8	------	------	------	------	------	None	------	------	None	----
243	E. F. Anger	10	6	7	------	Dug	------	140	24.0	------	2,857.1	2,818.1	Cylinder	------	------	Gasoline engine	----
244	J. Seward	11	6	7	------	Dug	------	------	23.2	------	2,869.0	2,845.8	Deep well	------	------	Gasoline engine	----
245	E. J. Krause	11	6	7	1916	Drilled	12	210	21.0	Feb. 21, '18	2,849.2	2,828.2	Centrifugal	------	42	Gasoline engine	8
246	K. McDonald	11	6	7	------	Dug	------	25	21.5	Feb. 21, '18	2,853.9	2,832.4	None	------	------	None	----
247	Grace E. Davis	2	6	7	1916	Drilled	14	226	20.5	Feb. 21, '18	2,841.1	2,820.6	Centrifugal	5	45	Gasoline engine	15
248	W. M. Gray	3	6	7	1912	Drilled	12	392	16.0	------	------	------	None	------	------	None	----
249	W. M. Gray	3	6	7	------	Drilled	12	367	23.1	Mar. 7, '17	------	------	None	------	------	None	----
250	T. R. Croswell	4	6	7	1912	Drilled	12	183	27.0	------	------	------	Deep well	------	15	Gasoline engine	15
251	T. R. Croswell	9	6	7	------	Dug	------	26	26.0	------	------	------	None	------	------	None	----
252	Marian B. Charles	5	6	7	1912	Drilled	7	157	25.0	------	------	------	Centrifugal	2½	18	Gasoline engine	15
253	Marian B. Charles	5	6	7	1917	Dug	------	41	36.0	Feb. 16, '18	2,853.3	2,817.3	Cylinder	6x8	4	Gasoline engine	6
254	W. H. Anderson	5	6	7	1916	Drilled	8	58	22.0	------	------	------	Centrifugal	½	15	Gasoline engine	10
255	S. P. R. R.	7	6	6	1890	Dug	------	24	23.0	Feb. 14, '18	2,838.2	2,815.2	None	------	------	None	----
256	L. C. Wheeler	35	7	7	------	Dug	------	------	42.0	Feb. 14, '18	2,859.3	2,717.3	Centrifugal	------	------	Gasoline engine	5
257	C. W. Brockman	32	7	7	1915	Drilled	12	80	27.0	Feb. 16, '18	2,843.3	2,816.3	None	------	------	None	----
258	L. L. Whitlock	28	7	7	------	Drilled	7	93	31.0	Feb. 16, '18	2,848.0	2,817.0	Centrifugal	4	------	Gasoline engine	15
259	C. Munsey	22	7	7	1913	Drilled	7	118	78.0	------	------	------	Cylinder	------	------	Windmill	----
260	L. Hess	27	7	7	1917	Drilled	10	125	46.0	Feb. 16, '18	2,862.9	2,816.9	Centrifugal	6	75	Gasoline engine	----
261	J. Young	8	7	7	------	Dug	------	100	95.0	------	------	------	None	------	------	None	----
262	F. Busch	10	5	4	1917	Dug	------	------	8.0	------	2,719.6	2,711.6	Centrifugal	3	------	Gasoline engine	6
263	G. Smith	10	5	4	------	Drilled	14	59	3.0	------	2,714.0	2,711.0	Centrifugal	6	------	Electric	10
264	E. Doulch	10	5	4	------	Drilled	14	39	10.5	------	2,715.8	2,705.3	None	------	------	None	----
265	S. Rogers	3	5	4	------	Drilled	------	------	14.6	------	2,708.6	2,694.0	Cylinder	------	------	Windmill	----
266	C. Bassini	34	6	4	------	Drilled	14	75	------	------	2,696.4	------	Centrifugal	4	70	Gasoline engine	18
267	C. Bassini	34	6	4	------	Drilled	12	107	87.0	------	2,758.4	2,671.4	Deep well	5x18	30	Gasoline engine	5
268	—— Hadley	34	6	4	------	Drilled	------	------	56.3	Feb. 16, '17	------	------	None	------	------	None	----
269	—— ——	10	5	4	------	Dug	------	------	48.2	------	2,770.9	2,722.7	None	------	------	None	----
270	—— ——	5	5	5	------	Dug	------	------	------	------	2,780.7	------	None	------	------	None	----
271	—— ——	32	6	4	------	Dug	------	------	3.0	------	2,737.3	2,734.3	None	------	------	None	----
272	—— ——	32	6	4	------	Dug	------	------	9.1	------	2,721.4	2,712.3	None	------	------	None	----
273	Victor Cement Co.	18	6	4	1909	Drilled	12	260	------	------	------	------	Centrifugal	3	------	Electric	15
274	Victor Cement Co.	18	6	4	1916	Drilled	16	125	------	------	------	------	Centrifugal	8	180	Electric	30
275	Victor Cement Co.	18	6	4	1916	Drilled	16	270	------	------	------	------	Centrifugal	8	180	Electric	30
276	W. Watkins	30	7	4	1914	Drilled	12	202	54.0	------	------	------	Double dp. w.	8	15	Gasoline engine	12
277	W. Watkins	30	7	4	1914	Drilled	12	100	15.0	------	------	------	Centrifugal	4	------	Gasoline engine	10
278	C. A. Poole	19	7	4	1916	Drilled	12	225	30.6	April 8, '17	------	------	Centrifugal	8	12	Gasoline engine	32
279	A. Edwards	26	7	5	------	Dug	------	------	171.0	Feb. 18, '18	2,737.0	2,566.0	None	------	------	None	----
280	J. M. Peden	27	7	5	------	Dug	------	------	------	------	------	------	None	------	------	None	----
281	—— Kirkpatrick	27	7	5	------	Dug	------	------	------	------	------	------	None	------	------	None	----
282	W. Warren	27	7	5	------	Dug	------	------	81.0	Feb. 18, '17	2,718.3	2,637.3	None	------	------	None	----
283	—— Gwyne	15	7	5	------	Drilled	12	235	------	------	------	------	None	------	------	None	----
284	Y. M. C. A.	31	7	5	1914	Drilled	12	230	------	------	------	------	None	------	------	None	----
285	—— Mallman	2	6	5	1915	Drilled	12	235	208.0	Feb. 18, '18	2,786.0	2,578.0	None	------	------	None	----
286	L. P. Burgmeir	26	7	5	------	Dug	------	------	105.0	Feb. 18, '18	2,724.0	2,619.0	None	------	------	None	----
287	—— ——	2	6	5	------	Dug	------	------	204.0	Feb. 18, '18	2,780.0	2,576.0	Cylinder	------	------	Windmill	----
288	—— ——	10	6	5	------	Dug	------	------	108.0	Feb. 18, '18	2,807.0	2,699.0	None	------	------	None	----
289	E. H. Richardson	28	6	5	1917	Drilled	12	------	------	------	2,878.0	------	None	------	------	None	----
290	E. H. Richardson	28	6	5	1917	Drilled	8	350	133.0	Feb. 14, '18	2,878.0	2,745.0	None	------	------	None	----
291	—— ——	14	6	5	------	Dug	------	------	113.5	Feb. 18, '18	2,823.0	2,709.5	None	------	------	None	----
292	B. S. Hook	14	6	6	------	Dug	------	------	42.5	Feb. 20, '18	2,833.0	2,790.8	Centrifugal	------	------	Gasoline engine	----
293	W. J. Jensen	35	7	7	------	Drilled	12	203	36.0	Feb. 14, '18	2,853.0	2,817.0	None	------	------	None	----
294	B. M. Elsey	26	7	7	------	Dug	------	44	42.0	Feb. 14, '18	2,857.0	2,815.0	None	------	------	Gasoline engine	----

TABLE OF DATA ON WELLS AND PUMPING PLANTS IN VICTOR VALLEY—Continued.

Number	Owner	Location			Well						Elevations		Pump			Power	
		Section	Township	Range	Year made	Class	Size, inches	Depth, feet	Depth to water feet	Date measured	Ground, feet	Water, feet	Kind	Size, inches	Discharge claimed, mi. in.	Kind	Horsepower
295	—— Gilbert	26	7	7	1917	Dug	------	------	74.0	Feb. 14, '18	2,891.0	2,817.0	None	------	------	None	----
296	L. B. Coleman	6	5	7	------	Drilled	10	------	199.0	Feb. 17, '18	3,109.0	2,910.0	None	------	------	None	----
297	John Breen	35	7	7	------	Dug	------	25	20.0	Feb. 21, '18	2,837.5	2,817.5	None	------	------	None	----
298	—— ——	2	6	7	------	Dug	------	------	17.0	Feb. 21, '18	2,835.7	2,817.7	None	------	------	None	----
299	El Mirage School	3	6	7	------	Dug	------	------	22.0	Feb. 21, '18	2,842.8	2,820.8	None	------	------	None	----
300	—— ——	12	6	7	------	Dug	------	------	21.0	Feb. 21, '18	2,867.0	2,846.0	Cylinder	------	------	None	----
301	F. L. Thomas	18	4	5	------	Drilled	7	330	Dry	------	------	------	None	------	------	Windmill	----
302	W. H. Robinson	6	6	4	------	Dug	------	41	35.0	------	------	------	Cylinder	------	------	None	----
303	E. B. Rowley	19	7	4	------	Drilled	------	270	60.0	------	------	------	Centrifugal	------	100	Windmill	----
304	E. B. Rowley	19	7	4	------	Dug	------	110	92.0	------	------	------	None	------	------	Gasoline engine	60
305	P. Herlick	7	7	4	------	Dug	------	40	34.0	------	------	------	None	------	------	None	----
306	F. C. Abbott	18	7	4	------	Drilled	------	270	55.0	------	------	------	Centrifugal	------	105	None	----
307	C. A. Garbutt	21	6	5	------	Dug	------	------	170.0	------	------	------	None	------	------	Gasoline engine	40
308	A. H. Diamond	26	6	5	------	Dug	------	------	120.0	------	------	------	None	------	------	None	----
309	H. C. Jones	19	6	5	------	Dug	------	87	75.0	------	------	------	None	------	------	None	----
310	J. C. White	30	6	5	------	Dug	------	------	96.0	------	------	------	None	------	------	None	----
311	Olive A. Stone	30	6	5	------	Dug	------	------	100.0	------	------	------	None	------	------	None	----
312	W. L. Norris	20	6	6	------	Drilled	12	------	130.0	------	------	------	None	------	------	None	----
313	—— ——	27	6	6	------	Drilled	12	------	128.0	------	------	------	None	------	------	None	----
314	R. R. Jamison	18	6	6	------	Dug	------	58	56.0	------	------	------	None	------	------	None	----
315	R. R. Jamison	14	6	6	------	Dug	------	50	43.0	------	------	------	None	------	------	None	----
316	—— ——	14	6	6	------	Dug	------	54	40.0	------	------	------	None	------	------	None	----
317	W. W. McKinney	30	6	7	------	Dug	------	159	139.0	------	------	------	Cylinder	------	------	Windmill	----
318	G. Penaul	2	5	6	------	Dug	------	------	236.0	------	------	------	None	------	------	None	----
319	T. A. De Bolt	12	5	6	------	Dug	------	------	150.0	------	------	------	None	------	------	None	----
320	D. S. Ball	12	5	6	------	Drilled	------	423	300.0	------	------	------	None	------	------	None	----
321	P. Weile	18	5	5	------	Drilled	------	365	313.0	------	------	------	None	------	------	None	----
322	S. I. Pickert	34	5	5	------	Drilled	------	578	570.0	------	------	------	None	------	------	None	----
323	—— ——	24	5	5	------	Drilled	------	------	240.0	------	------	------	None	------	------	None	----
324	—— ——	1	5	5	------	Dug	------	------	119.0	------	------	------	None	------	------	None	----
325	A. T. & S. F. R. R.	10	5	4	------	Drilled	------	200	10.0	------	------	------	Centrifugal	------	------	Electric	----
326	L. Harris	34	5	3	------	Drilled	------	344	187.0	------	------	------	None	------	------	None	----
327	R. W. Miller	15	4	3	------	Drilled	------	195	145.0	------	------	------	None	------	------	None	----
328	E. D. Vessey	4	4	2	------	Dug	------	------	160.0	------	------	------	Cylinder	------	------	Windmill	----
329	F. H. Nett	19	5	2	------	Dug	------	------	98.0	------	------	------	None	------	------	None	----
330	—— Hitchcock	19	5	2	------	Dug	------	------	100.0	------	------	------	None	------	------	None	----
331	W. C. Marston	27	7	3	------	Dug	------	------	130.0	------	------	------	Deep well	------	10	Gasoline engine	----
332	A. J. Allen	28	6	2	------	Dug	------	------	123.0	------	------	------	None	------	------	None	----
333	—— Jackson	33	6	2	------	Dug	------	------	160.0	------	------	------	None	------	------	None	----


C.36
SEC. 31
SEC. 32
R.5 W.
R.4 W.
DAM SITE NO. 2
990 FEET
WEST FORK MOJAVE RIVER
LOS FLORES DITCH NO. 1
EL. 3300
EL. 3280
EL. 3260
EL. 3240
EL. 3220
EL. 3200
EL. 3180
EL. 3160
CROSS SECTION OF DAM SITE NO. 2
LOOKING DOWN STREAM
RESERVOIR SITE NO. 2
T. 3 N.
T. 2 N.
SEC. 1
SECTION 6
SECTION 5
SEC. 4
DAM SITE NO. 3A
DAM SITE NO. 3 1
DAM SITE NO. 3
1075 FEET
WEST FORK OF WEST FORK
EAST FORK OF WEST FORK
EL. 3380
EL. 3360
EL. 3340
EL. 3320
EL. 3300
EL. 3280
EL. 3260
EL. 3240
CROSS SECTION OF DAM SITE NO. 3
LOOKING DOWN STREAM
RESERVOIR SITE NO. 3
RESERVOIR SITES NOS. 2 AND 3
WEST FORK MOJAVE RIVER
CONTOUR INTERVAL 20 FT.
500 0 500 1000 1500 2000
SCALE OF FEET
SEC. 12
SEC. 7
SEC. 8
SEC. 9