November 21, 1917.

Mr. Ellis:

The Governement engineer has asked for a report on the net safe yield of the Volcan system. Get two copies of the five engineers reports.

Ed Fletcher.

F-S

H. HAWGOOD
M. AM. SOC. C. E.
M. INST. C. E. (LONDON)
M. AM. RY. ENG. & M. W. ASSOC.
CONSULTING ENGINEER
H. W. HELLMAN BUILDING
LOS ANGELES, CALIFORNIA

# Supplemental Report

on the Projects of the

## Volcan Land & Water Company

San Diego County, California.

July, 1914.

H. HAWGOOD
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# Supplemental Report
## on the Projects of the
## Volcan Land & Water Company,
## San Diego County, California.

July, 1914.

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This report on the projects of the Volcan Land & Water Company carries the subject matter forward to the end of the water season 1913-14 and is supplemental to a previous report dated November, 1912, to which reference is made.

The hydrological data of the former report has been enlarged by the rainfall and run-off data of the two additional seasons, and by data as to evaporation obtained by tests extending over a period of fifteen months.

During the time which has elapsed since the previous report, the Company has been systematically advancing the developement of its properties.

Surveys of reservoir sites and conduits have been amplified; core drilling explorations have been completed of the underlying rock at the Pamo Dam Site on Santa Ysabel Creek, and similar explorations are now in progress at the

Carroll Dam Site, acquired by the Company during the past twelve months. This dam site is situated on the Santa Ysabel or San Dieguito River, five miles below the road bridge on the highway between San Diego and Escondido, and nineteen miles below the Pamo Reservoir Site on the same stream.

In common with all Southern California water enterprises, the projects of the Volcan Land & Water Company are based in the main on the storage of storm waters. The Company is now possessed of six reservoir sites:

1. Warner, on the San Luis Rey
2. Sutherland, )
3. Pamo, ) on the Santa Ysabel-San Dieguito
4. Carroll, )
5. Santa Maria, on a feeder of the Santa Ysabel
6. San Clemente, Linda Vista Mesa.

The particulars of these reservoirs are given in the data forming part of this report.

The outlet tunnel from the Warner Reservoir, 1,020 feet in length, has been driven, and is at this time being lined with concrete.

The rapid growth of the City of San Diego during recent years has demonstrated the necessity of a greater water supply for that City. The properties of the Volcan Land & Water Company are capable of furnishing this needed supply.

The use of these properties for the main purpose of irrigation was discussed in the previous report, their adequacy and availability as a municipal supply for San Diego is covered herein.

As the basis for the determination of the two controlling elements of

(a), Quantity of water to be had from the properties of the Volcan Land & Water Company

(b), Cost of delivery.

There are available for item (a) sundry stream measurements of the San Luis Rey for 11 seasons, 1903-04 to 1913-14, and of the Santa Ysabel for 9 seasons, 1905-06 to 1913-14, and rainfall records of various lengths of duration, commencing in the case of San Diego as far back as 1850: and for item (b) the surveys and engineering investigations and plans of the Company, defining the work to be performed in installing the structures necessary to the delivery of the water.

# Q u a n t i t y  o f  W a t e r .

## Table 1.

### Run-off of the San Luis Rey River and Santa Ysabel Creek.

### Seasons 1903-04 to 1913-14.

### Seasonal Year, 1st July to 30th June.

| | San Luis Rey 318 sq. mi. | 210 sq. mi. | Santa Ysabel. 128 sq. mi. | |
|---|---|---|---|---|
| | Pala | Warner | San Pasqual | Carroll |
| Season | Acre-feet | Acre-feet | Acre-feet | Acre-feet |
| 1903-04 | 10,000 | (10,000) | | |
| 04-05 | 42,000 | (40,500) | | |
| 05-06 | 106,500 | 70,000 | 62,000 | |
| 06-07 | 84,500 | (53,000) | 35,500 | |
| 07-08 | 25,000 | (20,000) | 12,500 | |
| 08-09 | 48,000 | (41,000) | 46,000 | |
| 09-10 | 47,000 | (40,000) | 35,000 | |
| 1910-11 | 34,500 | (26,500) | (20,000) | |
| 11-12 | 13,500 | 11,500 | 15,500 | |
| 12-13 | 6,000 | 6,000 | 6,000 | |
| 13-14 | 28,500 | 22,500 | 21,000 | 24,500 |

Quantities within brackets are interpolations.

The soundness of the interpolations is graphically demonstrated by the agreement in inclination of the lines representing the run-offs of the various streams, Diagram, page 5.

Measurements, San Luis Rey at Pala, U. S. G. S.
" " " " " Warner, P. L. & P. Co. & V. L. & W. Co.
" Santa Ysabel at San Pasqual, U. S. G. S.
" " " " Carroll, V. L. & W. Co.

# Seasonal Run-off

San Luis Rey River

Santa Ysabel Creek

San Diego River

Seasons 1899-1900 to 1913-1914

Seasonal Year 1st July to 30th June

H. Hawgood
Consulting Engineer Los Angeles

June 1914

1899-1900 | 1900-01 | 1901-02 | 1902-03 | 1903-04 | 1904-05 | 1905-06 | 1906-07 | 1907-08 | 1908-09 | 1909-10 | 1910-11 | 1911-12 | 1912-13 | 1913-14

Scale 1" = 10,000 Acre Feet

San Luis Rey at Pala.

San Luis Rey at Warner Dam Site.

Santa Ysabel at head San Pasqual Valley.

San Diego at diverting dam.

On page 7 the quantities given in Table 1 for the run-off of the San Luis Rey at Warner have been logarithmically plotted as ordinates and the rainfall in per centages of the normal as abscissae, and through the points thus plotted has been traced a line showing the general relationship between run-off and rainfall.

On page 8 the run-off of the Santa Ysabel at the head of the San Pasqual Valley is treated in a similar manner.

The run-off curves thus established have been used in the construction of the Mass Diagrams for the San Luis Rey at Warner and the Santa Ysabel at the head of the San Pasqual Valley, (pages 9 and 10), covering the 64 years from the season of 1850-51 to that of 1913-14, both inclusive. The rainfall percentages for these seasons are those of San Diego, where the rain observations have been made since 1850, modified by such shorter time local rain records as are available, to represent as closely as ascertainable the local conditions. Details as to rainfall are discussed later on under the heading of "Rainfall".

On page 11 is a mass diagram of the flow of the San Dieguito River at the Carroll Dam Site. This stream is one and the same as the Santa Ysabel Creek, by which name it is known above Bernardo.

The Carroll mass diagram has been projected from the Santa Ysabel mass diagram by comparison of the run-off at the two places so far as shown by the measurements of 1914, and consideration of the general conditions affecting their relationship.

At times of low water there may be little or no flow at Carroll by reason of irrigation diversions above and from evaporation; during high water their relative run-off has been assumed as approximately proportional to the areas drained.

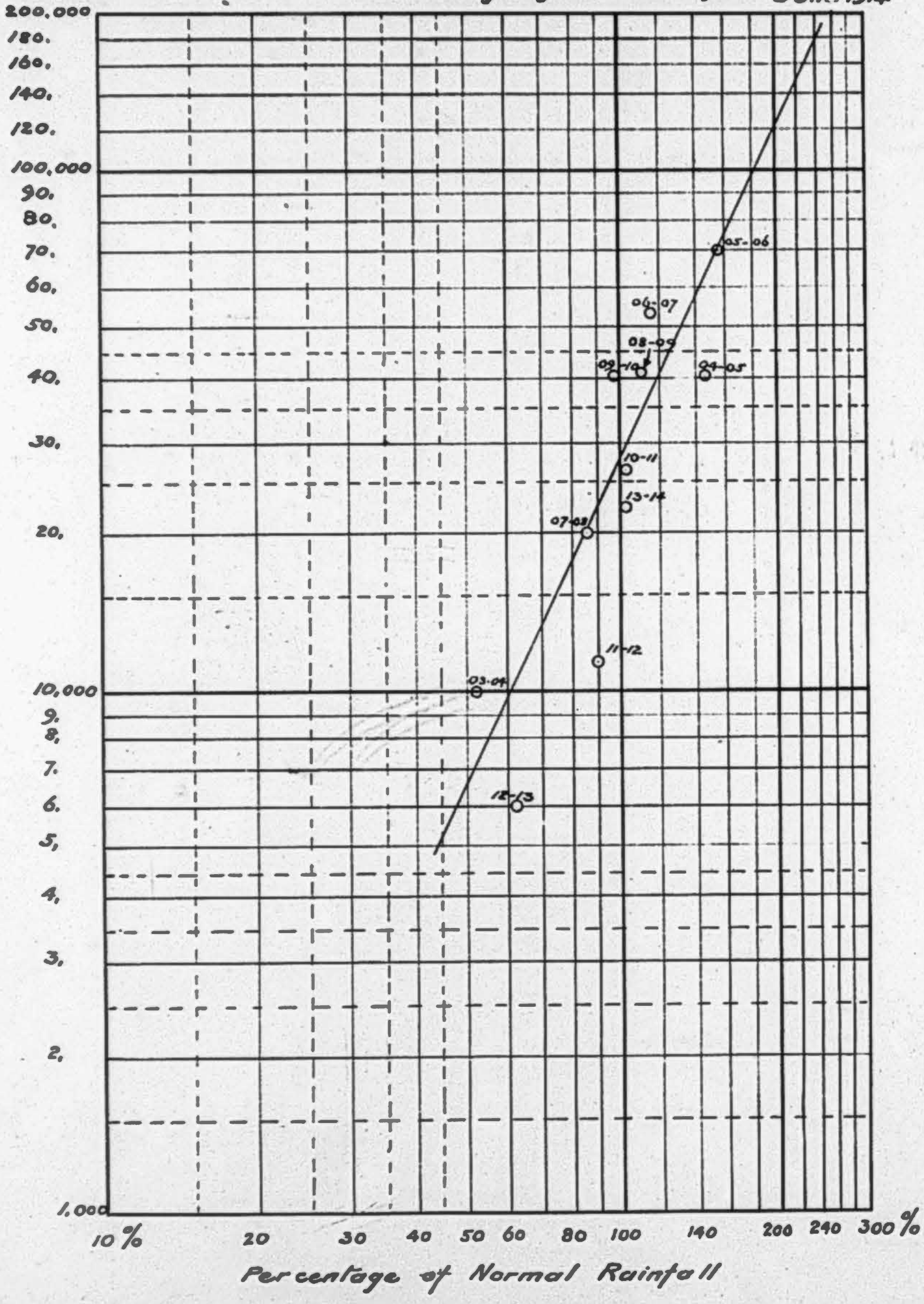
# San Luis Rey River

## Seasonal Run-off at Warner Dam-Site

Seasons 1903-4 to 1913-14 Seasonal Year 1st July to 30th June

Logarithmic Plotting - 30 Scale

H. Hawgood
Consulting Engineer Los Angeles June. 1914



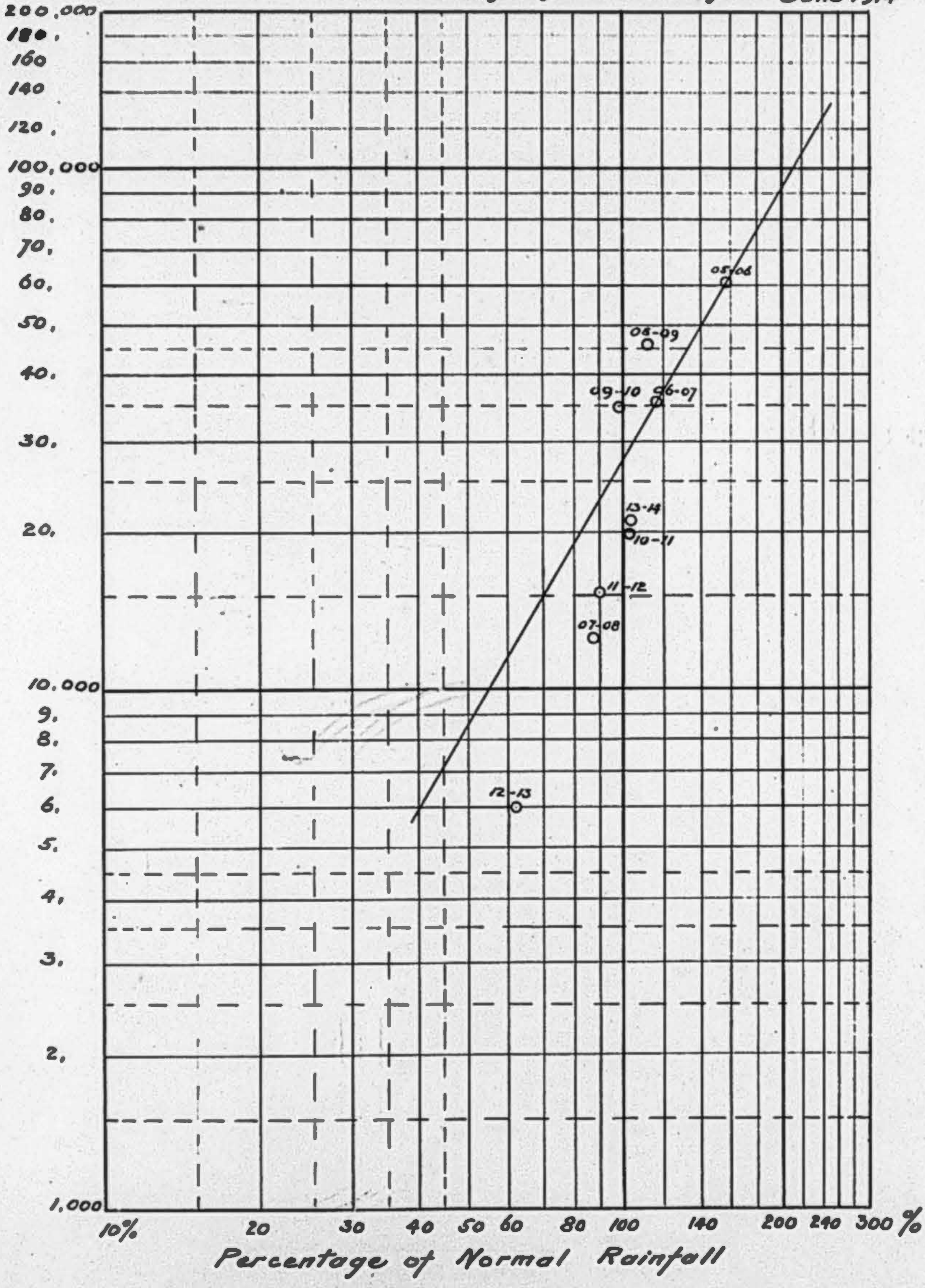
# Santa Ysabel Creek.

## Seasonal Run-off at head of San Pasqual Valley.

Seasons 1905-06 to 1913-14. Seasonal Year 1st July to 30th June

Logarithmic Plotting - 30 Scale

H. Hawgood
Consulting Engineer Los Angeles June 1914



# Mass Diagram
## San Luis Rey River at Warner Dam-Site

9

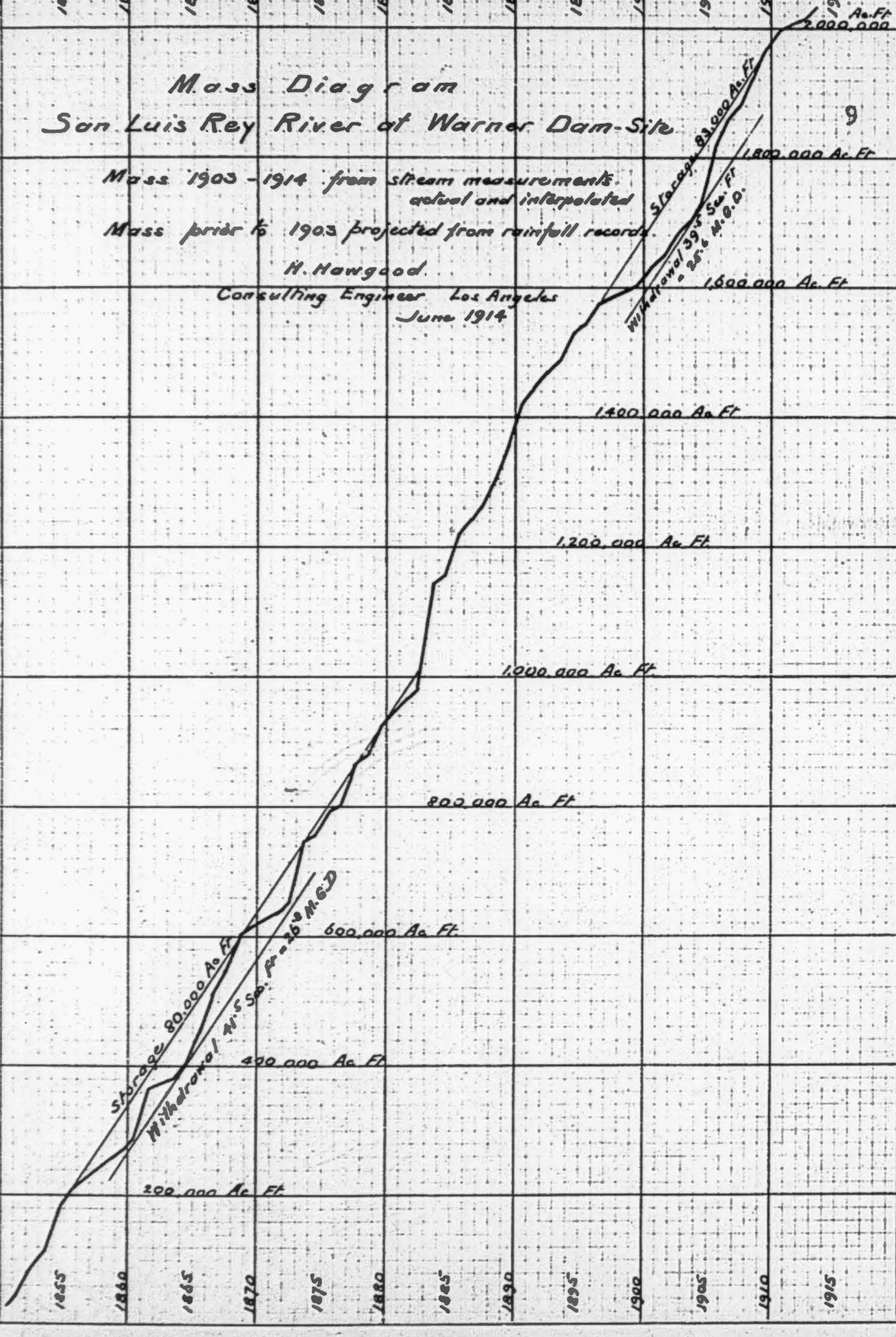
Mass 1903 - 1914 from stream measurements. actual and interpolated

Mass prior to 1903 projected from rainfall records.

H. Hawgood.

Consulting Engineer Los Angeles

June 1914



# Mass Diagram

## Santa Ysabel Creek at head of San Pasqual Valley

Mass 1905 - 1914 from stream measurements actual and interpolated

Mass prior to 1905 projected from rainfall records

H. Hargood

Consulting Engineer Los Angeles

June 1914.

20

1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915

200,000 Ac Ft.

400,000 Ac Ft

600,000 Ac Ft

800,000 Ac Ft.

1,000,000 Ac Ft

1,200,000 Ac Ft

1,400,000 Ac Ft

1,600,000 Ac Ft

1,800,000 Ac. Ft

Storage 66,000 Ac. Ft.

Withdrawal 37 Sec. Ft. = 24.3 M.G.D.

Storage 75,000 Ac. Ft.

Withdrawal 55 Sec. Ft. = 35.2 M.G.D.

11

# Mass Diagram

(Projected from Mass Diagram Santa Ysabel Creek)

## San Dieguito River at Carrol Dam Site

H. Hamgood
Consulting Engineer Los Angeles
June 1914

Storage 88,000 Ac Ft
Withdrawal 38.0 Sec Ft. 24.5 M.G.D.

Storage 20,000 Ac Ft
Withdrawal 18.7 Sec Ft - 12.1 M.G.D.

Storage 87,000 Ac Ft
Withdrawal 38.0 Sec Ft - 24.5 M.G.D.

Storage 83,000 Ac Ft
Withdrawal 38.0 Sec Ft

3,000,000 Ac Ft
2,800,000 Ac Ft
2,600,000 Ac Ft
2,400,000 Ac Ft.
2,200,000 Ac Ft
2,000,000 Ac Ft
1,800,000 Ac Ft
1,600,000 Ac Ft
1,400,000 Ac Ft
1,200,000 Ac Ft
1,000,000 Ac Ft
800,000 Ac Ft
600,000 Ac Ft
400,000 Ac Ft
200,000 Ac Ft

1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915

Diagram Carrol Fut
Showing relation between run-off at Carrol dam-site and at head of San Dieguito Valley

Santa Ysabel Acre Feet 40 60 80 100
San Dieguito Acre Feet 40 60 80

STANDARD CROSS SECTION. 10 x 10.

## R a i n f a l l .

Fourteen rain gauge stations are maintained within the Warner catchment area, and thirteen in places immediately adjacent thereto. The records of the two seasons last past indicate the normal rainfall in this region to be greater than that shown by the rain chart on page 44 of the 1912 report. The general form and direction of the isohyetals remains substantially the same, but their values are increased.

Table 2.

Precipitation for Seasons 1911-12 to 1913-14.

| Location | Station No. | 1911-12 | 1912-13 | 1913-14 | Length of Record Years | Weighted Mean or Normal |
|---|---|---|---|---|---|---|
| Warner Dam Site | 1 | 26.31 | 19.58 | 31.77 | 4 | 30.5 |
| Dannon's | 2 | 26.15 | 23.46 | 34.73 | 3 | 33.0 |
| Monkey Hill | 3 | 11.68 | 9.63 | 16.53 | 3 | 15.0 |
| Warner Summer Road | 4 | 15.26 | 11.93 | 19.35 | 3 | 18.0 |
| Puerta Cruz | 5 | 14.20 | 11.53 | 19.32 | 3 | 18.0 |
| Deadman's Hole | 6 | 18.06 | 12.19 | 23.82 | 3 | 21.0 |
| Santa Ysabel Ranch | 8 | 23.22 | 17.39 | 26.39 | 3 | 26.0 |
| Santa Ysabel Store | 9 | 25.34 | 17.12 | 25.75 | 14 | 26.5 |
| Witch Creek | 10 | 26.24 | 20.25 | 27.00 | 3 | 29.0 |
| Ramona | 12 | 17.44 | 9.66 | 18.26 | 3 | 18.0 |
| Rose Glen | 13 | 20.63 | 16.27 | 24.17 | 3 | 24.0 |
| Mesa Grande | 14 | 27.60 | 25.65 | 31.51 | 9 | 32.5 |
| Nellie | 15 | 39.08 | 39.59 | 53.14 | 10 | 47.0 |
| Mendenhall Valley | 17 | 30.38 | 24.05 | 37.21 | 3 | 36.0 |
| Chihuahua Mt. | 19 | 16.09 | 13.53 | 26.00 | 3 | 21.5 |
| Eagles Nest | 20 | 10.88 | 11.32 | 17.21 | 3 | 15.5 |
| Warners Hot Springs | 21 | 13.84 | 13.81 | 22.34 | 8 | 18.5 |
| Warner Ranch House | 22 | 14.01 | 11.64 | 20.27 | 3 | 18.0 |
| San Felipe | 23 | 21.82 | 15.56 | 26.42 | 3 | 24.5 |
| Metagual | 24 | 19.05 | 16.61 | 24.35 | 3 | 23.5 |
| Volcan Mt. | 25 | 32.93 | 32.83 | 32.46 | 3 | 32.5 |
| Aguanga | 27 | 12.83 | 8.68 | 15.28 | 3 | 14.0 |
| Julian | 28 | 26.70 | 20.76 | 35.46 | 28 | 31.5 |
| Cuyamaca | 29 | 31.90 | 30.21 | 34.26 | 27 | 38.5 |
| Hot Springs Mt. | 32 | | 14.39 | 18.92 | 2 | 20.0 |

In some instances, to round out the full season, it has been necessary to interpolate monthly precipitation, this is particularly true of the month of June, 1914, but as it is a month of little or no rainfall, no appreciable error can have been introduced.

## Evaporation.

In the 1912 report, for lack of direct information, the subject of evaporation had of necessity to be treated inferentially, the observed evaporation at Sweetwater and Cuyamaca Reservoirs being used as the base. It was deduced therefrom, page 53, that the annual evaporation at Warner Reservoir would be 34.9 inches.

In December, 1912, evaporation tests were instituted at Warner Dam Site by observing the evaporation from a pan on the hill about 80 feet above the river.

In February, 1913, a 3 ft. x 3 ft. floating pan was installed in the pond above the cut-off wall at the Warner Dam Site.

In March, 1913, a 3 ft. x 3 ft. floating pan was installed in a lake of approximately 30 acres in area and 2½ to 4 ft. deep, situated 4½ miles north-easterly from Warner Dam Site, and at 160 feet greater elevation.

In the same month of March, 1913, a similar pan was installed in the moist ground by the side of the above lake.

The recorded evaporation and rainfall at the above observation stations are given in the following table:

Table 3.

Evaporation Observations.

| | At Warner Dam Site | | | | At Lake, 30 ac., 2½ to 4' deep | | | |
|---|---|---|---|---|---|---|---|---|
| | Floating Pan 3' x 3' x 1.25' | | Pan in air 9" above ground 9" x 9" x 13" | | Floating pan 3' x 3' x 1.25' | | Pan in Moist Ground 3' x 3' x 1.25' | |
| Month | 1912-3 | 1913-4 | 1912-3 | 1913-4 | 1912-3 | 1913-4 | 1912-3 | 1913-4 |
| July | | 4.42 | | 10.07 | | 6.51 | | 6.67 |
| Aug. | | 3.72 | | 9.62 | | 5.53 | | 5.85 |
| Sept. | | 4.01 | | 9.04 | | 6.18 | | 6.73 |
| Oct. | | 4.93 | | 6.68 | | 6.29 | | 4.90 |
| Nov. | | 3.30 | | 3.36 | | 3.67 | | 2.82 |
| Dec. | | 3.40 | 4.97 | 2.77 | | 2.79 | | 1.93 |
| Jan. | | 2.76 | 4.12 | 3.05 | | 1.69 | | 1.70 |
| Feb. | 4.12 | *2.50 | 3.01 | 3.38 | | 3.50 | | 2.67 |
| Mar. | 3.79 | 1.50 | 5.93 | 5.55 | 4.31 | 4.60 | 3.58 | 3.49 |
| Apr. | 4.17 | 2.00 | 5.77 | 5.70 | 5.71 | 4.98 | 4.97 | 3.07 |
| May | 3.89 | 4.87 | 7.15 | 6.23 | 6.03 | 5.23 | 4.96 | 3.30 |
| June | 4.41 | 6.30 | 7.40 | °7.50 | 5.76 | 6.60 | 4.66 | 4.34 |
| | | 43.71 | | 74.95 | | 57.57 | | 47.47 |

* Interpolated. Records disturbed by floods.
° Interpolated.

It is to be inferred by reason of the capilary creeping of the water up the sides of the pan, thus exposing greater surfaces to evaporation, and by the absence of circulation to keep down temperature, that the evaporation from a floating pan is in excess of evaporation from open water.

There is nothing in the climatological conditions of the season 1913-14 suggestive of a light evaporation season. If on the one hand the season's precipitation of 31.77 inches, which is about 4% above the normal, indicates greater humidity than existed say in the previous 19.58-inch season, with consequent lower evaporation, on the other hand the mean monthly temperatures of 1913-14 exceeded the normal for ten months out of the twelve at Cuyamaca, for eight months at Escondido, and for ten months at San Diego. It is therefore concluded that the normal annual rate of evaporation from open water at Warner is, as shown by the pan, under 44 inches.

The floating pan at Warner is the only one of the observations which has direct bearing on the subject, but indirectly the other three sets of observations may be used.

The U. S. Weather Bureau reports on the evaporation experiments conducted by the Department at the Salton Sea, show that the evaporation from a pan, 2 feet in diameter, near the ground, is 86 per cent greater than the evaporation from open water. Applying this ratio to the pan in air at Warner, the observed 74.95 inches would represent an evaporation of 40 inches from open water.

The one-third greater evaporation from the floating pan in the 30-acre lake than from the pan in the Warner Dam pond may be attributed to a correspondingly greater area exposed to evaporation per unit of ponded water.

The evaporation from the pan sunk in moist earth may be used as indicating the evaporation from the surface of small spring-fed pools, of which there are many in the Warner Valley. In general it is in harmony with the results of tests made in the Livermore and Owens River Valleys, and elsewhere, that the evaporation from wet ground is about the same as that from open water.

Evaporation from Wet Lands in the Reservoir Basin.

It has been estimated, (1912 Report, page 54), that there are about 500 acres of wet lands that would be submerged, and evaporation therefrom would be thus saved. Opposed to this would be the moist lands created and maintained by the reservoir around its margin.

The Owens Valley tests go to show that evaporation from the ground takes place to a depth of about 9 feet at rates proportional to depth of water below the ground surface.

Examination of the maps of the reservoir shows that at average height of water, and giving due weight to the varying

slopes and earthy or rocky nature of the lands, that there would be about 350 acres of damp margin lands, in which the depth to water would range from 0 to 9 feet. The equivalent evaporative area of open water would be 175 acres. Deducting this acreage from the 500 acres of wet lands which would be submerged, there is left a net saving of 325 acres of open water evaporating surface.



## Net Evaporation from Reservoir.

The surface area of the lake exposed to evaporation at mid height would be about 2,000 acres. As an offset to this is the above 325 acres of saved evaporation from submerged wet lands. The net loss would be that from 2,000 acres, less 325, or 1,675 acres, which, at an average of 3.65 feet per annum, (43.8 inches), would amount in round figures to 6,100 acre-feet.

Of the rain which would fall on the 2,000 acres of water surface, 100 per cent would be realized where now less than 20 per cent appears in the streams, there would therefore be a gain of at least 80 per cent of the precipitation on these 2,000 acres or the equivalent of 100 per cent of the rainfall on 1,600 acres.

The normal rainfall along the south side of the reservoir,

as shown by gauges Nos. 1 and 2, is 31.75 inches, and along the north side, as shown by gauges Nos. 3 and 4, 16.5 inches, with a general weighted average of 1.9 feet.

The yield of 1,600 acres at 100 per cent of 1.9 feet rainfall would be 3,040 acre-feet, and the evaporation given above of 6,100 acre-feet being reduced by this amount leaves 3,060 acre-feet as the net annual loss to be anticipated from evaporation.

Quantity of Water Available from San Luis Rey River.

The general average run-off for the 64 year period shown in the mass diagram, page 9, is 31,820 acre-feet per year. The quantity available is controlled by the period from 1907-08 to 1901-02 inclusive, these five consecutive seasons of drouth being the lowest in the 64 years for which we have rain records.

The mass curve is computed on data acquired since 1903, chief among which is the reported run-off of the San Luis Rey River at Pala. As said in the 1912 report, it follows from the infrequency of making the measurements that they fail to account for all the water passing. Much of the run-off passes in flood peaks, to fully record which hourly measurements would be needed. The actual one, or at most in a few instances, two measurements a day, undoubtedly gave results below the truth.

The amount of this palpable shortage cannot be estimated and the records are used as they stand, but it is proper that recognition should be given to the probability that the early flood records are as a matter of fact too low.

From the mass diagram, page 9, it will be seen that with a storage of 83,000 acre-feet, a withdrawal of 39.5 second-feet, or 28,600 acre-feet per annum, could be sustained.

The evaporation loss, as previously determined, would be 3,060 acre-feet, and the net available quantity of water would be 28,600 less 3,060 or 25,540 acre-feet per annum, equivalent to a continuous flow of 35.6 second-feet or 23.1 million gallons daily.

The evaporation loss in this case is about 11 per cent of the catch. In the 1912 report, arguing from the Sweetwater evaporation records and the run-offs and rainfalls then known, the loss was placed at 14 per cent. The recorded loss at Sweetwater under conditions conducive to greater evaporation, and without elimination of any wet land evaporation, is 15 per cent.

The present finding of 35.6 second-feet as against the 44.2 second-feet of the 1912 report is brought about by the influence upon the run-off curve of the apparently abnormally low discharge, in comparison with the rainfalls, of the successive seasons of 1911-12 and 1912-13. It is probable that continuance of the records will minimize the influence of these two particular seasons upon the general average.

The subject of conduit losses is discussed in the 1912 report, pages 57-59. The total conduit loss from Warner to San Clemente Reservoir would be about 9 per cent. The net delivery from Warner Reservoir, as before given, is estimated at 35.6 second-feet, from which the net delivery to San Clemente Reservoir would be 32.4 second-feet, or 21 million gallons daily.

From San Clemente, the distribution to the City of San Diego, 8 miles distant, or to the neighboring Linda Vista lands, would be by pipe without evaporation loss.

Quantity of Water available from Santa Ysabel Creek.

The average yearly discharge, as computed for the past 64 years, is 28,900 acre-feet at the San Pasqual station, and 32,400 acre-feet at the Carroll station, the lower station having an excess over and above the upper station, notwithstanding the irrigation diversions and evaporation losses which take place in the nineteen miles between the two stations.

The position of the Carroll Reservoir, coming as it does below the irrigated lands of San Pasqual and Bernardo, is advantageous, its operation cannot be an interference, it gets the benefit of the return waters, and lessens the storage capacity requisite on the upper waters.

The projected reservoir at Carroll has a capacity of 20,000 acre-feet. It will be seen by reference to the mass

diagram that this amount of storage would sustain a withdrawal of 18.7 second-feet, or 12.1 million gallons daily, and as the delivery to the City of San Diego would be by pipe, without evaporation losses, the quantity of 12.1 million gallons is not.

The average stream flow at Carroll is computed at 32,400 acre-feet, equivalent to 44.7 second-feet: after supplying the foregoing 18.7 second-feet, there would be left 26 second-feet, part of which would be dissipated in evaporation and the remainder run to waste unless conserved in up-stream reservoirs.

So far as the available measurements show, the river gains 3,500 acre-feet in the nineteen miles between the head of the San Pasqual Valley and Carroll. This quantity being computed from a limited number of observations, may be changed by additional measurements made as time goes on. For the present purposes, however, its absolute accuracy is not material, it suffices to show that notwithstanding irrigation diversions and evaporation losses direct, and through vegetation, the stream is a gaining one.

The increment of 3,500 acre-feet, 4.8 second-feet, is the balance between the water additions and depletions between the two points of measure, and is therefore a net quantity fitted for direct use.

With a reservoir evaporation loss of 14 per cent, a net withdrawal of 18.7 second-feet, as designed, would require a

gross supply of 19.5 second-feet, of which 4.8 second-feet would come from the river gain, and the balance of 14.7 second-feet represents the quantity passing the upper station which, together with the inter-station gain, would supply the anticipated withdrawal. The Carroll withdrawal being thus accounted for, the surplus water amounting to 44.7 - 19.5 or 25.2 second-feet can be impounded up-stream without interference with the uses below.

For conservatism it will be assumed that five per cent less, or 24.0 second-feet would be impounded for diversion at the upper station. The question as to proportioning the requisite storage between Pamo and Sutherland is quite important, but not essential at this time. The quantity of water available would be unaffected, and the estimated costs are considered sufficient to cover the case.

The storage at Pamo requisite to 24.0 second-feet is 18,500 acre-feet, mass curve page 10, to which is to be added provision for regulating the flow from Warner and the discharge to Carroll, requiring in all a storage of approximately 20,000 acre-feet. This can be obtained at Pamo by a dam 145 feet high at Site No. 1, and 125 feet high at Site No. 2.

The estimates of cost accompanying the report of 1912 provided for a 185-foot dam at Pamo, the saving by the reduction in height of dam will partly offset the cost of the Carroll Dam.

No account is taken in the present cost estimates for a dam at Sutherland or for the power conduit from there to Pamo.

These structures would have returns from power, and, less the saving due to the lower dam which would then be required at Pamo, are chargeable to power plants, costs of which are not included in these estimates.

With evaporation allowances of 14 per cent for reservoir and 4 per cent for conduit, the 24.0 second-feet gross at Pamo becomes 19.6 second-feet at San Clemente.

Santa Maria Creek.

For present purposes is is assumed that the water of this creek will be allowed to follow its natural course to the San Pasqual Valley as a source of irrigation water. It might with advantage be regulated with a dam. The fall into the San Pasqual Valley would be available for power.

Summary of Quantity of Water available at San Clemente Reservoir or at San Diego.

| | | | | | | |
|---|---|---|---|---|---|---|
| From Warner | 32.4 | second-feet | 21.0 | million | gallons | daily |
| Pamo | 19.6 | " " | 12.7 | " | " | " |
| Carroll | 18.7 | " " | 12.1 | " | " | " |
| | 70.7 | second-feet | 45.8 | million | gallons | daily |

## Pumping at Carroll.

The pumps at Carroll would deliver against a total head, including friction, of 250 to 300 feet. The consumption of power would correspondingly be from 75 to 90 Horse Power per million gallons daily, and the total amount of power required to handle 13.7 M. G. D. would be 1030 to 1230 Horse Power, all of which and much more could be furnished from the power drops along the various conduits if so desired.

### Available Power Drops.

| | |
|---|---|
| Warner-Pamo Conduit | 1,500 feet |
| Sutherland-Pamo Conduit | 900 " |
| Santa Maria-San Pasqual Conduit | 700 " |

### Estimate of Cost, exclusive of Power Plants.

| | |
|---|---|
| Warner-Pamo | $550,000 |
| Pamo-Linda Vista | 1,765,000 |
| Carroll | 950,000 |
| | $3,265,000 |
| Overheads, etc., 15% | 490,000 |
| | $3,755,000 |

For detailed estimates and unit prices see report of 1912.

N. Haywood

# Tabulation of Dimensions
# of the Various Reservoir Sites
# of the
# Volcan Land & Water Company

| San Luis Rey Warner Elev. 2618 | | | | Santa Ysabel Sutherland Elev. 1910 | | |
|---|---|---|---|---|---|---|
| | Capacity above Outlet | | | | Capacity above Outlet | |
| Acres Flooded | Acre-feet | Million Gallons | Depth Feet | Acres Flooded | Acre-feet | Million Gallons |
| 17 | 0 | 0 | 10 | 1 | 0 | 0 |
| 98 | 0 | 0 | 20 | 4 | 0 | 0 |
| 260 | 1,490 | 490 | 30 | 16 | 0 | 0 |
| 875 | 8,210 | 2,370 | 40 | 36 | 150 | 50 |
| 1,027 | 16,780 | 5,470 | 50 | 62 | 650 | 210 |
| 1,822 | 30,930 | 10,080 | 60 | 97 | 1,450 | 470 |
| 2,300 | 51,750 | 16,860 | 70 | 138 | 2,610 | 850 |
| 2,960 | 76,370 | 24,880 | 80 | 173 | 5,030 | 1,360 |
| 4,055 | 112,900 | 36,780 | 90 | 219 | 6,140 | 2,000 |
| 5,740 | 162,300 | 52,880 | 100 | 268 | 8,560 | 2,790 |
| | | | 110 | 318 | 11,510 | 3,750 |
| | | | 120 | 373 | 14,950 | 4,870 |
| | | | 130 | 434 | 18,170 | 5,920 |
| | | | 140 | 510 | 23,700 | 7,720 |
| | | | 150 | 568. | 29,100 | 9,480 |
| | | | 160 | 630 | 34,780 | 11,330 |
| | | | 170 | 692 | 41,590 | 13,580 |
| | | | 180 | 752 | 48,940 | 15,940 |
| | | | 190 | 797 | 56,670 | 18,460 |

| S A N T A Y S A B E L<br>P a m o N o . 1<br>Elev 805 | | | | P a m o N o . 2<br>Elev 845 | | |
|---|---|---|---|---|---|---|
| | Capacity above Outlet | | | | Capacity above Outlet | |
| Acres Flooded | Acre-feet | Million Gallons | Depth Feet | Acres Flooded | Acre-feet | Million Gallons |
| 3 | | | 10 | 3 | | |
| 8 | | | 20 | 9 | | |
| 12 | | | 30 | 21 | | 0 |
| 18 | | | 40 | 63 | 140 | 45 |
| 25 | | | 50 | 103 | 960 | 310 |
| 40 | | | 60 | 147 | 2,219 | 690 |
| 55 | | | 70 | 184 | 3,860 | 1,260 |
| 80 | 0 | 0 | 80 | 245 | 6,010 | 1,950 |
| 120 | 2,560 | 840 | 90 | 303 | 8,750 | 2,850 |
| 170 | 3,340 | 1,090 | 100 | 362 | 12,130 | 3,790 |
| 230 | 5,630 | 1,840 | 110 | 443 | 16,150 | 5,050 |
| 320 | 8,680 | 2,830 | 120 | 539 | 21,060 | 6,540 |
| 401 | 12,390 | 4,040 | 130 | 662 | 27,070 | 8,460 |
| 476 | 16,790 | 5,470 | 140 | 805 | 34,410 | 11,210 |
| | | | 145 | 885 | 38,500 | 12,550 |
| 615 | 22,320 | 7,280 | 150 | | | |
| 709 | 29,360 | 9,560 | 160 | | | |
| 810 | 36,560 | 11,910 | 170 | | | |
| 900 | 43,260 | 14,100 | 180 | | | |
| 925 | 47,360 | 15,420 | 185 | | | |

## Santa Ysabel
## Carroll
## Elev. 175

| Acres Flooded | Capacity above Outlet: Acre-feet | Capacity above Outlet: Million Gallons | Depth Feet |
|---|---|---|---|
| 4 | | | 10 |
| 20 | 0 | 0 | 20 |
| 65 | 180 | 60 | 30 |
| 133 | 1,350 | 440 | 40 |
| 220 | 3,160 | 1,030 | 50 |
| 336 | 5,860 | 1,910 | 60 |
| 490 | 10,080 | 3,280 | 70 |
| 720 | 16,050 | 5,230 | 80 |
| 883 | 20,100 | 6,530 | 85 |
| 980 | 22,800 | 7,460 | 90 |
| 1,308 | 34,550 | 11,260 | 100 |

## Santa Maria
## Elev. 1260

| Acres Flooded | Capacity above Outlet: Acre-Feet | Capacity above Outlet: Million Gallons |
|---|---|---|
| 2 | | |
| 8 | 0 | 0 |
| 23 | 60 | 20 |
| 41 | 480 | 160 |
| 80 | 1,090 | 330 |
| 154 | 2,260 | 740 |
| 286 | 4,460 | 1,450 |
| 561 | 8,690 | 2,830 |
| | | |
| 900 | 13,500 | 4,400 |

## S a n  C l e m e n t e
Elev. 595

| Acres Flooded | Capacity above Outlet: Acre-foot | Million Gallons | Depth Feet |
|---|---|---|---|
| 8 | 0 | 0 | 10 |
| 23 | 120 | 4 | 20 |
| 60 | 410 | 135 | 30 |
| 79 | 1,060 | 345 | 40 |
| 93 | 1,920 | 625 | 50 |
| 129 | 3,050 | 995 | 60 |
| 166 | 4,500 | 1,465 | 70 |
| 201 | 6,370 | 2,075 | 80 |
| 238 | 8,550 | 2,785 | 90 |
| 277 | 11,130 | 3,625 | 100 |
| 317 | 14,100 | 4,595 | 110 |

# Ed Fletcher Papers

# 1870-1955

# MSS.81

# Box: 38 Folder: 2

# Business Records - Reports - Hawgood, H - "Supplemental Report on the Projects of the Volcan Land & Water Co."