SPECIAL SEWAGE PROBLEM

REPORT ON THE SEWAGE PROBLEM OF THE CITY OF LOS ANGELES

WITH CONCLUSIONS AND RECOMMENDATIONS

Report Made

By

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Pasadena California

-GENERAL OUTLINE-

I. Possible Ways of Disposal Other than that by Dilution

A. Introduction

B. Character of Sewage

C. Screening and Straining

1. Hand operated screens or gratings

a. Bar screens or gratings

b. Wire mesh screens

c. Basket screens

d. Upward flow screens

2. Mechanically operated screens

a. Stationary screens with power-driven rakes or brushes

b. Revolving screens

I. The wing screen

II. The shovel-vane screen

III. The drum screen

IV. The Riensch screen

V. The Reading screen

3. Coarse filters or strainers

4. Efficiency of screening

5. cost of screening

D. Sedimentation

1. Grit chambers

2. Fine sedimentation

a. Intermittent-flow tanks

b. Continuous-flow tanks

E. Preliminary Treatment of Sewage by Chemical Precipitation

AN INVESTIGATION OF THE BIG TUJUNGA CREEK

AS A POSSIBLE WATER SUPPLY FOR PASADENA

PART ONE.

LOCATION AND DESCRIPTION Tujunga Reservoir Site No.1, or the Hoyt Reservoir as it is sometimes called, is located at a narrow place in the Big Tujunga Canyon approximately eight miles from the canyons mouth.

The Tujunga watershed comprises 37.27 square miles above the dam-site. The length of the main tributary measured along the meanderings of the stream is about 34 miles. The main tributaries are Alder Creek, North Fork, Mill Creek, Fox Creek.

The watershed is comparatively long and narrow with the longer axis running approximately north and south. The mean elevation is 4,150 feet. The upper half of the Tujunga, 36,900 acres, has a radiating system of main feeders 29 miles long as follows:

North Fork	5 miles
Mill Creek	5 miles
Alder Creek	9 miles
Wickiup	2.5 miles
Coldwater	1.5 miles
Main Tujunga	6 miles

DATA AVAILABLE The data available for this work was daily discharge of Tujunga Creek from November, 1916 to February, 1922. Daily combined discharge of San Gabriel River and Canals from January, 1909 to February, 1922. Precipation at Hansens Ranch, (near reservoir site), from 1917 to 1922. Precipation at Echo Mountain, which compares very favorably with that at Hansens Ranch, from 1897 to 1922. Precipitation at Azusa, near San Gabriel gaging station, from 1897 to 1922.

METHODS OF ATTACK

In view of the fact the precipitation at Echo Mountain and that at Hansens Ranch are in such close aggrement an attempt was made to develope a formula for use in estimating run-off, the precipitation being known. It soon became apparent that there were too many indeterminable variables involved so this method was discarded in favor of that used by Mr. H. W. Dennis in adapting the records of stream flow at one point to another point on the same stream. This method is fully explained by Mr. Dennis in a paper in "Transactions of the American Society of Civil Engineers" Vol. LXXXIV page 551. In this paper Mr. Dennis showed the results of a rather extended study of the flow of the Kern River in the State of California, wherein it was desired to make use of a long period of observations of stream taken on this river at one point and to apply these records at a point about 75 miles distant on the same river where it was contemplated to divert the water for power purposes.

EXPLANATION OF CURVES USED IN ESTIMATING DISCHARGE

In developing the curves for use in estimating discharge, the flow in second feet for five day periods was averaged for each stream. This data was then divided into monthly periods and the average discharge for five day periods plotted as shown in Figs. 1-13. The averages for San Gabriel were plotted against the corresponding averages for Tujunga regardless of the time of month and for all years for which data was available for both streams. All curves were plotted to the same relative scale with San Gabriel to one half the scale as Tujunga. This ratio of scales was used because of the fact that San Gabriel has approximately twice the drainage area as Tujunga. The points for the month of January gave the most perfect curve, only one point being off the curve an appreciable amount. This curve was used in projecting curves for other months to cover greater discharges than those recorded within the past five years.

MASS CURVE The ordinates for the mass curve were obtained from the discharge curves by noting the average discharge of San Gabriel for a given period, locating this point on the San Gabriel axis, moving up to the curve and across to the Tujunga axis. The points obtained in this way from 1909 to 1917 were added successively and the actual average discharge added from 1917 to 1922. The summations were then reduced by 85 %, the reduction being obtained as follows:

Drainage area above dam-site	87.27	Sq. Mi.
Drainage area above gaging station	106	Sq. Mi.

87.27/106 82.3 %. Since the tributaries below the dam-site flow only during the rainey season, all the summer flow coming from the upper reaches of the stream, the total flow was reduced by only 85 %, which is thought to be a conservative figgure.

The average flow for five day periods in second feet is shown to be one tenth of the total flow in acre feet as follows:

1 sec. ft. for 30 days 60 acre feet (59.50)

1 sec. ft. for 5 days 10 acre feet.

REGULATED FLOW In determining the possible rates of regulated flow five different amounts of reservoir capacity were considered. They were net amounts of 30,000, 20,000, 11,200, 8,400, and 6,200 acre feet, corresponding to heights of dam of 300, 250, 200, 180, and 160 feet respectively. In determining thse rates of regulated flow tangents were drawn from the mass curve thru the highest points located by laying off the storage downward from the curve. In addition to the regulated flow these lines show the amount of spill at periods of flood. The period giving the lowest rate of flow was from February 1916 to December 1921. This rate is given in the following table.

Height Of Dam	Rate
160 Feet	10.0 sec. ft.
180	12.6
200	13.9
250	18.8
300	25.0

AREA OF WATER SHED ABOVE DAM-SITE

Planimeter reading,	one	17.22	Sq. In.
	two	34.55	
	three	51.74	
	four	68.99	
Average		17.25	

Planimeter reading,	one	37.85
	two	75.56
	three	113.41
	four	151.14
Average		37.78

Planimeter reading,	one	17.35
	two	34.77
	three	52.16
	four	69.55
Average		17.39

Planimeter reading	one	17.32
	two	34.66
	three	51.99
	four	69.28
Average		17.32
Total Area		89.74

Planimeter measures actual area of 100 sq.in. as
100.06 sq.in. Correction factor---- 1.0006
89.74x1.0006=89.69

Scale of map 1/62500

$[(62500)^2 x89.69 /(144x43560x640)=87.27$ sq.mi.

Area between dam-site and
gaging station 19.23 sq.in.
0.974x19.23 +18.72
Total area above gaging sta. 105.99

ESTIMATED DISCHARGE OF TUJUNGA CREEK.

1909

Period.	1-5	6-16	11-15	16-20	21-25	26-30
Jan.	9	11	15	13	750	77
Feb.	45	615	450	150	60	53
Mar.	48	48	40	36	140	120
Apr.	110	60	56	55	48	41
May	38	32	30	27	25	18
June	15	15	13	12	12	11
July	8	6	5	4	3	3
Aug.	2.2	1.8	1.5	1.7	1.5	1.5
Sept.	2.2	1.8	1.5	1.4	1.4	1.5
Oct.	3	2.6	2	2.6	2	2
Nov.	3	4	6	6	5	9
Dec.	9	85	30	19	25	170

1910

Jan.	1850	250	[illegible]	[illegible]	[illegible]	[illegible]
Feb.	41	31	28	26	25	25
Mar.	21	21	20	20	25	26
Apr.	20	19	18	17	16	15
May	10	9	7	6	6	5
June	4	4	3	3	3	3
July	1	0.7	0.6	0.5	0.5	0.5
Aug.	0.5	0.4	0.4	0.3	0.3	0.3
Sept.	0.6	0.6	0.5	0.5	0.5	0.5
Oct.	1.2	1.2	1.5	[illegible]	1.[illegible]	1.4
Nov.	2	2	3	3	2	3
Dec.	4.5	4.5	4.5	5	5	5

1911

Jan.	6	55	90	45	63	856
Feb.	445	215	135	67	37	40
Mar.	246	1850	250	370	230	135
Apr.	110	75	57	53	54	45
May	38	37	37	31	26	20
June	16	12	10	8	7	6
July	6.4	6.4	5.5	5	4.8	3.5
Aug.	3.5	3	2.5	2	1.6	1.5
Sept.	2	2	1.8	1.7	1.7	4
Oct.	5.5	4	3.5	3	5	4
Nov.	5	5	6	5	5	4.5
Dec.	7	8	7.2	7.3	7.2	8

ESTIMATED DISCHARGE OF TUJUNGA CREEK

1912

Period.	1-5	6-10	11-15	16-20	21-25	26-30
Jan.	10	10	10	9	9	9
Feb.	10	10	10	9	9	9
Mar.	17	204	304	48	21	20
Apr.	16	20	64	51	44	35
May	26	25	16	16	14	13
June	7	6	3	5	5	4
July	2.5	1.5	1	0.9	0.7	0.7
Aug.	0.6	0.5	0.5	0.5	0.4	0.4
Sept.	0.9	0.9	0.7	0.7	0.6	0.6
Oct.	2	2	1.9	1.7	1.7	1.9
Nov.	1.2	1.2	2.2	2	1.2	1.2
Dec.	4.5	4.1	4	4.1	4.2	4.2

1913

	1-5	6-10	11-15	16-20	21-25	26-30
Jan.	6	6	8	20	10	9
Feb.	10	20	15	12	125	92
Mar.	30	30	25	21	20	20
Apr.	18	16	15	15	15	15
May	8	8	7	6	6	5
June	[illegible]	5	2	3	2	3
July	0.5	0.5	0.5	0.5	0.5	0.5
Aug.	0.3	0.3	0.3	0.3	0.3	0.3
Sept.	0.5	0.4	0.3	0.2	0.3	0.3
Oct.	0.4	0.4	0.4	0.3	0.3	0.4
Nov.	0.5	0.6	4.5	8	6	3.8
Dec.	5	4.6	4.5	4.5	6	6.3

1914

	1-5	6-10	11-15	16-20	21-25	26-30
Jan.	9	8	16	680	287	1225
Feb.	125	90	45	1300	2400	345
Mar.	428	252	109	78	67	60
Apr.	45	45	45	44	44	43
May	41	37	35	31	28	25
June	23	20	15	12	13	10
July	9	6.5	5.8	5.5	5	5
Aug.	3.5	2.6	2.5	2.1	2	1.4
Sept.	2.5	2.4	2.4	2.2	2.0	1.7
Oct.	3.5	3.6	3	3	3.2	3
Nov.	4.5	4.1	4.5	4	3.9	4
Dec.	8.7	8.7	11	16	16	13

ESTIMATED DISCHARGE OF TUJUNGA CREEK

1918

Period.

	1-5	6-10	11-15	16-20	21-25	26-30
Jan.	3.9	4.6	6.1	4.7	4.5	5.1
Feb.	5	5	5	13	149	95
Mar.	58	275	269	153	108	67
Apr.	50	44	37	50	37	37
May	31	23	18	18	19	18
June	11	9	[illegible]	7	6	4
July	4	2	1.3	0.[illegible]	1.3	0.6
Aug.	0.5	0.4	0.4	0.4	0.5	0.5
Sept.	0.4	0.4	0.4	0.5	0.8	2.4
Oct.	1.5	2.4	1.6	1.9	1.8	1.[illegible]
Nov.	2.3	3.6	4.[illegible]	11	8.7	7.2
Dec.	6.1	28	13	9.6	9	8.3

1919

Jan.	7	7	7.6	8	7.3	8
Feb.	14	11	39	16	14	13
Mar.	12	12	25	32	55	32
Apr.	21	17	13	10	9.4	12
May	9.6	7.1	6.4	6	5.5	5.2
June	1.6	1.6	1.5	1	0.7	0.7
July	0.7	0.7	0.5	0.4	0.4	0.5
Aug.	0.5	0.3	0.3	0.4	0.4	0.4
Sept.	0.4	0.3	0.3	0.2	0.2	0.8
Oct.	1.0	0.3	0.5	0.6	1.0	0.9
Nov.	0.8	1.0	1.0	1.0	1.0	3.8
Dec.	10	19	8.1	8	7.4	5.9

1920

Jan.	7.6	6.1	4	4.1	5.2	5.1
Feb.	6.5	8.0	8.5	11	67	37
Mar.	165	61	54	38	370	187
Apr.	98	76	55	50	34	37
May	25	23	31	16	14	13
June	11	9.3	8.7	7.4	5.8	6.0
July	5.9	4.1	3.4	2.6	2.5	2.1
Aug.	2.1	2.3	2.1	1.7	1.1	2.4
Sept.	1.7	2.5	2.7	3.3	5.2	3.9
Oct.	3.2	2.2	2.3	4.7	4.5	2.8
Nov.	2.5	5.2	2.6	2.5	2.5	2.7
Dec.	4.8	5.6	6.3	13	13	11

ESTIMATED DISCHARGE OF TUJUNGA CREEK

1915

Period.	1-5	6-10	11-15	16-20	21-25	26-30
Jan.	14	13	15	12	15	77
Feb.	30	95	160	85	70	57
Mar.	66	50	40	51	52	55
Apr.	40	36	35	32	32	33
May	49	49	44	44	38	34
June	33	25	20	17	16	12
July	20	13	11	10	8.5	6
Aug.	5.5	3.5	2.6	2.1	1.6	2.4
Sept.	3.5	3.4	3.4	2.8	2.5	2.8
Oct.	3.4	3	3.4	3.2	3	3
Nov.	4.2	7	6.5	5.7	5	5
Dec.	9	9	10	10	9	9

1916

Jan.	18	70	46	5100	288	1350
Feb.	316	154	110	93	74	130
Mar.	108	103	94	95	118	80
Apr.	58	46	44	36	55	38
May	26	18	16	16	15	12
June	9	7	7	6	6	6
July	6	5	4.6	4.4	4	3.6
Aug.	2.4	2.4	2.4	2.4	2	1.7
Sept.	2.4	2.4	2.2	2.2	2.4	2.4
Oct.	28	16	14	10	9	7
Nov.	10	10	9.4	9.3	9	9
Dec.	12	12	11	11	155	32

1917

Jan.	32	31	31	43	39	34
Feb.	33	32	28	39	156	129
Mar.	75	58	53	42	33	32
Apr.	28	26	24	30	23	22
May	19	18	17	19	18	17
June	14	12	9	6	5	4
July	3	3	2	1.3	1.2	1.5
Aug.	1.5	0.6	0.5	0.4	0.4	0.4
Sept.	0.6	0.6	0.5	0.4	0.5	0.4
Oct.	0.4	0.3	0.6	0.4	0.6	0.2
Nov.	2.3	6	4.5	3.1	2.7	3.7
Dec.	5.5	4.0	4.1	4.4	5.6	3.4

ESTIMATED DISCHARGE OF TUJUNGA CREEK

1931

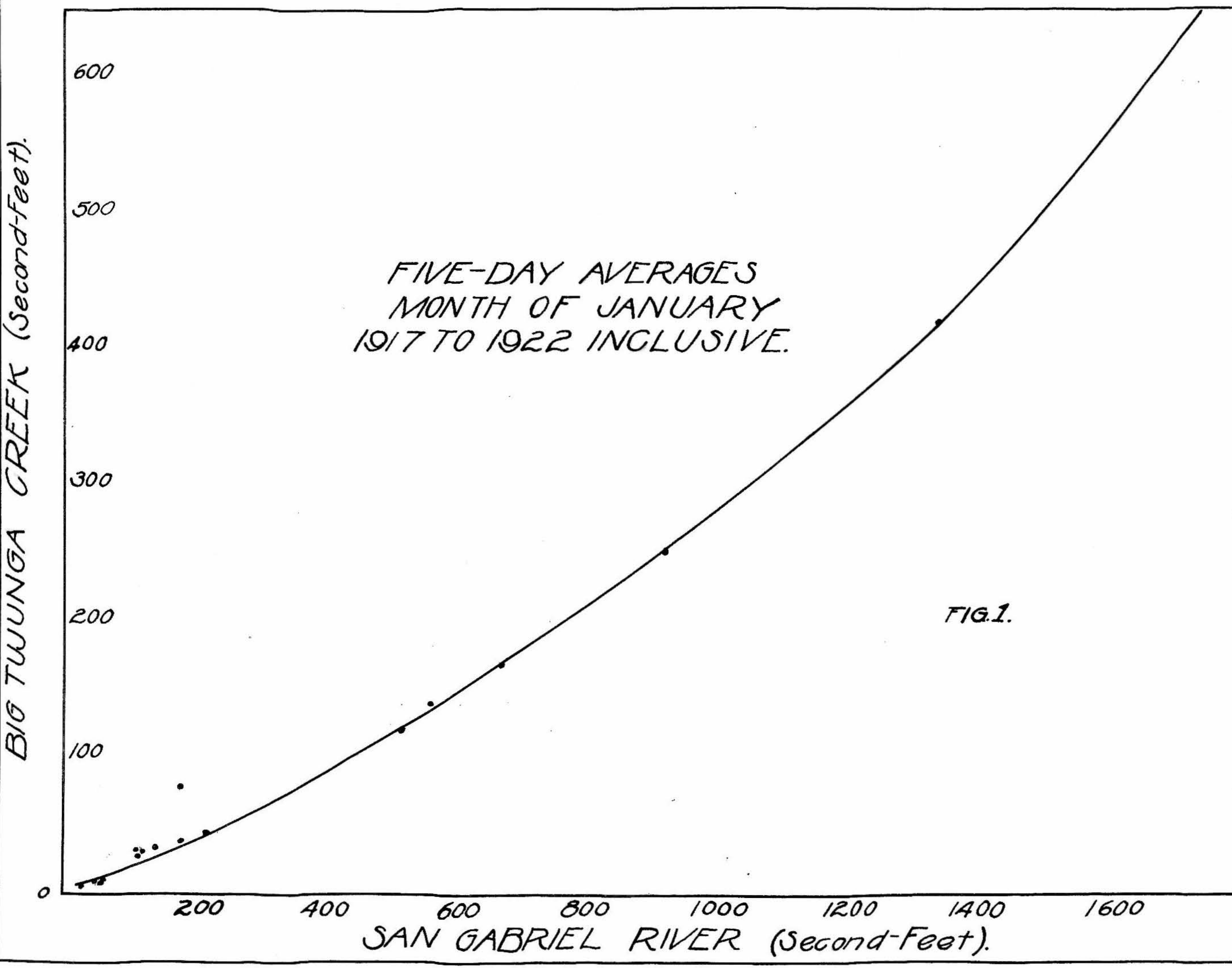
Period.	1-5	6-10	11-15	16-20	21-25	26-30
Jan.	8.8	7.3	7.4	80	30	38
Feb.	21	18	18	17	13	18
Mar.	9.6	101	99	50	29	25
Apr.	19	16	15	13	13	8.3
May	12	18	9.4	13	173	45
June	37	20	17	14	9.8	6.0
July	4.5	2.9	2.6	2.1	2.1	2.1
Aug.	1.8	1.8	1.4	1.1	7.4	3.1
Sept.	1.0	0.8	1.0	1.8	0.9	0.6
Oct.	1.9	2.3	2.1	2	3.5	2.9
Nov.	2.6	2.7	3.6	5	5.1	5.7
Dec.	5.4	5.6	6.1	5240	695	1165

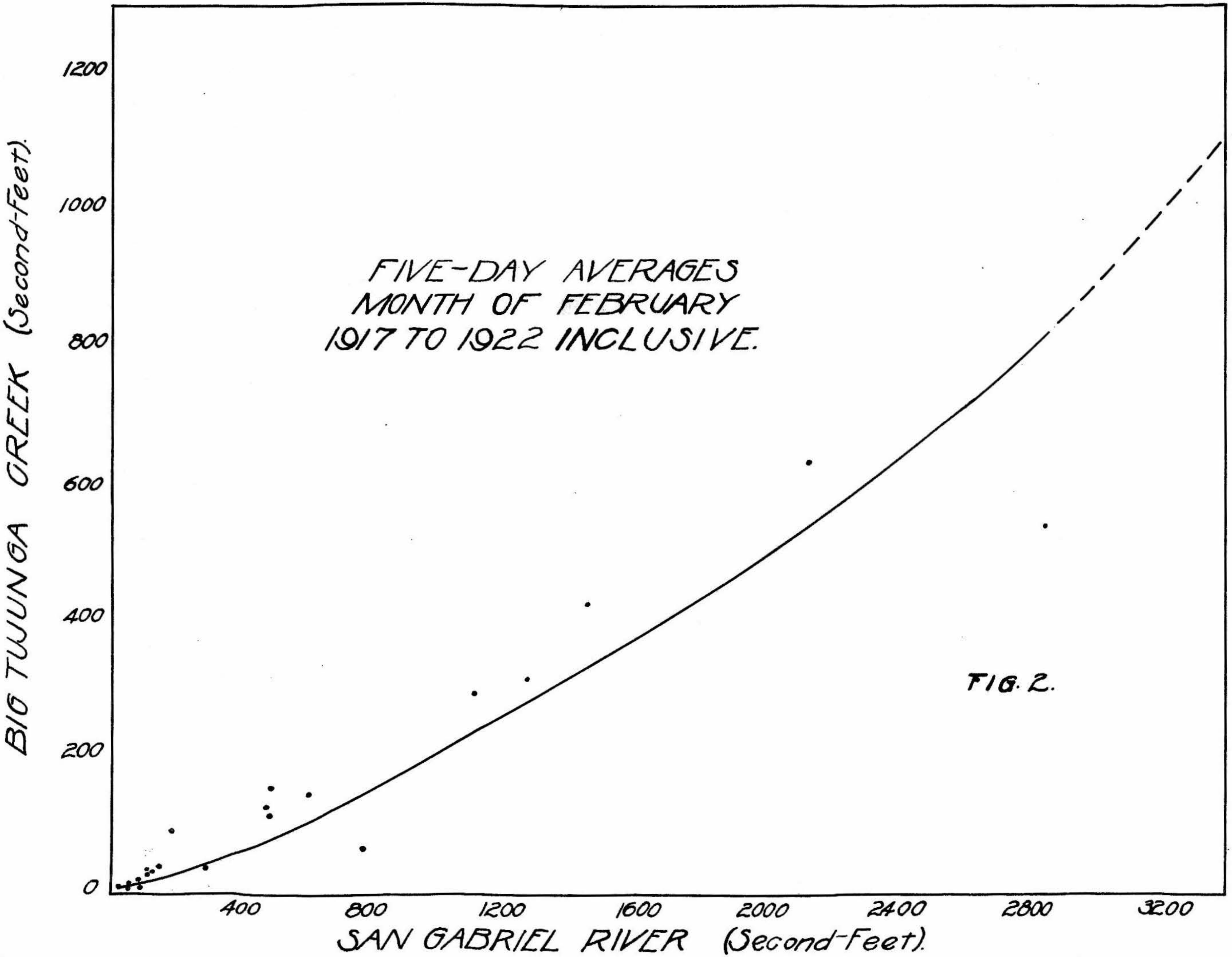
1932

Jan.	756	417	252	171	123	140
Feb.	116	537	641	426	313	293
Mar	282	225				

RATE OF REGULATED FLOW FOR VARIOUS HEIGHTS OF DAM

Height Of Dam Feet	Regulated Flow Second Feet
160	10.0
180	12.6
200	13.9
250	18.8
300	23.0


FIVE-DAY AVERAGES
MONTH OF JANUARY
1917 TO 1922 INCLUSIVE.
BIG TUJUNGA CREEK (Second-Feet).
SAN GABRIEL RIVER (Second-Feet).
0
100
200
300
400
500
600
200
400
600
800
1000
1200
1400
1600
FIG.1.



FIVE-DAY AVERAGES
MONTH OF FEBRUARY
1917 TO 1922 INCLUSIVE.
BIG TUJUNGA CREEK (Second-Feet).
0
200
400
600
800
1000
1200
400
800
1200
1600
2000
2400
2800
3200
SAN GABRIEL RIVER (Second-Feet).

FIG. 2.

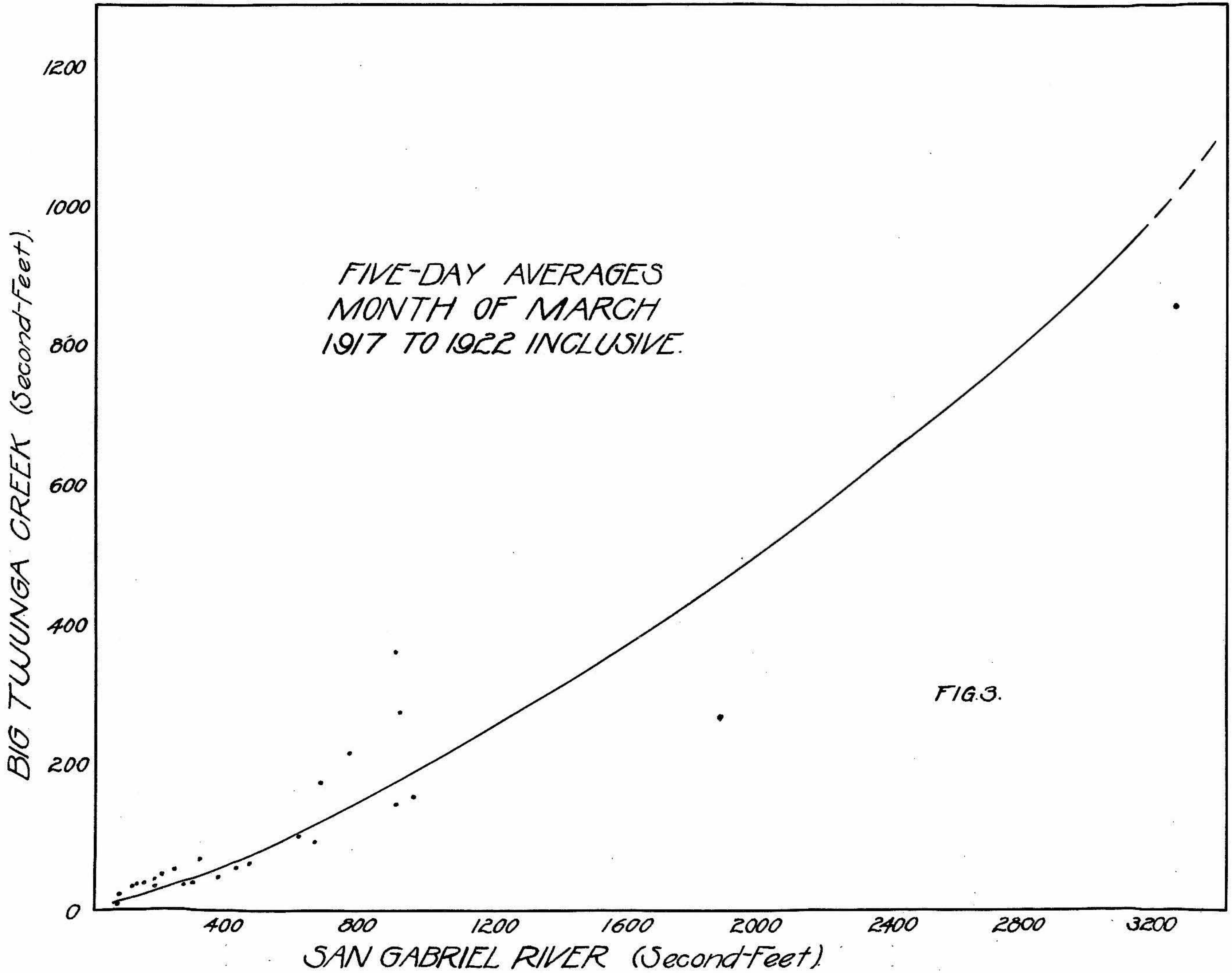

FIVE-DAY AVERAGES
MONTH OF MARCH
1917 TO 1922 INCLUSIVE.
BIG TUJUNGA CREEK (Second-Feet).
SAN GABRIEL RIVER (Second-Feet).
0
200
400
600
800
1000
1200
400
800
1200
1600
2000
2400
2800
3200

FIG.3.

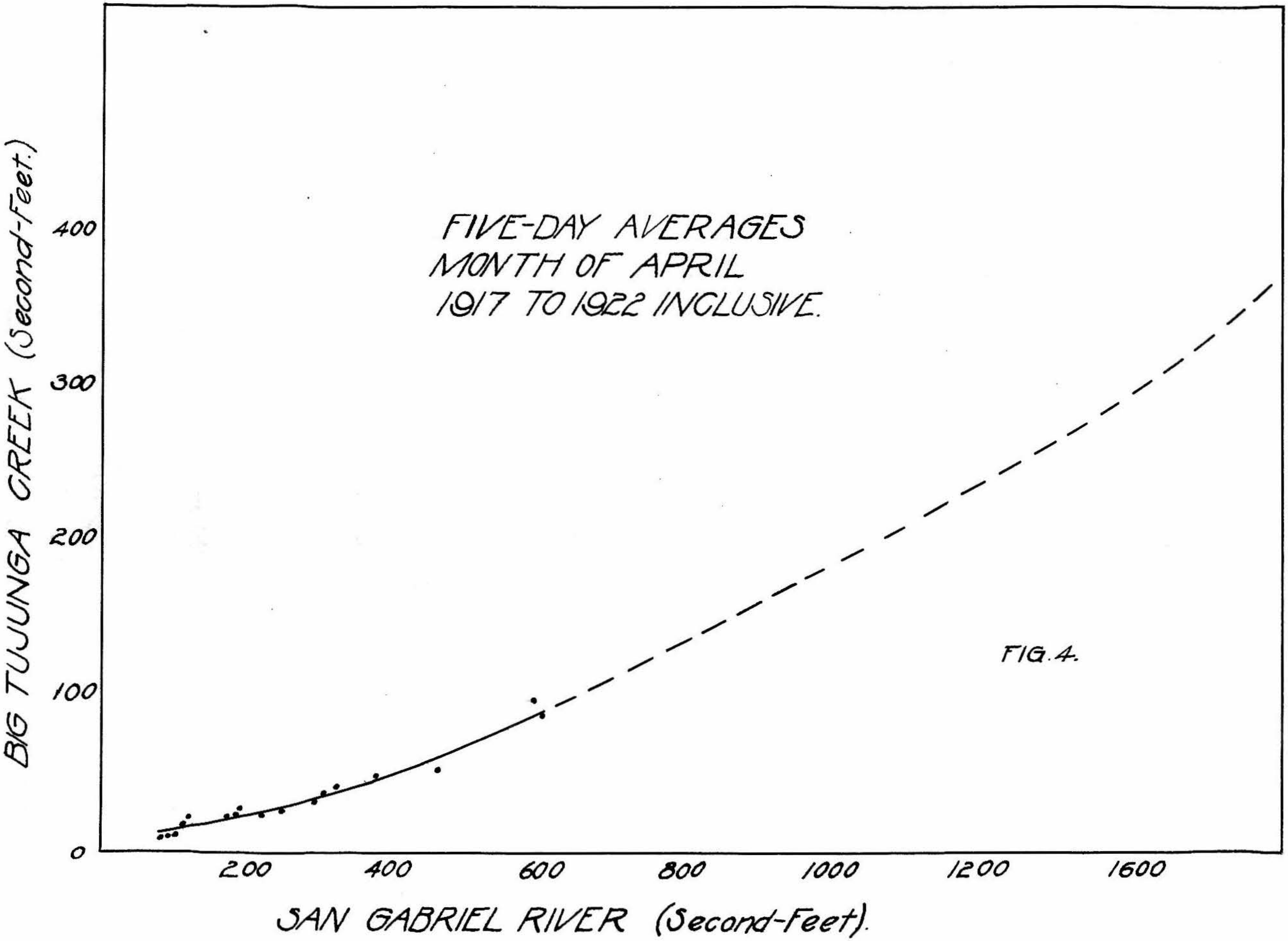
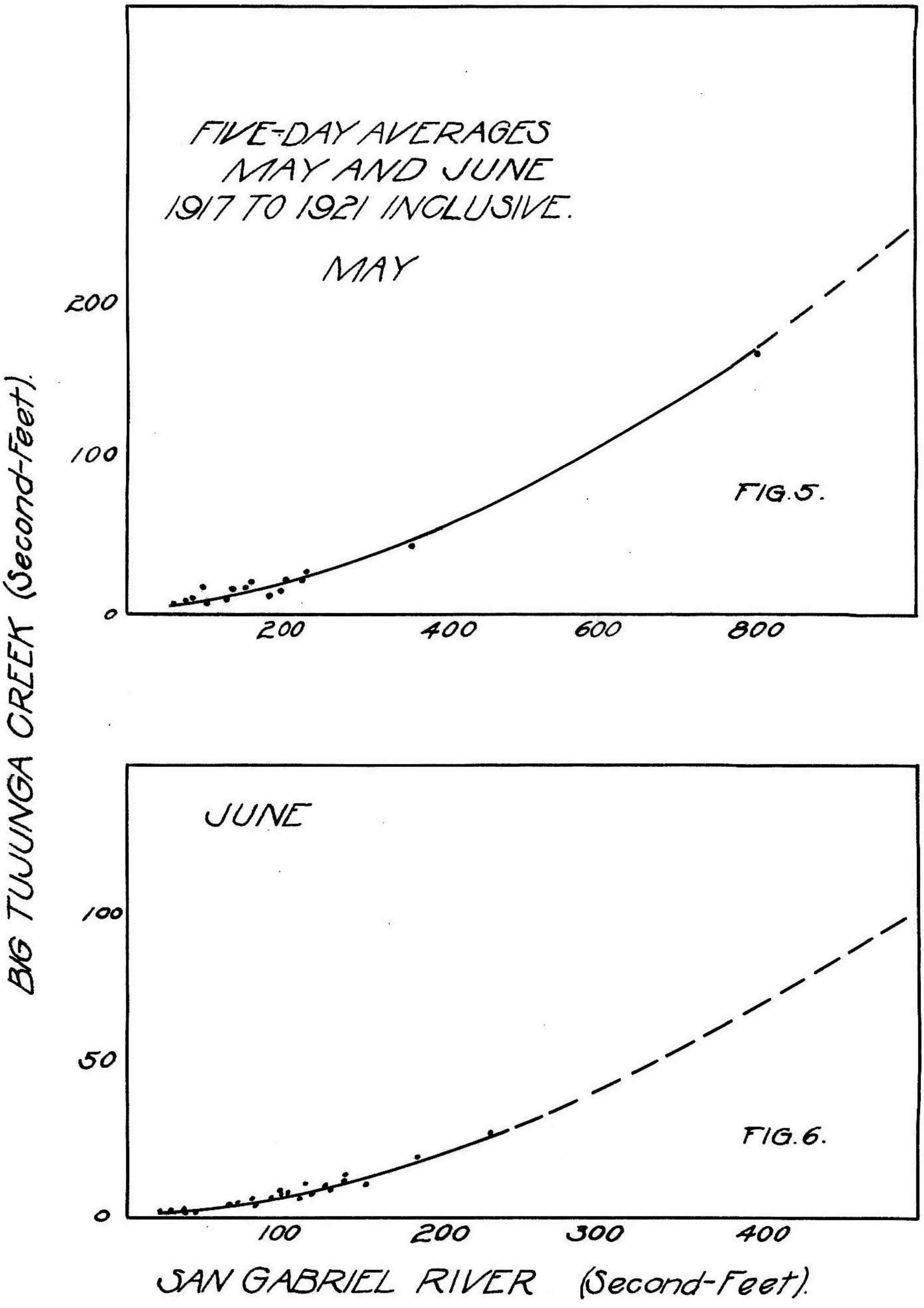
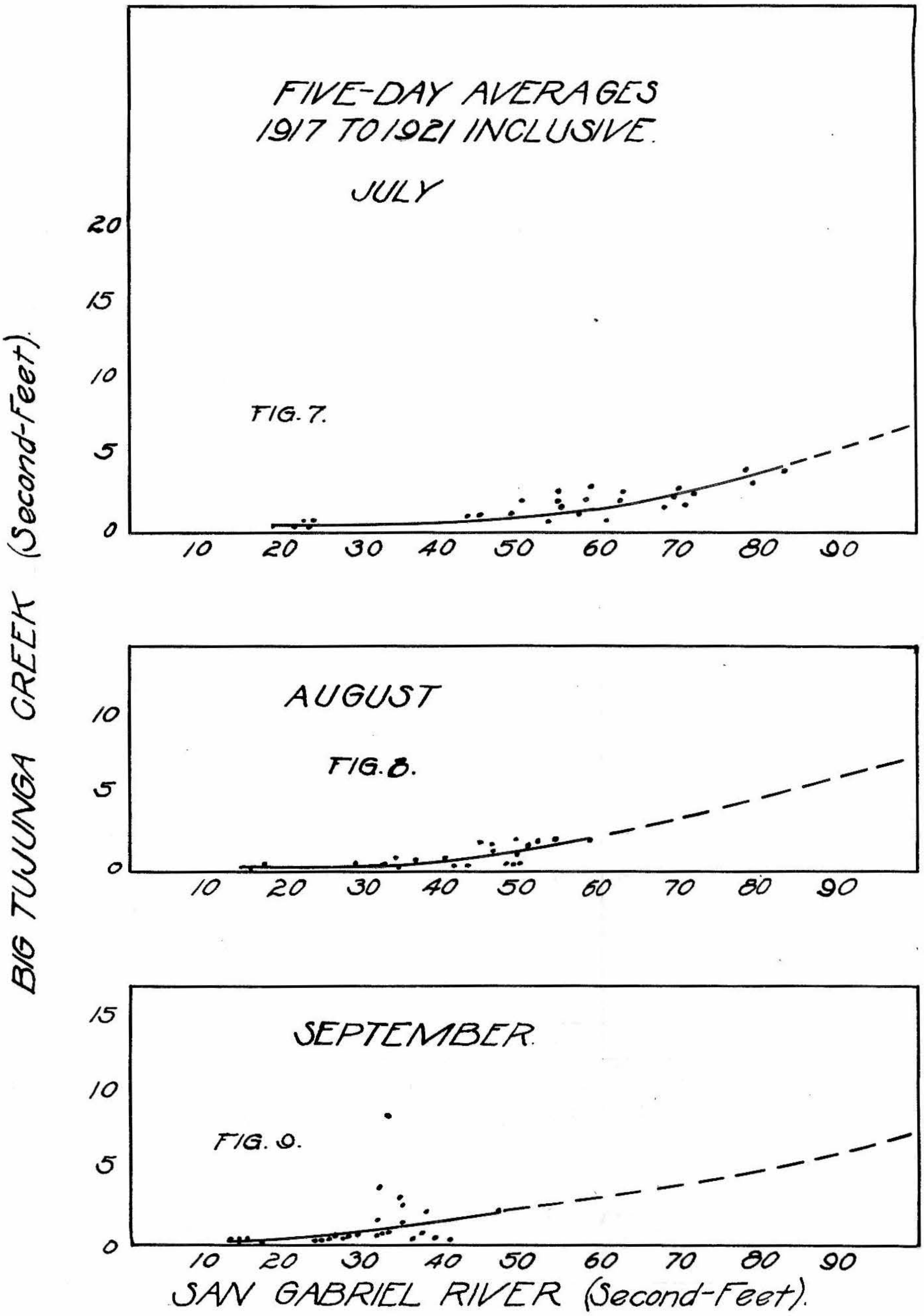
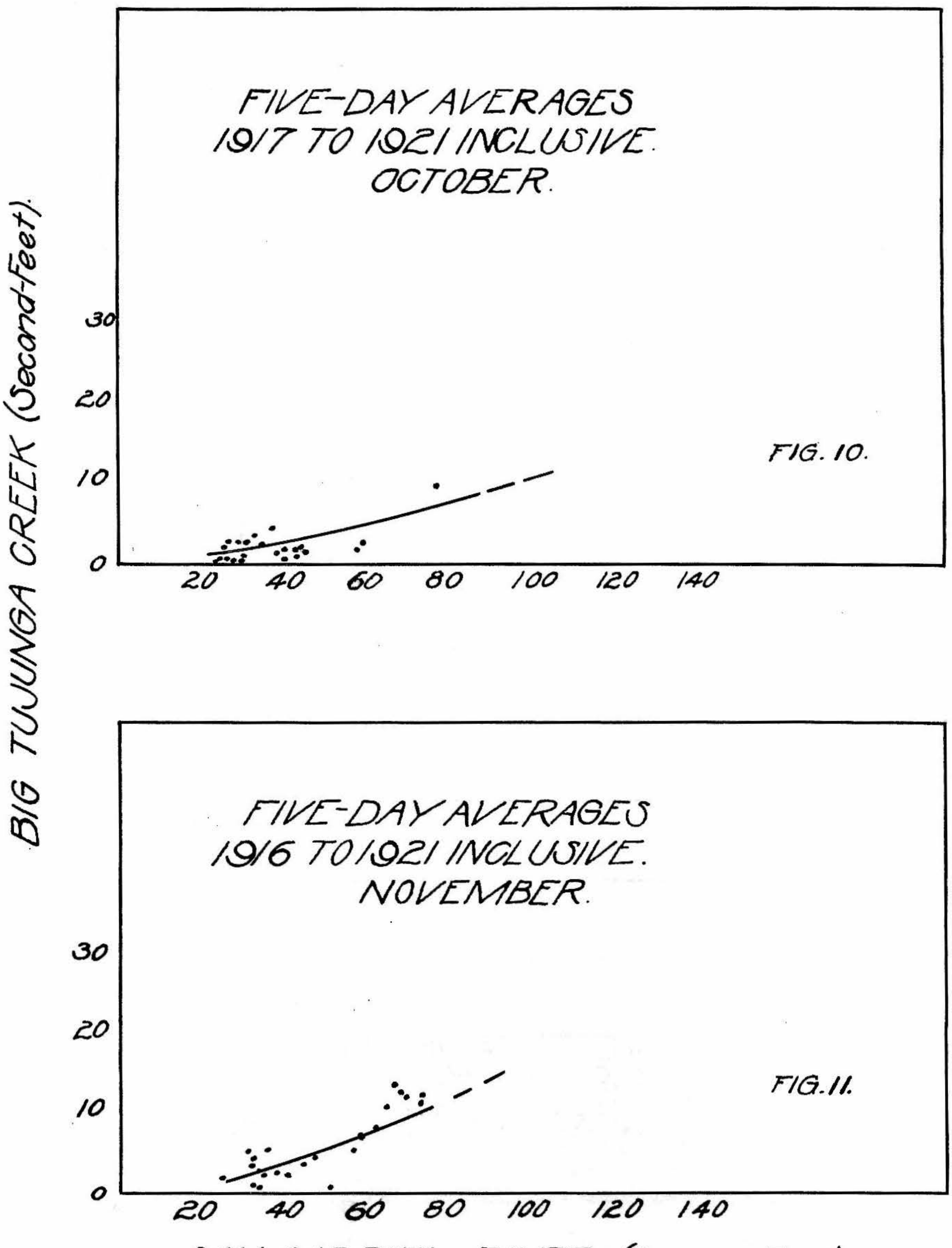

FIVE-DAY AVERAGES
MONTH OF APRIL
1917 TO 1922 INCLUSIVE.
BIG TUJUNGA CREEK (Second-Feet.)
400
300
200
100
0
200
400
600
800
1000
1200
1600
SAN GABRIEL RIVER (Second-Feet).

FIG. 4.


FIVE-DAY AVERAGES
MAY AND JUNE
1917 TO 1921 INCLUSIVE.
MAY
200
100
0
200
400
600
800
FIG.5.
JUNE
100
50
0
100
200
300
400
FIG.6.
BIG TUJUNGA CREEK (Second-Feet).
SAN GABRIEL RIVER (Second-Feet).



FIVE-DAY AVERAGES
1917 TO 1921 INCLUSIVE.
JULY
FIG. 7.
AUGUST
FIG. 8.
SEPTEMBER.
FIG. 9.
BIG TUJUNGA CREEK (Second-Feet).
SAN GABRIEL RIVER (Second-Feet).
0
5
10
15
20
10 20 30 40 50 60 70 80 90


FIVE-DAY AVERAGES
1917 TO 1921 INCLUSIVE.
OCTOBER.
FIG. 10.
0
10
20
30
20
40
60
80
100
120
140
FIVE-DAY AVERAGES
1916 TO 1921 INCLUSIVE.
NOVEMBER.
FIG. 11.
0
10
20
30
20
40
60
80
100
120
140
BIG TUJUNGA CREEK (Second-Feet).
SAN GABRIEL RIVER (Second-Feet).

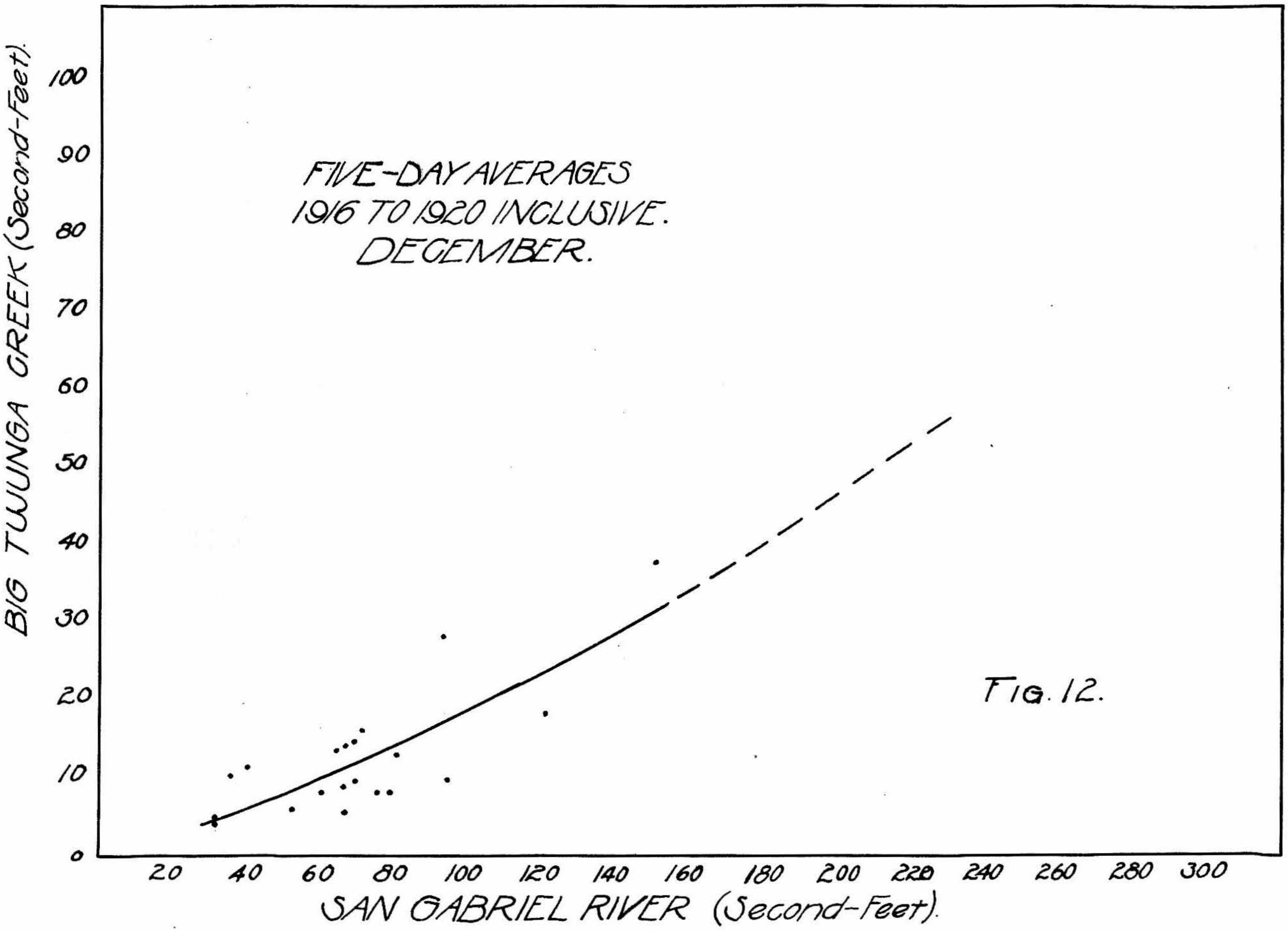
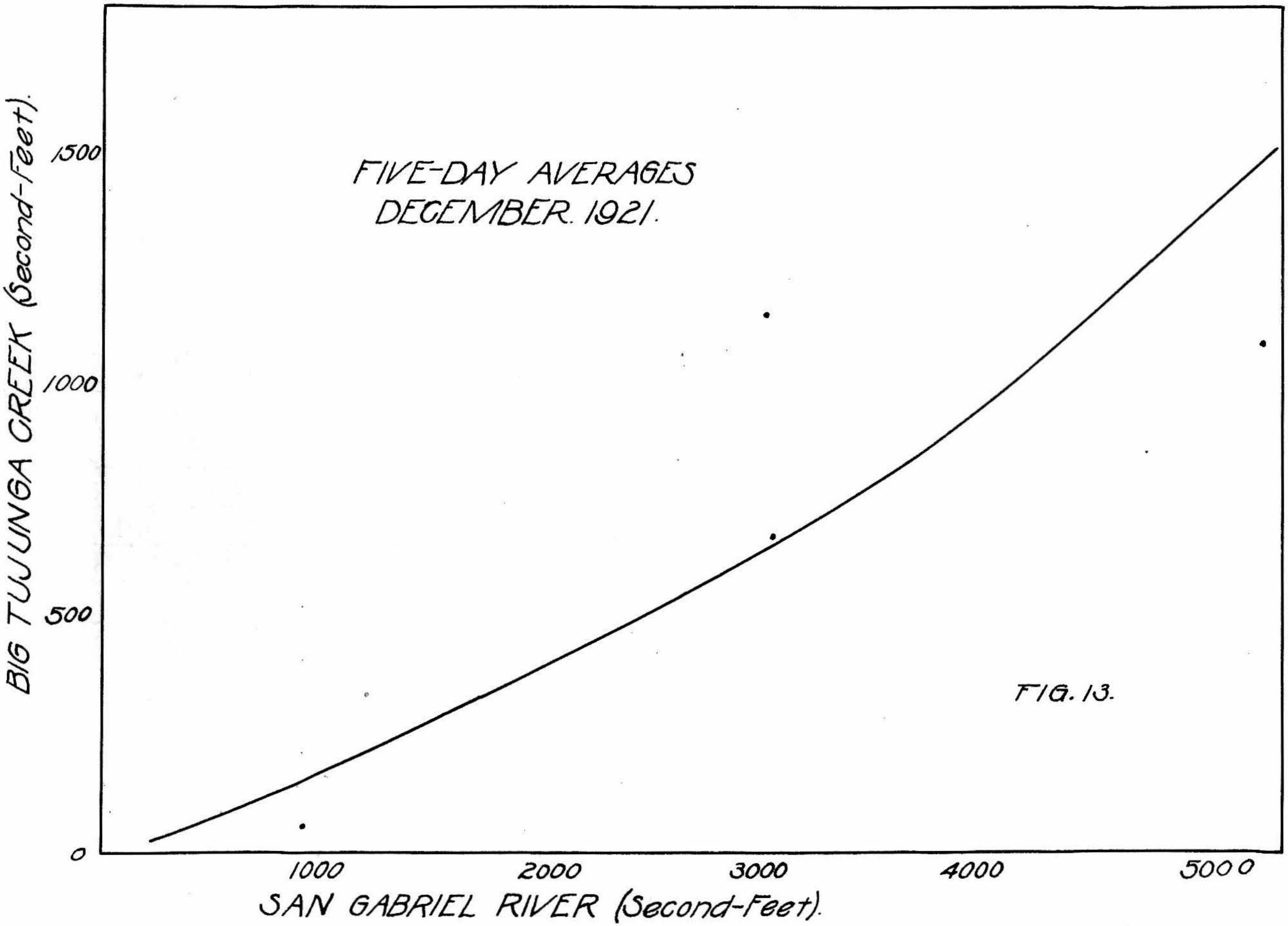

FIVE-DAY AVERAGES
1916 TO 1920 INCLUSIVE.
DECEMBER.
BIG TUJUNGA CREEK (Second-Feet).
100
90
80
70
60
50
40
30
20
10
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
SAN GABRIEL RIVER (Second-Feet).

FIG. 12.



FIVE-DAY AVERAGES
DECEMBER. 1921.
BIG TUJUNGA CREEK (Second-Feet).
1500
1000
500
0
1000
2000
3000
4000
5000
SAN GABRIEL RIVER (Second-Feet).

FIG. 13.

PART TWO

SELECTION OF HEIGHT OF DAM.

The structure was selected as a gravity section on account of there being no information over this portion of the canyon as bed rock conditions, and the uncertainty as to the strength of the east abutment The cost of an arch dam should not be over 50% to 60% of the type here estimated if it should be found practicable later to install this class of structure.

The profile shown in Fig. 16 was taken from "The Design And Construction Of Dams", (Wegmann). This design was for a 200 foot dam but both faces were produced to give a profile 300 feet high. The 300 foot profile was investigated as to the location of the resultant with the reservoir full and found to be near enough the third point to justify using this profile for calculating volumes of concrete.

The cross-section of the canyon at the dam-site was obtained by measuring the distance between the same contour on opposite sides of the canyon. This data was taken from Map No.T.O.226 of the Los Angeles Flood Control District.

The reservoir capacity curve was drawn from data furnished by Mr.S.B.Morris, Chief Engineer of the Pasadena Water Department.

The profile of the dam was divided into 20 foot sections and the area of each computed. The length of each section for various heights of dam was measured on Fig. 14 and the volumes computed as shown on page . In estimating the cost of the dam a unit cost of $13.00 per cubic yard for concrete was used.

To bring the water into Pasadena it will be necessary to drive a tunnel two and one-half miles long from the Tejunga to the Arroyo. The cost of driving the tunnel was estimated after reading numerous descriptions of types and cost given in "Modern Tunneling " by Brunton and Davis. The Elizabeth Lake Tunnel on the Los Angeles Aqueduct cost $40.50 per foot. It is 26,870 feet in length and 9 by 10 feet in cross-section. It was driven through medium to hard granite,completed February 1911. The Mission Tunnel,Santa Barbara,cost $19.91 per foot driven through shale and hard sandstone,length 19,560 feet,cross-section trapezoid,4.5 feet wide at the top,6 feet wide at the base,and 7 feet high. These tunnels were built during a period of low construction cost but the Elizabeth Lake Tunnel is of considerably larger cross-section than would be necessary in this case. The location of the work,especially at the Arroyo portal would be more economical than that at Elizabeth Lake. It is belived that the cost of constructing such a tunnel would not be over $50.00 per foot at the present prices.

POWER DEVELOPMENT.

The water could be brought into the Arroyo at elevation 2,000 by placing the tunnel intake at 2,000 or giving a fall of four feet per mile to the tunnel. Placing the tunnel intake at this elevation would waste about 250 feet of storage, which amount has been deducted in estimating the regulated flow for different heights of dam. With the tunnel at this point there would always be a pool of still water 2,100 feet in length and covering about twelve acres which would cause the stream to deposit well above the dam all gravel and boulders brought down in time of flood.

Following around the 2,000 contour for two miles on the east side of the Arroyo a site for a power-house is found with an available net head of 240 feet. Owing to the proximity of this site to the power market power could be transmitted at 11,000 volts with a small line loss. The construction of a steel-tower line would not be necessary to carry this voltage.

The American Electrical Engineers Handbook (1914 Edition), gives $67.00 per kilowatt of capacity as the maximum cost of a complete plant of 200 K.W. capacity. Two-hundred dollars per K.W. will be allowed in this estimate. which will include the two mile conduit and the pole line.

VALUE OF WATTER AND POWER.

It has been stated by one of the City Managers that Pasadena can afford to pay $2,000 a miners inch for a domestic water supply. This at first thought seems an enormous price but is really $8.50 an acre foot when capitalized at 6%. Los Angeles sells Owens River water for irrigation purposes at $6.00 an acre foot.

The production cost of power sold by Pasadena during the year 1920-21 was $.01147 per kilowatt hour. This was sold at an average price of $.03371 per K.W.H. making a net profit of $.02224 per K.W.H. or $195 per K.W.year.

From the table showing the ratio of cost of the project to the capitalized value of the revenue derived it is seen that at the unit prices used here, any height of dam between 160 and 200 feet could be built at some profit to the city. The margin of profit is so small that the project would hardly be expected to more thn pay the interest on h the investmnent.

If more than sufficient storage could be secured in the Arroyo to fully develope that stream it is possible that a great part of the flood flow of the Tejunga could be saved which otherwise would be lost. The total amount of spill shown on the last curve amounted to 212,000 acre-feet or an aveage spill of 16,300 acre-feet per year.

AREA OF PROFILE OF DAM.

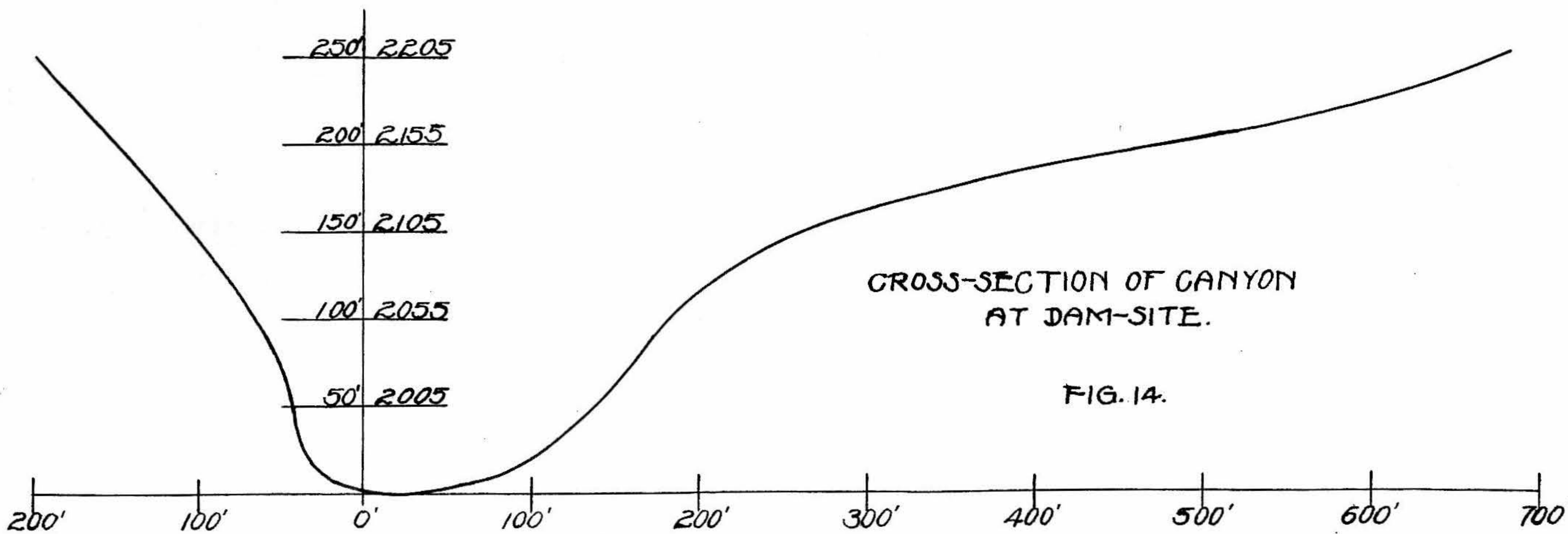
Section	Base Feet	Area Sq.Ft.	Summation Of Areas
0-20	20	400	400
20-40	24	440	840
40-60	35.4	594	1434
60-80	50	854	2288
80-100	64	1140	3428
100-120	78.8	1428	4856
120-140	92.5	1713	6569
140-160	105.8	1983	8552
160-180	118.9	2247	10799
180-200	132.5	2514	13313
200-220	145.5	2780	16093
220-240	159	3045	19138
240-250	166	3250	22388
250-270	180	3460	25848
270-290	193	3730	29578
290-300	200	3930	33508

WIDTH OF CANYON AT DAM-SITE.

Elevation Above Ground Level	Width North Of Center	Width South Of Center	Total Width
25'	40'	110'	150'
50	45	140	185
75	50	160	210
100	70	180	250
125	85	210	295
150	105	280	385
175	125	365	490
200	150	500	650
225	175	610	785
250	200	680	880

CAPACITY OF RESERVOIR FOR VARIOUS HEIGHTS OF DAM.

Height Of Dam	Capacity Of Reservoir Acre Feet
25'	0
50	150
75	790
100	1970
125	3400
150	5600
175	8400
200	11700
225	15800
250	20500



CROSS-SECTION OF CANYON
AT DAM-SITE.

FIG. 14.

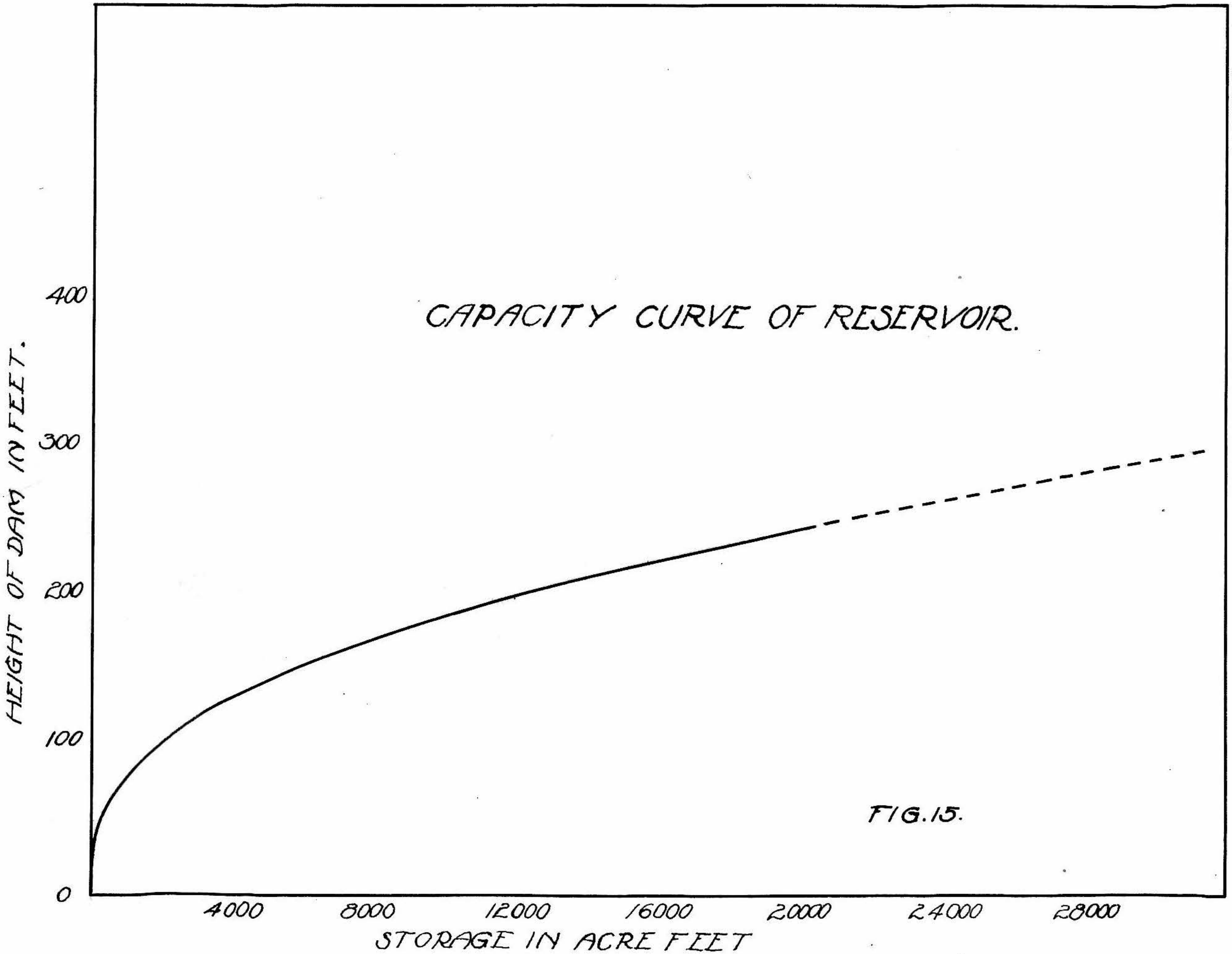
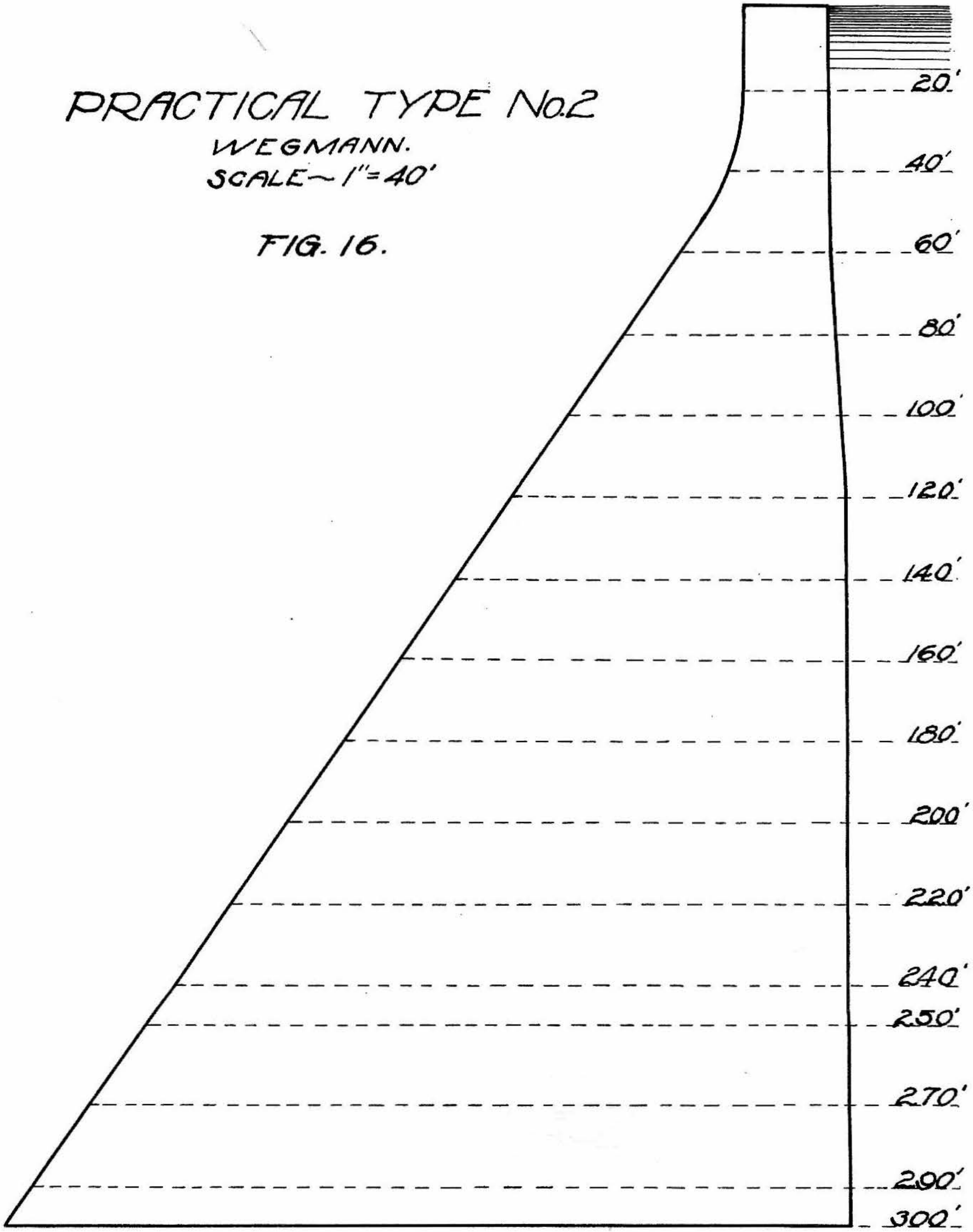

CAPACITY CURVE OF RESERVOIR.
HEIGHT OF DAM IN FEET.
400
300
200
100
0
4000
8000
12000
16000
20000
24000
28000
STORAGE IN ACRE FEET

FIG. 15.

VOLUME OF CONCRETE REQUIRED FOR VARIOUS HEIGHTS OF DAM.

		160' Dam		180' Dam	
Section	Area Sq.Ft.	Length Of Section	Volume Cu.Ft.	Length Of Section	Volume Cu.Ft.
0-20	400	374'	149500	458'	183000
20-40	440	310	136300	374	164500
40-60	594	266	158000	310	184000
60-80	854	234	199600	266	227000
80-100	1140	208	237000	234	267000
100-120	1428	183	261000	208	297000
120-140	1713	157	269000	183	314000
140-160	1983	105	208000	157	311000
160-180	2247			105	236000
Total Cu. Ft.			1618400		2183500
Total Cu.Yd.			59440		80870

		200' Dam		250' Dam	Cu. Yds.
0-20	400	560	224000	845	12520
20-40	440	458	202000	760	12380
40-60	594	374	222000	630	13820
60-80	854	310	265000	505	15950
80-100	1140	266	303000	415	17480
100-120	1428	234	334000	340	17940
120-140	1713	208	357000	285	18070
140-160	1983	185	363000	250	18350
160-180	2247	157	352000	220	18230
180-200	2514	105	263000	195	18100
200-220	2780			170	17500
220-240	3045			155	15700
240-250	1625			70	4200
Total Cu. Ft.			2885000		
Total Cu. Yd.			106850		200290



PRACTICAL TYPE No.2

WEGMANN.

SCALE ~ 1" = 40'

FIG. 16.

POWER DEVELOPMENT

Assuming an over all efficiency of 80%.

H.P. = QxH/11 = Second Feet x Head/11

Head = 240'   H/11 = 21.8

K.W. = Qx21.8x0.746 = 16.3xQ

Q	K.W.	Value @ $195 per K.W. Yr.	Capitalized Value (6%)
10.0	163	$31800	$530,000
12.6	205	40000	666,000
13.9	226	44000	735,000
18.8	306	59800	995,000

COST OF PROJECT FOR VARIOUS HEIGHTS OF DAM

Height Of Dam	Concrete In Dam $13/Cu.Yd.	Power House $200/K.W.	Tunnel $50/Ft.	Total
160'	780,000	32,600	660,000	$1,472,000
180	1,050,000	41,000	660,000	1,751,000
200	1,390,000	45,200	660,000	2,095,000
250	2,610,000	61,200	660,000	3,331,000

CAPITALIZED VALUE OF REVENUE DERIVED

Height Of Dam	Water	Power	Total
160'	1,000,000	530,000	$1,530,000
180	1,260,000	666,000	1,926,000
200	1,390,000	735,000	2,125,000
250	1,880,000	995,000	2,875,000

RATIO OF COST OF PROJECT TO CAPITALIZED VALUE OF REVENUE DERIVED

Height Of Dam	Ratio
160'	0.96
180	0.91
200	0.99
250	1.16