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REPORT ON

WARNER - PAMO WATER SYSTEM

OF THE

VOLCAN LAND & WATER CO.

BY WILLIAM S. POST,

MARCH 16, 1912.

WILLIAM S. POST
ASSOC. MEM. A.S.C.E.
1217 HIBERNIAN BLDG.
LOS ANGELES, CALIFORNIA

Report on

Warner-Pamo Water System.

of the Volcan Land & Water Co.,

San Diego Co., Cal.

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Mar. 16, 1912.

AUTHORITY AND PURPOSE.

This report in prepared in accordance with the instructions of Mr. Wm. G. Henshaw, in order to set down and arrange the results of accumulated surveys and estimates; to give a complete final cost estimate of the Warner-Pamo Water System, and further to state alternative projects or changes suggested by new data and show the debits and credits of such changes, as affecting the total outlay involved.

WARNER-PAMO SYSTEM

Outline.

Warner Project.

Warner Reservoir provides for the storage of the San Luis Rey River at Warner's Dam with a 90 ft. dam, and capacity of 105,000 acre feet. The outlet discharges into

Warner Conduit. This conduit pierces the divide into Pamo drainage at 6.6 miles, which is sufficient for irrigation purpose. It is continued to 9.4 miles to reach the power forebay and pipeline.

The mean flow in the conduit (for the purpose of this report) is taken at 40 cu. ft. per sec. or 2000 Miner's Inches, but the maximum capacity is designed for 60 sec. ft. in order to provide for long peaks or emergency service in the power station, and variations of irrigation demand.

Pint Mt. Forebay Is the regulating basin for the Power House, and contains 32 acre feet, capable of carrying the plant without the conduit for 8 hours, or carrying 100% overload with normal flow in the conduit for the same period.

Pressure Pipe Line is 6800 ft. long, of which 4600 ft. is under less than 500 ft. head, and 2200 ft. between 500 and 1500 ft. head.

The Power House may be designed to suit the preceding hydraulic conditions, as follows, using for convenience the single unit "not kilowatts on switch board at San Diego" assuming 70% combined hydraulic and electrical efficiency.

	Net on Switchboard S.D. K.W.	Daily K.W. Hours	Peak Max K.W.
(a) Continuous output	3600	86,400	3600
or			
(b) Continuous output	2400	57,600	6000
8 hrs. Peak add't'l	3600	28,800	
		86,400	
(c) Continuous output	1200	28,800	
8 hrs. Peak (50% extra water) additional	3600	28,800	8400
8 hrs. Peak as before	3600	28,800	
		86,400	

Pamo Project.

Pamo Reservoir. The tail waters of the Power plant flow directly into the Pamo Reservoir. This also gathers the watershed of the Santa Ysabel Creek.

The maximum height of dam considered feasible is 150 feet, which impounds 39,000 acre feet. It is here estimated as an hydraulic fill, simply because it is the cheapest structure. It is not recommended for this height.

It will be noted that Pamo Reservoir has a dual function, to store the Santa Ysabel winter flood waters and to act as a receiving reservoir for Warner power water sent down in the non-irrigating season. This last will amount to 15,000 acre feet, leaving only 24,000 acre feet storage for Santa Ysabel floods. In reality to put reserve or over year storage on the same basis as Warner's (capacity 3 times normal draft) there is required 66,000 acre feet plus 15,000 acre feet regulation or 81,000 acre feet in all. This is the main problem of the system, and a solution is found in the supplementary "Ramona Project" which is discussed later.

The present outline neglects this and confines itself to the 39,000 acre feet plus 14,000 acre feet lower down, it being understood that the Warner winter power would thus be somewhat curtailed, but irrigation requirements would be largely attended to.

Pamo Conduit. For the purpose of this report the mean flow due to the Santa Ysabel is taken at 30 second feet or 1500 M.I. Adding this to the 40 second feet from San Luis Rey, we have 70 second feet continuous flow for which provision must be made. Reduce this to 60 second feet for conduit losses.

As this is for irrigation use the rate of delivery will be greatly in excess in the summer period. This will be true also of domestic service.

It is probable that from	
May 1 to Nov. 1 - the rate would be	90 to 105 sec. ft.
Nov. 1 to May 1 - the rate would be	30 to 15 " "
Mean flow	60 to 60

An important regulating storage existing in San Clemente Reservoir of 14,000 acre feet capacity. This allowing for partial evaporation will act as a "give and take" to the extent of 25 sec. ft.

Out table then becomes	
Mayl to Nov. 1 the rate will be	90 to 105 sec. ft.
Subtract water supplied from San Clemente Reservoir	25 25
Summer flow requirement in Pamo Conduit	65 to 80 sec. ft.
Nov. 1 to May 1 the rate will be	30 to 15 sec. ft.
Add water required to fill San Clemente Reservoir	30 30
Winter flow in Pamo Conduit	60 to 45 sec. ft.

On the whole a conduit section of 75 sec. ft. or 3750 M.I. is considered ample for Pamo Conduit, and is so used in this report.

The length of this conduit is 24.8 miles, on a grade of 5.28 ft. per mile. The initial elevation is 890 feet above the sea and the terminal elevation 730 feet.

Three miles of conduit consists of steel syphons, 5 miles is in tunnels, and with minor exceptions the balance on steep disintegrated granite slopes.

The last 5 miles is over and along the coastal gravel mesas. These are eroded into many valleys, whose elevation is not over 100 to 250 feet below the general elevation of the mesas. In the writer's opinion, it will be cheaper to traverse this area in a nearly straight line consisting of pipe lines and tunnels, and this plan has been followed in this estimate, using compiled topographic data. This conclusion was reached after a study of the recent location survey, which conformed closely to the winding contour of the mesas.

At the 8th mile the conduit crosses the Santa Maria Creek, which in this plan is connected by a short feeder;

San Clemente Reservoir has a capacity of 14,000 acre feet with a dam 110 ft. high and will act as a regulating and distribution reservoir.

ESTIMATE NO. 1.

WARNER PAMO SYSTEM - IRRIGATION ONLY.

Warner Reservoir-Hydraulic fill type. 90 ft.

Dam - Capacity 105,000 acre feet.

Stream bed Excavation (15 ft)

87,000 cu yds. at $.60 52,200

Stripping sides (4 ft.)

10,000 cu. yds. at .50 5,000

Hydraulic fill

selected clays, 1500 ft. haul stream shovel work, supplemented by short flume and pumped water
320,000 cu. yds. at .27 86,400

Riprapping 18 inches thick

25,000 sq. yds. at $1.00 25,000

Gate shaft and Gates 6,600

Levee on South side (earth fill) 1,000

Spillway (Excavation put in

Hydraulic fill or riprap.)

Spillway Concrete - 200 cu.yds. at $10 2,000

Cut-off wall - extended up sides

500 cu.yds. at $10 5,000 $183,200.

Warner Conduit - 6.6 miles Dam to Temescal Cr.

Lined Ditch Class "A" 3120 lin.ft. at			$2.00	$6,240
" " " "B"10700 " "			2.50	26,750
" " " "C" 1990 " "			4.00	7,960
" " " "D" 350 " "			6.00	2,100
Flume on Bench 5500 Lin.ft. at			4.50	24,750
" " Trestle 1430 " "			7.00	10,010
Tunnels 11,600 lin.ft.		"	18.00	209,880 $ 287,690.

Pamo Reservoir Site "B" 150 ft. high.

Lands not owned 600 acres at $25.				15,000
Dam earth fill.				
Stream excavation	90,000	cu.yds at	$.60	54,000
Stripping	40,000	" "	.50	20,000
Fill	1,000,000	" "	.25	250,000
Outlet Tunnel 800 lin.ft.			.18	14,400
Gates and shaft				7,000 360,400

Pamo Conduit 24.8 miles.

Lined Ditch				
Class A	11,605	lin.ft. at	$2.00	23,210
" "B"	19,824	" "	2.50	49,560
" "C"	14,655	" "	4.00	58,620
" "D"	1,847	" "	6.00	11,080
Flumes				
On bench	37,080	" " at	$5.00	185,400
on Trestle	6,576	" "	7.00	46,030
Tunnels				
Hard Rock	16,216	" "	18.00	291,890
Gravel	8,170	" "	12.00	98,040
Syphons				
Low head	8,737	" "	6.00	52,420
High head	5,990		8.00	47,920
Santa Maria Feeder				
Flume 4770 lin. ft.			4.00	19,100 883,270

San Clemente Reservoir -- 110 ft. high.

Hydraulic fill, party moved in with steam shovel and placed by water		
1,373,000 cu. yds. at .20		$274,600
Outlet pipe and water tower		
500 lin. ft. at $6.00	3,000	
Tower	5,000	
Gates	5,000	
Cost of lands in site 200 acres at 50.	10,000	$297,600
Supply Roads - 30 miles at $1000		30,000
Engineering		50,000
Estimate No. 1 Warner-Pamo System as an irrigation project only.		$2,092,160

Analysis Warner-Pamo System Irrigation only.

	Cost per acre foot stored.	Cost per Miner's continuous flow
Warner Reservoir	$2.	
Pamo Reservoir	9.	
San Clemente Reservoir	21.	
Warner Conduit - 7 miles		$144
Pamo Conduit 26		294
All Reservoirs	5.59	290.
Total conduit 33 miles		407.
The System		697.

Results. This system delivers at Linda Vista

44,000 acre feet

1,350,000 thousands of gallons.

or

60 sec. ft. continuous flow

3000 miner's inches " "

with 25% temporary increases.

Estimate No. 1 (a)

Warner-Pamo System Irrigation, long route.

via Highland Valley.

Beyond Santa Maria Creek, an alternative line exists through Highland Valley. This eliminates 14,806 feet including 9730 lin. ft. of tunnel and adds 33,196 feet of conduit. This has an advantage in reaching a nearer point for Escondido, but introduces 2 miles of unsatisfactory bluffs, and loses 23 feet in grade.

Credit Between miles 10 and 13, alignment from station 494+34 to station 639+46 is 14,506 ft.

Tunnel 9730 lin. ft. at $18.00		$175,140	
Flume			
on bench 3278 lin.ft. at $5.		16,390	
Lined ditch			
Class "C" 1498 " "	$4.	5,990	$197,520.

Debit Alternative line connecting above stations via High Valley - 33.096 ft.

Lined Ditch				
Class "A"	5516 lin.ft. at	$2	11,032	
"B"	3991 " "	2.50	9,978	
"C"	4385 " "	4.00	17,540	
Flume				
On bench	9655 " "	5.00	48,275	
On trestle	3908 " "	7.00	27,356	
Tunnel	3831 " "	18.00	68,958	
Syphons	1910 " "	6.00	10,860	$194,000.

Changes on remainder of line

Changes on remainder of line due to lowering grade 23 ft.	
Lined Canal Class "D" 1000 ft. at $6.	$ 6,000
Tunnels 560 lin. ft. at $18.	10,800
Loss of power at San Clemente due to lowering grade 23 ft. 75 K.W. at $200 (Capitalized value)	15,000
Total Debits	$225,800.
Total Credits	197,520.
Difference in favor of Short route	$ 28,280
Add Estimate No. 1	2,092,160.
Estimate No. 1 (a) (Warner-Pamo via High Valley)	$2,120,440.

Estimate No. 1 (b).

Warner-Pamo Irrigation and Power System.

To introduce Warner power development requires only the construction of 3 miles additional of Warner Conduit, a forebay, pipe line and power house as follows:

Warner Conduit-extended.

Lined canal.

Class "A"	510	lin.ft.	at $2.		$1020.
" "B"	3100	"	"	2.50	7750
" "C"	8040	"	"	4.	32160
" "D"	500	"	"	6.	3000
Flume					
On bench	1840	"	"	5.	9200
on trestle	1370	"	"	7.	9590 $62,720.
Forebay					
Earth dam					
48,000 cu. yds. at $.30					14400
Outlet Culvert	400	ft.	at $5.		2000
Waste Pipe	400	"	" 5.		2000 18,400
Pipe Line					
Steel pipe, 1,515,000 lbs at .07					106050
Trench 6500 ft. at $2.00					13000
Concrete anchorage 500 cu yds at $10.					5000 124,050
Power Station, Electrical and Hydraulic machinery and power house installed, to produce 7200 K.W. net, delivered at San Diego, at $43. per net K.W.					309,600
Land and other buildings					10,000 319,600
Total					526,770
Add Estimate No. 1					2,092,160
Estimate No. 1 (b) (combined irrigation and power)					$2,616,930

Results.

The use of power in normal years will not interfere with irrigation. The receiving capacity of Pamo and San Clemente Reservoirs totals 53,000 acre-feet. Warner Power plant will deliver 15,000 acre-feet in the non irrigating season, leaving 38,000 acre feet for Santa Ysabel floods. Allowing one third of this 38,000 for evaporation, we still have 25,000 acre-feet net sufficient to secure the 30 cu.ft. net which we have taken as due from the Santa Ysabel; However in wet years Santa Ysabel will over flow and be wasted, and dry years will decrease this 30 sec.ft. Warner's Dam if called on to make up the deficiency, may be forced to transfer water, not usefully used in the wheels, and to that extent impair its earning power and its future average constant flow. This does not seem desirable, and it were better to adjust Warner flow as a constant, supported by its reservoir and allow the Santa Ysabel to vary with the vicissitudes of the seasons. To put it on the same basis of constancy which we give Warner's viz: a ratio of capacity 3 times the draft, we would allow Santa Ysabel's 39,000 acre feet, a draft of 13,000 acre feet or only 15 sec.ft. This reduces our total delivery at San Clemente to 45 sec.ft. instead of 60 sec.ft.

We have then as definite results:

Power	K.W. Continuous	3600
	Max. K.W. Peak	7200
	Daily K.W. hours output	86400

Irrigation - 35,000 acre feet
of 10,800,000 thousand of gallons
or 45 sec. ft. continuous flow
or 2250 Miner's Inches.

Assessing on power the entire cost of Warner Project we have:-

Warner Power Project - 3600 K.W.

Total Cost,	$ 1,035,660.
Cost per net K.W.	$288.

Pamo Project - 2250 M.I.

Total cost,	$ 1,581,270.
Cost per Miner's Inch	$703.

Estimate No. 1 (c)

The conditions of Estimate No. 1 (b) may be improved greatly by adding Sutherland Reservoir.

The writer is not informed on the estimates of this dam. Assuming however, that a storage of 40,000 acre feet can be had then for $150,000, we have

Estimate No. 1 (c)

Warner-Pamo System with Sutherland Reservoir.

Total	$ 2,776,930.

This gives us

Irrigation 3000 M.I.

Total cost	1,731,270
Cost per M.I.	$566.

Power 3600 K. W.

Total Cost	1,035,660.
Cost per K. W.	$288.

Supplementary Systems.

There is no lack of storage on the Santa Ysabel Creek. Sites exist on Santa Ysabel Ranch, Ballena Valley, Hatfield Creek, Sutherland Valley, Ramona Valley, and the Santa Maria Reservoir.

Pamo Reservoir is more important for its position on the line of the Warner-Pamo System, than for its inherent value. It is low in altitude and requires a long conduit for its outlet. No power is extracted by its construction.

To utilize the Santa Ysabel for power, and increase its storage, and to include the drainage area of the Santa Maria Creek, survey has been made of a diversion into Ramona Valley. This supplementary system will be termed the "Ramona Project."

The Ramona Project.

Black Canyon Reservoir. The diversion is at the junction of Black Canyon and the Santa Ysabel. It secures 74 sq. miles of drainage area, or 65% of the Pamo Reservoir watershed. The continuous flow is taken in this report as 20 sec. ft. The elevation of outlet is 1625 feet.

The reservoir with a 60 ft. dam stores 384 acre feet and would be designed simply to equalize flood rushes and carry them away rapidly in a conduit of 100 sec. ft. capacity of 5000 M.I. Its reserve during a typical three days storm would represent 2500 M.I. held back for 3 days, and then sent down the conduit after the storm. This however would not be sufficient for the great storms.

Black Canyon Conduit is 8 miles long including 1 mile of tunnel, and discharges into the Ramona Reservoir. The capacity is 6000 acre feet, with a 50 ft. dam. This also receives the waters of the 28 sq. miles of Hatfield Creek and adjoining watersheds. The overflow is by the natural channel of the Santa Maria Creek into Santa Maria Reservoir.

Irrigation of Ramona Valley. The Ramona Reservoir would be the distribution reservoir for the irrigation of Ramona Valley where 4000 acres could be placed under ditch. This would require 400 Miner's inches or 8 sec.ft. The seepage or return waters from this irrigation as usually estimated would be one-third or 3 sec.ft. Judging from the "hard pan" formation, it may amount to one-half or 4 sec. ft.

Santa Maria Reservoir.

A careful survey of this site was made by Alverson in 1895, for a dam 80 ft. in maximum height, storing 8700 acre feet. The dam site is in excellent rock and should be constructed of concrete, in the arched form. In masonry it can be carried to 150 ft. Surveys are now being made to obtain the increased capacity, which will be given in a supplementary report, but it can be stated at once that the storage can be made to equal the water supply. In other words further survey is expected to show a storage capacity of say 50,000 acre feet for a higher dam, say of 130 feet height.

Santa Maria Power Station.

Santa Maria Reservoir has an elevation of about 1340 feet. The Pamo conduit immediately below it has an elevation

840 feet, producing a fall of 500 feet. The distance for a pressure pipe is not over 5000 ft. The reservoir forms an ideal forebay and the peak load capacity is limited only by the electrical installation, by the capacity of the Pamo Conduit to take away the waters discharged, and by the receiving capacity of San Clemente Reservoir.

The design of the Power House may cover the following conditions:-

	Net on switchboard at S.D.		
	K. W.	Peak max.K.W.	Daily K.W.Hours
(a) Continuous output	800	800	19,200
or			
(b) 6 hrs. peak and shut down 18 hrs.		3200	19,200
or			
(c) 2 hrs peak, shut down 22 hrs. (Limit of Pamo Conduit receiving capacity)		9600	19,200

Additional Power will exist between Ramona Reservoir and Santa Maria Reservoir. This could be utilized in connection with the valley's irrigation distribution canal, in the non-irrigating season, amounting to about 80 K.W. Overflow water would thus be transferred without waste, from Ramona Reservoir to Santa Maria Reservoir. This additional power is not estimated or included in this report.

Estimate No. 2 (Preliminary)

Ramona Project -- Irrigation only.

Black Canyon Dam, 60 ft. high

Concrete 6,000 cu.yds. at $5.	30,000	
Gates and outlet	3,000	$33,000

Black Canyon Conduit.

Lined Conduit,			
Class "A" 11,620 lin.ft. at $2.		23,240	
" "B" 10,740 " "	2.50	26,850	
" "C" 11,060 " "	4.	44,240	
Flume			
On Bench 1,000 " "	4.50	4,500	
" Trestle 2,660 " "	7.	18,620	
Tunnel			
5720 lin.ft. at $18.	102,960		230,400

Ramona Reservoir. 50 ft. high - 6000 acre feet.

Earth fill, 170,000 cu.yds. at $25.	42,500	
Paddle wall	10,000	
Outlet and gates	5,000	
Lands 400 acres at $25.	10,000	67,500

Santa Maria Reservoir.
130 ft. high - 50,000 acre ft.

Concrete 45,000 cu.yds at $5.	225,000.	
Gates	5,000	
Lands 1000 acres at $15.	15,000	245,000
Engineering,		30,000

Total Estimate No. 2, $ 595,900.

Results.

The delivery into Pamo Conduit at the 8th mile of 25 sec. ft. or 1250 M.I. as demanded. Or the irrigation of 4000 acres requiring at least 400 M.I., and the delivery of 1000 M.I. to Pamo Conduit.

Analysis:

	Cost per acre foot	Cost per M.I. continuous flow
Black Canyon Reservoir	$86	
Ramona Reservoir	$12	
Santa Maria Reservoir	$ 5	
All Reservoirs	$ 6	
Black Canyon Conduit		$231.
The System - delivering at 8th mile of Pamo Conduit		$477.

Estimate No. 2 (a) - (Preliminary)

Pressure Pipe.

2000 lin.ft. at $6		12,000	
1500 " "	10	15,000	27,000.
Electrical & Hydraulic Machinery			
to produce at net delivery of			
3200 K.W. at S.D. at $43		137,600	$164,600
Add Estimate No. 2			595,900
Total Estimate No. 2 (a)			$760,500.

(Ramona System - Irrigation & Power)

Changing one-half of amount to power, we have $119 peak K.W. of $476 per continuous K.W.

COMBINED.

Warner - Pamo and Ramona Systems.

Irrigation and Power.

The joining of the two systems give the following results:-

(a) The storage of the Santa Ysabel is brought up to the Warner Standard of capacity equals 3 times draft.

(b) The Pamo Dam may be reduced from a capacity of 39,000 acre feet to 22,000acre feet, lowering the dam to 130 feet.

(c) The water delivered at Linda Vista would be

65 sec. ft. or 3250 M.I.

(d) Power would not interfere with irrigation as the receiving storage is ample. The total power would be

	Continuous K.W.	Daily K.W. Hours	Max.peak K.W.
Warner Plant	3600	86,400	7200
Santa Maria Plant	800	19,200	3200
Total	4400	105,600	10,400

Estimate No. 3.

Combined Warner-Pamo and Ramona Systems.

(Irrigation & Power)

Estimate No. 1 (c) (Warner-Pamo System Irrig. & Power)	$ 2,616,930.
Estimate No. 2 (a) (Ramona Irrig.-Power)	760,500
	$ 3,377,430.
Substract reduction in Cost Pamo Reservoir, 150 ft. dam to 130	127,000
Estimate No. 4, Combined Systems.	$ 3,250,430.

Analysis-

Assessing Warner Project and one half of Ramona System to power, we have for "Combined Systems";-

Power

Total Cost,	$ 1,415,910
Cost per net K.W.	$322.

Irrigation,

Total Cost	$ 1,834,520
Cost per continuous M.I.	$523.

Witch Creek - Hatfield Project.

Higher on the drainage of Santa Ysabel, is a very similar situation to the Ramona Project." A diversion above the junction of Witch-Creek into the Ballena Valley and from there into Hatfield Creek (or the upper Santa Maria), is feasible. Storage would then be obtained in the excellent Hatfield reservoir.

From the irrigation and storage standpoint, both are not necessary. Of the two, Ramona project is preferred because it is on a larger scale and accomplishes the most.

As a small power plant, Hatfield may have merit, in which case the cost of diversion works should be assessed to its power. It could be made to equalize the winter shortage in power indicated in Ramona plants -- due to lack of receiving capacity in the Pamo Conduit and below.

We have figured sufficient average irrigation storage for the Santa Ysabel and Santa Maria or Hatfield Creek without the Hatfield reservoir. Probably it has a very low cost per acre foot and it should be retained if for nothing else, for reservoir over year storage which will become increasingly important in Southern California, as water becomes more valuable, and is sold in cubic quantities rather than the Miner's Inch per year.

A survey of Hatfield Reservoir has been made and results will be submitted in a supplementary report.

Sutherland - Hatfield Project.

Again, even more similar to the "Ramona System," is the Sutherland-Hatfield" System. If the Black Canyon Reservoir and the Ramona Reservoir are conceived to be raised 200 feet in altitude, the arrangement and the probable costs would correspond very closely.

In favor of it, is the direct use of the large Sutherland reservoir for equalizing flood rushes, the direct use of Hatfield Reservoir also for Santa Ysabel flood water. Hatfield is a better reservoir than Ramona. Hatfield Reservoir is high enough to reach the pass at the head of Mussey Grade, 4 miles South West from Ramona, and covers a feasible routing of water through t his pass.

Against it, would appear possible excessive price for Sutherland Reservoir, and the need of providing a connection with Black Canyon to divert its flood water into Sutherland Reservoir, a distance of about 2 miles.

WARNER-RAMONA SYSTEM.

In the preceeding study there arises the question, "Is Pamo Reservoir and the first 9 miles of Pamo Conduit necessary?"

It is necessary as long as Warner waters are delivered at the head of Temescal creek. The problem then goes back to Warner's. Two solutions will be suggested on this problem.

One proposes the joint use of Escondido Ditch for Warner water as is given later under the title, "EscondidoO Ramona System." It involves considerable waste of power.

The other here described under the title "Warner-Ramona System" preserves the power. It proposes a 4½ mile tunnel direct from Warner's Reservoir to Black Canyon, a power drop of 1000 feet to Black Canyon Reservoir, and thence conveying Warner waters through the "Ramona System" to Santa Maria Reservoir and thence by the Pamo Conduit as surveyed from the 9th to 25th mile or a modified higher route if cheaper. The cost would be approximately as follows:

Estimate No. 5.

Warner-Ramona System - Power & Irrigation.

Warner's Dam,	
as before given,	183,200
Warner-Black Canyon tunnel,	
4.25 miles at $25. per ft.	561,000
Ramona System,	
Estimate No. 2 (a)	760,500
Pamo Conduit,	
9th to 25th Mile	627,000
San Clemente Reservoir,	
as before given,	297,600
Black Canyon Power House and Pipe Line,	
4800 K.W.	246,400
Santa Maria Power House increased from	
3200 K.W. to 8300 K.W.	219,300
Roads	20,000
Engineering	50,000
	$2,965,000.

Analysis: -- Irrigation only. 3400 M.I.

Omitting from estimate No. 5 the charges for machinery etc. for Power Houses, we have:

Estimate No. 5,	$ 2,965,000.
Deduct Power House etc.	660,300.
Estimate No. 5, (a)	$ 2,304,700.

Irrigation Analysis:

	Cost per acre foot	Cost per continuous M.I.
Warner Reservoir,	$2.	
Warner-Black Canyon, tunnel conduit,		$280.
Black Canyon Reservoir	86.	
Black Canyon Conduit		231.
Ramona Reservoir	12.	
Santa Maria Reservoir	5.	
Pamo Conduit 9th to 25th		209.
San Clemente Reservoir	21.	
All Reservoirs,	6.40	328.
All Conduits,		350.
The System		678.

Analysis: Irrigation and Power.

Assessing all of Warner's Dam and tunnel, and one-half of "Ramona System" to power, we have:

Power	4480 K.W.	
	Total Cost,	$1,630,150.
	cost per net K.W.	$362
Irrigation	3400 M.I.	
	Total Cost,	$1,344,850.
	Cost per continuous M.I.	$392.

Results:

a) The abandonment of Pamo Reservoir and the watershed below Black Canyon involves the abandonment of 10 sec.ft. or 500 M.I. This is partly or wholly required to settle San Pasqual riparian rights. The total delivery at Linda Vista amply supported by reservoirs is

44,000 acre ft.

or 14,400,000 thousands of Gallons

or 60 sec. ft. continuous flow

or 3000 M.I. " "

To which should be added the Ramona Valley irrigation of

400 M.I. continuous flow.

b) The s torage on the system totals 175,000 acre feet, It is so distributed as to take care of continuous output of power. As the lowest receiving basin, San Clemente, is comparatively small, this means that in winter the Black Canyon plant must carry the bulk of the overloads, the water being held in transit in Santa Maria. The estimates cover this feature.

c) The total power would be

	Continuous net K.W.	Daily K.W.hrs	Max.Peak K.W.
Black Canyon Plant	2400	57,600	4800
Santa Maria Plant	2080	49,700	8300
	4480	107,300	13,100

ESCONDIDO RAMONA SYSTEM.

The other solution to by-pass Warner water around the Pamo site, proposes continuing Warner Conduit to the head of the Escondido Ditch, utilize the fall of about 1000 feet, deliver the tail waters into the Escondido ditch which then would become a joint carrier to the Escondido Bear Valley Dam.

From Bear Valley dam a pipe line would be required probably 12 miles long, and 30" diameter, costing $15,000. per mile.

Estimating this roughly we have

WARNER DAM	$183,000.
Power Plant 2400 K.W..	
Conduit, Pressure Pipe,	
Machinery	565,000.
Escondido Ditch	
1/2 Interest and Improvement	170,000.
Pipe Line	
12 Miles at $15,000	180,000.
Ramona System	
Estimate No. 2 (a)	760,000.
Pamo Conduit	
10th to 25th mile	627,000.
San Clemente Reservoir	298,000.
Engr and Roads	80,000.
Estimate No 6.	$ 2,743,000.

CONCLUSIONS

1. The Warner-Pamo system if adopted should include Sutherland Reservoir.

2. The preceding comparative financial statement indicates the Warner-~~Pamo~~ Ramona system will give the maximum amount of water and of power, at the lowest cost per unit.

In other ways it has merits, It provides water for San Pasqual riparian uses. All the dams will be conservative engineering structures. The location of conduits is on satisfactory ground and of low maintenance cost.

The zone of irrigation has 1300 feet above sea as its upper limit.

To review and slightly modify the main points of this plan, it is believed the following should constitute the system.

1. Warners Dam
2. Long Tunnel to Black Canyon.
3. Black Canyon Power Plant.
4. Sutherland Reservoir.
5. A conduit to Ramona Valley.
6. Hatfield Reservoir.
7. A small power plant below Hatfield Reservoir.
8. Santa Maria Reservoir.
9. A conduit parallel to and above the Pamo conduit between the 8th and 10th miles, on about

the 1300 foot contour above sea.

10. A Power Plant at tne of this conduit, delivering water at the 10th mile of Pamo Conduit.

11. The Pamo Conduit 10th to 25th miles.

12. San Clemente Reservoir.

In this outline the equivalent reservoirs- Sutherland - Hatfield are substituted for Black Canyon- Ramona, which were used in the preceding estimate. It does not change the conclusion drawn from the estimates.

Los Angeles, California.

March 16, 1912.

APPENDIX "A"

-------- PANO CONDUIT --------

Classification of Ditch

PAMO CONDUIT THE

VOLCAN LAND AND WATER COMPANY

Accompanying Report of W.S.Post.

Estimate RAMO CONDUIT.

Feb. 1912. W. S. Post Engr

	Lined Ditch				Flume			Syphon	
	A	B	C	D	Bench	Trestle	Tunnel	H 150'	H 150'4
1st mile	687'	2047'	1895'		167'	484'			
2nd "		4957'				323'			
3rd "		640'	637'	282'	2070'	148'	860'	493'	150'
4th "	1099'	622'		219'	2722'	331'		287'	
5th "	345'	918'	849'	61'	1826'	575'	706'		
6th "					3440'	430'	1410'		
7th "		2686'	908'		897'	353'	436'		
8th "		324'	1859'		1835'	390'	772'	(Short Mile)	
9th "			1816'	277'	2093'	124'		400'	570'
10th "					1374'		3906'		
11th "							5280'		
12th "			1498'		2628'		1154'		
13th "					5173'		107'		
14th "		330'	753'		1968'	169'	1246'	814'	
15th "	1837'	439'	975'			435'	339'	955'	300'
16th "	5030'					250'			
17th "	1625'	1515'	726'	700'		714'			
18th "	982'	1446'	677'	308'	487'	1380'			
19th "		2435'	1227'			270'			
20th "		1465'	835'						
21st "					3090'				
22nd "					2050'	200'			
23rd "					2700'				
24th "					2560'				
Fr'l "							4080'		
Total	11605	19824	14655	1847	37080	6576	24386	8737	5990

Estimate No. 1 (a)

PAMO CONDUIT VIA HIGH VALLEY.

Summary — Lengths in ft.

	Lined Ditch				Flume			Syphon
Miles	A	B	C	D	Bench	Trestle	Tunnel	H 150 - H 150
Fr'l 10th					2575	791		
11th					4080	1200		
12th	1360				3000	500	420	
13th	2685	1600	600			395		
14th		367	2600			662	1651	
15th	1471	1324	485			240	1760	
Fr'l 16th		700	700			120		1810
Total	5516	3991	4385		9655	3908	3831	1810

APPENDIX "B"

Method of determining quantities and prices.

****

The method adopted in these estimates has been to use "the linear foot" of various types of conduit as the only unit. The excavation is almost entirely in the granite, so uniformly found in San Diego County or its disintegrated product. Rock mesas lie strewn above the deeply disintegrated material, imbedded but not as a rule constituting solid rock excavation. It was considered that if a type of conduit was adopted which would serve either in disintegrated granite or in solid rock, the estimates would best represent the conditions after the work was opened up. Further the flume proposed is taken at about the same cost as heaviest excavation in rock, and either lined conduit or flume may be used, as detail location requires. Flume is used in this estimate wherever the slopes were considered unsafe from a maintenance standpoint owing to the steepness and depth of overburden.

In the prices assigned to the three classes of excavation a uniform price of $1.50 per linear foot was adopted for concrete lining and an excavation price of 50¢, $1.00 and $2.50 per foot adopted for various classes. This is roughly 25¢ per cu. yd for all material; and correspond closely with road making costs in the County which is very similar and to other conduits.

The price for hard rock tunnel was taken at $14. per foot, lining at $6. per foot, or $20. total. As it is not anticipated that lining will be necessary throughout $18. was adopted as an average price.

The two types of flume presented are regarded as permanent constructions, which alone would be feasible where power is involved.

The prices used are considered to be for first-class construction throughout, and includes superintendence of construction charges. It is probable that in places the full expense need not be met at once, and economies may be introduced in others. The same values have been used in the comparative estimates, and the point is made that a modification of style of construction or of prices would not change the relative costs of the various systems discussed.

The instructions did not include assigning prices to electrical and hydraulic installations, but some figure was found necessary to bring out the unit costs of the various systems.

The figure adopted for this purpose was the actual cost (including all items, buildings, etc.) of the Cottonwood plant of the Los Angeles Aqueduct. This was $30. per "kilowatt installed" or reducing to the unit used in this report "net kilowatts on switchboard at San Diego, assuming 70% efficiency" we have $\frac{100}{70} \times \$30$ or $43 per "net kilowatt" which is used in this report.

APPENDIX "C"

Capacities of Reservoirs.

****

Capacity

WARNER RESERVOIR.

From final surveys by Volcan Land & Water Co:,

W.S.Post Engr.
(Revised final figures inserted Nov. 1912)

ELEVATION of High Water Surface	Depth	Acres flooded	Capacity in Acre feet.
2620	0	0	0
2630	10	17	58
2640	20	58	381
2650	30	260	1870
2660	40	875	7650
2670	50	1027	17156
2680	60	1822	31400
2690	70	2300	52010
2700	80	2960	78310
2710	90	4055	113390
2720	100	5740	162360

CAPACITY

PAMO RESERVOIR DAM SITE"B"

Elevation of High Water Surface	Depth	Acres	Capacity Acre feet.
850	0	0.15	
860	10	3.	15. acre feet
870	20	9.	72. " "
880	30	21.	219. " "
890	40	63.	635. " "
900	50	103.	1463. " "
910	60	147.	2709. " "
920	70	184.	4364. " "
930	80	245.	6508. " "
940	90	303.	9248. " "
950	100	362.	12628. " "
960	110	443.	16654. " "
970	120	539.	21564. " "
980	130	662.	27571. " "
990	140	805.	34905. " "

Capacity.

SANTA MARIA RESERVOIR.

Compiled from Alverson's Report.

Elevation of high water surface	Depth	Acres flooded	Capacity Acre feet.
1260	0	0	0
1270	10	1	1
1280	20	8	45
1290	30	23	100
1300	40	41	522
1310	50	80	1108
1320	60	154	2305
1330	70	286	4500
1340	80	561	8736
1400	140	approx 5000	———

Capacity.

A
BLCK CANYON RESERVOIR.

on Santa Ysabel Cr.

Elevation of high water surface	Depth	Acres flooded	Capacity Acre feet.
1620	0	0	0
1625	5	0.5	0.6
1635	15	1.2	7
1645	25	6	36
1655	35	10	108
1665	45	13	224
1675	55	19	384
1685	65	22	589
1695	75	27	836
1705	85	33	1138
1715	95	40	1501
1725	105	47	1933

Capacity.

Upper San Clemente Site in

N.E. ¼ of Section 10.

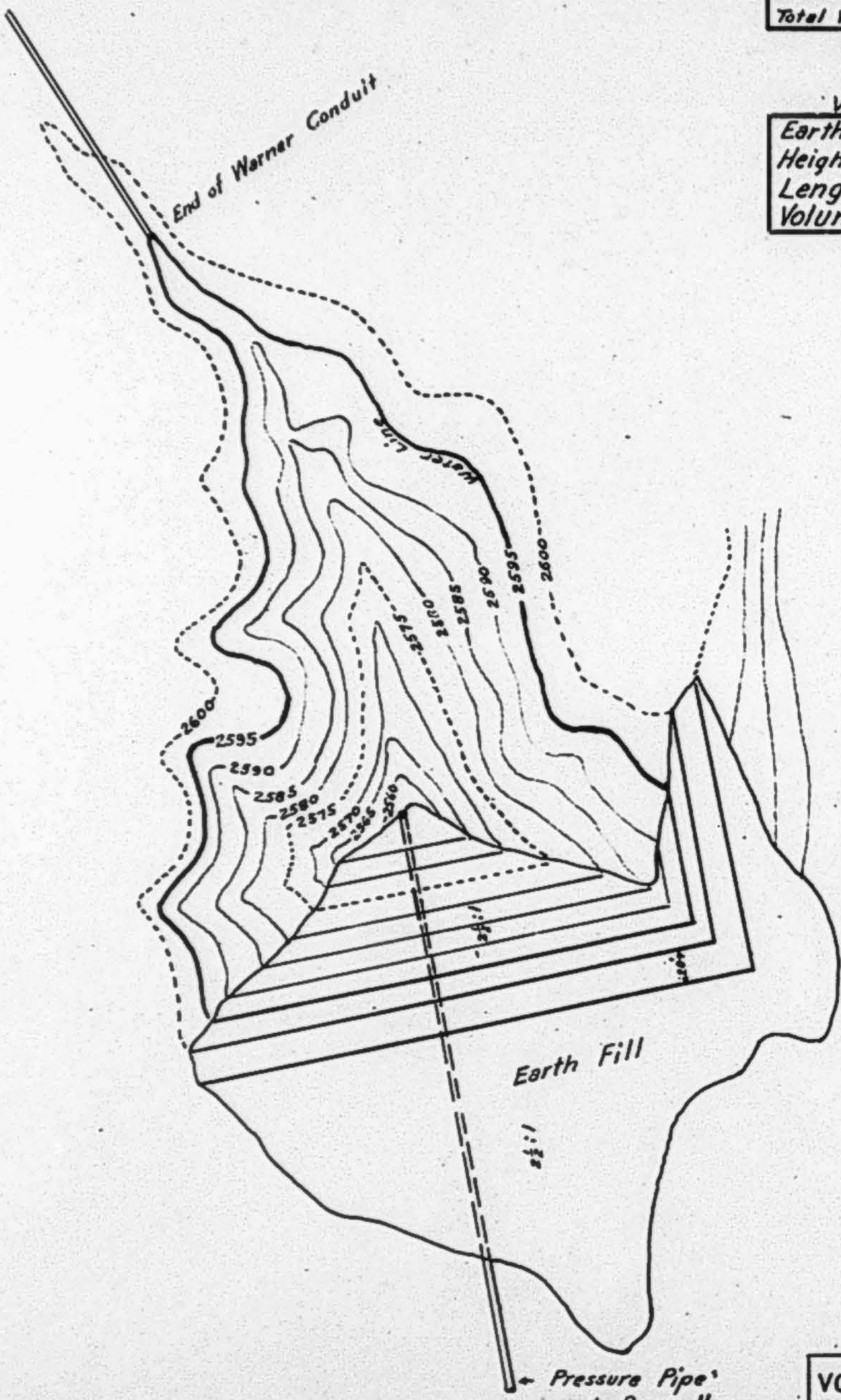
Contour	Depth	Acres flooded	Capacity Acre feet.
600	10	8	2
610	20	23	15
620	30	60	431
630	40	79	1085
640	50	93	1943
650	60	129	3054
660	70	166	4530
670	80	201	6370
680	90	238	8570
690	100	277	11140
700	110	317	14110

Capacity of Reservoir

Elev. Water Surface	Depth	Surface A.	Capacity Acre Feet
2555	0'	0	0
2565	10'	.03	0.1
2575	20'	.25	1.5
2585	30'	.69	6.2
2595	40'	1.60	17.3
Add ½ Vol. of Dam Excavation			14.9
Total Vol. when completed			32.2

Volume of Dam

Earth Fill	
Height	45 Feet
Length	470 "
Volume	48,000 Cu.Y.



VOLCAN LAND & WATER CO.
WARNER CONDUIT
PINE MOUNTAIN FOREBAY
SCALE: 1"=100'

Mar. 1912
W.S. Post Engr.

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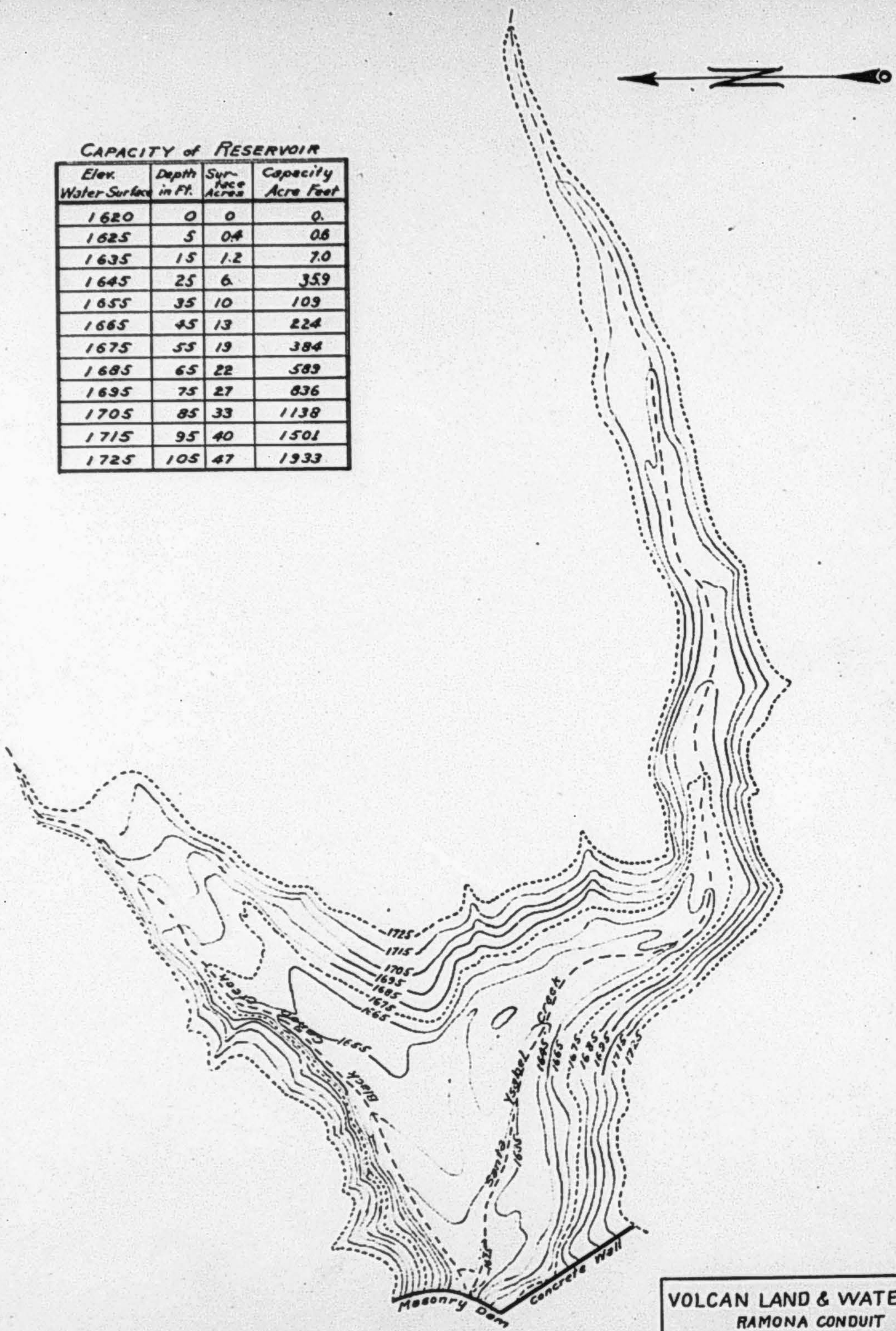
CAPACITY of RESERVOIR

Elev. Water Surface	Depth in Ft.	Surface Acres	Capacity Acre Feet
1620	0	0	0.
1625	5	0.4	0.6
1635	15	1.2	7.0
1645	25	6.	35.9
1655	35	10	109
1665	45	13	224
1675	55	19	384
1685	65	22	589
1695	75	27	836
1705	85	33	1138
1715	95	40	1501
1725	105	47	1933



VOLCAN LAND & WATER CO.
RAMONA CONDUIT
BLACK CAÑON RESERVOIR
SCALE: 1" = 400'

Mar. 1912
W.S. Post, Engr.

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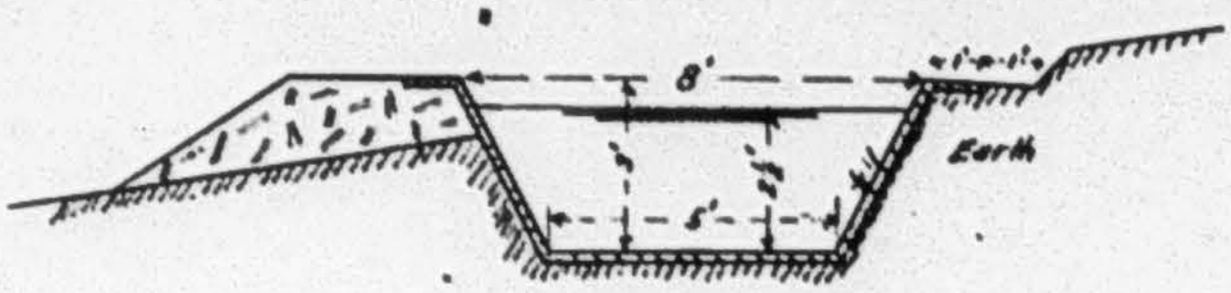
Section

CLASS "A"

Typical of Classes "B" & "C".

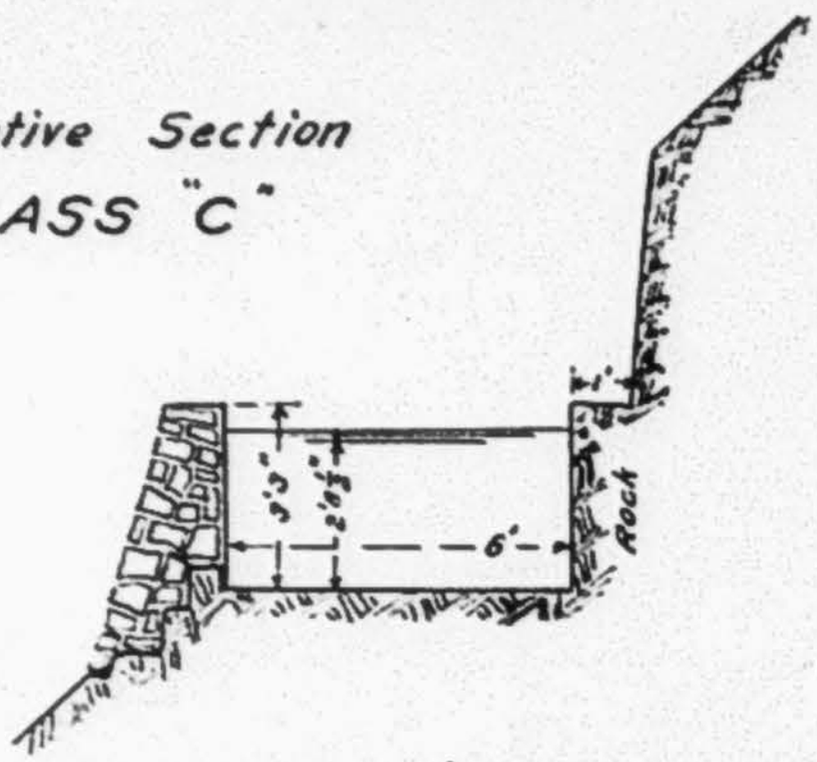


Alternative Section

CLASS "C"

HYD. PROP

S = .0009
R = 1.42
n = .015
c = 106
A = 16.2 sq. ft.
V = 3.8 ft/sec.
Q = 61.6 cu. ft/sec.



Cross Sections

CONCRETE LINED DITCH

CLASS "A"

Ground Slope 0° to 15° in earth Avg. Exca. 0.75 Cu Yds/Lin ft.

CLASS "B"

Ground Slope 15° to 25° in earth Avg. Exca. 1.1 Cu Yds/Lin ft.
" " 0° to 15° - rock " " 0.9 "

CLASS "C"

Ground Slope 25° to 35° in earth Avg. Exca. 1.5 Cu Yds/Lin ft.
" " 15° to 25° - rock " " 1.3 "

CLASS "D"

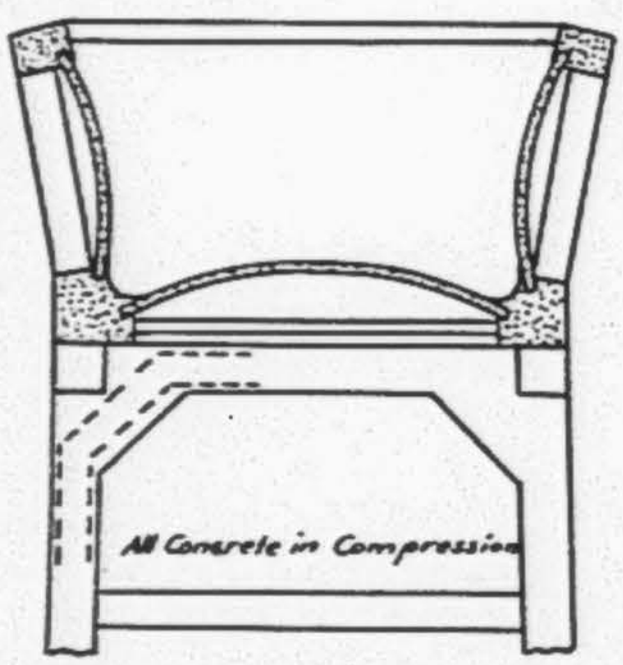
Special Cases where the cut or rock work is heavy

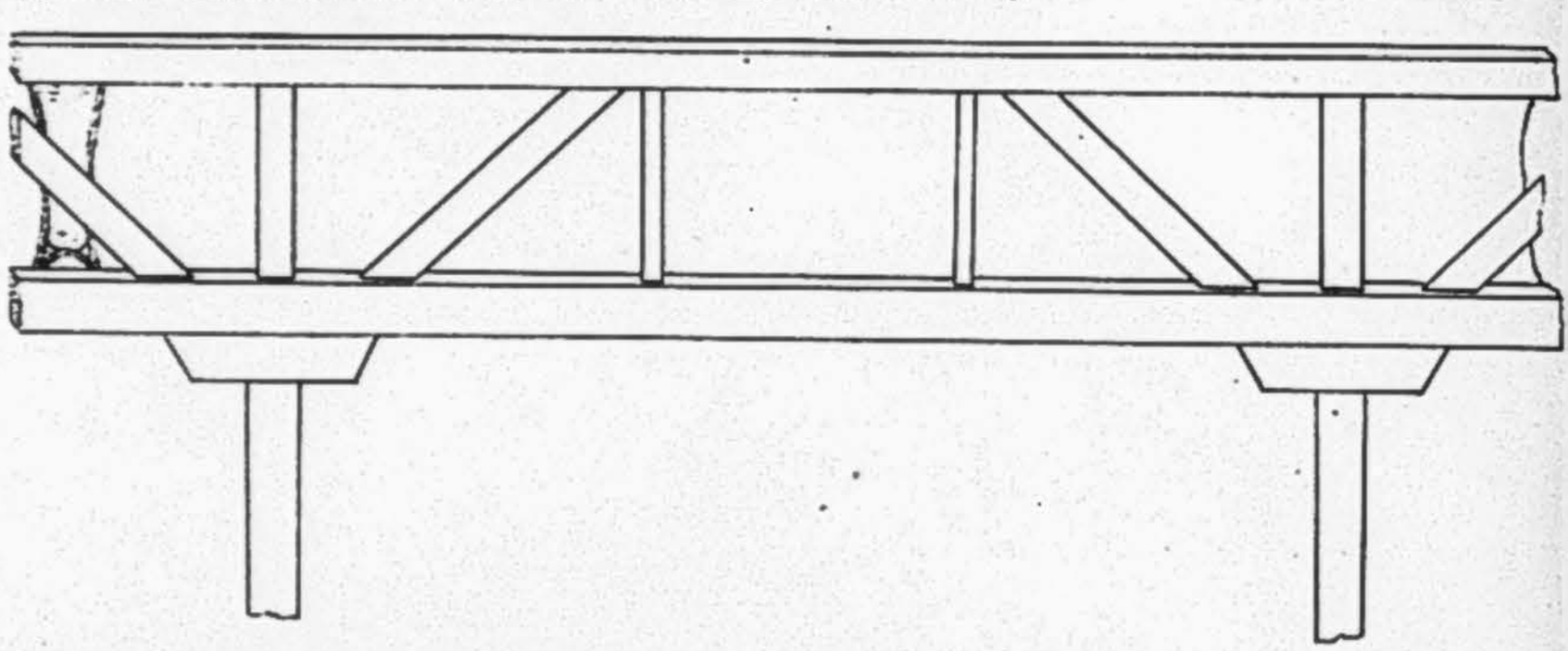
CU. YDS. Concrete lining per lin. ft. of ditch = .0863 Cu Yds

HYDRAULIC PROPERTIES

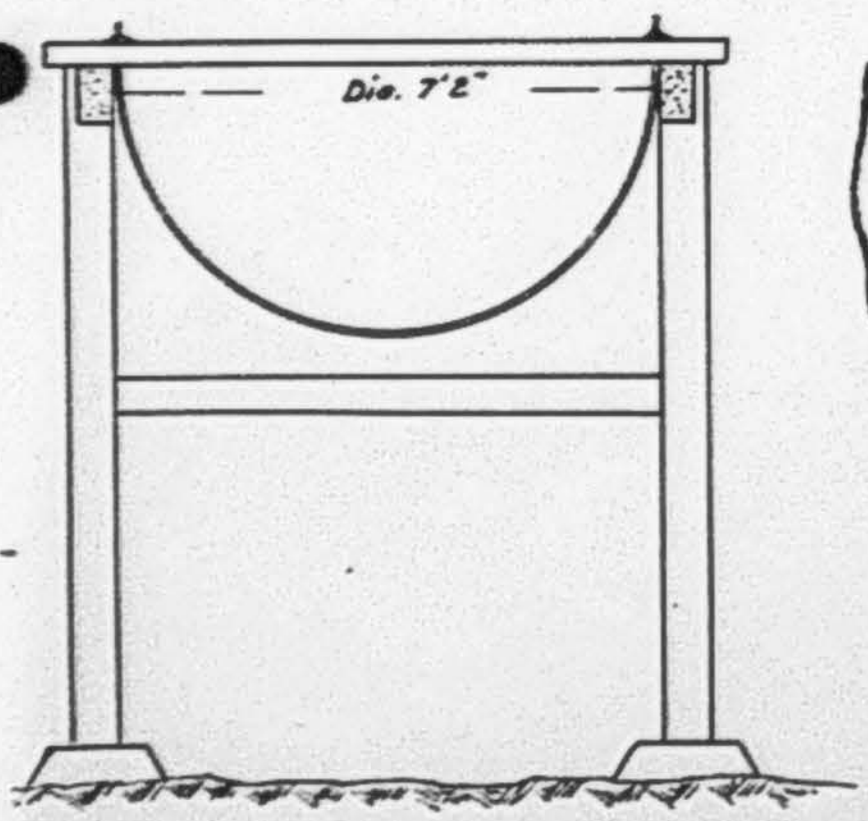
S = .0009	A = 15.6 sq. ft.
R = 1.5	V = 3.9 ft/sec.
n = .015	Q = 60.8 cu. ft/sec.
c = 108	

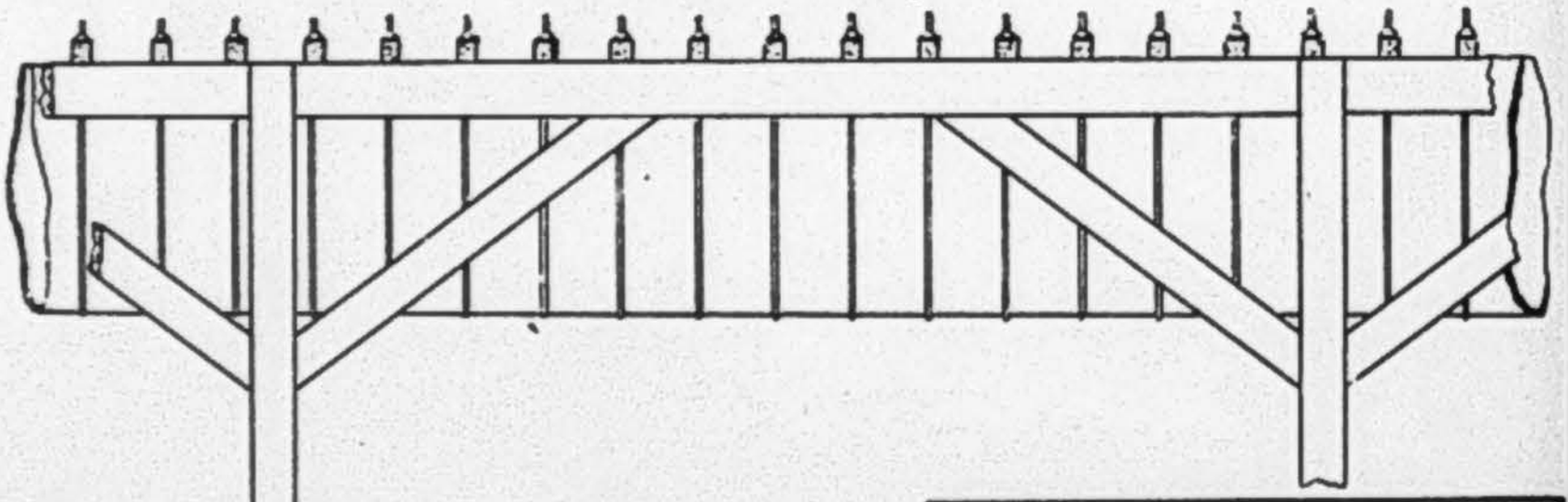
REINFORCED CONCRETE DITCH & FLUME (PAT'D)





GALVANIZED STEEL FLUME (PAT'D)





VOLCAN LAND & WATER CO.

DETAILS DITCH & FLUME

Mar. 1912
W.S. Post, Engr.

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PACIFIC OCEAN

SAN DIEGO

ESCONDIDO

MAP
OF PROJECT OF
VOLCAN LAND & WATER CO.
San Diego County, Calif.
Accompanying Report of
W. S. POST.
Engineer

LEGEND

Warner - Pamo System Estimate No. 1.
Warner - Ramona " " No. 5.
Escondido - Ramona " " No. 6.

San Luis Rey River

Warner Reservoir
V=102,000 A.F. 2646 ft. Elev.

Tunnel – length 4 miles

Pine Mt. Forebay
V=32 A.F. 2535 ft. Elev.

San Luis Rey River

Bear Valley Reservoir
V= A.F. 1500' Elev.

Cedar Creek

WARNER
POWER HOUSE
3600 K.W.

Pamo Reservoir
V=33,000 A.F. 830' Elev.

Santa Ysabel Creek

BLACK CANYON
POWER HOUSE
2400 K.W.

Black Canyon Reservoir
V=384 A.F. 1625 ft. Elev.

Ramona Conduit

Santa Ysabel Creek

Sutherland Reservoir (City)
V= A.F. 1900 ft. Elev.±

Witch Creek

Hatfield Creek

Hatfield Reservoir
V= A.F. 1900 Elev.

Ramona Reservoir
V=4,000 A.F. 1460 ft. Elev.

Santa Maria Reservoir
V=50,000 A.F. 1300± ft. Elev.

Pamo

SANTA MARIA
POWER HOUSE
600 or 2100 K.W.

San Clemente Reservoir
V=14,000 A.F. 700 ft. Elev.

Bernardo Reservoir
V= A.F. 300 ft. Elev.

VOLCAN LAND & WATER CO.
Profile Sketch

Mar. 1912
W.S. Post, Engr.

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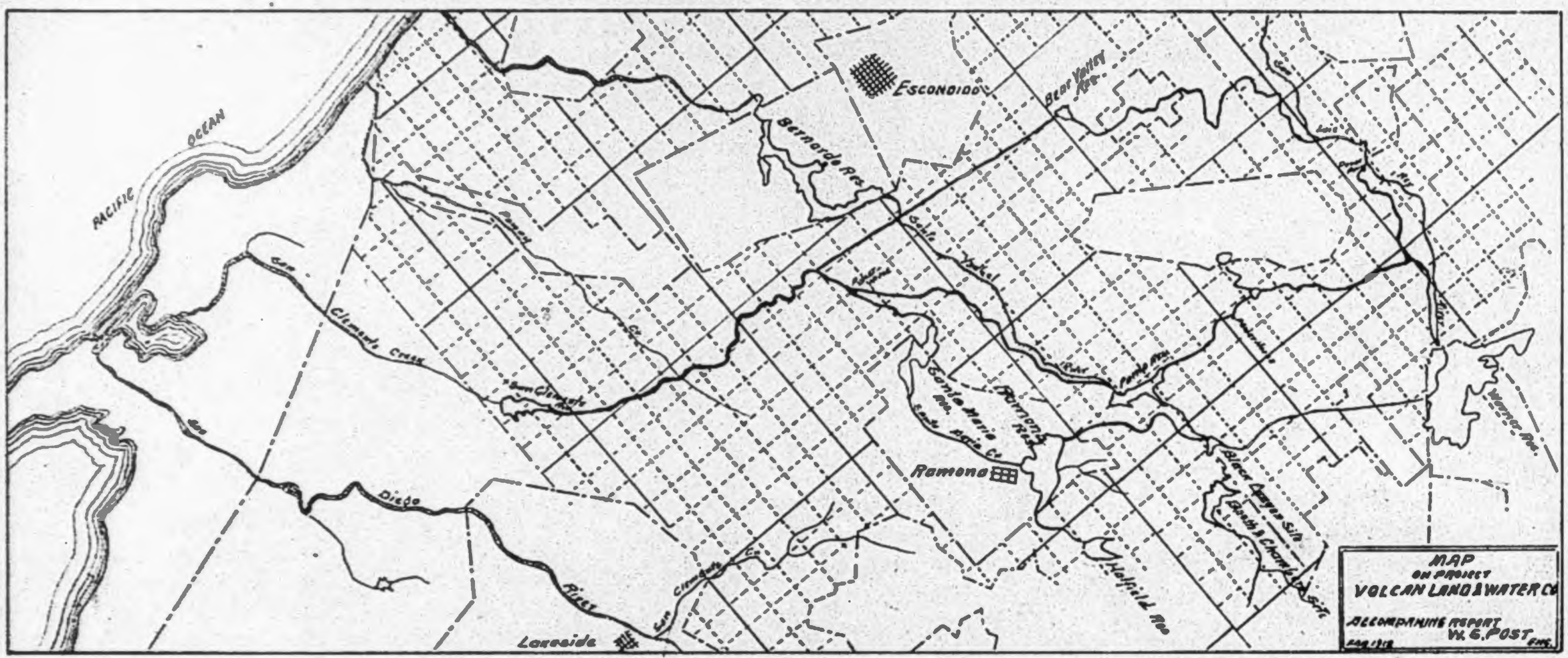

LEGEND

- Warner - Pamo System Estimate No. 1.
- Warner - Ramona " " No 5.
- Escondido - Ramona " " No. 6.

San Luis Rey River

Warner Reservoir
V=185,000 A.F. 2645 ft. Elev.

Tunnel — length 4 miles

Pine Mt. Forebay
V=32 A.F. 2535 ft. Elev.

San Luis Rey River

Bear Valley Reservoir
V= A.F. 1500' Elev.

WARNER
POWER HOUSE
3000 K.W.

Canada Agua Caliente

Agua Caliente Creek

Pamo Reservoir
V=35,000 A.F. 830' Elev.

PAMO

Pamo

CONDUIT

SANTA MARIA
POWER HOUSE
600 or 2100 K.W.

Santa Ysabel Creek

Santa Ysabel Creek

Sutherland Reservoir (Site)
V= A.F. 1900 ft. Elev. ±

BLACK CANYON
POWER HOUSE
2400 K.W.

Black Canyon Reservoir
V=38? A.F. 1625 ft. Elev.

Ramona Conduit

Ramona Reservoir
V=6,000 A.F. 1460 ft. Elev.

Santa Maria Reservoir
V=50,000 A.F. 1300 ± ft. Elev.

Santa Maria Creek

Witch Creek

Hatfield Creek

Hatfield Reservoir
V= A.F. 1700 ± ft.

San Clemente Reservoir
V=15,000 A.F. 1319 ft. Elev.

Bernardo Reservoir
V= A.F. 300 ft. Elev.

VOLCAN LAND & WATER CO.
Profile Sketch

Mar. 1912
W.S. Post, Engr.

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San Luis Rey River

Warner Reservoir
V= 105,000 A.F. 2646 ft. Elev.

Tunnel — length 4 miles

Pine Mt. Forebay
V= 32 A.F. 2535 ft. Elev.

San Luis Rey River

Bear Valley Reservoir
V= A.F. 1500' Elev.

Cedar Creek

WARNER POWER HOUSE
3600 K.W.

River

Pamo Reservoir
V= 33,000 A.F. 830' Elev.

PAMO CONDUIT

Santa Ysabel Creek

BLACK CANYON POWER HOUSE
2400 K.W.

Black Canyon Reservoir
V= 384 A.F. 1625 ft. Elev.

Ramona Conduit

Sutherland Reservoir (Site)
V= A.F. 1700 ft. Elev.±

Santa Ysabel Creek

Witch Creek

Hatfield Creek

Hatfield Reservoir
V= A.F. 1700 Elev.

Ramona Reservoir
V= 6,000 A.F. 1460 ft. Elev.

Santa Maria Reservoir
V= 50,000 A.F. 1300± ft. Elev.

Creek

SANTA MARIA POWER HOUSE
600 or 2100 K.W.

CONDUIT

San Clemente Re
V= 1400 A.F. 700 ft. Elev.

Santa Ysabel Creek

Bernardo Reservoir
V= A.F. 300 ft. Elev.

VOLCAN LAND & WATER CO.

Profile Sketch

Mar. 1912
W.S. Post, Engr.

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907 - Final, revised March 17 1912.

Report on

Warner-Pamo Water System.

of the

Volcan Land & Water Co..

by William S. Post.

Mar.16, 1912..

(13)

WILLIAM S. POST
CIVIL ENGINEER
ASSOC. MEM. AM. SOC. C. E.
1217 HIBERNIAN BLDG.
LOS ANGELES, CALIFORNIA

Report on

Warner-Pamo Water System,

of The Volcan Land & Water Co.,

San Diego Co., Cal.

by W. S. Post.

Mar. 16,1912.

AUTHORITY and PURPOSE.

This report is prepared in accordance with the instructions of Mr. Wm. G. Henshaw, in order to set down and arrange the results of accumulated surveys and estimates; to give a complete final cost estimate of the Warner-Pamo Water System, and further to state alternative projects or changes suggested by new data and show the debits and credits of such changes, as affecting the total outlay involved.

WARNER-PAMO SYSTEM.

Outline.

Warner Project.

Warner Reservoir provides for the storage of the San Luis Rey River at Warner's Dam with a 90 ft. dam, and capacity of 105,000 acre feet. The outlet discharges into Warner Conduit. This conduit pierces the divide into Pamo drainage at 6.6 miles, which is sufficient for irrigation purpose. It is continued to 9.4 miles to reach the power forebay and pipeline.

The mean flow in the conduit (for the purpose of this report) is taken at 40 cu. ft. per sec. or 2000 Miner's Inches, but the maximum capacity is designed for 60 sec. ft. in order to provide for long peaks or emergency service in the power station, and variations of irrigation demand.

Pine Mt. Forebay is the regulating basin for the Power House, and contains 32 acre feet, capable of carrying the plant without the conduit for 8 hours, or carrying 100% overload with normal flow in the conduit for the same period.

Pressure Pipe Line is 6800 ft. long, of which 4600 ft. is under less than 500 ft. head, and 2200 ft. between 500 and 1500 ft. head.

The Power House may be designed to suit the preceding hydraulic conditions, as follows, using for convenience the single unit "net kilowatts on switch board at San Diego" assuming 70% combined hydraulic and electrical efficiency.

		Net on Switchboard S.D.		
		K.W.	Daily K.W.Hours	Peak Max.K.W.
(a)	Continuous output	3600	86,400	3600
	or			
(b)	Continuous output	2400	57,600	6000
	8 hrs. Peak add't'l	3600	28,800	
			86,400	
	or			
(c)	Continuous output	1200	28,800	
	8 hrs. Peak (50% extra water) additional	3600	28,800	8400
	8 hrs. Peak as before	3600	28,800	
			86,400	

Pamo Project.

Pamo Reservoir. The tail waters of the Power plant flow directly into the Pamo Reservoir. This also gathers the watershed of the Santa Ysabel Creek.

The maximum height of dam considered feasible is 150 feet, which impounds 39,000 acre feet. It is here estimated as an hydraulic fill, simply because it is the cheapest structure. It is not recommended for this height.

It will be noted that Pamo Reservoir has a dual function, to store the Santa Ysabel winter flood waters and to act as a receiving reservoir for Warner power water sent down in the non-irrigating season. This last will amount to 15,000 acre feet, leaving only 24,000 acresfeet storage for Santa Ysabel floods. In reality to put reserve or over year storage on the same basis as Warner's (capacity 3 times normal draft) there is required 66,000 acre feet plus 15,000 acre feet regulation or 81,000 acre feet in all. This is the main problem of the system, and a solution is found in the supplementary "Ramona Project" which is discussed later.

The present outline neglects this and confines itself to the 39,000 acre feet plus 14,000 acre feet lower down, it being understood that the Warner winter power would thus be somewhat curtailed, but irrigation requirements would be largely attended to.

Pamo Conduit. For the purpose of this report the mean flow due to the Santa Ysabel is taken at 30 second feet or 1500 M.I. Adding this to the 40 second feet from San Luis Rey, we have 70 second feet continuous flow for which provision must be made. Reduce this to 60 second feet for conduit losses.

As this is for irrigation use the rate of delivery will be greatly in excess in the summer period. This will be true also of domestic service.

It is probable that from

May 1 to Nov. 1- the rate would be	90 to 105 sec. ft.
Nov. 1 to May 1- the rate would be	30 to 15 " "
Mean flow	60 to 60

An important regulating storage existing in San Clemente Reservoir of 14,000 acre foot capacity. This allowing for partial evaporation will act as a "give and take" to the extent of 25 sec. ft.

Our table then becomes

May 1 to Nov. 1 the rate will be	90 to 105 sec. ft.
Subtract water supplied from San Clemente Reservoir	25 25
Summer flow requirement in Pamo Conduit	65 to 80 sec. ft.
Nov. 1 to May 1 the rate will be	30 to 15 sec. ft.
Add water required to fill San Clemente Reservoir	30 30
Winter flow in Pamo Conduit	60 to 45 sec. ft.

On the whole a conduit section of 75 sec. ft. or 3750 M.I. is considered ample for Pamo Conduit, and is so used in this report.

The length of this conduit is 24.8 miles, on a grade of 5.28' per mile. The initial elevation is 890 feet above the sea and the terminal elevation 730 feet.

Three miles of conduit consists of steel syphons, 5 miles is in tunnels, and with minor exceptions the balance on steep disintegrated granite slopes.

The last 5 miles is over and along the coastal gravel mesas. These are eroded into many valleys, whose elevation is not over 100 to 250 foot below the general elevation of the mesas. In the writer's opinion, it will be cheaper to traverse this area in a nearly straight line consisting of pipe lines and tunnels, and this plan has been followed in this estimate, using compiled topographic data. This conclusion was reached after a study of the recent location survey, which conformed closely to the winding contour of the mesas.

At the 8th mile the conduit crosses the Santa Maria Creek, which in this plan is connected by a short feeder.

San Clemente Reservoir has a capacity of 14,000 acre feet with a dam 110 ft. high and will act as a regulating and distribution reservoir.

ESTIMATE NO. 1.

WARNER PAMO SYSTEM - IRRIGATION ONLY.

Warner Reservoir- Hydraulic fill type. 90 ft.

Dam - Capacity 105,000 acre feet.

Stream bed Excavation (15 ft)

87,000 cu. yds. at $.60 52,200.

Stripping sides (4 ft.)

10,000 cu. yds. at .50 5,000.

Hydraulic Fill

Selected Clays, 1500 ft.haul
Steam shovel work,supplemental
by short flume and pumped
water-
320,000cu.yds. at .27 86,000.

Ripropping 18 Inches thick

25,000 sq. yds. at $1.00 25,000.

Gate Shaft and Gates 7,000.

Levee on South side (earth fill) 1,000.

Spillway (Excavation put in

Hydraulic fill or riprap.)

Spillway Concrete - 200 cu.yds. at $10. 2,000.

Cut-off wall- extended up sides

500 cu.yds. at $10. 5,000. $183,200.

Warner Conduit - 6.6 miles Dam to Temescal Cr.

Lined Ditch Class "A"	3120 lin.ft.	@	$2.00	$6,240.
" " " "B"	10700 " "		2.50	26,750.
" " " "C"	1990 " "		4.00	7,960.
" " " "D"	350 " "		6.00	2,100.
Flume on Bench	5500 lin.ft.	@	4.50	24,750.
" " Trestle	1430 " "	"	7.00	10,010.
Tunnels	11,660 lin.ft.	"	18.00	209,880. $ 287,690.

Pamo Reservoir Site "B" 150 ft. high.

Lands not owned	600 acres	@	$25.	15,000.

Dam Earth fill.

Stream excavation	90,000 cu.yds.	@	$.60	54,000.
Stripping	40,000 " "	"	.50	20,000.
Fill	1,000,000 " "	"	.25	250,000.
Outlet tunnel	800 lin.ft.	"	.18	14,400.
Gates & Shaft				7,000. $ 360,400.

Pamo Conduit 24.8 miles.

Lined Ditch

Class "A"	11,605 lin.ft.	@	$2.00	23,210.
" "B"	19,824 " "	"	2.50	49,560.
" "C"	14,655 " "	"	4.00	58,620.
" "D"	1,847 " "	"	6.00	11,080.

Flumes

On bench	37,080 " "	@	5.00	185,400.
On trestle	6,576 " "	@	7.00	46,030.

Tunnels

Hard Rock	16,216 " "	@	18.00	291,890.
Gravel	8,170 " "	@	12.00	98,040.

Syphons

Low head	8,737	@	6.00	52,420.
High Head	5,990	@	8.00	47,920.

Santa Maria Feeder
Flume, 4770 lin ft. @ 4.00 19,100. 883,270.

San Clemente Reservoir -- 110 ft. High

Hydraulic fill, party moved in with steam shovel and placed by water			
1,373,000 cu. yds. @ .20			$274,600.
Outlet pipe and water tower			
500 lin. ft. @ $6.00		3,000.	
Tower		5,000.	
Gates		5,000.	
Cost of lands in site 200 acres @ 50.		10,000.	$ 297,600.
Supply Roads- 30 miles @ $1000.			30,000.
Engineering			50,000.
Estimate No. 1 Warner-Pamo System as an irrigation project only.			$ 2,092,160.

Analysis Warner-Pamo System Irrigation only.

	Cost per acre foot stored.	Cost per Miner's continuous flow.
Warner Reservoir	$2.	
Pamo Reservoir	9.	
San Clemente Reservoir	21.	
Warner Conduit- 7 miles		$144.
Pamo Conduit 26		294.
All Reservoirs	5.59	290.
Total Conduit 33 miles		407.
The System		697.

Results. This system delivers at Linda Vista

44,000 acre feet

1,350,000 thousands of gallons.

or

60 sec.ft. continuous flow

3000 miner's inches " "

with 25% temporary increases.

Estimate No. 1 (a)

Warner-Pamo System Irrigation, Long Route via Highland Valley.

Beyond Santa Maria Creek, an alternative line exists through Highland Valley. This eliminates ~~including~~ 14,506 feet 9730 ~~9300~~ lin. ft. of tunnel and adds 33,196 feet of conduit. This has an advantage in reaching a nearer point for Escondido, but introduces 2 miles of unsatisfactory bluffs, and loses 23 feet in grade.

Credit Between Miles 10 and 13, alighment from station 494+34 to station 639+46 = 14.506 ft.

Tunnel 9730 lin ft.	@ $18.00	175,140.	
Flume			
on bench 3278 lin.ft.	@ $5.	16,390.	
Lined Ditch			
Class "C" 1498 " "	@ $4.	5,990.	197,520.

Debit Alternative line connecting above stations via High Valley = 33.096 ft.

Lined Ditch			
Class "A" 5516 lin.ft.	@ $2.	11,032.	
" "B" 3991 "	"2.50	9,978.	
" "C" 4385 "	"4.00	17,540.	
Flume			
On Bench 9655 "	" 5.00	48,275.	
On Trestle 3908 "	" 7.	27,356.	
Tunnel 3831 "	" 18	68,958.	
Syphons 1810 "	" 6	10,860.	194,000.

Changes on remainder of line

Changes on remainder of line due to lowering grade 23 ft.	
Lined Canal Class "D" 1000 ft. @ $6.	$6,000.
Tunnels 560 lin. ft. @ $18.	10,800.
Loss of power at San Clemente due to lowering grade 23 ft. 75 K.F. @ $200 (Capitalized value)	15,000.
Total Debits	$225,800.
Total Credits	197,520.
Difference in favor of Short Route.	$ 28,280.
Add Estimate No. 1	2,092,160.
Estimate No. 1 (a) (Warner-Pamo via High Valley)	$2,120,440.

Estimate No. 1 (b).

Warner-Pumo Irrigation and Power System.

To introduce Warner power development requires only the construction of 3 miles additionnal of Warner Conduit, a forebay, pipe line and power house as follows:

Warner Conduit-extended.

Lined canal.

Class "A"	510 lin.ft.	@	$2.	$1020.	
" "B"	3100 " "		2.50	7750.	
" "C"	8040 " "		4.	32160.	
" "D"	500 " "		6.	3000.	
Flume					
On Bench	1840 " "	@	$5.	9200.	
On Trestle	1370 " "		7.	9590.	$62,720.
Forebay					
Earth Dam					
48,000 cu.yds.		@	$.30	14400.	
Outlet Culvert	400 ft.	@	$5.	2000.	
Waste pipe	400 "		5.	2000.	18,400.
Pipe line					
Steel pipe,1,515,000 lbs.		@	.07	106,050.	
Trench 6500 ft.		@	$2.00	13,000.	
Concrete anchorage 500 cu.yds.		@	$10.	5,000.	124,050.
Power Station, Electrical and Hydraulic machinery and power house installed, to produce 7200 K.W. net, delivered at San Diego,		@	$43. per net K.W.	309,600.	
Land and other buildings				10,000.	319,600.
Total,					524,770.
Add Estimate No. 1					2,092,160.
Estimate No. 1 (b) (Combined irrigation and power)					$2,616,930.

Results.

The use of power in normal years will not interfere with irrigation. The receiving capacity of Pamo and San Clemente Reservoirs totals 53,000 acre-feet. Warner Power plant will deliver 15,000 acre-feet in the non irrigating season, leaving 38,000 acre feet for Santa Ysabel floods. Allowing one third of this 38,000 for evaporation, we still have 25,000 acre-feet not sufficient to secure the 30 cu.ft. net which we have taken as due from the Santa Ysabel; However in wet years Santa Ysabel will over flow and be wasted, and dry years will decrease this 30 sec.ft. Warner's Dam if called on to make up the deficiency, may be forced to transfer water, not usefully used in the wheels, and to that extent impair its earning power and its future average constant flow. This does not seem desirable, and it were better to adjust Warner flow as a constant, supported by its reservoir and allow the Santa Ysabel to vary with the vicissitudes of the seasons. To put it on the same basis of constancy which we give Warner's viz: a ratio of capacity 3 times the draft, we would allow Santa Ysabel's 39,000 acre feet, a draft of 13,000 acre feet or only 15 sec.ft. This reduces our total delivery at San Clemente to 45 sec.ft. instead of 60 sec.ft.

We have then as definite results:

Power	K.W. continuous	3600
	Max. K.W. Peak	7200
	Daily K.W. hours output	86400

Irrigation-38,000 acre feet
or 10,800,000 thousands of gallons
or 45 sec. ft. continuous flow
or 2250 Miner's Inches.

Assessing on power the entire cost of Warner Project we have:-

Warner Power Project - 3600 K.W.

Total Cost,	$ 1,035,660.
Cost per net K.W.	$ 288.

Pamo Project - 2250 M.I.

Total cost,	$ 1,581,270.
Cost per Miner's Inch	$ 703.

Estimate No. 1 (c)

The conditions of Estimate No. 1 (b) may be improved greatly by adding Sunderland Reservoir.

The writer is not informed on the estimates of this dam. Assuming however, that a storage of 40,000 acre feet can be had then for $150,000, we have

Estimate No. 1 (c)

Warner-Pamo System with Sunderland Reservoir.

Total	$2,776,930.

This gives us

Irrigation 3000M.I.	
Total Cost	1,731,270
Cost per M.I.	$566.
Power 3600 K. W.	
Total Cost	1,036,660
Cost per K. W.	288.

Supplementary Systems.

There is no lack of storage on the Santa Ysabel Creek. Sites exist on Santa Ysabel Ranch, Bellena Valley, Hatfield Creek, Sunderland Valley, Ramona Valley, and the Santa Maria Reservoir.

Pamo Reservoir is more important for its position on the line of the Warner-Pamo system, than for its inherent valne. It is low in altitude and requires a long conduit for its outlet. No power is extracted by its construction.

To utilize the Santa Ysabel for power, and increase its storage, and to include the drainage area of the Santa Maria Creek, survey has been made of a diversion into Ramona Valley. This supplementary system will be termed the "Ramona Project".

The Ramona Project.

Black Canyon Reservoir. The diversion is at the junction of Black Canyon and the Santa Ysabel. It secures 74 sq. miles of drainage area, or 65% of the Pamo Reservoir watershed. The continuous flow is taken in this report as 20 sec.ft. The elevation of outlet is 1625 feet.

The reservoir with a 60 ft. dam stores 384 acre feet and would be designed simply to equalize flood rushes and carry them away rapidly in a conduit of 100 sec. ft. capacity of 5000 M.I. Its reserve during a typical three days storm would represent 2500 M.I. held back for 3 days, and then sent down the conduit after the storm. This however would not be sufficient for the great storms.

Black Canyon Conduit is 8 miles long including 1 mile of tunnel, and discharges into the Ramona Reservoir. The capacity is 6000 acre feet, with a 50 ft. dam. This also receives the waters of the 28 sq. miles of Hatfield Creek and adjoining watersheds. The overflow is by the natural channel of the Santa Maria Creek into Santa Maria Reservoir.

Irrigation of Ramona Valley. The Ramona Reservoir would be the distribution reservoir for the irrigation of Ramona Valley where 4000 acres could be placed under ditch. This would require 400 Miner's Inches or 8 sec.ft. The seepage or return waters from this irrigation as usually estimated would be one-third or 3 sec. ft. Judging from the "hard pan" formation, it may amount to one-half or 4 sec.ft.

Santa Maria Reservoir.

A careful survey of this site was made by Alverson in 1895, for a dam 80 ft. in maximum height, storing 8700 acre feet. The dam site is in excellent rock and should be constructed of concrete, in the arched form. In masonry it can be carried to 150 ft. Surveys are now being made to obtain the increased capacity, which will be given in a supplementary report, but it can be stated at once that the storage can be made to equal the water supply. In other words further survey is expected to show a storage capacity of say 50,000 acre feet for a higher dam, say of 130 feet height.

Santa Maria Power Station.

Santa Maria Reservoir has an elevation of about 1340 feet. The Pamo Conduit immediately below it has an elevation

840 feet, producing a fall of 500 feet. The distance for a pressure pipe is not over 5000 ft. The reservoir forms an ideal forebay and the peak load capacity is limited only by the electrical installation, by the capacity of the Pamo Conduit to take away the waters discharged, and by the receiving capacity of San Clemente Reservoir.

The design of the Power House may cover the following conditions:-

	K.W.	Net on switchboard at S.D. Peak max.K.W.	Daily K.W. Hrs.
(a) Continuous output	800	800	19,200
or			
(b) 6 hrs. peak and shut down 18 hrs.		3200	19,200.
or			
(c) 2 hrs. peak, shut down 22hrs. (Limit of Pamo Conduit receiving capacity.)		9600	19,200.

<u>Additional Power</u> will exist between Ramona Reservoir and Santa Maria Reservoir. This could be utilized in connection with the valley's irrigation distribution canal, in the non-irrigating season, amounting to about 80 K.W. Overflow water would thus be transferred without waste, from Ramona Reservoir to Santa Maria Reservoir. This additional power is not estimated or included in this report.

Estimate No. 2 (Preliminary)

Ramona Project -- Irrigation only.

Black Canyon Dam. 60 ft. high			
Concrete 6,000 cu.yds. @ $5.		30,000.	
Gates and Outlet		3,000.	$33,000.
Black Canyon Conduit.			
Lined Conduit.			
Class "A" 11,620 lin.ft. @ $2.		23,240.	
" "B" 10,740 " "	2.50	26,850.	
" "C" 11,060 " "	4.	44,240.	
Flume			
On Bench 1000 " " @	4.50	4,500.	
" Trestle 2660 " "	7.	18,620.	
Tunnel			
5720 lin ft. @ $18.		102,960.	230,400.
Ramona Reservoir. 50 ft. high - 6000 acre feet.			
Earth Fill, 170,000 cu.yds. @ $.25		42,500.	
Paddle Wall		10,000.	
Outlet & Gates		5,000.	
Lands 400 acres @ $25.		10,000.	67,500.
Santa Maria Reservoir. 130 ft. high - 50,000 acre ft.			
Concrete 45,000 cu.yds. @ $5.		225,000.	
Gates		5,000.	
Lands, 1000 acres @ 15.		15,000.	245,000.
Engineering.			30,000.
Total Estimate No. 2,			$595,900.

Results.

The delivery into Pamo Conduit at the 8th mile of 25 sec. ft. or 1250 M.I. as demanded. Or the irrigation of 4000 acres requiring at least 400 M.I., and the delivery of 1000 M.I. to Pamo Conduit.

Analysis:

	Cost per acre foot	Cost per M.I. continuous flow.
Black Canyon Reservoir	86	
Ramona Reservoir	$12	
Santa Maria Reservoir	$ 5	
All Reservoirs	$ 6	
Black Canyon Conduit		$ 231.
The System - delivering at 8th mile of Pamo Conduit.		$ 477.

Estimate No. 2 (a) -(Preliminary)

Pressure Pipe.

2000 lin.ft. @	6	12,000		
1500 " "	10	15,000	27,000.	
Electrical & Hydraulic Machinery				
to produce at net delivery of				
3200 K.W. at S.D. @ $43.			137,600.	$164,600.
Add Estimate No. 2				595,900.
Total Estimate No. 2 (a)				$760,500.

(Ramona System - Irrigation & Power)

Changing one-half of amount to power, we have $119 per Peak K.W. of $476 per continuous K.W.

WILLIAM S. POST
CIVIL ENGINEER
ASSOC. MEM. AM. SOC. C. E.
1217 HIBERNIAN BLDG.
LOS ANGELES, CALIFORNIA

Combined.

Warner-Pauma and Ramona Systems.

Irrigation and Power.

The joining of the two systems give the following results:-

(a) The storage of the Santa Ysabel is brought up to the Warner Standard of "capacity equals 5 times draft."

(b) The Pauma Dam may be reduced from a capacity of 39,000 acre feet to 22,000 acre feet, lowering the dam to 180 feet.

(c) The water delivered at Linda Vista would be

65 sec. ft. or 3250 K.I.

(d) Power would not interfere with irrigation as the receiving storage is ample. The total power would be

	Continuous K.W.	Daily K.W. Hours	Max.Peak K.W.
Warner Plant	3600	86,400	7200
Santa Maria Plant	800	19,200	3200
Total	4400	105,600	10400

Estimate No. 3.

Combined Warner-Pamo and Ramona Systems.

(Irrigation & Power)

Estimate No. 1 (c) (Warner-Pamo System Irrig. & Power)	$2,616,930.
Estimate No. 2 (a) (Ramona Irrig.- Power)	760,500.
	$3,377,430.
Substract reduction in Cost Pamo Reservoir, 150 ft. dam to 130	127,000.
Estimate No. 4, Combined Systems.	$3,250,430.

Analysis-

Assessing Warner Project and one half of Ramona System to power, we have for "Combined Systems":-

Power

Total Cost,	$1,415,910
Cost per net K.W.	$ 322.

Irrigation

Total Cost	$1,834,520
Cost per continuous M.I.	$ 523.

WILLIAM S. POST
CIVIL ENGINEER
ASSOC. MEM. AM. SOC. C. E.
1217 HIBERNIAN BLDG.
LOS ANGELES, CALIFORNIA

Witch Creek - Hatfield Project.

Higher on the drainage of Santa Ysabel, is a very similar situation to the "Ramona Project". A diversion above the junction of Witch-Creek into the Ballena Valley and from there into Hatfield Creek (or the upper Santa Maria), is feasible. Storage would then be obtained in the excellent Hatfield reservoir.

From the irrigation and storage standpoint, both are not necessary. Of the two, Ramona project is preferred because it is on a larger scale and accomplishes the most.

As a small power plant, Hatfield may have merit, in which case the cost of diversion works should be assessed to its power. It could be made to equalize the winter shortage in power indicated in Ramona plants -- due to lack of receiving capacity in the Pamo Conduit and below.

We have figured sufficient average irrigation storage for the Santa Ysabel and Santa Maria or Hatfield Creek without the Hatfield Reservoir. Probably it has a very low cost per acre foot and it should be retained if for nothing else, for reserve over year storage which will become increasingly important in Southern California, as water becomes more valuable, and is sold in cubic quantities rather than the Miner's Inch per year.

A survey of Hatfield Reservoir has been made and results will be submitted in a supplementary report.

WILLIAM S. POST
CIVIL ENGINEER
ASSOC. MEM. AM. SOC. C. E.
1217 HIBERNIAN BLDG.
LOS ANGELES, CALIFORNIA

Sunderland - Hatfield Project.

Again, even more similar to the "Ramona System", is the "Sunderland-Hatfield" System. If the Black Canyon Reservoir and the Ramona Reservoir are conceived to be raised 200 feet in altitude, the arrangement and the probable costs would correspond very closely.

In favor of it, is the direct use of the large Sunderland reservoir for equalizing flood rushes, the direct use of Hatfield Reservoir also for Santa Ysabel flood water. Hatfield is a better reservoir than Ramona. Hatfield Reservoir is high enough to reach the pass at the head of Kimsey Grade, 4 miles South West from Ramona, and covers a feasible routing of water through this pass.

Against it, would appear possible excessive price for Sunderland Reservoir, and the need of providing a connection with Black Canyon to divert its floodwater into Sunderland Reservoir, a distance of about 2 miles.

WILLIAM S. POST
CIVIL ENGINEER
ASSOC. MEM. AM. SOC. C. E.
1217 HIBERNIAN BLDG.
LOS ANGELES, CALIFORNIA

WARNER-RAMONA SYSTEM.

Warners -

In the preceeding study there arises the question, "Is Pomo Reservoir and the first 9 miles of Pomo Conduit necessary?"

It is necessary as long as Warner waters are delivered at the head of Temecool Creek. The problem then goes back to Warner's. Two solutions will be suggested on this problem.

One proposes the joint use of Escondido Ditch for Warner water.as is given later under the title, "Escondido-Ramona System." It involves considerable waste of power.

The other here described under the title "Warner-Ramona System" preserves the power. It proposes a 4½ mile tunnel direct from Warner's Reservoir to Black Canyon, a power drop of 1000 feet to Black Canyon Reservoir, and thence conveying Warner waters through the "Ramona System" to Santa Maria Reservoir and thence by the Pomo Conduit as surveyed from the 9th to 25th mile or a modified higher route if cheaper. The cost would be approximately as follows:

Estimate No. 5.

Warner-Ramona System - Power & Irrigation.

Warner's Dam,	
as before given,	183,200.
Warner-Black Canyon tunnel,	
4.25 miles @ $25. per ft.	561,000.
Ramona System	
Estimate No. 2 (a)	760,500.
Pamo Conduit,	
9th to 25th mile	627,000.
San Clemente Reservoir	
as before given	297,600.
Black Canyon Power House and Pipe Line,	
4800 K.W.	246,400.
Santa Maria Power House increased from	
3200 K.W. to 8300 K.W.	219,300.
Roads	20,000.
Engineering.	50,000.
	$ 2,965,000.

Analysis: — Irrigation Only. 3400 M.I.

Omitting from estimate No. 5 the charges for machinery etc. for Power Houses, we have:

Estimate No. 5,	$ 2,965,000.
Deduct Power House etc.	660,300.
Estimate No. 5 (a)	$ 2,304,700.

Irrigation Analysis:

	Cost per Acre foot	Cost per Continuous M.I.
Warner Reservoir,	$ 2.	
Warner-Black Canyon,		
Tunnel Conduit,		$ 280.
Black Canyon Reservoir	86.	
Black Canyon Conduit		231.
Ramona Reservoir	12.	
Santa Maria Reservoir	5.	
Pamo Conduit 9th to 25th		209.
San Clemente Reservoir	21.	
All Reservoirs,	6.40	328.
All Conduits		350.
The System		678.

Analysis: Irrigation and Power.

Assessing all of Warner's Dam and tunnel, and one-half of "Ramona System" to power, we have:

Power 4480 K.W.

Total Cost.	$ 1,630,150.
Cost per net K.W.	$ 362.

Irrigation 3400 M.I.

Total Cost.	$ 1,344,850.
Cost per continuous M.I.	$ 392.

Results:

a) The abandonment of Pamo Reservoir and the watershed below Black Canyon involves the abandonment of 10 sec. ft. or 500 M.I. This is partly or wholly required to settle San Pasqual riparian rights. The total delivery at Linda Vista amply supported by reservoirs is

44,000 acre ft.

or 14,400,000 thousands of Gallons

or 60 sec. ft. continuous flow

or 3000 M.I. " "

To which should be added the Ramona Valley irrigation of

400 M.I. continuous flow.

b) The storage on the system totals 175,000 acre feet. It is so distributed as to take care of continuous output of power. As the lowest receiving basin, San Clemente, is comparatively small, this means that in winter the Black Canyon plant must carry the bulk of the overloads, the water being held in transit in Santa Maria. The estimates cover this feature.

c) The total power would be

	Continuous net K.W.	Daily K.W.hrs.	Max.Peak K.W.
Black Canyon Plant	2400	57,600	4800
Santa Maria Plant	2080	49,700	8300
	4480	107,300	13,100.

ESCONDIDO RAMONA SYSTEM.

The other solution to by-pass Warner water around the Pamo Site, proposes continuing Warner Conduit to the head of the Escondido ditch, utilize the fall of about 1,000 feet, deliver the tail waters into the Escondido ditch which then would become a joint carrier to the Escondido Bear Valley Dam.

From Bear Valley dam a pipe line would be required probably 12 miles long, and 30" diameter, costing $15,000. per mile.

Estimating this roughly we have

WARNER DAM	$183,000.
Power Plant 2400 H. P.	
Conduit, Pressure Pipe,	
Machinery	565,000.
Escondido Ditch	
1/2 Interest & Improvement	170,000.
Pipe Line	
12 miles @ $15,000	180,000.
Ramona System	
Estimate No. 2 (a)	760,000.
Pamo Conduit	
10th to 25th mile	627,000.
San Clemente Reservoir	298,000.
Engr & Roads	80,000.
Estimate No.6.	$ 2,743,000.

SUMMARY

	Total Cost	Cost per Continuous M.I. or K. W.
Estimate No.1.		
Warner-Pamo System		
Irrigation- 3000 M.I.	$ 2,092,160	$ 697 M.I.
Estimate No. 1 (b)		
Same		
Irrigation 2250 M.I.	1,581,270	$ 703 M.I.
Power 3600 K.W.	1,035,660	288 K.W.
	$ 2,616,930	
Estimate No. 1 (c)		
Same - with Sunderland Reservoir		
Irrigation 3000 M.I.	1,731,270	$ 566 M.I.
Power 3600 M.I.	1,035,660	288 K.W.
	$ 2,766,930	
Estimate No. 2.		
Ramona-System		
Irrigation 400 M.I. Ramona	$	
& 1000 M.I.at 9th mile Pamo	595,900	$ 477 M.I.
Estimate No. 2 (a)		
Same		
Irrigation, same	$ 595,900	$ 477 M.I.
Power, added. 800 K.W.	164,600	206 K.W.
Estimate No.3		
Combined Warner-Pamo and Ramona systems		
Analysis (a)		
Irrigation 3250 M.I.	$ 1,834,520	$ 523 M.I.
Power 4400 K.W.	1,415,910	322 K.W.
	$ 3,250,430	
Analysis (b) using same power		
Cost as in Est. No.1 (b)$288.		
Irrigation 3250 M.I.	$ 1,997,230	$ 614 M. I.
Power 4400 K.W.	1,267,200	288 K.W.
	$ 3,250,430	
Estimate No. 5 (a)		
Warner-Ramona system.		
Irrigation 3400 M.I.	$ 2,304,700	$ 678 M.I.
Estimate No. 5.		
Same		
Analysis (a)		
Irrigation 3400 M.I.	$ 1,334,850	$ 392 M.I.
Power 4480 K.W.	1,630,150	362 K.W.
	2,965,000	
Analysis (c) using same power		
Cost as in Est. No. 1 (c)$288.		
Irrigation 3400 M.I.	$ 1,674,760	$ 495 M.I.
Power 4480 K.W.	1,290,240	288 K.W.
	$ 2,965,000	
Estimate No. 6.		
Escondido-Ramona System		
Irrigation 3000 M.I.	$ 1,821,400	$ 607 M.I.
Power (as above) 3200 K.W.	921,600	$ 288 K.W.
	$ 2,743,000	

CONCLUSIONS

1. The Warner-Pamo system if adopted should include Sunderland Reservoir.

2. The preceding comparative financial statement indicates the Warner-Ramona system will give the maximum amount of water and of power, at the lowest cost per unit.

In other ways it has merits. It provides water for San Pasqual riparian uses. All the dams will be conservatice engineering structures. The location of conduits is on satisfactory ground and of low maintenance cost.

The zone of irrigation has 1300 feet above sea as its upper limit

To review and slightly modify the main points of this plan, it is believed the following should constitute the system.

1. Warners Dam
2. Long Tunnel to Black Canyon.
3. Black Canyon Power Plant.
4. Sunderland Reservoir.
5. A conduit to Ramona Valley.
6. Hatfield Reservoir.
7. A small power plant below Hatfield Reservoir.
8. Santa Maria Reservoir.
9. A conduit parallel to and above the Pamo conduit between the 8th and 10th miles, on about

the 1300 foot contour above sea.

10. A Power Plant at end of this conduit, delivering water at the 10th mile of Pamo Conduit.

11. The Pamo Conduit 10th to 25th miles.

12. San Clemente Reservoir.

In this outline the equivalent reservoirs- Sunderland- Hatfield are substituted for Black Canyon- Ramona, which were used in the preceding estimate. It does not change the conclusion drawn from the estimates.

Los Angeles, California.
March 16, 1912.

PACIFIC OCEAN

SAN DIEGO

MAP
OF PROJECT OF
VOLCAN LAND & WATER CO.
[illegible]
Accompanying Report of—
W. S. POST.
[illegible]

LEGEND

Warner - Pamo System — Estimate No. 1
Warner - Ramona System — " No. 5
Escondido - Ramona System — " No. 6

Warner Reservoir
V=105,000 A.F. 3648 ft. Elev.

Tunnel – length 4 miles

Pine Mt. Forebay
V=38 A.F. 2595 ft. Elev.

Santa Ysabel Creek

Witch Creek

Hatfield Creek

Sutherland Reservoir (site)
V= A.F. 1300 ft. Elev.

BLACK CANYON
POWER HOUSE
2400 K.W.

Hatfield Reservoir
V= A.F. 1700 Elev.

Black Canyon Reservoir
V=304 A.F. 1825 ft. Elev.

Romona Conduit

Romona Reservoir
V=4000 A.F. 1410 ft. Elev.

San Luis Rey River

Bear Valley Reservoir
V= A.F. 1500' Elev.

Santa Ysabel Creek

Santa Maria Reservoir
V=50,000 A.F. 1300 ft Elev.

WARNER
POWER HOUSE
3000 K.W.

Flume

Pipe Line

Pamo Reservoir
V=38,000 A.F. 830' Elev.

Pamo

Conduit

SANTA MARIA
POWER HOUSE
800 or 2100 K.W.

San Clemente Reservoir
V=14,000 A.F. 700 ft. Elev.

Santa Ysabel Creek

Bernardo Reservoir
V= A.F. 300 ft. Elev.

VOLCAN LAND & WATER CO.
Profile Sketch

Mar. 1912
W.S. Post, Engr.

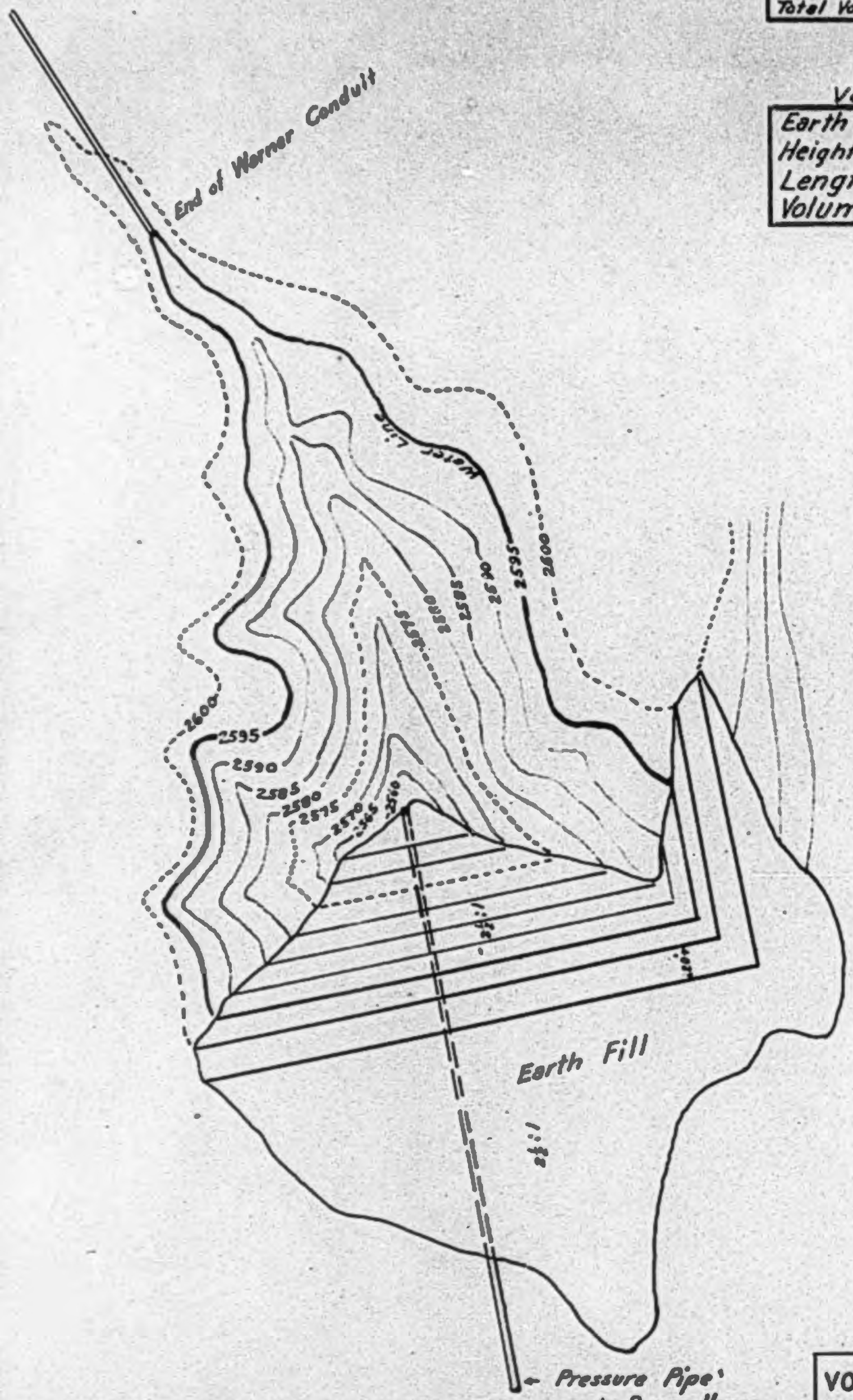
192 – 2

Capacity of Reservoir

Elev. Water Surface	Depth	Surface A.	Capacity Acre Feet
2555	0'	0	0
2565	10'	.03	0.1
2575	20'	.25	1.5
2585	30'	.69	6.2
2595	40'	1.60	17.3
Add ½ Vol. of Dam Excavation			14.9
Total Vol. when completed			32.2

Volume of Dam

Earth Fill	
Height	45 Feet
Length	470 "
Volume	48,000 Cu.Y.



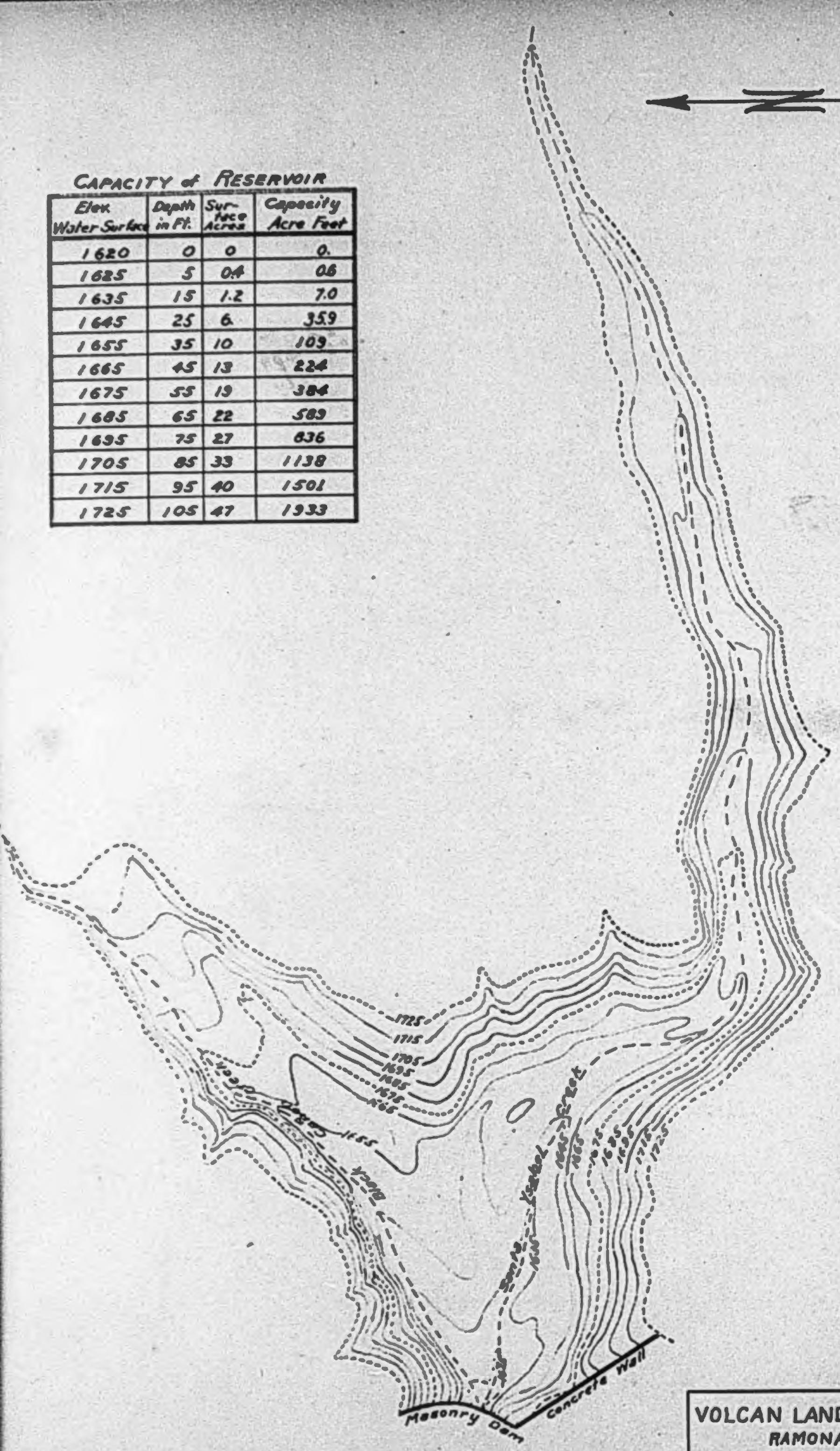
VOLCAN LAND & WATER CO.
WARNER CONDUIT
PINE MOUNTAIN FOREBAY
SCALE: 1"=100'

Mar. 1912
W.S. Post Engr.

147-60

CAPACITY of RESERVOIR

Elev. Water Surface	Depth in Ft.	Surface Acres	Capacity Acre Feet
1620	0	0	0.
1625	5	0.4	0.6
1635	15	1.2	7.0
1645	25	6.	35.9
1655	35	10	109
1665	45	13	224
1675	55	19	384
1685	65	22	589
1695	75	27	836
1705	85	33	1138
1715	95	40	1501
1725	105	47	1933

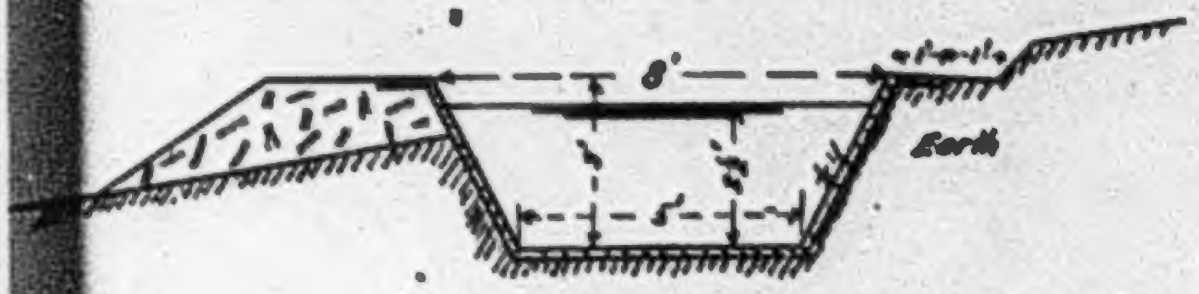


VOLCAN LAND & WATER CO.
RAMONA CONDUIT
BLACK CAÑON RESERVOIR
SCALE: 1"=400'

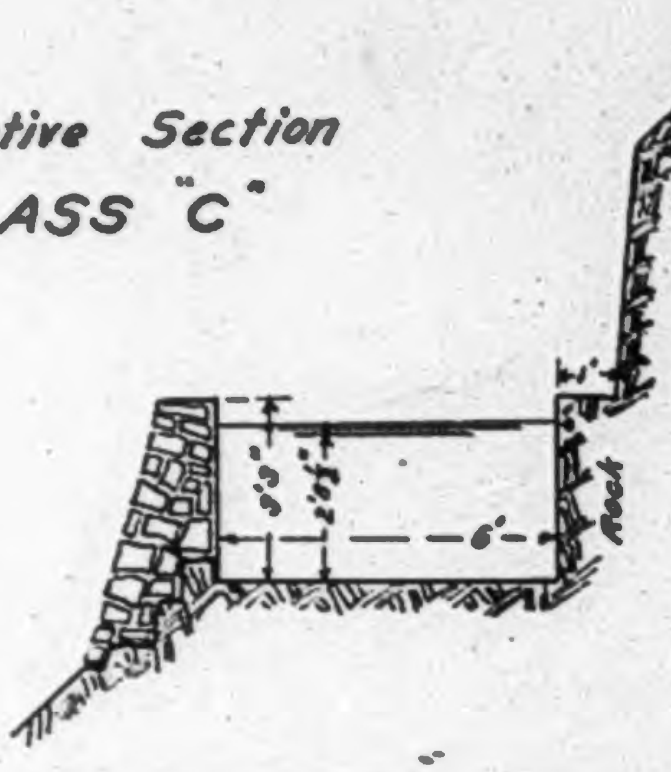
Mar. 1912
W.S. Post, Engr.

192 - 1

Section
CLASS "A"
Typical of Classes "B" & "C".



Alternative Section
CLASS "C"



...ROP
= .0009
= 1.42
= .015
= 106
= 16.2 sq. ft.
= 3.8 ft/sec.
= 61.6 cu. ft/sec

Cross Sections
CONCRETE LINED DITCH

CLASS "A"

Ground Slope 0° to 15° in earth Avg. Exca. 0.75 Cu Yds/Lin ft.

CLASS "B"

Ground Slope 15° to 25° in earth Avg. Exca. 1.1 Cu Yds/Lin ft.
" " 0° to 15° - rock - " 0.9 "

CLASS "C"

Ground Slope 25° to 35° in earth Avg. Exca. 1.5 Cu Yds/Lin ft.
" " 15° to 25° - rock " " 1.3 "

CLASS "D"

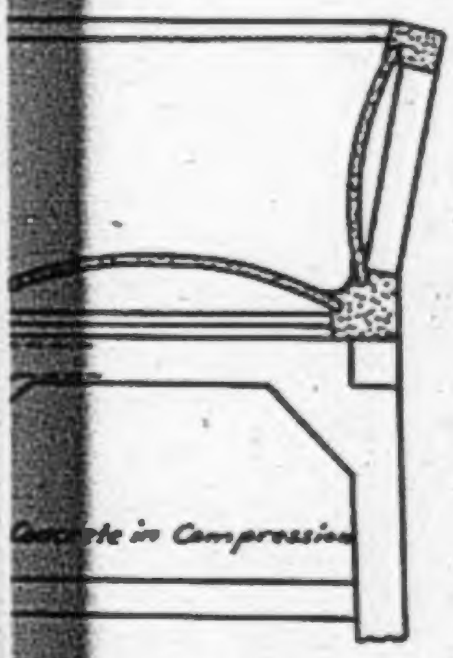
Special Cases where the cut or rock work is heavy

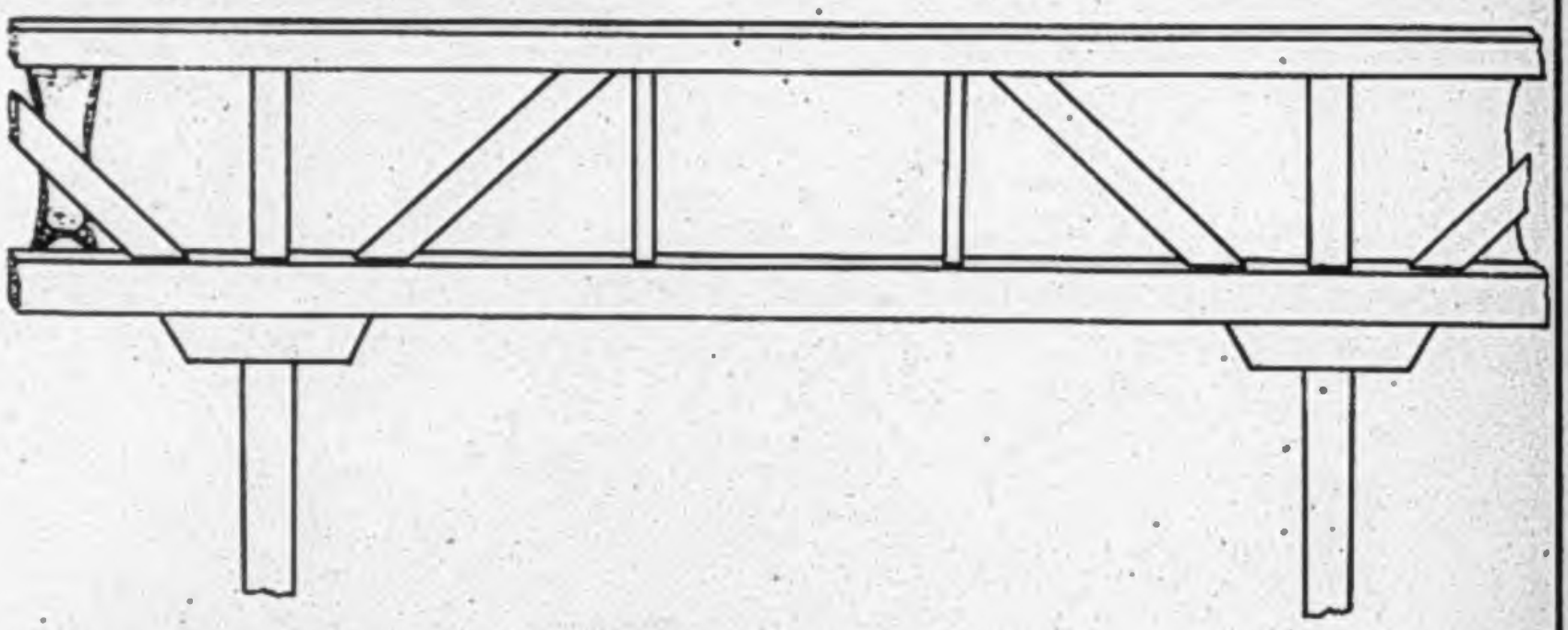
CU. YDS. Concrete lining per lin. ft. of ditch = .0863 cu. yds.

HYDRAULIC PROPERTIES

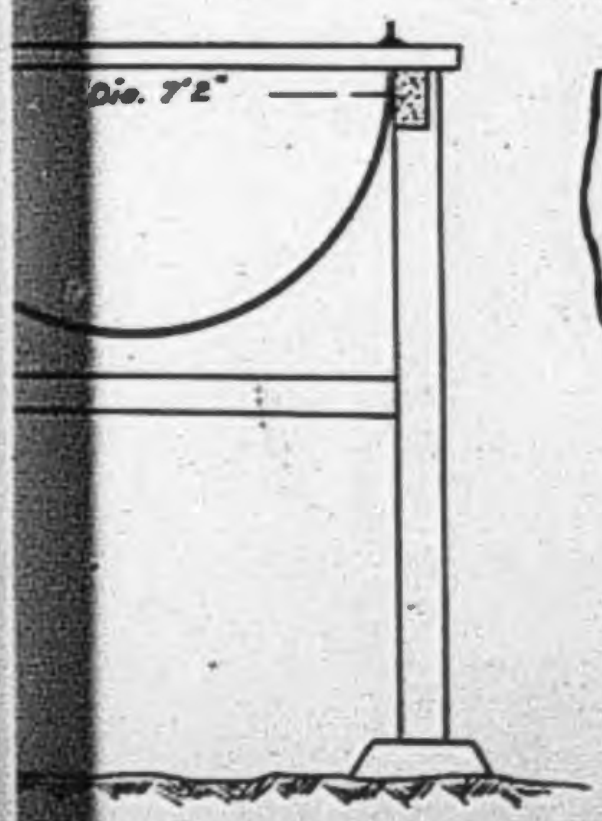
S = .0009	A = 15.6 sq. ft.
R = 1.5	V = 3.9 ft/sec.
n = .015	Q = 60.8 cu. ft/sec.
c = 108	

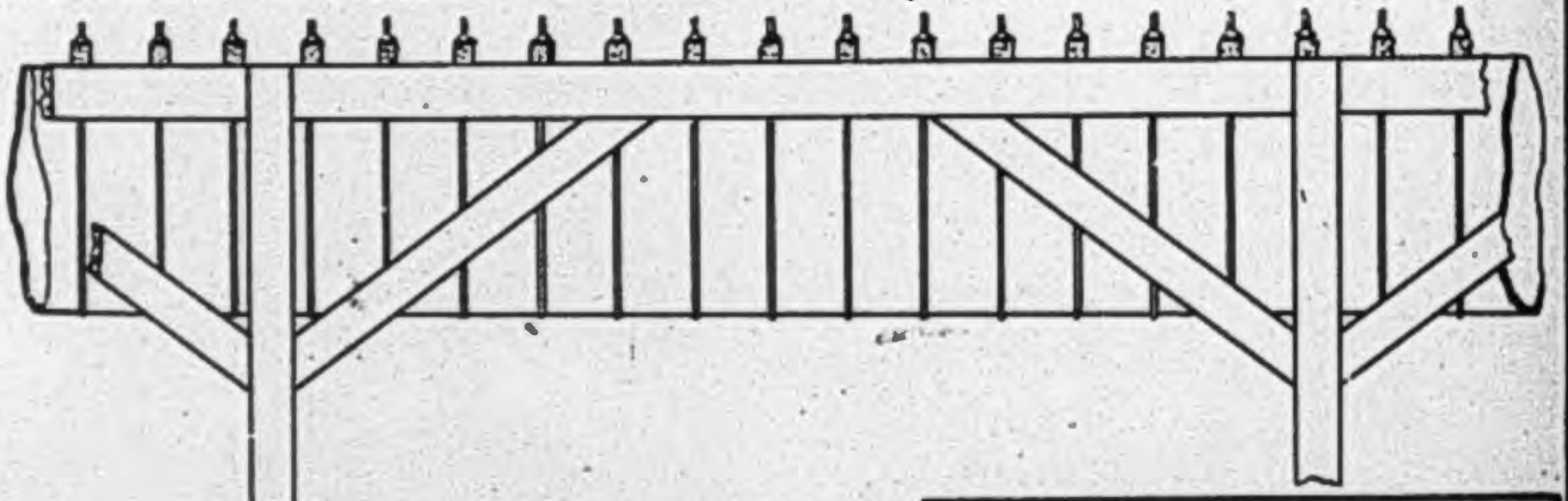
REINFORCED CONCRETE DITCH & FLUME. (Mat'd)





GALVANIZED STEEL FLUME (Mat'd)





VOLCAN LAND & WATER CO.

DETAILS DITCH & FLUME

Mar. 1912
W.S. Post, Engr.

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WILLIAM S. POST
CIVIL ENGINEER
ASSOC. MEM. AM. SOC. C. E.
1217 HIBERNIAN BLDG.
LOS ANGELES, CALIFORNIA

APPENDIX "A"

----- PAMO CONDUIT -----

WILLIAM S. POST
CIVIL ENGINEER
ASSOC. MEM. AM. SOC. C. E.
1217 HIBERNIAN BLDG.
LOS ANGELES, CALIFORNIA

Classification of Ditch

P A N O C O N D U I T

the

VOLCAN LAND and WATER COMPANY

Accompanying Report of W.S.Post.

Estimate PAMO CONDUIT.

eb.1912 — W.S.Post Engr.

Sta.	Lined Ditch A	B	C	D	Flume Bench	Trestle	Tunnel	Syphon H 150'-	H 150'+
0									
	139	152	200			48			
5+39									
		255				24			
8+16									
		85	50			26			
9+77									
		128				57			
11+62									
	274				167	91			
16+94									
	274		311			79			
23+58									
		123	1268			109			
38+58									
		1306	66			50			
1st Mile	687'	2047'	1895'		167'	484'			
		137				20			
54+37									
		1533				96			
70+66									
		1305				207			
85+78									
		1982							
2nd Mile		4957'				323'			
		365	492		65	40			
115+22									
					360	20			
119+02									
					98	23			
120+23									
				74	648	65	860		
136+70									
		275		108	562				
146+15									
				100	337				
150+52									
			145					493	150
3rd Mile		640'	637'	282'	2070'	148'	860'	493	150
	923	622		111	1457	77		287	
193+22									
				108	609	76			
201+15									
					656	60			
208+31									
	171					118			
5th Mile	1099'	622'		219'	2722'	331'		287	

Estimate PAMO CONDUIT

Sta.	Lined Ditch A	B	C	D	Flume Bench	Trestle	Tunnel	Syphon H 150-	H 150+
th Mile		245				28			
213+93					539	45			
219+77				61	250	143			
224+31					1037	147			
236+15	345	172	638						
247+70		501				164	706'		
261+41			211			48			
h Mile	345'	918'	849'	61'	1826'	575'	706'		
					1284	69			
277+53					385	132			
282+70					964	93	1410		
307+37					415	86			
312+38					392	50			
h Mile					3440'	430'	1410'		
					671	118			
324+59		743			226		436		
338+74		834				28			
347+36		177	908			73			
358+94		932				134			
h Mile	2686'	908'			897'	353'	436'		
	324	629				75			
379+88		952				98			
390+38		278			752	182	772		
411+22					1083	35			
h Mile	324'	1859'			1835'	390'	772'	(Short Mile)	
		363	277						
428+80		484			1586	80			
450+30		969			507	44		400	570
h Mile		1816'	277'		2093'	124'		400'	570'

Estimate PAMO CONDUIT

Sta.	Dined Ditch A	B	C	D	Flume Bench	Trestle	Tunnel	Syphon H 150'-	H 150'+
Mile					455		540		
5+15					919		3366		
Mile					1374'		3906'		
Mile							5280'		
Mile			1498'		2628'		1154'		
Mile					5173'		107'		
			753		751	61	685	814	
04									
		330			821	108			
63									
					396		561		
Mile		330'	753'		1968'	169'	1246'	814'	
	366					100	339		
25									
	175	165	602			67		955	300
89									
	1296	274	373			160			
92									
						108			
Mile	1837'	439'	975'			435'	339'	955'	300'
	1775					64			
39									
	2125					166			
30									
	1130					20			
Mile	5030'					250'			
	720	509		700					
09									
	445					267			
21									
	460		294			52			
27									
			432			112			
71									
		1006				283			
Mile	1625'	1515'	726'	700'		714'			

Estimate PAHO CONDUIT

	Lined Ditch				Flume			Syphon	
	A	B	C	D	Bench	Trestle	Tunnel in Gravel	H 150	H 150
th Mile		104				67			
99-31		447		116		422			
9-16		134		192		70			
3-12	386					168			
8-66	412	286	144			212			
9-20	184	208				88			
4-00		182				108			
6-90		85			487	80			
5-42			533			165			
th Mile	982	1446	677	308	487	1380			
		956	779			47		1048	300
1-70		775	448			223			
		704							
th Mile		2435	1227			270		1048	300
		641	346						
13-07		824	489					900	2080
th Mile	1465	835						900	2080
st Mile					3090			400	1790
nd Mile					2050	200	1980	1050	
rd Mile					2700		1370	810	400
					1380				400
1-50					1180		740	1580	
th Mile					2560		740	1580	400
25th M							4080		

Estimate PAMO CONDUIT

mary

Lengths in Feet

es	Lined Ditch				Flume		Tunnel	Syphon	
	A	B	C	D	Bench	Trestle		H 150-	H 150-
	687	2047	1895		167	484			
		4957				323			
		640	637	282	2070	148	860	493	150
	1099	622		219	2722	331		287	
	345	918	849	61	1826	573	706		
					3440	430	1410		
		2686	908		897	353	436		
8th		324	1859		1835	390	772		
			1816	277	2093	124		400	570
					1374		3906		
							5280		
			1498		2628		1164		
					5173		107		
		330	753		1968	169	1246	814	
	1837	439	975			435	339	955	300
	5030					250			
	1625	1515	726	700		714			
	982	1446	677	308	487	1380			
		2435	1227			270		1048	300
		1465	835					900	2080
					3090			400	1790
					2050	200	1980	1050	
					2700		1370	810	400
					2560		740	1580	400
							4080		
	11605	19824	14655	1847	37080	6576	24386	8737	5990

Estimate No. 1 (a)

PAMO CONDUIT - Via High Valley

Additional Quantities.

	Lined Canal			Flume		Tunnel	Syphon
	A	B	C	D	Bench Height	Bench Width	
+34					1476	420	
						75	
+60					1040	200	
+33						68	
+75					59		
+41							
ract1							
h Mile					2575	791	
					1275	200	
+00					2805	1000	
+75							
+59							
rom)							
Mile					4080	1200	
					3000	500	
+80							420
+80							
+64							
rom)							
+00	1360						
Mile	1360				3000	500	420
+60	2685					300	
+45		1600	600			95	
Mile	2685	1600	600			395	
+40			1700			165	
+05			900			67	
+72						430	
+02		367					
+69							1651
Mile		367	2600			662	1651

PAMO CONDUIT - Via High Valley
(Cont.)

	Lined Canal A	B	C	D	Flume Bench Trestle	Tunnel H 150-	H 150+
					849		
+20			175				
+69		1324					
+44					70		
+68	178						
+58							
+16	1050				120		
+36							
+86					50		
+36	243						
+79		310					
+89					911		
Mile	1471	1324	485		240	1760	
00		700	700		120		
20						1810	
t'l							
Mile		700	700		120		1810

Estimate No. 1 (a)

PAMO CONDUIT via High Valley

ary	Lined Ditch			Flume		Lengths in Feet	Syphon	
						Tunnel		
	A	B	C	D	Bench	Trestle	H 150-	H 150-
10th					2575	791		
h					4080	1200		
h	1360				3000	600	420	
h	2685	1600	600			395		
h		367	2600			662	1651	
h	1471	1324	465			240	1760	
6th		700	700			120		1810
al	5516	3991	4365		9655	3908	3831	1810

APPENDIX "B"

Method of determining quantities and prices.

****

The method adopted in these estimates has been to use "the linear foot" of various types of conduit as the only unit. The excavation is almost entirely in the granite, so uniformly found in San Diego County or its disintegrated product. Rock masses lie strewn above the deeply disintegrated material, imbedded but not as a rule constituting solid rock excavation. It was considered that if a type of conduit was adopted which would serve either in disintegrated granite or in solid rock, the estimates would best represent the conditions after the work was opened up. Further the flume proposed is taken at about the same cost as heaviest excavation in rock, and either lined conduit or flume may be used, as detail location requires. Flume is used in this estimate wherever the slopes were considered unsafe from a maintenance standpoint owing to the steepness and depth of overburden.

In the prices assigned to the three classes of excavation a uniform price of $1.50 per linear foot was adopted for concrete lining and an excavation price of 50¢, $1.00 and $2.50 per foot adopted for various classes. This is roughly 25¢ per cu. yd. for all material; and correspond closely with road making costs in the County which is very similar and to other conduits.

The price for hard rock tunnel was taken at $14. per foot, lining at $6. per foot, or $20. total. As it is not anticipated that lining will be necessary throughout $18. was adopted as an average price.

The two types of flume presented, are regarded as permanent constructions, which alone would be feasible where power is involved.

The prices used are considered to be for first-class construction throughout, and includes superintendence of construction charges. It is probable that in places the full expense need not be met at once, and economies may be introduced in others. The same values have been used in the comparative estimates, and the point is made that a modification of style of construction or of prices would not change the relative costs of the various systems discussed.

The instructions did not include assigning prices to electrical and hydraulic installations, but some figure was found necessary to bring out the unit costs of the various systems.

The figure adopted for this purpose was the actual cost (including all items, buildings, etc.) of the Cottonwood plant of the Los Angeles Aqueduct. This was $30. per "kilowatt installed" or reducing to the unit used in this report "net kilowatts on switchboard at San Diego, assuming 70% efficiency" we have $\frac{100}{70}$ x $30 or $43 per "net kilowatt" which is used in this report.

WILLIAM S. POST
CIVIL ENGINEER
ASSOC. MEM. AM. SOC. C. E.
1217 HIBERNIAN BLDG.
LOS ANGELES, CALIFORNIA

APPENDIX "C"

Capacities of Reservoirs.

****

APPENDIX C.

Capacities of Reservoirs.

Take new quantities

WARNER'S RESERVOIR CAPACITY.

Elevation of High Water Surface	Depth	Acre Acres	Capacity in Acre feet.
2618	0	0	0
2630	12	20	110
2640	22	51	460
2648	30	100	1060
2650	32	111	1270
2658	40	1095	7300
2668	50	1398	19760
2678	60	1840	35950
2688	70	2456	57470
2698	80	3498	87210
2708	90	4315	126260
2718	100	5042	173040

Computed between Elevation 2618 to 2650 from Survey by W. S. Post, February 1911, and extended for higher elevation from contour map of early surveys.

CAPACITY

PAMO RESERVOIR DAM SITE "B"

Elevation of High Water Surface	Depth	Acres	Capacity Acre feet.
850	0	0.15	
860	10	3.	15. Acre Feet
870	20	9.	72. " "
880	30	21.	219. " "
890	40	63.	635. " "
900	50	103.	1463. " "
910	60	147.	2709. " "
920	70	184.	4364. " "
930	80	245.	6508. " "
940	90	303.	9248. " "
950	100	362.	12628. " "
960	110	443.	16654. " "
970	120	539.	21564. " "
980	130	662.	27571. " "
990	140	805.	34905. " "

SANTA MARIA RESERVOIR.

Compiled from Alverson's Report.

Depth	Acres.	Capacity Acre feet.
10	1	1
20	8	45
30	23	100
40	41	522
50	80	1,108
60	154	2,305
70	286	4,500
80	561	8,736

CAPACITY

BLACK CANYON RESERVOIR

On Santa Ysabel Creek

Elevation of Water Surface.	Depth.	Surface Acres.	Capacity Acre-feet.
1620	0	0.0	0.0
1625	5	0.5	0.6
1635	15	1.2	7.0
1645	25	6.	36.
1655	35	10.	108.
1665	45	13.	224.
1675	55	19.	384.
1685	65	22.	589.
1695	75	27.	836.
1705	85	33.	1138.
1715	95	40.	1501.
1725	105	47.	1933.

next page the Sutherland Res.

APPENDIX "C"

Capacity

Upper San Clemente Site in

N. E. 1/4 of Section 10.

Contour	Depth	Area in Acres	Capacity Acre Feet
600	10	8	2
610	20	23	15
620	30	60	431
630	40	79	1085
640	50	93	1945
650	60	129	3054
660	70	166	4830
670	80	201	6370
680	90	238	8570
690	100	277	11140
700	110	317	14110

NO. 1.

WARNER'S RESERVOIR SITE

from the Dam Site. The high water line extends to Monkey Hill in the right back ground.

NO. 2.

WARNER'S DAM SITE during

Construction.

No. 3.

WARNER'S CUT-OFF WALL.

at end of season 1911.

No. 4.

WARNER'S CUT-OFF WALL

when water was turned in. The wall will act as a measuring weir in floods.

NO. 5.

Measuring Weir below

WARNER'S DAM.

Daily measurements have been made here

from May 1911.

NO. 6.

The Measuring Weir

as extended for high water.

No. 7.

Typical location of

WARNER CONDUIT

The 6th mile is in this view.

No. 8.

WARNER CONDUIT.

9th Mile.

No. 9.

Pine Mt. Forebay Site.

The dam would extend from the Tree on the left to the Rock on the right.

No. 10.

Location of the WARNER PRESSURE LINE. - the first 3000 feet descend this long ridge, past the white rock in the foreground.

The right lower corner of the picture looks down the steep slope of the last 3000 ft. of the pressure line. The power house would be near the sandy bed of Temescal Creek in the foreground. Pamo Valley and site of Pamo Reservoir extends in the right of the picture.

No. 12.

Looking up the pipe line location from Power House site. The Power House will be behind the large Oak Tree in the picture.

NO. 13.

PAMO CONDUIT 2nd Mile.

Here a typical flume bench is already graded as a road.

NO. 14

PAMO CONDUIT. 3rd to 5th Mile.

Latta Peak in the distance. This projecting ridge is pierced by a tunnel. The picture is typical of much of the PAMO CONDUIT.

Ed Fletcher Papers

1870-1955

MSS.81

Box: 40 Folder: 8

Business Records - Reports - Post, W.S - "Report on Warner-Pamo Water System of the Volcan Land and Water Co."

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