[c. 1911]

REPORT ON THE WORKS

OF THE

Southern California Mountain Water Company

Aerating Table
Method of aerating water before it enters Reservoir.

SUPPLYING THE CITY OF SAN DIEGO WITH WATER

Description of Works of

Southern California Mountain Water Co.

San Diego, California.

The water works system of the Southern California Mountain Water Company is the largest of its kind in California outside of the aqueduct system of Los Angeles.

RESERVOIR SUPPLIES OF THE SOUTHERN CALIFORNIA MOUNTAIN WATER COMPANY:

Name of Reservoir	Type of Dam	Height in Feet	Outlet Altitude in Feet	Area Submerged Acres	Capacity in Gallons
Lower Otay.....	Rock fill.....	150	400	1000	13,000,000,000
Upper Otay.....	Arched Concrete....	77	521	164	1,090,000,000
Chollas Heights...	Earth and Steel Plate.	34	385	17	90,000,000
Morena.....	Rock fill.....	265	2912	1370	15,000,000,000
	Total Capcity.....				29,180,000,000

This gives a total storage capacity for San Diego of over twenty-nine billion gallons as against twenty-six billion gallons, the supply of San Francisco for four hundred and fifty thousand people.

RAINFALL:

Year	Barrett Dam Rain Guage. Elevation 1,700 ft.	Morena Dam Rain Gauge. Elevation 3300 ft.	Run-off in gallons from Cottonwood watershed at Barrett, 250 sq. miles area.
1906	29.94 inches	34.73 inches	19,506,000,000
1907	12.79 "	18.56 "	11,080,000,000
1908	16.82 "	20.56 "	4,227,000,000
1909	24.54 "	32.98 "	9,414,000,000
1910	11.28 "	13.94 "	5,500,000,000

HISTORY

LOWER OTAY DAM—

The Lower Otay Dam was commenced in 1887 and completed August 18th, 1897, to the 130-foot level above the stream bed. The masonry core at the base is 62 feet wide, 28 feet high and 160 feet across the valley of the Otay River. It has a steel-plate core, protected with concrete on each side, and is composed of loose rock fill. It has a water-shed of about 100 square miles behind it, with an average altitude of about 1600 feet.

UPPER OTAY DAM—

This structure, of original and bold design, is composed of reinforced concrete, built on the arched type, being curved up-stream with a radius of 359.26 feet from the center line of the crest. The dam is only four feet thick on top, and fourteen feet thick at the base, being eighty-four feet high and stepped with offsets on the down stream side. Two tiers of steel plates were placed longitudinally on the foundation at the axis of the dam, while above this at intervals of two feet vertical, 1¼-inch railway cable for reinforcing was placed. The highest cable was five feet from the top of the dam. The concrete near the base was made of a very rich mixture, becoming gradually poorer as it reached the top. This dam is a splendid example of efficient engineering construction, and was built by Mr. C. M. Bose under the general direction of Mr. Babcock.

CHOLLAS HEIGHTS—

This dam is located along the route of the main supply pipe from the Lower Otay reservoir into San Diego, and is built across the Chollas Valley about four miles from the city limits of San Diego. It is situated on a tract of land comprising 180 acres in area, a short distance east of the filter plant. At the 23-foot contour, the Chollas reservoir contains over ninety million gallons of water, being about five times the capacity of the New University Heights reservoir, which has cost the city about $110,000. The Chollas dam is of the earth-fill type, with a ¼-inch steel core plate anchored into a foundation wall of concrete. It is fifty-six feet high above this foundation and 526 feet long on top, and was completed between June and September, 1901, under the direction of Mr. E. F. Tabor, as engineer. It is connected by means of

reinforced concrete outlet tower and 24-inch cast-iron outlet pipe with the main 30-inch pipe from Otay. The main function of this reservoir is to act as an emergency source in case of any accident to the main pipe-line from Otay, and as it holds fifteen days' supply for the city of San Diego it makes the continuous supply of water absolutely assured.

MORENA DAM—

This structure was begun in July, 1896, under the administration of Mr. Babcock, and operations were suspended in April, 1898, with the dam partially completed, and it was allowed to rest until May, 1909, when the work was actively resumed, under the direction of Mr. Spreckels. The dam is built high enough to impound water to the 150-foot contour, thus giving a storage capacity of about 15,000,000,000 gallons. The dam is so designed that five and a half feet additional height can be made at a small outlay, and thereby increasing the capacity of the reservoir to 17,500,000,000 gallons. The dam is located in a canyon eighty feet wide at the bed of the original stream, with side slopes in the solid granite rising at an angle of forty-five degrees to a height of more than 400 feet above the stream bed. Excavation for the foundation of the dam developed a remarkable fissure or pot-hole, which extended to a depth of 112½ feet. The contents of this comprising sand, clay and gravel were cleaned out and it was refilled with solid concrete for a depth of 142½ feet to the 30-foot contour, the entire height of the finished dam from foundation being 265 feet. This concrete is 36 feet thick at the bottom, and twelve feet thick at the top. In the top is a groove one foot wide by six feet deep, to which the facing of the dam is being keyed.

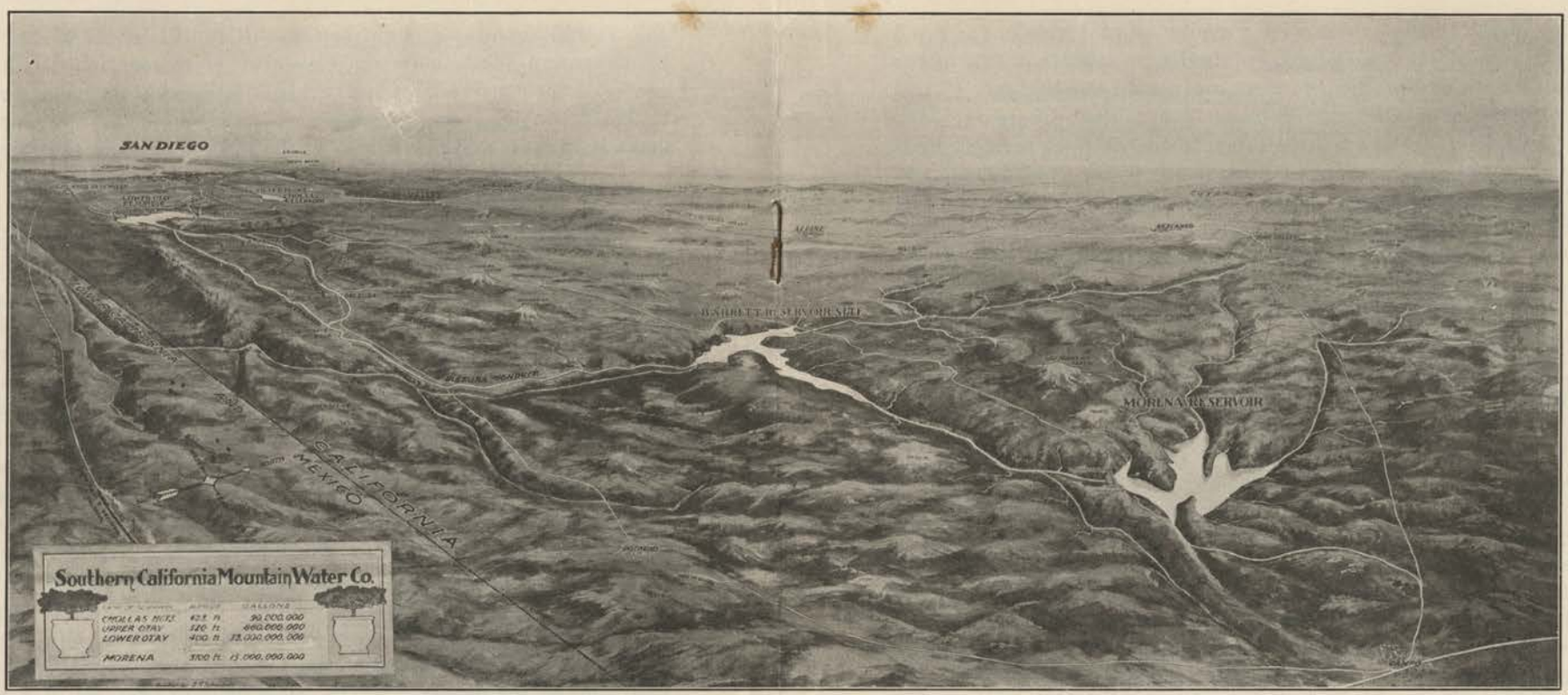
The up-stream face of the dam is composed of six to ten-ton blocks of rubble granite set in cement mortar, one cement to two and a half sand, and is built on a slope of nine horizontal to ten vertical. Grooves three feet square on 48-foot centers have been left in this masonry, into which are subsequently placed solid concrete. The water face of the dam is composed of reinforced concrete slabs about one and a half feet thick, which are attached to the solid masonry by means of iron rods on 4-foot centers anchored in same. The top of the dam is sixteen feet wide by 500 feet long, and the down-stream side is composed of loose rock-fill on a slope of one and a half to one. All of the rock-fill along the upper half of the dam is derrick and hand-placed, the crevices being carefully chinked with small stone, so there will be no serious settlement when the dam takes on the full load of water pressure.

Should there be a slight settlement, it will be taken care of by expansion joints between the slabs before mentioned, which center on the concrete ribs built into the masonry slots. There will be 306,000 cubic yards of granite rock in the entire dam, which will make it in mass and height one of the largest dams in California.

OUTLET TOWER—

Through the solid bed rock on the south side of the dam, there has been drifted a tunnel 387 feet long, eight feet wide by seven and a half feet high, through which the water from the reservoir will be drawn off. Connecting with this tunnel is now being built a reinforced concrete tower fifteen feet six inches in external diameter, with walls of concrete varying in thickness from three feet to two feet, the top of which is situated at a level of 155½ feet, and on which an operating platform is being built to regulate the outlets. These consist of four 24-inch cast-iron pipes passing through the outer walls of the tower, and connecting with a 30-inch vertical pipe, which discharges into the tunnel before mentioned. These outlets are located twenty-eight feet apart, vertically, so that the water may be drawn off from any level. Each outlet has a double control, the exterior one on the outer face being a Coffin Sluice Valve, while an alternative emergency valve of the Crane type can be operated by hand from platforms at the different levels inside of the tower, all of which are reached by a vertical iron ladder. There is also an independent 24-inch scouring gate, connected with a 24-inch cast iron pipe, for washing out the sediment which may accumulate near the outlet tower which passes through the foundation of same and connects with the tunnel before mentioned. The inner seventy-five feet of this tunnel, connecting with the tower, has been lined with concrete eight inches thick, so that every precaution is being taken to have one of the most perfect outlet systems of any reservoir in the United States. From the outer end of this tunnel outlet the water for the present will follow the natural grade of the Cottonwood Creek until picked up at the Barrett damsite by the Dulzura Conduit.

Construction operations are being prosecuted at Morena Dam by means of two Lidgerwood cableways and seven derricks, and 100 men are being constantly employed thereon until its completion. The rock has all been quarried out of the mountain above the dam, and on the 30th of August, 1909, a most successful explosion of about twenty tons of powder was made on the side of the mountain above the north end of Morena Dam, when 180,000 tons of solid granite rock were displaced with one shot, and broken



for handling. The powder was placed in a tunnel drift 115 feet long in a chamber and was exploded by electricity, giving the most satisfactory results. The rock for the dam is picked up by the Lidgerwood cableways and moved to the different derricks, where it is put in place. This work since being started has been practically free from serious accident. The only other dam of this type at present completed is the Relief Dam of the Stanislaus Power Company in the high Sierras. This work will be completed May 1st, 1912.

DULZURA CONDUIT—

The Dulzura Conduit leads the water from the Cottonwood watershed into that of the Lower Otay. It is 13.38 miles long from the intakes to its present western terminus at the Dulzura Divide; whence it throws the water into the Dulzura Creek, through which it flows at present a distance of 12 miles along the natural channel of same into the Lower Otay reservoir. In August, 1907, this work was commenced under my direction and was

completed on the 3rd of January, 1909. It averages about 5 feet wide by 4 feet 2 inches deep, besides having side slopes of 3 inches horizontal to 1 foot vertical. The grade is 4 feet fall in 5000, thus dropping about 52 feet between the intakes at Pine and Cottonwood Creeks and the discharge point at Dulzura. The canal has a carrying capacity, when full, of 40,000,000 gallons in 24 hours. The temporary intakes are each about ½ mile above the junction of Pine and Cottonwood Creeks. The Pine Creek intake is a concrete dam, which virtually continues the river wall of the conduit up stream and across the opposite bank. The Cottonwood intake consists of a box construction of reinforced concrete with 5 separate inlets so as to keep the water as free from sand as possible. Several sand settling and scouring chambers are located below the intakes to intercept the sand, considerable of which is floated along by the water during periods of high freshets in the winter.

From Barrett Dam south, canal, flume and tunnel alternate as the topography and location requirements make necessary. There are 17 tunnels from 40 feet to 2060 feet long, aggregating 9219 feet. There are 56,957 feet of concrete lined aqueduct, the concrete

being about 4 inches thick with a coping on each side at the top 6 inches square. It is proposed, eventually, to roof the whole of the conduit with a reinforced concrete roof, about one-half mile of this being done now to obviate damage from slides. There are 4490 feet of flume, which was kept down to the shortest possible limit owing to the great danger of fires, which in the dry summer and fall sweep across the dry brush which covers the country through which the conduit passes. The water from both intakes is carried across Pine Creek by means of a bridge composed of 2 Howe trusses 40 feet long, 7 feet 10 inches from center to center of chords. It then follows the north bank of the Cottonwood River until it crosses the hill at Dulzura through a tunnel 976 feet long.

The rock encountered in the tunnels was the hardest kind of granite and porphyry, so that the greater part of them cost as high as $20.00 per lineal foot to cut through. The tunnels are 6 feet wide by 7 feet high, having extra capacity to carry still more water if the ditch and flumes are subsequently enlarged.

With the storage systems of Morena and Barrett completed, it will be unnecessary, for perhaps 30 or 40 years, to pass more than 30 or 40 million gallons a day of water to take care of the future supply of San Diego, so that the necessity for this modification will be a long time deferred. It is contemplated, however, at some future time, to extend this conduit from its present terminus at Dulzura to above the Lower Otay where a 700 foot drop can be had for generating electric power. Surveys have been made and rights of way procured from the government for this work, but many more pressing demands on the resources of the company require attention at the present time to protect the storage supply of San Diego.

CONDUIT LINE FROM LOWER OTAY TO SAN DIEGO—

This commences at the outlet from the Lower Otay reservoir at an elevation of 400 feet above the sea, and traverses the country between the Lower Otay, Bonita, Chollas Valley and San Diego. To obtain the best delivering capacities in this conduit, and preserve an effecient hydraulic grade line, four tunnels were bored through the intervening hills, aggregating 6735 feet in length. For the first two and a half miles, a 40-inch pipe leads from the outlet tunnel to the junction with the Coronado pipe-line; from thence six miles of 36-inch wooden stave pipe leads to Bonita Valley, across which there is three-quarters of a mile of 32-inch steel pipe under high pressure. From thence to the Chollas Filtering Plant, the pipe is thirty inches in diameter, aggregating 15.16 miles from the Otay Lake. From the junction at Chollas into the filter plant and balancing reservoir of that name, four miles of 24-inch pipe

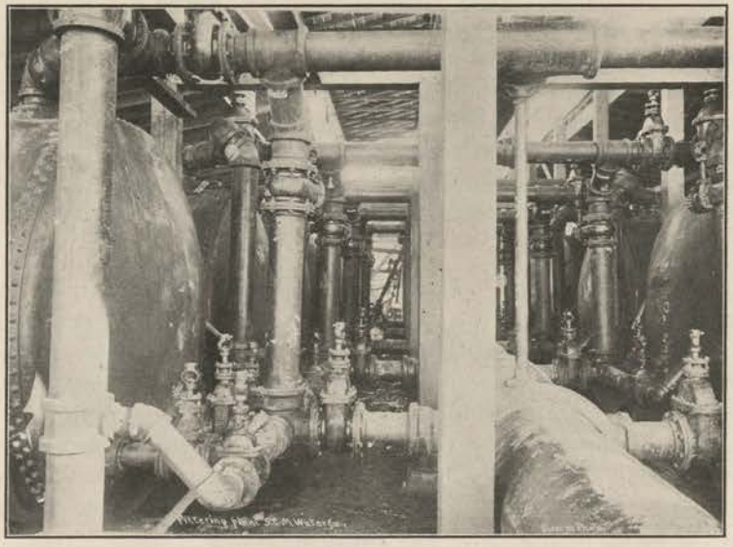
is laid into the University Heights reservoir, where it is delivered to the city distributing system, all water being measured through same by means of a Venturi meter. The first eight and a half miles of this pipe to Bonita has been under continuous pressure since August 12th, 1901, the maximum head being 293 feet. For the high pressure pipe the wood staves were dressed from 3x6 inch redwood. The staves were bound together with iron bands a half inch in diameter, sometimes as close together as one inch center to center.

The wooden pipe is in a splendid state of preservation, and where it runs through the tunnels aerating shafts have been made in same to promote ventilation so that practically no deterioration from rot has taken place, showing the result of very conscientious and efficient workmanship in the construction of this pipe. The balance of the pipe-line connecting with Chollas and town was completed in 1905 and 1906, water for permanent municipal consumption being turned on in August, 1906, and the water supply for the future and greater San Diego solved.

CHOLLAS FILTERING PLANT—

Notwithstanding the high character of the drainage area from which the water supply, by means of the Southern California Mountain Water Company's system is obtained, the company decided to install the most modern type of filtering plant used in the United States. The agreement which the Mountain Water Company had made with the City of San Diego was to furnish a good, pure, wholesome, domestic supply of water, and although under no obligation to do so, the company has installed a system of mechanical filteration, combining sedimentation, filtration and aeration, from which water of the purest quality known to science is delivered into the city mains.

This filtration plant is located about 4 miles from San Diego in the Chollas Valley, and has a capacity of 7,000,000 gallons per day, and is known as the New York Jewel Horizontal Pressure System. This plant is contained in a stout building with a substantial concrete floor and foundation, and sufficient spare capacity has been provided for so that in the future its capacity can be increased to 12,000,000 gallons daily without disturbing present arrangement. The plant consists of a battery of 10 filters, each 8 feet in diameter and 20 feet long, and they are made of steel plates ½-inch thick. The Filtering medium in each filter contains over 30 tons of pure silica sand brought to this city from New Jersey. The water enters the top of the filters and percolating through the layers of sand goes through the lateral pipes into the large



Interior view of Filter Plant, all San Diego's water passes through these Filters

mains, foreign and detritus matter remaining on top of the sand. Cleansing the filters from impurities deposited is accomplished by simply reversing the valves, when all foreign and objectionable matter is blown out of the filters into a trough to waste pipes. The whole operation of washing occupies 9 minutes and is the work of one man. This cleansing takes place once every 24 hours, but once every 48 hours would be sufficient as the water is practically free from impurities and simply needs aeration. The engineering work in completing the Otay pipe line and installing the filters was supervised in 1905 and 1906 by A. Ervast, C. E., who has general charge of the distributing system.

CHARACTER OF WATER—

This water is of superior quality for drinking and manufacturing purposes, and San Diego City now occupies the unique position of having the lowest death rate from typhoid of any city in the State of California. Herewith is an analysis of the water:

ANALYSIS OF WATER—

	Parts Per Million
Odor	None
Taste	Good
Color	Slight
Sediment quick falling (Turbidity)	Clear
Total Solids	365.

Vol. and Organic Matter	11.
Chlorine	74.
Free Ammonia	.05
Albumoid Ammonia	.11
Nitrogen in Nitrates	Nil
Oxygen required to oxidize organic matter at 212 degrees Fahrenheit	5.32
Bacillus Coli, Communis	Nil

Hardness, French Degrees—

Permanent	6.
Temporary	6.
Total	12.

CONCLUSION—

With the completion of the Morena Dam, the system is now capable of furnishing a seven years' supply for the City of San Diego with no rainfall. At the present time there is a reserve of two years' supply for the consumption of the city behind the dams of this company, so the water supply situation of the City of San Diego is now absolutely protected from the sources of this company.

OFFICERS OF THE SOUTHERN CALIFORNIA MOUNTAIN WATER COMPANY.

President	John D. Spreckels
Vice-President	W. C. Clayton
General Council	H. L. Titus
General Superintendent	B. M. Warner
Chief Engineer	M. M. O'Shaughnessy
Secretary and Auditor	A. H. Kayser

LOWER OTAY DAM