The Mono Basin Project

Aqueduct to Supply Los Angeles with Additional Water Now Under Construction

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To augment the flow of the Owens River Aqueduct, Los Angeles is preparing to divert to the Owens River watershed the major part of the stream flow of the Mono Basin. An 11-mile tunnel is the outstanding feature of the project, which also includes two storage reservoirs and several miles of reinforced concrete conduit. What was believed to be a new world's record for hard-rock tunnel driving was established on the project in April of 1935, and was broken thereafter three times in as many months. A maximum of 90 ft of progress was made at one heading in 24 hours on July 15. The project, costing about $11,000,000, is scheduled for completion in 1938.

ADDITIONAL water for the City of Los Angeles is the aim of the Mono Basin project. It embraces the acquisition of properties and water rights and the construction of conduits, tunnels, and reservoirs necessary for the collection and storage of water from the several streams in Mono Basin and its transmission to the Owens River and thence to Los Angeles. The project was made financially possible by a water bond issue, which was authorized by the voters of the city at an election held on May 20, 1930.

Three sources now contribute to the water supply of Los Angeles First in point of time is the Los Angeles River, the water of which has been owned by the city since pueblo days. Later, in the early years of the present century, several large pumping plants tapped the great subterranean reservoirs which are peculiar to the Los Angeles district, thus augmenting the Los Angeles River supply. Finally, in 1913, water from the snow-capped peaks of the Sierra Nevada in the north was brought by the Owens River Aqueduct 238 miles to Los Angeles.

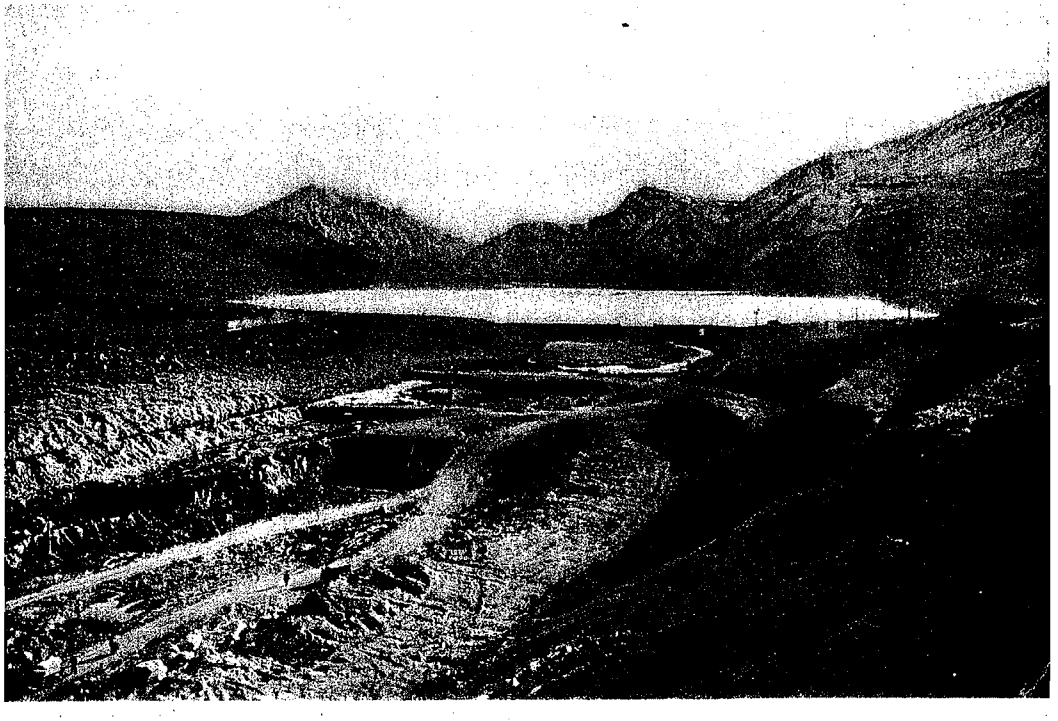
Mono Basin (Fig. 1) is situated partly in Mono County, California, and partly in Mineral County, Nevada. It is about 47 miles in length and 22 miles in width and ranges in elevation above sea level from about 6,400 ft at the surface of Mono Lake to more than 13,000 ft on the highest peaks.

The principal water supply of the basin originates on the eastern slope of the Sierra Nevada. The runoff from this area is collected by several streams which empty into Mono Lake, approximately in the center of the basin. In June of 1931, this lake had an area, exclusive of its two islands, of 86.8 sq miles. The surface drainage is supplemented by many springs, some of them of considerable size. Most of the springs are either in the bottom of the lake or near its shores; there are also a number along the base of the mountains that skirt the western shore. The easterly part of the basin is very arid, largely destitute of vegetation, and not productive of sufficient water to reach far into the basin.

The important streams of the basin, in decreasing order of magnitude of flow, are Rush Creek, Lee-vining Creek, Mill Creek, and Gibbs Canyon Creek. These four account for practically all the surface drainage of the basin, and are the ones from which a supplementary supply of water can be obtained.

Hydrographic studies have shown that it would be possible to impound within, and divert from Mono Basin a quantity of water which, added to the Owens River supply and supplemented by the Owens Valley underground supply when necessary, would enable the city to operate the Los Angeles Aqueduct continuously at its maximum mean and annual flow of 480 cu ft per sec.

For the 26-year period 1906 to 1931, inclusive, the average annual flow of all these Mono Basin streams, as nearly as can be determined, was 226 cu ft per sec, of which 195 cu ft per sec, or 86 per cent, could have been diverted had the water supply system now being



Finishing a Job the Glaciers Started

On the Grant Lake Moraine, an Earth Dam Is Being Built to Regulate the Diversion from Mono Basin

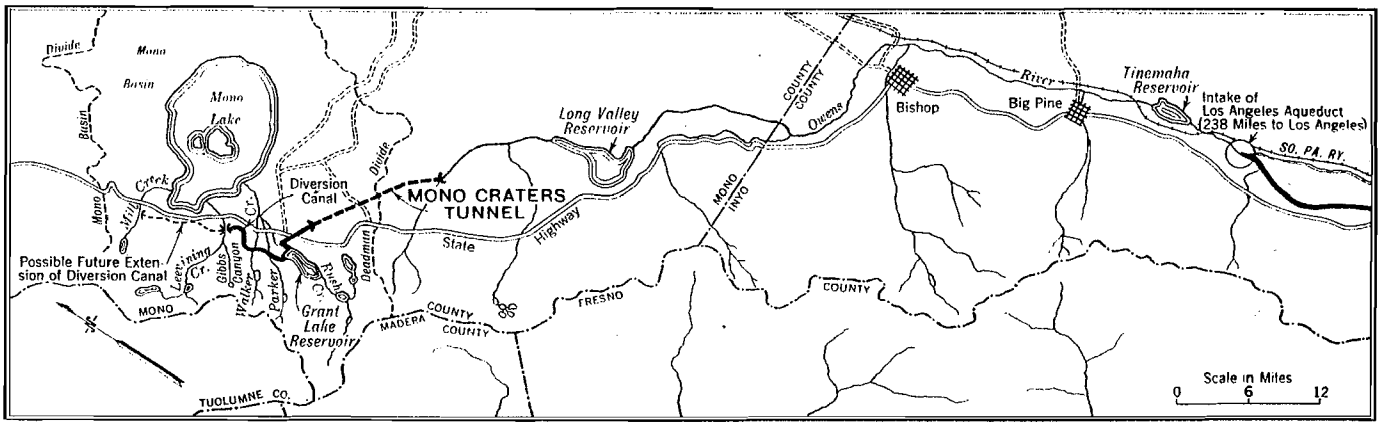
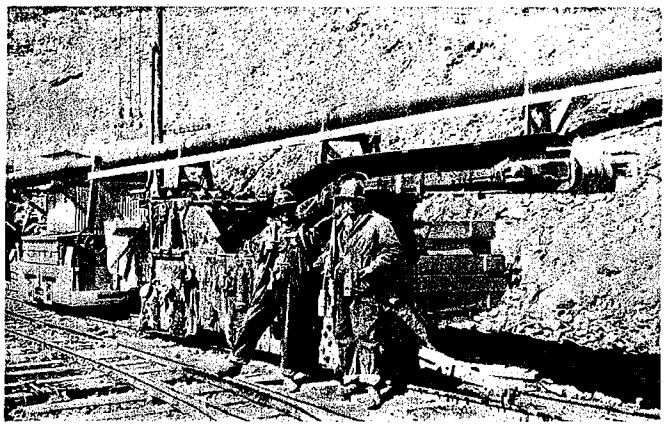


FIG. 1. MONO BASIN EXTENSION OF LOS ANGELES AQUEDUCT

constructed been in operation. However, for the 11 years 1923 to 1933, inclusive, a period of subnormal stream flow, the average annual flow of these streams was only 150 cu ft per sec. Of this amount, 140 cu ft per sec, or 93 per cent, could have been diverted.

Prominent engineers have estimated that the water level of Mono Lake will eventually be lowered by the diversion until the lake occupies approximately one-third of its present area. The inflow from the springs around and under the lake will then balance the evaporation and hold the lake level constant.

The principal features of the project are (1) a diversion canal heading in Leevining Creek intercepting two tributaries of Rush Creek, and emptying into Grant Lake Reservoir; (2) the Grant Lake Reservoir, to store and regulate the flow of Rush Creek proper and the contribution of the diversion canal; (3) a gravity line (pipe line and tunnels) from the Grant Lake Reservoir outlet to the headwaters of the Owens River; and (4) the Long Valley Reservoir, several miles below the outlet of the tunnel, for storage and regulation of both Owens River and Mono Basin water. The diversion canal later may be extended northward from Leevining Creek to Mill Creek.



ONE OF THE MUCKING MACHINES IN USE IN THE MONO CRATERS TUNNEL

This Equipment Has an Overall Width of Only 45 In.

The general plan of operation will be to divert the entire flow of the various streams, up to the capacity of the canal, throughout the entire year. Major fluctuations in discharge are to be smoothed out in the Grant Lake and Long Valley reservoirs.

The most suitable reservoir site in Mono Basin is Grant Lake on Rush Creek, where a capacity of 48,000 acre-ft will be created by a dam 72 ft in height above the stream bed. The dam, located in the narrows below Grant Lake, is now being constructed. It is of earth fill and rests on a morainal foundation. Preliminary work, to April 1, 1936, consisted of removing the top soil at the dam site and digging a ditch to divert the waters of Rush Creek during the period of construction. About 240,000 cu yd of earth had been removed from the dam site and 6,500 yd from the diversion ditch by this date.

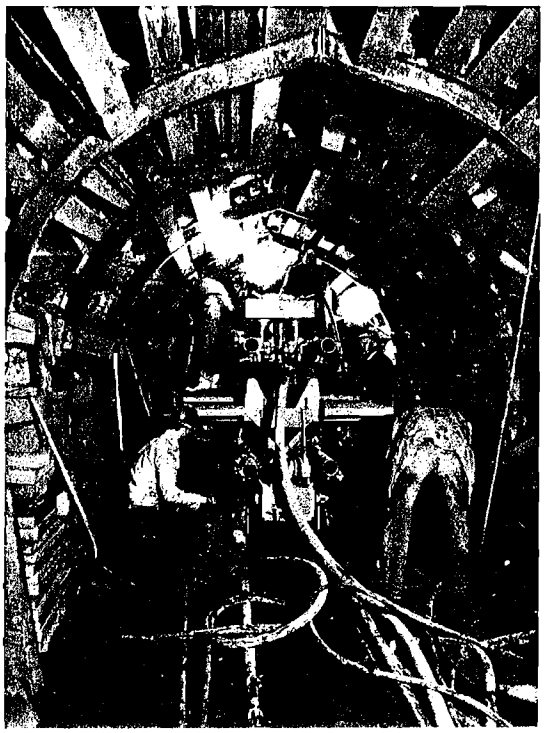
The different sections of the proposed Mono Basin Aqueduct will vary in capacity, to carry the added water as the different streams are diverted into it at convenient points along the line. From Leevining Creek to Walker Creek the capacity of the aqueduct will be 300 cu ft per sec, increasing to 325 cu ft per sec at the Walker Creek diversion and to 350 cu ft per sec at the Parker Creek diversion. The aqueduct from Grant Lake Reservoir to the Owens River is to be a gravity line, consisting of a short tunnel approximately 3,450 ft long at Grant Lake, about three miles of trapezoidal conduit, and the Mono Craters tunnel, 59,812 ft long, with a capacity of 420 cu ft per sec. The conduit sections are of the trapezoidal type, increasing in size from 6 ft $4\frac{1}{2}$ in. in height and width to 8 ft 3 in. as the capacity is increased. The walls have a batter of 1 in 12 and a flat-slab reinforced cover. The conduit will be buried, with a minimum of 2 ft of earth on top, to prevent freezing.

The Mono Craters tunnel, 11.3 miles in length, is to be 9 ft in diameter and to have a wide horseshoe-type section, concrete lined throughout. Because of its length, two shafts, one 950 ft deep and the other 350 ft, have been sunk along its axis to permit excavation to be carried on simultaneously from six headings. The estimated time required to complete the Mono Craters tunnel is $3\frac{1}{2}$ years. Actual drilling was started at the west portal in September 1934, and at the east portal two months later. Excavation for sinking the two shafts followed shortly thereafter. By April 1, 1936, 12,507 ft of tunnel had been drilled from the west portal, 9,095 ft from the east portal, and a total of 3,815 ft from the two headings reached by the shorter shaft. The deeper shaft had been put down 763 ft.

What is believed to be a new world's record for hard-rock tunnel driving was established at heading No. 1 on April 29, 1935, when 65 ft of tunnel was excavated in 24 hours. This was broken on May 17 and again on May 18, when an advance of 72 ft in 24 hours was made; also on July 15, 1935, 90 ft of progress was made in the same heading in 24 hours. For the three-month period—October, November, and December 1935—

tunneling progressed at the rate of 18.7 ft per day per heading in four headings.

It is planned to carry on construction continuously. The work is being conducted in three 8-hour shifts for six days a week. Four $3\frac{1}{2}$ - in. automatic-feed drifter drills mounted on a carriage built in the Water and Power Department shops are being used at each of the four faces. Compressed-air lines 6 in. in diameter have been installed, and ventilation is provided through an 18-in. 14-gage pipe. A specially designed mucking machine with an overall width of 45 in. is being used at each face. The machines are equipped with manganese cast booms and dippers. The muck is emptied into two-way side-dump cars, and is carried out in nine-car trains hauled by storage-battery locomotives. The track is 24-in. gage with 40-lb rail. California-type portable jump switches are used at the faces while ordinary one-way switches are used elsewhere.



JUMBO DRILL CARRIAGE IN OPERATION
Little Space Goes to Waste in the Mono Craters Tunnel Headings

In addition to the survey camp there are four permanent camps along the tunnel line, each housing about 200 men. All the camps are electrically lighted and all the kitchens are electrically equipped throughout. For heating, butane gas is used as fuel, the dormitories being equipped with hot-air units while the other buildings are heated directly by gas stoves. Every provision has been made for the comfort and welfare of the men. Roads have been built to provide access to all the camps; a water supply for camps and construction use has been provided, and a 33-kva power transmission line has been put through from the Southern Sierras Power Company's Leevining plant No. 3 to each camp, with a substation at each. Telephone lines have been built to provide direct communication by telephone and teletype from Los Angeles to the work. Because of snow and deep drifts during the winter months, snowsheds have been erected at each tunnel portal to provide access to the tunnel and permit the work to go on.

From the east portal of the Mono Craters Tunnel, the water will be emptied into the Owens River, whence it will flow approximately 30 miles into the Long Valley Reservoir. This reservoir will provide storage for 163,000 acre-ft of water and have a surface area of approximately 5,000 acres. The dam, of the rock-fill type, will be located at the upper end of the Owens River gorge. Its crest, 30 ft in width and approximately 530 ft long, will be 132 ft above stream bed. On the upstream side the dam will be faced with arc-welded steel on a slope of 1 vertical to $1\frac{1}{2}$ horizontal. The slope of the downstream face is to be 1 vertical to $1\frac{3}{4}$ horizontal. Including an estimated depth of 40 ft of stripping, the volume of the dam will be approximately 510,000 cu yd.

The estimated construction cost of the Mono Basin project, including Long Valley Reservoir, is $11,321,500, segregated as follows:

Mill Creek extension (for future construction)	$ 371,500
Leevining to Grant Lake	1,120,000
Grant Lake Reservoir	540,000
Grant Lake to Mono Craters tunnel	540,000
Mono Craters tunnel	7,200,000
Long Valley Reservoir	1,550,000

It is estimated that an average of approximately 1,000 men will be employed over the 42-month construction period, with a maximum of some 1,800 men at any one time.

Work on the Mono Basin project is being carried on by H. L. Jacques, construction engineer, and E. A. Bayley, field engineer, under the direction of H. A. Van Norman, chief engineer and general manager of the Bureau of Water Works and Supply, City of Los Angeles, Calif. All three are Members of the Society.

LOOKING ALONG ROUTE OF MONO CRATERS TUNNEL

UPPER LEEVINING FALLS IN THE MONO BASIN