WILLIAM MULHOLLAND: FATHER OF THE LOS ANGELES MUNICIPAL WATER SUPPLY SYSTEM

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William Mulholland 1855-1935

- Mulholland was Chief Engineer of the Los Angeles Water Co. from 1886-1902
- Chief Engineer & General Manager of the Los Angeles Bureau of Waterworks & Supply from 1902-1929
- Principal visionary and architect of the first Los Angeles Aqueduct and vigorously promoted the Colorado River Aqueduct

- 1878 photograph of William Mulholland (standing) and his brother Hugh Patrick, who was 11 months younger
- In 1876-77 the Irish brothers followed their Aunt Catherine Deakers from Pittsburgh to Los Angeles, via Panama, Acapulco, and San Francisco

FIRST RESERVOIR IN LOS ANGELES

- **Buena Vista Reservoir was constructed in 1868-69 by the Los Angeles Water Company as their first storage facility.**
- **The embankment was surfaced with riprap, and had a crest elevation of 378 feet. It was located near what is now the southeastern tip of Elysian Park.**

Deputy Water Ditch Tender to Superintendent (1878-85)

- In the spring of 1878 Mulholland took a job as a deputy Zanjero, or “water ditch tender” with the Los Angeles Water Company. The principal ditches ran along the western side of the Los Angeles River.
- When Fred Eaton accepted the role as City Engineer in Dec 1885 Mulholland became the Superintendent of the water company
- During torrential flooding in Dec 1889, Mulholland endeared himself to the citizens of Los Angeles by providing water after the 3.5 ft dia Zanje Madre conduit was severed and fill with sand on Christmas Eve. He was awarded a gold watch by a grateful water company, which he carried the rest of his life.

William Mulholland at left, and his engineering mentor and colleague Fred Eaton, at right. In 1904-05 Eaton convinced Mulholland that an aqueduct approximately 240 miles long could bring Owens river water to Los Angeles from the eastern slope of the Sierras.

- The independent Board of Engineers appointed to review Mulholland's scheme for the Los Angeles Aqueduct visiting the Owens Valley in 1906.
- From left, John R. Freeman, James D. Schuyler, Joseph P. Lippincott, Frederick P. Stearns, and William Mulholland.

First Los Angeles Aqueduct 1907-13

- With a length of 233 miles, the Los Angeles Aqueduct was the longest ever constructed up until that time
- The Owens River has a drainage area of 2,629 square miles (the Santa Ana River drains a watershed of 728 mi^2)
- The average flow was to be 280 million gallons per day

Funding for the First Aqueduct

- The aqueduct was built in 1907-13 with a $23 million bond passed by City voters in June 1907
- The average grade from inlet to terminus was 15 feet/mile
- These views show the 60-mile long open channel section above Haiwee Reservoir, which had a capacity of 900 cubic feet per second, or 581 million gallons per day

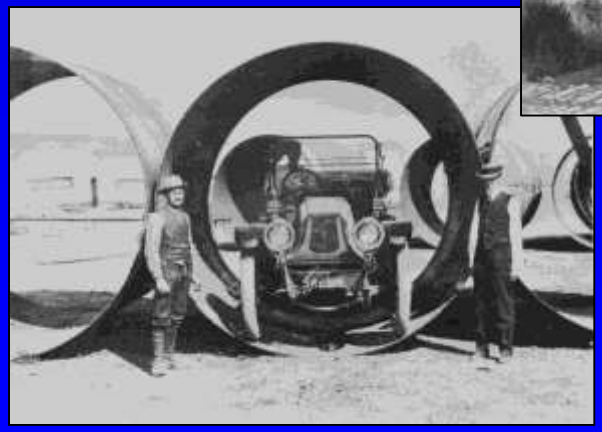
Cut-and-cover section

- 98 of the aqueduct's 233 miles were of cut-and-cover construction, as shown at left.
- Haiwee Reservoir near Olancha served as a re-regulation facility, storing up to 60,000 acre-feet of water
- Downstream of Haiwee, the aqueduct was designed to convey 422 cubic feet per second, or 280 million gallons per day

By constructing hydroelectric plants along the aqueduct, Los Angeles became the largest public owned utility provider in the world

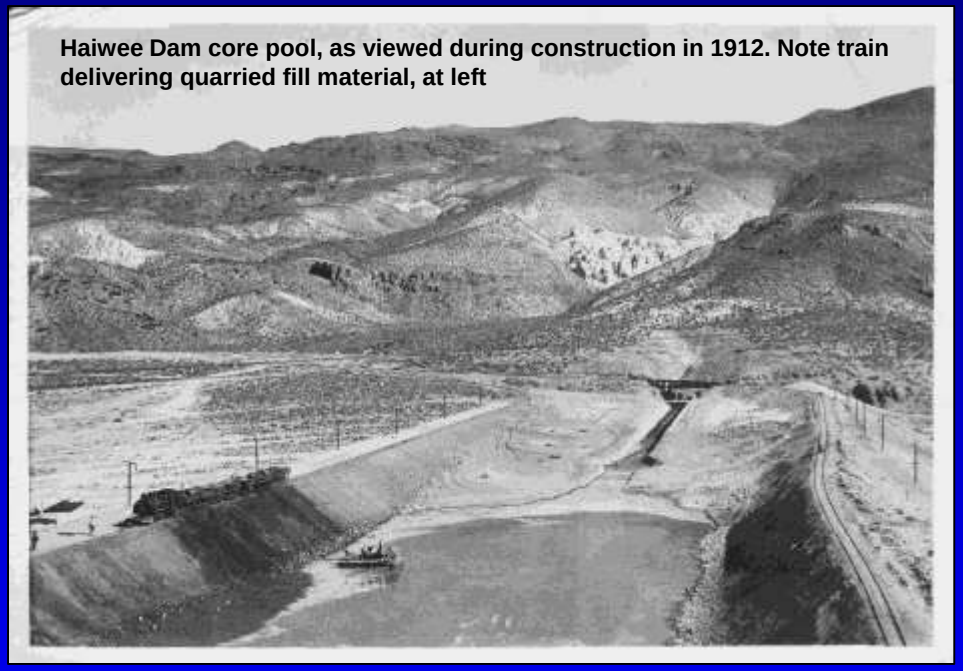
First use of Caterpillar tractors in general construction

The 232 mile long aqueduct was driven by gravity flow

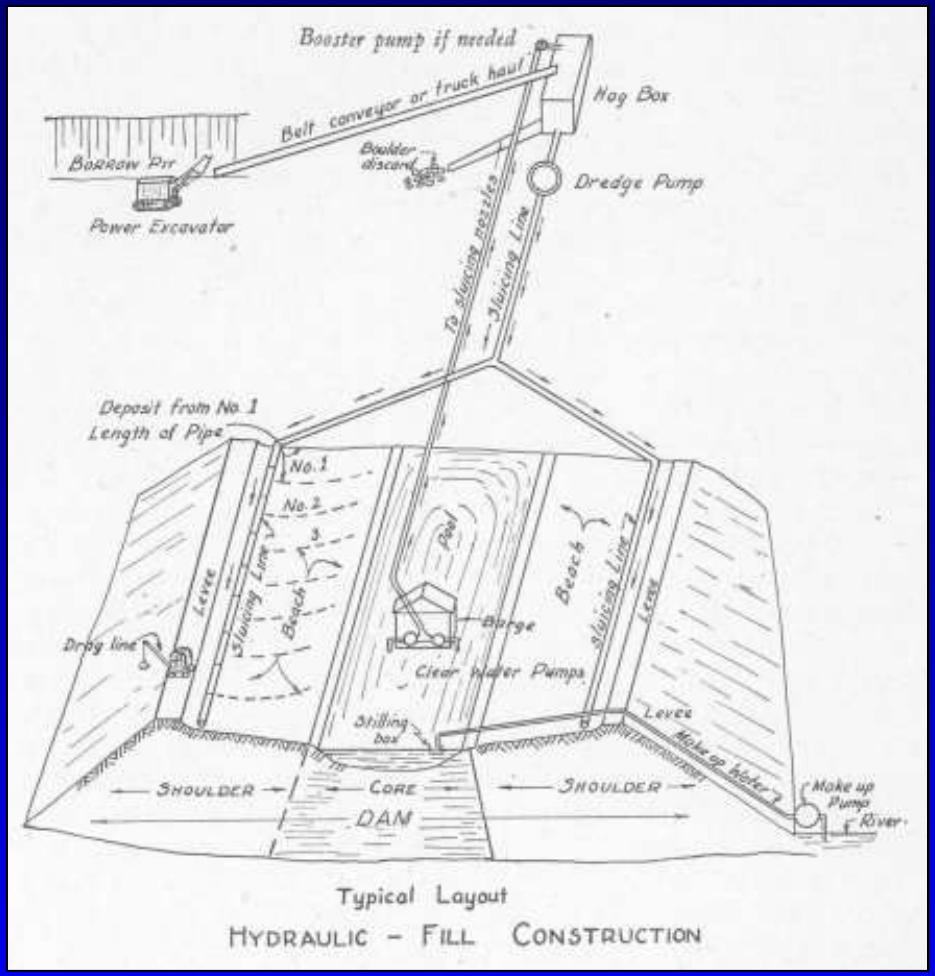


The City also built the largest cement calcining plant in the world at Monolith

HYDRAULIC FILL TECHNOLOGY



Haiwee Dam core pool, as viewed during construction in 1912. Note train delivering quarried fill material, at left



- Haiwee Dam core pool during construction in 1912. Note train delivering fill material to construct the dam's shoulders, at far left
- Prior to 1940 most earthfill dams were constructed using hydraulic monitors to sluice a slurry of fine-grained soils that were piped to the dam site and deposited without benefit of mechanical compaction

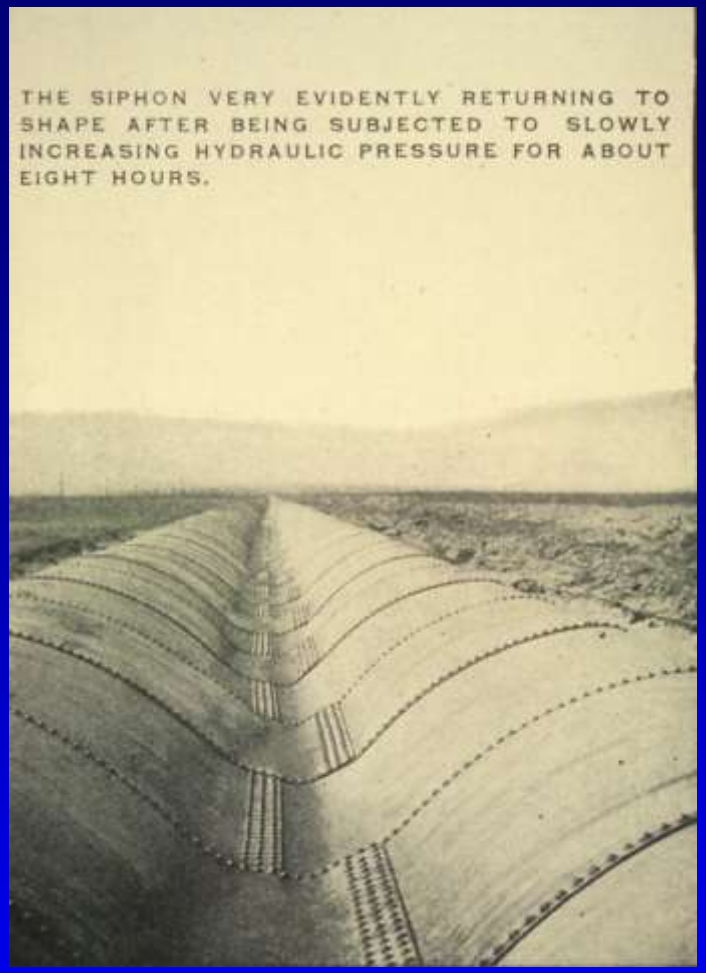
Big Bill Mulholland, the problem solver

- Mulholland was the first civil engineer to recognize the hazard posed to water supply systems by active faults.
- He identified the San Andreas fault zone 400 ft beneath Lake Elizabeth
- Saving miners trapped in a collapse of the Elizabeth Lake Tunnel by using pipes and hard boiled eggs

RECORD SAG PIPES

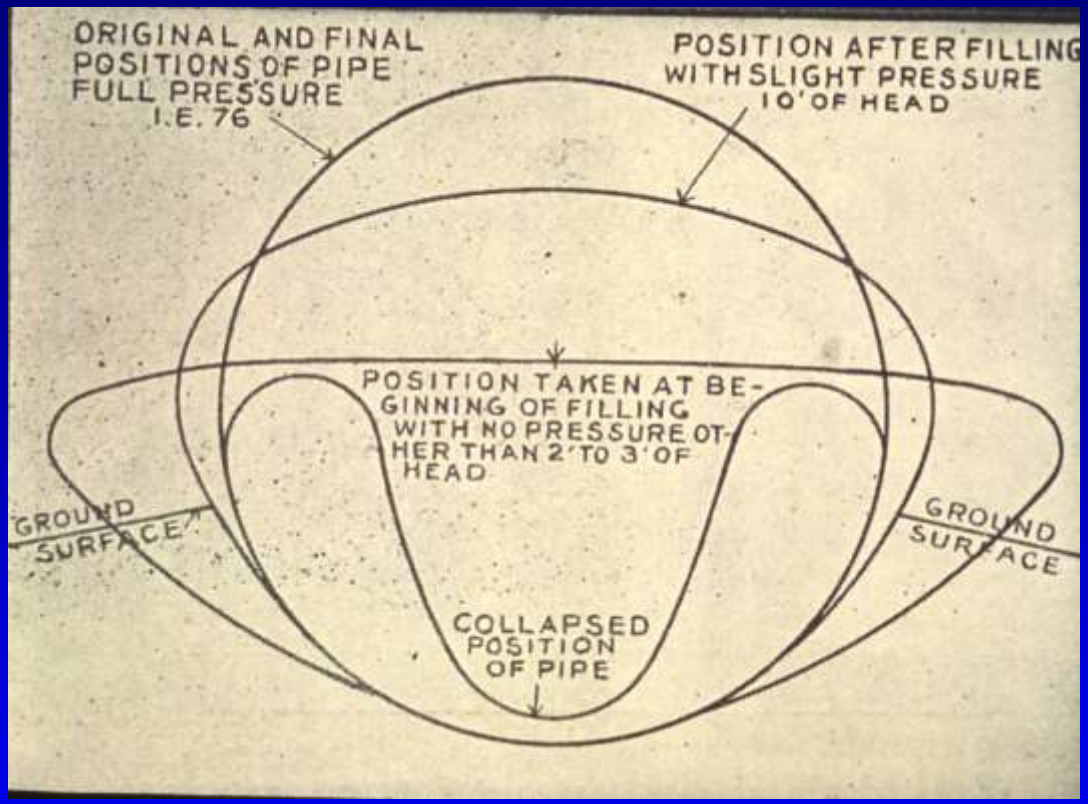
Above: Collapse of sag pipe in Sand Canyon in early 1913, after leaks undermined one of the footings, triggering implosion

Right: Sag Pipe crossing Jawbone Canyon, dropping and rising 850 feet



- **The inverted sag pipe across the Antelope Valley was 21,767 feet long, with a drop of 200 feet**
- **In February 1914 a flash flood eroded some supporting pedestals and 15,600 feet of steel siphon imploded**

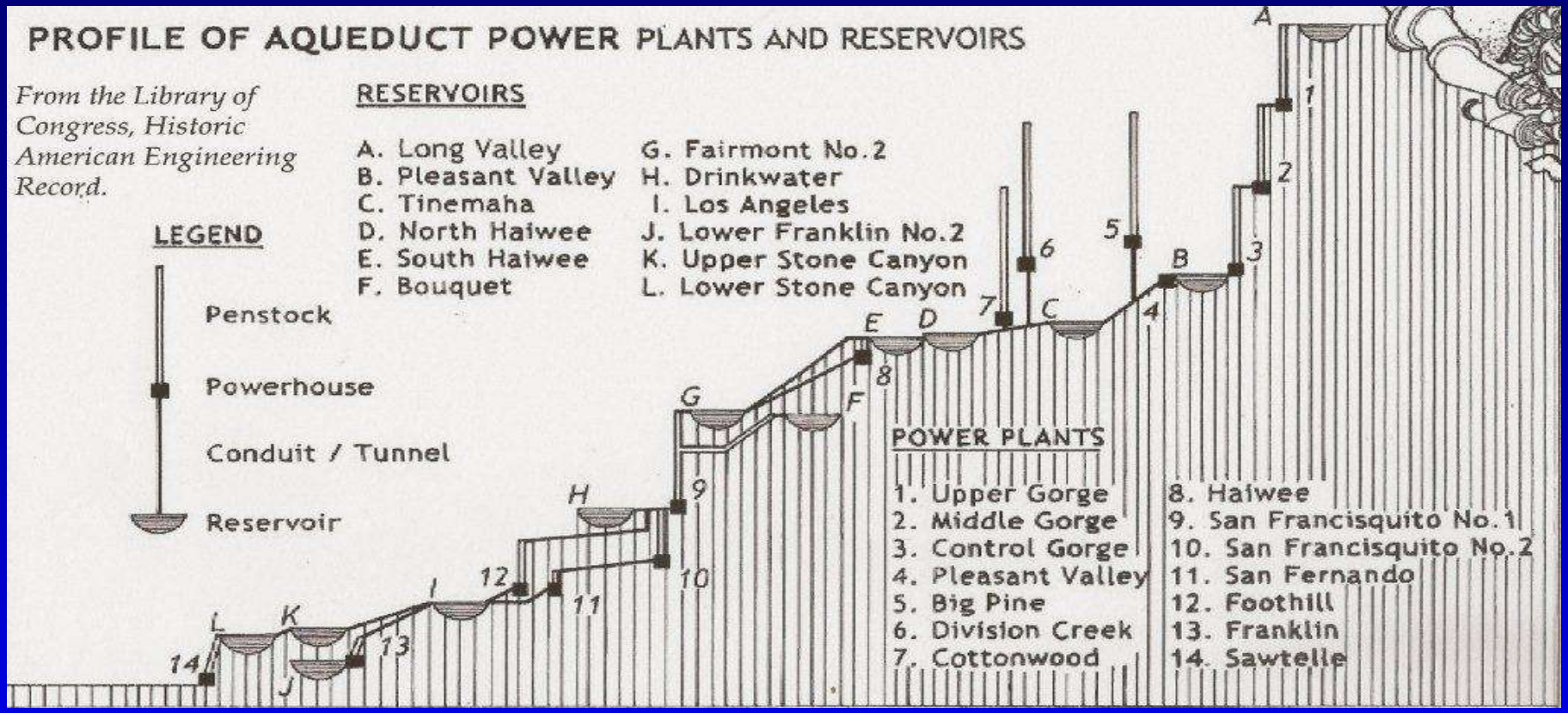
Mulholland repairs the damaged sag pipe



- **Faced with a systemic failure that would cost $250,000 and many months to replace, Mulholland decided to pump water into the collapsed pipe under increasing pressure, caulking the leaks as they appeared.**
- **He succeeded in recovering the siphon's circular section along its entire length, for a cost of just $3000**

Completion of the Aqueduct

- Mulholland brought the aqueduct to completion on-time and on-budget with a gala opening held on November 5, 1913
- 30,000 people attended the event, which brought international acclaim to the City's water chief

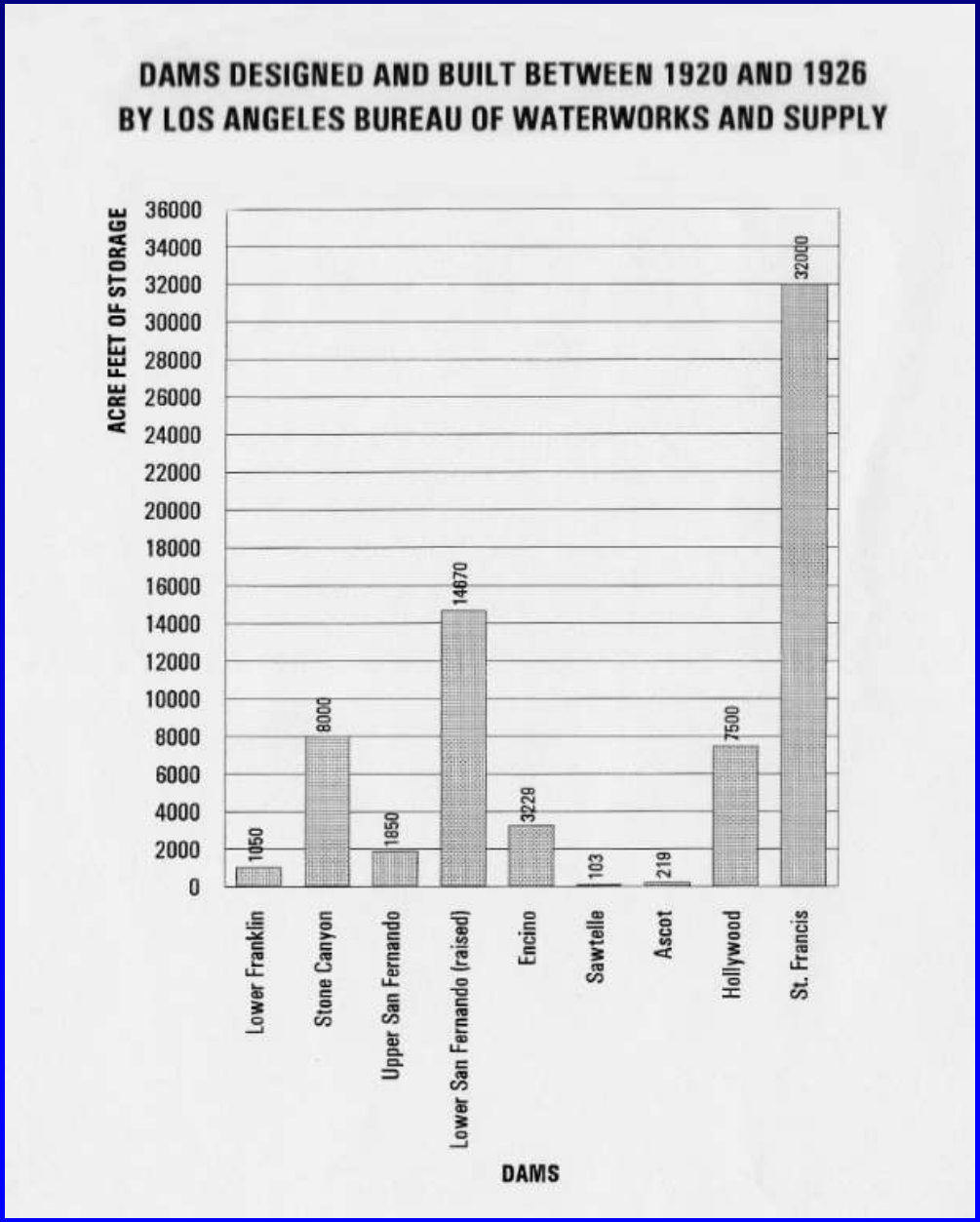


- **Profile of the Los Angeles Aqueduct after extensions completed in 1941, between Long Valley (Lake Crowley) (A) and Sawtelle (14), just north of downtown Los Angeles**
- **The original aqueduct intake was at Black Rock Springs north of Lone Pine at an elevation of 3,814 feet. It discharged at an elevation of 1,465 feet at the San Fernando Outlet (11).**

The San Francisquito Powerhouses paid back the $23 million cost of the aqueduct

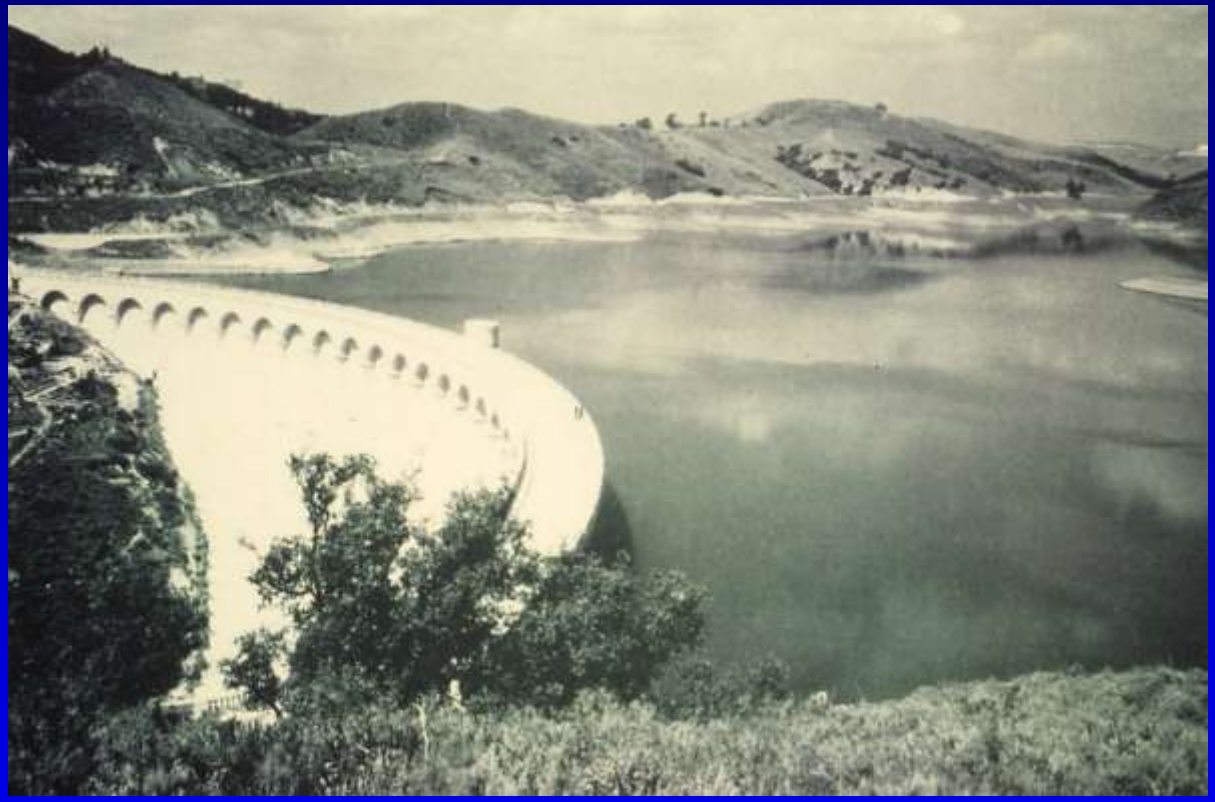
- The aqueduct passed through penstocks dropping 937 feet into San Francisquito Powerhouse No. 1, which opened in 1917 (shown at left).
- Nine miles downstream, the water drops another 540 feet into Powerhouse No.2, completed in 1920 (shown at right)
- After a lengthy battle with private power companies, Mulholland persuaded City voters to approve referendums that allowed the City to produce their own electricity, and Los Angeles DWP went on to become the largest municipal-owned utility in the United States

Another Water Crisis 1918-26



- While the aqueduct was under construction, the City's population grew from 284,000 to 425,000 people
- Near record-low rainfall beset the LA area, beginning in the winter of 1918-19, lasting till 1924-25
- Cultivation of the San Fernando Valley increased 567% from 1914-1923
- More water storage was needed in the Los Angeles vicinity
- St. Francis was the largest of 9 reservoirs built or enlarged between 1920-26

The City's First Concrete Dam



- Prior to 1923 all of the City's dams had been constructed of earth fill. Weid Canyon or Hollywood Dam was the City's first concrete structure, because there was insufficient clay to construct an earth dam.
- It was christened Mulholland Dam when completed in May 1925. The lake has always been called Hollywood Reservoir.

Present day view looking upstream of the dam site

The perfect dam site in San Francisquito Canyon

- A construction camp had been established in San Francisquito Canyon in 1911 to excavate 6.5 miles of tunnels in the Pelona Schist, between Powerhouses No. 1 and 2
- Mulholland believed that the natural constriction of the canyon was an ideal location for a dam

- **St. Francis Dam was completed in May 1926, with a capacity of 38,168 acre-feet; a one-year supply of water south of the San Andreas fault**
- **Concrete volume was 130,000 cubic yards**
- **11 spillway panels were fitted on the crest, each 18” high and 20 ft wide**
- **Five 30”- diameter outlet pipes had a maximum capacity of 1184 cfs with a full reservoir**

St Francis Dam fails catastrophically

- Near midnight on March 12-13, 1928 the St. Francis Dam failed, sending a flood wave 140 ft deep down the canyon, killing at least 432 people
- 13 different panels investigated the St Francis failure
- Most blamed the failure on hydraulic piping along the inactive San Francisquito fault running beneath the right abutment
- The City of Los Angeles paid out $14 million in damages

- **A sorrowful Mulholland told the Coroner's Inquest that he "*only envied those who were killed*"**
- **He went on to say *"Don't blame anyone else, you just fasten it on me. If there was an error in human judgment, I was the human."***

The responsibility for the error in engineering judgment rests upon the Bureau of Water Works and Supply, and the Chief Engineer thereof.

The responsibility for the error in public policy belongs to those to whom the Chief Engineer is subservient, including the Department of Water and Power Commissioners, the legislative bodies of city and state, and to the public at large. It is a logical result of a set of conditions that the citizenship has allowed to develop and continue. This is the more fundamental error, for if proper safeguards had been provided in the city charter and in the state laws, making it impossible for excessive responsibility to be delegated to or assumed by any one individual in matters involving great menaces to public safety, it is unlikely that the engineering error would have escaped detection and produced a great disaster.

A sound policy of public safety and business and engineering judgment demands that the construction and operation of a great dam should never be left to the sole judgment of one man, no matter how eminent, without check by independent expert authority, for no one is free from error, and checking by independent experts will eliminate the effect of human error and insure safety.

The exemption of municipalities from supervision by state authorities in the building of dams involving public hazards is a very serious defect of the state law that should be corrected.

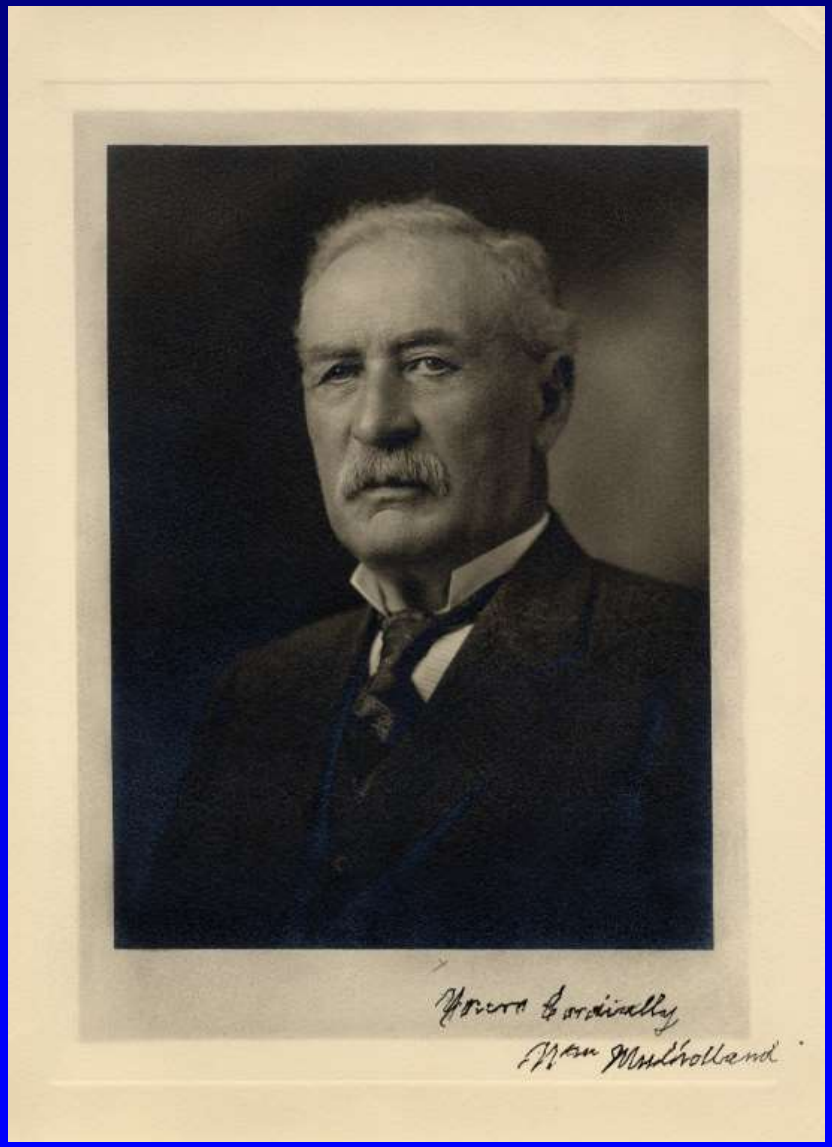
RECOMMENDATIONS

We respectfully recommend:

That the regulations governing the conduct of all municipal and county bodies engaged in building and operating dams be revised

- **The LA Co Coroner's Inquest found that "… *the construction and operation of a great dam should never be left to the sole judgment of one man, no matter how eminent…*"**

REQUIEM FOR MULHOLLAND



- Like any person, Bill Mulholland had weak points in his character.
- His thirst for thriftiness was perhaps one of these flaws, but that same trait allowed Los Angeles to build its municipal infrastructure AHEAD of its burgeoning population, at rock bottom prices
- He had an enormous capacity for getting difficult projects completed on-time and on-budget.
- Engineers of that era tended to underestimate the complexities of pore pressure response, especially, on concrete dams
- He had the depth of character to accept responsibility for shortcomings in the dam's design and construction, which very few people at the time comprehended