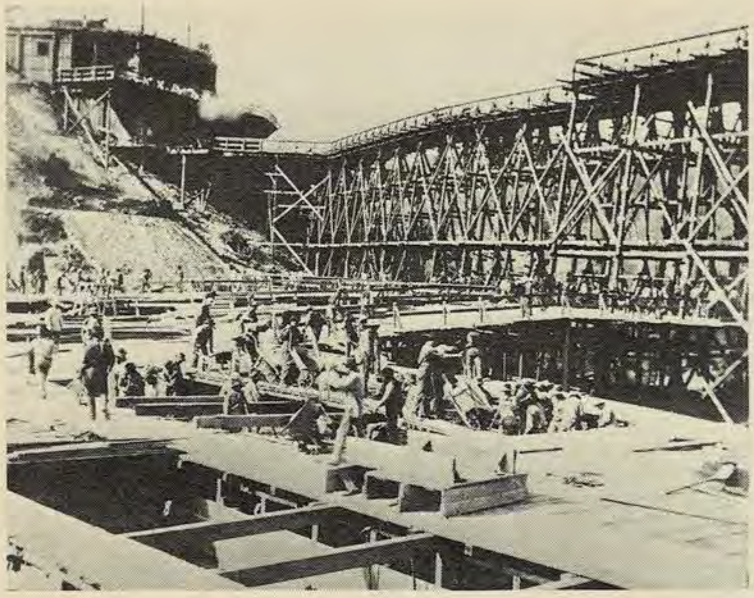
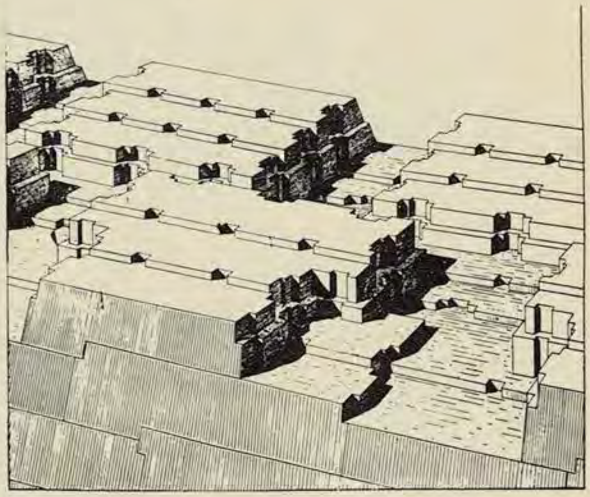
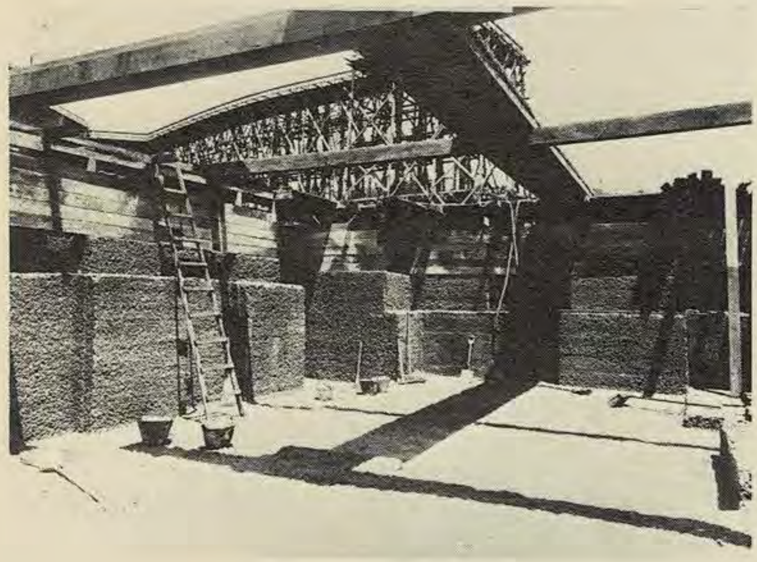


Crystal Springs Dam, 1890





Construction methods used for Crystal Springs Dam were the most advanced of their day. The three illustrations on this page show in detail the method of placing the blocks of concrete. (Upper left) *Workmen are making a pour.* (Lower left) *Block faces have been cleaned and roughened prior to the next pour.* (Above) *Diagram shows in perspective Engineer Schussler's system of interlocking blocks.*

on a branch of Alameda Creek on the property of General Mariano Vallejo's old mill, was offered for sale. Unable to raise money quickly enough, the city lost the land and water rights to the water company, which then developed the area as its "Alameda Creek System." A pipeline under the southern end of the bay was constructed to carry Alameda Creek water into the company's peninsula system. Development of the Alameda system included sinking wells in the gravel beds near Pleasanton, construction of Sunol Dam with its famous water temple and underground filtration galleries in 1900, and the eventual completion of Calaveras Dam in 1925.

The new city charter of 1900 provided for the eventual municipalization of the water system. With this end in mind, city engineers turned towards the Sierras for an adequate long-term source of high quality domestic water. Confirmed by a congressional grant embodied in the Raker Act of 1913, the city's acquisition of the Hetch Hetchy Valley for a reservoir, along with water rights on the Tuolumne River, were the first firm steps in the municipalization program. At that time, due in part to disruption from the 1906 earthquake and fire seven years earlier, water was selling in San Francisco for more than 25 cents a thousand gallons, and a large

In 1896, members attending the American Society of Civil Engineers convention visited Crystal Springs Dam, a pleasant day's outing by carriage.

Crystal Springs Dam today. The San Andreas fault runs through the middle of the reservoir behind the dam. Despite an eight-foot shift in 1906, the dam survived undamaged.

percentage of the city's residences were without waterlines, being served from water wagons. Somewhat unfairly, the company was blamed for much of the fire damage in the disaster, as the earthquake had ruptured its mains, and water ran freely from broken pipes in thousands of burned buildings.

Construction of the Hetch Hetchy system began in 1915, with a railroad and facilities for the hydroelectric portion of the system. The principal reservoir was impounded behind O'Shaughnessy Dam, completed to its first height in 1923. The transbay portion of the Hetch Hetchy Aqueduct was finished in 1925 to bring additional water from the Spring Valley company's newly finished Calaveras Dam. The city acquired the water company's entire operating properties in 1930, and the first Hetch Hetchy water was delivered in 1934, upon the completion of the Coast Range Tunnel.

Although the phenomenal post-World War II growth of the Bay Area was never imagined by Hetch Hetchy planners, the system has proven adequate in years of average precipitation to supply the needs of San Francisco and San Mateo County populations nearly three times greater than originally predicted.

Crystal Springs Dam, 1890

A key component of the old Spring Valley Water Company's peninsula system, the Crystal Springs Dam, completed in 1890, stands as a monument to the water company's chief engineer, Swiss-born Herman Schussler. Built when knowledge of concrete technology was very meager, it is an outstanding example of a structure free from physical defects after nearly 90 years of service.

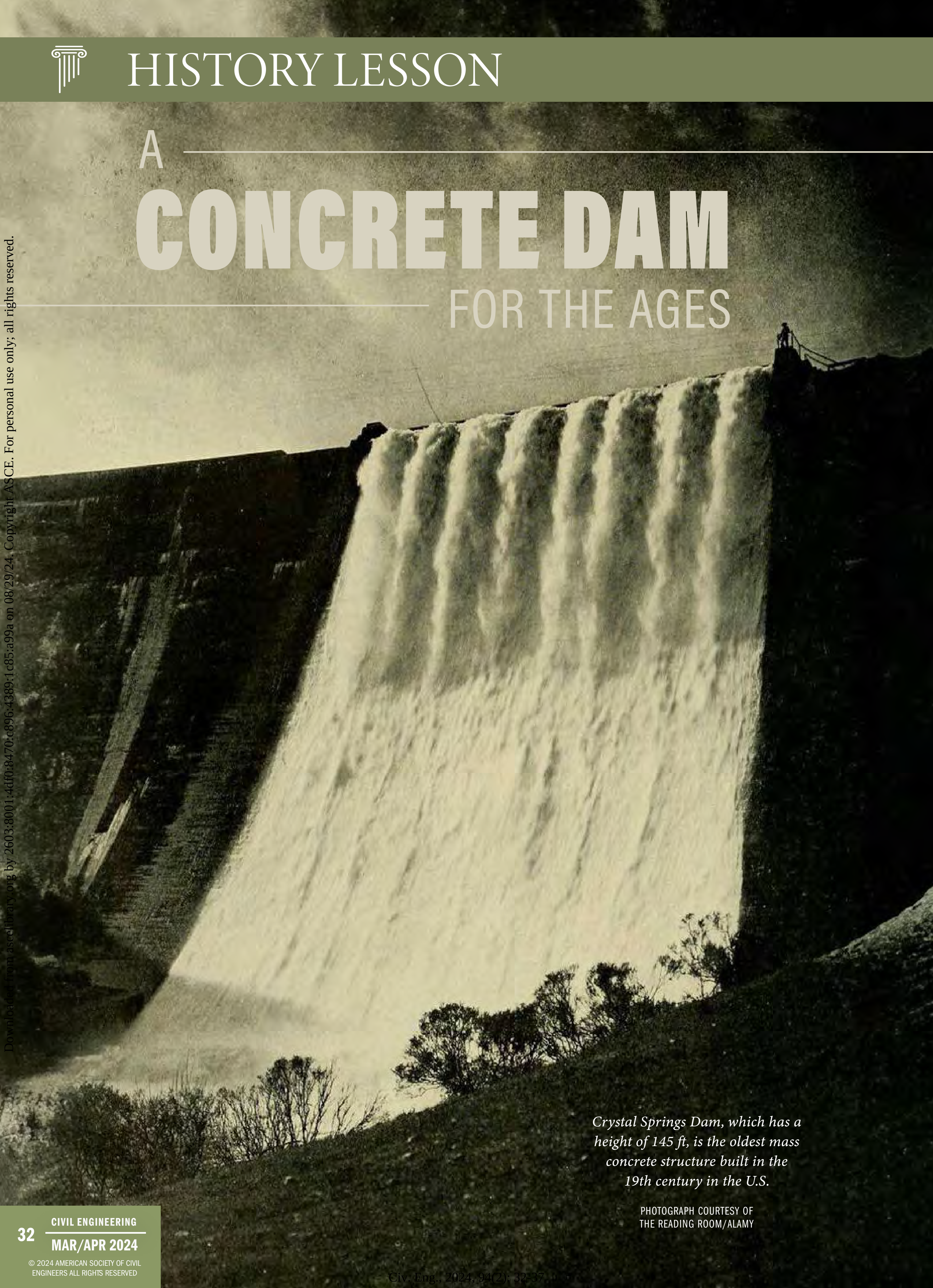
By far the largest of the few pre-1900 concrete dams remaining in service today, its excellent quality was no accident but the result of practices even today regarded as excellent. Washed sands and coarse aggregates were used, the first known instance in this country, and, also for the first time, the water-to-cement ratio was carefully specified and monitored. In addition to ensuring a high quality in the materials used, engineer Schussler prepared a careful method of erection. Concrete was put into place within 15 minutes of being mixed. Spread in layers no more than three inches thick and thoroughly hand-rammed to fill all spaces, the placed concrete was water cured until completely hardened. Before each new placement, the exposed surfaces against which new concrete was to be placed were roughed with picks, then broomed and washed clean. Concrete was placed in an intricate system of interlocking blocks, cast alternately to minimize the effects of shrinkage. The blocks were staggered as to depth and height so that neither horizontal or vertical joints would be continuous.

The foregoing description is rather detailed so as to explain why the Crystal Springs Dam survived a disaster of magnitude great enough to destroy an entire city. At the time of the magnitude 8.3 San Francisco earthquake of 1906 along the San Andreas fault, the reservoir behind the dam was virtually full. The dam was located less than a quarter mile east of the fault, which runs through the reservoir. At this point the horizontal movement along the fault was eight feet; yet, although the Crystal Springs Dam was subjected to a torturous series of thrusts and pulls, no failures or cracks appeared, and no water was lost from the reservoir.

Crystal Springs Dam remains in service today, still forming a key segment of San Francisco's water system.


CALIFORNIA HISTORIC
CIVIL ENGINEERING LANDMARK
AMERICAN SOCIETY OF CIVIL ENGINEERS
CRYSTAL SPRINGS DAM
1887 - 1890
SAN FRANCISCO SECTION ASCE 1976

A CONCRETE DAM FOR THE AGES



Crystal Springs Dam, which has a height of 145 ft, is the oldest mass concrete structure built in the 19th century in the U.S.

PHOTOGRAPH COURTESY OF THE READING ROOM/ALAMY

Civ. Eng., 2024, 94(2): 32-37

By Lawrence M. Magura, P.E., F.ASCE, BC.WRE (Ret)

Propelled by the continuing flood of riches from the Mother Lode gold mines of California and the Comstock Lode of Nevada and opportunities afforded by the newly completed first transcontinental railroad, San Francisco, by the early 1870s, was the most populous city on the West Coast and was rapidly growing in prestige.

Situated at the northern tip of the San Francisco Peninsula and blessed with one of the world's greatest natural harbors, with saltwater on three sides and a mild Mediterranean climate, there was only one thing that threatened the city's continued growth: an adequate water resource. Despite its optimal location, San Francisco lacked a sufficient watershed within its boundaries from which to develop a potable water supply.

THE QUEST FOR WATER

In 1858, the Spring Valley Water Works (later renamed the Spring Valley Water Co.) was formed to develop San Francisco's water supply by tapping the surface waters of neighboring San Mateo County south of the city. The county included the largely undeveloped 23,000-acre San Andreas Valley watershed. Work to develop the county's water resources began modestly with the construction of two fairly small earthen storage reservoirs — San Andreas and Upper Crystal Springs dams in the watershed — followed by a more substantial stone masonry dam on Pilarcitos Creek, situated in a neighboring watershed immediately west of Spring Valley, according to an interview with Mike Housh, San Francisco Public Utilities Commission historian and archivist.

Although these projects provided some relief from San Francisco's perpetual water shortage, it was clear that significantly more storage capacity was required to ensure the city could meet its short- and long-term water needs.

Enter Hermann Schussler, a young German civil engineer. Born on Aug. 4, 1842, he received an education in civil engineering schools in Zurich and Karlsruhe, Germany. After receiving his engineering diploma, he left his homeland in 1864 intent on making his mark in a California where opportunities for an ambitious young person were virtually unlimited.

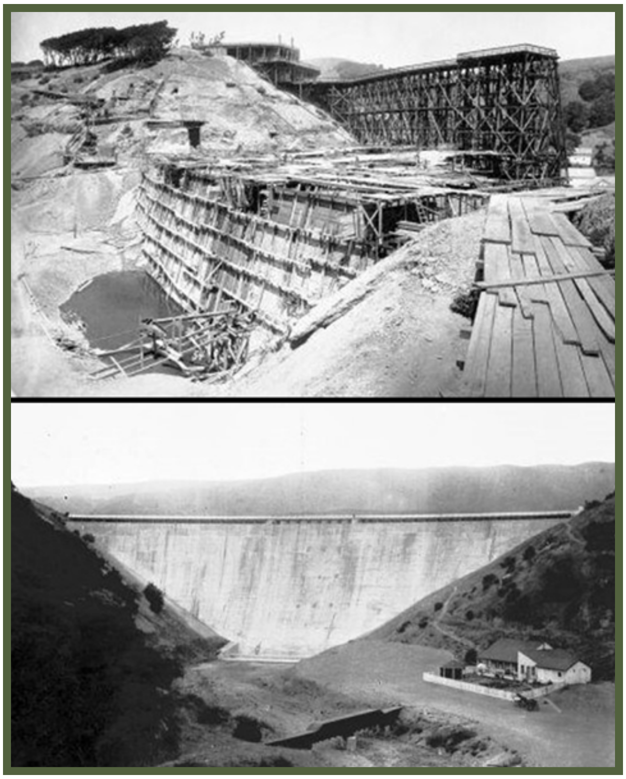
Within months of his arrival in San Francisco, Schussler landed his first job with Spring Valley at a starting salary of $50 per month. Hired as a field engineer, Schussler was a member of the engineering team involved in the construction of the aforementioned Pilarcitos Dam.

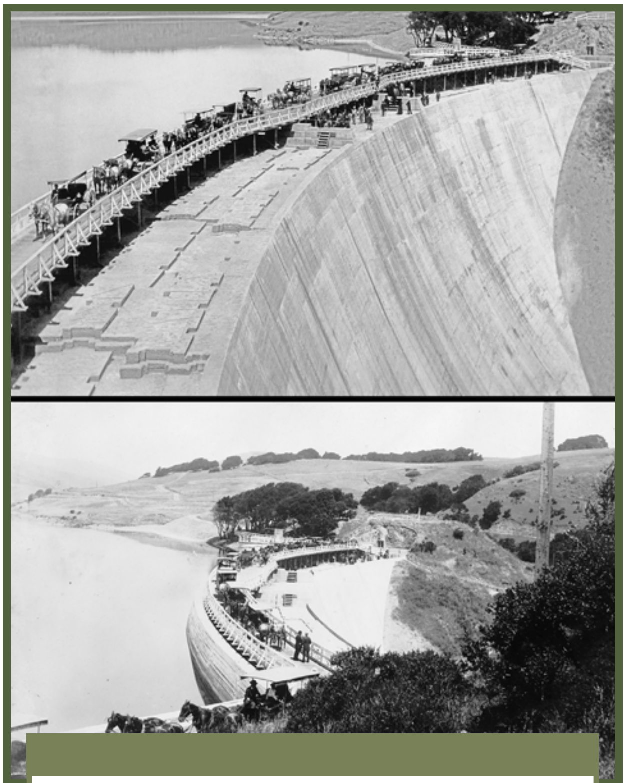
Company managers noted Schussler's drive and engineering competence, and his rise within the company was nothing short of "meteoric," according to Gary M. O'Neill in *La Peninsula*, the journal of the San Mateo County Historical Association (Vol. XXVI, No. 2, August 1990). Within two years, he was promoted to chief engineer, his salary was more than tripled, and he was assigned to the company's San Francisco headquarters. The company would be Schussler's primary employer until he retired 48 years later.

Schussler encouraged the Spring Valley board of directors to purchase as much of the San Andreas Valley watershed as possible, with an eye toward eventually constructing a large dam at the mouth of San Mateo Creek canyon. With the board's approval, agents were quietly dispatched to the area to acquire watershed property from local landowners. Within a few years, the company had purchased essentially the entire 23,000-acre watershed.

Schussler began planning for the new high dam in the mid-1880s. According to a *Historic American Engineering Record* report on the dam, "... when Schussler was planning and designing what was to be called the Lower Crystal Springs Dam with a projected height of 145 feet, there were only 17 dams exceeding 95 feet in height in the entire world. All 17 dams were outside of (the) United States, and although several high dams were built in the U.S. at about the same

Civ. Eng., 2024, 94(2): 32-37





It took three years to build the dam, and upon completion it contained approximately 157,000 cu yd of concrete, top two. *In 1896, engineers and guests attending the ASCE 1896 Convention in San Francisco paid a visit to the dam,* bottom two.

PHOTOGRAPHS COURTESY OF THE SAN FRANCISCO PUBLIC UTILITIES COMMISSION

time as Lower Crystal Springs Dam, all of the large American dams were rock or earth-fill dams." (Brad Brewster, Environmental Science Associates, *Lower Crystal Springs Dam*, September 2010)

Although Schussler may have preferred to build Crystal Springs Dam from these materials, no source of rock of sufficient quantity or quality existed in the vicinity of the dam site. Schussler was forced to think creatively, and he pivoted his design concept to construct the new dam using mass concrete.

It is worth noting that in the 1880s, the use of large quantities of concrete to build structures was in its infancy, and there were no existing standards or guidelines to assist Schussler in the design process, according to Chuck Spinks, P.E., M.ASCE, former chair of the ASCE History & Heritage Committee, who has studied the development of the Portland cement industry. Schussler had to rely on his formal engineering training and what he had learned from his prior work experience. He was literally on his own.

Another major challenge for Schussler was finding a source for the large quantities of Portland cement the project would require. At the time, there was no large-scale manufacturer of the cement in the country. Undaunted, Schussler procured most of the needed quantities from John Bazley White & Brothers Ltd. in Swanscombe, England, the world's leading supplier of the product at that time.

Although the first transcontinental railroad had been completed nearly two decades earlier, by the 1880s there was insufficient transportation infrastructure in the U.S. to deliver large quantities of Portland cement overland to the project site, so it was packed into watertight wooden barrels and shipped some 16,000 nautical mi from England to San Francisco.

When the barrels arrived in San Francisco, they were loaded onto rail cars at the docks and transported by train 20 mi down the San Francisco Peninsula to San Mateo, where workers then loaded the barrels onto horse-drawn freight wagons for the final 12 mi haul to the dam site.

Sand for the concrete mix came from the local sand dunes at the then-undeveloped North Beach section of San Francisco, and a small rock quarry was developed near the dam site that supplied rock nodules that could be crushed for the concrete aggregate. Schussler also required all crushed rock and sand for the concrete to be thoroughly washed on site to remove salt, dirt, and other impurities before being mixed with the Portland cement.

Civ. Eng., 2024, 94(2): 32-37

Although Schussler settled on Portland cement for the construction of the dam, he was acutely aware of its limitations. His primary concern was the potential for cracking of the concrete due to shrinkage and heat buildup during the curing process. In response, Schussler developed an innovative solution: interlocking, irregularly shaped concrete blocks — 10-15 ft wide, 6-10 ft high, and 30-40 ft long, according to the *HAER* report.

Surveying work commenced in early 1886, but it was not until late in the year that things began to take shape. On Dec. 1, the Spring Valley board met and decided that construction of the main (or Lower) Crystal Springs Dam should begin immediately, according to the *HAER* report. By early 1887, a work camp had been established at the site that included "a lodging house, boarding house, woodshed and chicken house, stable, and officers' quarters. The camp was later enlarged to accommodate the swelling ranks of workers and an accelerated construction schedule."

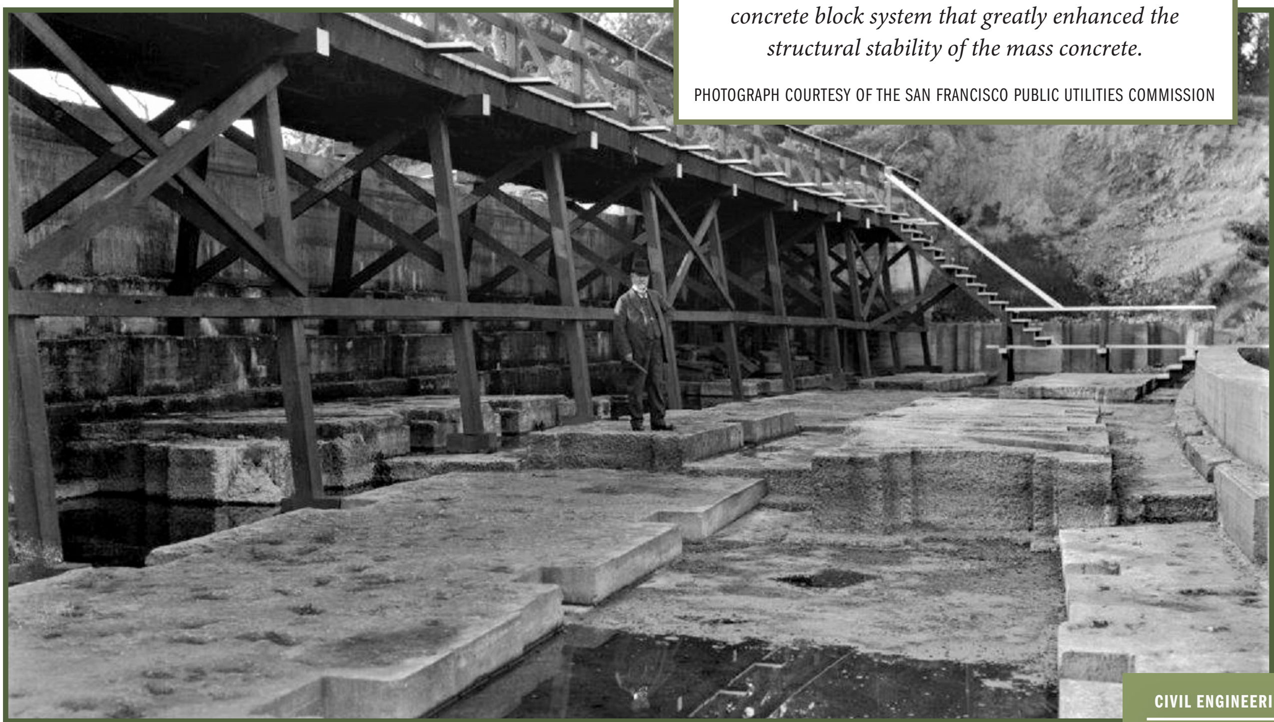
Dam construction began in spring 1887 with clearing and grubbing of the dam site and excavation of a 6 ft deep trench to anchor the dam into bedrock. Schussler specifically required this phase of the work to be performed using only hand tools. Rock blasting was prohibited to avoid possible fracturing of the bedrock, which was a wise precaution to minimize any future leakage beneath the dam.

By 1888, full-scale construction of the dam was underway, and at its peak, the workforce numbered nearly 1,000 workers. As part of the site development plan, Schussler added a trestle structure across the dam site. Next to it, on the north side of the site, workers constructed a three-story concrete mixing platform that held six steam-powered engines, each of which was connected by a shaft to a rotating rock crusher, a revolving perforated cylinder for washing the crushed rock, and a concrete mixer — all of Schussler's own design — according to the *HAER* report.

Proportions of ingredients for the concrete carefully followed Schussler's exacting specifications: 6.5 barrels of cleaned, crushed rock; two barrels of washed sand; one barrel of Portland cement; and two-thirds barrel of water, per the *HAER* report.

After mixing, the concrete "was dumped into hand cars which were pushed out onto the trestle. The concrete was (then) dumped into vertical 16-inch diameter iron pipes which were placed at intervals along this trestle. These extended down to the work platform on the dam itself. Heavy steel plates were placed at the end of these pipes to absorb the blow of the falling concrete. The concrete was then quickly shoveled up and taken in wheelbarrows to its point of consumption," according to the *HAER* report.

Within 15 minutes of mixing, the concrete was poured into wooden forms by a large crew of workers, according to the San Francisco Public Utilities Commission report, *Lower Crystal Springs Dam*. Once in the forms, Schussler's directions called for a crew to carefully ram the wet concrete into



Hermann Schussler, center, *devised an ingenious method for constructing the dam: an interlocking concrete block system that greatly enhanced the structural stability of the mass concrete.*

PHOTOGRAPH COURTESY OF THE SAN FRANCISCO PUBLIC UTILITIES COMMISSION

Civ. Eng., 2024, 94(2): 32-37

the corners of the irregularly shaped forms in thin layers no more than 3-4 in. thick to eliminate voids. Workers then covered the blocks with boards to avoid exposure to sunlight and sprinkled them with water until the concrete hardened. Concrete placement rates approached 1,000 cu yd per day during the peak of construction.

The blocks were "allowed to set individually, initially separated from each other like the spaces between the alternate square(s) of a checkerboard," per the *HAER* report. "Once fully set, the spaces would be filled in by another block. Most of the blocks were keystone shape except for recesses and projections on all sides, built this way so that the blocks could be dovetailed together."

After each layer hardened, Schussler had a crew strip the wooden forms and remove by hand all laitance or rock pockets, which were then repaired by troweling in fresh concrete as needed before raising and reinstalling the forms and pouring the next layer. Such a level of hand-finishing work would not be possible in a later era.

Once one level was completed, the blocks of the next level were placed so that the center of each was approximately over the place where four of the blocks beneath joined. This ensured that there would be no "continuous horizontal or vertical joints through the dam. The end result of this plan was a dam with a very large amount of friction between its elements and consequently, great strength," according to *HAER*.

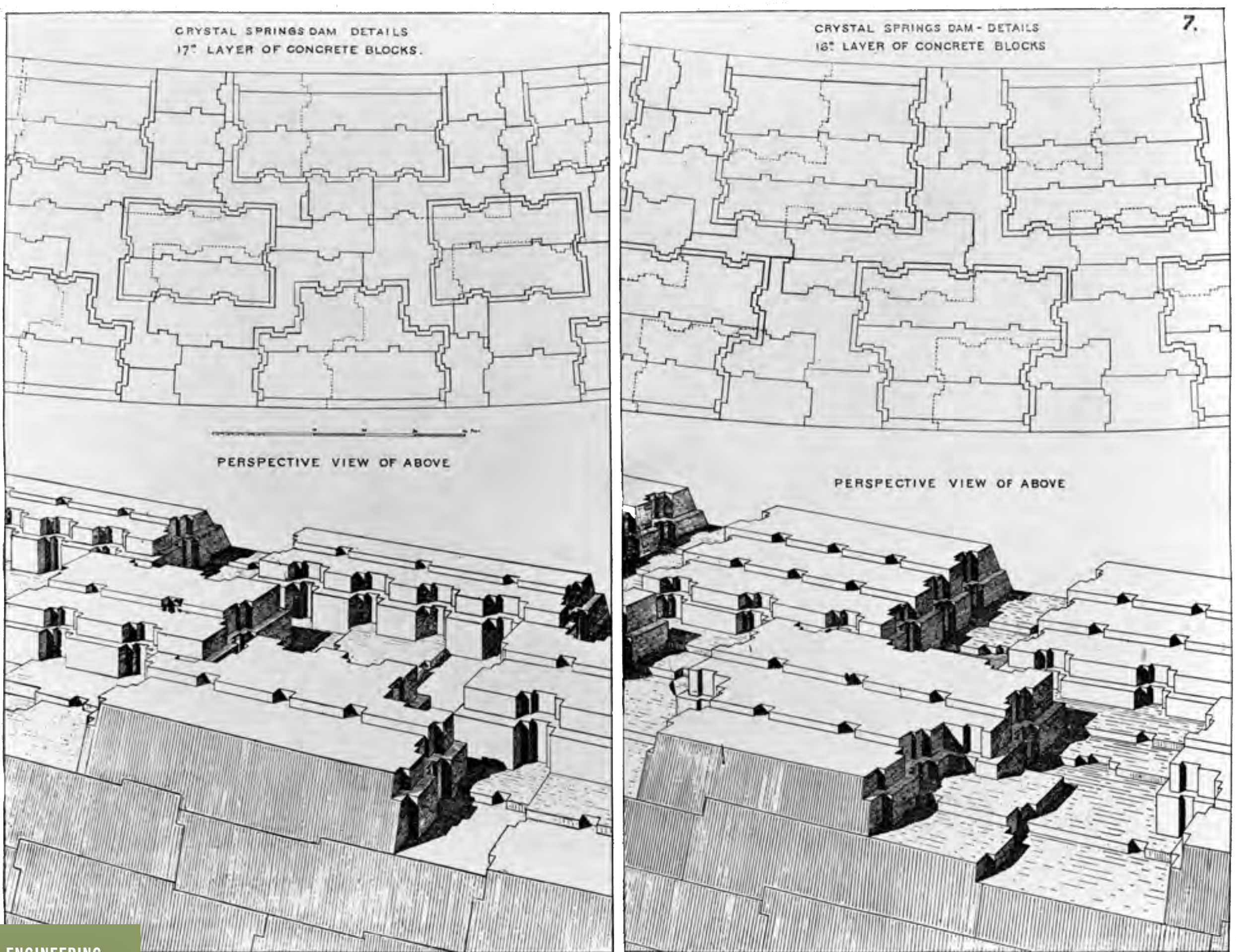
By late 1889, the dam had risen to a height of 120 ft above the stream bed, and Schussler was inclined to consider the dam complete at that point, although he had enlarged the foundation in his original plans so the dam could be raised higher at a future date.

The winter of 1889-90 proved to be an exceptionally wet one, and by January 1890 water was flowing uncontrollably over the top of the dam. To counteract future events like this, the Spring Valley board decided to increase the dam's height to 145 ft, a task completed by November 1890, according to *La Peninsula*.

Upon completion, the curved concrete gravity dam contained approximately 157,000 cu yd of concrete. Its crest length is about 600 ft, and its total capacity is approximately 19 billion gal.

CONCRETE BLOCK ARRANGEMENT

IMAGES COURTESY OF THE SAN FRANCISCO PUBLIC UTILITIES COMMISSION



Civ. Eng., 2024, 94(2): 32-37

SUPPLEMENTARY WORKS

Schussler's project also included construction of outlet works and a pipeline to convey stored water in Crystal Springs Reservoir to San Francisco and neighboring communities. The outlet works, which are still in use today, consist of a tower, main shaft, tunnel, and three feeder delivery tunnels, which were "built through the hill on the north side of the dam. The main outlet tunnel was drilled deep within the hill in order to be able to draw water out of Lower Crystal Springs Reservoir when it is at a low level," according to the *HAER* report. The outlet works were connected to a single, 44 in. diameter, 89,500 ft long, wrought iron gravity flow pipeline that connected to a terminal storage reservoir in the city. The pipeline was constructed at a foundry in San Francisco using the highest-quality sheet iron available.

The pipeline performed well for many years before being replaced.

SEISMIC CONCERNS?

The site chosen by Schussler is approximately 1,100 ft east of the trace of the northern section of the San Andreas Fault, the famous fault zone that on April 18, 1906, generated the great 7.9 moment magnitude earthquake that devastated San Francisco.

Was Schussler aware of the dam's proximity to the fault zone? The first description of the fault was published by University of California, Berkeley geology professor Andrew Lawson in 1895, five years after Schussler's dam was completed. While Schussler had no formal geologic training, he had become thoroughly familiar with the lay of the land in the vicinity of the dam site and may have had some inkling about the restless fault zone nearby, even though its north section had not previously generated a major earthquake since Spanish settlement of California in the 1770s.

Since Schussler's field notes and records relating to the dam were lost when Spring Valley's San Francisco offices were destroyed by the 1906 earthquake and fire, no hard evidence has survived noting if he intentionally included seismic-resilient elements into his design. What is clear, however, is that the dam and the pipeline connected to it survived the massive 1906 earthquake and without any significant damage — tributes to the resilience of his design.

HISTORIC SIGNIFICANCE

Research conducted in support of developing the application to name Crystal Springs Dam an ASCE Historic Civil Engineering Landmark confirmed that it is the oldest mass concrete structure constructed in the 19th century in the U.S., according to the *HAER* report.

However, an interesting question arose during the course of this research: Could Crystal Springs Dam also be the oldest mass concrete dam in the world? Since almost all Portland cement at the time the dam was constructed was manufactured in England, it seems logical that if there is an older mass concrete structure anywhere in the world, this structure would almost certainly have been constructed somewhere within the vast British Empire. In response to an inquiry to the London-based Institution of Civil Engineers, the author learned that it had no record of any large mass concrete structure within the former British Empire predating Crystal Springs.

In 1930, most of the assets of Spring Valley — including Crystal Springs Dam — were purchased by the city of San Francisco and placed under the operation and maintenance of the SFPUC. Today, the dam continues to be a vital component of San Francisco's water system, and it is a continuing reminder of Schussler's brilliance.

Crystal Springs Dam was named an ASCE Historic Civil Engineering Landmark in a ceremony on Dec. 6. **CE**

LAWRENCE M. MAGURA, P.E., F.ASCE, BC.WRE (RET)
society director, region 8

Note: The author wishes to acknowledge the efforts of Mike Housh, San Francisco Public Utilities Commission historian/archivist, who made the archives of the utility available for this article, in particular its extensive collection of glass plate negatives documenting the dam's construction.

Civ. Eng., 2024, 94(2): 32-37

From left to right: Larry Magura (ASCE Region 8 Director) Dr. Feniosky Pena-Mora (ASCE President-Elect), Rami Selim (ASCE SF Section President 2023), Tim Paulson (SFPUC Commission President), Sophie Maxwell (SFPUC Commissioner), Dennis Herrera (SFPUC General Manager), Kate Stacy (SFPUC Commissioner), Nicole Sandkulla (CEO/General Manager, Bay Area Water Supply & Conservation Agency), Andy Mangney (Field Engineering Branch Manager, Department of Water Resources - Division of Safety of Dams).


NATIONAL HISTORIC
CIVIL ENGINEERING LANDMARK
AMERICAN SOCIETY OF CIVIL ENGINEERS
1852
CRYSTAL SPRINGS DAM
IN 1890 THE SPRING VALLEY WATER COMPANY COMPLETED THE CONSTRUCTION OF THE FIRST MASS CONCRETE DAM IN THE UNITED STATES TO SUPPLY WATER TO THE CITY OF SAN FRANCISCO. IT SET MANY STANDARDS FOR SUBSEQUENT CONCRETE DAM DESIGN AND CONSTRUCTION. CHIEF ENGINEER HERMANN SCHÜSSLER PIONEERED INNOVATIONS FOR A NEW TYPE OF DAM CONSTRUCTION USING INTERLOCKING BLOCKS OF SPECIAL HIGH STRENGTH CONCRETE TO ALLOW FOR MOVEMENT OF THE DAM. THESE FEATURES ENABLED THE DAM TO WITHSTAND THE MAJOR 1906 EARTHQUAKE ON THE NEARBY SAN ANDREAS FAULT WITHOUT DAMAGE.
DESIGNATED: AUGUST 2023
COMPLETED: 1890

IS THE FOLLOWING CURRENTLY DESIGTNATED AS A LOCAL OR STATE HISTORIC CIVIL ENGINEERING LANDMARK? Yes – designation received in 1976

NAME OF NOMINATED PROJECT: LOWER CRYSTAL SPRINGS DAM

LOCATED AT: San Mateo, San Mateo County, California

LATITUDE AND LONGITUDE: 37.5285°N 122.3622°W

DMS 37° 31′ 42.6″ N, 122° 21′ 43.92″ W
Decimal 37.5285, -122.3622
Geo URI geo:37.5285,-122.3622
UTM 10S 556354 4153694

ATTACH DETAILED LOCAL AND VICINTY MAPS THAT SHOW ACCESS FROM A MAJOR CITY OR THE INTERSTATE - provided in two styles each

THE PROPOSED LANDMARK'S OWNER: San Francisco Public Utilities Commission (SFPUC)

1. **DATE OF CONSTRUCTION AND OTHER SIGNIFICANT DATES**

   1887 - construction commenced
   1890 – construction completed
   1911 – four-foot parapet wall added (raised the dam crest - spillway elevation remained unchanged)
   2012 – Water System Improvement Program project "Lower Crystal Springs Dam Improvements" (WD-2591) to increase spillway capacity and to pass the current estimated Probable Maximum Flood completed

2. **NAMES OF KEY CIVIL ENGINEER AND OTHER PROFESSIONALS ASSOCIATED WITH PROJECT**
   a. Hermann Schlusser, civil engineer designed and built the dam (need to confirm if he was an ASCE member or not)
   b. 2012 Improvements: Project Engineer (at least listed as such at the time of bid in 2010), Chu S. Liu and the listed Civil Engineer is Stephen S. Lau.

3. **HISTORIC (NATIONAL OR LOCAL) SIGNIFICANCE OF THIS LANDMARK**
   a. "He (Schlusser) designed the first concrete dam in the United States, constructed of ingenious interlocking blocks, so that there is no continuous vertical or horizontal seam."[1]
   b. "At the time of its construction, no engineer in America had completed any dam over 95 feet; and no concrete dam of this size had ever been attempted. Although several large earthen dams were under construction elsewhere at the time, Lower Crystal Springs had

[1] *AQUA PURA* by San Francisco Water Department, 1992 (page 64)

the distinction of being the first large dam built of concrete as well as one of America's first high dams."[2]

c. Situated approximately 1,100 feet easterly of the San Andreas Fault and withstood 1906 and 1989 earthquakes without damage
d. "Though construction of the Lower Crystal Springs Dam was begun in the late 1880's, records confirm that due to well-planned design and construction methods, even today it is a structurally sound and seismically safe dam."[3]
e. LCSD was the model for constructing Hoover Dam

4. COMPARABLE OR SIMILAR PROJECTS, BOTH IN THIS COUNTRY AND OTHER COUNTRIES (PROVIDE NAME, LOCATION, DATES, SHORT DESCRIPTION OF EACH PROJECT)

ASCE can help source necessary information on these (?)

5. UNIQUE FEATURES OR CHARACTERICS WHICH SET THIS PROPOSED LANDMARK APART FROM OTHER CIVIL ENGINEERING PROJECTS, INCLUDING THOSE IN #4

a. Engineering innovations: gravity-arch design and interlocking structure with poured-in-place concrete blocks.
b. "The (concrete) blocks were set in an alternating pattern and when the first course would dry and shrink, a second course would fill in the adjoining spaces in a checkerboard fashion. Each block had irregular projection on each side, the better "lock" with neighboring pieces. The result of this projectile and block system was that the dam sported no continuous vertical or horizontal seams, but instead held together like an immense jigsaw puzzle."[4]
c. "In building Lower Crystal Springs Dam, Schussler pioneered use of concrete building material and innovative constructions techniques. Schussler's innovative construction methods on Lower Crystal Springs Dam include: washing aggregate; controlled mixing of aggregate, cement and water; machine mixing; defined water and cement ratios; short pour time; roughening existing surfaces; curing by covering and wetting; and controlled joints. Many of these innovations were subsequently adopted as standard construction techniques in later engineering works."[5]
d. "The dam was built in an era of masonry dams. However, suitable rock for masonry blocks was not available in the vicinity, and the dam was therefore constructed of Portland cement concrete. At the time, there was no cement industry in California, and the transcontinental transport system was not adequately developed to handle large

[2] The Top of the Peninsula – A History of Sweeney Ridge and the San Francisco Watershed Lands, San Mateo County, California. By Marianne Babel, 1990 (page 91)
[3] Lower Crystal Springs Dam Fact Sheet by SFPUC
[4] The Top of the Peninsula – A History of Sweeney Ridge and the San Francisco Watershed Lands, San Mateo County, California. By Marianne Babel, 1990 (page 94)
[5] The Top of the Peninsula – A History of Sweeney Ridge and the San Francisco Watershed Lands, San Mateo County, California. By Marianne Babel, 1990 (page 96)

shipments. Therefore, the cement was imported by sea from England, mostly from J.B. White, although four other brands were used in parts of the structure."[6]

6. **CONTRIBUTION WHICH THIS STRUCTURE OR PROJECT MADE TOWARD THE DEVELOPMENT OF (1) THE CIVIL ENGINEERING PROFESSION AND (2) THE NATION OR REGION THEREOF**

The Lower Crystal Springs Dam has made a significant impact on dam engineering and is recognized as a pioneer in concrete dam design and construction control practices. It is recognized as the model for building the Hoover Dam. According to the US Bureau of Reclamation, "Hoover Dam is a testimony to a country's ability to construct monolithic projects in the midst of adverse conditions. Built during the Depression; thousands of men and their families came to Black Canyon to tame the Colorado River. It took less than five years, in a harsh and barren land, to build the largest dam of its time. Now, years later, Hoover Dam still stands as a world-renowned structure. The Dam is a National Historic Landmark and has been rated by the American Society of Civil Engineers as one of America's Seven Modern Civil Engineering Wonders".[7]

7. **A LIST OF PUBLISHED REFERENCES CONCERNING THIS NOMINATION**

1. *A History of the Municipal Water Department & Hetch Hetchy System* – "San Francisco Water and Power" by Warren D. Hanson, 1985.
2. *La PENINSULA* The Journal of the San Mateo County Historical Association. Volume XXVI, No. 2, August 1990
3. *Development of Dam Engineering in the United States* by Kollgaard and Chadwick.
4. *Lower Crystal Springs Dam Improvements Project Project Summary* by San Francisco Public Utilities Commission, Summer 2019.
5. *The Top of the Peninsula. A History of Sweeney Ridge and the San Francisco Watershed Lands, San Mateo County, California* by Marianne Babel, 1990
6. *San Francisco Water*, Published by Spring Valley Water Company, San Francisco, January 1922, Vol. 1, No. 1
7. *CUW 354 Lower Crystal Springs Dam Improvements Project Performance Objective and Design Criteria*. Prepared by SFPUC Engineering Management Bureau and URS Corporation, July 15, 2008 (Revision 1)

8. **A LIST OF ADDITIONAL DOCUMENTATION IN SUPPORT OF THIS NOMINATION (PLEASE LIST ALL SUPPORT DOCUMENTS…)**
   a. Photos (confirm which ones to be submitted and then list individually)
   b. Plans – "Plans of Some Important Structures, Excluding Distribution Pipe System" by Spring Valley Water Company, December 31, 1913. (need to list specific pages)
   c. TBC

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[6] *Development of Dam Engineering in the United States* by Koogaard Chadwick (Page 51)
[7] Historical Information (usbr.gov)

9. **PLEASE RECOMMEND TEXT TO APPEAR ON THE LANDMARK PLAQUE THAT DESCRIBES THE LANDMARK AND WHY IT IS WORTHY OF RECOGNITION FROM A CIVIL ENGINEERING AND HISTORICAL POINT OF VIEW.**

   ASCE has a template which Elizabeth confirmed they can share with SFPUC.

   **We need to confirm if this will be a national or international recognition received to determine text

10. **A STATEMENT OF THE OWNER'S SUPPORT OF THE NOMINATION AND THE OWNER'S COMMITMENT TO PROVIDE A LOCATION TO MOUNT THE LANDMARK PLAQUE WHERE IT WILL BE PUBLICLY ASSESSIBLE AND HIGHLY VISIBLE TO THE PUBLIC.**

    Elizabeth has provided draft – Angela adding SFPUC content to finalize

San Francisco
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Services of the San Francisco Public Utilities Commission

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Sent via E-mail to Larry Magura at maguralm@comcast.net

October 19, 2022

Mr. Larry Magura, PE
American Society of Civil Engineers Region 8 Director
ASCE History and Heritage Committee
19700 River Run Drive
Lake Oswego, OR 97034

Subject: Support for Nomination of Lower Crystal Springs Dam to Historic Civil Engineering Landmark Program

Dear Mr. Magura:

The San Francisco Public Utilities Commission (SFPUC) is writing in support of ASCE's History and Heritage Committee's nomination of Lower Crystal Springs Dam to the Historic Civil Engineering Landmark Program.

Lower Crystal Springs Dam is being recognized as a pioneer in dam engineering and modern concrete dam design. Its contribution to construction control practices is still lauded today. Completed in 1890, it is the largest of the few pre-1900 concrete dams still in service today. Innovative technologies at the time, such as proper concrete mix design and placement control, have made this dam fully operational more than 130 years after its construction.

Built by the Spring Valley Water Company and now owned and operated by the SFPUC, Chief Engineer Herman Schussler's work represented a unique and important civil engineering accomplishment of its time. Building the first concrete dam in the United States, Schussler introduced the first system of interlocking concrete blocks which resulted in no continuous horizontal or vertical seams. His groundbreaking ingenuity allowed the dam to withstand both the 1906 and 1989 San Francisco Bay Area earthquakes without any damage to the dam.

Kollgaard and Chadwick described the construction of the Lower Crystal Springs Dam in the *Development of Dam Engineering in the United States* in detail, "The dam was built in an era of masonry dams. However, suitable rock for masonry blocks was not available in the vicinity, and the dam was therefore constructed of Portland cement concrete. At the time, there was no cement industry in California, and the transcontinental transport system was not adequately developed to handle large shipments. Therefore, the cement was imported by sea from England, mostly from J.B. White, although four other brands were used in parts of the structure." The construction of Lower Crystal Springs Dam truly paved the way for a whole new era of dam construction, establishing design and construction best practices, which were later used on projects such as Hoover Dam.

The dam has undergone upgrades throughout the years, including a four-foot parapet wall added to raise the dam crest in 1911, as well as an increase to the spillway capacity to pass the Probable Maximum Flood in 2012. However, the fundamental structure has remained sound, seismically safe, and continues to be a key component of the SFPUC's Regional Water System.

Should Lower Crystal Springs Dam be successful in securing the ASCE Historical Landmark recognition, we understand that it will in no way impact future updates or improvements to the dam or surrounding site. With this caveat, the SFPUC supports this nomination and confirms a location will be provided to mount the landmark plaque where it will be accessible and visible to the public.

Please direct any questions of our nomination to Mr. Steven Ritchie, Assistant General Manager for Water, at (415) 934-5736 or SRitchie@sfwater.org.

Sincerely,

Dennis J. Herrera
General Manager

Crystal Springs Dam References

Crystal Springs Dam Recognized as National Historic Civil Engineering Landmark
San Francisco Water-Power-Sewer

Ingenious design helps California's Crystal Springs Dam stand strong
By Lawrence M. Magura, P.E., F.ASCE, BC.WRE (Ret)

Crystal Springs Dam recognized as National Historic Civil Engineering Landmark
American Society of Civil Engineers

Crystal Springs Dam
Wikipedia

Crystal Springs Reservoir
Wikipedia

FEATURED

From the Daily Journal archives

San Mateo County's Crystal Springs Dam receives National Historic Engineering Landmark status

Sierra Lopez Daily Journal staff Dec 7, 2023 Updated Dec 7, 2023 0

Representatives from the San Francisco Public Utilities Commission and the American Society of Civil Engineers pose on the Crystal Springs Dam and Bridges as the dam was honored as a National Historic Civil Engineering Landmark Wednesday, Dec. 6.

Sierra Lopez/Daily Journal

Two major earthquakes and 130 years later, the Crystal Springs Dam has finally been honored with a National Historic Civil Engineering Landmark designation, recognizing the nation's largest concrete structure of its era for its innovative construction.

"Civil engineers are not always in the spotlight but the Crystal Springs Dam is an exception. The dam has not only influenced dam construction over the past 100 years but also shaped the future of civil engineering. This landmark stands as a testament of human innovation that will be recognized for generations to come," Feniosky Peña-Mora, American Society of Civil Engineers president elect, said during the ceremony.

Lower Crystal Springs Dam was completed in 1890, making the structure the first mass concrete dam of its kind in the nation and possibly the world. The dam was built by about 1,000 workers over a period of five years under the supervision of Chief Engineer Hermann Schussler using interlocking blocks of concrete. Each block was poured and cured before the neighboring block was poured, and the joints sealed with cement.

Its design and innovative construction techniques revolutionized dam building and would go on to become standard practices, influencing the development of other notable concrete dams including the Hoover Dam in Nevada and the Grand Coulee Dam in Washington state.

The dam, initially constructed by the Spring Valley Water Company and now owned and operated by the San Francisco Public Utilities Commission, has also survived two significant earthquakes — one in 1906 and the Loma Prieta Earthquake of 1989 — a significant feat given that it sits just 1,000 feet from the San Andreas Fault.

These collections of facts are key reasons for why the American Society of Civil Engineers has decided to honor the Lower Crystal Springs Dam as a National Historic Engineering Landmark. The dam joins the Golden Gate Bridge, the San Francisco-Oakland Bay Bridge, and the Alvord Lake Bridge as one of only four projects to receive the honor in Northern California, and is one of 14 projects in the state. A ceremony presenting the honor was held on the dam between rain showers Wednesday, Dec. 6.

“This dam is more than just a structure. It symbolizes the growth and resilience of our community over 100 years,” Rami Selim, president of the ASCE San Francisco chapter, said. “Together we pledge to preserve this piece of our history for future generations.”

Tim Paulson, president of the San Francisco Public Utilities Commission, noted the significant role Crystal Springs Dam has played in the region. It helped create the Crystal Springs Reservoir, which provides drinking water to about a million people in northern San Mateo and San Francisco counties and has the capacity to hold up to 22.5 billion gallons of water when full.

The dam has undergone improvements over the years. Its parapet was placed in 1891 and the dam was raised another 25 feet in 1911. The bridge atop the dam has been replaced multiple times, most recently in 2018, opening to the public in 2019.

"We invest in our infrastructure. We maintain our infrastructure. We're not going to be like Flint, Michigan. We're going to maintain our valuable resources and what is needed for our residents of our areas to have the water they need," Paulson said. "This dam continues to be a masterpiece of civil engineering we have to have."

Surrounding the dam and reservoir is thousands of acres of open space managed in partnership between SFPUC and the San Mateo County Parks Department including the Sawyer Camp Trail north of the lower dam and the Crystal Springs Regional Trail just south. County Parks Director Nicholas Calderon lauded SFPUC as an upstanding partner during the event, sharing that the department feels fortunate to have recreational facilities that highlight the historic landmark.

"The Crystal Springs Dam and Bridge are beloved landmarks offering scenic routes for recreational activities and critical connections for motorists, pedestrians and bicyclists," Calderon said in a press release. "We here in San Mateo County have always known it is special and we're thrilled it now gets national recognition too."

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