HOOVER DAM

FIFTY YEARS

On September 30, 1935, President Franklin D. Roosevelt dedicated Hoover Dam. In his dedication speech, President Roosevelt referred to the dam as an "engineering victory of the first order—another great achievement of American resourcefulness, skill, and determination . . . "

Hoover Dam was indeed this. And more. For 50 years, this outstanding engineering feat has been providing multipurpose benefits for the entire lower Colorado River Basin, benefits manifested throughout the economy of the United States.

At the time of its construction, Hoover Dam was unprecedented. It would be the highest dam in the world, its reservoir the largest manmade lake. It was being constructed in a desolate region where there were no transportation facilities, no living quarters, no workforce. Its construction was made possible by the cooperation of the seven basin States and the United States Government. It was an undertaking on a grand scale. It was a daring venture.

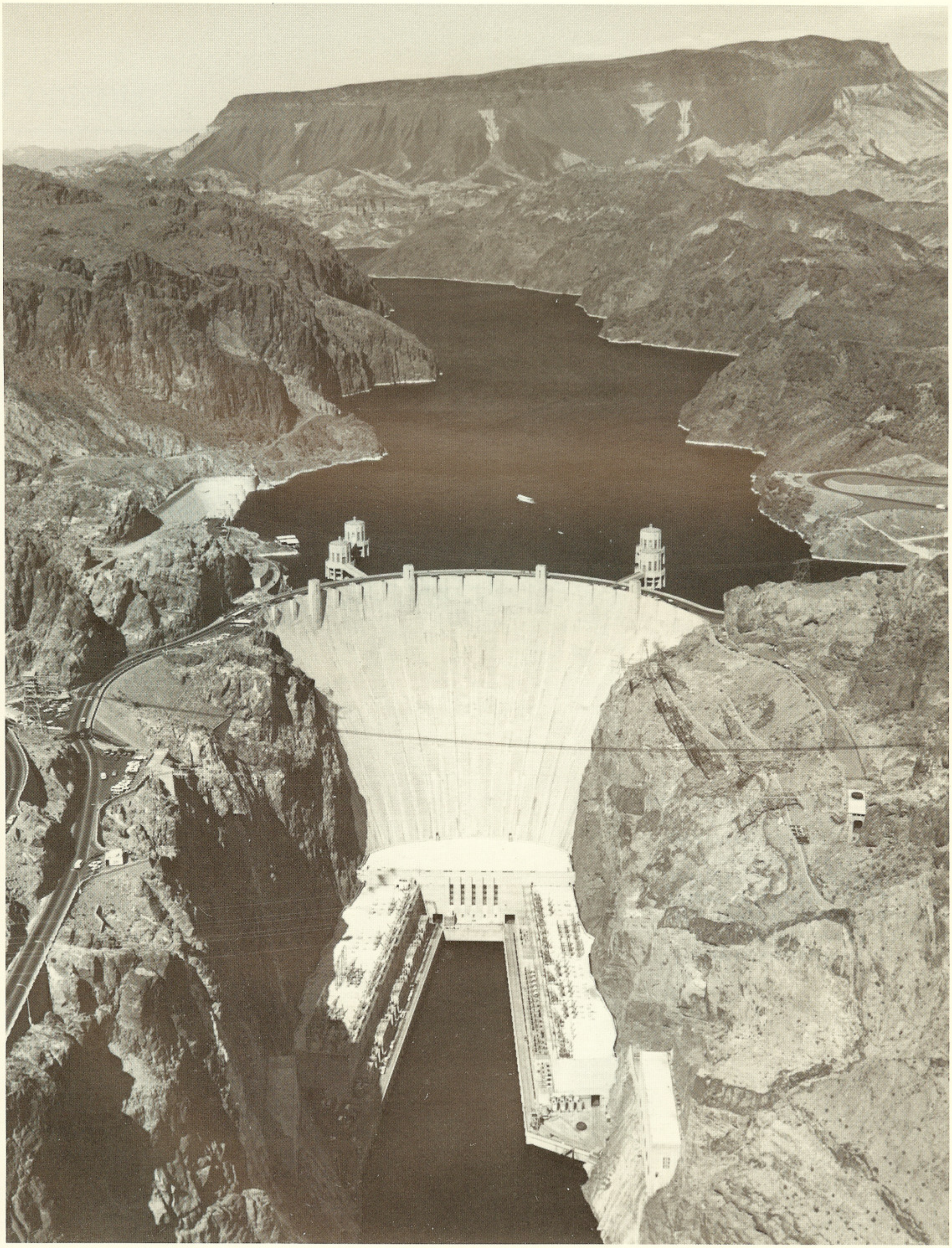
The success of that venture is clearly visible today. Controlling and regulating the previously untamed Colorado River, storing and releasing water for crops, cities, industries, and power production, Hoover Dam has been a major force in the development of the Southwest.

In recognition of Hoover Dam's 50th anniversary, the Bureau of Reclamation has published this special edition of *Hoover Dam*. The booklet tells the story of the dam—its concept, its construction, its benefits.

UNITED STATES DEPARTMENT OF THE INTERIOR

Bureau of Reclamation

Hoover Dam, one of the world's outstanding engineering achievements, was selected by the American Society of Civil Engineers in 1955 as one of America's seven modern civil engineering wonders. Majestic in its clean graceful lines, the dam stands with one shoulder against the Nevada wall and the other against the Arizona wall of Black Canyon, harnessing the Colorado River.



Foreword

Rolling swiftly on its tortuous course through the hot, arid southwestern United States, battering its way through deep canyons, the Colorado was once considered America's most dangerous river.

Man's desperate need for water in the arid Southwest caused him early to turn speculative eyes on the Colorado, but whenever he attempted to control it, he brought disaster upon himself.

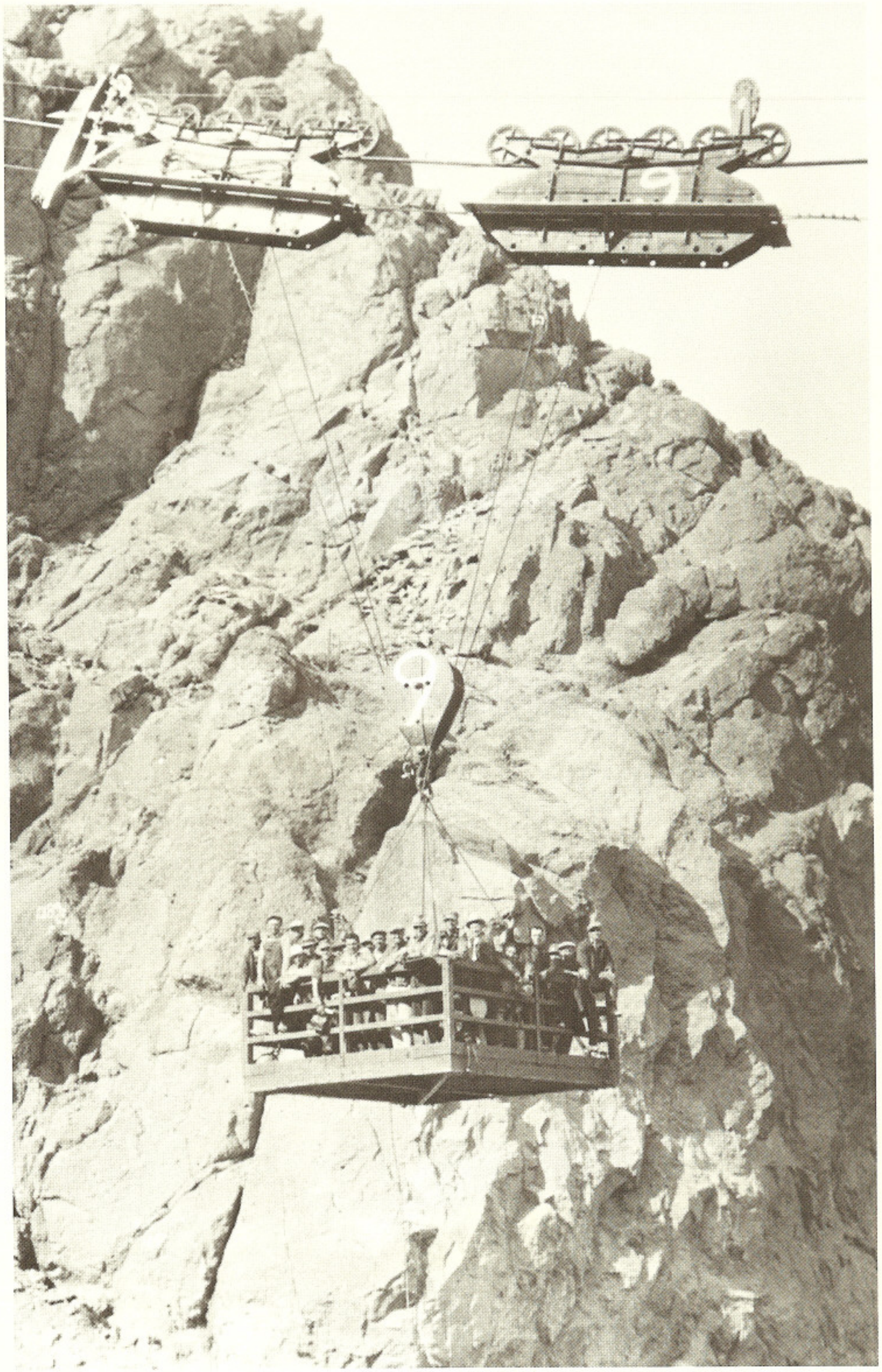
Farmers blessed with fertile desert soil tapped the Colorado to irrigate their lands and create rich gardens. But each year the river's destructive spring floods destroyed their crops, and each year its flow dwindled away in summer's heat until all living things were faced with water shortages.

A great cry finally arose for control and conservation of the waters of the Colorado, the most valuable natural resource of this desert empire.

The cry was answered. Bureau of Reclamation engineers successfully mastered the Colorado by designing and constructing one of the most significant engineering achievements of all time—Hoover Dam.

The dramatic story of the dam's construction and the benefits it has brought are of world-wide interest. This is that story.

(This booklet does not present minute details of engineering techniques or technical data. Technical information on the dam's design and construction is available in the Boulder Canyon Project reports. Write the Bureau of Reclamation, Engineering and Research Center, P.O. Box 25007, Denver, Colorado 80225, Attn: D-922 for information on these reports.)



Cableway lowered men and equipment into Black Canyon to work on the dam.

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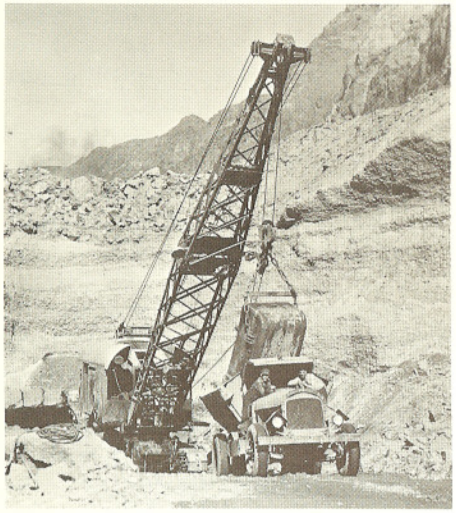
Chronology



Workmen excavated thousands of tons of riverbed material to reach foundation bedrock for the dam and powerplant.

1540 Alarcon discovers the Colorado River and explores its lower reaches. Cardenas discovers the Grand Canyon.

1776 Father Escalante explores the upper Colorado and its tributaries.

1857-58 Lt. J. C. Ives navigates the Colorado River and, with his steamboat *The Explorer*, reaches the lower end of Black Canyon.

1869 Maj. John Wesley Powell makes the first recorded trip through the Grand Canyon.

1902 President Theodore Roosevelt signs the Reclamation Act. Reclamation engineers begin their long series of investigations and reports on control and use of the Colorado River.

1905-07 The Colorado River breaks into Imperial Valley, causing extensive damage and creating the Salton Sea.

1916 Unprecedented flood pours down the Gila River into the Colorado, and flood waters sweep into Yuma Valley.

1918 Arthur P. Davis, Reclamation director and chief engineer, proposes control of the Colorado by a dam of unprecedented height in Boulder Canyon on the Arizona-Nevada border.

1919 All-American Canal Board recommends construction of the All-American Canal. Bill introduced to authorize its construction.

1920 Congress passes Kinkaid Act authorizing Secretary of Interior to investigate problems of Imperial Valley.

1922 Fall-Davis report entitled *Problems of Imperial Valley and Vicinity*, prepared under the Kinkaid Act and submitted to Congress February 28, recommends construction of the All-American Canal and a high dam on the Colorado River at or near Boulder Canyon. Representatives of the seven Colorado River Basin States sign the Colorado River Compact in Santa Fe, New Mexico, November 24. First of the Swing-Johnson bills to authorize a high dam and a canal is introduced in Congress.

1924 Weymouth report expands Fall-Davis report and further recommends Boulder Canyon project construction.

1928 Colorado River Board of California reports favorably on feasibility of project. Boulder Canyon Project Act, introduced by Senator Johnson and Representative Swing, passes the Senate December 14, the House December 18, and is signed by President Calvin Coolidge December 21.

1929 Six of the seven Basin States approve Colorado River Compact. Boulder Canyon Project Act declared effective June 25.

1930 Contracts for the sale of electrical energy to cover dam and powerplant financing are completed.

1932 Bureau of Reclamation opens bids for construction of Hoover Dam and Powerplant March 4, awards contract to Six Companies March 11, and gives contractor notice to proceed April 20.

1932 River is diverted around damsite November 14. Repayment contract for construction of All-American Canal is completed with Imperial Irrigation District.

1933 First concrete is placed for dam June 6.

1934 All-American Canal construction begins in August. Repayment contract between the United States and the Coachella Valley Water District covering cost of Coachella Main Canal executed October 15.

1935 Dam starts impounding water in Lake Mead February 1. Last concrete is placed in dam May 29. President Franklin D. Roosevelt dedicates dam September 30.

1936 First generator, N-2, goes into full operation October 26. Second generator, N-4, begins operations November 14. Third generator, N-1, starts production December 28.

1937 Generators N-3 and A-8 begin operation March 22 and August 16.

1938 Lake Mead storage reaches 24 million-acre feet,[1] and lake extends 110 miles upstream. Generators N-5 and N-6 begin operation June 26 and August 31.

1939 Storage in Lake Mead reaches 25 million acre-feet, more than 8,000 billion gallons. Generators A-7 and A-6 begin operation June 19 and September 12, respectively. With an installed capacity of 704,800 kilowatts, Hoover Powerplant is the largest hydroelectric facility in the world—a distinction it held until surpassed by Grand Coulee Dam in 1949.

1940 Power generation for the year totals 3 billion kilowatt-hours. All-American Canal placed in operation. Metropolitan Water District of Southern California successfully tests its Colorado River Aqueduct.

1941 Lake Mead elevation reaches 1220.45 feet above sea level July 30; lake is 580 feet deep, 120 miles long. Storage reaches 321 million acre-feet. Spillways are tested August 6, the first time they have ever been used. Generator A-1 placed in service October 9. Dam closes to public at 5:30 p.m. December 7, and traffic moves over the dam under convoy for duration of World War II.

1942 Generator A-2 placed in operation July 11.

1943 Generator A-5 begins operating January 13.

1944 Generator N-7 placed in service November 1.

1945 Dam reopens to the public September 2.

1946 Tenth year of commercial power production at dam observed October 23, with Secretary of the Interior, Commissioner of Reclamation, and dignitaries from the seven Basin States participating.

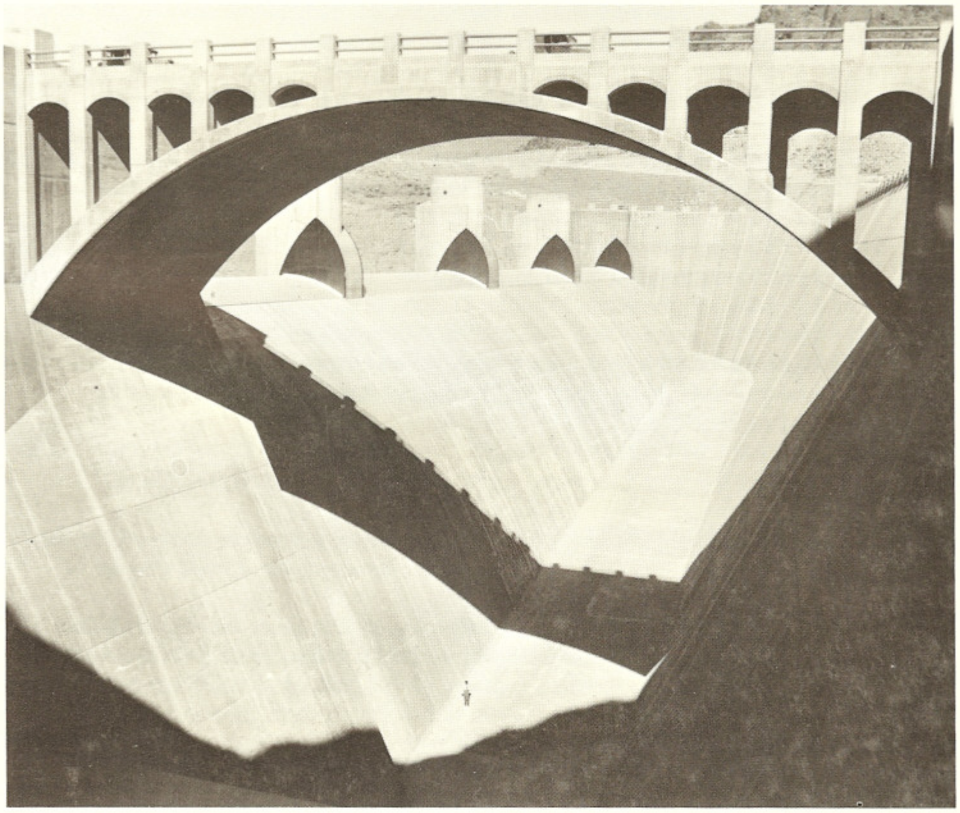
1947 80th Congress passes legislation officially designating the Boulder Canyon Project's key structure "Hoover Dam" in honor of President Herbert Hoover.

1951 More than 2 million persons visit Lake Mead National Recreation Area, setting a new record.

Government housing under construction in Boulder City, 1931

[1]One acre-foot equals 325,851 gallons, or enough water to cover one acre of land to a depth of 1 foot.

Arizona spillway, 1936. Spillways are 650 feet long, 150 feet wide, and 170 feet deep. Note man at bottom of spillway.



1952 Generators A-9, A-4, and A-3 placed in service April 1, May 1, and September 19. Federal and State officials and other dignitaries gather at dam April 29 to dedicate the State of Arizona's two generators, A-3 and A-4, and celebrate Reclamation's 50th Anniversary.

1953 Maximum generation of 6,397 million kilowatt-hours in operating year 1952-53 is new record. A record of 448,081 people visit the dam and powerplant during the year.

1955 Hoover Dam selected by the American Society of Civil Engineers as one of seven modern civil engineering wonders of the United States.

1958 The 7 millionth visitor takes the guided tour through the dam and powerplant August 7.

1959 Visitors number 472,639 for this year, the highest number recorded since visitor services began in 1937.

1960 Hoover Dam celebrates its 25th anniversary May 29.

1961 The power installation at Hoover Dam is complete when the final generating unit, N-8, goes "on-line" December 1. The installed generating capacity of Hoover Powerplant, including station service units, reaches 1,334,800 kilowatts.

1962 Visitors for the year exceed 500,000 for the first time.

1963 The dam closes to visitors November 25, a day of mourning for President John F. Kennedy.

1964 August 10, the 10 millionth visitor tours the dam.

1966 July 5, the 11 millionth visitor takes the guided tour.

1967 The number of yearly visitors exceeds 600,000 for the first time. The boat boundary below Hoover Dam is moved upstream to open an additional half-mile of prime trout-fishing water to the public.

1968 The 12 millionth visitor takes the guided tour of the dam and powerplant February 11.

1969 The dam closes to visitors March 31, a day of mourning for former President Dwight D. Eisenhower. The 13 millionth visitor tours the dam August 7.

1970 Units N-1, N-2, N-3, and N-4 receive stainless steel turbine runners to replace original cast steel runners.

1972 The 15 millionth visitor tours the dam and powerplant October 20. Additional visitor facilities in the Nevada powerplant wing are completed.

1973 More than 638,000 visitors tour the dam and powerplant.

1974 The 16 millionth visitor is recorded July 12.

1976 Ultrasonic flow measuring systems installed in all four penstocks for measuring water use. October 26 ceremonies mark 40 years of power generation at Hoover Dam. The 17 millionth visitor is recorded January 26 and 726,000 visitors are recorded for the year, marking the first time the visitor total surpassed 700,000 in one year.

1977 Parker-Davis Project and Boulder Canyon Project, less power marketing and transmission functions, are combined into one operational unit called the Lower Colorado Dams Project Office. The 18 millionth visitor is recorded July 12.

1978 New track cables are installed on the 150-ton cableway. The 19 millionth visitor takes the tour November 2.

1979 Agency name changes from Bureau of Reclamation to Water and Power Resources Service.

1980 20 millionth visitor is recorded May 30.

1981 21 millionth visitor is recorded October 29. Agency name changes back to Bureau of Reclamation.

1982 Generator A-5 uprated from 82,500 kilowatts to 127,000 kilowatts by General Electric Corporation; Generator N-7 uprated from 85,000 to 127,000 kilowatts by the National Electric Coil Division of McGraw-Edison Corporation.

1983 22 millionth visitor recorded June 2. Unpredictable record-high runoff sweeps the Colorado River. Lake Mead storage reaches and flows over the top of raised spillway gates in the late evening of July 2, the first spill since 1941, when releases were made to test the dam spillways. Reservoir system crests at 1225.83 feet July 24 (4.43 feet above raised spillway gates). Lake level recedes to 1221.4 and spill ceases September 6.

1984 The 23 millionth visitor tours the dam and powerplant on November 1.

1985 Hoover Dam celebrates 50th anniversary.

The River

The southwestern United States is a picturesque land of high mountains, deep canyons, and scorching deserts. Of Joshua trees and giant cacti, bighorn sheep and wild burros, rattlesnakes and Gila monsters. The Colorado River is its lifeline.

The river rises in the snowcapped mountains of northcentral Colorado and zigzags southwest for more than 1,400 miles before reaching Mexico's Gulf of California.

It drains 242,000 square miles in the United States, or one-twelfth of the country's continental land area, and 2,000 square miles in Mexico. Parts of seven large Western States drain into this immense system.

The mighty Colorado once slashed through all in its path, gouging the rock of the mesas into gorges and chasms. One of the gorges, the Grand Canyon, is world-famous—a titanic cleft 277 miles long, 600 feet to 18 miles wide, and a mile deep.

Below the canyons, the Colorado flows through wide, sloping desert plains bordered by low mountain ranges—the hottest, driest region in the United States. Temperatures run as high as 125° Fahrenheit. The sun shines almost every day of the year and, except for devastating thunderstorms now and then, there is very little rain. Bone-dry and shimmering in the heat, this is an American Sahara.

The Exploring Spaniards Come

Venturing north from Mexico into what is now southern Arizona, Spanish conquistadors and missionaries were the first white men to penetrate this arid land. They found the desert wastes peopled to some extent with Indians—Pimas, Maricopas, Papagos, Yumas, and Cocopahs.

The Spaniards also discovered traces of earlier inhabitants who had, apparently, developed cultures of a fairly high order. Imposing ruins of communal architecture—multifamily dwellings sometimes three or four stories high—testified to the achievements of a bygone age.

How the Indians and their predecessors wrung a living from the desert was explained by the canals and ditches the Spainards saw carrying precious river water to fields of maize, beans, calabashes, squash, and melons. The art of irrigation, probably introduced into the area around the beginning of the Christian era, has been underwriting human existence and promoting a succession of cultures in the lower Colorado River Basin for nearly 2,000 years.

In 1539, the Spanish explorer Francisco de Ulloa sailed into the Gulf of California. From the rolling, murky waters at the head of the gulf, he assumed there was a large stream somewhere in the immediate area. Although he did not see the river, he drew a map showing its supposed location.

The following year, Hernando de Alarcon was sent to the gulf with instructions to sail up the coastline until he made contact with Francisco Vasquez de Coronado and his overland expedition, just then starting north from Mexico to search for the fabled seven cities of Cibola. Alarcon could not carry out his assignment—the geography of the area was not what those early adventurers expected—but he did discover the Colorado River. He followed the river upstream, making his way to a point just above the junction of the Colorado and Gila Rivers, a few miles north of present-day Yuma, Arizona.

It was also in 1540 that Lopez de Cardenas, one of Coronado's lieutenants, led a dozen men across the Hopi Indian country in northern Arizona, and suddenly found himself on the rim of the Grand Canyon. But he did not linger long beside the mighty chasm he had discovered. Food and other staples were in short supply and difficult to obtain. The nature of the terrain made even a rough reconnaissance of the canyon impossible. After several unsuccessful attempts to descend the sheer rock walls, Cardenas and his men turned back eastward.

Cardenas was not the last to be stopped by the canyon. Later explorers and missionaries were consistently halted by its awesome depth. It was not until the mid-1700's that the canyon was successfully crossed.

On July 29, 1776, a party of 10 led by Father Silvestre Velez de Escalante and Father Atanacio Dominquez left Santa Fe, New Mexico, to find a northern route to Monterey on the Pacific Coast. Crossing the Colorado River just west of what is now Parachute, Colorado, the party made its way westward across the Wasatch Mountains to Utah Lake, near Provo, Utah. There, beset by the rigors of winter, the party abandoned its original plans and decided to return to Santa Fe. They traveled south through Utah, crossed the Virgin River into northwestern Arizona and then east. Their food ran out, and they endured incredible hardships. Early in November they reached the Colorado and finally crossed it at Glen Canyon, at a point just northeast of what is now Lees Ferry. The place they forded the river is now known as the "Crossing of the Fathers."

It is not surprising that Colorado River lore, during the two centuries following the advent of the white man, consisted more of legend than fact. The belief that the river was a long, narrow strait separating California from the mainland persisted for many years. Then there were the rumors that the stream ran underground for hundreds of miles. In any case, it was agreed that to travel through the Grand Canyon by boat would be to court certain death.

Lower Colorado River, 1932

A Dangerous Obstacle

Many rivers have served as arteries for exploring the wilderness. But the Colorado blocked rather than helped exploration. Travelers found it a dangerous obstacle and detoured hundreds of miles to avoid its hazards and bypass its canyons. The venturesome few who attempted to trace its course were punished by extraordinary hardship, even death, for their lack of caution.

The river could be crossed at only a few favorable points. When gold was discovered in California in 1848, hordes of adventurers flocked westward. Many followed a southern route that took them across the Colorado near its junction with the Gila River. According to one historian, 10,000 people crossed the river there in 1849-50. But the Grand Canyon area, roughly 500 miles to the north, remained unconquered.

The treaty ending the Mexican War in 1848, and the Gadsden Purchase which was ratified in 1854, added the territories of New Mexico, Arizona, and California to the United States. After these territories were acquired, the unknown stretches of the lower Colorado River needed to be explored.

In 1857 the War Department dispatched Lt. J.C. Ives to proceed up the Colorado by boat as far as possible from the Gulf of California. Ives started his trip early in 1858, and succeeded in bringing his steam boat, *The Explorer*, about 400 miles upstream before wrecking it on a submerged rock at the lower end of Black Canyon. He then proceeded by skiff through the canyon, past the point where Hoover Dam now stands, until he reached Las Vegas Wash, approximately 5 miles upstream.

Viewing the Colorado as a potential avenue of transportation, Ives submitted a report which said:

"I would again state my belief that the Colorado would be found an economical avenue for the transportation of supplies to military outposts in New Mexico and Utah. . . .The first organization of transportation establishments, to connect the upper part of the river with the interior of the Territories mentioned, would be attended with expense and trouble; but I am convinced that it would ultimately be productive of a great saving in both. . . "

However, of the Grand Canyon area, which he also visited, Ives had this to say:

"The region last explored is, of course, altogether valueless. It can be approached only from the south, and after entering it there is nothing to do but to leave. Ours was the first, and will doubtless be the last, party of whites to visit this profitless locality. It seems intended by Nature that the Colorado River, along the greater portion of its lonely and majestic way, shall be forever unvisited and undisturbed."

Twelve years later, Maj. John Wesley Powell successfully led a river expedition through the canyons of the Colorado. Powell's party traveled downstream from the Green River in Wyoming to the mouth of the Virgin River in Nevada. Powell and his companions, covering 1,000 miles of uncharted rapids and treacherous canyons, were the first to gaze from a boat up at the sheer walls of Grand Canyon and live to tell the story.

Even before Lt. Ives and Maj. Powell explored the river, others had seen the possibilities of using its water to irrigate the rich and fertile lands in southern California's Imperial Valley. The idea is reflected in several writings of the 1850's, but it was not until some 40 years later that actual development began.

The privately owned California Development Company began constructing irrigation canals in 1896, and the first Colorado River water reached Imperial Valley fields in 1901. The water flowed through a canal that looped through Mexico for about 60 miles, following the old Alamo River, one of the Colorado's overflow channels, much of the way. But this system could not assure a stable water supply for the valley's irrigated lands.

Flood. . .and Drought

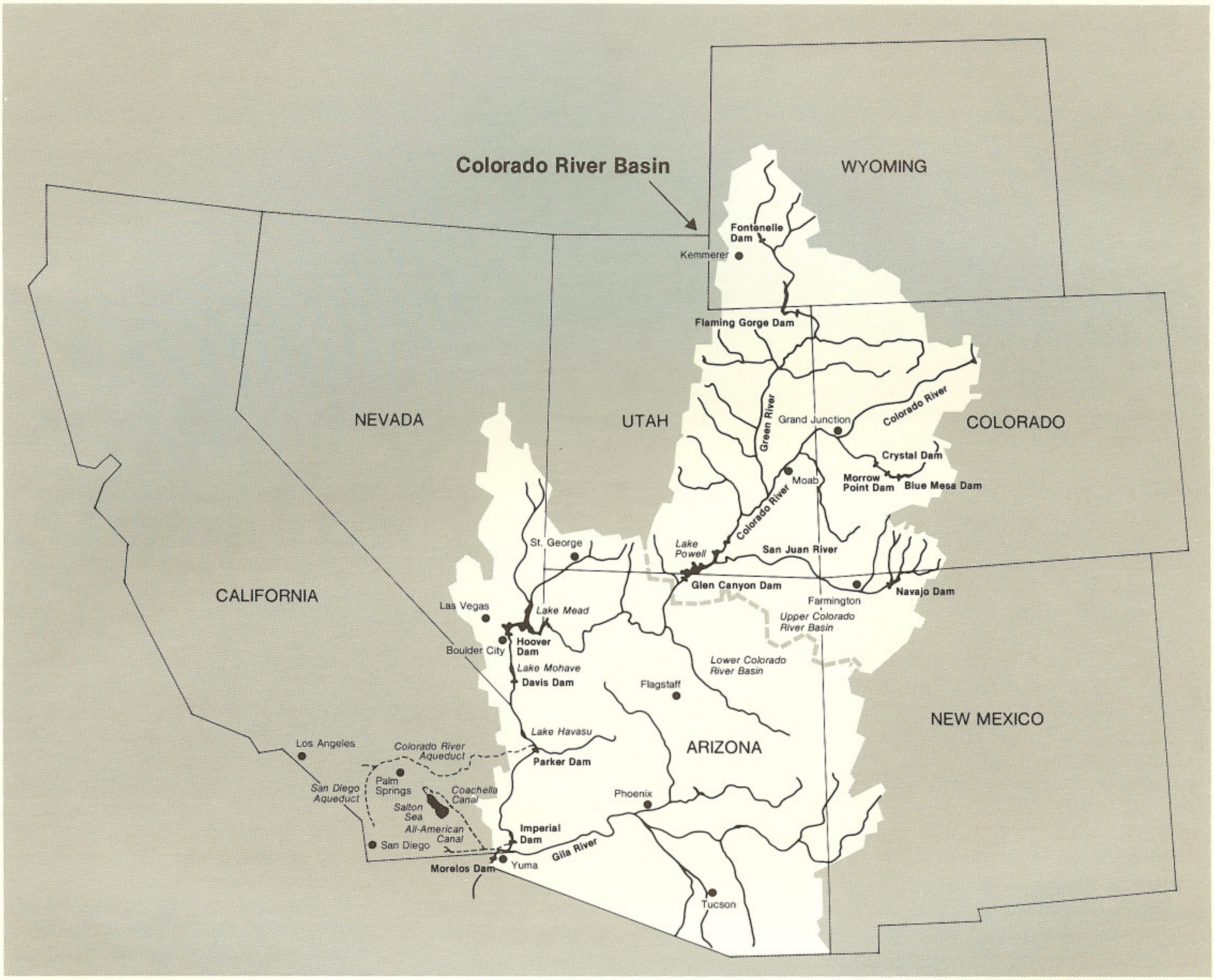
Like other western streams, the Colorado River usually ran high in the late spring and early summer. Fed by rapidly melting snows, the river frequently swelled to a torrent that swept over its banks and inundated land for miles around. Following these high water periods, the flow was often too low for diversion. These irregularities presented many difficulties for irrigators along the lower river in the early 1900's.

When flooding, the river carried immense quantities of sediment, which clogged diversion headworks and irrigation canals, creating serious water delivery and maintenance problems. And, without irrigation water, growing crops rapidly withered and died. The heavy flooding also led to high costs for building headworks and levees to handle the flows—or repair them after the floods subsided.

Low flows also caused difficulties. Special diversion works were needed for these periods, and, because low flows were a recurring problem, the amount of land that could be successfully irrigated was limited. Also, water diverted by users farther up the river caused still worse shortages downstream.

A particularly devastating flood hit the lower river in 1905, when a combination of sediment difficulties, unseasonal flash floods, and regular spring and early summer runoff caused the Colorado to change its course and flow uncontrolled into the Imperial Valley for more than a year.

The Imperial Valley is like a deep saucer. Its lowest point, the Salton Sink, was about 280 feet below sea level in 1900. Its southeastern rim, along which the Colorado River flows for a short distance, was roughly 100 feet above sea level near the United States-Mexico boundary. The descent from the valley's rim to the Salton Sink, once established on a uniform grade, was much steeper than the descent to the Gulf of California, the river's natural outlet.



The Imperial Canal, which originally carried Colorado River water to the Imperial Valley, had its headworks on the California side of the river about 100 yards north of the international boundary. The canal ran south from the headworks, paralleling the Colorado for 4 miles. Then it turned west, away from the river, and followed the Alamo River channel, an old river course that ran to the Salton Sink.

A spring flood in 1904 left the first 4 miles of the canal filled with silt. When the flood receded, not enough water could be diverted through the headworks for irrigation. So a bypass channel was dredged directly from the river to the point where the canal made its westward turn.

No regulating gate was built for the bypass— it was supposed to be closed well before the next regular spring and summer floods. And winter floods had been so rare that there was no particular concern about one occurring. But the winter of 1904-05 proved an exception. By March 1905, three heavy floods had already come down the river. Following the third flood, measures were taken to close the bypass, but it was too late. A fourth and then fifth flash flood came along, destroying the dams intended to plug the bypass channel.

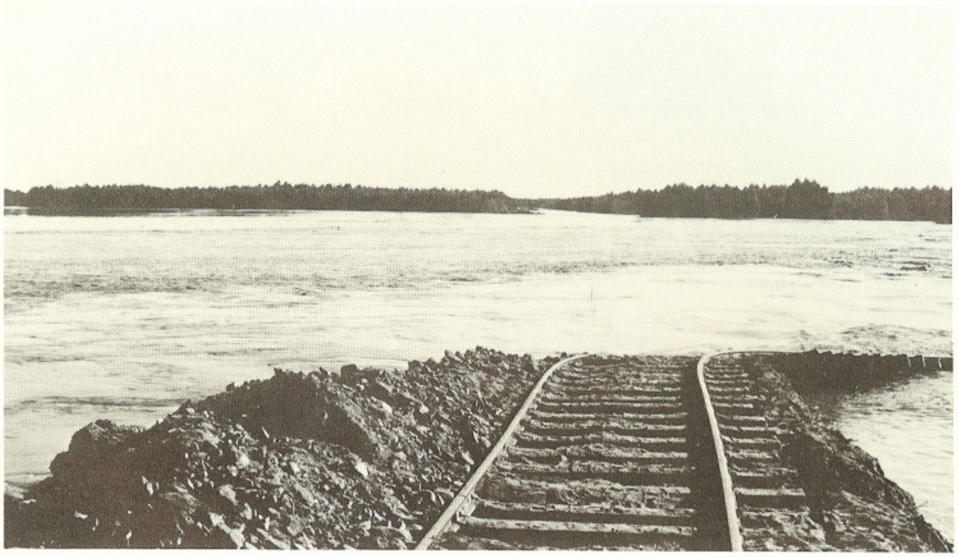
Rock and earth fill barrier was constructed at Imperial Canal inlet after the gates were destroyed in the 1906 flood.

The flow from the river began cutting away the sand and soft alluvial soil in the channel, making it deeper and deeper. Before long, the entire river had changed course, flowing through the bypass channel into the Alamo and New Rivers and on into the Salton Sink. The River was out of control until November 4, 1906, when the bypass channel was finally closed. On December 5 a second flood came down the Gila and into the Colorado. It breached the levees that had been built, and again the river flowed to the Salton Sea via the Imperial Canal. By this time, however, the technique of handling the unruly river was better developed. This break was closed February 10, 1907.

For about 16 months the river had wreaked havoc in the Imperial Valley, threatening lives, ruining farms and agricultural land, destroying highways and homes. The Southern Pacific Railroad, which was forced to move its tracks to higher ground, ultimately threw its resources and engineering skill into the battle. At a cost of nearly $3 million, the Colorado was finally forced back into its own channel.

One good thing did result from the bout with the river—the deeply excavated Alamo and New River channels through which the Colorado had poured its floodwaters provided the start of a good drainage system for the Imperial Valley.

But the fight had only begun. The Colorado's natural regimen had been upset while it was flooding Imperial Valley. When the river overflowed its bank south of the main canal during the 1907 and 1908 summer floods, fingers of erosion began cutting back toward the river from the low area to the west. It was apparent that the river could take a new course if one of these fingers reached the main channel—and that is exactly what happened during the 1909 summer flood. After the flood passed, the entire Colorado River flow went down the Bee River, another of the Colorado's old overflow channels, to Volcano Lake.



Southern Pacific Railroad tracks in the Imperial Valley were washed out during the 1905-06 flood.

From there, it drained off through Hardy's Colorado channel and eventually reached the gulf. This was a stroke of good luck because the Colorado could have flowed from Volcano Lake to New River and on into the Imperial Valley again.

The fight with the river went on. Levees were built and more money was spent. In 1910, a levee at the cost of $1,000,000 was built along the west side of the river to put the Colorado in its old channel and keep it there. That levee failed. Other levees were also built, but the continual deposit of sediment at critical places made higher and higher embankments necessary. The costs of combating sediment and floods soon mounted to over $500,000 a year, yet the threat was not stopped.

For the Imperial Irrigation Project, it was a continuous, harassing fight, come high or low water. Without greater control over the Colorado, the situation would become intolerable.

The Imperial Valley was not the only area along the lower Colorado that suffered from the vagaries of the river and its tributaries. The lowlands of the Yuma Valley, where the growing city of Yuma and the Bureau of Reclamation's Yuma Project were located, also felt the punishing effects of both Colorado and Gila River floods.

In 1893, a levee less than a mile long was built along Yuma's eastern boundary at a cost of $10,000 to protect the town from Gila River rampages. Between 1905 and 1908, the Federal Government built a levee south from Yuma to the Mexican border, and from 1909 to 1912, spent $240,000 for levees to safeguard the Yuma Project. Yet, when 200,000 cubic feet of water per second (1.5 million gallons) came down the Gila in January 1916, the levees were breached, water stood 4 feet deep in the streets of Yuma, and project lands were inundated.

A Bold Decision

Faced with the constant cycles of flood and drought, the people of the Southwest appealed to the Federal Government for help. Reclamation engineers clearly saw the solution to the problem—harness the untamed river and control its flow. This would protect the low-lying valleys against floods and assure a stable year-round water supply. But this would not be an easy task.

Uncontrolled and unregulated, the Colorado had limited value. The yearly flood-drought cycle made large irrigation or power developments uncertain and unprofitable, and the heavy load of silt carried by the river made it unsuitable as a municipal water supply. Also, without regulation, the amount of land under cultivation could not be expanded.

With the river dammed and under control, the danger of recurring floods and droughts would end. And many potential damsites existed along the river.

The Colorado River drainage area is roughly divided into an upper and a lower basin which are about equal in area. This natural geographical division was used to simplify negotiations over the river's water. The "upper basin," it was agreed, should include the drainage area above Lees Ferry, a point one mile downstream from the mouth of the Paria River in northern Arizona. The "lower basin" would include all the drainage area below Lees Ferry.

In their search for a location to build a dam that could protect the lower river from flooding and store enough water to minimize droughts, Reclamation and Geological Survey engineers investigated 70 sites throughout the Colorado River Basin.

Upper basin sites considered the most suitable were: the Flaming Gorge site on the Green River in northern Utah, with 4,000,000 acre-feet in potential reservoir capacity; the Juniper site on the Yampa River in Colorado, with 1,500,000 acre-feet; and the Dewey site on the Colorado in eastern Utah, with 2,370,000 acre-feet.

From the standpoint of major lower river regulation, these sites left much to be desired. First, none of them offered sufficient storage capacity for adequate river regulation. Second, they were all too far from the places where regulation was most needed—hundreds of miles separated them from the irrigable fields of Arizona and California. And third, there were too many tributaries below these sites capable of causing destructive floods.

Two excellent sites were found in the lower basin—Boulder Canyon and Black Canyon. Each site offered potential reservoir capacity of over 30,000,000 acre-feet. However, each site also posed unprecedented engineering problems.

Selecting a Site

Reclamation engineers, primarily concerned with controlling the lower river, concentrated their studies on the lower basin after 1919. Their intensified investigations, including geologic and topographic surveys, revealed that Black Canyon was superior to Boulder Canyon in several respects: the depth to bedrock was less in Black Canyon; the geologic structure was better; and a dam of lesser height would give the same reservoir capacity.

From 1920 to 1923, men lived in Black Canyon, drilling for rock samples. The rock had to provide an unquestionably sound foundation–it was going to support the highest dam the world had ever seen.

The engineering problems that would have to be overcome before this dam could be built were formidable. Even nature seemed to conspire against those pioneers of river control. Summer temperatures of 125° F on the canyon floor, cloudbursts, high winds, and sudden floods battered the surveyors, but the work moved steadily ahead.

While investigations for a suitable damsite were underway, similar investigations were being conducted to find a route in southern California for a canal to carry water from the Colorado River to the Imperial Valley–an "All American" canal.

In 1918, the United States Department of the Interior and the Imperial Irrigation District, successor to the California Development Company, entered into an agreement regarding investigations, surveys, and cost estimates for the construction of such a canal. The surveys were to follow a general plan agreed upon by the All-American Canal Board, which consisted of one representative each from the Federal Government, the Imperial Irrigation District, and the University of California.

The board's report, submitted in 1919, recommended that the Federal Government construct an all-American canal and large storage dams on the Colorado River.

The first bill introduced in Congress for constructing this canal–often spoken of as the first Kettner bill–occurred about the time the All-American Canal Board submitted its report. The bill never came to a vote, however, because Congress was not satisfied with the available data.

The Kinkaid Act, which authorized and directed the Secretary of the Interior to examine and report on the condition and possible irrigation development of Imperial Valley, was passed in May 1920. Approximately half the cost of this examination was to be paid by the United States, the other half by local interests.

In 1921, Arthur P. Davis, Director of Reclamation, reported the results of the Colorado River investigations to Secretary of the Interior Albert B. Fall. In February 1922, the "Fall-Davis Report," recommending that the Federal Government construct an All-American Canal and a high dam at or near Boulder Canyon on the Colorado River, was sent to the United States Senate.

In 1924, Reclamation's chief engineer, F.E. Weymouth, submitted eight volumes of precise data to the Secretary. This "Weymouth Report," which represented 2 additional years of work under the Kinkaid Act, emphasized the feasibility of a dam at Boulder or Black Canyon.

In March 1928, the Senate Committee on Irrigation and Reclamation agreed that "The overwhelming weight of opinion favors the Boulder or Black Canyon site. . .natural conditions at these sites are extremely favorable for the construction of a great dam at a minimum cost." A board of consulting engineers also reviewed the two lower basin sites. This board agreed with the Bureau of Reclamation that Black Canyon was the better choice.

Thus, the site of the projected dam was settled. However, engineering was only one phase of the problem. Another phase–the legislative–also had to be solved.

Rights to Water

The most difficult legislative aspect concerned the equitable division of the Colorado's waters. The people living in the basin depended on this water–wherever they lived; their right to use Colorado River water was far more valuable to them than their title to the land.

Because of the laws governing rights to water, the prospect of a large dam in the lower Colorado River Basin caused an understandable apprehension on the part of Basin States other than California.

The basic doctrine of water law recognized in all the Basin States except California was that of prior appropriation and use. In other words, the person or agency meeting the required preliminary legal formalities and first appropriating water for beneficial use had first right to the water.

California had a dual system of water rights. In addition to appropriation rights, the State also recognized riparian rights–the right of a landowner on the bank of a stream to use the water flowing past his property. Other Basin States had abolished the riparian doctrine.

With construction of a large dam, California would be able to beneficially use a large amount of Colorado River water. The State seemed to have the financial resources and, obviously, the inclination, to proceed with a large irrigation development.

There would not be enough water for all potential developments in the basin, however. Under the appropriation doctrine, what was to prevent California from getting the lion's share of the Colorado's flow by being first with water development?

All the States involved could see, theoretically, the advantage of a great dam in the lower basin. But, in all cases, they were concerned about its effect on their individual fortunes. They were haunted by the vision of their water leaving their border, to be used by a State whose better fortunes enabled it to make first use of the water.

Survey party in 1922 investigating Black Canyon site where Hoover Dam stands today

The ideal solution, it appeared, would be for all the Basin States to agree in advance upon their respective rights. Certainly, without agreement, any large-scale development on the Colorado would be impossible.

In 1920, representatives of the Governors of the Basin States met and endorsed a proposal for an interstate compact. Wyoming appointed a commissioner in 1921, and all the States had appointed commissioners by mid-year. On August 19, 1921, President Warren G. Harding appointed Herbert Hoover, then Secretary of Commerce, as the Commission's Federal representative. On January 26, 1922, the Commission held its first meeting, and elected Hoover its presiding officer.

The Commission members first tried to devise a compact that would divide the water among the individual States but they could not agree on this proposition. Then Hoover made a proposal that cleared the way for agreement. Known as the Hoover Compromise, the proposal was that the water be apportioned to two groups, the Upper and the Lower Basin States, and the division of water between the individual States of each basin would be left for future agreement.

The resulting agreement, the Colorado River Compact, was signed by the Commission members on November 24, 1922, in Santa Fe, New Mexico. For this reason, it is often referred to as the Santa Fe Compact. The compact was approved over a period of years by the Basin State legislatures and the United States.

The Colorado River Compact divided the Colorado River Basin into the Upper and Lower Basins. The division is at Lees Ferry, which is on the mainstem of the Colorado River in northern Arizona, approximately 30 river miles south of the Utah-Arizona boundary.

The term "Upper Basin" means those parts of the States of Arizona, Colorado, New Mexico, Utah, and Wyoming from which waters naturally drain into the Colorado River system above Lees Ferry, and all parts of these States that are not part of the river's drainage system, but which may benefit from waters diverted from the system above Lees Ferry.

The term "Lower Basin" means those parts of the States of Arizona, California, Nevada, New Mexico, and Utah within and from which waters naturally drain into the Colorado River system below Lees Ferry, and all parts of these States that are not part of the river's drainage system, but which may benefit from waters diverted from the system below Lees Ferry.

The Colorado River Compact apportioned from the Colorado River system in perpetuity to the Upper Basin and to the Lower Basin, respectively, the exclusive, beneficial consumptive use of 7,500,000 acre-feet of water per year. In addition, the compact gave the Lower Basin the right to increase its annual beneficial consumptive use of water by 1,000,000 acre-feet.

The Colorado River Compact did not apportion water to any State. This was left to the States in each Basin to resolve among themselves. On October 11, 1948, the Upper Basin States entered into the Upper Colorado River Basin Compact, which states how much of the Upper Basin's 7,500,000 acre-foot annual allotment each State is entitled to use. (see pg. 49 for States and amounts.)

Although the Boulder Canyon Project Act authorized the States of Arizona, California, and Nevada to enter into an agreement apportioning the Lower Basin entitlement, the States could not reach an agreement. In a suit filed before the U.S. Supreme Court in 1952, Arizona asked for a determination of how the river's water should be divided among the three States. During the next 8 years, a Special Master appointed by the Court heard testimony from the States and other interested parties. He presented his recommendations to the Court in 1960. In October Term 1962, the Court ruled that of the first 7,500,000 acre-feet of mainstem water delivered to the Lower Basin, California was entitled to 4,400,000 acre-feet; Arizona 2,800,000 acre-feet; and Nevada 300,000 acre-feet.

Bureau of Reclamation signs the contract with Six Companies, Inc., for the construction of Hoover Dam, powerplant, and appurtenant works. The $48,890,995.50 contract was the largest construction contract let by the United States Government up to that time.

The Boulder Canyon Project Act

On December 21, 1928, the Boulder Canyon Project Act became law. As passed, the Act:

- approved the Colorado River Compact;
- provided that in the event only six States should ratify the compact, it would become effective as a six-State compact; and that California should agree to limit its use of water for the benefit of the other six States;
- authorized construction of a dam at Black Canyon or Boulder Canyon;
- authorized construction of the All-American Canal system connecting the Imperial and Coachella Valleys with the Colorado River; and
- authorized $165 million for construction of the entire project.

Further, the Act stated that the dam authorized for construction would have the following purposes:

- flood control;
- improvement of navigation and regulation of the Colorado River;
- storage and delivery of Colorado River waters for reclamation of public lands and other beneficial uses exclusively within the United States; and

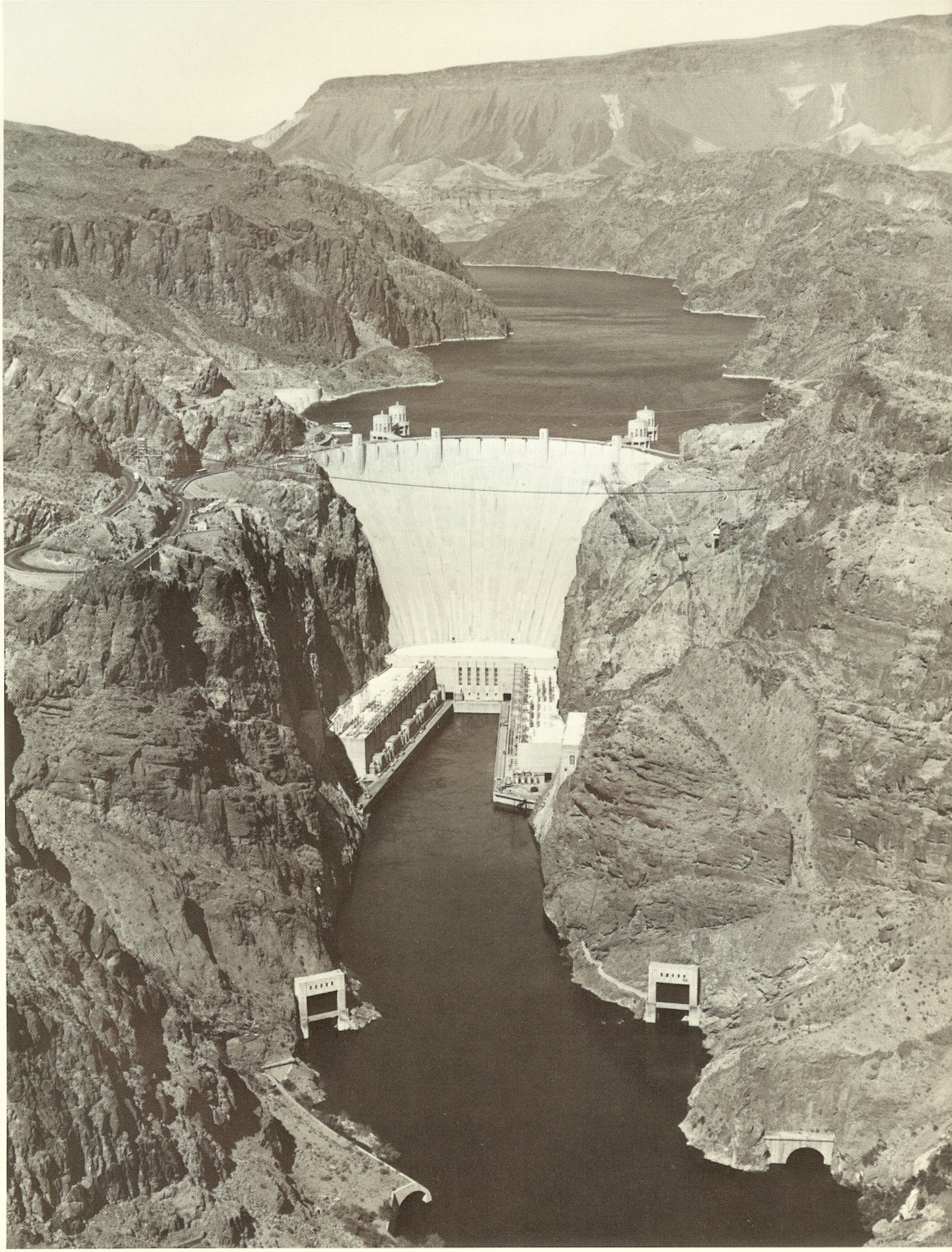
Hoover Dam, completed in 1935, controls and regulates the lower Colorado River.

- hydroelectric power production.

The Act established a special fund – the "Colorado River Dam Fund" – to finance construction of the project and authorized the transfer of $165 million from the United States Treasury to the fund. It also stated that, before the dam could be constructed, the Secretary of the Interior should provide adequate revenues to ensure operation, maintenance, and amortization. These revenues were to repay, within 50 years, all advances for construction of Hoover Dam and Powerplant with interest, except for $25 million allocated to flood control. Repayment of this money, without interest, could be deferred until the interest-bearing portion of the debt was paid, subject to Congressional direction. Revenues were to come mainly from the sale of hydroelectric power generated at the dam. Contracts for selling the energy were speedily negotiated.

The stage for construction was set. Work could begin. The Bureau of Reclamation had a job which would demand all the skill and knowledge it had obtained in its quarter century of experience.

On September 17, 1930, Secretary of the Interior Ray Lyman Wilbur announced that a new dam to be built in Black Canyon would be called Hoover Dam, and Congress affirmed the name to honor the then President of the United States. Later, the names Boulder Canyon Dam and Boulder Dam were used. The name Hoover Dam was restored by Congress in April 1947.



The Dam

The Fundamental Problem

After the Boulder Canyon Project was authorized, the problem of construction was placed squarely before Reclamation engineers. To achieve the purposes set forth in the legislation, the low-lying valleys of Arizona and southern California had to be protected from the yearly threat of flood and the annual spring runoff needed to be stored for later use. The reservoir created by any dam would have to be large enough to store the vast quantities of sediment annually carried downstream by the river. And a powerplant large enough to economically use the full flow of the river, serve power markets in the Southwest, and assure repayment of the project had to be provided.

To effectively harness the river and obtain the desired objectives, a huge dam more than 700 feet high would have to be constructed. The reservoir created by a structure this massive would safely store the normal flow of the river for 2 years. Measured by volume, the reservoir would be the largest artificial lake in the world. When filled to maximum, it would impound more than 31 million acre-feet of water, or enough to cover the State of Pennsylvania one foot deep. And it would be large enough to trap the millions of tons of sediment which the Colorado carried downstream every year without impairing its storage capacity or interfering with its power generating capability. In fact, a reservoir this large would make it possible to construct a powerplant capable of producing over 6 billion kilowatt-hours of energy annually.

As is often the case in undertakings without precedent, there was opposition. Some critics viewed the dam as a potential white elephant. Financially speaking, they believed it would take many years for the power market to absorb the energy produced. Other critics said that the fluctuating reservoir, loading and unloading the earth's crust, would set up destructive earthquakes. There were those who magnified the difficulty of controlling the river during construction until it seemed insurmountable, or predicted that the reservoir would fill with sediment, limiting its useful life. Some said there were so many unknown and unpredictable factors involved in such an undertaking that the project should be abandoned. And in the minds of some was the thought of what would happen if the dam failed after it was built—the whole area below Black Canyon would face utter destruction.

There were serious problems to be solved. What contractor, for instance, would dare undertake such a mammoth job? The proposed damsite was in a desolate region — where there were no transportation facilities or living quarters; where protection from the harsh and unfriendly natural elements did not exist.

All these questions and problems were raised but Reclamation went steadily forward with exploration and preliminary work. Geologic examinations revealed that faults which passed through the block of rock on which the dam was to rest had long since healed—the block was sound. Challenges were there, but none that could not be met. The job could, and did, go on.

Engineering specifications and drawings for the dam and appurtenant structures were being rapidly prepared in the Bureau's main design office in Denver, Colorado. Design and specification work was being pushed forward so construction could start as soon as possible. The year was 1930, and the country was in a depression.

The specifications were completed 6 months ahead of schedule. On March 11, 1931, the Secretary of the Interior awarded the contract for construction of Hoover Dam to the lowest bidder, Six Companies, Inc., of San Francisco, California. Six Companies, known on the job as the "Big Six," was composed of the Utah Construction Co.; the Pacific Bridge Co.; Henry J. Kaiser and W. A. Bechtel Co.; MacDonald & Kahn Co., Ltd.; Morrison-Knudsen Co.; and J.F. Shea Co. All members of the group were major western contracting firms.

The bid was $48,890,995.50, the largest construction contract let by the Federal Government up to that time.

Preliminary Construction Steps

Before construction of Hoover Dam could begin, all essentials for living and working in the desert had to be planned and built. Incomplete planning would mean costly delays in construction. It was the responsibility of Reclamation engineers and the contractors to plan this project so well that nothing would be overlooked.

The problem of living quarters required particular attention. Construction workers, recruited from all parts of the Nation, had to have places to live. They could not be expected to live in the immediate vicinity of the damsite, where summer temperatures as high as 125° F caused heat waves to rise from the canyon as from a blast furnace.

After studying climate and soil conditions in the area, Reclamation engineers selected a location 7 miles southwest of the damsite. There, on a high plateau, a complete town—Boulder City, Nevada—was erected. Homes were built, lawns and parks planted, streets laid out and paved, and schools, churches, and stores erected. A sewer system was installed, and Colorado River water was piped into the town. A modern oasis was created in a desert wilderness.

Construction materials would be required in quantities never before shipped to a single construction job in so short a time—5 million barrels of cement, 18 million pounds of structural steel, 21 million pounds of gates and valves, and 840 miles of pipe were actually hauled by rail to the damsite during the first 4 years of construction.

A never-before-attempted project like construction of Hoover Dam demanded specialized machinery. For example, trucks as small as 16-cubic yards capacity and as large as 50-ton capacity were

Aerial view looking upstream to Hoover Dam with Lake Mead in background needed, as were vehicles capable of transporting 100 to 150 men to the damsite.

The plant that would provide the aggregate for the concrete would be the largest of its type. It would be capable of screening, washing, and preparing more than 16½ tons of aggregate each minute to mix with cement and water.

Finally, recruiting an army of laborers for the job presented special problems in spite of the fact that the Nation was in a depression. It was imperative that men qualified to do the work at hand be selected.

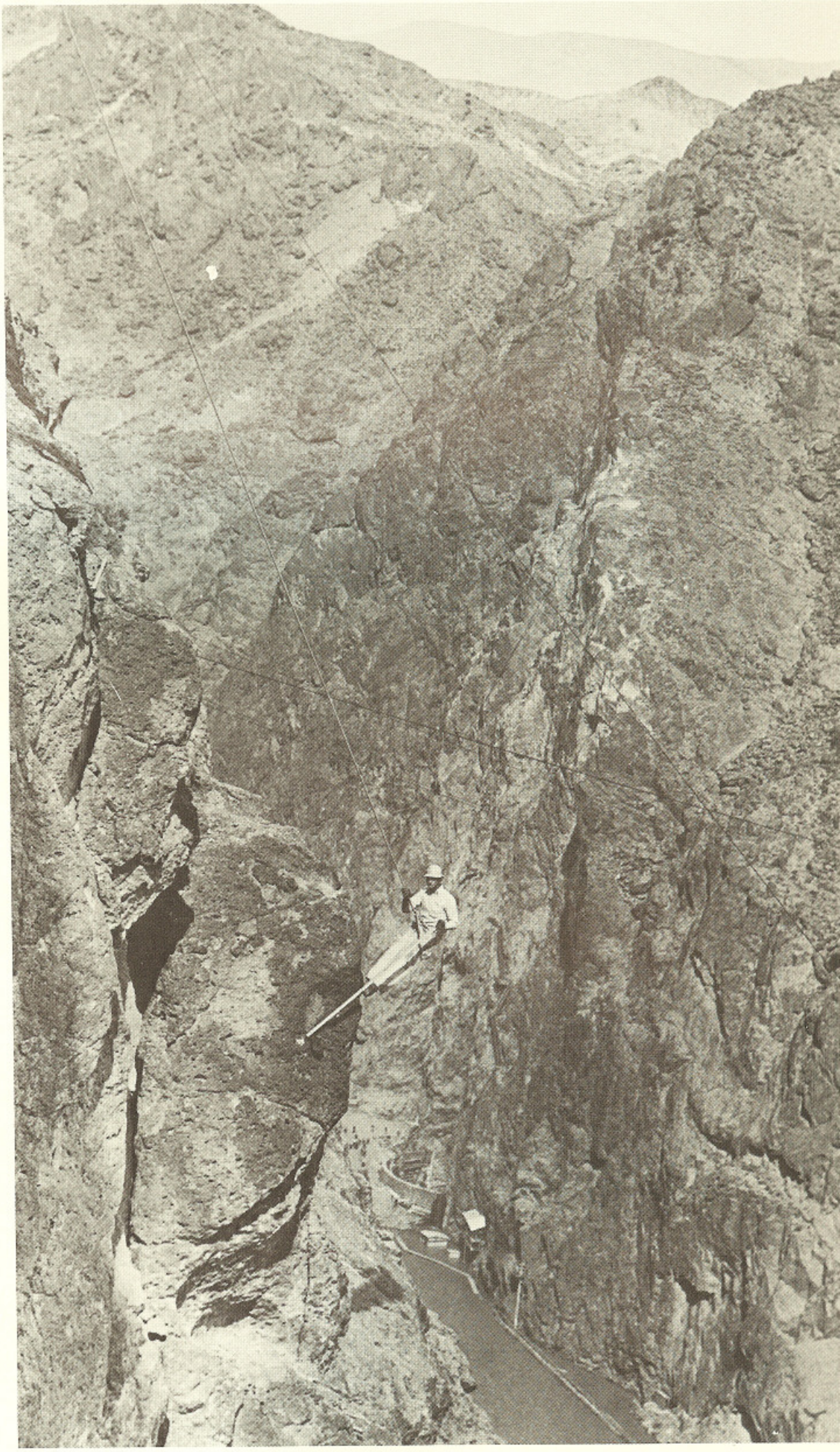
The Federal Government and the contractors together employed 5,218 men at the peak of construction, with a gross monthly payroll of more than $750,000. The workmen ate at a mess hall that could feed 1,300 men at once. Single men were each charged $1.60 a day for meals, rooms, and transportation to and from the damsite. Married men rented unfurnished houses from the contractor for $15 to $50 a month.

Plan of Attack

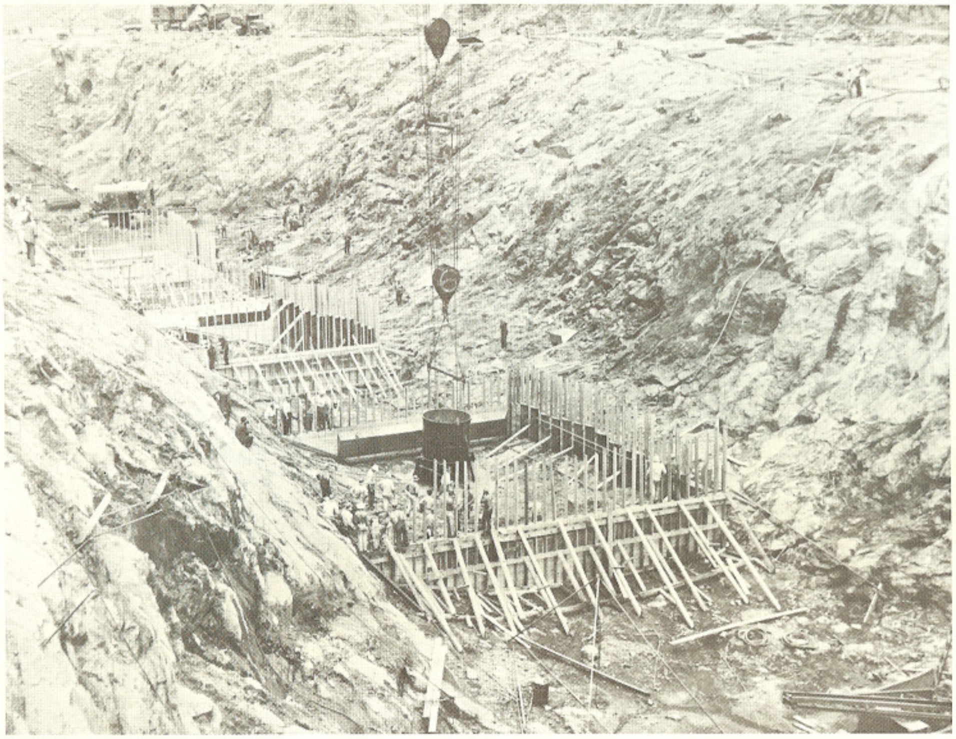
The general plan of attack for building Hoover Dam was to drive tunnels through the canyon walls around the damsite and divert the Colorado through the tunnels. After the river was routed around the damsite, workers could excavate the site and build the dam and powerplant.

The narrowness of the canyon, the spread of activity up and down the river, and the possible large fluctuation of the river's flow made the job of diverting the river a difficult one.

The engineers decided to drive four diversion tunnels, two on each side of the river, around the damsite. The four tunnels would serve other purposes when they were no longer needed as diversion tunnels. The two outer tunnels would become outlets for the huge spillways. Penstocks, or large pipes, would be installed in the inner tunnels to carry water from the intake towers in the reservoir to the powerplant or to the outlet valves below the dam.



Rigger-rodmen working with topography survey party on Nevada side of Black Canyon at Hoover damsite lowered over canyon rim to provide survey control points which were later used in the design and constr of the dam.



First bucket of concrete for Hoover Dam was placed June 6, 1933.

Tunnel excavation began in June 1931 and was completed in November 1933. The tunnels were constructed by traditional drill-and-blast methods. After batteries of compressed-air drills had bitten 10 to 20 feet into solid rock, a ton of dynamite was loaded into the holes. The electrically fired blasts, which broke 1,000 cubic yards of rock and advanced the heading 17 feet on average, shook the canyon walls. The resulting rock and debris were loaded into trucks and dumped into side canyons.

During one 24-hour period, 256 feet of tunnel were driven, and the highest total for a single month was 6,848 feet. It required 3,561,000 pounds of dynamite, or 2.38 pounds per cubic yard, to remove the 1½ million yards of rock from the four tunnels.

Each of the tunnels was holed out to a 56-foot diameter, then lined with concrete 3-feet thick. The combined length of the 4 tunnels is approximately 3 miles.

The River Is Turned

When the two Arizona tunnels were complete, steps were taken to divert the river's flow.

A small earth and rock dam known as a cofferdam was constructed in the river just below the tunnel inlets. Twenty-four hours after the dam was started, it was high enough to block the channel and force the river through the tunnels.

At the same time, another cofferdam was built across the river channel below the damsite but above the tunnel outlets. This prevented the river from backing into the construction area.

On November 14, 1932, the mighty Colorado River had been diverted!

Now, excavation for the dam and powerplant foundation proceeded swiftly. Manning huge power shovels, draglines, and other equipment, men labored 24 hours a day digging through the mud and silt of the river channel before reaching solid bedrock. More than 500,000 cubic yards of muck were removed.

Removal of loose and projecting rock from the canyon walls also continued. To reach the desired spots, "high scalers" either climbed up ropes or were suspended from anchors sunk in the canyon walls. These men swung in safety belts or "bosun" chairs, pendulum fashion, hundreds of feet above the river and gouged at weak spots or drilled blasting holes. Nearly one million cubic yards of rock were dislodged from the walls of the canyon.

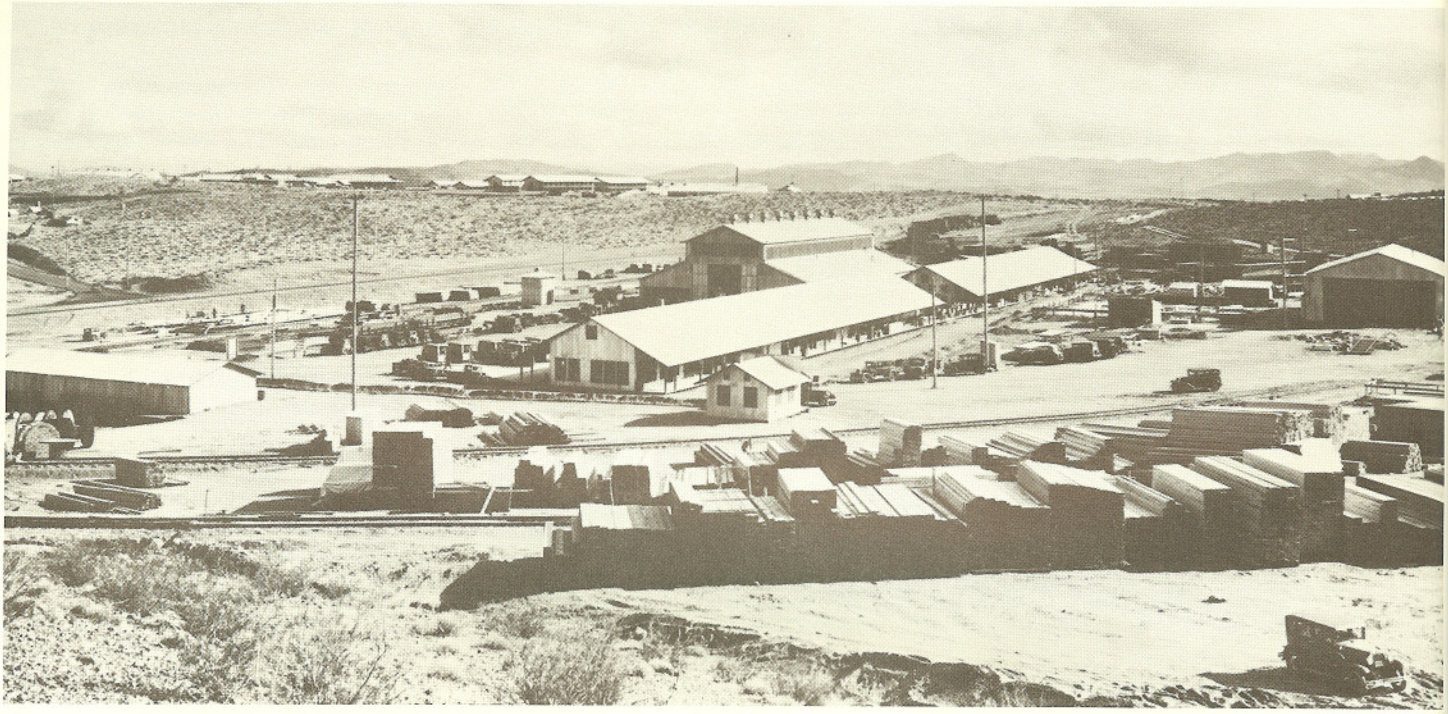
Building the Penstocks

When the time came to install the dam's penstocks, the huge waterpipes that would carry water from the reservoir to the powerplant through the canyon walls, the engineers were faced with a major problem.

The penstocks were to be built of nearly 3-inch-thick plate-steel pipe. Two and three-quarter miles of this pipe, weighing more than 44,000 tons, would be needed. It was obvious that the pipe sections could not be built and shipped from eastern plants—standard railroad cars couldn't handle the weight, and the sections wouldn't fit through a normal railroad tunnel.

To surmount this problem, a plate-steel fabricating plant was built along the construction railroad 1½ miles from the damsite on the Nevada side of the canyon. Flat steel plates were shipped to the plant and made into the required sections.

Special equipment was required for fabricating and transporting the finished pipe sections to the damsite. Planers, rollers, presses, electrical equipment for welding the plates, and x-ray equipment for examining the welds were installed in the plant. A 200-ton trailer, pulled and controlled by two 60-horsepower crawler tractors, transported the heavier pipe sections from the plant to the canyon rim. From here the pipe was lowered to the portal of one of the construction passages by a 150-ton cableway. A specially constructed car received each



Warehouse and machine shop area, February 1932. Boulder City is in background.

section and carried it to the penstock header tunnel, and the pipe was then pulled into position by winches and hoists.

Except for the 8½-foot outlet conduits, which were hot-riveted, and a few miscellaneous sections that were welded, all pipe sections were joined with steel pins, the largest of which were 3 inches in diameter.

While the penstock pipes were being installed, placement of concrete for the dam itself was swiftly being carried out. On June 6, 1933, the first bucket of concrete was placed. Six months later one million yards were in place. Another million were placed in the following half year, and the third million by December 6, 1934, only 18 months after the first bucket was poured.

The River Harnessed At Last

As soon as construction of the dam, intake towers, and outlet works had been sufficiently completed, and the upstream portions of the two inner diversion tunnels were plugged with concrete, a steel gate was lowered at the outer diversion tunnel inlet on the Arizona side of the river. This was on February 1, 1935.

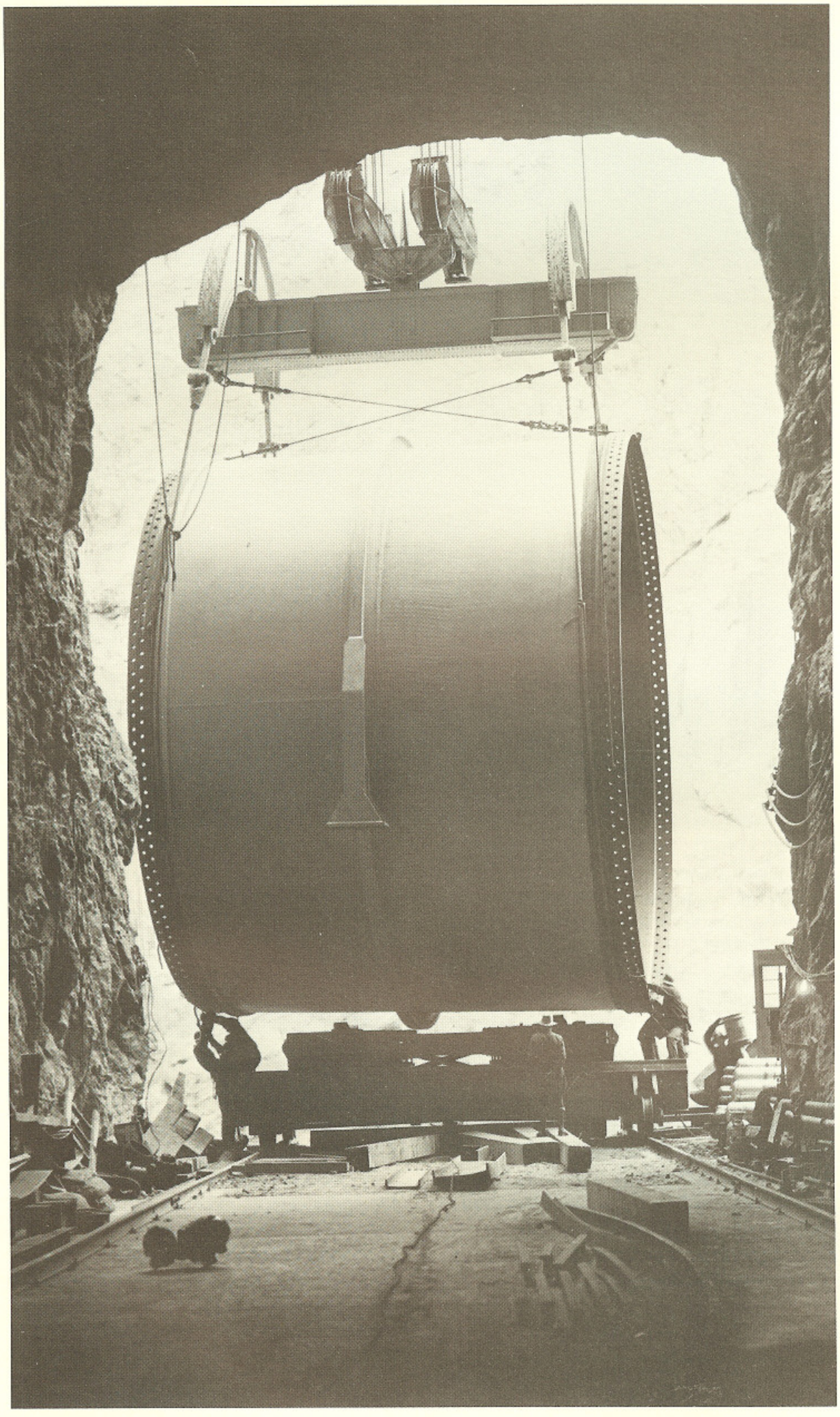
Behind the unfinished dam, water started to rise. By midsummer the new reservoir held more than 3 million acre-feet of water and had a maximum depth of 271 feet. The formerly muddy Colorado, dropping its sediment in the reservoir, was transformed into a lake of clear blue water sparkling in the desert sun.

When the waters of Lake Mead had risen to the base of the intake towers, 260 feet above the riverbed, the one remaining opening, the outer diversion tunnel on the Nevada side, was closed. From that time the Colorado had to respond to rein. For the first time in history, the Colorado River had been harnessed.

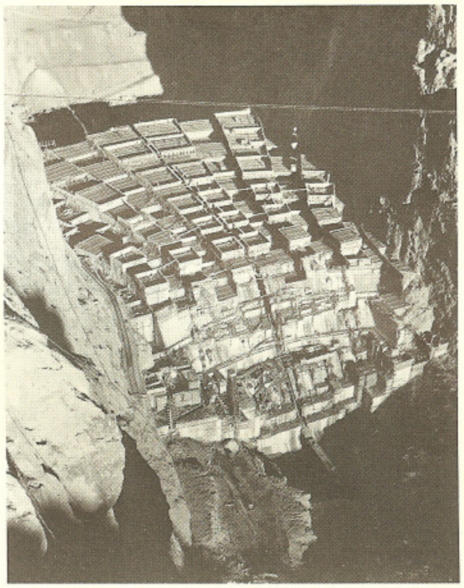
Concrete placement continued, and the crest of the dam was reached March 23, 1935. By the following summer all concrete—3,250,335 cubic yards or 6,600,000 tons—was in place.

In less than 2 years, 5,000 men with new concrete technology had built a structure greater in volume than the largest pyramid in Egypt, a structure which, according to Herodotus, required 100,000 men working 20 years to complete.

The dam towers 726.4 feet above bedrock, a distance equivalent to the height of a 60-story skyscraper. It has a base thickness of 660 feet, or the length of two ordinary residential blocks; is 45 feet thick at the crest; and stretches 1,244 feet or nearly a quarter of a mile between the Nevada and Arizona walls



Penstock pipe sections were lowered into the canyon by a 150-ton capacity cableway, then carried into the tunnels on railroad cars.



The dam as seen from the control tower of the 150-ton cableway on the Nevada rim of Black Canyon, December 1933

of Black Canyon. Nevada Highway 93 crosses the top of the dam.

The Government's contract had given Six Companies, Inc., 7 years to finish the job. Using efficient personnel, the finest of equipment, and detailed planning before the start of construction, the company completed the contract 2 years ahead of schedule.

One of the innovative ideas used during the dam's construction was cooling the concrete. Without artificial cooling, it would have taken more than a century for the dam to lose the heat created by the setting cement, and it would have shrunk and cracked as it cooled. The solution, Reclamation engineers determined, was to build the dam in pier-like blocks and cool the concrete by running ice-cold water through pipes embedded in the blocks. As the blocks contracted and gaps appeared between them, cement grout was pumped into the breaches, making the structure monolithic—of one piece.

Hoover Dam was completed. A permanent asset had been added to the Nation's economy. The years of study, the plans, and the blueprints had materialized into lasting structural achievement. And within a few short years, far more quickly than Reclamation designers expected, Hoover Dam had amply demonstrated its economic and social worth to the Southwest and to the Nation.

Boulder City, Nevada

A major argument against constructing a dam in Black Canyon was that no facilities existed for housing the workers who would build the project. The engineers who conducted the preliminary surveys knew that suitable living quarters would be vital to construction progress.

A camp in the vicinity of the dam was out of the question—the summer heat would have made living conditions unbearable. So the search began for an acceptable townsite.

Several factors figured in the choice of a high plateau about 7 miles southwest of the dam as the townsite. With an elevation of about 2,500 feet above sea level, the plateau is more than 1,800 feet above the Colorado River, more than 1,200 feet higher than the crest of Hoover Dam, and nearly 500 feet higher than nearby Las Vegas. Temperatures recorded during the townsite selection showed that the climate would be more tolerable here than at other locations.

Named Boulder City after the Boulder Canyon Project, the new town was laid out in a triangle, with the apex pointing north. The Bureau of Reclamation's administration building was erected at this apex with the city's principal streets fanning out from it.

The townsite was on Government-owned land, and title to all land was retained by Reclamation. Private citizens granted land leases were permitted to erect buildings. No land taxes were levied, but the lessee was charged a ground rental by the Federal Government.

Boulder City, January 1946

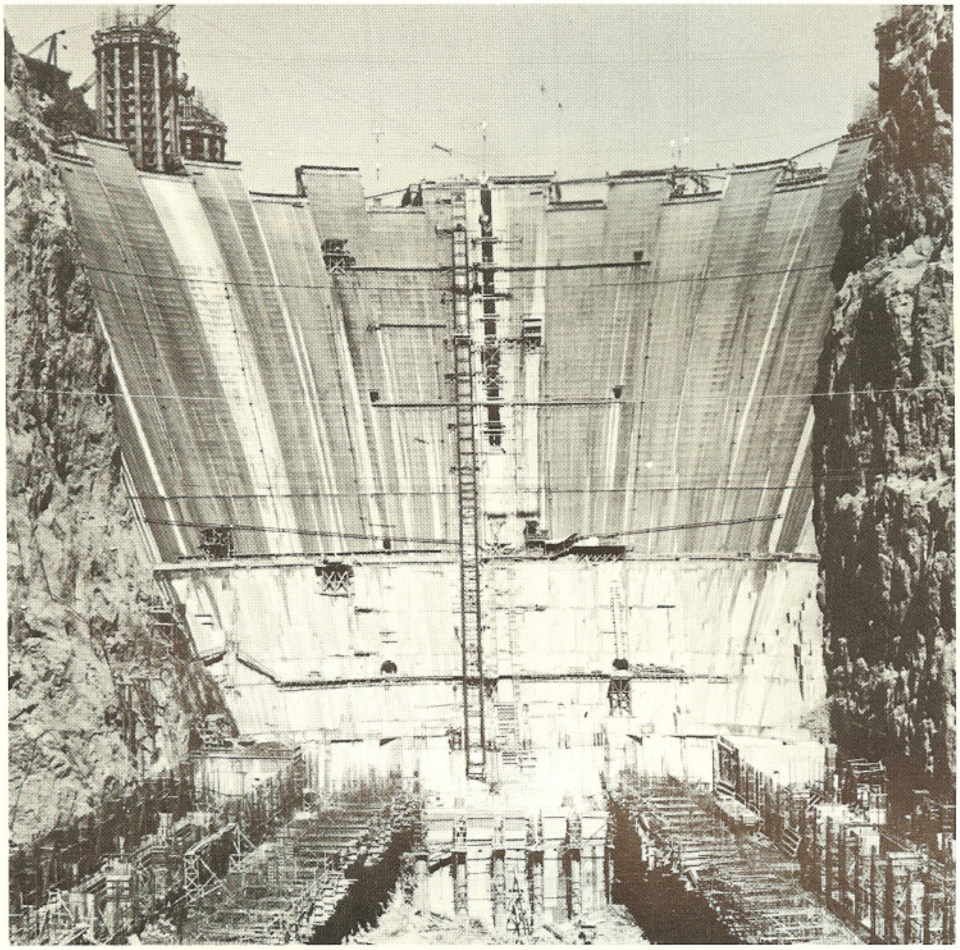
Boulder City began rising from the desert early in 1931. Streets were surveyed and paved, trees and lawns planted, and spacious parks laid out. Reclamation and the contractors building the dam constructed houses and other buildings. Private businesses were licensed and were soon in operation. Sewer, water, and electricity were provided. By mid-1932, more than 2,500 people resided in Boulder City. By 1934, with a population of slightly more than 6,000, Boulder City was Nevada's third largest town.

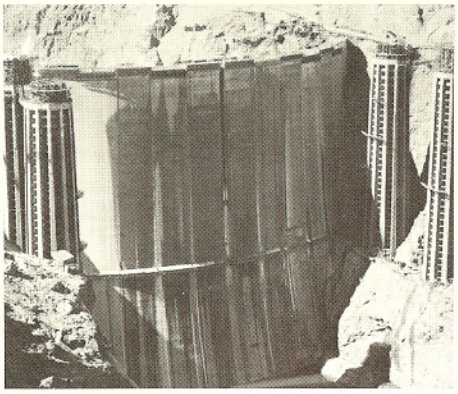
As the dam neared completion the contractors and many of their workers began moving to other jobs. The population gradually declined until, by 1940, fewer than 3,000 people were left. Some believed the decline would continue until the only remaining residents would be those concerned directly with project operation and maintenance.

Then came World War II. Although Hoover Powerplant was the world's largest in 1940, the demand for the power in the industrial areas of the Pacific Southwest was so great that additional generating units were ordered. Workers were needed to install these units and, with other industries moving into the area, Boulder City began to grow once more.

In 1941, the Defense Plant Corporation began constructing a huge magnesium plant halfway between Boulder City and Las Vegas. This new plant brought thousands of workmen and their families into the area, with resultant overcrowding in Las Vegas and Boulder City.

When Boulder City was planned, only the requirements foreseen for the dam's construction were taken into account. Government buildings and some houses had been built as permanent structures, but many of the buildings were designed to serve during the construction period





Upstream face of Hoover Dam and intake towers, February 1935

Downstream face of Hoover Dam in February 1934. Dam was built in blocks varying in size from 60 feet square at the upstream side to 25 feet square on the downstream side. Concrete placement in any one block was limited to no more than 5 feet in 72 hours.

only. And all the original leases negotiated in 1931 were good only until 1941.

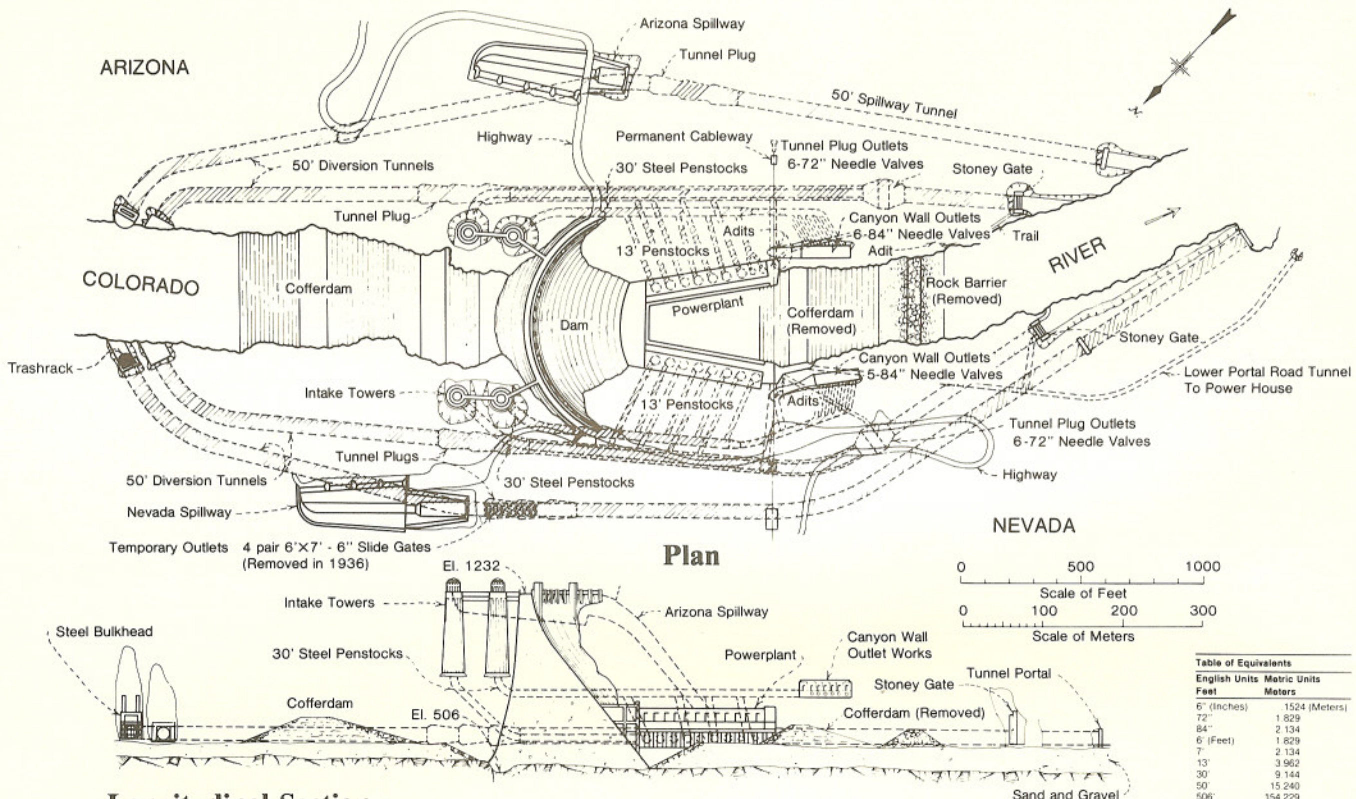
With Boulder City facing a housing shortage in 1941 and with the original leases expiring, there was an urgent need for additional housing and an extension of the leases then in effect. For the most part, all leases were renewed for another 10 years. And as it became apparent that the new structures would be permanent, some 20-year leases were issued.

Boulder City showed steady though not phenomenal growth. The Bureau of Reclamation built 100 temporary houses and 40 semipermanent housing units in 1941-42, and added 16 permanent residences in 1949-50. The Defense Plant Corporation erected 60 houses and 26 apartment units, in addition to the considerable building done by individuals.

Other entities had established locations in Boulder City also, and many of the people who worked for them lived in the town. Included in this list were the City of Los Angeles Department of Water and Power and the Southern California Edison Co., the agencies which operate Hoover Powerplant under contract with the Federal government; the National Park Service, which has jurisdiction over Lake Mead National Recreation Area and has maintained offices in Boulder City since 1936; and the Bureau of Mines, which maintained a Boulder City office from 1938 to 1983. In 1943, the city also became headquarters for Reclamation's Lower Colorado Region.

As time went on, it became clear that Boulder City's development was not temporary. With growth and expansion there came an air of permanence and stability.

After World War II, all municipal facilities were expanded. Today, Boulder City is a thriving community of approximately 11,500 with its own hospital and a 9-hole golf course.



Longitudinal Section
Hoover Dam and Appurtenant Works

Table of Equivalents	
English Units Feet	**Metric Units Meters**
6" (Inches)	.1524 (Meters)
72"	1.829
84"	2.134
6' (Feet)	1.829
7'	2.134
13'	3.962
30'	9.144
50'	15.240
506'	154.229
1232'	375.514
55.000 H.P.	55.765 Metric H.P.
70.000	70.973
115.000	116.598

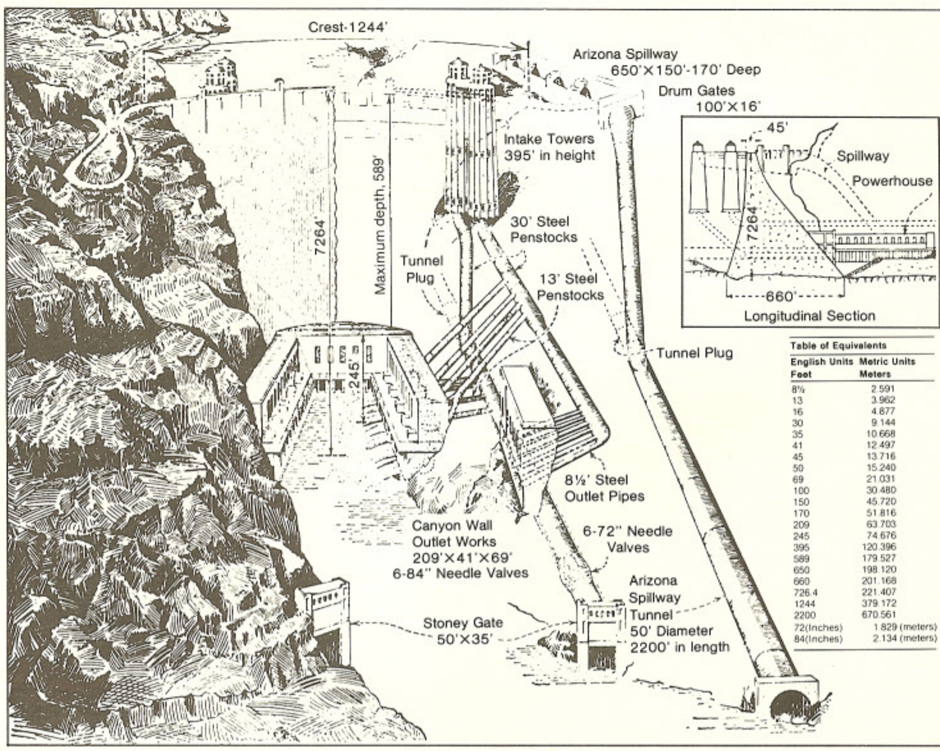
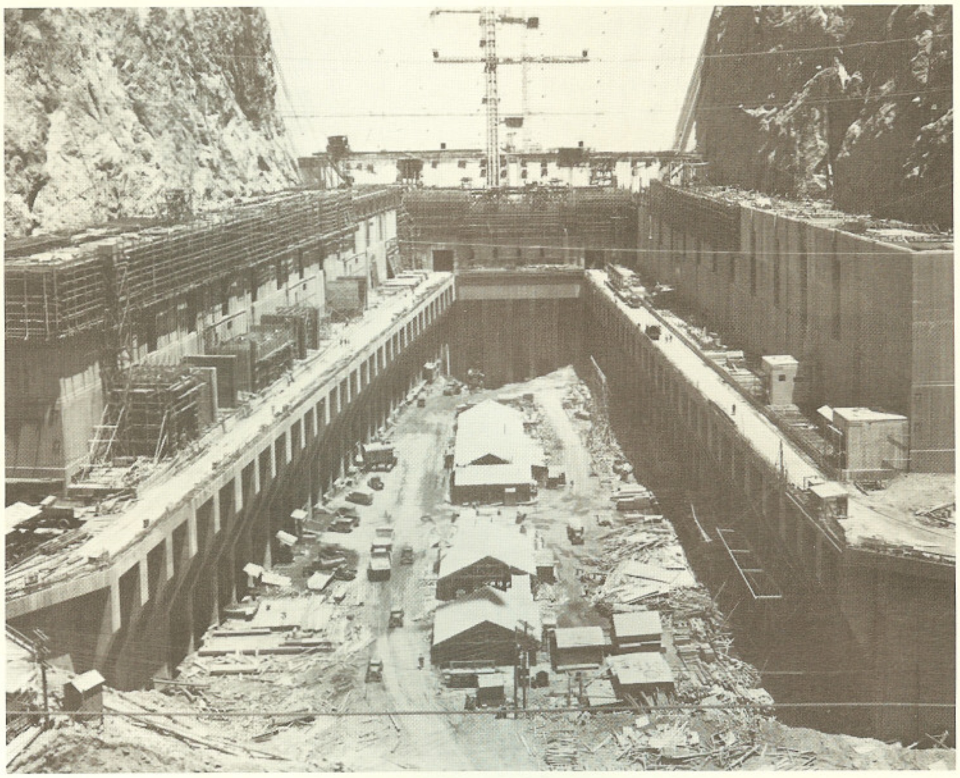
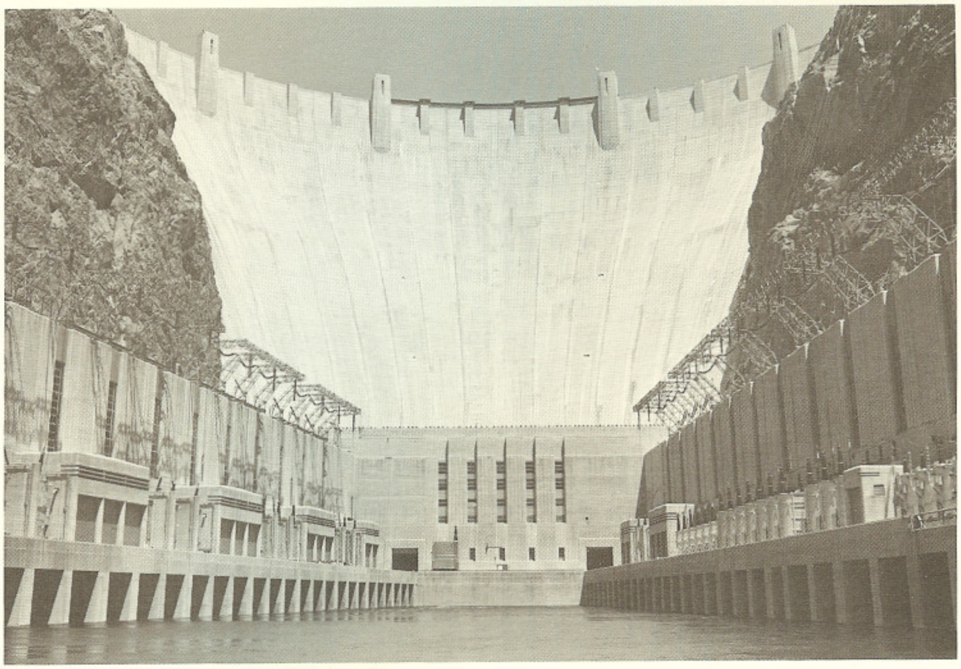


Table of Equivalents	
English Units Feet	**Metric Units Meters**
8½	2.591
13	3.962
16	4.877
30	9.144
35	10.668
41	12.497
45	13.716
50	15.240
69	21.031
100	30.480
150	45.720
170	51.816
209	63.703
245	74.676
395	120.396
589	179.527
650	198.120
660	201.168
726.4	221.407
1244	379.172
2200	670.561
72(Inches)	1.829 (meters)
84(Inches)	2.134 (meters)

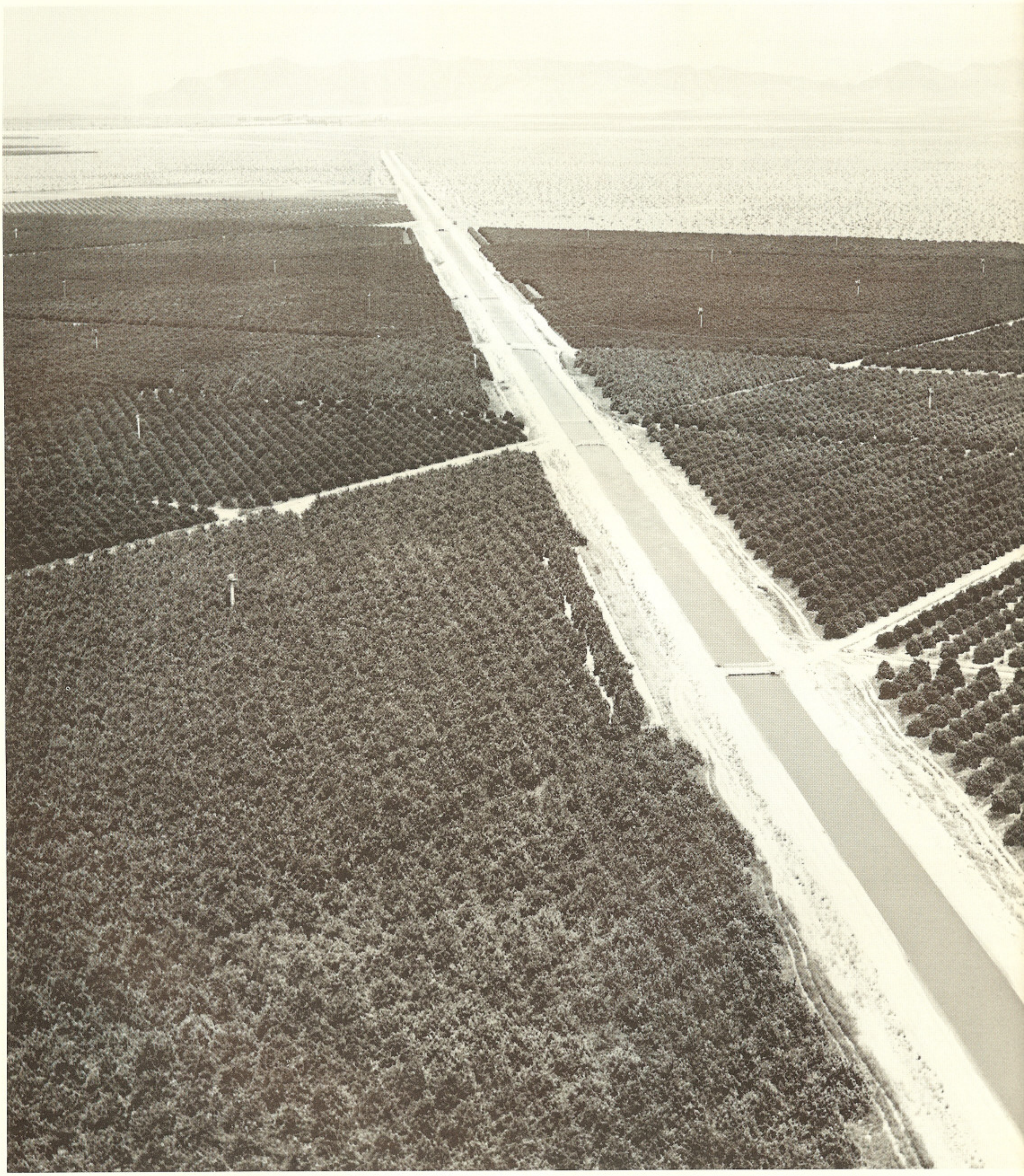
Boulder City was incorporated on January 4, 1960. In 1951, the Secretary of the Interior ordered that the city be separated from the Boulder Canyon Project and incorporated under the laws of Nevada. After several years of study and preparation, Congress approved the Boulder City Act of 1958, giving the Secretary permission to dispose of the city. The community's citizens overwhelmingly approved a charter providing for incorporation, which was effective October, 1959. Approximately 2 months later, after 29 years of Federal control, the Bureau of Reclamation transferred ownership to some 33 square miles; municipal electric, water, and sewer systems; municipal buildings; streets, sidewalks and curbs; parks and parkways, and other equipment and property to Boulder City's government. Reclamation retained only those facilities necessary for operation and maintenance of Hoover Dam and the Lower Colorado Regional offices.



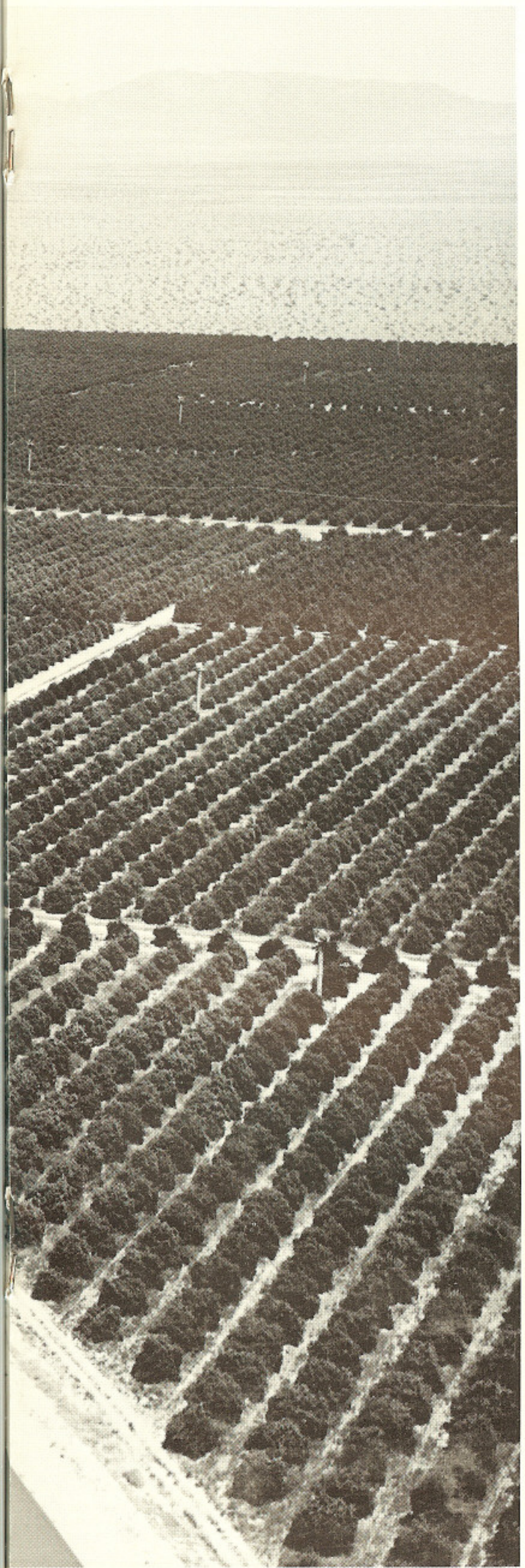
Powerplant construction activity, June 1935



River level view of Hoover Dam. Nevada wing of powerplant is on left, Arizona wing on right. Seven story building at base of dam houses powerplant control rooms and administrative offices.



The Benefits



A Significant Prophecy Realized

On September 30, 1935, less than 5 years after construction started, President Franklin D. Roosevelt said in dedication ceremonies at Hoover Dam:

"This is an engineering victory of the first order—another great achievement of American resourcefulness, skill and determination. This is why I congratulate you who have created Boulder Dam[2] and on behalf of the Nation say to you, 'well done.'"

The huge dam, an outstanding feat of modern engineering technique and construction skill, was complete. It stands today as an enduring monument to man's ingenuity.

Hoover Dam is significant beyond its physicial proportions and the construction skills and techniques it represents. It is also significant because of the benefits it confers on the entire Lower Coloradio River Basin, benefits manifested in every phase of the Nation's economy. It was the prospect of these benefits that provided the driving incentive for those whose concerted action made it possible to construct the project.

When the U.S. Senate Committee on Irrigation and Reclamation endorsed construction of Hoover Dam in March 1928, it made this prophecy:

"A mighty river, now a source of destruction, is to be curbed and put to work in the interests of society."

Fulfillment of this prophecy has brought about several major benefits:
- Flood control—lives and property formerly at the mercy of the unbridled river are less likely to be flooded.
- Water for irrigating up to a million acres of rich land in this country and nearly one-half million in Mexico. More than half of the acreage in the United States was under cultivation when Hoover Dam was built, but crop success or failure was dictated largely by the vagaries of the river.
- Water for domestic, industrial, and municipal use by the people of the Southwest.
- Elimination of the damaging, clogging sediment that formerly cost more than a million dollars yearly to remove from canals and irrigation ditches.
- A national playground and recreation area.
- Fish and wildlife conservation.
- Generation of pollution-free, low-cost hydroelectric power.

Controlling the Floods

Set in the midst of the deep mauve and russet tones of the surrounding mountains and mesas, shining in the bright southwestern sun, a clear blue lake stands behind Hoover Dam. It is called Lake Mead in honor of Dr. Elwood Mead, Bureau of Reclamation commissioner from 1924 to 1936.

Lake Mead, America's largest man-made lake, holds 28,537,000 acre-feet of water when full at elevation 1221.4 feet above sea level. At this elevation, the lake extends 110 miles upstream above the dam, has a maximum depth of 500 feet and a water surface area of 157,900 acres.

With the help of upstream dams and reservoirs, Lake Mead controls not only flash floods that may occur at any time, but also the high runoff that normally occurs each spring and summer.

Lake Mead is operated for flood control purposes under criteria established by the Bureau of Reclamation and the U.S. Army Corps of Engineers. Fulfilling this function, and meeting the seasonal needs of storing or releasing

[2]Renamed Hoover Dam in 1947 by the 80th Congress

Colorado River water has turned desert land near Yuma, Arizona, into productive croplands.

water for irrigation and power production, causes the lake's level to fluctuate annually. From about February to June each year, the lake gradually lowers as water is released to meet downstream commitments. Between June and February, water released from Glen Canyon Dam upstream coupled with lowered downstream demands allows the lake's level to be gradually raised again.

Because of this ability to adjust releases to changing conditions, and because the lower river's channels and levees are maintained, the homes and highly productive farmlands in the low, flat valleys of southern California and southwestern Arizona are less likely to be flooded. However, flood control does not mean flood prevention.

The Flood of 1983

Each winter and spring, forecasts of snowmelt runoff are updated monthly to assist in preparing reservoirs for the forthcoming runoff. In January 1983, the predicted runoff for the Colorado River was 112 percent of normal—not unusually high. The forecast dropped slightly in February. In the spring, forecasts rose, but predictions were still for only a moderately high runoff.

Then a series of unpredicted weather patterns altered forecasts dramatically. Late snows, cooler-than-normal weather in the early spring, an extremely warm weather trend in late spring, and substantial rains, caused a sudden and unforeseen magnitude of runoff. The snowmelt runoff for April through July was about 210 percent of normal. Reservoirs in the Upper Colorado Basin began to fill.

Regulations require that on January 1st each year, at least 5.35 million acre-feet (maf) of flood control space be available in Lake Mead and upstream reservoirs. On that date in 1983, 6.5 maf were available. But record flows soon raced down the river. Bureau of Reclamation engineers increased releases from all Colorado River dams.

Water rushing over the Nevada spillway at peak capacity of 13,944 cubic feet per second and 4-1/2 feet above spillway gates, July 1983

By late June, it was apparent Lake Mead would soon reach the top of the spillway gates, and that the sight of water flowing into the Hoover Dam spillways—not seen since the spillways were tested in 1941—was a certainty.

Finally, in the late hours of the evening of July 2, water began to slide across the top of the spillway gates. Within days, over 4 feet of water poured into the foaming basins and into the spillway tunnels—falling at over 100 miles per hour.

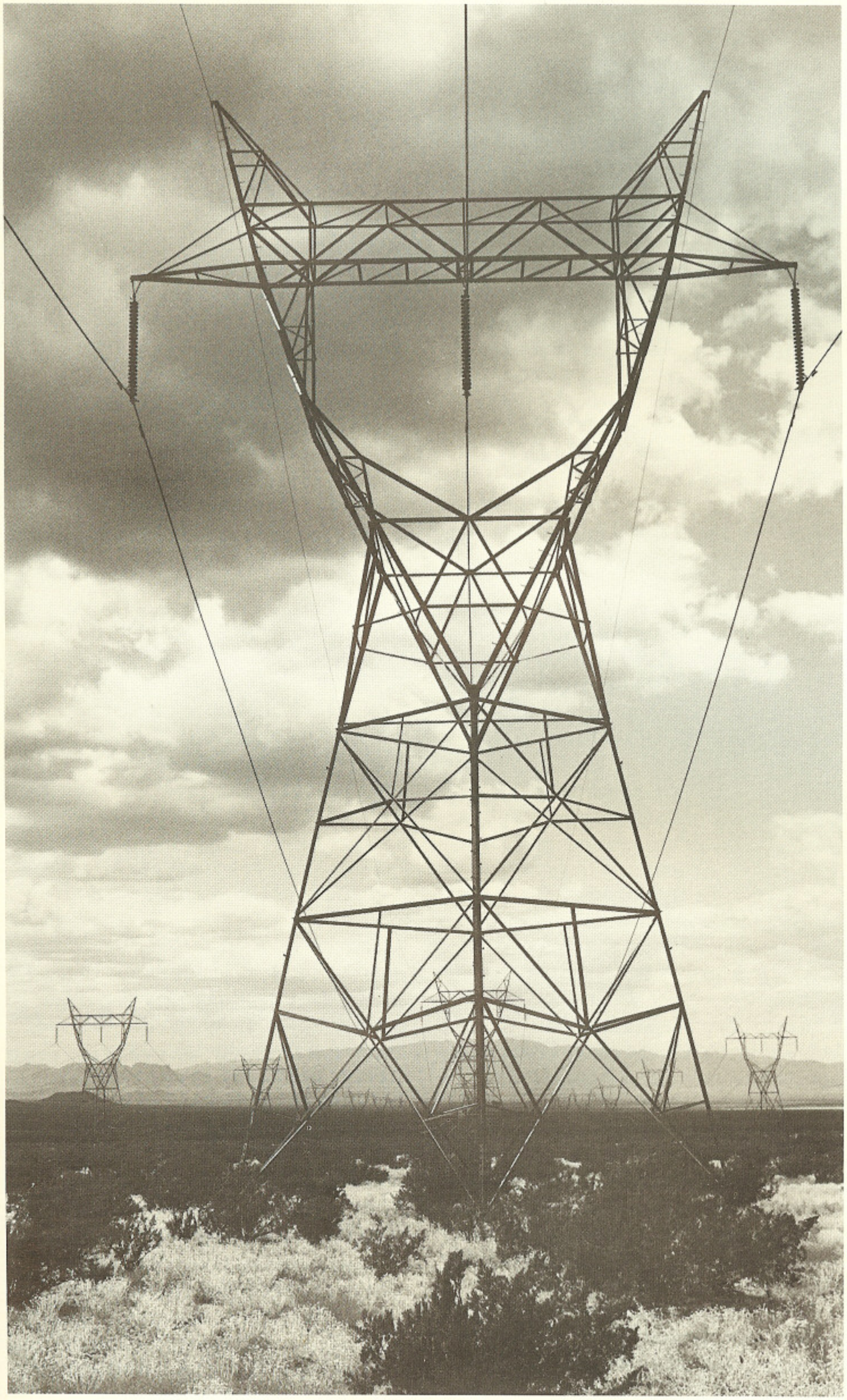
The reservoir system peaked at 1225.83 feet on July 24. On September 6, the lake level receded below 1221.4 feet and the spill ceased on September 6. The peak passed, but higher than normal flows continued through the Colorado River Basin the remainder of the year.

Although the Colorado River reservoir system did function in 1983 as it was designed, flooding caused a great deal of hardship for people located in the floodway and for businesses located near the river or adjacent to Lakes Mead and Powell. At the same time, the 1983 flood illustrated how effective Reclamation's system of dams and reservoirs can be, not only to store precious water in normal times, but to cut peaks from inevitable floods.

No More Drought

Hoover Dam also provides an adequate and reliable water supply for downstream agricultural users.

The irrigated lands of the Southwest provide fresh vegetables and fruits for the entire Nation year-round. An adequate and dependable supply of irrigation water, rich soils, and warm climate in the valleys of the lower Colorado River



Transmission lines carry Hoover Dam power across the Nevada desert to southern California.

Basin combine to produce, even in winter, lettuce, carrots, cauliflower, tomatoes, onions, sweet corn, asparagus, green peas, and other vegetables. Cantaloupes, watermelons, citrus fruits, grapes, dates, and pecans are also produced. Alfalfa hay and seed, cotton, small grains, sorghums, and sugar beets are grown in some sections of the region. A flourishing seed industry exists. Winter pasturing of cattle and sheep, beef cattle fed on locally grown feeds, and poultry and milk production are also part of the Southwest's agriculture.

In southern California's Imperial Valley there are more than 500,000 acres of irrigable land; about 460,000 of these acres have been farmed by irrigation in recent years. In 1934, when the Colorado River flow was only slightly over 4 million acre-feet, a crop value of $10 million was lost, and the existence of entire communities was jeopardized. A decade later, with Hoover Dam regulating the Colorado River and the All-American Canal delivering irrigation water, the area produced crops valued at nearly $70 million. In 1981, crops valued at nearly $377 million were produced in the Imperial Valley.

The Coachella Canal carries water northwestward from the All-American Canal into the rich Coachella Valley in California, where some 75,500 acres may eventually be irrigated by Colorado River water. Before the 123-mile-long Coachella was completed, about 20,000 acres of valley land were irrigated by pumping underground water. This dangerously lowered the water table, threatening the irrigated lands with water shortages. Now, water deliveries assure farmers on these fertile lands of an adequate supply for full crop production. In 1981, crops valued at more than $145 million were produced on 58,203 acres of irrigated farmland in the Coachella Valley. The cumulative value of crops produced in the Imperial and Coachella Valleys from Colorado River water since 1943 totals more than $8 billion.

Imperial and Coachella Valley lands are not the only areas that benefit from control of the Colorado River. The Yuma Project, with 53,415 acres in Arizona and 14,676 acres in California, also receives a stable water supply from the All-American Canal. On the Gila Project southeast of Yuma, approximately 93,000 of the 102,000 irrigable acres are fully developed and receiving a dependable flow of irrigation water as a direct result of the river control afforded by Hoover Dam. The Yuma Auxiliary Project, located on the mesa south of Yuma, receives Colorado River water through facilities of the Gila Project to serve 3,406 acres of highly developed citrus groves. Upstream from Yuma, 92,000 acres of land in the Palo Verde Irrigation District, near Blythe, California, and 75,000 acres on the Colorado River Indian Reservation, at Parker, Arizona, flourish from water provided by Lake Mead.

A Vital Metropolitan Water Supply

The dependable supply of domestic and industrial water furnished to southern California and southern Nevada is also an important benefit.

In semiarid southern California, where the average annual rainfall is about 15 inches, metropolitan Los Angeles recognized many years ago that obtaining domestic water was, and would continue to be, one of its most pressing problems. By 1906, it was apparent that the Los Angeles River was an inadequate supply source, even though the population at that time numbered only 160,000. It was then that the city began to import water.

The city first constructed the Los Angeles Aqueduct, which brings water from the Sierra Nevada mountains 250 miles away. Although this aqueduct could deliver enough water for 2 million people, Los Angeles grew so rapidly that by 1920 it was again faced with impending shortages of domestic water, and another source of water was needed.

The only obvious source was the Colorado River. But the river in its natural state did not offer a reliable supply. To assure water for domestic use, just as for irrigation use, the river had to be controlled and regulated. Hoover Dam could provide the necessary river regulation. So, from the beginning of the project in the early 1920's, southern California was directly interested.

In 1928, 11 southern California cities formed the Metropolitan Water District of Southern California (MWD) to acquire the needed water. Later that same year, district members approved a $220 million bond issue to finance the construction necessary to bring Colorado River water to southern California.

Once Hoover Dam was controlling the Colorado River, Parker Dam could be constructed. Located 155 miles below Hoover, Parker Dam created Lake Havasu, from which water could be pumped into the Colorado River Aqueduct for delivery to the MWD service area. The Bureau of Reclamation built Parker Dam with funds advanced by the Metropolitan Water District, and the district built the Colorado River Aqueduct.

The aqueduct was completed in 1941. It carries water through tunnels, conduits, canals, siphons, and pumping plants across 300 miles of mountains and desert to homes and industries in southern California. In 1955, the aqueduct was named one of America's seven modern wonders by the American Society of Civil Engineers.

The first San Diego Aqueduct, designed by the Bureau of Reclamation, taps the Colorado River Aqueduct and delivers water to the San Diego water supply system. The Department of the Navy constructed the first section of this aqueduct in 1945-46. The second section was completed by Reclamation in early 1955. A second San Diego aqueduct was completed on November 30, 1960, by the San Diego County Water Authority.

Today, over 125 city, municipal, and county water districts, county water authorities, and utility districts receive water through MWD facilities. In 1983, the district delivered over 907,864 acre-feet of Colorado River water, or about 296 billion gallons, to 13 million people.

Lake Mead is also a major source of water for the growing cities and towns in southern Nevada.

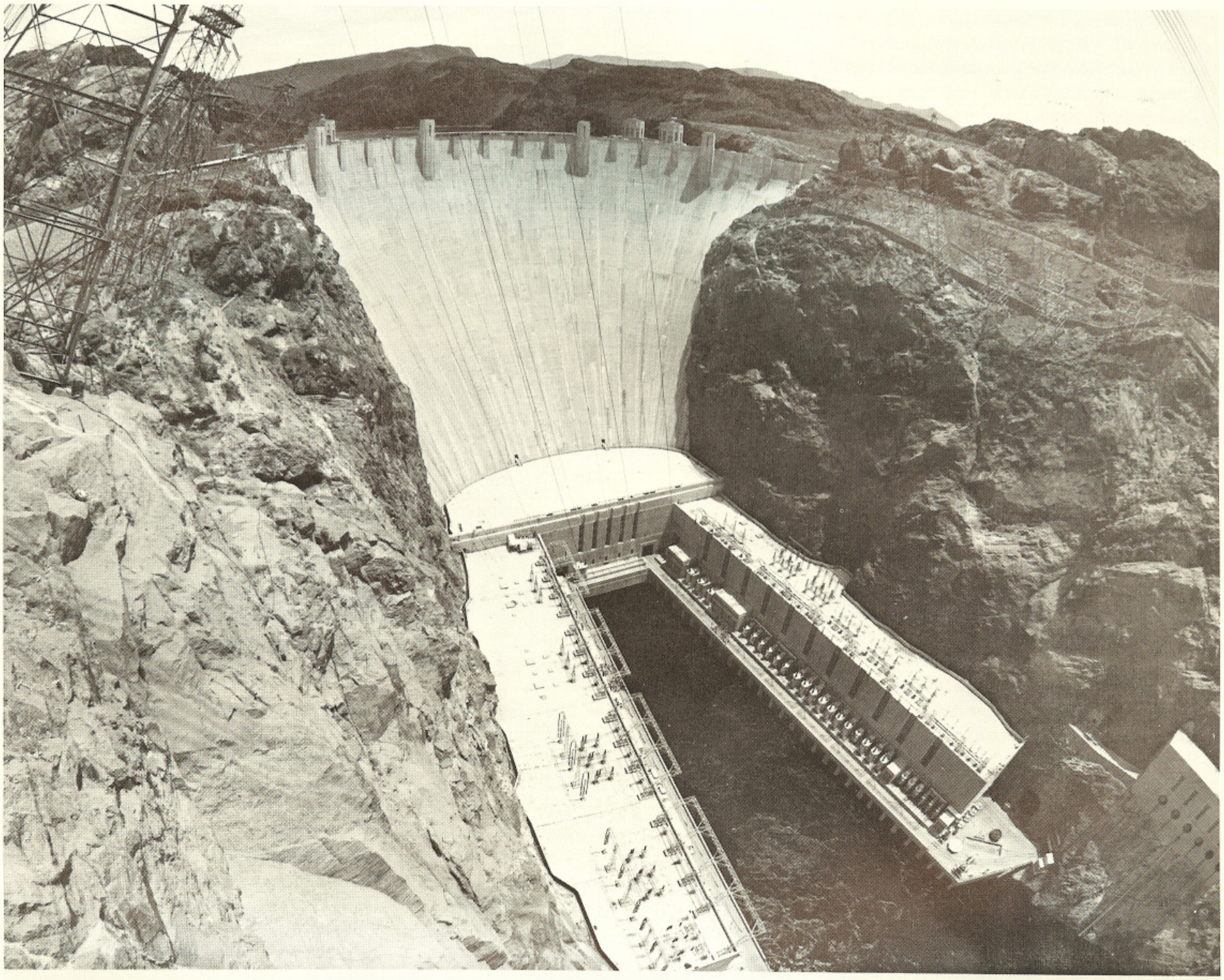
Early settlers in the Las Vegas Valley depended on ground water for their domestic supply. But by 1944 this supply was rapidly being depleted. In 1947, the Nevada State legislature passed a bill establishing the Las Vegas Valley Water District, and gave the District the task of bringing Lake Mead water into the Las Vegas Valley.

A contract was signed between the United States and the Colorado River Commission of Nevada for construction of project works and delivery of water on August 25, 1967. Work began in 1968.

The project was planned in two stages to provide flexibility in installation of future facilities. This allowed for deviations in the projected growth rates of population and industry. The first stage of the project, named the Robert B. Griffith Water Project (formerly the Southern Nevada Water Project), was completed in November 1971. It can deliver 132,200 acre-feet of Colorado River water annually to the Las Vegas area. But the rapid growth of the region between 1971 and 1975 placed an unanticipated strain on the system. Construction of the second stage was begun in 1977.

Delivery of water through second stage facilities began in March 1982. The second stage increases the project's delivery capability by 166,800 acre-feet, bringing the system's total delivery capacity to 299,000 acre-feet annually. Nevada's yearly allotment of Colorado River water is 300,000 acre-feet.

In 1981, project facilities delivered nearly 125,000 acre-feet of Colorado River water from Lake Mead to about 490,000 people in southern Nevada.



Hoover Dam controls and regulates the Colorado River for multipurpose uses.

The Sediment Menace Reduced

The Colorado is named for its reddish-brown color, which comes from the sediment it carries. Engineers have estimated that, prior to construction of Glen Canyon Dam, the river's average flow carried 266 tons of sediment and sand past the Bright Angel gauging station in Grand Canyon each minute, or 383,040 tons every 24 hours.

Hoover Dam has trapped hundreds of millions of tons of sediment in Lake Mead, significantly reducing downstream problems formerly caused by this silt load.

This sediment, untrapped, not only obstructed diversion works, canals, and ditches, it also created a dangerous situation in the lower Colorado River as it was deposited. A committee of the United States Senate reported in 1928:

"The river has an annual discharge at Yuma of more than 100,000 acre-feet of silt. This silt greatly aggravates the flood menace. No temporary works can be built to hold it. It was the silt deposit that built the deltaic ridge on which the river now flows. It was the silt deposit that filled Bee River and Volcano Lake, so that the river could no longer be held at that point, and the same silt deposit will quickly fill the depression where the river now flows.

"The gradient to the north into Imperial Valley is much greater than that to the south into the gulf, and when the depression is filled there is no means known which, at any cost within reason, can prevent the river from again flowing into the Imperial Valley.

"The dam proposed in this bill will catch and hold the silt. Most of the silt finding its way onto the delta is from and above the canyon section. If no other dams were provided on the river, the one proposed in this bill would retain all of the silt finding its way into the reservoir for a period of 300 years, and for more than 100 years before its storage capacity and usefulness would be seriously interfered with. As other dams are constructed on the river they will catch and retain the silt, thereby further extending the usefulness of Boulder Canyon reservoir."

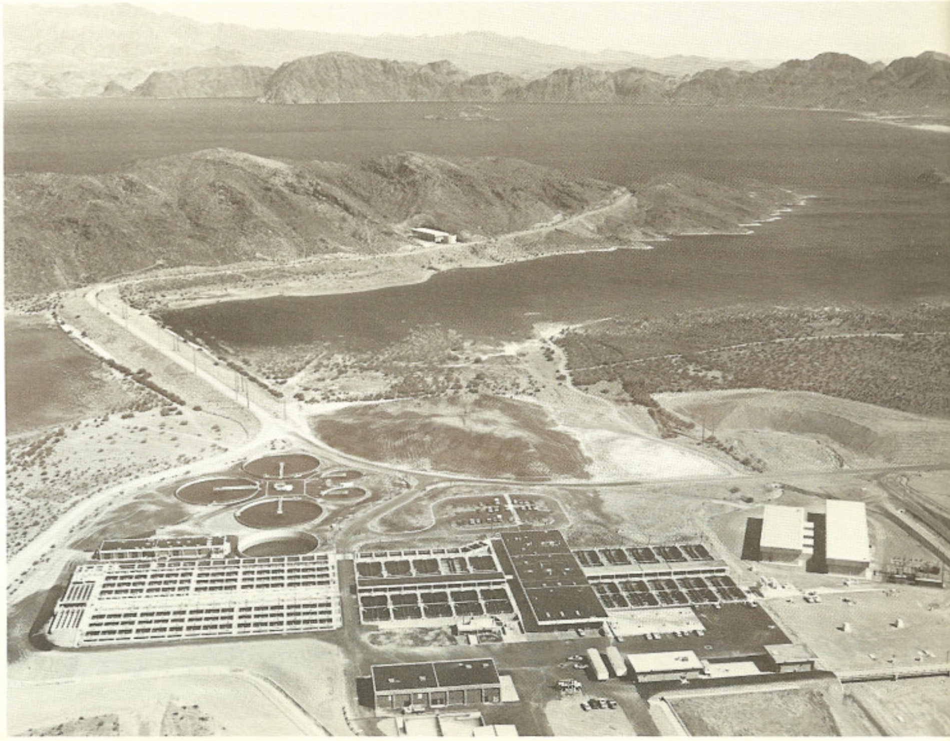
Reclamation engineers set aside approximately 3 million acre-feet of Hoover Dam's reservoir capacity to settle out sediment. The deep reservoir forms a natural trap. The river's flow slows as it enters the lake and the sediment, heavier than water, sinks to the bottom. The clean blue waters of Lake Mead testify that the reservoir's task of retaining silt is well performed. Glen Canyon Dam, 370 miles upstream from Hoover Dam, retains 75 percent of the silt that previously entered Lake Mead, so there is no likelihood of Lake Mead being filled with silt in the foreseeable future. Additional amounts of sediment are collected by other dams on Colorado River tributaries.

Navigation on the Colorado

Hoover Dam's completion also improved navigation on the Colorado River below Grand Canyon.

Technically, the Colorado was always considered a navigable stream. In reality, navigating the river under natural conditions was extremely hazardous and decidedly impracticable. Now, craft ranging in size from small boats to luxurious cabin cruisers ply the waters of Lake Mead.

Boating is also popular on Lakes Mohave (behind Davis Dam) and Havasu (behind Parker Dam) downstream from Hoover Dam, and along reaches of the river below these and other downstream control and diversion structures.



Lake Mead water is treated by the State of Nevada's Alfred Merritt Smith plant, part of the Robert B. Griffith Water Project, before it is delivered to users in southern Nevada.

A Nation's Playground

The ultimate aim of Hoover Dam is, essentially, to promote the well-being and enjoyment of the American people. Lake Mead National Recreation Area, a national playground, typifies this aim.

The recreation area was formed under a 1936 agreement between the Bureau of Reclamation and the National Park Service. On October 8, 1964, Congressional action gave the National Park Service direct administration of the area for recreational purposes. The Park Service's efforts have made this area one of the Nation's outstanding attractions.

Lake Mead National Recreation Area, as originally established, included all the lands surrounding Lake Mead and extending downstream from Hoover Dam on both sides of the Colorado River for almost 40 miles. In 1947, the area was enlarged to encompass Lake Mohave and a short stretch of the river below Davis Dam, 67 miles below Hoover.

Visitors to the Lake Mead National Recreation Area numbered about 6 million in 1983. These visitors came from all parts of the United States and from many foreign lands.

Lake Mead is a favorite recreation site for people from throughout the Southwest.

Lake Mead alone is worth traveling hundreds of miles to visit. It reaches up into the lower end of the Grand Canyon, penetrating colorful canyons and narrow gorges, opening up vistas and areas of nature's majestic handiwork that, through preceding centuries, were inaccessible to other than the bravest explorers.

With their hundreds of miles of shoreline, Lakes Mead and Mohave afford wonderful possibilities for camping, swimming, boating, and fishing. Although temperatures are high during the summer, the heat is not exhausting because of the extremely low relative humidity.

Although all types of water sports are popular, boating and fishing are the prime attractions. Lake Mead abounds in black and striped bass, bluegill, crappie, and catfish. There is no closed season, and licensed fishermen may try their luck on this lake any day of the year.

The clear, cold waters released from the depths of Lake Mead into the upper reaches of Lake Mohave create a perfect habitat for rainbow trout. Thousands of these beauties have been planted there. Lake Mohave's lower reaches, where the waters are deep and still, abound in black bass.

In 1959, the Bureau of Reclamation, the National Park Service, and the Fish and Wildlife Service jointly built a fish hatchery at Willow Beach, Arizona, approximately 15 miles below Hoover Dam. The hatchery provides trout for the entire lower Colorado River, contributing much to the overall economic development and recreation facilities in the region.

In 1973, Nevada's Department of Wildlife began operating its trout hatchery at Lake Mead. Trout from this facility were initially stocked in the lake. More recently, they have been stocked in Lake Mohave and in other waters in Nevada.

Except for a closed and posted area extending one-half mile below Hoover Dam, and where Arizona and Nevada State regulations may forbid fishing during the winter trout spawning season, there are no restrictions on Lake Mohave fishing. Excellent facilities are available at Willow Beach.

Although the National Park Service handles recreational facilities at Lake Mead, Reclamation is by no means unmindful of its visitors and their interests. Bureau of Reclamation guards are on duty at Hoover Dam 24 hours a day, primarily for plant protection, but also to assist travelers. The dam is open to the public every day. Competent, well-trained guides are on hand between 8:30 a.m. and 4:15 p.m. (7:30 a.m. to 7:15 p.m. Memorial Day through Labor Day) to conduct visitors through the famous structure and its powerplant.

Over 22 million people have taken guided tours of Hoover Dam since 1937. From every state in America, from all over the world, they come to see and study this magnificent engineering achievement. Notable foreign visitors have included the King and Queen of Nepal, the Duke and Duchess of Windsor, the Soviet Ambassador, and several delegates from the People's Republic of China.

An exhibit building located at the dam further accommodates visitors. A topographical model of the entire Colorado River Basin and an operating scale model of a generating unit housed here are very enlightening. Together they clearly explain Hoover Dam and its part in the life of the Southwest.

Wildlife Benefits

Resident and migratory wildlife in the Lake Mead National Recreation Area and elsewhere along the lower Colorado River also benefited from Hoover Dam's construction.

The reservoirs formed by Hoover and other lower Colorado River dams provide excellent habitat for game fish and favorable conditions for their propagation. In addition, they serve as huge waterholes for mountain sheep and other wildlife of adjacent mountain and mesa uplands.

The manmade lakes act as sanctuaries for such waterfowl as the pintail, mallard, Canada goose, and snow goose, for wading birds like the egret and blue heron, and for many varieties of sandpipers.

And water-loving birds are not the only fowl to profit. More than 250 species of birds have been counted within the boundaries of Lake Mead National Recreation Area alone. Hunting and trapping are allowed in the area, subject to applicable Federal, State, and local laws.

The upper part of the Bill Williams arm of Lake Havasu and most of the large marsh areas extending above the reservoir are included in the Havasu National Wildlife Refuge. The refuge is located on a flyway of transient and migratory waterfowl, and is heavily used on a seasonal basis by migratory birds. The endangered Yuma Clapper Rail and marsh and wading birds are also present here.

Wildlife such as the desert bighorn sheep are plentiful in the Lake Mead National Recreation Area.

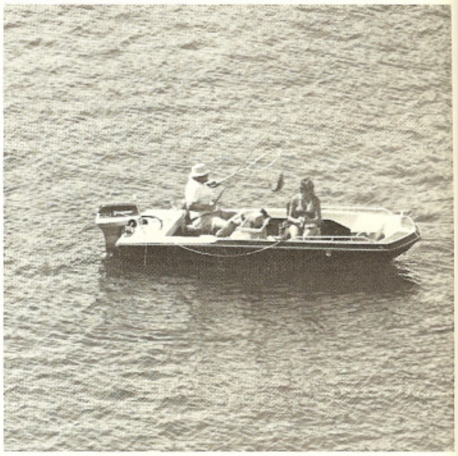
Hydroelectric Power—Strength of the West

A major benefit of Hoover Dam, particularly in the Southwest, is the pollution-free, low-cost electrical energy generated at the structure.

From America's earliest days, the West has lured the Nation's expanding population. Growth and development have been more rapid than in any other part of our country. This is particularly true for Arizona, southern Nevada, and southern California—these states experienced a population expansion from 1960 to 1980 that was unmatched by any other section of the Nation.

This growth, begun in the 1920's, was aided by Reclamation projects that made power available to stimulate the West's economy.

Intensive agricultural development and rapid increases in population in the Southwest have required an assured water supply beyond what underground resources could provide. Power also was needed to assure continued progress. During the decade-and-a-half preceding the passage of the Boulder Canyon Project Act, electrical energy use in southern California increased three times as rapidly as in the rest of the United States.



Fishing at Lake Mead is a year-round sport.

Sailing on Lake Mead is a popular pastime.

Water, which also meant power, was within reach and obtainable, but it was being wasted annually in Colorado River floods. Instead of being allowed to destroy, the floodwaters could be harnessed and put to beneficial use. But the problem of how best to control the river was a difficult one. Not the least perplexing problem was the question of how to finance so large an undertaking.

When plans for the construction of Hoover Dam began to take shape, Reclamation planners recognized that hydroelectric power could be produced and sold, and the revenues from this sale returned to the United States Treasury. Moreover, they believed enough power could be generated and sold to make the project self-liquidating. Power made construction of Hoover Dam possible.

Today, Hoover Powerplant can supply whole cities with light and power. Transmission lines carry hydroelectric power from the dam to homes, farms, stores, factories, mines, smelters, pumping plants, and refineries in southern California, southern Nevada, and Arizona.

Hoover Powerplant has 17 giant generators, with an installed capacity of 1,407,300 kilowatts. Until 1949, it was the largest hydroelectric powerplant in the world.

During the 1970-1980 operating years, Hoover Powerplant generated an average of nearly 3.5 billion kilowatt-hours of energy each year. During the operating year June 1, 1952, through May 31, 1953, the plant produced 6,463,483,000 kilowatt-hours of electrical energy, an all-time high. A total of 171,599,085,030 kilowatt-hours of energy was generated at Hoover between June 1, 1937, and May 31, 1983.

Income from the sale of Hoover Dam power has risen steadily. Revenue from October 26, 1936, to May 31, 1942, was more than $21 million, and revenues for the operating years 1943 through 1965 averaged more than $8 million annually. Beginning in 1965, the revenues amounted to over $10 million annually until 1970, when they surpassed the $11 million mark for the first time.

During 45 years of operation, June 1, 1937, through May 31, 1982, total revenue from all sources was $471,074,224. Up to May 31, 1982, $215,365,591 had been returned to the United States Treasury: $128,692,485 for interest and $86,673,106 for principal. Operating costs account for the remaining revenue.

Commercial power generation at Hoover Powerplant began October 26, 1936, when unit N-2[3], the first of four generating units then being installed, began serving the Los Angeles metropolitan area.

By the end of 1936, units N-4 and N-1 had also been installed; unit N-3 was placed in operation in 1937.

These units serve the cities of Los Angeles, Glendale, Burbank, and Pasadena, California, and Las Vegas and Boulder City, Nevada.

In August 1937, unit A-8 went into operation for the California Electric Power Company, a private utility supplying customers in Nevada and southern California. Power generated by this unit now serves Southern California Edison Co. customers.

In 1938, units N-5 and N-6, installed for the Metropolitan Water District of Southern California, were operating. Energy generated by these units is used primarily for pumping Lake Havasu water into and along the district's Colorado River Aqueduct. Energy not required for pumping may be sold to municipalities and utilities.

[3]"N" or "A" designates location of unit in Nevada or Arizona wing of the powerplant.

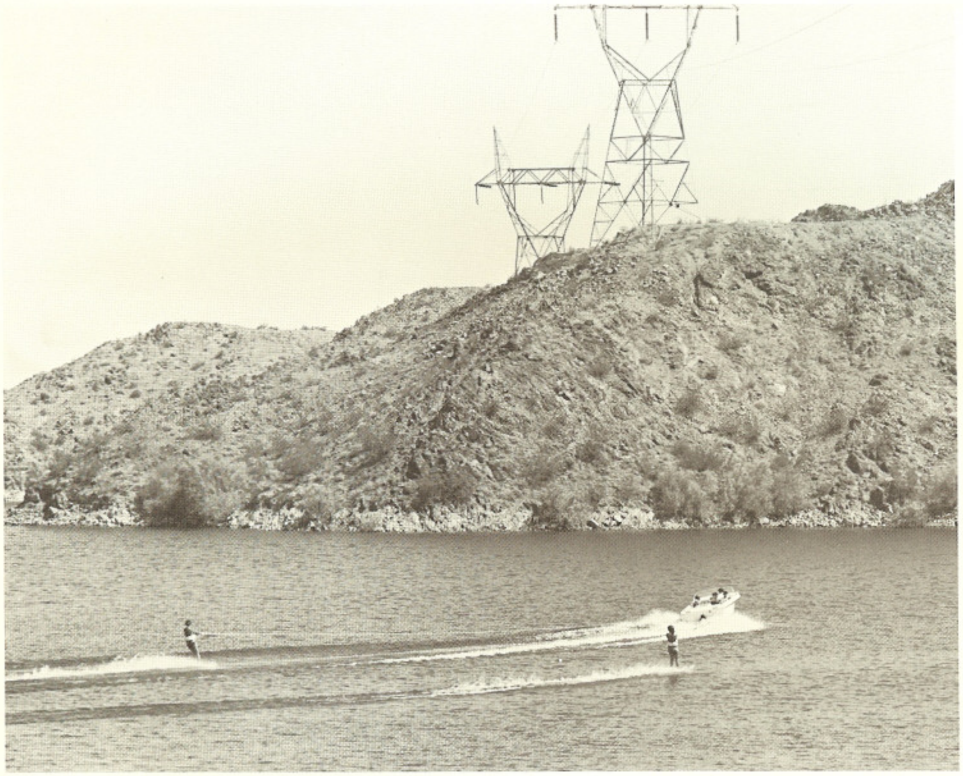
Nearly 13 million people in the Southwest depend on Colorado River water stored by Hoover or Parker Dams for part of their daily supply.

The Southern California Edison Co., which serves seven counties in southern California, exclusive of the city of Los Angeles, was to begin receiving power from the plant by June 1, 1940. But a power shortage in the area served by Edison speeded installation of units A-6 and A-7, supplying energy to the company by the end of 1939.

At the close of 1939, with an installed capacity of 704,800 kilowatts, Hoover Powerplant was the world's largest hydroelectric facility.

With the outbreak of World War II, installation of additional generating units at Hoover Dam accelerated. By October 1944, units A-1, A-2, A-5, and N-7 were operating. The plant's capacity was 1,034,800 kilowatts when the war ended.

Units A-1 and A-2 supply power mainly to Los Angeles, but also help supplement power supplies of the Federal Government and the State of Nevada. Unit



Waterskiers enjoy Lake Mohave, part of Lake Mead National Recreation Area.

A-5 was installed for the Southern California Edison Co. Unit N-7, installed for the Defense Plant Corporation, was transferred to the State of Nevada on June 1, 1951. Since September 1, 1961, however, the unit has served the Metropolitan Water District of Southern California.

One of the major users of hydroelectric power from Hoover during World War II was the huge magnesium plant near Henderson, about 10 miles northwest of Boulder City. Built by the Defense Plant Corporation, this facility used one-fourth of the energy generated by the powerplant in 1943.

In 1952, generating units A-3, A-4, and A-9 began production. A-3 and A-4 were installed for the State of Arizona, while unit A-9 serves Nevada.

The latter units completed installation in the Arizona wing of the plant. Installation of Unit N-8 in 1961 completed the Nevada wing of the powerplant, and brought the plant's capacity to 1,344,800 kilowatts. Following the uprating of generators A-5 and N-8 in 1982, the plant's rated capacity was increased to 1,407,300 kilowatts. Under consideration is additional uprating of existing units, or addition of more generating units, to further increase the plant's peaking capacity.

Sixteen high-voltage transmission lines connect Hoover Dam with its power market area. Two lines terminate at Los Angeles, a line distance of 266 miles. A third line extends to Los Angeles via the McCullough switching station, where the energy is stepped up to 500,000 volts. One line extends to San Bernardino, California. Three lines extend to Las Vegas, Nevada. One of the latter connects with the Davis Dam transmission system. Other lines extend to Kingman, Arizona; Needles, California; and nearby Boulder City.

Hoover Powerplant is interconnected with the downstream Davis and Parker Powerplants. Energy supplied by the Parker and Davis plants is delivered to Arizona and southern California, and to industries in Henderson, Nevada. The Department of Energy's Western Area Power Administration markets energy produced by these three hydroelectric powerplants.

Davis Powerplant, 67 miles below Hoover, has an installed capacity of 225,000 kilowatts. Parker Powerplant, 155 miles below Hoover Dam, has an installed capacity of 120,000 kilowatts. For the years 1951 to 1982, Davis Powerplant generated an average of more than 1 billion kilowatt-hours each year, while the average annual energy generation for Parker Dam from 1946 through 1982 was about 595 million kilowatt-hours.

As the amount of energy generated at Hoover Dam rose, the benefits of that energy spread throughout the Pacific Southwest economy. For example, energy rates in Los Angeles were lowered, saving Los Angeles metropolitan area consumers an estimated $1,320,000 during the first year the plant was in operation. But perhaps no other phase of the area's economy was more directly affected than its mining and mineral industries.

Directly, or through interconnection, Hoover-produced energy figured in Southwest mineral production in the following places and industries: in California, tungsten at Bradensburg; saline deposits at Owens and Searles Lake; steel at Fontana; borax near Karmer; cement at Victorville, Colton, and Monolith; aluminum at Torrance. In Nevada, burcite and magnesite at Gabbs; silica sand near Overton; and manganese near Boulder City. In the Bagdad, Arizona area, the low-cost energy revitalized the copper industry.

The mines near Pioche, Nevada, also benefited. This region, 156 transmission-line miles north of Hoover Dam, was completely without electricity before energy from the facility became available.

Perhaps the most dramatic industrial development resulting from the construction of Hoover Dam was the growth of the light-metals industry in southern Nevada, beginning with construction of a magnesium plant at Henderson.

The magnesium plant was started in 1941. The plant was sited in Henderson because the water and power needed to support the installation were easily available from Lake Mead and Hoover Dam. The plant was built in record time and contributed greatly to America's war effort. Although magnesium has not been processed at the plant since World War II ended, it still stands. Stauffer Chemical Company, Kerr-McGee Chemical Corporation, Genstar Company, and Titanium Metals Company of America have purchased the plant buildings and appurtenant facilities. These companies formed Basic Management, Inc., to manage common-use facilities at the industrial complex.

Nonpolluting hydroelectric power from Hoover Dam not only stimulates the Southwestern economy, it also helps conserve one of our most precious natural resources–oil. It would take about 6 million barrels of oil each year to produce the same amount of electric energy Hoover Dam generates.

Water from Lake Mead is used for many municipal purposes.

The Benefits Multiplied

The story of Hoover Dam and the Boulder Canyon Project spans the gamut of river regulation: flood control; water for irrigation, domestic and industrial use; sediment retention; increased recreational opportunity; fish and wildlife enhancement; and hydroelectric power generation.

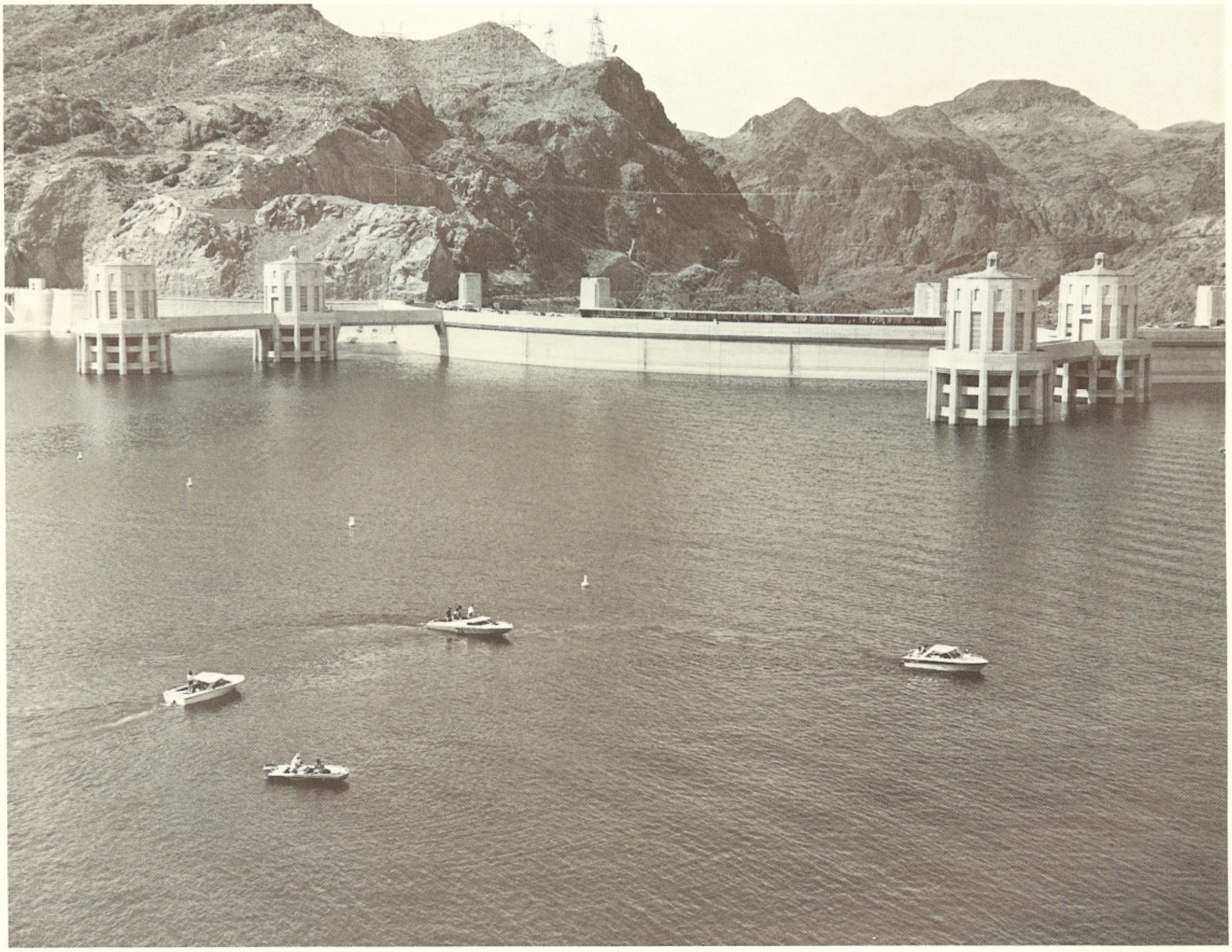
Hoover Dam was Reclamation's first multipurpose dam, and its contribution to the Southwest's growth and economy are immeasurable. But its influence doesn't end there.

The uncontestable success of Hoover supported construction and continued development of other great multipurpose Reclamation structures throughout the West. There are, for example, Grand Coulee Dam on the Columbia River in Washington State, Shasta Dam on California's Sacramento River, and other dams too numerous to mention. All these dams provide multipurpose benefits that have greatly strengthened the economies of the local areas they serve and often reach into areas far away from their immediate surroundings.

Hoover Dam also made it possible to construct other dams in the Colorado River Basin. These dams help control the river and its tributaries, allowing the stored waters to be beneficially used along the stream's entire length.

Glen Canyon Dam, key feature of the Colorado River Storage Project (CRSP), is one such structure. A concrete arch spanning the Colorado in northern Arizona, the dam rises 710 feet above foundation bedrock–about 17 feet less than Hoover Dam. The dam's reservoir, Lake Powell, holds 27 million acre-feet of water, just slightly less than Lake Mead's capacity. And Glen Canyon's powerplant, with eight main generators and a capacity of 1,021,000 kilowatts, is about three-fourths the size of the Hoover powerplant.

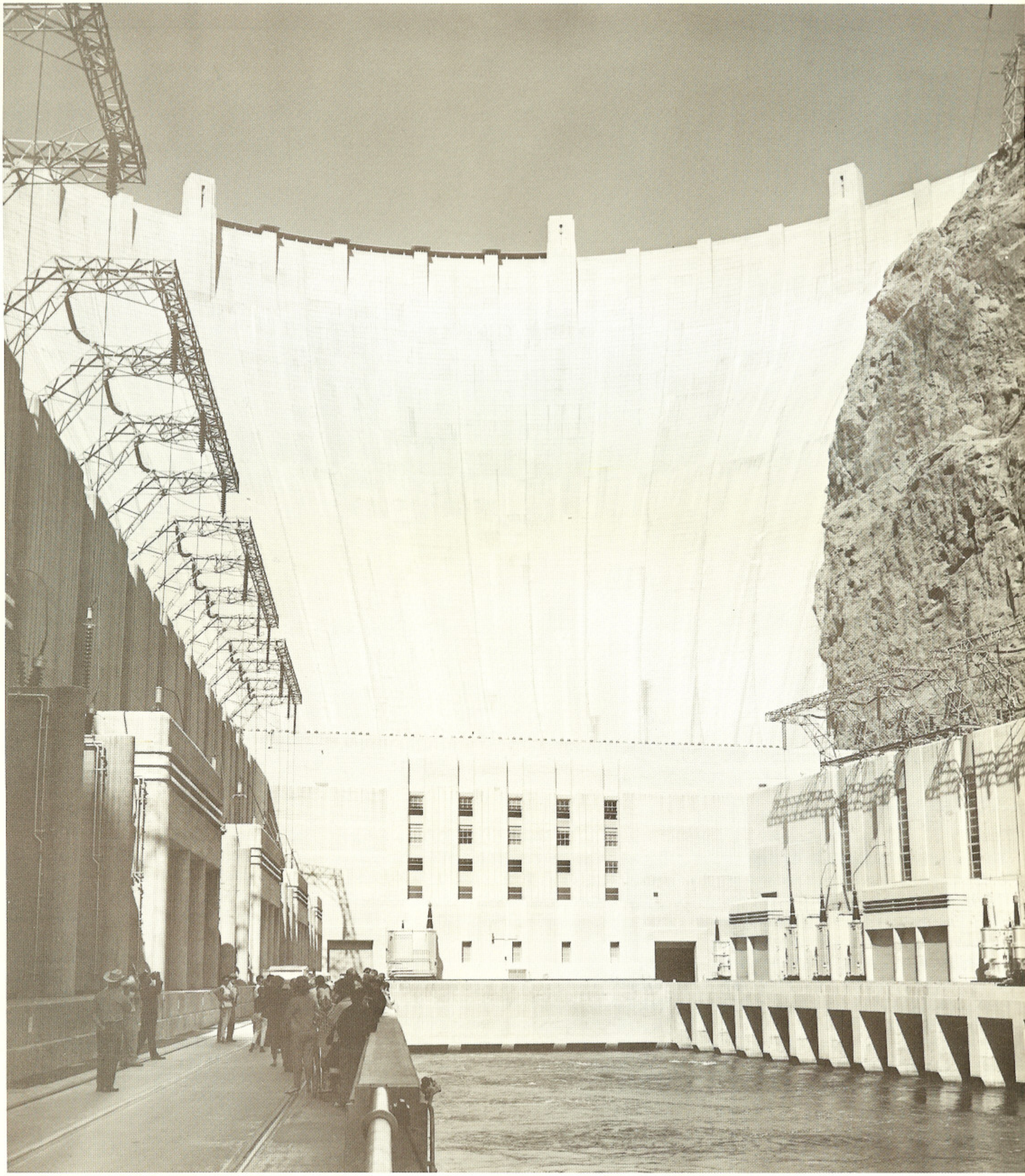
Other major CRSP dams are Flaming Gorge on the Green River in northeastern Utah, Navajo on the San Juan River in northern New Mexico, and Blue Mesa, Morrow Point, and Crystal on the Gunnison River in western Colorado.



Boating on Lake Mead

Several smaller projects in the Upper Basin, called participating projects, were authorized with, but are not part of, the CRSP. The participating projects constructed will share in CRSP power revenues to help pay for irrigation construction costs. Together, the CRSP and its participating projects constitute a program for development and use of the water resources of the upper Colorado River—a complementary role to that performed by Hoover Dam and the Boulder Canyon Project for the Lower Basin.

The Hoover Dam Story—countless people the world over know it, and millions who directly benefit from this great structure have first-hand acquaintance with its full meaning. It is a story that has been—and will continue to be—written into the records of our times.



Facts and Figures

The Dam

Where is Hoover Dam?
In Black Canyon on the Colorado River, about 30 miles southeast of Las Vegas, Nevada.

What does the Boulder Canyon Project include?
Hoover Dam and Powerplant and the All-American Canal in southern California, together with appurtenant structures.

How high is Hoover Dam?
It is 726.4 feet from foundation rock to the roadway on the crest of the dam. The towers and ornaments on the parapet rise 40 feet above the crest.

How much does Hoover Dam weigh?
More than 6,600,000 tons.

What type of dam is Hoover?
A concrete arch-gravity type, in which the water load is carried by both gravity action and horizontal arch action.

What is the maximum water pressure at the base of the dam?
45,000 pounds per square foot.

How much concrete is in the dam?
Three and one-quarter million cubic yards. There are 4,360,000 cubic yards of concrete in the dam, powerplant, and appurtenant works. This much concrete would build a monument 100 feet square and 2½ miles high; or, if placed on an ordinary city block, would rise higher than the Empire State Building (which is 1,250 feet). Or, it would pave a standard highway, 16 feet wide, from San Francisco to New York City.

The first concrete for the dam was placed on June 6, 1933, and the last concrete was placed in the dam on May 29, 1935. Approximately 160,000 cubic yards of concrete were placed in the dam per month. Peak placements were 10,462 cubic yards in one day (including some concrete placed in the intake towers and powerplant), and slightly over 275,000 cubic yards in one month.

How much cement was required?
More than 5 million barrels. The daily demand during construction of the dam was from 7,500 to 10,800 barrels. Reclamation had used only 5,862,000 barrels in its 27 years of construction activity preceding June 30, 1932.

How was chemical heat, caused by setting cement in the mass structure, dissipated?
By embedding more than 582 miles of 1-inch steel pipe in the concrete. Icewater circulated through this pipe from a refrigeration plant that could produce 1,000 tons of ice in 24 hours. Cooling was completed in March 1935.

What was an unusual feature of Hoover Dam's construction?
The dam was built in blocks or vertical columns varying in size from about 60 feet square at the upstream face of the dam to about 25 feet square at the downstream face. Adjacent columns were locked together by a system of vertical keys on the radial joints and horizontal keys on the circumferential joints. Concrete placement in any one block was limited to 5 feet in 72 hours. After the concrete was cooled, a cement and water mixture called grout was forced into the spaces created between the columns by the contraction of the cooled concrete to form a monolithic (one piece) structure.

What were the principal items of work?
More than 5,500,000 cubic yards of material were excavated, and another 1,000,000 cubic yards of earth and rockfill placed. By feature, this included:

Excavation—for the diversion tunnels, 1,500,000 cubic yards; for the foundation of the dam, powerplant, and cofferdams, 1,760,000 cubic yards; for the spillways and inclined tunnels, 750,000 cubic yards; for the valve houses and intake towers, 410,000 cubic yards; earth and rockfill for the cofferdams, 1,000,000 cubic yards.

Other work items included 4,400,000 cubic yards of concrete placed; 410,000 linear feet of drilling grout and drainage holes; and 422,000 cubic feet of grout placed under pressure.

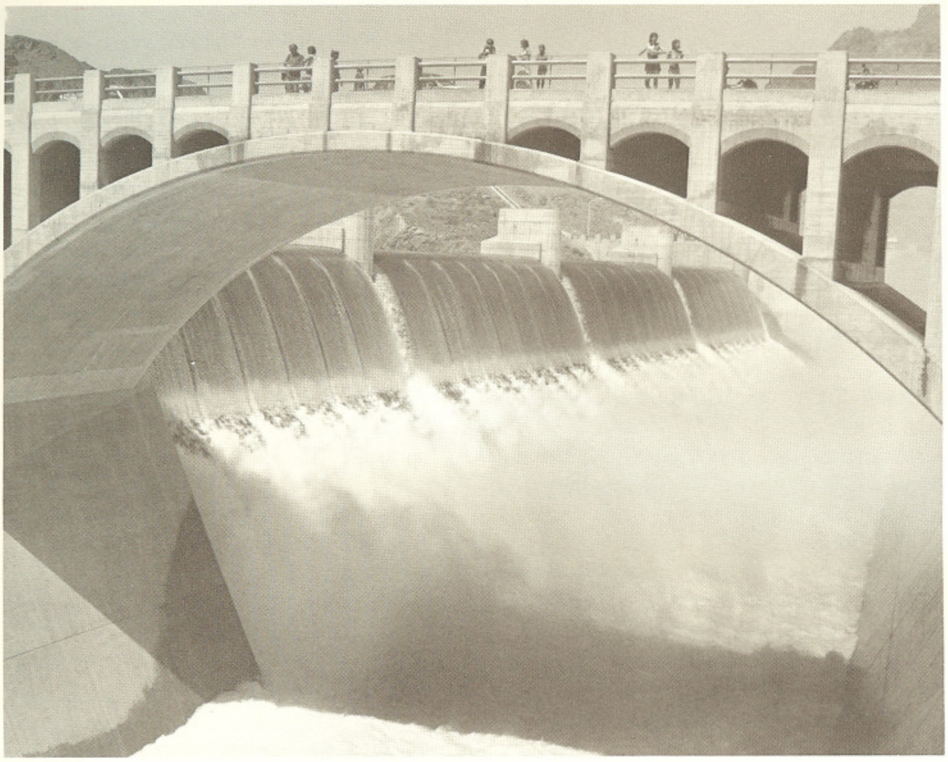
What were the quantities of principal materials used in the dam?
Reinforcement steel, 45,000,000 pounds; gates and valves, 21,670,000 pounds; plate steel and outlet pipes, 88,000,000 pounds; pipe and fittings, 6,700,000 pounds or 840 miles; structural steel, 18,000,000 pounds; miscellaneous metal work, 5,300,000 pounds.

Did the Government buy these materials?
Yes.

What are the geologic conditions at the damsite?
The foundation and abutments are rock of volcanic origin geologically called "andesite breccia." The rock is hard and very durable.

What were the excavation depths from the river's low-water surface to foundation rock?
In the upstream cutoff trench, 139 feet of material were excavated. The remaining excavation depths from low-water surface to foundation rock average 110 to 130 feet.

Sightseers behind Hoover Dam



Beneath the Arizona Bridge, a spectacular view of Hoover Dam's Arizona Spillway, July 1983

How long did it take to build the dam, powerplant, and appurtenant works?
Five years. The contractors were allowed 7 years from April 20, 1931, but concrete placement in the dam was completed May 29, 1935, and all features were completed by March 1, 1936.

How many men were employed during the dam's construction?
An average of 3,500 and a maximum of 5,218, which occurred in June 1934. The average monthly payroll was $500,000.

What construction work was necessary before operations started at the damsite?
(1) Construction of Boulder City to house both Government and contractor employees. (2) Construction of 7 miles of 22-foot wide, asphalt-surfaced highway from Boulder City to the damsite.
(3) Construction of 22.7 miles of standard-gauge railroad from the Union Pacific main line in Las Vegas to Boulder City and an additional 10 miles from Boulder City to the damsite. (4) Construction of a 222-mile-long power transmission line from San Bernardino, California, to the damsite to supply energy for construction.

Lake Mead

What is the elevation of the reservoir at high-water?
The high-water line is 1,229 feet above sea level. At this elevation, the water would be more than 7½ feet over the top of the raised spillway gates. At elevation 1221.4 feet, the water would be at the top of the raised spillway gates. All lands below elevation 1,250 have been retained for reservoir purposes.

What is the reservoir's area?
About 157,900 acres or 247 square miles at water surface elevation 1221.4 feet.

How long and wide is the reservoir?
At elevation 1221.4, Lake Mead extends approximately 110 miles upstream toward the Grand Canyon. It also extends about 35 miles up the Virgin River. The width varies from several hundred feet in the canyons to a maximum of 8 miles.

How much water will Lake Mead hold?
At elevation, 1221.4, it would contain 28,537,000 acre-feet. An acre-foot is the amount of water required to cover 1 acre to a depth of 1 foot, or approximately 326,000 gallons. The reservoir will store the entire average flow of the river for 2 years. That is enough water to cover the State of Pennsylvania to a depth of one foot.

How is the reservoir capacity allotted?
Below elevation 1,229, about 1,500,000 acre-feet of storage capacity is reserved exclusively for flood control; about 2,378,000 acre-feet for sedimentation control; about 15,853,000 acre-feet for joint use (flood control, municipal and industrial water supply, irrigation, and power); and 10,024,000 acre-feet for inactive storage.

Who operates the dam and reservoir?
The Bureau of Reclamation operates and maintains the dam, reservoir, penstock tunnels, intake and outlet works, and penstocks to, but not including, shutoff valves at the inlets to the turbine scroll-case. The National Park Service administers Lake Mead as part of the Lake Mead National Recreation Area.

How much sediment will be deposited in the reservoir?
Between 1935 and 1963, about 91,500 acre-feet of sediment was deposited in Lake Mead each year. With closure of Glen Canyon Dam, about 370 miles upstream, the life of Lake Mead is indefinite.

What is the estimated annual evaporation on the reservoir?
800,000 acre-feet.

Tunnels, Towers, Penstocks, and Spillways

How was the river diverted during dam construction?
By an earth and rockfill cofferdam, through four 50-foot diameter tunnels, excavated to 56 feet and lined with 3 feet (300,000 cubic yards) of concrete. Driven through the canyon walls, two on each side of the river, the four tunnels had a total length of 15,946 feet, or about 3 miles. These tunnels could carry over 200,000 cubic feet or almost 1½ million gallons of water per second! The river was diverted through the two Arizona tunnels on November 14, 1932.

After their use for river diversion, how were the tunnels used?
The inner tunnels were plugged with concrete approximately one-third their length below the inlets, and the outer tunnels were plugged approximately halfway. The two inner tunnels contain 30-foot diameter steel pipes which connect the intake towers in the reservoir with the penstocks to the powerplant and the canyon wall outlet works. The downstream halves of the two outer tunnels are used for spillway outlets.

What gates are installed on the tunnels?
The inlets of the two outer tunnels are permanently closed with 50- by 50-foot bulkhead gates. Each gate, with steel frame, weighs about 3,000,000 pounds, and required 42 railroad cars for shipment. At the outlets of the two inner tunnels, 50- by 35-foot Stoney gates are installed. These gates can be closed when the tunnels need to be emptied for inspections or repairs.

What are the intake towers?
They are four reinforced-concrete structures located above the dam, two on each side of the canyon. Diameter of these towers is 82 feet at the base, 63 feet 3 inches at the top, and 29 feet 8 inches inside. Each tower is 395 feet high and each controls one-fourth the supply of water for the powerplant turbines. The four towers contain 93,674 cubic yards of concrete and 15,299,604 pounds of steel.

How are these towers connected to the powerplant and outlet valves?
By 30-foot-diameter penstocks installed in 37- and 50-foot diameter concrete-lined tunnels. The upstream intake towers are connected to the inner diversion tunnels by 37-foot-diameter inclined tunnels. Thirty-seven-foot diameter tunnels also connect the downstream towers to the penstocks and outlet works.

How do the intake towers control water flow?
Through two cylindrical gates, each 32 feet in diameter and 11 feet high. One gate is near the bottom and the other near the middle of each tower. The gates are protected by trashracks. Total weight of the gates is 5,892,000 pounds; the trashracks weigh 7,024,000 pounds.

What pipes are installed in the tunnels for reservoir outlets?
There are 4,700 feet of 30-foot-diameter pipe and 2,000 feet of 8½-foot-diameter pipe. Maximum thickness of the largest pipe is about 3 inches.

How are the 30-foot-diameter pipes connected to the powerplant turbines?
By sixteen 13-foot-diameter platesteel penstocks installed in 18-foot-diameter concrete-lined tunnels. Total length of these penstocks is 5,800 feet.

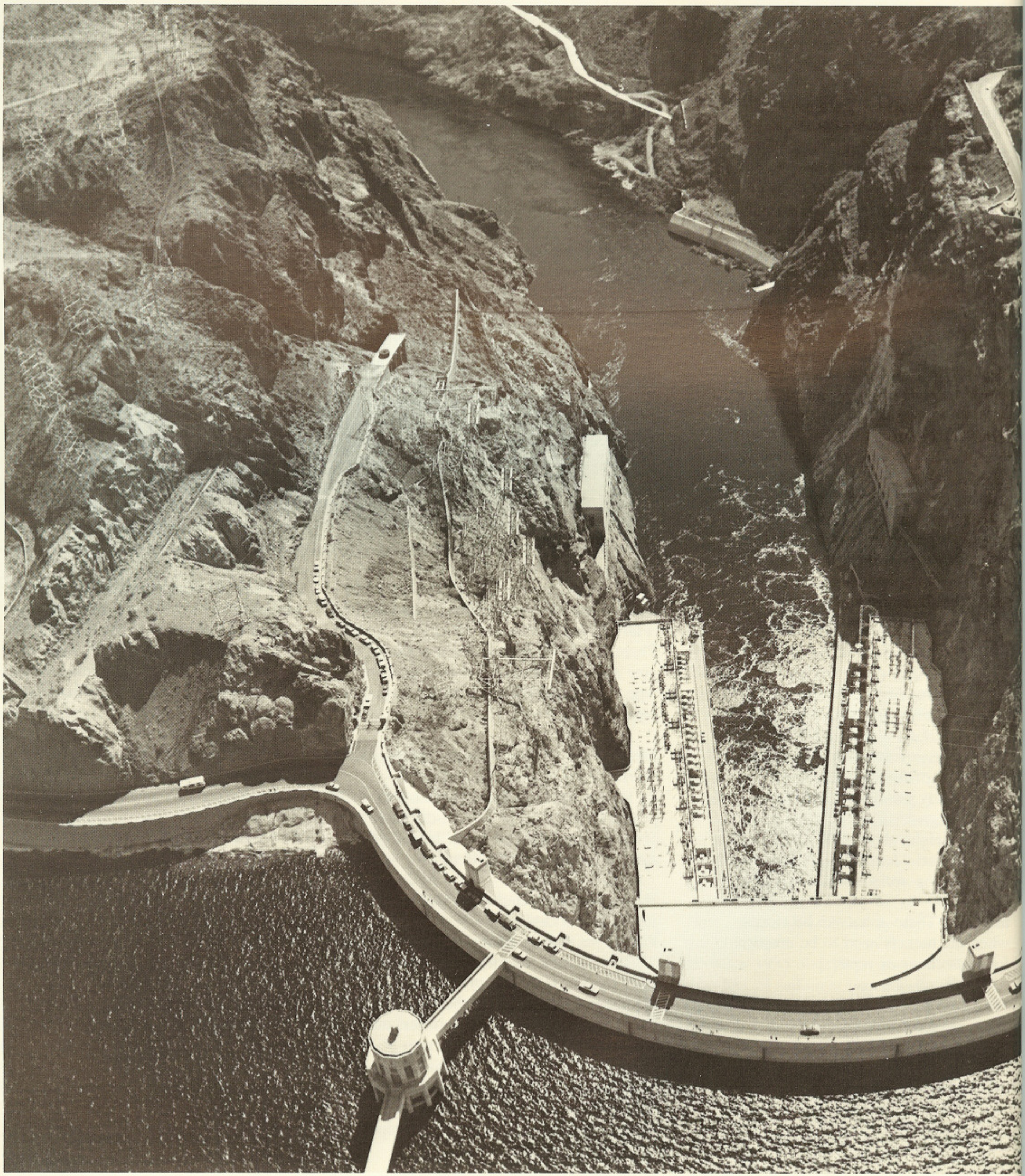
What are the main characteristics of the penstock and outlet pipes?
Forty-four thousand tons of steel were formed and welded into 14,800 feet of pipe varying from 8½ to 30 feet in diameter. Each length of the largest pipe —12 feet long, 30 feet in diameter, and 2¾ inches thick—was made from 3 steel plates, of such weight that only two plates could be shipped from the steel mill to the fabricating plant on one railroad car. Two such lengths of pipe welded together make one section weighing approximately 135 tons and, at intersections with the penstocks, as much as 186 tons.

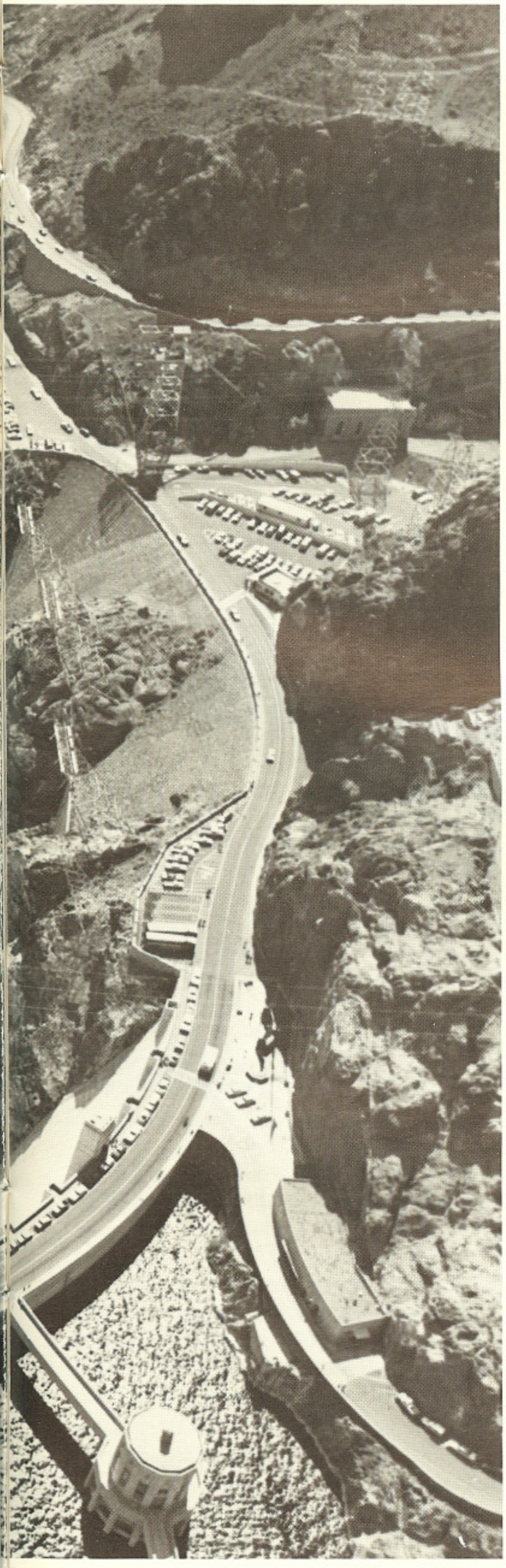
What outlets are used?
Four 72-inch needle valves in each inner diversion tunnel plug outlet; two 84-inch needle valves in the Arizona canyon wall valve house; and two 84-inch needle valves in the Nevada canyon wall valve house. The needle valves in the canyon walls are about 180 feet above the river level. Canyon wall valves are designed to bypass water around the dam under emergency or flood conditions, or to empty the penstocks for maintenance work.

What is the maximum capacity of these works?
About 118,000 cubic feet per second (ft^3/s): 32,000 ft^3/s for power generation and 86,000 ft^3/s of valve discharge. One cubic foot per second of water equals nearly 7½ gallons passing a given point in one second.

What are the Arizona and Nevada spillways?
Concrete-lined open channels about 650 feet long, 150 feet wide, and 170 feet deep on each canyon wall. More than 600,000 cubic yards of rock were excavated for the spillways. The spillway walls are lined with 18 inches of concrete and the floors with 24 inches; 127,000 cubic yards of concrete were placed for the spillways.

How is water discharged from the spillways?
Into the outer diversion tunnels through inclined shafts 50 feet in diameter and 600 feet long. The discharge is controlled by four automatically or manually operated 100- by 16-foot, 500,000-pound drum gates on each spillway crest. Maximum water velocity in the spillway tunnels is about 175 feet per second, or 120 miles per hour.





What is the maximum discharge capacity of the spillways, valves, and powerplant?
Five hundred and eighteen thousand ft^3/s. Each spillway can discharge 200,000 ft^3/s. If the spillways were operated at full capacity, the energy of the falling water would be about 25,000,000 horsepower. The flow over each spillway would be about the same as the flow over Niagara Falls, and the drop from the top of the raised spillway gates to river level would be approximately three times as great.

The Power Development

Where is the powerplant located?
In a U-shaped structure at the base of the dam. Each powerplant wing is 650 feet long, 150 feet above normal tailrace water surface, and 299 feet (nearly 20 stories) above the powerplant foundation. In all of the galleries of the plant there are 10 acres of floor space.

What is the installed capacity of the Hoover Powerplant?
There are 17 main turbines in Hoover Powerplant. The turbines in units A-5, A-7, N-5, and N-7 have been replaced with new units. With a rated capacity of 2,011,000 horsepower and two station-service units rated at 3,500 horsepower each for a plant total of 2,018,000 horsepower, the plant has a nameplate capacity of 1,407,300 kilowatts. This includes the two station-service units, which are rated at 2,400 kilowatts each.

What is horsepower in terms of falling water?
One cubic foot of water falling 8.81 feet per second equals one horsepower at 100 percent efficiency.

How does the water reach the turbines?
Through four pressure penstocks, two on each side of the river. Shutoff gates control water delivery to the units.

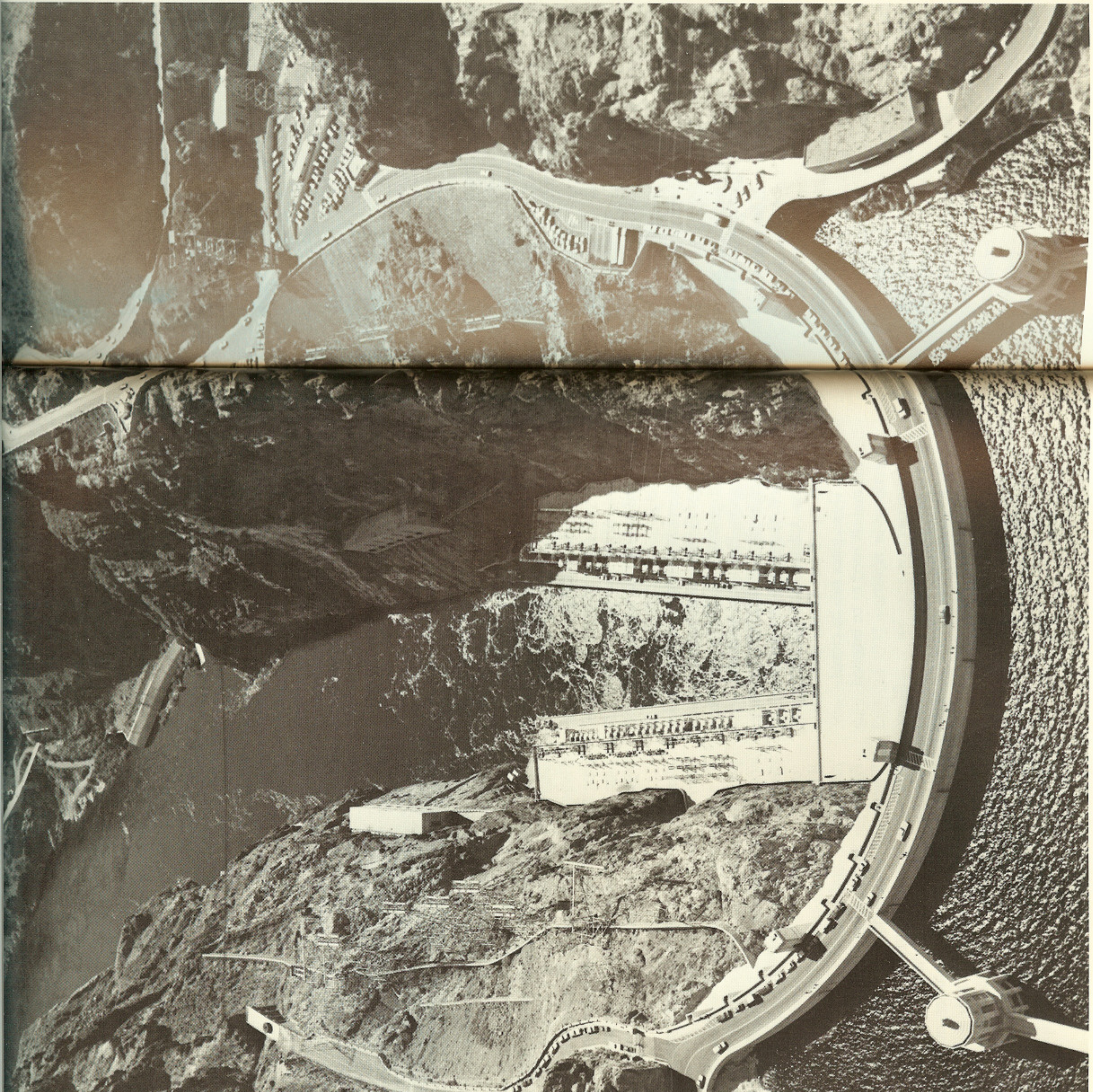
Under what heads do the turbines operate?
Maximum head (vertical distance water travels), 590 feet; minimum, 420 feet; average, 510 to 530 feet.

When were power installations in the plant completed and of what do they consist?
Installation was completed in 1961. With the uprating completed in 1982, there are four 157,000-horsepower, eleven 115,000-horsepower, one 70,000-horsepower, and one 55,000-horsepower Francis-type vertical hydraulic turbines. There are thirteen 82,500-kilowatt, one 130,000-kilowatt, one 115,000-kilowatt, one 50,000-kilowatt, and one 40,000-kilowatt generator. Some machines are rated at 50 cycles; however, all are operated at 60 cycles. There are also two 2,400-kilowatt station-service units driven by Pelton water wheels. These provide electrical energy for lights and for operating cranes, pumps, motors, compressors, and other electrical equipment within the dam and powerplant.

How was the powerplant machinery transported from the canyon rim to the powerplant?
An electrically operated cableway of 150 tons rated capacity, with a 1,200-foot span across the canyon, lowered all heavy and bulky equipment. The cableway is still used when necessary.

How much energy does Hoover Powerplant produce on a yearly basis?
The average annual net generation for Hoover Powerplant for operating years 1937 through 1982 is about 3.5 billion kilowatt-hours. The maximum annual net generation at Hoover Powerplant was 6,463,483,000 kilowatt-hours in 1953, while the minimum annual net generation since 1940 was 2,614,512,600 kilowatt-hours in 1965. About 6 million barrels of oil would be required by an oil-fired generating plant to supply the average amount of energy generated by the plant annually.

Aerial view of powerplant and Colorado River far below crest of Hoover Dam



What is a kilowatt-hour?
It is a unit of work or energy equal to that done by one kilowatt of power acting for one hour. A kilowatt is 1,000 watts or 1.34 horsepower.

Who operates and maintains the powerplant?
The powerplant is operated and maintained directly by the Bureau of Reclamation except for the generating machinery, which is operated and maintained directly through the City of Los Angeles Department of Water and Power and the Southern California Edison Co., the operating agents. The City of Los Angeles generates for itself, other municipalities, the States of Arizona and Nevada, and the Metropolitan Water District of Southern California. Southern California Edison generates for itself.

Who are the principal contractors for energy?
The States of Arizona and Nevada, the City of Los Angeles Department of Water and Power, the Southern California Edison Co., the Metropolitan Water District of Southern California, and the cities of Glendale, Burbank, and Pasadena.

How is the firm energy generated at Hoover Dam allocated?
States of Arizona and Nevada, 17.6259 percent each; Metropolitan Water District of Southern California, 35.2517 percent; city of Burbank, 0.5773 percent; city of Glendale, 1.8475 percent; city of Pasadena, 1.5847 percent; city of Los Angeles, 17.5554 percent; Southern California Edison Co., 7.9316 percent.

How is the income from the sale of energy used?
To pay all operation and maintenance expenses and to repay the major part of the construction cost of the dam and powerplant, at interest not exceeding 3 percent. The cost of construction completed and in service by 1937 will be repaid by May 31, 1987. All other costs will be repaid within 50 years of the date of installation or as established by Congress. Repayment of the $25 million construction cost allocated to flood control is deferred beyond 1987, when further action will be subject to Congressional direction. Arizona and Nevada each receive $300,000 annually, paid from revenues, and $500,000 annually is set aside from revenues for further irrigation and power development of the Colorado River Basin.

Colorado River Water Allocation

What States have beneficial interests in the Colorado River system?
Those lying within the Colorado River Basin: Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. Each of these States is party to the Colorado River Compact entered into in Santa Fe, New Mexico, on November 24, 1922. The compact has been ratified by the legislatures of all the signatory States.

How is the Colorado River Basin divided?
The Colorado River Compact divided the Colorado River Basin into the Upper Basin and the Lower Basin. The division point is Lees Ferry, a point in the mainstem of the Colorado River about 30 river miles south of the Utah-Arizona boundary. The "Upper Basin" includes those parts of the States of Arizona, Colorado, New Mexico, Utah, and Wyoming within and from which waters naturally drain into the Colorado River system above Lees Ferry, and all parts of these States that are not part of the river's drainage system but may benefit from water diverted from the system above Lees Ferry.

The "Lower Basin" includes those parts of the States of Arizona, California, Nevada, New Mexico, and Utah within and from which waters naturally drain into the Colorado River system below Lees Ferry, and all parts of these States that are not part of the river's drainage system but may benefit from water diverted from the system below Lees Ferry.

How is Colorado River water apportioned?
The Colorado River Compact apportioned to each basin the exclusive, beneficial consumptive use of 7,500,000 acre-feet of water per year from the Colorado River system in perpetuity. In addition, the compact gave to the Lower Basin the right to increase its annual beneficial consumptive use of such water by 1,000,000 acre-feet.

How much water is each State in the Colorado River Basin apportioned?
The Colorado River Compact did not apportion water to any State.

On October 11, 1948, the Upper Basin States entered into the Upper Colorado River Basin Compact, which apportioned use of the Upper Basin waters among them. The compact permits Arizona to use 50,000 acre-feet of water annually from the upper Colorado River system, and apportioned the remaining water to the Upper Basin States in the following percentages: Colorado, 51.75 percent; New Mexico, 11.25 percent; Utah, 23 percent; and Wyoming, 14 percent.

The Lower Basin States of Arizona, California, and Nevada were not able to reach agreement. In 1952, Arizona filed suit in the United States Supreme Court to determine how the waters of the Lower Basin should be divided. In October 1962, the Court ruled that of the first 7,500,000 acre-feet of mainstem water in the Lower Basin, California is entitled to 4,400,000 acre-feet, Arizona 2,800,000 acre-feet, and Nevada, 300,000 acre-feet.

The United States has contracted with the States of Arizona and Nevada and with various agencies in Arizona and California for the delivery of Colorado River water. These contracts make delivery of the water contingent upon its

Boulder City today. Lake Mead is in background.

availability for use in the respective States under the Colorado River Compact and the Boulder Canyon Project Act.

What are Mexico's rights to Colorado River water?
The United States and Mexico entered into a treaty on February 3, 1944, which guarantees Mexico 1,500,000 acre-feet of Colorado River water annually. This entitlement is subject to increase or decrease under certain circumstances provided for in the treaty.

Boulder City, Nevada

Where is Boulder City?
Boulder City is located on U.S. Highway 93, about 7 miles southwest of Hoover Dam and 25 miles southeast of Las Vegas, Nevada.

What is Boulder City's population?
The 1980 census showed the city had a population of about 9,600. This was up 83 percent from the 1970 population of 5,223. The estimated 1985 population is 11,500.
What is Boulder City's domestic water supply source?
Boulder City originally obtained its water through a water supply system and filter plant built by the Federal Government in 1931, with an additional pumping plant

and pipeline constructed in 1949. The water was taken from the penstocks at Hoover Dam and pumped to the city. In 1971, additional water became available through First Stage works of the Robert B. Griffith Water Project (formerly the Southern Nevada Water Project), which pumps water from Lake Mead. In 1982, Second Stage works of this project also began delivering Lake Mead water to Boulder City. In late 1982, the original system, badly deteriorated, was placed in a standby mode. The city now receives its entire water supply from the Griffith Project.

Did the contractor's employees live in the town during the construction period?
Yes. Part of the town was set aside for the contractor's use during the construction period. Service establishments, dormitories, mess halls, and clubhouses for the employees' use were also built, as were maintenance shops for servicing equipment.

What is the present status and form of Boulder City's government?
Boulder City's role as an isolated construction and operating camp ended with completion of Hoover Dam in 1935. Several years later, the Department of the Interior began studies for separating the community from Federal control. In 1949, Dr. Henry Reining, Jr., then professor of public administration and political science at the University of Southern California, was hired to determine how this could be accomplished. His report was the basis of an order issued by the Secretary of the Interior in 1951 which administratively separated Boulder City from the Boulder Canyon Project Act.

On September 2, 1958, President Dwight D. Eisenhower signed the Boulder City Act. This legislation authorized the Bureau of Reclamation to dispose of those properties in the community not required for continuing Federal activities and permitted the citizens to establish self-government responsive to local and State statutes.

At a special election on September 29, 1959, Boulder City residents voted overwhelmingly to create Nevada's newest chartered city. The municipality was incorporated on October 28, 1959, under Nevada law, and January 4, 1960, was established as the date of separation from the Federal Government. On that date, the contract effecting the transfer was presented to the Governor of Nevada and the mayor of Boulder City. The first mayor of Boulder City was Robert N. Broadbent who, in 1981, was named Commissioner of the Bureau of Reclamation.

The Bureau of Reclamation transferred ownership of 33 square miles, or 21,674.23 acres of land, to the incorporated city. A total of 1,021 leased residential and nonresidential lots, valued by the Federal Housing Administration at $2,393,900, was included in this area.

The Federal Government also disposed of its 179 housing units within the city. These units, appraised by the FHA at $1,224,800, were sold to Federal employees, who were priority purchasers under the act.

Municipal electric, water, and sewer systems, municipal buildings, streets, sidewalks and curbs, parks and parkways, equipment, and other property not needed by the Federal Government for its operations were also turned over to the incorporated city. Federal investment in these properties was approximately $2,500,000. School buildings and facilities in Boulder City, with a total investment of $1,552,554, were transferred to the Clark County School District of Nevada.

What is Boulder City's climate?
Boulder City, at an elevation of about 2,500 feet above sea level, experiences temperatures from 20 to 110° F. Such extremes are rare, however. The winters are usually mild, with a few light frosts. Although the summers are hot, the extremely low humidity acts as a compensatory factor. The net result is a hot, dry climate that is not nearly as exhausting as one with lower temperatures and higher relative humidity.

All-American Canal System

Is the All-American Canal System part of the Boulder Canyon Project?
Yes. The Boulder Canyon Project Act of December 21, 1928, authorized construction of a main canal from the Colorado River to the Imperial and Coachella Valleys in southern California.

Why the name "All-American"?
Because the canal is built entirely within the United States. The old Alamo Canal, which formerly served Imperial Valley, ran part way through Mexico.

Where is the All-American Canal intake?
At Imperial Dam (a diversion structure) and the All-American Canal desilting works, about 18 miles northeast of Yuma, Arizona.

What type of structure is Imperial Dam?
Imperial Dam is a concrete slab-and-buttress overflow structure that raises the river water surface about 23 feet. The headworks structure for the All-American Canal in California is located at the west abutment, and the headworks structure for the Gila Canal in Arizona is on the east abutment. The All-American Canal desilting works are located below the California headworks. The desilting works consist of three large basins, each 540 feet wide and 770 feet long. The basins remove the silt picked up by the river on its 148-mile journey from Parker Dam.

How big is the All-American Canal?
The canal's maximum width is about 232 feet at the water surface and 160 feet at the bottom. Maximum depth is 20.6 feet. Maximum carrying capacity of the canal is 15,155 cubic feet of water per second.

How long is the canal?
The canal extends westward for 80 miles through Imperial Valley. The 123-mile-long Coachella Canal branches off from

the All-American about 20 miles west of Yuma and runs northwest to a point near Indio, California, where it loops back to the south for a short distance.

What structures are built along the canal?
The usual irrigation canal checks, wasteways, and turnouts. Also, siphons or culverts are used to carry the canal under many washes, while discharge from washes is carried over the canal in concrete overchute structures. Because normal operating elevation of the water surface in the Colorado River above Imperial Dam is 179.5 feet above sea level and many of the lands are below sea level, six drop structures were also required along the canal to control the water's flow. Highway and railroad bridges span both the All-American and Coachella Canals at certain points, and flood protection works have been constructed in the Coachella Valley.

Are there power developments on the All-American Canal?
Yes. Under terms of the All-American Canal Contract of 1932, the Imperial Irrigation District was given all rights to power developments on both the All-American and Coachella Canals. To date, the developments on the All-American Canal are: Drop 2, two units of 10,000-kilowatt capacity each; Drop 3, one unit of 4,800-kilowatt capacity; Drop 4, two units of 9,600-kilowatt capacity each; and Drop 5, two units of 2,000-kilowatt capacity each. At Pilot Knob, between the canal and river, there are two units of 16,000 kilowatts each. Other facilities are currently planned for Drop 1 and the East Highline Canal Turnout.

What are the principal areas benefited by the All-American Canal system?
The Imperial Valley, the Coachella Valley, and the Yuma Project, with lands in both Arizona and California, near Yuma, Arizona.

Do Imperial and Coachella Valley water users pay for water?
Imperial and Coachella Valley water users do not pay for the use, storage, or delivery of water for irrigation or for potable purposes. They do pay the costs of construction, operation, and maintenance of Imperial Dam, the All-American Canal, and other works built under repayment contracts with the United States executed by the Imperial Irrigation District and the Coachella Valley Water District on December 1, 1932, and October 15, 1934, respectively.

Imperial Valley

Where is the Imperial Valley?
In the extreme southern part of California, bordering Mexico. The valley ranges from 234 feet below sea level to 50 feet above sea level. Average rainfall in the valley is 3 inches yearly. The growing season is 365 days.

What is the Salton Sea?
An inland sea in a depression, formerly called the Salton Sink, to the north of Imperial Valley. It was created in 1905 when the Colorado broke through temporary diversion canal headworks and poured its entire flow into the valley and the Salton Sink for 16 months.

The sea presently covers 380 square miles, is about 35 miles long, varies from 8 to 14 miles wide and has a water surface elevation of about 227 feet below sea level.

What is the irrigable area of the Imperial Valley?
About 500,000 acres.

What are its principal crops?
Alfalfa, cotton, sugar beets, winter vegetables, cantaloupes, and small grains.

Coachella Valley

Where is the Coachella Valley?
North of the Salton Sea, which separates it from the Imperial Valley. Coachella Valley ranges from about 220 feet below sea level near the Salton Sea to about 220 feet above sea level at its northern end. Like Imperial Valley, the Coachella Valley receives an average of about 3 inches of rainfall per year, and has a 365-day growing season.

What is the Coachella Valley's irrigable acreage?
About 78,500 acres may ultimately be irrigated with Colorado River water. In 1981, approximately 58,000 acres were irrigated. Prior to construction of the Coachella Canal, about 20,000 acres had been developed by pumping water from underground.

What are the principal crops grown in the Coachella Valley?
Dates, grapes, citrus fruit, winter vegetables, cotton, and alfalfa. About 90 percent of the Nation's domestic date supply is grown here.

Yuma Project

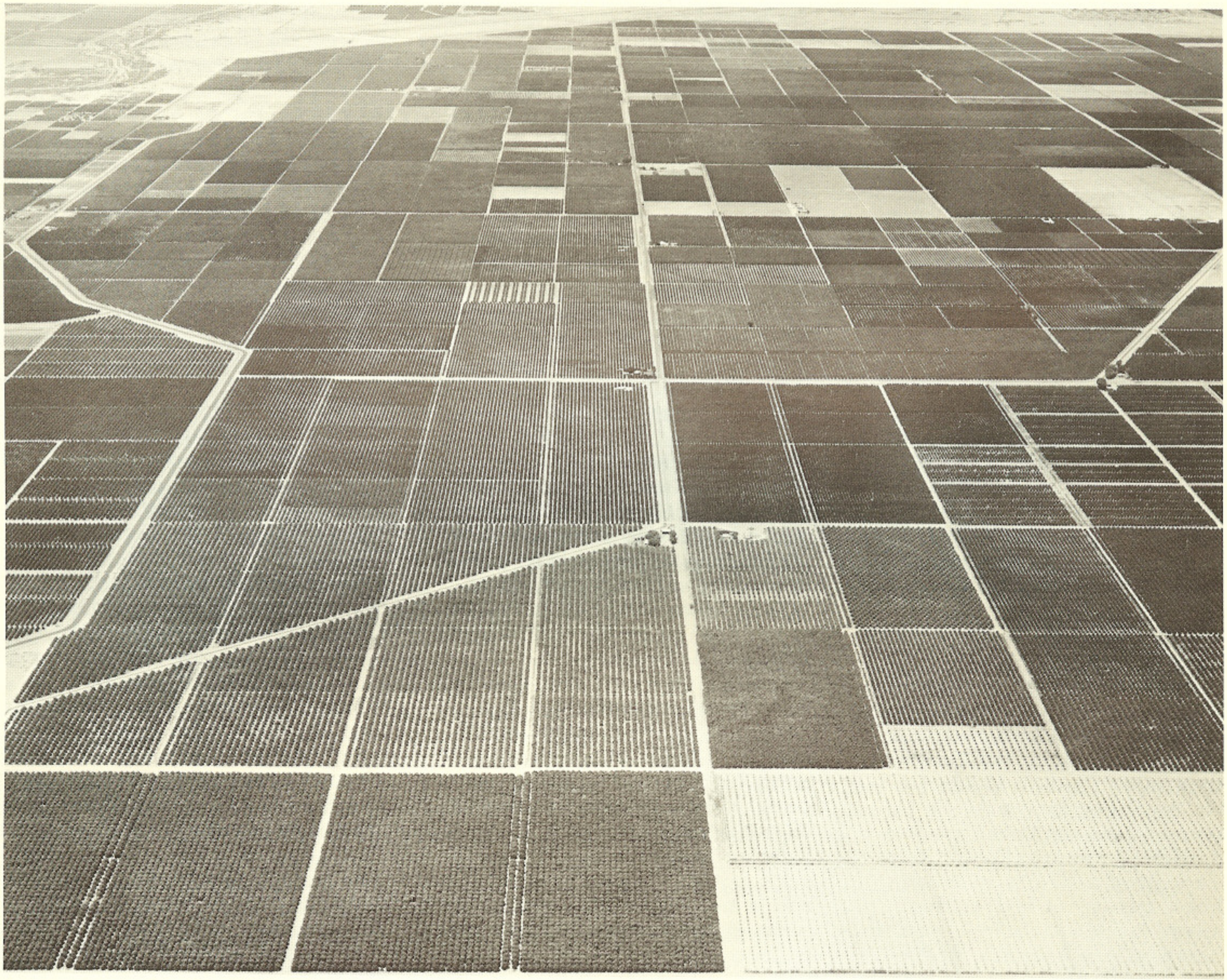
Where is the Yuma Project?
In southwestern Arizona and southeastern California, on the flood plains of the Colorado River adjacent to the city of Yuma, Arizona.

How many acres does it contain?
About 68,000—approximately 53,000 acres on the Valley Division in Arizona and 15,000 acres in the Reservation Division in California.

What are its principal crops?
Alfalfa, hay, lettuce, cotton, wheat, citrus fruit, and some dates.

What is the annual rainfall?
A little over 3 inches a year.

How long is the growing season?
365 days.



Imperial Valley farmlands

Davis Dam

Is Davis Dam part of the Boulder Canyon Project?
No, but it furthers the work of harnessing the lower Colorado begun by Hoover Dam and is included here to give a well-rounded picture of Lower Basin development.

Where is Davis Dam?
Davis Dam is in Pyramid Canyon, 67 river-miles below Hoover Dam and about 10 miles north of the point where Arizona, Nevada, and California meet. The dam is 32 miles west of Kingman, Arizona, and can be reached by highways Arizona 68 and Nevada 77, which cross the river on the crest of the dam.

How did Davis Dam get its name?
The project originally was named Bullshead after a rock formation in the river near the damsite which was said to resemble the head of a bull. In 1941, it was renamed in honor of Arthur Powell Davis, director of Reclamation from 1914 to 1923. Davis's courage, foresight, and vision helped spark the beginning of Colorado River development.

When did construction of Davis Dam begin?
The dam was authorized in April 1941, and construction began in August 1942. Some excavation was undertaken, but the demands of World War II halted work in December of the same year. Work resumed in March 1946.

When was Davis Dam completed?
The main dam embankment was completed in April 1949. The intake and spillway structures were substantially completed the same month. The six temporary diversion openings of the spillway structure were closed in January 1950, and first storage of water in the reservoir began. The powerhouse was completed in October 1950, the first unit went on line in January 1951, and all five units were operating by mid-June 1951. The dam and powerplant were dedicated in December 1952.

What type of structure is Davis Dam?
It is an earth and rockfill embankment with a concrete spillway, intake structure, and powerplant. It has a crest length of 1,600 feet and a top width of 50 feet. It rises 200 feet above the lowest point of the foundation and about 128 feet above the river surface.

What are the purposes of Davis Dam?
Davis Dam generates electric power for Arizona, southern California, and southern Nevada; helps regulate the Colorado River; and services provisions of the Mexican Water Treaty of 1944. Its reservoir, Lake Mohave, is also a significant Southwestern recreation area.

How big is Lake Mohave?
Lake Mohave, which can store 1,818,300 acre-feet of water, extends 67 miles upstream to the tailrace of Hoover Powerplant.

How much power is developed?
The Davis powerplant, with an installed capacity of 225,000 kilowatts provided by five 45,000-kilowatt semi-outdoor-type generators, generates more than 1,000,000,000 kilowatt-hours a year.

Parker Dam

Is Parker Dam part of the Boulder Canyon Project?
No, but construction of Parker Dam would have been impossible if Hoover Dam had not been built.

What type of structure is Parker Dam?
Parker Dam is a concrete-arch structure, with five 50- by 50-foot Stoney gates at its crest to control releases from its reservoir, Lake Havasu. The dam has a structural height of 320 feet, with 65 percent of that height located below the riverbed; only 85 feet of the dam extends above the riverbed.

What is the dam's purpose?
The primary purpose of Parker Dam is to provide a reservoir from which water can be pumped into the Metropolitan Water District of Southern California's (MWD) Colorado River Aqueduct. The dam and powerplant were constructed with funds advanced by MWD for this purpose.

Parker also has other uses. It generates hydroelectric power; captures floodflows from the Bill Williams River, a Colorado River tributary below Davis Dam; and reregulates water releases from Hoover and Davis Powerplants. In creating Lake Havasu, the dam also created Topock Marsh, a major Southwest fish and wildlife habitat that is part of the Havasu National Wildlife Refuge. Lake Havasu is also a major Southwestern recreation spot. Beginning in 1985, water for the Central Arizona Project will be pumped from Lake Havasu to begin a nearly 300-mile journey into Arizona's midsection.

How large is the Parker powerplant and how is its production allocated?
Four hydroelectric generating units, each with a 30,000-kilowatt capacity, give the powerplant an installed capacity of 120,000 kilowatts. About 50 percent of the plant's annual output is reserved by MWD for pumping water along the Colorado River Aqueduct. The remaining power is marketed in Arizona, southern Nevada, and southern California by the Western Area Power Administration, a Department of Energy agency.

Who owns the dam?
Parker Dam, powerplant, and appurtenant works are owned by the United States. The powerplant is operated by the Bureau of Reclamation, which also controls all water passing over the dam.

Colorado River Aqueduct

Is the Colorado River Aqueduct part of the Boulder Canyon Project?
No. The aqueduct was built by the Metropolitan Water District of Southern California to transport water pumped from Lake Havasu above Parker Dam to the Pacific Coast, primarily the Los Angeles area.

What is the Metropolitan Water District?
The Metropolitan Water District of Southern California (MWD) is a public corporation formed in 1928 to obtain additional domestic water for the southern California region. Colorado River water pumped from lake Havasu by the MWD serves more than 130 municipalities.

The District can pump up to 1,212,000 acre-feet of Colorado River water each year until the Central Arizona Project goes on line in 1985. The District's annual allotment will then be reduced to 550,000 acre-feet per year. In 1981, MWD pumped almost 814,000 acre-feet of water to about 12,000,000 people in its service area.

Where does MWD obtain electrical energy for pumping and other operational needs?
From the Hoover and Parker Dam powerplants and steam purchases. This energy, transmitted over lines constructed by the district, lifts the water 1,617 feet through five pumping plants between Lake Havasu and its final destination.

Hoover Dam Sculptures

One of the highlights for many of the people who visit Hoover Dam each year is the sculpture work they find. While most people are impressed by these works, they often ask the question "What do they mean?"

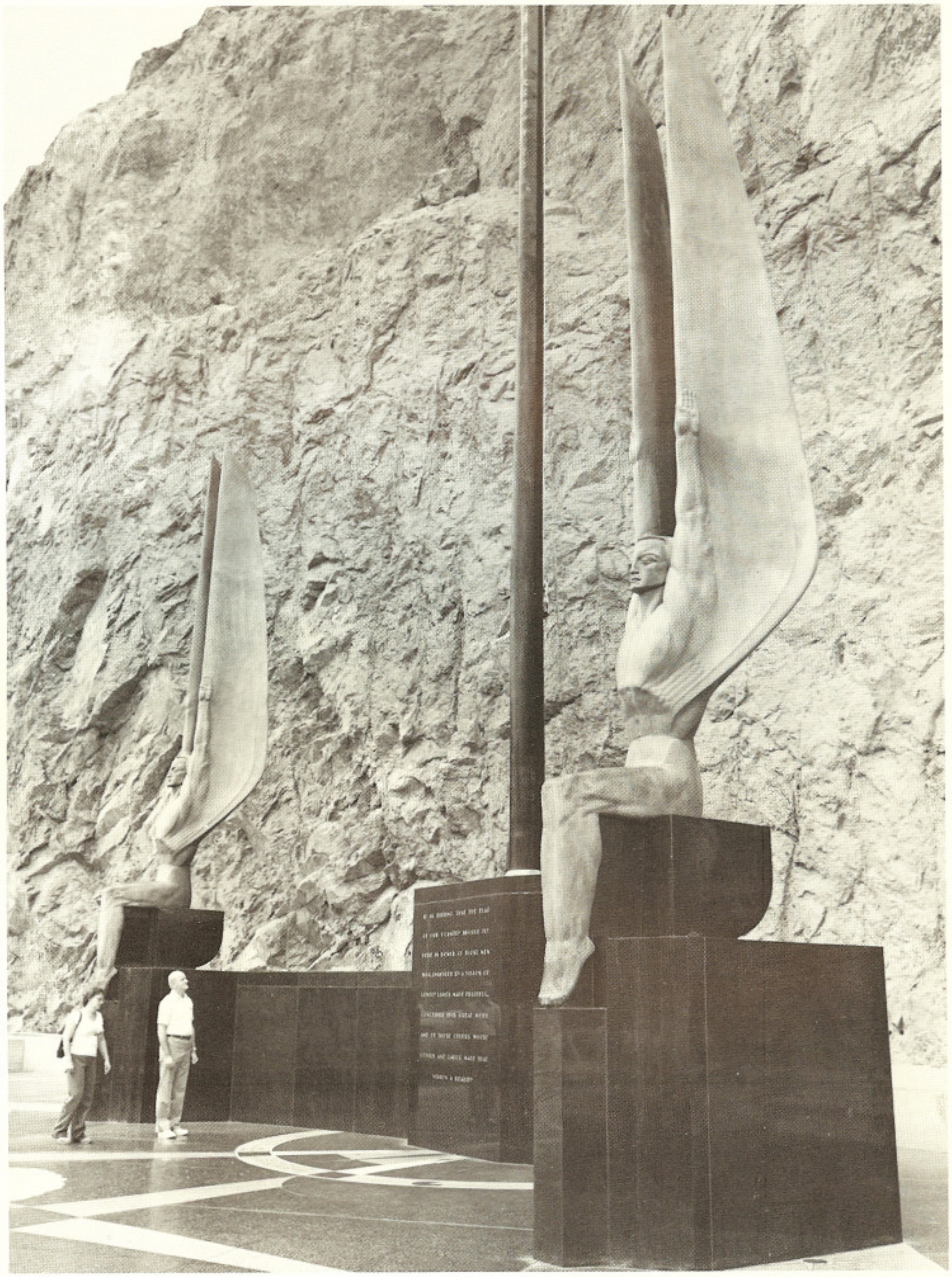
Much of the sculpture is the work of Norwegian-born, naturalized American Oskar J.W. Hansen. Mr. Hansen fielded many questions about his work while it was being installed at the dam. In response to those questions, he later wrote about his interpretation of his sculptures.

Hoover Dam, said Hansen, represented for him the building genius of America, "a monument to collective genius exerting itself in community efforts around a common need or ideal." He compared the dam to such works as the great pyramids of Egypt, and said that, when viewing these man-made structures, the viewer often asks of their builders "What manner of men were these?"

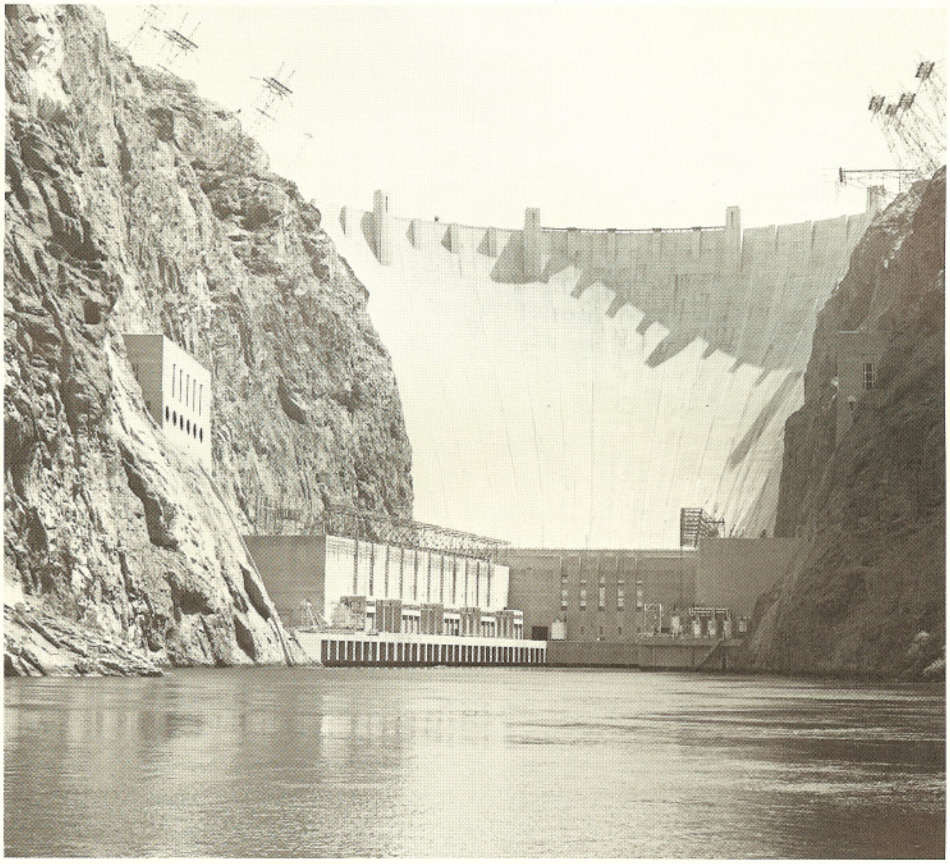
The sculptor, according to Hansen, tries to answer this question objectively, by "interpreting man to other men in the terms of the man himself." In each of these monuments, he said, can be read the characteristics of these men and on a larger scale, the community of which they are part. Thus, mankind itself is the subject of the sculptures at Hoover Dam.

Hansen's principal work at Hoover Dam is the monument of dedication on the Nevada side of the dam. Here, rising from a black, polished base, is a 142-foot flagpole flanked by two winged figures, which Hansen calls the Winged Figures of the Republic. They express ". . the immutable calm of intellectual resolution, and the enormous power of trained physical strength, equally enthroned in placid triumph of scientific accomplishment."

"The building of Hoover Dam belongs to the sagas of the daring. The winged bronzes which guard the flag therefore wear the look of eagles. To them also was given the vital upward thrust of an aspirational gesture; to symbolize the readiness for defense of our institutions and keeping of our spiritual eagles ever ready to be on the wing".



Winged Figures of the Republic at Hoover Dam pay tribute to those who conceived and built it.



Calm waters below Hoover Dam attest to its success in controlling and regulating the Colorado River.

The winged figures are 30 feet high. Their shells are 5/8-inch thick, and contain more than 4 tons of statuary bronze. The figures were formed from sand molds weighing 492 tons. The bronze that forms the shells was heated to 2,500° Fahrenheit, and poured into the molds in one continuous, molten stream.

The figures rest on a base of black diorite, an igneous rock. In order to place the blocks without marring their highly polished finish, they were centered on blocks of ice, and guided precisely into place as the ice melted. After the blocks were in place, the flagpole was dropped through a hole in the center block into a predrilled hole in the mountain.

Surrounding the base is a terrazzo floor, inlaid with a star chart, or celestial map. The chart preserves for future generations the date on which President Franklin D. Roosevelt dedicated Hoover Dam — September 30, 1935.

The apparent magnitudes of stars on the chart are shown as they would appear to the naked eye at a distance of about 190 trillion miles from earth. In reality, the distance to most of the stars is more than 950 trillion miles.

In this celestial map, the bodies of the solar system are placed so exactly that those versed in astronomy could calculate the precession (progressively earlier occurrence) of the Pole Star for approximately the next 14,000 years. Conversely, future generations could look upon this monument and determine, if no other means were available, the exact date on which Hoover Dam was completed.

Near the figures and elevated above the floor is a compass, framed by the signs of the zodiac.

Hansen also designed the plaque commemorating the 96 men who died during the construction of Hoover Dam, as well as the bas-relief series on both the Nevada and Arizona elevator towers.

The plaque, originally set into the canyon wall on the Arizona side of the dam, is now located near the winged figures. It reads:

"They died to make the desert bloom. The United States of America will continue to remember that many who toiled here found their final rest while engaged in the building of this dam. The United States of America will continue to remember the services of all who labored to clothe with substance the plans of those who first visioned the building of this dam."

The five bas-reliefs on the Nevada elevator tower, done in concrete, show the multipurpose benefits of Hoover Dam—flood control, navigation, irrigation, water storage, and power.

On the Arizona elevator tower is a series of five bas-reliefs, also in concrete, depicting "the visages of those Indian tribes who have inhabited mountains and plains from ages distant." Accompanying the illustrations is the inscription, "Since primordial times, American Indian tribes and Nations lifted their hands to the Great Spirit from these ranges and plains. We now with them in peace buildeth again a Nation."

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

U.S. Department of the Interior
Bureau of Reclamation

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