All American Canal System

Nomination for National Historic Civil Engineering Landmark

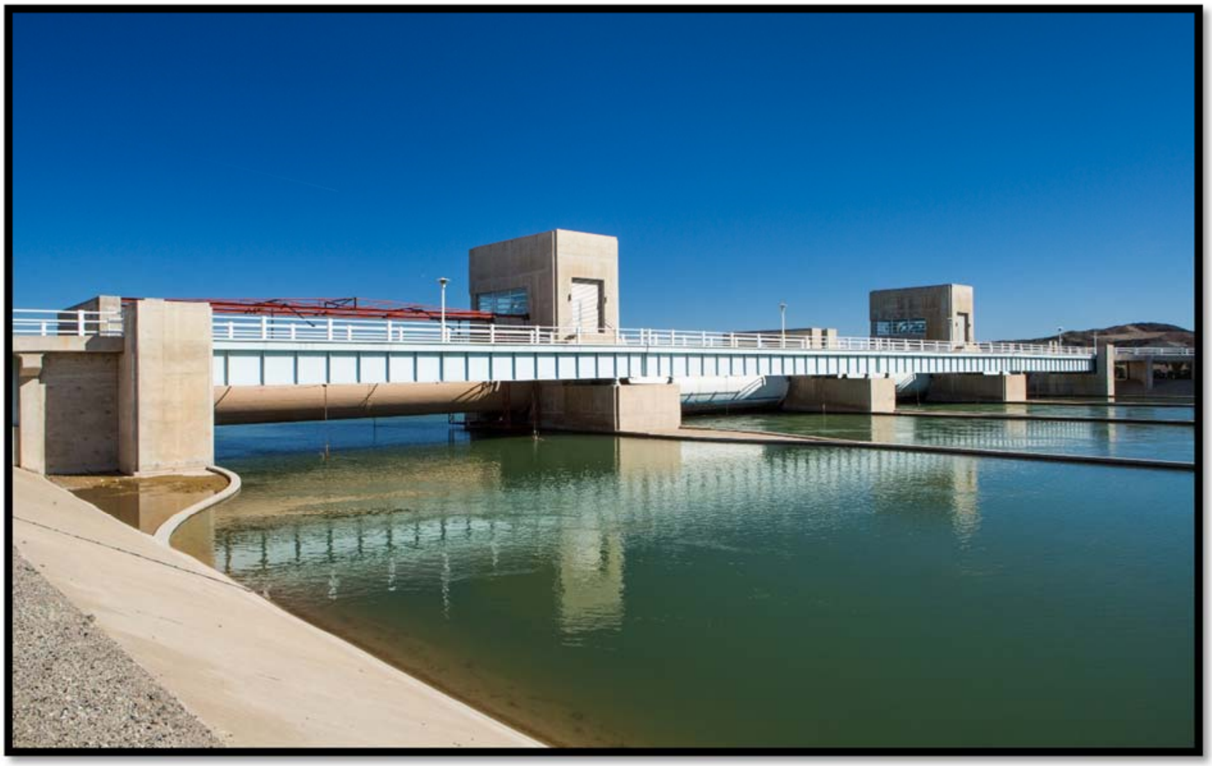
September 15, 2015

Owner:
Unites States Bureau of Reclamation

Operator:
Imperial Irrigation District

Prepared By:
American Society of Civil Engineers, San Diego Section

Philip R. Kern, PE M.ASCE
Chair, Historical Landmarks Committee



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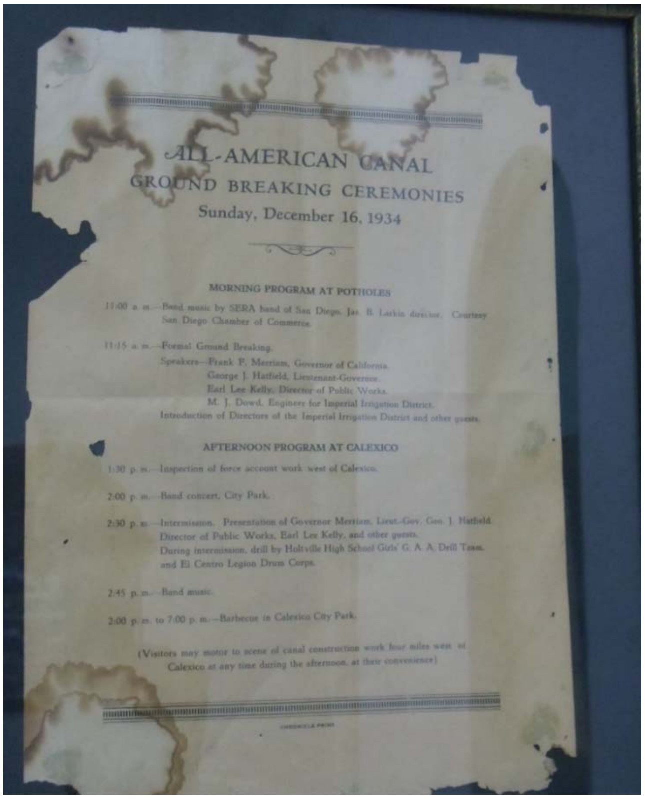
1. Date of construction (and other significant dates)

The All American Canal (AAC) system was authorized by the US Congress on December 31, 1928 as part of the Boulder Canyon Project Act. Other elements of this authorization included Boulder (now Hoover) Dam, Imperial Dam, and the Coachella Canal. Groundbreaking ceremonies were held on December 16, 1934 at “Potholes” (the site of Imperial Dam) in the morning and at Calexico, 70 miles away, in the afternoon. Actual construction took place from 1935-38 with the first water deliveries made in 1940. The canal system was fully operational that year and became the sole source of water for the Imperial Valley by 1942.



ALL-AMERICAN CANAL
GROUND BREAKING CEREMONIES
Sunday, December 16, 1934

MORNING PROGRAM AT POTHOLES

11:00 a. m.—Band music by SERA band of San Diego, Jas. B. Larkin director. Courtesy San Diego Chamber of Commerce.

11:15 a. m.—Formal Ground Breaking.
Speakers—Frank F. Merriam, Governor of California.
George J. Hatfield, Lieutenant-Governor.
Earl Lee Kelly, Director of Public Works.
M. J. Dowd, Engineer for Imperial Irrigation District.
Introduction of Directors of the Imperial Irrigation District and other guests.

AFTERNOON PROGRAM AT CALEXICO

1:30 p. m.—Inspection of force account work west of Calexico.

2:00 p. m.—Band concert, City Park.

2:30 p. m.—Intermission. Presentation of Governor Merriam, Lieut.-Gov. Geo. J. Hatfield Director of Public Works, Earl Lee Kelly, and other guests.
During intermission, drill by Holtville High School Girls' G. A. A. Drill Team, and El Centro Legion Drum Corps.

2:45 p. m.—Band music.

2:00 p. m. to 7:00 p. m.—Barbecue in Calexico City Park.

(Visitors may motor to scene of canal construction work four miles west of Calexico at any time during the afternoon, at their convenience)

CHRONICLE PRINT

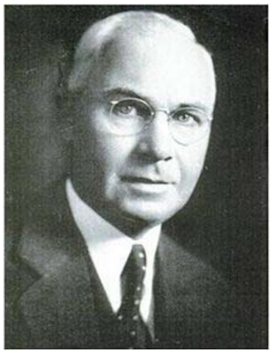
Original agenda for the groundbreaking ceremonies for the All American Canal. Courtesy of Imperial County Department of Public Works.

The AAC system has had few improvements or major repairs since being completed nearly 75 years ago, a testament to the quality and durability of the original design and construction. Hydroelectric facilities have been added from shortly after completion of the canal, up until the mid-1980s. Off-line storage facilities were added between 2008 and 2010 in the form of Brock Reservoir near Drop 2 and as part of the AAC lining project.

Losses due to seepage from the canal were known to be problematic and constituted a loss of 70,000 acre feet per year. These losses were originally considered unrecoverable. A solution was authorized by Public Law 100-675 in 1988, a final Record of Decision was signed in 1994, design of a 23 mile lined, parallel canal was authorized in 2006, and construction of the canal lining project was completed in 2010.

2. Name of key civil engineer and other professionals associated with project

The All American Canal system was designed under the supervision of John L. Savage, Chief Designing Engineer of the US Bureau of Reclamation (USBR) from 1924-1945.



John Lucian Savage was born on December 25, 1879 in Cookesville, Wisconsin. During summers, while attending college at the University of Wisconsin, he worked on government survey crews, and graduated with a degree in civil engineering in 1903. Savage worked for the Idaho Division of the USBR for the first time from 1903-08, and worked on his first dam and canal system during this period. In 1908 he left USBR for private consulting and joined A.J. Wiley Engineering Associates in Boise, Idaho. Business boomed due to expansion in the western states and he continued to consult as a specialist in the design of dams, canal systems and hydropower plants. Savage returned to USBR and served as the first designing engineer, and then as Chief Designing Engineer starting in 1924 and continuing until his retirement in 1945. Due to his demonstrated talent and abilities he was given free rein by the Chief Engineer of USBR and delivered many notable water supply projects in the west, including Hoover (originally Boulder) Dam, Parker Dam, Grand Coulee Dam, Shasta Dam, Imperial Dam and the All American Canal System.

Savage was aware of his unique talents and was willing to apply them where needed. Existing law prohibited Federal employees from accepting money from foreign countries but there were demands from abroad for Savage's services. When the government of New South Wales in Australia requested his help with a potentially failing dam, he offered his services pro bono and even declined reimbursement for his travel expenses to avoid running afoul of the law. In 1941, the US Congress actually passed a new law allowing him to consult internationally. He eventually provided consulting engineering on hundreds of dam projects in many different countries including Australia, Mexico, Afghanistan, India, Palestine, China and Spain; all while an employee of the US government. His penultimate project would not be completed until 60 years after his initial involvement: the Three Gorges Dam on the Yangtze River.

Following his retirement from USBR in 1945, Savage continued to consult internationally in many countries and was recognized with a host of honors and awards. He was awarded the John Fritz Medal by the American Association of Engineering Societies in 1945, was elected to the National Academy of Sciences in 1949, and received honorary degrees in the sciences and engineering from the University of Wisconsin, University of Denver and the University of Colorado. It has been estimated that one in five people in the 17 western states receive their water supply from facilities designed under John L. Savage's supervision.

3. Historic (national or local) significance of this project

The AAC system is the largest water supply and irrigation canal in terms of capacity in the United States. Although there are longer aqueduct systems in the US, with a capacity of 15,155 cubic feet per second (cfs) the All American Canal conveys flows significantly higher than either the California Aqueduct, Central Arizona Project (Hayden-Rhodes Aqueduct), Colorado River Aqueduct, Los Angeles Aqueduct, Delaware Aqueduct or the Catskill Aqueduct as seen in the table in Section 4 of this nomination.

The 80-mile-long canal system irrigates over 630,000 acres of agricultural lands and provides domestic water service to nine communities and municipalities with a combined population of over 150,000 residents. This essential and reliable water source combined with the favorable weather in the area has been instrumental in facilitating the development of the Imperial and Coachella Valleys and established them as one of the premier year-round agriculture producing regions in the US, particularly for winter crops that cannot be grown in other regions. The water supplied by the AAC to the region has created an agricultural “breadbasket” that serves the entire southwestern US and the nation as a whole.

Conceived and developed in the depths of the Great Depression, the AAC brought jobs to thousands in a region that was struggling even more than the rest of the nation. The engineering challenges were confronted and conquered in a way that created a unique and enduring water supply facility that has survived natural disasters and proved to be adaptable to future needs.

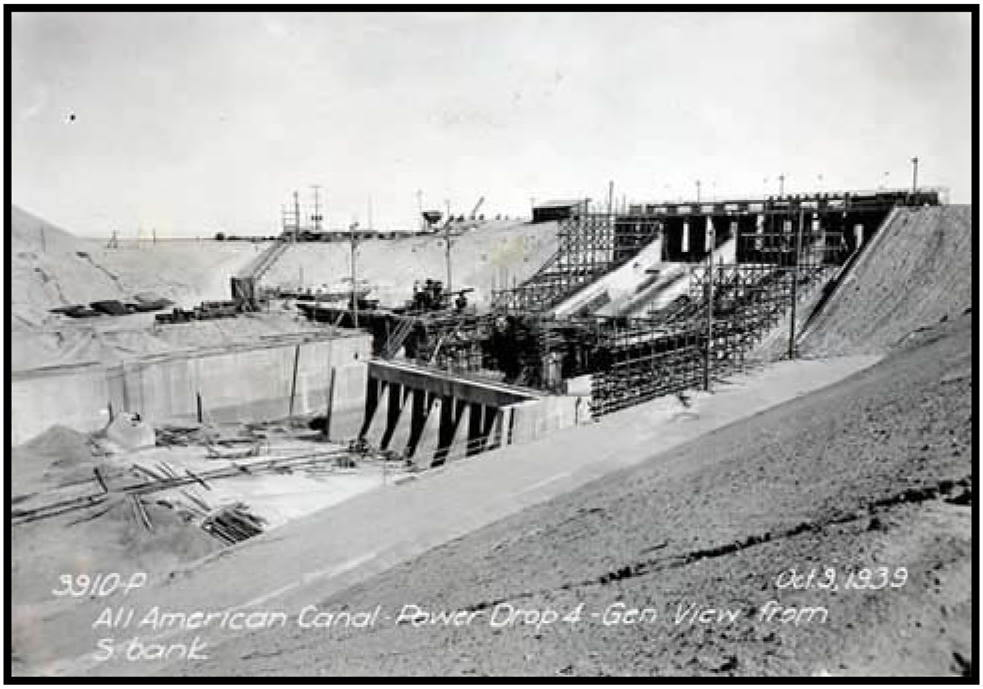
The design team, led by noted civil engineer John L. Savage, innovatively resolved issues with silt laden river waters, threaded the canal through 250 foot high sand dunes, economically solved crossings of natural watercourses, foresaw the need for future renewable power and designed earthquake resistant structures located in one of the most seismically active areas in the continental US. The design has proven to be flexible and adaptable enough to allow the addition of a concrete lining to reduce seepage, additional hydropower facilities and storage facilities to recover seasonal water resources that otherwise might be lost.

Based on innovative design features and the ability to foresee future environmental impacts, the All American Canal System has withstood the test of time

4. Comparable or similar projects

The All American Canal system is the largest capacity water supply canal in the United States, if not in the world. Comparable facilities are shown below.

Facility	Capacity (cfs)	Length (miles)
All American Canal	15,155	80
California Aqueduct	13,000	715
Central Arizona Project (Hayden-Rhodes Aqueduct)	3,000	336
Delaware Aqueduct	2,000	115
Colorado River Aqueduct	1,600	242
Los Angeles Aqueduct (1st & 2nd Aqueducts)	1,000	419
Catskill Aqueduct	850	163



**All American Canal Power Drop 4 –Gen View from S-Bank. Oct 3, 1939.
Courtesy of Imperial County Department of Public Works.**

5. Unique features or characteristics

In solving the challenges of the project, the All American Canal features a number of design solutions that were unique and innovative at the time the system was developed in the 1930s. These features include the Imperial Dam, desilting works, large diameter dual inverted siphons at the New River, incorporation of low-head hydroelectric facilities, crossing of the Imperial Sand Dunes and maintaining connections to the existing network of distribution canals. The quality of the original design of the All American Canal system has also been proven through its durability; long term performance; and its ability to be upgraded over time through the addition of more hydroelectric facilities, lining of the canal to reduce seepage losses and the incorporation of storage facilities along its length.

Imperial Dam & Desilting Works-Prior to development of the AAC the water supply system for southeast California and southwest Arizona was plagued by periodic floods and sediment problems from the heavily silt-laden Colorado River waters. Constant dredging and maintenance was required for conveyance canals, diversion and flow control facilities, while pipelines were essentially unusable due to siltation problems, requiring difficult and costly maintenance. The entire AAC system, including Imperial Dam, was designed by the USBR under the supervision of John L. Savage. With Hoover Dam, also designed by Savage's team, controlling flood flows from the Colorado, Savage's designers could focus their attention on controlling the siltation issue. Flows into the AAC are regulated at the headworks, which consist of a motorized trash rack system, and four 75-foot-long by 22-foot-high roller gates, each including an apron and flash weir. Downstream of each gate is a concrete lined channel which carries water to three desilting basins. The fourth channel is designed to function as either a bypass or fourth desilting basin. Each basin is separated into halves by a tapered channel and an upstream bulkhead with vertical slots to slow and equalize flows. The silt settles to the bottom due to the low velocity of the flow through the basins, and is directed into drains by a system of motorized rotating scrapers and then flushed out through a piping system under the canal and into the California Sluiceway. Clear water near the surface flows over the downstream weirs and into the All American Canal. Sediment deposited in the sluiceway is periodically flushed out by short duration high rate flows, typically 12,000 cfs for 20 minutes. The three desilting basins are capable of removing up to 70,000 tons of silt per day.

New River Inverted Siphons-The AAC operates entirely by gravity from Imperial Dam to the Westside Main Canal 80 miles away. One challenge to the designers was the crossing of the 50-foot-deep valley of the New River just west of Calexico, CA with a facility to convey over 2,600 cfs to the western portion of the Imperial Irrigation District's (IID's) service area. The design team's solution was to install two parallel 196-inch-diameter steel plate siphons supported by reinforced concrete piers across the valley between the inlet and outlet structures. The siphons were constructed above the flood level of the New River but were less expensive than a bridge or similar structure built at the hydraulic grade line of the canal. The dual siphons also allow one to be taken out of service for maintenance while still delivering water to customers, although at a reduced rate, via the canal. Constructed in 1937, it is believed that these were the largest diameter inverted siphons constructed under USBR purview until construction of the Central Arizona Project in 1975.

On Easter Day 2010, the siphon structures were damaged by the 7.2 magnitude Cocopah-El Mayor earthquake centered 29 miles southeast of Mexicali, B.C. During the joint agency damage assessment, it was determined that the ground shaking had caused fill materials to consolidate beneath the concrete-lined wasteway (overflow spillway) near the inlet structure on the east side, drastically increasing seepage, and caused cracking and settlement around other concrete structures. The siphons and supports were relatively undamaged after 70 years of service in a corrosive environment and in a seismic event they were likely not designed for. Pressure injection grouting, installation of concrete piles, embankment stabilization and reinforcing of the wasteway structure (spillway) addressed the voids created beneath the slab and provided additional stability for the structure. Repair of this critical facility was completed on October 10, 2011 at a total cost of $4.8 million, about one fifth of the original cost of the entire canal system in 1944 dollars.

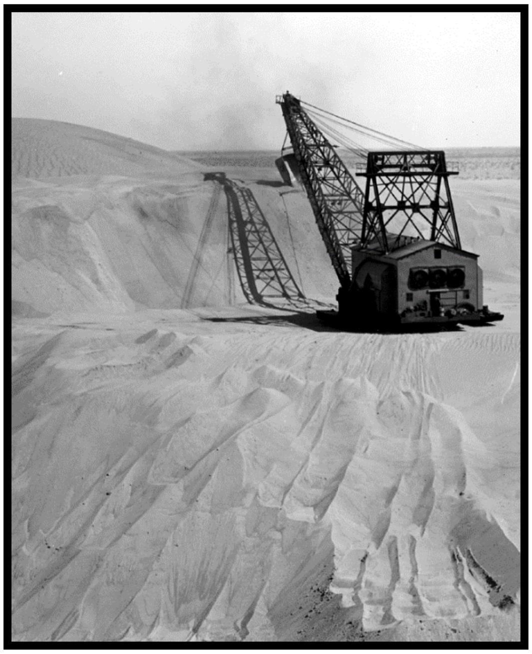
Low-head Hydroelectric Facilities-IID originally installed hydroelectric facilities on the All American Canal as a way to provide limited power for operations and to generate a small revenue stream to pay back the construction loan from the US government for the canal and related facilities, as required by the Boulder Canyon Project Act. The All American Canal featured one of the first uses of low-head (25 foot drop) hydroelectric facilities when hydroelectric equipment was installed at Drops 3 and 4 in 1941 shortly after the original canal construction was completed. When this was found to be successful, hydroelectric facilities were later installed at Drop 2 in 1952, Drop 5 in 1982, Drop 1 and the East Highline Turnout in 1984. A larger facility, Pilot Knob Power Plant, which was constructed in 1957, generates free energy from Colorado River flows that are passed through the All American Canal on their way to Mexico under treaty requirements. Total vertical drop of the All American Canal in its 80 mile length is only 175 feet, less than many large dams.

In accordance with the original contract between IID and the USBR, the construction loan of $25,020,000 was fully repaid over a 50-year period in 1994; however, the USBR continues to retain ownership of the All American Canal. With the construction loan paid off, the hydroelectric facilities have now been incorporated into IID’s suite of power generating facilities serving the Imperial Valley and surrounding areas.

All American Canal Lining Project- The original canal was lined with concrete only where dictated by hydraulic or structural needs. For most of its length it was an unlined earthen channel built in porous desert sands, including construction of the section through the Imperial Sand Dunes, a major challenge for the original project. The seepage was known by the designers to be a problem for the sections of the canal in alluvial soils west of Pilot Knob, but it was not considered economically feasible to resolve this issue at the time of initial construction. It is estimated that over 70,000 acre-feet per year was being lost to seepage just from the 23 mile segment of the canal near the dunes, enough to create significant wetlands and supply agricultural operations on the Mexican side of the border.

Beginning in 1988, a series of events began to unfold that would potentially lead to resolution of the seepage issue. That year Public Law 100-675 authorized construction of a parallel lined canal. It did not provide any federal funding, but did authorize the use of funds from water agencies receiving Colorado water. Environmental documents were completed jointly by IID and USBR. The original Record of Decision was approved in 1994, including mitigation of the impacts to wetlands created by the canal. Rights to the recovered water and funding for the project remained unresolved at this time.

California had long been dependent on surplus flows from the Colorado River to supply its water demands, but growth in other Western states and development of the infrastructure to take their share of the water was bringing that to an end. Approval of the Quantification Settlement Agreement (QSA) in 2003 resolved competing claims to the water between the states, Mexico and Native American interests and, equally importantly, laid the legal foundation for the largest agricultural to urban transfer of conserved water in the US. That year the California legislature also appropriated the funding for the lining project, later supplemented by funds from the San Diego County Water Authority. Although design of the project was completed, legal and environmental delays lingered until Congress directed the Secretary of the Interior in 2006 to complete the project "without delay." Construction was commenced in June 2007 and ultimately finished in early 2010.



Imperial Sand Dunes Crossing-The Imperial Sand Dunes are located between Yuma, AZ and El Centro, CA and are about 6 miles wide by 45 miles long, extending nearly from the Chocolate Mountains in the north to past the Mexican border in the south. To stay within the US, the canal alignment would need to pass through the shifting sands of the dunes at some point. The dunes trend in a southeast-northwest direction due to the prevailing winds coming from the southwest. Rather than punching due west through the dunes, the most direct route but one which would expose the canal to a broadside of drifting sand, the designers paralleled the dunes northwesterly on the east side for several miles before turning southwest. With this alignment the constantly moving dunes drift parallel to the canal without filling it with sand. The selected alignment had the added benefit of following the Buttercup Valley which vastly reduced the amount of excavation required.

Storage Facilities-One of the principal issues with the original All American Canal system (and the lower Colorado River in general) was the lack of storage below Parker Dam. Imperial Dam is a diverting structure only; it no longer provides any significant storage. At the time of construction Imperial Dam impounded 85,000 acre-feet, because of siltation this volume has now been reduced to about 1,000 acre-feet. This was anticipated in the original design and even now regular dredging is required to maintain diversion capacity to the All American Canal on the west and to the Yuma Gravity Canal on the east. Water ordered for irrigation purposes is released at the dam but may be lost downstream to the Salton Sea if the customer is unable to take delivery at the appropriate time. The All American Canal system proved to be flexible enough to allow the addition of the 8,000-acre-foot Brock Storage Reservoir near Drop 2 in 2008-10 to capture surplus flows below the dam and return them back to the system. Parallel storage facilities were also developed as part of the AAC lining project. USBR has also developed an off line pumped storage project at Senator Wash two miles north of Imperial Dam to take advantage of surplus flows in the Colorado, with the added bonus of the generation of electricity when the water is released downstream.

Connections to Existing Distribution Canals-In the 1930s the Imperial Valley had a partially developed agricultural water distribution system operated by IID. The design of the AAC had to work with the existing distribution system, provide for expansion of the system to the West Mesa and East Mesa areas as well as respect rights of way IID had already established in the Valley, all while delivering water by gravity alone. The designers strategically located Imperial Dam 25 miles northeast of Yuma at a significantly higher elevation than the headworks for the Alamo Canal, the AAC's predecessor, which allowed gravity supply to the East and West Mesas as well as Coachella Valley far to the north. The incorporation of five reinforced concrete drop structures into the design allowed the AAC to intercept the existing distribution system where the Alamo Canal crossed the international border just east of Calexico, with the added benefit of hydropower generation at the drops. In a unique solution to a unique issue, USBR engineers also designed a structure near the border that carries both Anza Road and the New Briar Canal over the All American Canal, with the cells of the bridge serving as a siphon for IID's smaller distribution canal.

6. Contribution towards a) civil engineering profession and b) nation or large region

a) The All American Canal system was originally authorized as part of the Boulder Canyon Act in 1928, a key part of that program being the construction of Hoover Dam (known at the time as Boulder Canyon Dam). As described in Section 5 of this nomination, the design of the original AAC and subsequent enhancements contributed significantly to the engineering profession through innovative solutions to unique and challenging problems.

b) Prior to construction of the All American Canal system, the arid region of southeastern California and southwestern Arizona was served by an unreliable and high maintenance water supply system that was subject to periodic flooding, ongoing siltation of the conveyance facilities, significant losses due to infiltration and the international political complexities of delivery facilities that were routed through Mexico. As detailed in Section 3 of this nomination, the water supplied by the AAC to the region has created a year round agricultural “breadbasket” that serves the entire southwestern US and the nation as a whole. In addition, because the project was conceived and developed in the depths of the Great Depression, the AAC brought jobs to thousands in a region that was struggling even more than the rest of the nation.

7. List of Published References

a. “Digging the World’s Biggest Ditch”, *Popular Science Monthly*, Volume 129, Number 4, (October 1936) Popular Science Publishing Company, Inc. New York

b. Wolman, Abel and Lyles, W.H., (1978) “John Lucian Savage 1879-1967”, National Academy of Sciences, Washington, DC

c. American Society of Civil Engineers, “John Lucian Savage, ASCE Engineer”, www.asce.org/

d. US Bureau of Reclamation, “The Boulder Canyon Project-All American Canal System”, (February 2012), www.usbr.gov

e. US Bureau of Reclamation, “The Boulder Canyon Project-Hoover Dam”, (February 2012), www.usbr.gov

f. Jackson, Donald C. (1988), “Great American Bridges and Dams”, The Preservation Press, Washington, DC

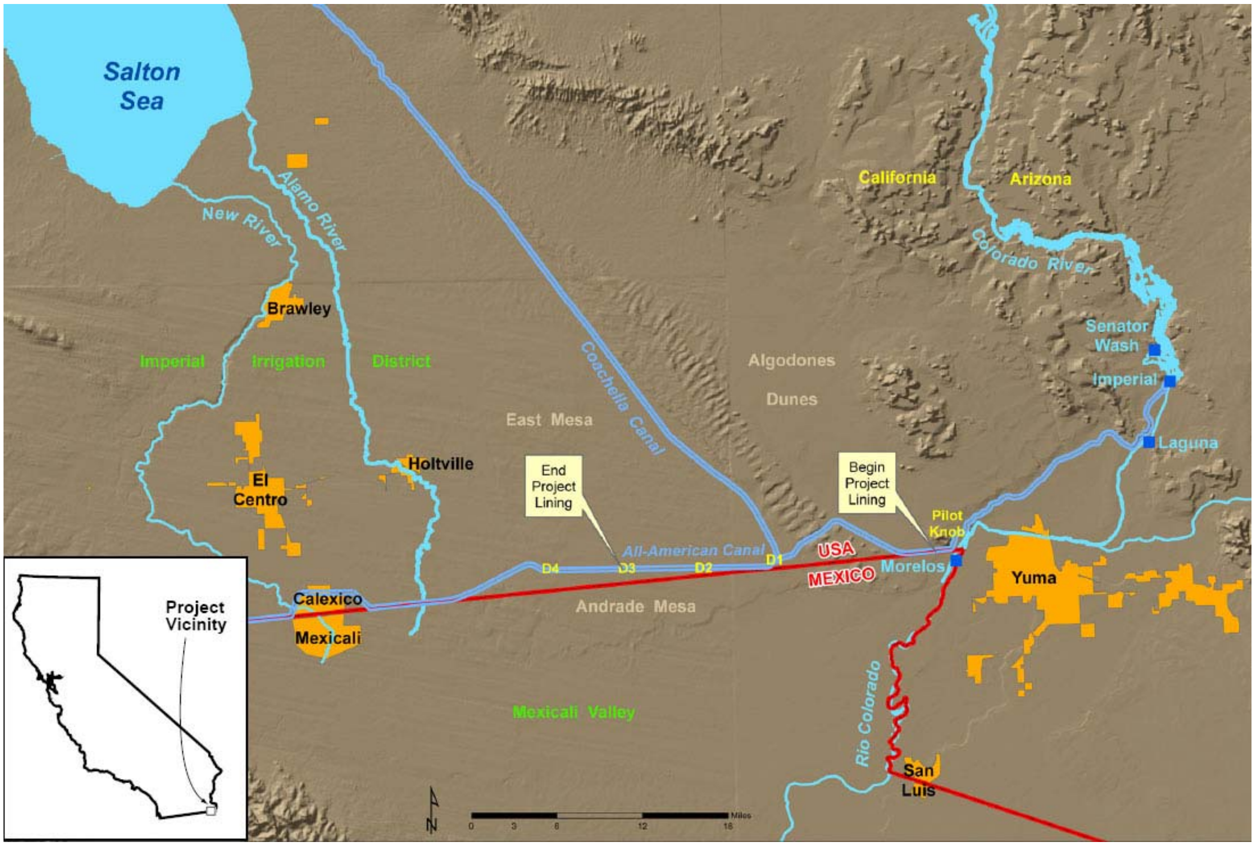
g. Dowd, M.J., “IID: The First 40 Years”, (1956), Imperial Irrigation District, Imperial, CA

h. Imperial Irrigation District, “IID History”,(undated), www.iid.com

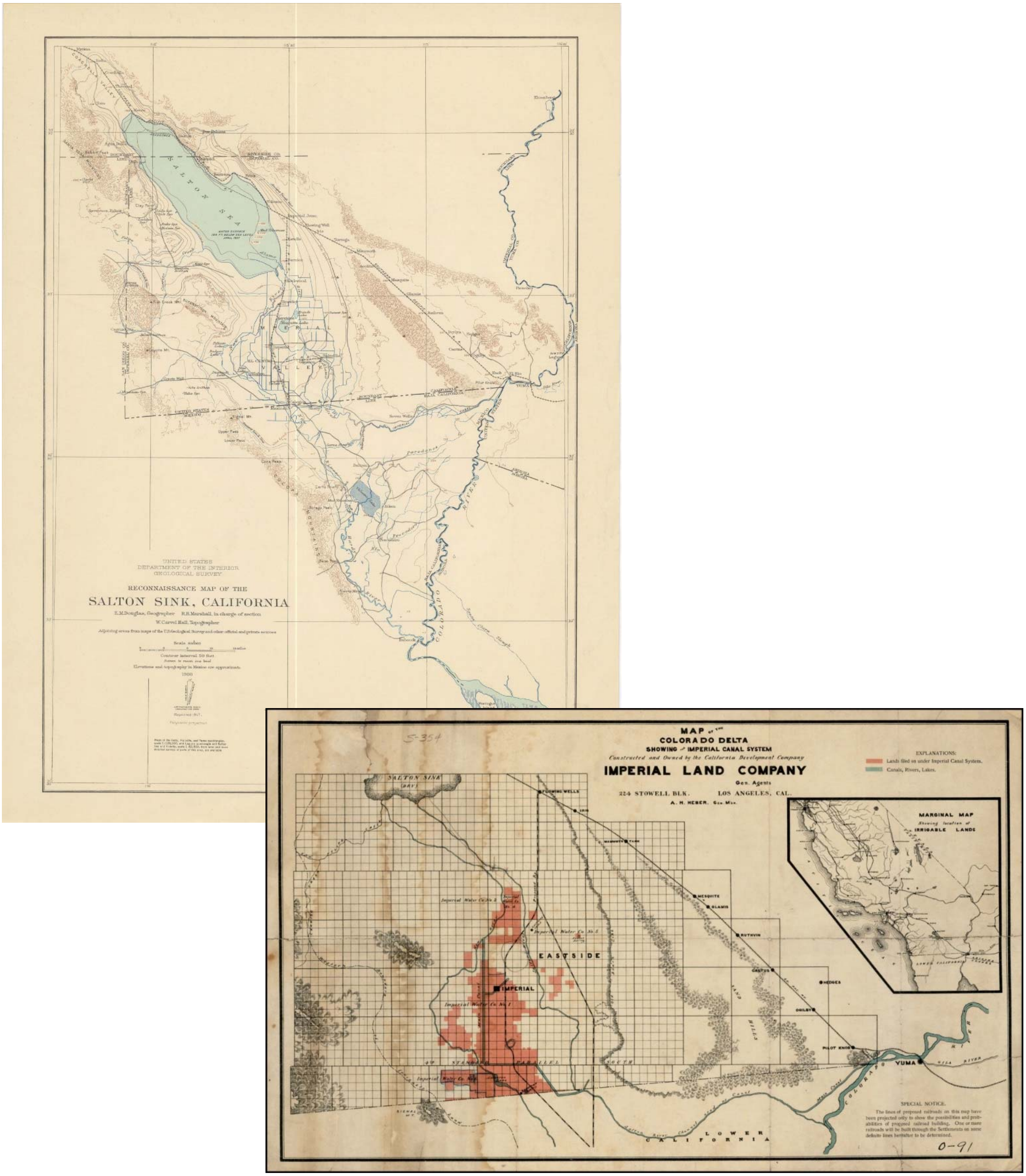
i. US Bureau of Reclamation, “All American Canal Lining Project”, (February 2012), www.usbr.gov

8. List of Additional Documentation

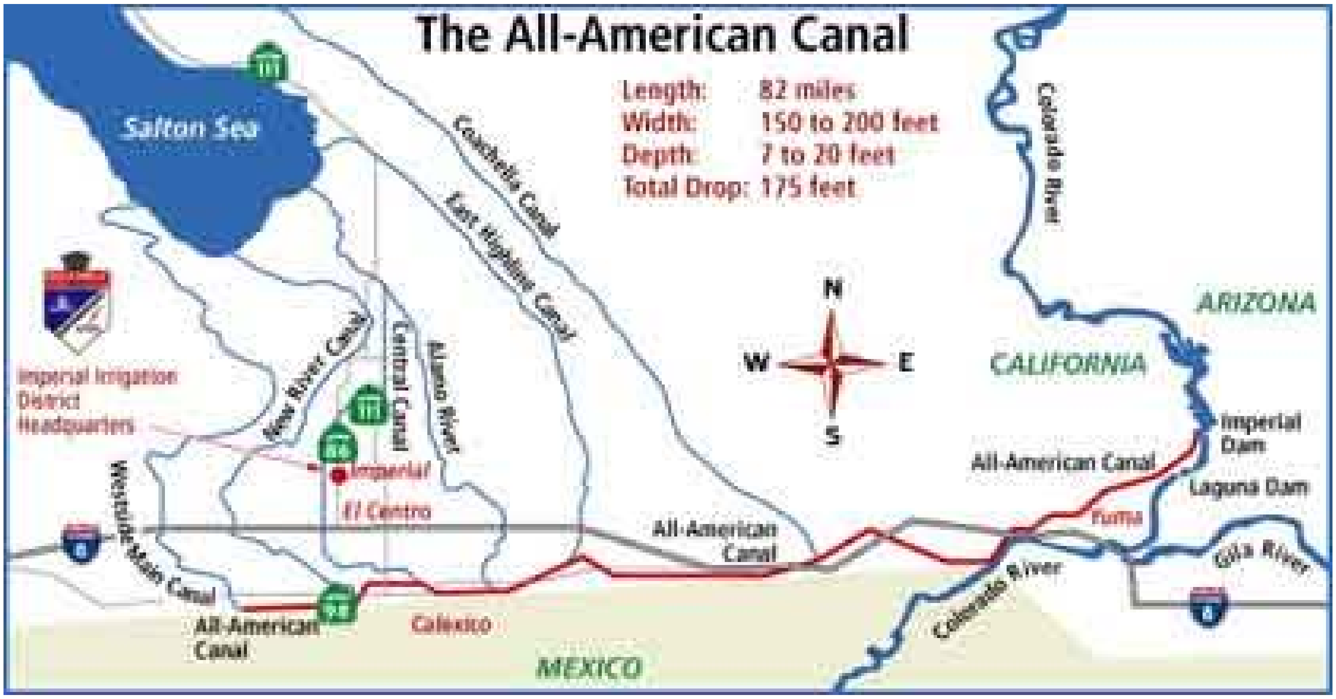
a. All American Canal Vicinity Map (Courtesy US Bureau of Reclamation)



B1. Project Area Map (Pre-All American Canal-Courtesy UC Berkeley)



B2. Project Area Map (Post-All American Canal-Courtesy Imperial Irrigation District)



c. List of Photographs

Photo Numbers	**Subject**
004, 005, 008, 018, 020, 026	Imperial Dam
036, 044, 048, 050, 051, 053, 056, 065, 095	Imperial Dam roller gates
063, 098	Imperial Dam trash rack
042, 043, 068, 070, 073, 089	Imperial Dam outlet channel
058, 061, 077, 085, 091	Imperial Dam emergency spillway & sluiceway
103, 105, 107, 110, 112, 114, 117, 119, 123, 124,126, 130, 134, 137, 141	Imperial Dam Desilting Facilities
143, 146, 154, 156, 158	All American Canal near Pilot Knob hydroelectric facilities
161	All American Canal through Imperial Sand Dunes
169, 171	Low Head Hydroelectric Facilities At Drop 1
174, 176	AAC through East Mesa
194, 197, 200	New River Siphons
184, 187, 190	AAC near Anza Road Bridge

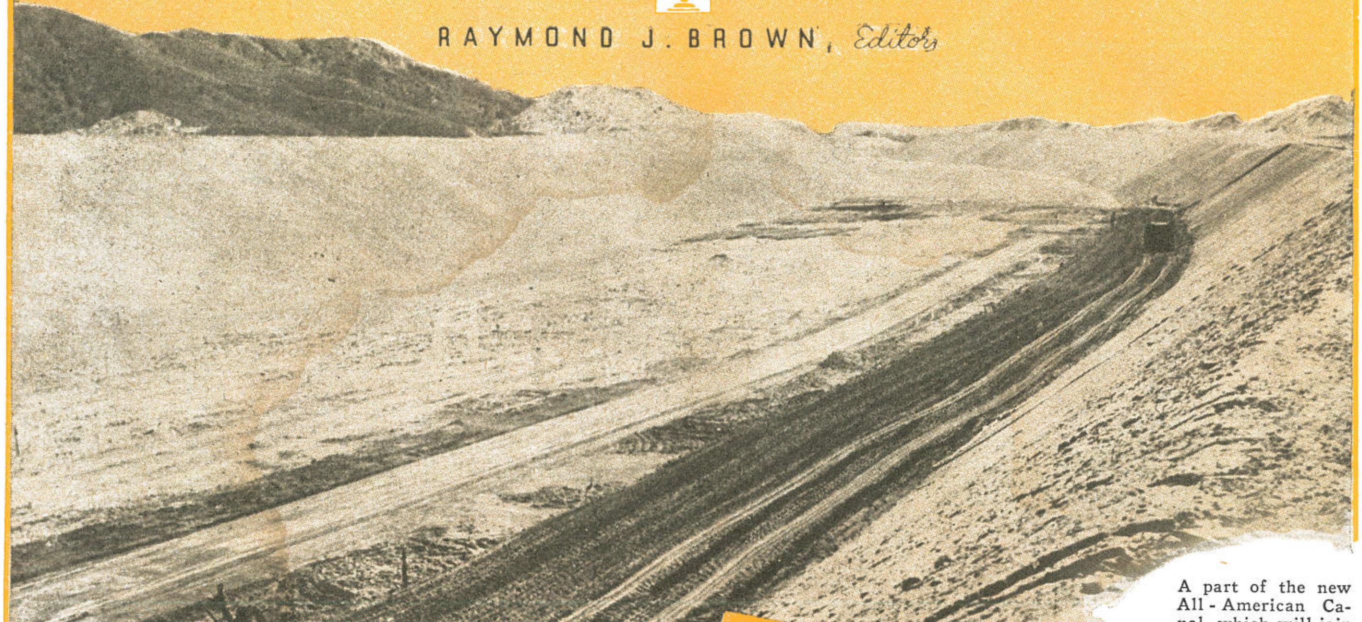
d. CD containing above information in digital format

CD with photographs enclosed.

POPULAR SCIENCE Monthly

OCTOBER 1936 VOL. 129 No. 4

RAYMOND J. BROWN, Editor



A part of the new All-American Canal, which will join the Colorado River with the Imperial Valley, California

The big balloon tires on this tractor keep it from sinking into the sand as it pulls a "buggy" up a hill

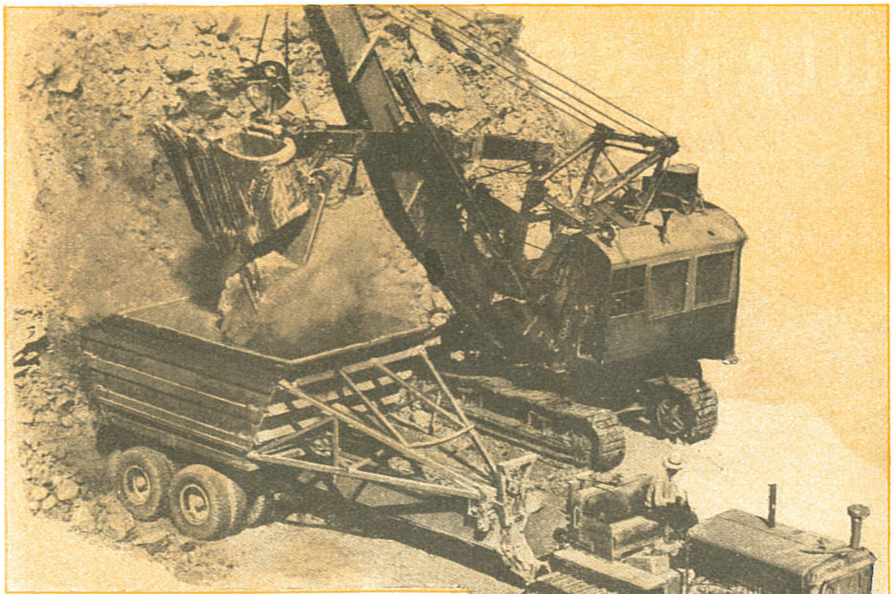
DIGGING THE World's Biggest Ditch

MONSTER MACHINES ARE SCOOPING AN ARTIFICIAL RIVER BED ACROSS EIGHTY MILES OF BLAZING DESERT IN HUGE NEW IRRIGATION PROJECT

By Sterling Gleason

TO CREATE a brand-new river, wide, smooth-walled, and straight, stretching across eighty miles of blazing desert, is the huge project now being tackled by Uncle Sam's engineers. In the southwestern corner of the United States, a mechanized army of workmen is gashing the desert with a giant irrigation ditch, the largest ever built and last of the sensational projects designed to harness and tame the turbulent Colorado River.

Rushing through miles of sage and mesquite, plunging under natural watercourses through concrete siphons, the new All-American Canal will tap the Colorado's muddy waters about fifteen miles north of Yuma, Ariz. Laundering them clear in a giant washing machine, it will lead them due west across the



A steam shovel filling a small "buggy" with rock for lining walls of the canal

At the dumping place, the tractor driver pulls a lever and the body of the trailer slides back beyond the end of the floor

The empty "buggy" after its load has fallen through the open bottom onto the side walls of the canal

This is the big bucket of the drag-line, largest digger ever made. Shown here in the dumping position, it will hold an automobile

sands without crossing the Mexican border, as does the present Imperial Canal dug by farmers half a century ago. The main canal will empty into the irrigation network of Imperial Valley, where, under a broiling sun, a phenomenally rich soil puts forth amazing crops. Ultimately, a branch will snake northward to Coachella Valley, the fertile, palm-covered oasis from which come America's home-grown dates.

Nowhere has the job of moving dirt become so highly developed a science as here on this colossal project. The place swarms with strange machines that resemble gigantic bugs, waving their long, skeleton feelers, scuttling back and forth, carrying sticks or stones, or marching in antlike processions, laden with cargoes of earth. Each is designed to shorten hauling by ten feet here or fifty feet there; to cut lifting by inches; or to clip a second or two off the time required for handling.

A herd of mechanical mastodons such as never before assembled has been marshaled for this task. Huge, lumbering "buggies," rolling on balloon tires eight feet in diameter, haul and dump enormous loads. Diesel-powered bulldozers nudge wide steel blades ahead of them, leveling off the hilltops. Gigantic power shovels, with gaping maws of lightweight alloy steel, gulp tons of earth at a single bite.

Monster drag-line machines extend their long necks half a block at a stretch, scraping up each time enough sand to fill a truck. Mechanical hens lay whole nests of octagonal concrete piles, to be picked up like match sticks by powerful cranes and driven by machines to form foundations for the structures built on the silt of the river. Skyscraper concrete-mixing towers automatically weigh, mix, and pour materials to test-tube specifications. Cylindrical samples of cured concrete are crunched between giant jaws to detect variations from formula. Miniature canals, built in the laboratory, forecast the performance of the real canal under the action of wind and water and shifting desert sands.

Long before a spadeful of earth was turned, the canal began to take form in models and drawings. Aerial photographers went aloft to sweep the country with their camera lenses. In an outdoor laboratory, experimenters made miniature canals, heaping up samples of materials, sprinkling, tamping them with rollers, and creating model embankments with varying degrees of slope. With instruments they gauged the density of the banks, measured the percolation when exposed to water, and learned exactly how steep the banks should be made.

But the most serious problem of all was that of crossing the valley of walking sand dunes—a Sahara-like waste of towering sand hills that slowly migrate under the influence of the wind. Reckless indeed seemed the engineers who dared to undertake the job, but careful observation of the dunes dispelled some of their terrors. The migration, though constant, was quite slow. A high embankment thrown up out of the material excavated from the canal would adequately guard against encroachment by the walking sand hills.

The engineers drew plans for a flat-floored ditch, half a city block wide at the water's surface, with V-shaped walls sloping back at a thirty-degree angle. Six feet above the water level is a "berm"—a flat roadway twenty feet wide. Another is located at the mesa floor on which the dunes march ceaselessly. Along these steps would move giant drag-lines, scooping out the channel below and building up the embankment above.

Ahead of the construction crews came surveyors and rodmen with transit and chain, staking out a path through the sagebrush and cactus. Behind them followed gangs of Indians, who cut away harsh brush with hooked, sharp instruments resembling medieval battle-axes. Tractors broke the virgin soil, loosening the earth and picking up heavy material. Where the surface was low, farmers drove four-horse teams pulling small "Fresnoes," or scrapers, to cut and fill. Nearly 1,000 horses were working at one time, and this phase of the work gave employment to hundreds of jobless men.

In their wake came the big machines. Steam shovels, Diesel tractors, and bulldozers puffed and snorted. Trucks by the hundred, piled high with excavated material, began to thunder over crude highways. Everywhere, dirt began to flow—load upon load, ton upon ton, streaming out of the steadily deepening cut being gouged out of the desert floor, and depositing itself upon the steadily growing embankments.

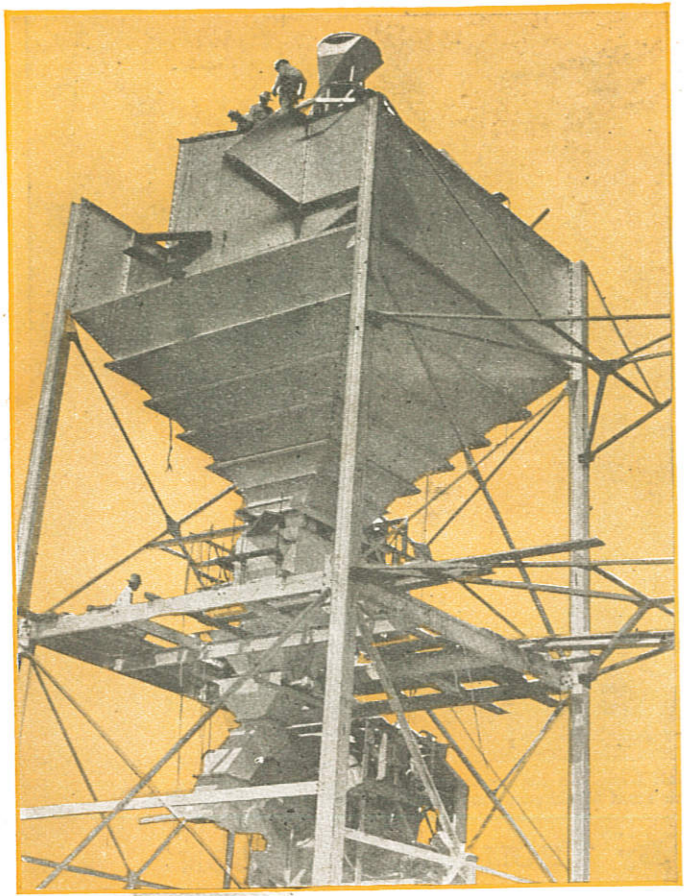
The long processions of trucks were joined by tractors pulling enormous "buggies," resembling toy wagons of the nursery but of Gargantuan size. Rolling on sixteen balloon tires taller than a man's head, these buggies carry their huge loads very near the ground, saving much lifting. When the desired spot is reached, the tractor driver pulls a lever and the side walls of the "buggy" slide backward, discharging the contents through the open bottom of the machine.

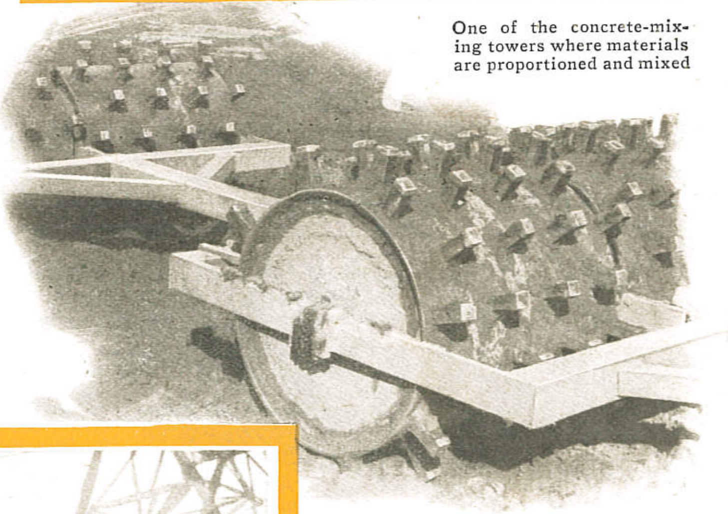
Dirt is spread by huge scrapers, attached to boxlike carts, which drop their blades and fill themselves as they move, then lift, carry, and dump, spreading their contents uniformly. One man does everything from his seat at the controls of the tractor which pulls the giant implement. Another simple but effective aid is the "tumblebug" scraper. Drawn by a tractor, it has a shoe on each side of its seven-foot blade, which enables the scraper to stand on its head, tumblebug fashion, dumping its contents instead of dragging to empty them. No helper is needed to turn the blade—it can be done by the tractor driver as he sits at his controls.

From the ancients, who built hard dirt roads by driving flocks of sheep over them to tamp them smooth and firm, the engineers learned a valuable lesson. Embankments now are compacted with a device called a "sheep's-foot tamper"—a huge roller studded with dozens of round "feet" several inches square. As it turns, each foot tramps the surface beneath it with a pressure of 250 pounds to the square inch. Tractors draw the bumpy rollers back and forth over the soft dirt until the impact of hundreds of mechanical feet has tamped it hard. Despite its spiky appearance, the tamper produces a much smoother surface than a solid roller.

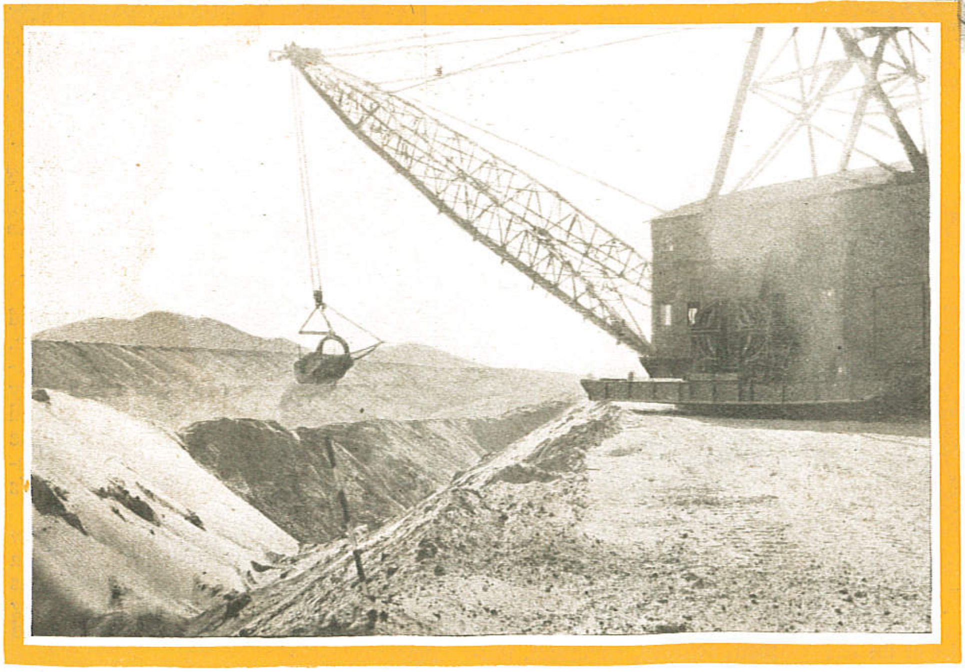
No larger digging machine ever walked the earth than the monster drag-lines that scoop out the main contours of the canal. Twenty freight cars are required to carry the dismantled parts of one such machine. A 100-car train was needed to bring in the equipment used in digging a single thirty-mile stretch of canal.

Each drag-line controls a huge bucket traveling on cables at the end of a movable steel boom as high as a fifteen-story building. The cab itself is a veritable power house—a nest of seventeen different electric motors and generators, which operate fans, centrifuges, and pumps for keeping up the "circulation" and "breathing" of the giant organism. Heart and muscles are the two huge Diesel motors, the larger of them rated at 450 horsepower—half the strength of a crack Diesel locomotive. Lubricating oil and water both are cooled by special equipment to permit the motors to withstand the extreme desert heat. Special devices clean the *(Continued on page 124)*


One of the concrete-mixing towers where materials are proportioned and mixed


"Sheep's-foot tampers"—heavy rollers studded with iron "feet" that tramp the earth hard. They are drawn by tractors

A giant drag-line in action. When it moves from one location to another, it literally walks on two large eccentrically mounted shoes



DIGGING THE WORLD'S BIGGEST DITCH

(Continued from page 13)

air before it is sucked into the jets of the Diesels, as a guard against sudden sand storms.

When the machine is ready to travel, it literally walks ahead on its own feet. Two gigantic shoes, each weighing some 42,000 pounds, are mounted eccentrically on an axle forty-five feet long and eighteen inches thick. As the axle turns, first one shoe and then the other moves to propel the drag-line ahead, seven feet at a step. Thus the 650-ton machine moves on its mechanical feet and walks smoothly across the desert sand without sinking in.

AN ARRAY of pneumatic controls, electric switches, throttles, and levers, makes the control room resemble the cab of a locomotive. Twenty-four men keep the big machine going day and night, eight men at a shift. In the forward part of the cab, behind glass windows, sits the man in charge. From his perch, the perspective is distorted as he looks down the barren slope of sand, so that distances cannot be accurately judged. He is peering intently before him. Far below, down the steep canal wall, the "pit man" waves his arms in a sweeping motion. He is talking in the private sign language by which the workmen communicate.

Around swings the cab on its pivoted base, rolling smoothly on the seventy dollies beneath its thirty-six-foot platform. The giant boom, a latticed steel girder, sweeps in a semicircle. It dips slightly.

The pit man is indicating a spot almost directly beneath the beam. The control man touches a lever. A steel cable, twice as thick as a man's thumb, begins to sing as it swiftly pays out. Down plunges the huge bucket, a scoop big enough to accommodate an ordinary automobile with room to spare at the sides. As it nears the designated spot, it hesitates slightly. Beam, cable, and drag-line work together to draw the bucket in and land it at the exact spot desired.

A heavy, shrieking chatter splits the air as the hoist engine goes into action. The drag cable, a steel sinew two inches in diameter, tightens, gouging the bucket into the sand bank. The scoop fills itself to overflowing, and begins its upward climb—slowly, laboriously, for with its load it weighs 50,000 pounds.

As it reaches the level of the embankment, the operator shifts his controls. The giant beam wheels smoothly, swings the bucket neatly above the embankment, and a seven-ton load of sandy earth cascades out of the scoop, adding its bit to the bulwark which is to check the movement of the shifting desert sands.

UNDER the scorching noonday sun, under the huge, desert moon, through summer heat and blinding sand storms, the work will go on. At night, the powerful glare of floodlights attached to the booms makes daylight where they work. Before water can flow, sixty million cubic yards of material must be excavated and hauled to its proper place—enough, loaded upon standard forty-foot gravel cars, to make a trainload 2,235 miles long, stretching from Chicago to Los Angeles.

But more than a colossal job of earth-moving, more than the biggest irrigation ditch ever built, is this huge gash engineers are cutting in the southern desert. In combination with Boulder Dam, it not only will bring life-giving water to parched desert lands, but will permanently end the menace of the millions of tons of water that thunder down the Colorado's steep-walled chasm.

For years, the Colorado has been a trouble maker in the West. From the northern plateau where sudden desert storms sweep across the barren mesas to discharge cloudbursts that race to join the river's brown torrent, to its mouth in the Gulf of California, where at times it creates some of the roughest ocean water in the world, it is a violent, powerful giant. Near its delta, where its rolling brown waters mingle with the blue of the ocean, it is sluggish but temperamental. News of rains in the mountains far to the north is brought by sudden, spectacular rises in the river's height at Yuma, where the government gauging station often records sensational jumps in the water flow within a few hours.

BUT the temptation of this precious fluid, going to waste, was too strong for dwellers in the thirsty lands near-by. At the turn of the century, farmers pierced the natural barrier separating the lower Colorado from the huge sink just to the north, in whose trough, far below sea level, lies the dead Salton Sea. The crude thirty-mile canal they dug brought the waters into a natural depression leading down into the Imperial Valley. But soon, in 1905, a flood crest suddenly swept down the river. The head gates controlling the flow of water stuck, and, before they could be released, the torrent surged madly through the newly excavated channel. For two years the runaway river, heavy with thousands of tons of silt, poured into the inland sea, raising its level seventy-three feet and swelling its area by 278,000 acres.

Though levees have since checked the flow and provided a measure of safety, the threat of flood has persisted. Even now, these embankments are in need of repair, and ordinary maintenance alone costs upward of $100,000 every year. With Boulder Dam cushioning the shocks of flood crests and the All-American Canal, with its diversion dam, as a valve to regulate the flow, the giant Colorado will be rendered as tame as a town waterworks system. Dredges no longer will be needed to remove the silt which constantly clogged the old canal, for the giant paddles of the washing machine will remove it.

ALREADY, Boulder Dam has begun its work as a good Samaritan. When, last spring, flood waters swelled the Colorado, rushing past the gauging station at Grand Canyon, Ariz., at the rate of 100,000 foot seconds, the heavy gates were lowered and its titanic bulk checked the flow, storing it for future use. The rising crest never reached Yuma to endanger the cracked levees. Soon afterwards, the floodgates were raised slightly and the impounded flood waters began to trickle down little by little as they were needed. Within a few weeks, enough water had been stored to meet the whole year's needs for irrigation, thus preventing a repetition of the 1934 drought which cost Imperial Valley farms a loss of $10,000,000.

ELECTRIC SHOCK USED TO REVIVE DYING MAN

SUCCESSFUL use of a heavy electric shock as a means of saving life was reported at a recent meeting of the American Institute of Electrical Engineers. An account of how a surgeon, sewing a gash in a man's heart, revived the patient after the heart stopped beating was given by Dr. Kowenhoven of Johns Hopkins University, Baltimore, Md. The method was developed at university's laboratory after many experiments on counter-shocking animals to revive them after they had suffered electric shocks. Experiments along this line have indicated that the method may be of assistance in reviving drowned persons.

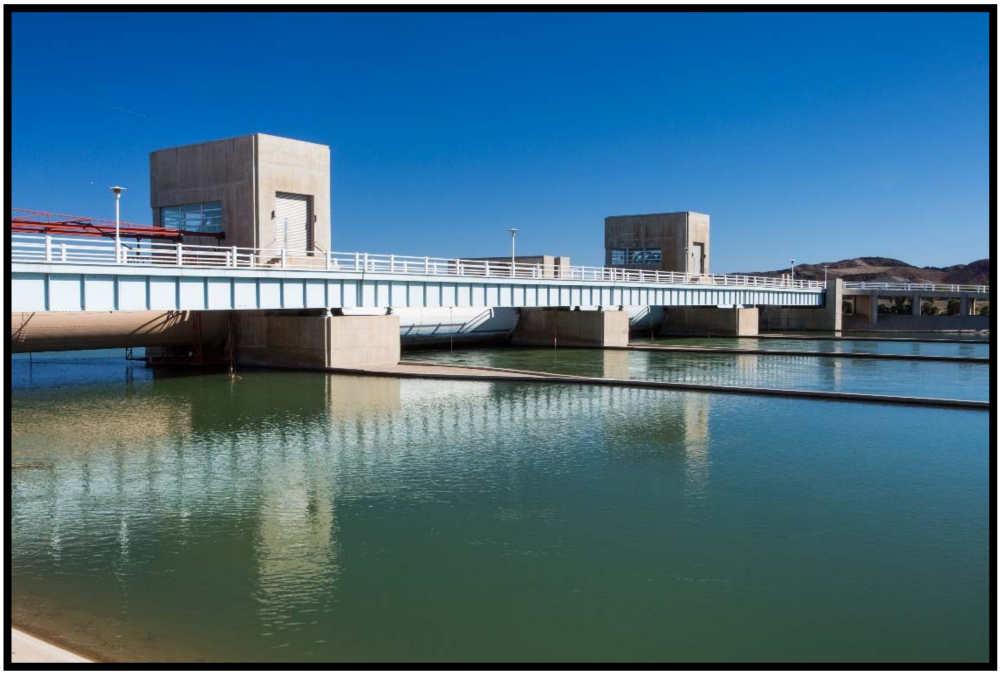
9. Recommended Citation

The All American Canal System, conceived and developed in the depths of the Great Depression, is the one of the pre-eminent water supply systems in the world. As the largest capacity water supply facility in the US, it provides a safe and reliable source of irrigation water for over half a million acres of year round agricultural production and provides domestic water for over 150,000 residents. Powered solely by gravity, energy generated by the canal paid for its own construction by retiring the nearly $25 million construction loan and continues to deliver renewable power to the Imperial Valley.

Development of the canal system innovatively solved significant challenges related to Colorado River floods, filtered out thousands of tons annually of conduit-clogging sediment, threaded through the once impassable Imperial Sand Dunes and designed structures to withstand the test of time in one of the most seismically active areas of the US.

75 years after entering service, the AAC continues to perform well beyond expectations. Reliability enhancements, operational storage improvements and power generation efficiencies incorporated into the original design have proven the foresight and flexibility of John L. Savage and his team of civil engineers.

For the reasons cited above, the All American Canal System deserves to be recognized as a National Historic Civil Engineering Landmark.



Historic Civil Engineering Landmark Nomination

This form may be printed. Please submit one copy for each committee member of all materials relating to the nomination. If more space is required to provide full response, please include additional documentation.

To: History & Heritage Committee
ATTN: Carol Reese
1801 Alexander Bell Drive
Reston, VA 20191-4400

Date: July 30, 2015 ASCE Section: San Diego

Circle one: This is to nominate the following for designation as a Historic Landmark [✓ National] or Local/State

All-American Canal System

Previously nominated for National: Yes [✓ No] If Yes, when N/A

Located at: Winterhaven County: Imperial State: California

The latitude and longitude to the nearest minute (or U.T.M. coordinates). Attach detailed local and vicinity maps that show access from a major city or the interstate. See attached map

The proposed landmark's owner: United States Bureau of Reclamation

In support of this nomination the following information must be provided:

1. Date of construction (and other significant dates).
   Original Construction: 1936-1938, Lining Project: 2007-2009
2. Names of key civil engineer and other professionals associated with project.
   John L. Savage - see attached biographical sketch
3. Historic (national or local) significance of this landmark.
   See attached
4. Comparable or similar projects, both in the United States and other countries.
   Los Angeles Aqueduct, California Aqueduct, and Colrado River Aqueduct
5. Unique features or characteristics which set this proposed landmark apart from other civil engineering projects, including those in #4 above.
   See attached
6. Contribution which this structure or project made toward the development of: (1) the civil engineering profession; (2) the nation or a large region thereof (part 2 is necessary for an NHCEL).
   See attached
7. A list of published references concerning this nomination.
   See attached article published in Popular Science, October 1936 edition
8. A list of additional documentation in support of this nomination. (Please list all enclosed documents, publications, photographs, and supporting historical evidence. Digital images and one 5" x 7" black & white glossy photo are required for publicity and presentation purposes.)
   See attached
9. The recommended citation for HHC consideration.
   See attached
10. A statement of the owner's support of the nomination.
    See attached letters from the United States Bureau of Reclamation and Imperial Irrigation District

If this nomination is approved for designation as a National Historic Civil Engineering Landmark by the Board of Direction of ASCE, we understand that the Section will have the major responsibility for the public presentation ceremony of the plaque and for plaque maintenance.

Chairman, Section History & Heritage Committee Philip R. Kern, PE, M. ASCE

Section Secretary Jon Rowland, PE, M. ASCE

Section President Steve Fitzwilliam, PE, M. ASCE

*Note: For State Historic Civil Engineering Landmark designation, the other Section presidents from the state should sign the nomination form or concur with the nomination in writing. If all Sections affected by the nomination agree on dedicating this landmark, the nominating Section should inform the HHC of their decision and send one (1) copy of the nomination package to the staff contact for the HHC

Note: Designation by ASCE as a National Historic Civil Engineering Landmark carries no legal commitment on the part of ASCE, the owner or the governmental jurisdiction in which it is located.

IID
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A century of service.

January 21, 2015

Ms. Carol Reese
American Society of Civil Engineers
History & Heritage Committee
1801 Alexander Bell Drive
Reston, Virginia 20191-4400

Dear Ms. Reese:

Subject: Imperial Irrigation District Support of San Diego Section American Society of Civil Engineers Nomination of All-American Canal System for Recognition as National Historic Civil Engineering Landmark

The Imperial Irrigation District is the operator of the 80 mile All-American Canal system, owned by the United States Bureau of Reclamation. The system, beginning at the Imperial Dam on the Colorado River carries water through the All-American Canal to the various distribution canals and pipelines serving the Imperial and Coachella Valleys in Imperial County in California. IID is aware that the San Diego Section of the American Society of Civil Engineers, which includes the Imperial Valley, proposes to nominate the All-American Canal system for recognition as a National Historic Civil Engineering Landmark. Based on the All-American Canal's unique contribution to the health, welfare, economy and quality of life of the southwest United States and, indeed, the country as a whole due to the agricultural and other products produced as a result of its reliable and essential water supply, we fully and enthusiastically support the preparation and submission of this nomination.

Should you have any questions, please do not hesitate to contact Mr. Ismael Gomez, Assistant Manager, and Chief Engineer at (760) 339-9559 or by email at igomez@iid.com.

Sincerely,

Kevin E. Kelley
General Manager

CC: Michael Pacheco, WD Interim Mgr.
Ismael Gomez, Asst. Mgr. & Chief Engineer, Engineering Services
Douglas Cox, Asst. Mgr. Imperial Dam & AAC
Shayne E. Ferber, Supervisor, Real Estate
Maria Ramirez, Area Manager USBR Yuma Area Office

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United States Department of the Interior

BUREAU OF RECLAMATION
Lower Colorado Region
Yuma Area Office
7301 Calle Agua Salada
Yuma, AZ 85364

FEB 18 2015

IN REPLY REFER TO:
YAO-2000
YAO-7000
PRJ-1.00

Ms. Carol Reese
American Society of Civil Engineers
History & Heritage Committee
1801 Alexander Bell Drive
Reston, VA 20191-4400

Subject: The Bureau of Reclamation's Support of San Diego Section American Society of Civil Engineers' Nomination of All-American Canal System for Recognition as National Historic Civil Engineering Landmark

Dear Ms. Reese:

Reclamation understands that the San Diego Sector of the American Society of Civil Engineers is attempting to garner support through the Imperial Irrigation District (IID) in nominating the All-American Canal System as a National Historic Engineering Landmark. Reclamation has no objections to the nomination and looks forward to the American Society of Civil Engineers submission of this nomination.

If you have any questions, please contact Mr. Jim Condit at 928-343-8342 or by email at jcondit@usbr.gov.

Sincerely,

Maria Ramirez

Maria Ramirez
Area Manager

cc: See next page.

cc: Mr. Michael Pacheco
Imperial Irrigation District
Interim Water Department Manager
P.O. Box 937
Imperial, CA 92251-0937

Mr. Ismael Gomez
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