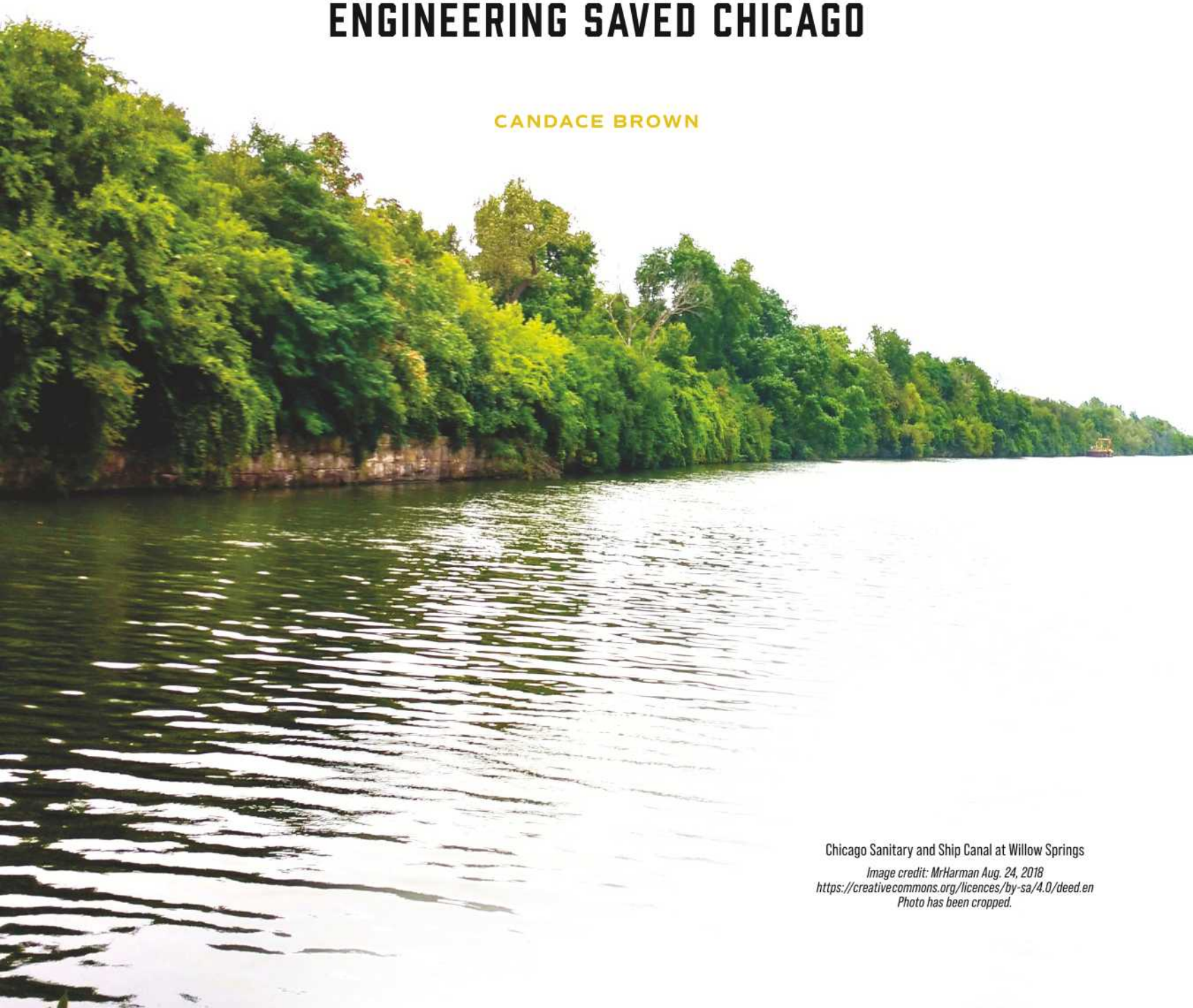
A RIVER REVERSED

HOW 19TH CENTURY ENGINEERING SAVED CHICAGO

CANDACE BROWN



Chicago Sanitary and Ship Canal at Willow Springs

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Devoid of raging rapids and waterfalls, the Chicago River in Illinois never offered much drama in its natural state, but its history contains plenty. By 1900, humans had completely reversed the direction of the river's flow by constructing the 28-mile-long Chicago Sanitary and Ship Canal. This project, the most ambitious example of civil engineering of its time, took eight years and the removal of 42,340,000 cubic yards of soil and rock. It stunned the world. Reversing the river reversed the deadly pollution of drinking water, allowing Chicago to become a great center of commerce and transportation and the third largest city in the nation.

Before the arrival of non-native settlers, the clear waters of the river's northern and southern branches moved along placidly through the grasses of a flat, poorly drained, and often soggy landscape. They merged about a mile west of Lake Michigan before flowing eastwardly into it as one. More soggy land made up the ten-mile-wide "Great Portage" between Lake Michigan and the Mississippi River to the west. A low ridge running north and south across the portage was just high enough to create a "sub-continental divide." Gravity sent the waters of the Chicago River east toward the lake and those of the nearby Des Plaines River west toward the Illinois and Mississippi rivers and eventually the Gulf of Mexico. The idea of a canal through the portage had existed as early as 1673 when the French explorer Louis Jolliet pictured how it would enhance opportunities for trade.

In 1832, the Blackhawk War ended with the defeat of the region's Native Americans, who were forced to move west of the Mississippi. A huge influx of white people followed. In 1833, the village of Chicago incorporated as a town of 350 citizens with a newly dredged harbor and horrible water pollution already. A local butcher, who processed 400-500 hogs per week, dumped all the waste into the river. The town passed an ordinance forbidding citizens from using the river to dispose of "dung, dead animal carrion, putrid meat or fish entrails, or decayed vegetables, or any other offensive substance whatever,"

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but could not enforce it. Chicago reincorporated in 1837, as a city, growing to 4,170 citizens by 1840. The meat packing industry grew just as rapidly. By 1845, numerous slaughterhouses created a horrific stench and made the already unsafe drinking water even more dangerous.

Meanwhile, in 1836, construction had begun on the Illinois & Michigan Canal (I & M Canal) across the portage, but the economic impacts of the "Panic of 1837" delayed its completion until 1848. The 96-mile-long canal, following the Chicago, Des Plaines, and Illinois Rivers was hand dug with picks and shovels, mostly by Irish immigrants, many of whom suffered from malaria from working in the swamplands or were injured or killed in accidents. By linking the Great Lakes to the Mississippi, the canal helped Chicago surpass St. Louis as a center of commerce. However, problems existed. To the west, the Illinois River flowed sluggishly at times, and its tributary, the Des Plaines River, often overflowed into the

This pictorial map of Chicago was issued by Walter Conley and O.E. Stelzer in 1933 to illustrate how it looked a century earlier when the small settlement was incorporated as a town in 1833. The map is oriented as if looking westward from Lake Michigan, with the north to the right.

Image credit: Public Domain

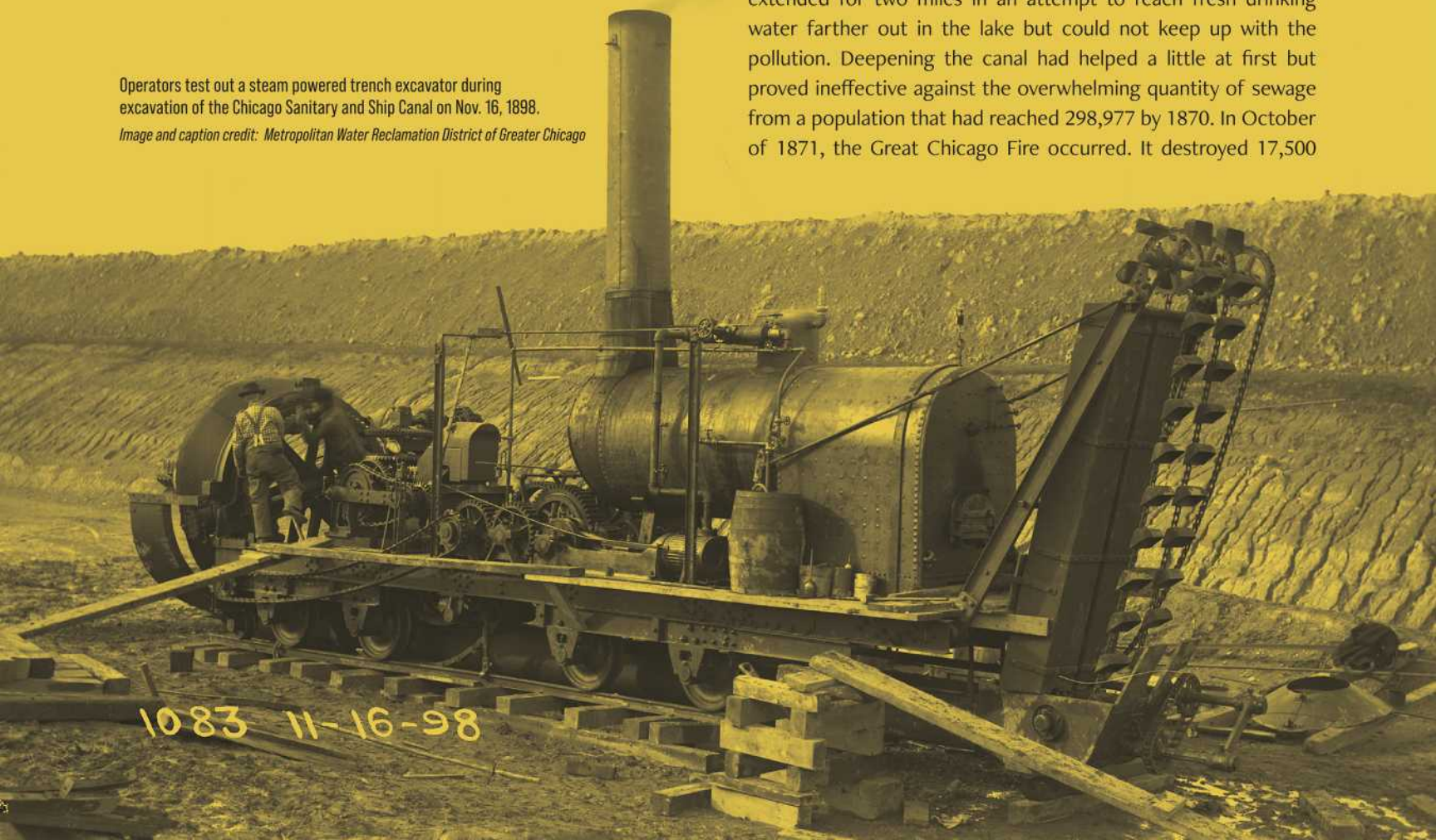
polluted Chicago River which carried the dirty water east into the lake. This caused epidemics of cholera and typhoid fever. After a particularly devastating flood in 1849, 678 Chicagoans died of cholera.

By 1852, railroads connected Chicago with eastern cities, bringing a boom in the meatpacking industry, along with more pollution and illness. Deaths from cholera exceeded 1,400 in 1854. The following year, a newly established Board of Sewerage Commissioners hired an engineer named Ellis S. Chesbrough to design the nation's first comprehensive sewer system. Sewer mains, spaced about 800′ apart, were fed by lateral branches draining side streets, but the side streets lacked sufficient grade to drain well. Beginning in 1856, Chesbrough increased the city's elevation, literally raising the buildings and the street level by as much as 12 feet. The project did improve street drainage but not water quality, as the mains still discharged sewage into the Chicago River, polluting Lake Michigan.

The Civil War started in 1861, and the Union Army needed beef and salt pork to feed its million soldiers. Suddenly, even more slaughterhouses sprang into existence along the Chicago River's two branches. Much of the meat reached the battlefields via the Illinois Central Railroad, one of nine terminating in the city by then. With the canal and the railroads improving transportation, Chicago became a busy commercial center, moving all kinds of agricultural products, lumber, and people. Trains now competed heavily with canal traffic, especially in periods of dry weather when the water level in the canal fell too low for navigation. Even prior to 1860, the city pumped water into it from the Chicago River, when necessary. A more permanent solution would require deepening the canal. The project know as the "Deep Cut" was approved by the Illinois General Assembly in 1865 and finished in 1871. City leaders hoped a deeper canal might also reduce the pollution problem that was about to grow even more hideous.

On Christmas Day of 1865, the infamous Union Stock Yards opened south of the south branch of the Chicago River. Even in its early years, the massive complex had 2,300 individual animal pens, and more than 400 million animals were slaughtered there by 1900. At 475 acres, it became the world's largest such facility. All the manure and waste entered the Chicago River through a short tributary that came to be called "Bubbly Creek" due to the methane gases escaping from the decaying matter in its depths. In his 1906 novel, *The Jungle*, author Upton Sinclair described it as follows: "Here and there the grease and filth have caked solid, and the creek looks like a bed of lava; chickens walk about on it... and many times an unwary stranger has started to stroll across and vanished temporarily." The river beyond the creek was nearly as bad.

Tunnels built under Lake Michigan in 1864 and again in 1874 extended for two miles in an attempt to reach fresh drinking water farther out in the lake but could not keep up with the pollution. Deepening the canal had helped a little at first but proved ineffective against the overwhelming quantity of sewage from a population that had reached 298,977 by 1870. In October of 1871, the Great Chicago Fire occurred. It destroyed 17,500



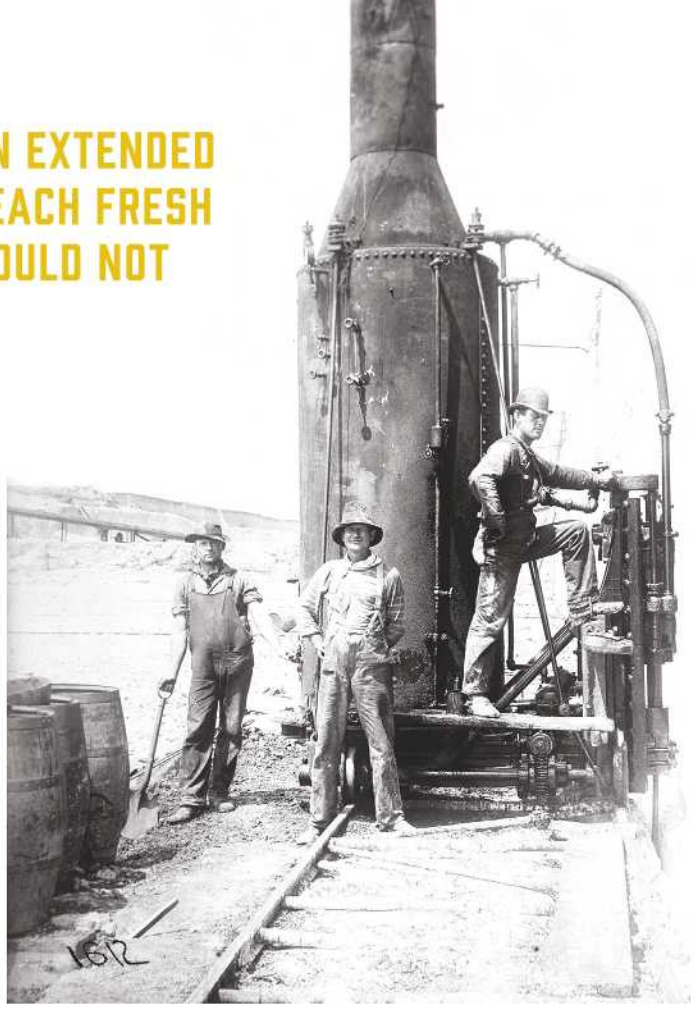
Operators test out a steam powered trench excavator during excavation of the Chicago Sanitary and Ship Canal on Nov. 16, 1898.
Image and caption credit: Metropolitan Water Reclamation District of Greater Chicago

TUNNELS BUILT UNDER LAKE MICHIGAN EXTENDED FOR TWO MILES IN AN ATTEMPT TO REACH FRESH DRINKING WATER FARTHER OUT BUT COULD NOT KEEP UP WITH THE POLLUTION

buildings, including the entire business district, but the stock yards, and most of the railroad tracks that served them, survived.

The river's stench was unbearable, and frequent incidents of drinking water contamination and epidemics continued. The wealthy bought bottled water. The poor could not afford it. When additional pumping of water from the Chicago River into the I & M Canal occurred, some polluted water flowed westward, away from the Lake, but not enough to end the danger. A massive storm on August 2, 1885, brought about six inches of rain. Once again, but more severely than usual, the Des Plaines River flooded into the Chicago River, and that pushed a huge plume of filth eastward into Lake Michigan. Thanks to an offshore wind, the pollution did not reach the drinking water intakes. Reports afterward sensationalized the number of deaths, but the incident badly alarmed the public. A Citizens Association, formed in 1880, demanded action from the city, resulting in the establishment of the Commission on Drainage and Water Supply in January of 1886. A year later, the Commission offered several proposals for dealing with the sewage, including disposal on land, but settled on the idea of sending the waste away by building a much larger canal from the Chicago River south and west through the Des Plaines and Illinois to the Mississippi. Political wrangling stalled progress for two years until, on May 29, 1889, the Illinois General Assembly approved "The Act to Create Sanitary Districts and to Remove Obstructions in the Des Plaines and Illinois Rivers," better known as the "Enabling Act." The state required sanitary districts to have clear boundaries and to be established by a vote of the people living within them. In the case of the 185-square-mile Sanitary District of Chicago, 70,958 citizens voted for it and only 242 against.

The goal was to build the Chicago Sanitary and Ship Canal (CSSC), one with far greater capacity than the I & M. By drawing more water from Lake Michigan, and using a series of locks, the new canal could permanently reverse the river, send diluted sewage toward the watershed of the Mississippi, and at the same time provide the depth and width needed to accommodate larger vessels. "Whereas navigation had been the prime concern behind the I&M Canal, the priority with the CSSC was safe drinking water. However, improved navigation would help to appease farmers, towns, and cities downstream opposed to receiving Chicago's sewage, diluted or not. Many would bring lawsuits anyway.



These workers posed with a channeling machine in 1894. It used a vertical engine, worm gear, and large chisel to cut through solid rock.

Image Credit: Metropolitan Water Reclamation District of Greater Chicago

Construction began with a "Shovel Day" groundbreaking celebration on September 3, 1892, featuring a parade of horse drawn carriages full of unrealistically optimistic dignitaries. They hoped to see the main channel completed by April of 1896, but unforeseen difficulties and disputes between certain contractors and the Sanitary District delayed completion until four years later. The Des Plaines River also had to be diverted into a new manmade, 13-mile-long channel just west of the original one and running parallel to the canal. From the Chicago River at Robey Street in the city, the CSSC would extend 28 miles to Lockport on the Des Plaines. Since the elevation of the Des Plaines was higher than the canal, spoil from the canal excavation would be used to build 19 miles of levees to prevent the river water from entering and mixing with the canal water during floods. The project also involved building 31 bridges and the controlling works at Lockport, where the canal ended. The works, when finished in mid-1899, had seven vertical sluice gates plus a movable 160-foot-long "Bear Trap Dam" that could be lowered to allow ice and other debris to pass downstream. Beyond Lockport, the Des Plaines River would be enlarged to handle the greater flow of water.

THE PLANNED DEPTH AND WIDTH WOULD REQUIRE BLASTING WITH 8,000 TONS OF DYNAMITE AND CHANNELING VERTICALLY

The Sanitary District divided the project into three sections based on geological characteristics, each requiring different earthmoving machines and methods. The easternmost section from Robey Street in Chicago to Summit, the high point of the portage, amounted to 7.8 miles and consisted of a mixture of soils. From Summit to Willow Springs was 5.3 miles of "glacial till"—a mixture of soil and rock. From Willow Springs to the canal's end at Lockport, a distance of about 15 miles, workers faced mostly solid rock. The planned depth of 24 feet and width of about 160 feet in that section would require blasting with 8,000 tons of dynamite and channeling vertically. The Sanitary District chose to tackle the rock section first, knowing it would be the most difficult. They divided it into 14 approximately one-mile-long sub sections assigned to different contractors and similarly subdivided the other two sections.

The total number of workers reached 8,700 by the autumn of 1895, but eventually increased to 15,000. Often soaked with water or covered with mud, and constantly in danger from accidents caused by broken machinery or rocks, they earned 15 cents per hour. Average daily wages ranged from $1.50 for laborers and teamsters to $3.50 for boilermakers. Most were immigrants or impoverished African Americans recruited in large numbers from the South. All lived in squalid camps run by contractors who charged 50 cents per week for a bed and up to $4.00 for food. From 1893-1894, smallpox ravaged the work force.

This photo from 1899 shows how carts on tracks were used to remove material as work continued under a newly constructed railroad bridge.

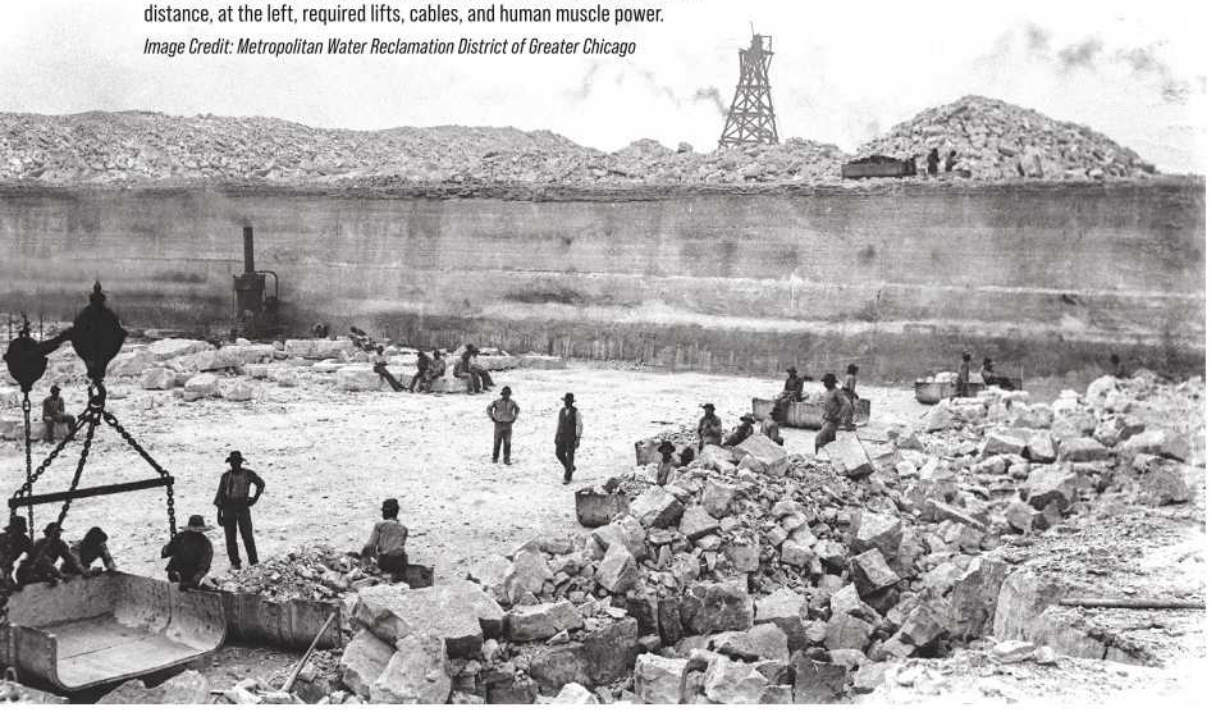
Image Credit: Metropolitan Water Reclamation District of Greater Chicago

The challenges of building the canal brought about new earthmoving machines and methods so innovative, and having so much impact on future projects, that they came to be known as the Chicago School of Earth Moving. Techniques and equipment developed for the CSSC helped build the Panama Canal. In the beginning, all material was moved by teams of horses or mules pulling wagons or carts, but about a year into construction, cable hoists and the Brown Cantilever Conveyor came into play, among other technologies. The Heidenreich Incline involved two dump cars on parallel tracks extending down into the excavation hole and up to the dumping area. In 1904, Volume 1 of a periodical called The Technical World described the scene:

"When one car was loaded, the signal was given, and the car sped away to the highest point of the incline, the empty car meanwhile traveling as rapidly

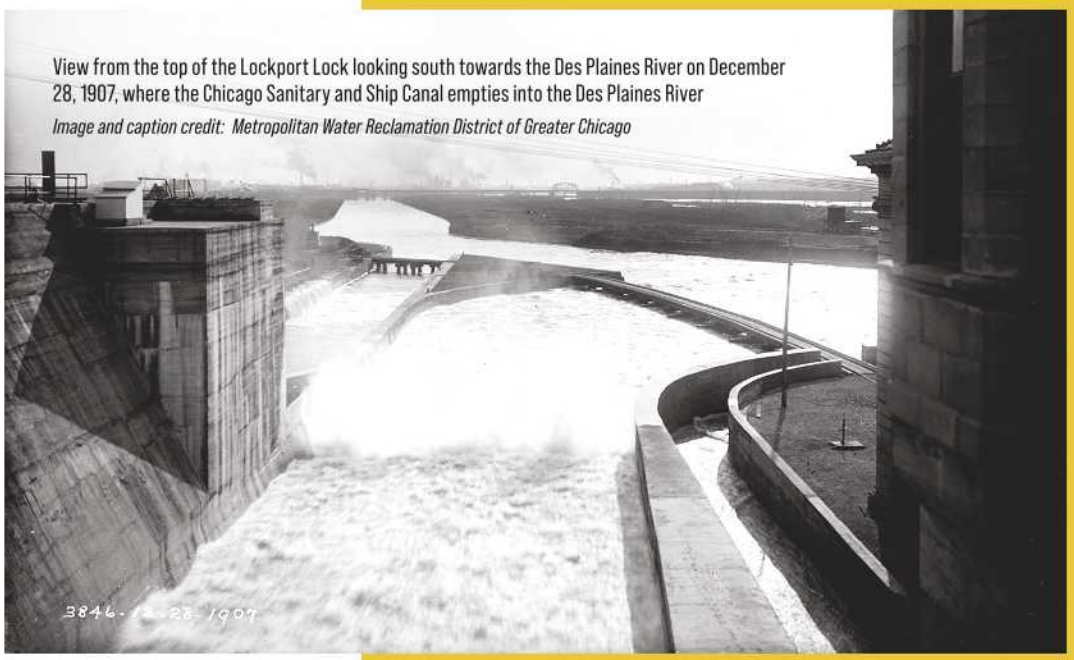
Removal of the solid rock cut away by the channeling machine seen in the distance, at the left, required lifts, cables, and human muscle power.

Image Credit: Metropolitan Water Reclamation District of Greater Chicago



toward the work. The loaded car ran out upon a 'tipple'—a sort of teeter board. Immediately it passed the center of gravity, the car was thrown forward and its contents were dumped. There was a pause of a few seconds—just long enough for the steam shovel to load the empty car. Then the steel cable hummed again, and the cars passed each other half way on the incline."

Steam shovels weighing 70-80 tons each, although not newly invented, played important roles, with as many as 52 in use at once. For example, they dropped clay into a large hopper containing a pair of rotating cylinders fitted with knives to cut the clay into small pieces. The Bates Conveyor, traveling beneath and stretched across the channel, moved the granulated clay to the spoil area. Plows and scrapers were important too. The New Era grader, pulled by 12-16 horses or mules, could move 100 cubic yards of friable soil per hour. Dipper type hydraulic steam dredges of up to six cubic yards capacity worked with dump scows to remove material to a point in Lake Michigan, the record being 11,000 cubic yards in 24 hours. The Mason & Hoover Conveyor spanned the channel like a bridge, with a cantilevered arm suspended over the spoil location and material carried on a steel belt made of four-foot, pan-like sections. Steam driven, it used manilla ropes to transfer the power. Some of the most amazing pieces of equipment were the channeling machines that cut straight down through solid rock by means of a huge chisel powered by a vertical engine and worm gear. Compressed air ran most of 193 drills that were used.



View from the top of the Lockport Lock looking south towards the Des Plaines River on December 28, 1907, where the Chicago Sanitary and Ship Canal empties into the Des Plaines River

Image and caption credit: Metropolitan Water Reclamation District of Greater Chicago

As work on the CSSC neared completion, legal troubles loomed. Downstream, the City of St. Louis, Missouri, grew more and more concerned about pollution of the Mississippi, its source of water, and threatened to file an injunction to stop the project. The official opening day had been scheduled for January 20, 1900, but the Sanitary District dared not wait. On the morning of January 2, without prior public announcement, officials and members of the press gathered to witness the breaching of a small dam separating the Chicago River from the new canal. Two weeks passed before the canal filled completely, and on January 17, the controlling gates at Lockport were opened and the Bear Trap Dam lowered, allowing the complete reversal of the Chicago River at last, beating the injunction. In 1906, the U.S. Supreme Court heard the case of Missouri v. The State of Illinois and the Sanitary District of Chicago, finding in favor of the District as no threat to St. Louis could be proven.

Chicago River water flowed toward the Mississippi, but navigation ended at Lockport. In order for the CSSC to totally replace the I & M, it would have to be extended to Joliet, four miles beyond, a stretch in which the Des Plaines dropped 36 feet. The extension was done between 1903 and 1907. The success of the CSSC led to the construction of two more canals, the North Shore Channel in 1910 and the Cal-Sag Channel, finished in 1922. What began as the Sanitary District of Chicago evolved into the award-winning Metropolitan Water Reclamation District of Greater Chicago (MWRD). Today, it controls the comprehensive Chicago Area Waterway System (CAWS), of which the Chicago Sanitary and Ship Canal is a part. Overseeing waterways, water treatment, surface water management, and most importantly, the quality of drinking water is a huge job, but the MWRD does it well.

Chicago's early residents could not have imagined, as they watched their river flow into Lake Michigan, that mankind could someday reverse it. That bold act gave this story the drama it needed for a happy ending.

Many thanks to Allison Fore of the Metropolitan Water Reclamation District of Greater Chicago, 100 E. Erie Street, Chicago, IL 60611 Phone: (312) 751-6633