gineers, April 22, 1861. He took part in the battles of Spottsylvania Court-house, battles and actions of Cold Harbor, siege and battles of Petersburg, and other engagements, and was breveted a lieutenant-colonel Aug. 1, 1864, for faithful and meritorious services in the field. He was breveted a colonel April 2, 1865, for gallant and meritorious services during the siege of Petersburg, and on the same day was breveted a brigadier-general for gallant and meritorious services during the rebellion. He was present at the capitulation of Gen. Lee with the Army of Northern Virginia at Appomattox Court-house, April 9, 1865. After the close of the war he was engaged in selecting a site for a Presidential mansion and park and in making preliminary surveys and drawings. He was a member of the board to prepare plans, specifications and estimates for new War Department buildings, and later was acting Commissioner of Public Buildings at Washington.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.*

BY J. JAMES R. CROES, M. AM. SOC. C. E.

(*Continued from page* 265.)

XXXVIII.—HARTFORD.

Hartford, Conn., is on the west side of the Connecticut River, 60 miles from its mouth, in lat. 41° 45′ 59″ N., long. 72° 40′ 45″ W.

Along the river there are large tracts of level land, portions of which have been dyked to prevent flooding. Further back the ground is high.

Settled in 1635, the population in 1854 was about 20,000, when water-works were constructed by the city, taking their supply from the Connecticut River opposite the city. From a stone inlet pier in the channel, with an opening 4 ft. below low water mark, a 24-in. iron pipe 140 ft. long leads to a well 6 ft. in diameter, outside of the engine house. The pumps are 10 ft. above water level, and 25 ft. distant from the well, and lift the water 125 ft. to the reservoir, through 6,879 ft. of 16-in. pipe. The engine, built after plans of William Wright, was a condensing beam and fly-wheel engine, with steam cylinder of 32-in. diameter and 60-in. stroke, with 4 bucket and plunger pumps of 19-in. diameter and 16½-in. stroke, worked by cams on a shaft geared to the fly-wheel shaft. The pumps have since been increased in size.

In 1864, the engine being overtasked, a large air chamber was added. This engine is on duty at present time, and though it has not been used constantly since the erection of the gravity works, yet every year it has been called upon for considerable service.

The reservoir at Asylum Hill, connected with the pumping works, of 8,000,000 gallons capacity, was by mistake, in original plans, quite inadequate. It is in embankment and excavation, with puddled walls.

In April, 1879, the waste gate of this reservoir was opened by some unknown person, and it was suddenly emptied and the slope walls slid into the reservoir. It was repaired.

In 1865–7 gravity works were built at West Hartford after plans and under superintendence of George Marsh and Samuel M. Gray. Water is taken from a mountain stream known as Trout Brook. An earthen dam 58 ft. high, 782 ft. long, was built, flowing 32 acres with a capacity of 165,000,000 gallons. The elevation of flow-line above low water in river is 260 ft. In September, 1867, a heavy fall of rain occurred, breaking away a partly constructed dam above, and washing the banks of this reservoir badly. The water, rising above the puddle wall in the dam, cut a channel over the top, and in 20 minutes the dam went down, sending 200,000,000 gallons of water into the valley, causing much damage. The dam was rebuilt under the direction of J. W. McAlpine, and finished by December of the same year.

In 1874 the waste way of this reservoir was widened to double its capacity, and an overflow of masonry near the outlet, with 1-foot flash-boards. This reservoir is called No. 1.

Another reservoir, called No. 3, was completed in 1869 with banks left sufficiently wide to be raised 5 ft., which was done in the following year. It has a capacity of 297,000,000 gallons.

In 1875, a reservoir called No. 4 was built on Trout Brook, above No. 3. A dam of earth was thrown across the ravine. A puddle trench, 25 ft. wide, is sunk to the rock 19 ft. below the bed of the stream.

The dam is 170 ft. long at the bottom and 560 ft. at the top. The extreme width at the base is 225 ft., at the top 30 ft., and at the top water line, or 5½ ft. below top of bank, it is 50 ft. thick. It is 42½ ft. high above the bed of stream. The inside slope is 3 to 1, covered with rip-rap 30 in. thick. The outside slope is 2 to 1 and sown with grass. The waste way was cut through to a small ravine, which joins the main stream 300 ft. below the dam. The 16 and 20-in. discharge pipes also enter this ravine. Near the upper end of the reservoir a dyke 6 ft. high and 310 ft. long separates the water from the water of Mine Brook Valley. A second dyke 125 ft. long and 4 ft. high separates the water of the reservoir from dyke pond lying between reservoirs No. 4 and No. 3. There is a 12-in. connection pipe through this dyke and into reservoir No. 3. About 6 acres of muck at the upper end of the reservoir were covered with gravel 3 ft. deep.

This reservoir (4) flows 25.42 acres, and has a capacity of 154,524,829 gallons. Its extreme length is 2,890 ft., and average width 380 ft.

In 1877 the dam of this reservoir leaked, and was repaired by drawing off the water and laying a strip of puddle wall along the bottom of the dam, inside.

In 1880 a reservoir was built after the plans of W. E. Worthen, C. E., in a ravine into which empties Caldwell and another small brook. It is known as the Coldwell or No. 2 Reservoir. The dam is an east embankment, built in 6-in. layers, well watered and rolled. The surface was excavated to hard rock, and a concrete heart wall built, and the remainder of the trench filled with puddle. This reservoir overflows 160 acres. Two 20-in. pipe lines lead through the dam, one for waste and one for supply. There is a masonry gate-house on the inside slope. The main dam is 1,450 ft. long. A second dam 700 ft. long was built to prevent the water from backing across the divide at the upper end. An open conduit and 561 ft. of 16-in cement pipe lead the water to reservoir No. 1, a distance of 15,840 feet.

The first conduit from Reservoir No. 1 at West Hartford was of 20-in. wrought iron and cement. This pipe lasted from 6 to 10 years. The Water Commissioners in 1876 reported that it was rapidly being replaced with cast iron. It was found that the cement separated from the iron, which oxidized rapidly, and the joints caulked with hemp also proved very leaky in soft ground.

From time to time the W. Hartford works failed in supply, and pumping from the river was resorted to.

In 1875 a new 20-in. cast-iron main was laid from the W. Hartford works to the city.

The distribution was at first largely by cement and wrought-iron pipe, but in 1875 their further use was abandoned and only cast-iron pipe are now used.

The total length of pipe laid to March 1880 was: Cast-iron 54.9 miles, wrought-iron and cement 15.7 miles, of which about 9 miles are less than 6 in. in diameter. There has been no regular division into high and low service, but the old river works supply when running only the lower part of the city.

The first 20-in. main crossed the river on the old wooden bridge. When this was taken down in 1869 the main was supported temporarily on piles. On the completion of the stone arch, the pipe was carried across it on wooden supports.

The population, pipeage and consumption every tenth year have been as follows:

	Population.	Miles of pipe.	Consumption in million gallons.
1860	30,000	20.1	0.78
1870	37,180	46.4	...
1880	42,553	70.6	4.50

In 1880 there were 4,904 service taps, 362 fire hydrants, 54 meters.

The use of meters was begun in 1877.

The cost of the works to 1880 was	$1,497,408.25
Repairs and maintenance	485,475.93
Interest	959,521.15
Total	$2,942,405.33
Income from water rents	$1,625,626.91
Bonded indebtedness	1,052,000.00

The works are controlled by a board of six Water Commissioners. Horace Bissell was President and Superintendent from 1867 to 1872; Seth E. Marsh was President, Superintendent and Chief Engineer from 1875 to 1878. Since 1878 Edward J. Murphy has been President and Superintendent.

XXXIX.—LYNN.

Lynn, Mass., is in lat. 42° 6′ 27.5″ N., long. 72° 35′ 12″ W., on the north side of Massachusetts Bay, along the shore of which for three miles the city extends, mostly on flat land, with salt marshes in front of it, and behind it, about a mile and a half from the shore, a range of hills, a spur from which advances into the heart of the city, rising to a height of 185 ft. Settled in 1629, it was incorporated as a city in 1850, with a population of 14,257.

In 1869, after a disastrous fire, a line of pipe was laid from Flat Pond to the centre of the city, about 2.5 miles, and a number of fire hydrants set. A Worthington engine was used to obtain fire pressure. This engine has been removed to the present engine house as auxiliary to the main engine.

In 1871, the population being 30,000, water-works were constructed by the city, under the direction of five commissioners, George H. Bishop being the chief engineer.

The supply is taken from Breed's Pond, at the confluence of two brooks which receive the drainage of about one square mile of steep, rocky hillsides. The first storage capacity was 150 million gallons, which was increased by 40 million gallons in 1878, by raising the dam 3 ft.

In 1873, a storage reservoir was constructed on another stream by building an earthen dam 210 ft. long and 16 ft., flooding 67 acres and storing 200 million gallons. This is called Birch Pond.

The water is conveyed from the ponds to the engine house by 20-in. wrought-iron and cement pipes, and is pumped by a Leavitt compound beam and fly-wheel engine with steam cylinders of 17½ in. diameter for the high pressure, and 36 in. for the low-pressure working a Thames Ditton pump, with bucket of 26.12-in. and plunger of 18.5-in. diameter, the stroke of pistons and pump being 84 in., and the capacity of the pump, at 18 revolutions of engine, 5 million gallons per day. The water is lifted 164 ft. through a 20-in. wrought-iron and cement pipe 1,904 ft. long into the distributing reservoir on Pine Hill, which is built in excavation and embankment, with five acres of water surface at 177 ft. above mean high tide, and a capacity of 20,000,000 gallons at 15 ft. depth. The bottom, being of apparently water-tight material, was not puddled, and when the reservoir was filled it leaked so badly as to be almost useless. In 1873 the bottom was excavated 3 ft., and then covered with a foot of clay puddle. The reservoir was also divided into two parts by a wall of stone with a puddle core. On being refilled, it leaked slightly at first, but gradually be-