

four or five feet in depth and six inches in diameter by driving down an iron pile and then withdrawing it. Three such piles were used, twenty-two feet long, and shod with iron at point and head. Into these holes a cannister containing twenty pounds of powder was inserted by a diver, when the charge was exploded by electricity. This method loosened the materials sufficiently to make the dredges effective.

(TO BE CONTINUED.)

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.*

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

(Continued from page 174.)

XIV.—NEWARK.

Newark, New Jersey, 9 miles from New York, on the west bank of the Passaic River, comprises an area of 17.91 square miles, 11¼ square miles of which are less than 50 ft. above the river. The remaining territory rises, by a moderate slope, to an elevation of about 225 ft.

About the year 1800 the Newark Aqueduct Company was incorporated to furnish water. The exact date at which the works were constructed is not known.

The source of supply was springs from the old red sandstone on the hill side, about 80 ft. above the river.

As the demand increased and the supply was found insufficient, additional springs were from time to time taken in, and wells sunk, in some places in a stratum of sand, and others into the rock.

All of these springs were affected more or less by the summer droughts, and some of them failed entirely.

The works were conducted by the Aqueduct Company until the year 1860, when they were purchased by the city of Newark for \$150,000.

The company at this time was supplying about one million gallons per day, through 17.51 miles of pipes, none of which were more than 10 in. in diameter, and 11.6 miles were less than 4 in.

The springs did not yield more than 700,000 gallons per day, and the supply was eked out by using water from a brook which ran through the reservoir grounds, and also by occasional draughts from the Morris Canal, which passed near the reservoir.

The first improvement of the old works was the enlarging and deepening of some of the springs, in order, if possible, to increase their yield.

No considerable increase was obtained in that way. In 1862 a new reservoir, east of the canal, was built by cleaning out the old pond and raising and strengthening the banks.

In 1865 a second reservoir was built, adjoining the first, on the north. The capacity of these reservoirs is about twelve million gallons.

They were built in that location in order to render available the whole supply of spring water, and also to make use of such other sources as were then at hand.

New works were built in 1867, after the plans and under the direction of Geo. H. Bailey, C. E.

The supply is drawn from the Passaic River at Belleville near the northern line of the city.

The plan of the works contemplated the filtering of the water through the gravel and sand comprising the river banks. Two basins, each 140 ft. by 340 ft., were excavated through strata of alluvial soil, sand and gravel to a depth of 9 ft. below low water in the river, and near the shore.

The interior walls are vertical and of stone masonry laid in cement.

It was supposed that the water from the river would be filtered through the sand and gravel

with sufficient rapidity to insure a plentiful supply.

At first, when the demand was small, the supply was ample. The quantity pumped was about 600,000 gallons per day in January, 1870, but as the demand increased the supply diminished, and in September, 1870, when about 2,000,000 gallons per day were needed, water had to be drawn from the river. In 1871 it became necessary to enlarge the conduit by which the river water was admitted to the basins.

These works are believed to have been the first in America in which the application of natural filter galleries or basins to city supply was attempted.

The Passaic River has a water-shed of 981 miles above Newark. The geological structure of this drainage ground is favorable to the collection of water of great purity, but a few miles above Newark the river receives the drainage and refuse from Paterson and Passaic, towns in which there are about 20 large manufacturing establishments and some 60,000 inhabitants.

The pollution from this source, and from the sewage of Newark, which is carried up by the tide past the pumping works, makes the water used at times unpleasant, if not unwholesome.

In 1879 the experiment was tried of procuring a portion of the water for use from tube wells driven in the gravel plain on the river bank, adjoining the pumping station. Ten 2-in. pipes connected to a suction-main, yielded 700,000 gallons daily for six months. Twenty 3-in. pipes were then driven, and two and a half million gallons per day pumped for several months. In the fall of 1880 forty more tubes were driven, and connection made with one of the five million gallons Worthington pumps. The water obtained in this way was of good quality, and being mixed on nearly equal proportions with the impure river water, greatly improved the quality of the supply to the city.

From the pump-well, which is arranged to draw independently from either of the basins, the water is lifted to the receiving reservoir by three Worthington engines. The first was erected in 1869, and is of five million gallons capacity. The second, put in operation in February, 1871, is a duplicate of the first. The third, put in operation in March, 1875, is a compound engine of eight million gallons capacity. The high-pressure cylinders are 29 in., the low pressure 52 in. and the pumps 28 in. in diameter and 50-in. stroke.

The receiving reservoir, 6,000 ft. from the engine-house, and 165 ft. above high water in the river, is in excavation and embankment, is 285 by 410 ft. at water surface and 20 ft. deep. The slopes are lined with a 12-in. stone wall, laid in cement. The 30-in. pumping main passes under the bottom to the centre, and is turned up, terminating in a bell mouth at 167.5 ft. above high tide. In 1878, during a season of great consumption of water and insufficient capacity of the 24-in. distributing main from the reservoir, this discharge pipe was capped and water pumped for a time, directly into the distribution pipe, under pressure, without passing through the reservoir. An additional 30-in. supply main was laid in 1879.

In 1871-3 a low-service reservoir was built about 8 miles from the receiving reservoir, with its surface 114 ft. above tide. It is circular, 460 ft. in diameter, and 20 ft. deep. Built on the site of an old quarry and its bottom filled in to some depth with stone chips, the puddling on the bottom gave way and the reservoir emptied itself several times. It was several times repaired, but would not hold water at all until all the loose material had been removed from a trench around the base of the banks, carried down to solid rock and filled with puddled clay.

For high-service supply two high-pressure engines, erected about 1870, taking the water from the main pipe, pumped it into a reservoir

built in 1871, at 225 ft. above tide. It is 260 by 308 ft., and holds two million gallons. A stand-pipe annexed enables the pumps to deliver a portion of the water 35 ft. higher than the reservoir.

This reservoir leaked for five years after its construction and was then repaired and made tight.

A Worthington tank engine of three million gallons capacity was erected for the high-service supply in 1876, and a second one in 1881.

All distribution pipes are of cast iron. Considerable trouble was experienced with the small pipes laid by the Aqueduct Company previous to 1870.

They had to be replaced by larger pipe, and by 1876 nearly all of those of 3 in. and less had been removed.

The use of meters was begun in 1873, and there are now about 159 in use.

The population, pipeage and consumption have been as follows:

Year.	Population.	Miles of pipe.	Consumption per day in millions of gallons.
1860.....	71,941	17.5	1.00
1870.....	105,542	51.6	2.50
1880.....	136,400	136.2	9.39

The cost of the works to Dec. 31, 1880, was \$2,671,580.40, exclusive of real estate, interest and operation. The outstanding bonds amount to \$3,240,000.

The income for 1880 was \$312,749.55, and the expenditures \$68,682.92 for operation and maintenance and \$223,800 for interest.

The works are managed by a board composed of the Mayor and six commissioners, elected by the people, two changing every year.

George H. Bailey, C. E., was Chief Engineer of the work from 1860 to 1877. Until 1875 he was also the Superintendent. Jerome B. Ward was Superintendent from 1875 to 1881.

XV.—LOUISVILLE.

Louisville, Kentucky, in lat. 38° 3' N., long. 85° 30' W., on the south bank of the Ohio River, covers 12½ square miles on an elevated plateau 70 ft. above low water in the river. Settled in 1775, its population in 1851 was about 45,000, when it was incorporated as a city.

The Louisville Water Company was chartered in 1854. On Sept. 6, 1856, the city was authorized by a popular vote of 1415 to 370, to subscribe for \$550,000 of the stock of the company and issue bonds to that amount.

Works were constructed after the plans of Theodore R. Scowden, C. E., and water was introduced on Oct. 16, 1860. The supply is taken from the Ohio River 1.52 miles above the city limits. The shore is of coarse gravel and the current rapid. A wrought-iron inlet pipe of 50 in. diameter, set in a crib of timber filled in with stone, the mouth of the inlet being 5 × 12 ft. and set 1 ft. below lowest water, conveys the water 300 ft. to two rectangular chambers with which the pump suction-pipes are connected.

By 1865 the inlet pipe was found to be half full of silt, and in 1866 so much trouble was caused by it that a well was sunk over the pipe 105 ft. from its end, intending to cut off the pipe and clean it. Work was stopped by high water, but resumed in 1867 and accomplished. The silt removed was half the capacity of the pipe. The pipe itself was found to be sound outside, and to have some tubercles on the inside, the deepest corrosion being ¼ of an inch.

Anchor ice stopped the pumps in Dec., 1870, and the strainer had to be removed temporarily. In Dec., 1874, a stoppage from floating leaves occurred. The pipe was cleansed of sediment again in 1877, when 20 in. in depth had accumulated. The top of the pipe was found to be considerably corroded, in some places ¼ in. deep.

Two Cornish beam engines, with steam cylinders of 70¼-in. diameter and 120-in. stroke and plungers of 36-in. diameter are used.

Stronger columns were put in to support the