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**GREAT STONE DAM
CITY OF LAWRENCE, MASSACHUSETTS**



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ON THE COVER:

Great Stone Dam City of Lawrence, Massachusetts

The cover photo shows the Great Stone Dam, located on the Merrimack River, in the heart of the City of Lawrence. Completed in 1848, this dam was built in conjunction with a series of canals to harness the hydropower of the Merrimack and fuel the factories that defined the American landscape at the time of the Industrial Revolution. Drawing from the successes of nearby Lowell, MA, Lawrence originated as a “planned factory city,” growing into a major player in the textile manufacturing industry.



Spanning 900 feet and with a height of 35 feet, Great Stone Dam is considered one of the greatest engineering projects of the 19th century due to its size, its method of construction, and the impact of its development to the Merrimack Valley area. The dam is constructed of large granite blocks embedded into the river bed below and laid with hydraulic injections of concrete. The Great Stone Dam contributed not only to Lawrence’s industrial past, but has created recreational opportunities directly upstream. As a result of the large mill ponds created by the dam, the location is ideal for activities such as boating, kayaking, and canoeing.

Lawrence’s earliest water systems resulted from the need to supply a reliable pipeline of water to extinguish fires that were commonplace in the textile factories. Factories built pumping stations along the canals and reservoirs to store and maintain adequate water pressure and supply in the event of an emergency. The system was ultimately expanded to include domestic customers, which resulted in the need for water treatment prior to distribution.

The Great Stone Dam is located approximately one mile downstream from the Water Treatment Facility, which draws its water source from the Merrimack River. In the late 2000s, the dam underwent extensive improvements, including the installation of a rubber bladder system to control water level. Construction of the Great Stone Dam was an integral part of the American Industrial Revolution, the development of the City of Lawrence, and ultimately the founding of the Lawrence Water Works.

Submitted by: Brian Peña, Water and Sewer Commissioner
City of Lawrence, Massachusetts

Cover Photo: Ross Elliott, Woodard & Curran

WATER SYSTEM PROFILE

Lawrence Water Works City of Lawrence, Massachusetts

Water has been of paramount importance to the City of Lawrence, as the city was formed as a result of the very access to the precious resource. Access to a reliable source of travelling water was paramount during the American Industrial Revolution, as hydropower fueled the spinning and weaving machines that provided jobs for thousands of immigrants living in the Merrimack Valley area at the time.

Due to the success in the harnessing and use of the Merrimack River's hydropower in the development of cotton mills in nearby Lowell, a group of industrialists, spearheaded by Abbot Lawrence, set out to develop a manufacturing city with a permanent dam and a system of adjoining canals. The construction of the Great Stone Dam in 1848 laid the foundation for the establishment of the city, eventually leading to its incorporation in 1853.

Early Water System

The "Lawrence Aqueduct Company" was chartered in 1848 by John Tenney of Methuen, Alfred Kittredge of Haverhill, Daniel Saunders of Lawrence, and associates. Their planned project of supplying water from Haggert's Pond was found unfeasible due to lack of appropriate capital and an underestimate of supply needs. The authorized capital of the company was only \$50,000, and the projectors based their supply calculations on an estimated per capita usage of 18 gallons per day. Experience showed that a supply of three and four times that quantity must have been provided to cover use, waste, and leakage.

In 1851, Bay State Mills and the Essex Company, sharing expenses, built a reservoir of 1,000,000 gallons capacity on Prospect Hill. Water in this reservoir was kept at a level of about 152 feet above crest of the dam and was raised by pumping through tested cast iron pipes. The reservoir was afterwards owned and operated by the associated corporations, which formed the Lawrence Reservoir Association, although each corporation had its own separate distribution network of pipes.

For twenty-four years, pipes and hydrants in corporations yards and principal business streets were supplied from this reservoir. The Common Pond was also filled from this source. In 1871-72, a project to construct public water works for the city was initiated. A petition signed by Henry Barton and eighteen leading citizens was presented to the City Council, asking for immediate action. The result was that a joint special committee concluded that supply must be taken from Merrimack River, rather than any pond in adjacent towns.

Water System Information

<i>System name</i>	Lawrence Water Works
<i>Service area</i>	Lawrence, MA
<i>Population served</i>	77,326
<i>Sources</i>	Merrimack River
<i>Treatment processes</i>	Flocculation/Coagulation, Upflow Clarification, Filtration, UV Disinfection, Chlorination
<i>Miles of pipe</i>	154
<i>Daily demand</i>	6 million gallons
<i>Number of employees</i>	40 + Contract Ops.
<i>Average Yearly Residential Water Bill</i>	\$373 (based on 90,000 gallon estimate)

Profile: Lawrence Water Works, City of Lawrence, Massachusetts

The City Council petitioned the Legislature for the passage of “An Act to supply the City of Lawrence with water.” This act was approved March 8, 1872, by Governor William B Washburn. The act provided for the appointment of three commissioners to be elected by the City Council in convention each for three years’ service. They were to execute and direct work done by authority of the Act, or subsequent Acts.

Legal voters approved of this Act in May 1872, by a vote of 1298 to 830. In June 1872, a joint special committee on water was appointed, which included James Payne and James A. Treat, aldermen, and Lorenzo D. Sargent, Henry J. Couch and George W. Russell, from the common council. James Payne, Esq., was chairman, and L. Fred Rice, of Boston, was engineer consulted. An exhaustive report was made, and April 18, 1873, an ordinance providing for the election and defining the duties of water commissioners was passed. As a result of this act, the Lawrence Water Works was formed.

Lawrence Water Works

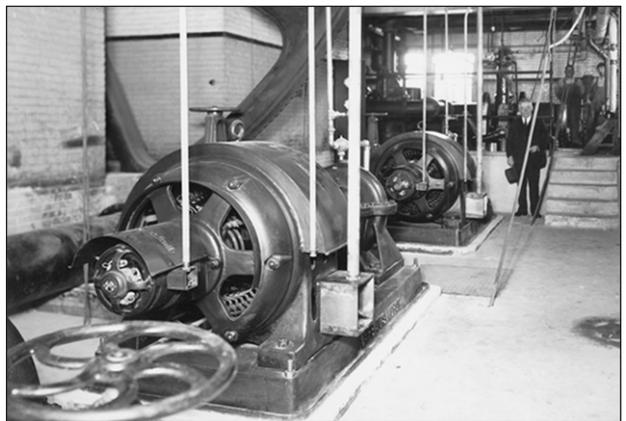
The Lawrence Water Works began supplying drinking water to the city in 1874. The first brick pumping-station consisted of two pumping engines made by I. P. Morris & Co. of Philadelphia – overhead beam engines with compound cylinders and capacity of 2,000,000 gallons per hour each, which forced the water from Merrimack River to the Reservoir on Bodwell’s Hill, a little more than a mile from the business center, through 5,000 feet of 30-inch diameter force main pipe.



Circa 1874 — Lawrence’s First Pump Station



Circa 1890s — Lawrence’s First Water Pumps



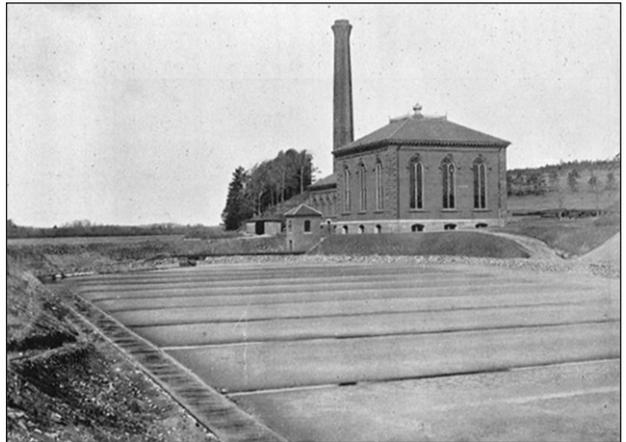
Circa 1890s — Lawrence’s First Water Pumps

Profile: Lawrence Water Works, City of Lawrence, Massachusetts

The water works system cost \$1,800,000, which was raised by creating a bonded debt. In 1892, slow sand filters were constructed adjacent to the pump station to provide additional treatment. Additionally, chlorine gas was used to disinfect the treated water.

As a result of flooding in 1939, which wiped out the original filter beds, the city began construction of its first Water Treatment Facility, which remained in operation from 1939 to 2007. This treatment facility consisted of sedimentation basins (constructed at the site of the original slow sand filters), lime addition, 10 rapid sand filters, and chlorine disinfection.

The city was divided into 4 distinct pressure zones, and water was pumped from this facility to storage tanks located within each of these zones. Excess capacity was stored in an open reservoir, consisting of two separate basins, with a combined capacity of 40 million gallons.



Circa 1892 — Lawrence's First Slow Sand Filters and Pumping Station



Circa 1901 — Lawrence's First 40 Million Gallon Reservoir

Between 1999 and 2000, as a result of increased government drinking water regulations, a 10 million gallon steel storage tank, designed by Metcalf & Eddy, was constructed and placed in one of the open reservoir sections, where it was buried. The remaining section was drained and until this day remains unused. This 10 million gallon tank provides sufficient storage, as Lawrence has actually seen a decline in population, and thus water demand has plateaued to an average of approximately 6 million gallons per day.

In 2007, a new state-of-the-art treatment facility (New Water Treatment Facility) was placed online, replacing the city's 70-year old plant.

Supply

Water from the Merrimack River is pumped through the Raw Water Pump Station to a 30-inch ductile iron pipe that feeds the treatment facility located adjacent to the pump station. The water is treated at the New Water Treatment Facility through conventional treatment. The treated water is then pumped to the distribution system or stored for later use.

During emergencies or periods of unusually high demand, Lawrence has the ability to buy water from surrounding communities through existing interconnections with Andover, Methuen, and North

Profile: Lawrence Water Works, City of Lawrence, Massachusetts

Andover. The sources of these interconnections are the Merrimack River and Haggets Pond in Andover, the Merrimack River in Methuen, and Lake Cochichewick in North Andover.

Treatment

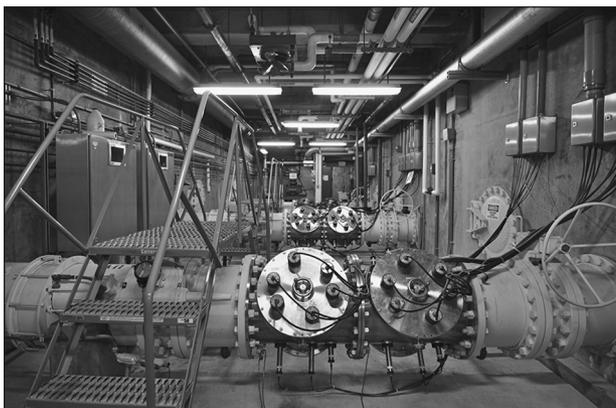
Lawrence was already on a path to modernizing its water treatment systems when it built a new 16 MGD surface water treatment plant, which went online in 2007 and serves more than 74,000 residents. The facility is operated by Woodard & Curran under a 5-year operations and maintenance agreement; the facility employs 5 full time licensed operators. The New Water Treatment Facility operates 24 hours a day, 7 days a week to provide the highest quality water to the residents of the city. The facility produces over 2 billion gallons of water each year. Water quality is continuously monitored by laboratory testing and online analysis to ensure our water meets and exceeds state and federal drinking water regulations at all times.



Lawrence's Current Treatment Facility Last Upgraded in 2014

The raw water is screened and then metered to allow for flow paced chemical injection before it travels to a static mixer. The raw water is injected with a chlorine dioxide, potassium hydroxide for pH control and aluminum sulfate for primary coagulation, followed by a polymer coagulation aid. The coagulated water is then transferred to two superpulsation clarifiers.

The system uses two Greenleaf Filtration trains using granular activated carbon (GAC) for taste and odor control and an Aquaray H₂O in line ultraviolet unit. The UV effluent is injected with hypochlorite and pumped to the clearwell by variable frequency drive (VFD) controlled pumps rated for 5,600 gpm each. Water then travels through a magmeter vault for flow pacing of potassium hydroxide and fluoride. Water



UV Reactor Room in the New Water Treatment Facility

enters the distribution system via the finished water high service pump station, which consists of 5 pumps (1 VFD unit and 4 constant speed units). Finished water is pumped to the Ames Street Reservoir, the High Service Water Tower (Tower Hill Tank), the Mount Vernon Tanks, and the Prospect Hill Tank.

The Plant employs a Supervisory Control and Data Acquisition (SCADA) system and is highly automated. There are four Human Machine Interfaces (HMIs) located within the plant and pump stations. The facility utilizes

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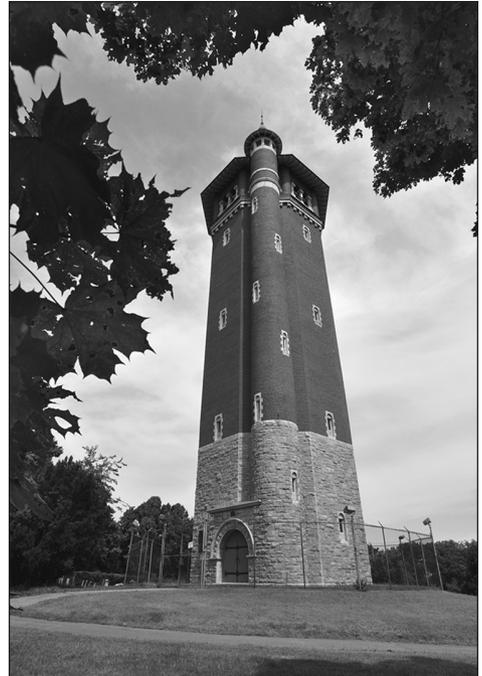
a computerized maintenance management system (CMMS) for effective management of repair and maintenance activities and OPS32 software for regulatory compliance reporting and process control trending requirements.

The Water Treatment Facility also monitors several ancillary facilities to maintain adequate water pressure and volume throughout the City of Lawrence.

Distribution

The Water Distribution System Maintenance Division is responsible for operating, maintaining and repairing the water distribution system; installing new water mains and fire hydrants; implementing the cross connection backflow prevention program; reviewing plans for new water mains and services; approving new water service applications; and maintaining records of the distribution system.

As described above, water is pumped into the distribution system from the New Water Treatment Facility. The distribution system includes approximately 154 miles of pipe that range in diameter from 6-inches up to 30-inches; there are approximately 4,400 water valves and 1,300 fire hydrants. Pipe materials include cast iron, lined cast iron, and lined ductile iron. Pressure and storage capacity are maintained by elevated storage tanks and pumping stations throughout the city. The pumping stations operate to fill storage tanks and/or pressurize separate high pressure zones.



High Service Water Tower

Recent Projects

Lawrence took advantage of the strong incentives and market for renewable energy in Massachusetts, installing roughly 36,500-square-feet of ground-mounted photovoltaic solar panels to provide supplemental power for operation of the water treatment plant. In 2013, Waterline Industries began the construction of a 300kW (AC) photovoltaic array. The solar panels, located adjacent to the treatment facility, went online in May 2014. At a cost of \$1.1 million, the city is expected to see rapid payback through a combination of energy savings and Solar Renewable Energy Credits (SRECs). The solar panels are expected to provide between 10-15% of the energy needs for the Water Treatment Facility. The total energy savings and sale of SRECs is expected to generate



Solar Panels, located adjacent to the New Water Treatment Facility, provide 10-15% of the plant's energy needs.

Profile: Lawrence Water Works, City of Lawrence, Massachusetts

well over \$100,000 per year. The installation and operation of these solar panels is a testament to the Water & Sewer Department's commitment to reduce its carbon footprint through a combination of renewable energy sources and energy efficiency upgrades. "We are committed to ensuring environmental stewardship in our day-to-day operations through conservation and sustainable practices," said Water & Sewer Commissioner Brian Pena. "These energy efficiency improvements are a great way to reduce our energy dependency, while maintaining some of the lowest water and sewer rates in the Commonwealth."

System Improvements

Like many New England cities, Lawrence's infrastructure is aging and will need significant investment to remain strong for the future. Having recognized this need, the city is proactively addressing a range of challenges and spending on improvements and upgrades. Many communities in similar positions are looking at rate increases to fund this type of work, but by prioritizing projects that reduce costs or recapture lost revenue, Lawrence has been able to avoid putting new costs on its ratepayers.

Lawrence has made steady improvements over several years, partnering with engineering firm Woodard & Curran to complete a range of projects. By replacing 12,000 aging water meters with new, high accuracy meters that have the ability to transmit usage data electronically, Lawrence expects to see an additional \$1.3 million in formerly unbilled revenue. The new water meters provide a higher degree of accuracy, more reliable and consistent readings, and have enhanced features like helping detect leaks and providing better security, which improves the efficiency and reliability of each city's water system. This work was funded through the State Revolving Fund program.

Efficiency has also been a focus of the city, and an energy audit uncovered several projects that not only improved performance, but provided significant savings. By replacing just two inefficient finished water pumps, the city will save approximately \$90,000 annually in energy costs. The new 150 HP pumps will have a capacity of 8.5 million gallons per day and will be equipped with VFDs, replacing the previous large, inefficient pumps that operated at 100 percent speed with a modulating valve.

Combined, these projects delivered significant new revenue and cost savings, which has allowed Lawrence to tackle other infrastructure projects, including the installation of 31,000 feet of new water main and the cleaning and lining of another 9,000 feet of main at a total cost of just under \$7 million without raising rates.

In the next few years, Lawrence will continue its water main rehabilitation work, about \$13 million worth, without a rate increase, thanks in part to low-interest financing, energy efficiency improvements, and increased revenue captured by new water meters.

Submitted by

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City of Lawrence, Massachusetts