# History of the Dover Water Works
## City of Dover, New Hampshire


Woodcut frontispiece in 2nd Annual Water Commissioner's Report for 1889.

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## 1. INTRODUCTION

*Vetturale di natura* – "the vehicle of nature" is how Leonardo da Vinci described water; that to the world what blood is to the body. When born, the human body is about 78% water, dropping to about 60% as it ages. Humans last about three days without water before organs begin shutting down. As human populations grow and cluster, ready sources of drinking water in streams and ponds become polluted and human survival wanes. Water from the ground was discovered to be clear and pure and settlement clustered around natural springs until humans developed the dug well, perhaps 8,000 BC – the first method of artificially obtaining a water supply. Water supply ditches, tunnels and aqueducts, storage cisterns and reservoirs followed over the centuries allowing humans to concentrate into large societies. One of the greatest surviving symbols of an ancient civilization's quest for a reliable water supply is the Roman aqueduct at Segovia, Spain, built c.100 AD (Figure 1).

FIGURE 1: Roman aqueduct, Segovia, Spain, 11 miles long overall, 94 feet high through the city, resting on foundations 20 feet deep (Aqueduct of Segovia).

The location of Boston was established in 1630 on the basis of available fresh water. The Winthrop Fleet, upon landing in Charlestown and finding no water, crossed to the south side of the Charles River to settle around a spring. Boston also was the first city in America to establish a private water supply system when in 1649 the General Court of the Colony granted The Water Works Company the right to build what became known as the *Ancient Conduit* consisting of piping leading from several springs to a reservoir about twelve feet square over which a protective building was erected. [1]

FIGURE 2: Philadelphia Water Works pump house by Benjamin Latrobe, 1800, the first public water system in the US. Latrobe was appointed Architect of the [US] Capitol in 1815 (William Birch, 1800).

Albany was next to establish a private water system in 1678 and during the 18th century another fifty systems were built in cities and towns across the country. Philadelphia formed the first public water system in 1799, hiring architect Benjamin Latrobe to design the works which included iron piping, a reservoir and a neoclassical pump house with two steam engines set in Centre Square (Figure 2).

## 2. EARLY NEW HAMPSHIRE WATER WORKS c.1785 – 1820

The first private water supply constructed in New Hampshire was apparently built in the small town of Nelson, New Hampshire, settled in 1767 and known as Packersfield up to 1812. Samuel Cummings, his cousin Stephen Cummings and another Nelson resident, Luther Emes, all became involved in building water supply piping and aqueducts. Samuel or Stephen invented a drill bit for boring pump logs and aqueduct piping and possibly with the assistance of Emes laid an aqueduct in Nelson about 1785. Unfortunately no records describing the makeup of the Nelson system are known to exist. Stephen was later responsible for building the Salem & Danvers Aqueduct in Massachusetts in 1797. Emes when on to build aqueducts in the neighboring town of Keene, in Lansingburgh (NY) and Boston.

In Keene, Luther Emes (or Eames) is believed to have built the first aqueduct in that town by 1793. The wood pipes ran under a street between a spring and Richardson Tavern. In 1794, Emes and Deacon Abijah Wilder collaborated to pipe water from Beaver Brook in Keene downhill to several homes and businesses.

FIGURE 3: Logs were bored out with a long drill bit and then tapered externally and internally at opposite ends to jam tightly together end-to-end. Iron ties or clamps often secured the joints. These redwood pipes in the photo above were unearthed from the early system installed at Fort Bragg, North Carolina in the 19th century. In New Hampshire similar log pipes but of white pine, elm or hemlock were typically used (Mendocino Coast).

The Shaker community at Canterbury was also an early manufacturer of log pipes, possibly supplying neighboring Boscawen with the pipes laid in 1794 to supply several homes. In 1797 the Shakers laid over 3000 feet of log pipe aqueduct in Canterbury, probably the largest water supply system in the state at that time.

Portsmouth is regarded as having built the first "public" water system in the state, incorporated in 1797 by seven men under the name "The Proprietors of the Portsmouth Aqueduct." Construction was completed in 1798 using white pine logs of not less than thirteen inches in diameter.[2] The NH Division of Environmental Services website provides this history of the Portsmouth system:

> This system brought water some 2.5 miles to serve the compact part of Portsmouth through a system of wooden pipes. Some of these pipes were supplied by the Shakers at Canterbury, NH. The second oldest large system in NH was the Exeter Aqueduct, which gained permission to operate from New Hampshire Legislature in 1801. Both the Portsmouth and Exeter water systems were engineered by Benjamin Clark Gilman, an Exeter clock maker who also designed similar water systems in Boston and Salem, Mass. and New London, Conn. The Portsmouth system had low pressure and limited volume capacity. In 1802, a devastating fire in Portsmouth quickly brought newspaper editorials recommending that the town be supplied with large underground cisterns to be kept filled with water from the aqueduct and constructed to act as reservoirs for fire-fighting. In response several cisterns were built in public squares.[3]

By 1820, six more water supply systems were built in New Hampshire towns and villages including Amherst, Drewsville, Hillsborough, Hanover, Lancaster, Peterborough and Haverhill; Dover soon followed suit.[4]

## 3. DOVER AQUEDUCT COMPANIES 1820 – 1889

Prior to the establishment of the publically owned and operated Dover Water Works in 1889, four private water companies supplied the rapidly growing city with service by subscription. The first efforts to deliver water to Dover were organized in 1823. Four prominent business men incorporated under the name Proprietors of the Dover Aqueduct "for the purpose of conveying water by subterraneous pipes into the Village of Dover."[5] The "proprietors" included John Williams, one of the founders of the Cocheco Manufacturing Company two years earlier, Asa Freeman, a practicing lawyer in Dover, William Hale, owner of a large store on the Cocheco River near the Washington Street Bridge, and Jesse Varney, a mill owner. The law authorized the corporation to

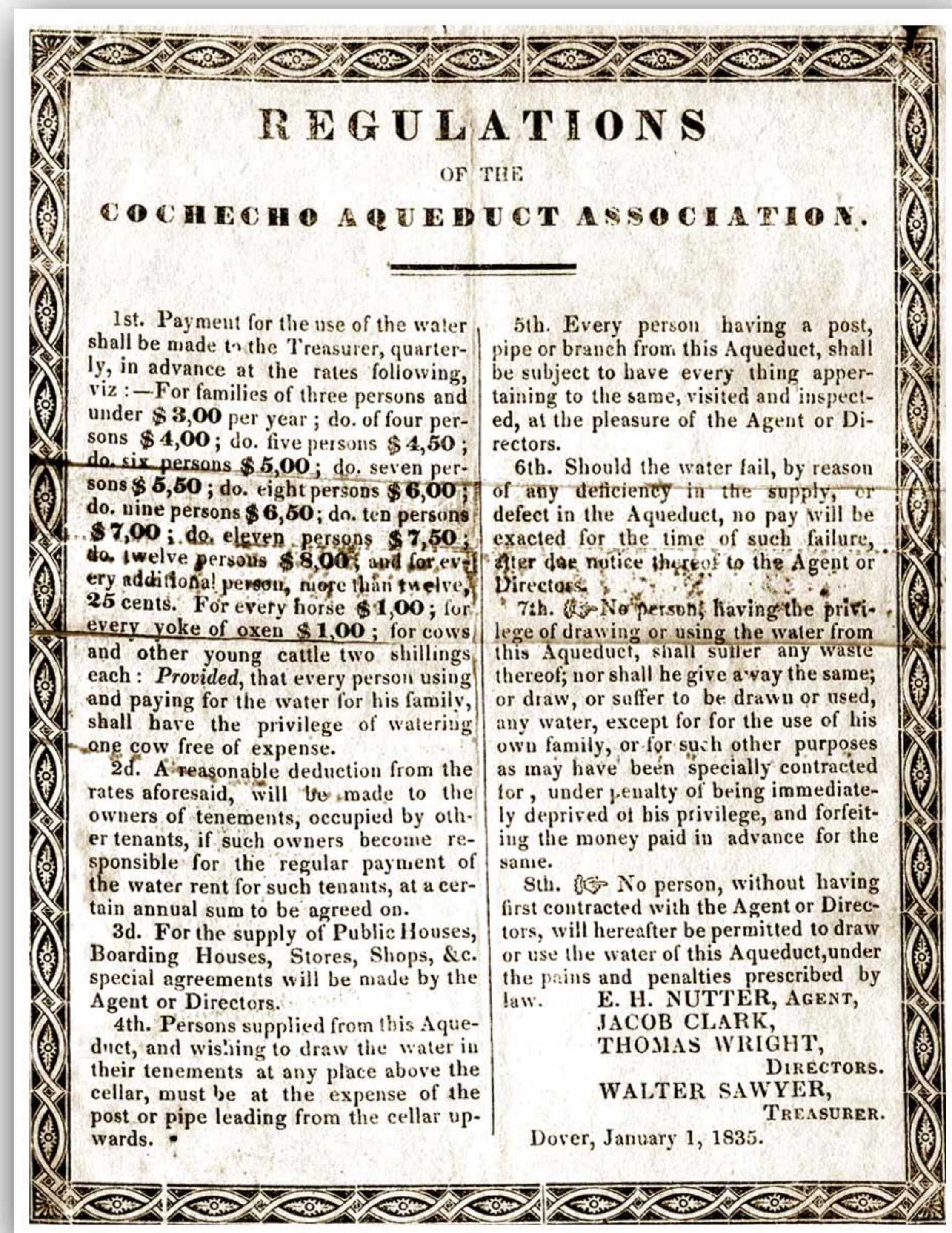
> "enter upon and break up the ground and dig ditches in any land or enclosures or any streets or highways, through which it may be necessary for said Aqueduct to pass, for the purpose of placing such pipes as may be necessary for building and completing said aqueduct, or of repairing the same when requisite; provided, that in case the said proprietors and the owners of the land through which said aqueduct must pass shall not agree on the compensation to be made for the damage done to said land, the Superior Court of Judicature upon application of said proprietors, or of the owners, may appoint a committee who shall ascertain the same and make report to said Court…"

A year later, on June 16, 1824, the Dover Landing Aqueduct Company was incorporated with the purpose of "conveying water by subterraneous pipes, into that part of the village of Dover which lies upon the northerly and easterly side of the Cochecho river."[6] With the charters for the two companies so close in time, it is reasonable to assume that the earlier system was located on the south side of the Cocheco River.

Details regarding the construction of these early Dover aqueducts has not been located but specifications for the building of the first water supply in the city of Concord in 1826 provides an example of the practice at the time:

> Aqueduct to be constructed of white pine logs, from 2 to 16 feet long, 12 inches diameter at the small end, exclusive of bark and sap, to admit of a 4 inch bore, the logs to be connected by seasoned white oak tubes 12 inches long, (a specimen of which may be seen) the logs to be secured from splitting by iron hoops driven into the ends, the ditch to be 4 feet deep in dry soil and about 2 feet in wet. Other logs are wanted for lateral branches, not less than 8 inches in diameter, exclusive of bark and sap, to admit of a 2 inch bore, to be connected in the same manner as the others.[7]

In 1832 Dover's third water company was incorporated as the Cochecho Aqueduct Association. By 1835 subscribers we being accepted and water rates and regulations were published (Figure 4). The rate for families of three or less was $3.00 per year. Additional family members were 50 cents each up to a family of twelve, then 25 cents each thereafter. Each horse and "yoke of oxen" – $1.00 per year; cows and "other young cattle" – two shillings each. "For the supply of Public Houses, Boarding Houses, Stores, Shops, &c. special agreements will be made by the Agent or Directors."[8]



# REGULATIONS

OF THE

## COCHECHO AQUEDUCT ASSOCIATION.

1st. Payment for the use of the water shall be made to the Treasurer, quarterly, in advance at the rates following, viz :—For families of three persons and under **$ 3,00** per year ; do. of four persons **$ 4,00** ; do. five persons **$ 4,50** ; do. six persons **$ 5,00** ; do. seven persons **$ 5,50** ; do. eight persons **$ 6,00** ; do. nine persons **$ 6,50** ; do. ten persons **$ 7,00** ; do. eleven persons **$ 7,50** ; do. twelve persons **$ 8,00** ; and for every additional person, more than twelve, **25** cents. For every horse **$ 1,00** ; for every yoke of oxen **$ 1,00** ; for cows and other young cattle two shillings each : *Provided*, that every person using and paying for the water for his family, shall have the privilege of watering one cow free of expense.

2d. A reasonable deduction from the rates aforesaid, will be made to the owners of tenements, occupied by other tenants, if such owners become responsible for the regular payment of the water rent for such tenants, at a certain annual sum to be agreed on.

3d. For the supply of Public Houses, Boarding Houses, Stores, Shops, &c. special agreements will be made by the Agent or Directors.

4th. Persons supplied from this Aqueduct, and wishing to draw the water in their tenements at any place above the cellar, must be at the expense of the post or pipe leading from the cellar upwards.

5th. Every person having a post, pipe or branch from this Aqueduct, shall be subject to have every thing appertaining to the same, visited and inspected, at the pleasure of the Agent or Directors.

6th. Should the water fail, by reason of any deficiency in the supply, or defect in the Aqueduct, no pay will be exacted for the time of such failure, after due notice thereof to the Agent or Directors.

7th. ☞ No person, having the privilege of drawing or using the water from this Aqueduct, shall suffer any waste thereof; nor shall he give away the same; or draw, or suffer to be drawn or used, any water, except for for the use of his own family, or for such other purposes as may have been specially contracted for, under penalty of being immediately deprived of his privilege, and forfeiting the money paid in advance for the same.

8th. ☞ No person, without having first contracted with the Agent or Directors, will hereafter be permitted to draw or use the water of this Aqueduct, under the pains and penalties prescribed by law.

E. H. NUTTER, AGENT,
JACOB CLARK,
THOMAS WRIGHT,
DIRECTORS.
WALTER SAWYER,
TREASURER.

Dover, January 1, 1835.

FIGURE 4: Regulations of the Cochecho Aqueduct Association 1835. Original document located in Dover Public Library special collections.

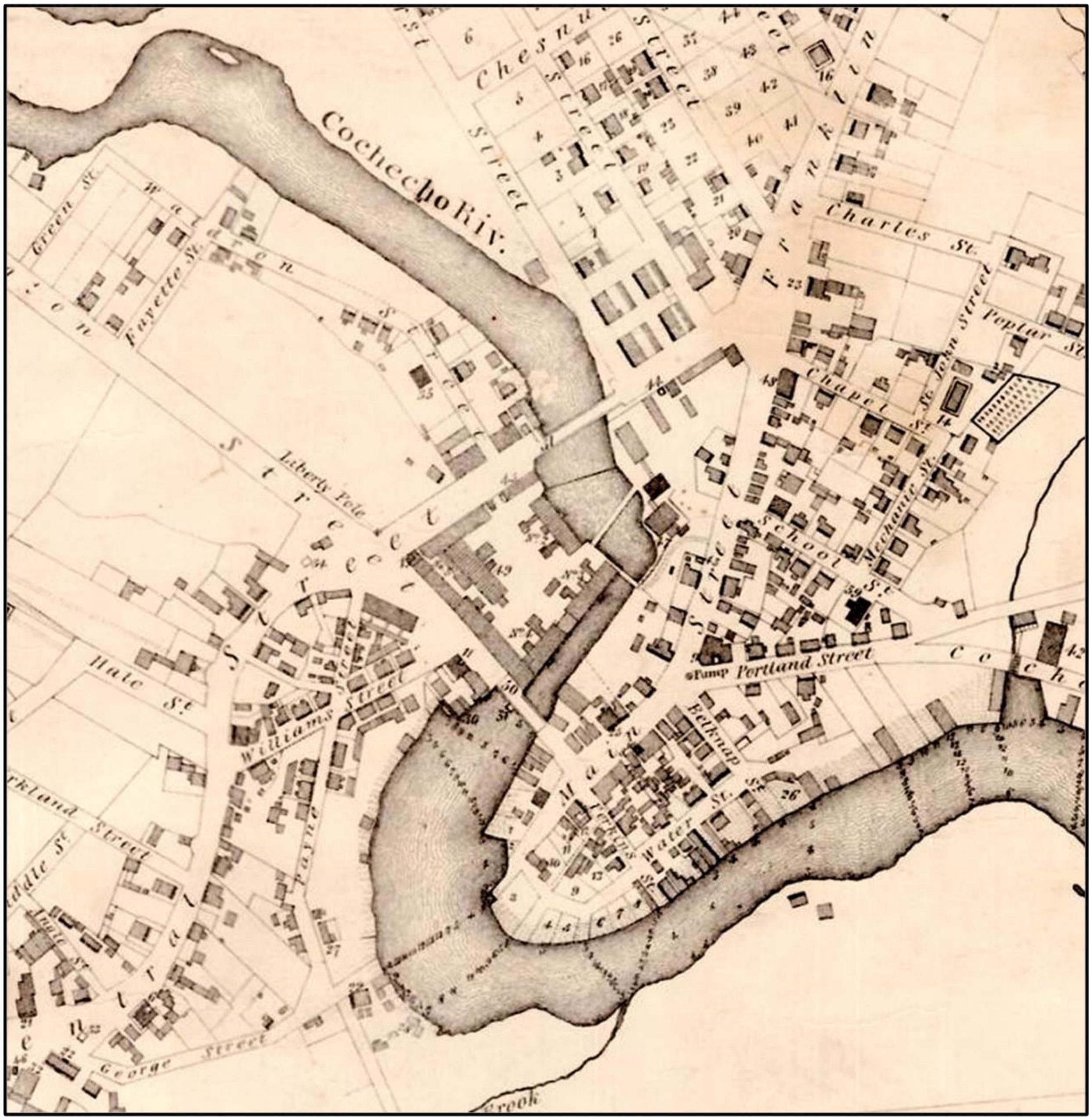


FIGURE 5: Map of Dover Village, 1834 by G. L. Whitehouse. Three private companies, Dover Aqueduct Co., Dover Landing Aqueduct Co., and Cochecho Aqueduct Assoc., were supplying water to the village by 1834.

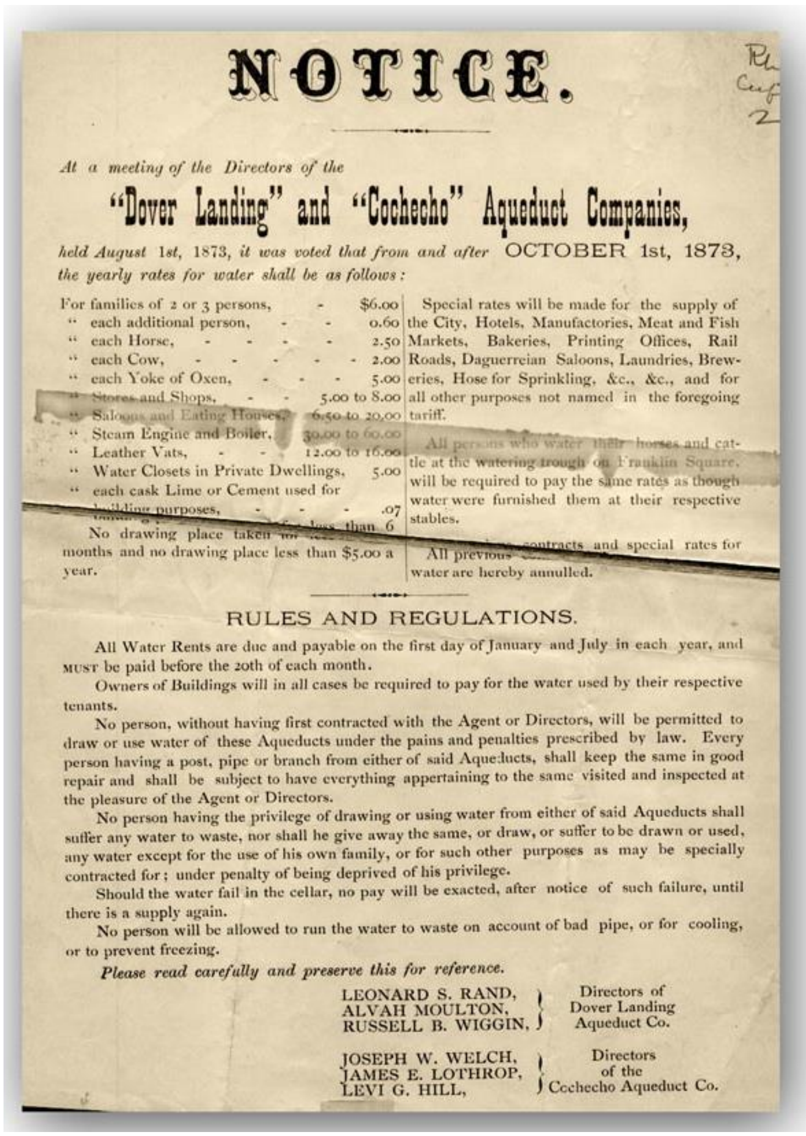
Between 1840 and 1890 Dover's population doubled from 6,458 to 12,790. During the 1880s a series of disastrous fires demonstrated the inadequacy of the water system for fighting fires. In 1881 the almshouse at the Strafford County Poor Farm burned to the ground killing thirteen people. In 1882 a fire in the Laskey Brush Factory spread to a house, barn and the Washington Street Free Will Baptist Church, destroying them all. On April 15, 1887, the Cocheco Print Works burned down in a fast moving and spectacular fire that severely rattled the citizenry. [See "A History of Fires in Dover" on the Dover Public Library website.[9]]

On June 28, two months after the Print Works fire, Dover City Council called a special meeting to consider building a modern public water works system for the city. In promoting the undertaking, Mayor B. Frank Nealley explained the need:

> Our present water service is crude, and has long been inadequate, deficient in its supply for domestic uses. In the lack of water for extinguishment of fires, certain sections of the city have been practically defenceless. The city is built in a way to invite conflagrations. Fire traps abound. A fire started in certain localities, under unfavorable conditions of weather, and property to the value of the cost of our system of water works may go up in smoke Thanks to an over-ruling Providence, we have escaped disaster.[10]

Sensing broad public support, the City Council authorized Mayor Nealley to "secure and employ a competent and experienced engineer to ascertain water supply and cost of constructing water works."[11]

John Holland, Agent of the Cocheco Mfg. Co., the city's largest employer and friend of the mayor, recommended Percy M. Blake, a civil engineer in Hyde Park, Massachusetts. Blake's study found water supplies capable of supporting a population of 25,000, roughly double Dover's population at the time.



NOTICE.

*At a meeting of the Directors of the*

"Dover Landing" and "Cochecho" Aqueduct Companies,

*held August 1st, 1873, it was voted that from and after* OCTOBER 1st, 1873, *the yearly rates for water shall be as follows:*

| | |
|---|---|
| For families of 2 or 3 persons, | $6.00 |
| " each additional person, | 0.60 |
| " each Horse, | 2.50 |
| " each Cow, | 2.00 |
| " each Yoke of Oxen, | 5.00 |
| " Stores and Shops, | 5.00 to 8.00 |
| " Saloons and Eating Houses, | 6.50 to 20.00 |
| " Steam Engine and Boiler, | 30.00 to 60.00 |
| " Leather Vats, | 12.00 to 16.00 |
| " Water Closets in Private Dwellings, | 5.00 |
| " each cask Lime or Cement used for building purposes, | .07 |

No drawing place taken [illegible] less than 6 months and no drawing place less than $5.00 a year.

Special rates will be made for the supply of the City, Hotels, Manufactories, Meat and Fish Markets, Bakeries, Printing Offices, Rail Roads, Daguerreian Saloons, Laundries, Breweries, Hose for Sprinkling, &c., &c., and for all other purposes not named in the foregoing tariff.

All persons who water their horses and cattle at the watering trough on Franklin Square, will be required to pay the same rates as though water were furnished them at their respective stables.

All previous [illegible] contracts and special rates for water are hereby annulled.

RULES AND REGULATIONS.

All Water Rents are due and payable on the first day of January and July in each year, and MUST be paid before the 20th of each month.

Owners of Buildings will in all cases be required to pay for the water used by their respective tenants.

No person, without having first contracted with the Agent or Directors, will be permitted to draw or use water of these Aqueducts under the pains and penalties prescribed by law. Every person having a post, pipe or branch from either of said Aqueducts, shall keep the same in good repair and shall be subject to have everything appertaining to the same visited and inspected at the pleasure of the Agent or Directors.

No person having the privilege of drawing or using water from either of said Aqueducts shall suffer any water to waste, nor shall he give away the same, or draw, or suffer to be drawn or used, any water except for the use of his own family, or for such other purposes as may be specially contracted for; under penalty of being deprived of his privilege.

Should the water fail in the cellar, no pay will be exacted, after notice of such failure, until there is a supply again.

No person will be allowed to run the water to waste on account of bad pipe, or for cooling, or to prevent freezing.

*Please read carefully and preserve this for reference.*

LEONARD S. RAND, ALVAH MOULTON, RUSSELL B. WIGGIN, — Directors of Dover Landing Aqueduct Co.

JOSEPH W. WELCH, JAMES E. LOTHROP, LEVI G. HILL, — Directors of the Cochecho Aqueduct Co.

FIGURE 6: Notice of the Dover Landing and Cochecho Aqueduct companies, 1878, apparently having merged operations. Water rates in most cases had more than doubled since 1835. Original document located in Dover Public Library special collections.

In a special election on November 30, 1887, Dover voters overwhelmingly approved building a municipal water works in a vote of 1326 to 346. Percy Blake was hired to prepare the plans and specifications. Negotiations began to purchase the water rights, property and equipment of the three private aqueduct companies operating in the city. In 1888 the Cocheco Aqueduct Co., Dover Aqueduct Co., and Dover Landing Aqueduct Co. were purchased by the city for $67,500, $20,000, and $13,000, respectively.[12]

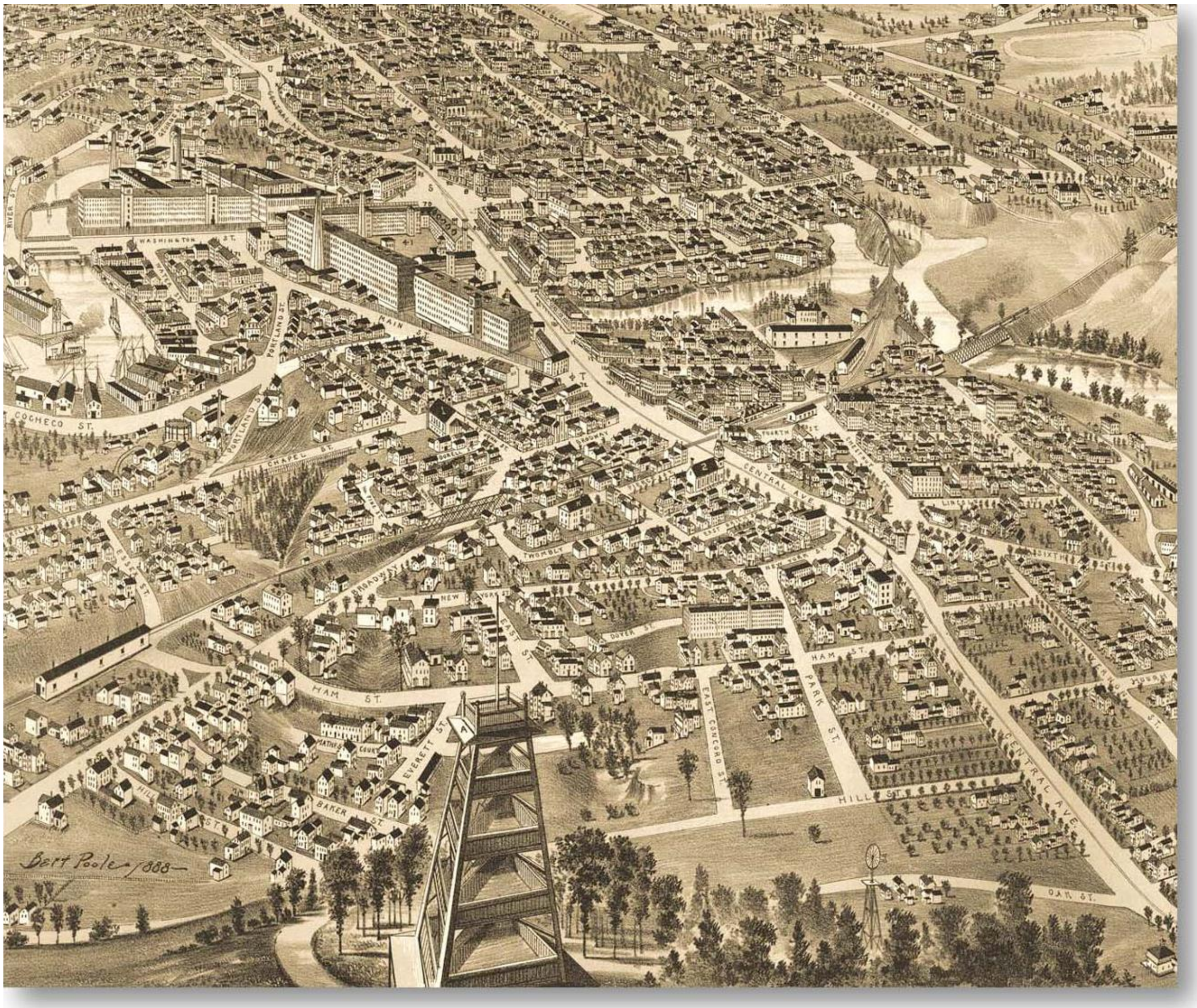



FIGURE 7: Bird's Eye View Map of Dover, 1888, by Albert F. Poole. Also known as a panoramic map, a high-resolution version of this map can be downloaded from the Library of Congress website. The map provides an elevated viewpoint from just north of Garrison Hill, looking southwest. The original Garrison Hill Observatory, a timber-frame tower 65 feet high erected atop the hill in 1880 is depicted at bottom center. See Dover Library website for more information about the Observatory. The map shows the dense development of Dover in the late 1880s that prompted the City Council to authorize the purchase of the three private water companies operating at the time and form the publically-owned Dover Water Works. A portion of Garrison Hill was purchased by the city in 1888 for the purpose of constructing a reservoir for the water system, completed in November that year.

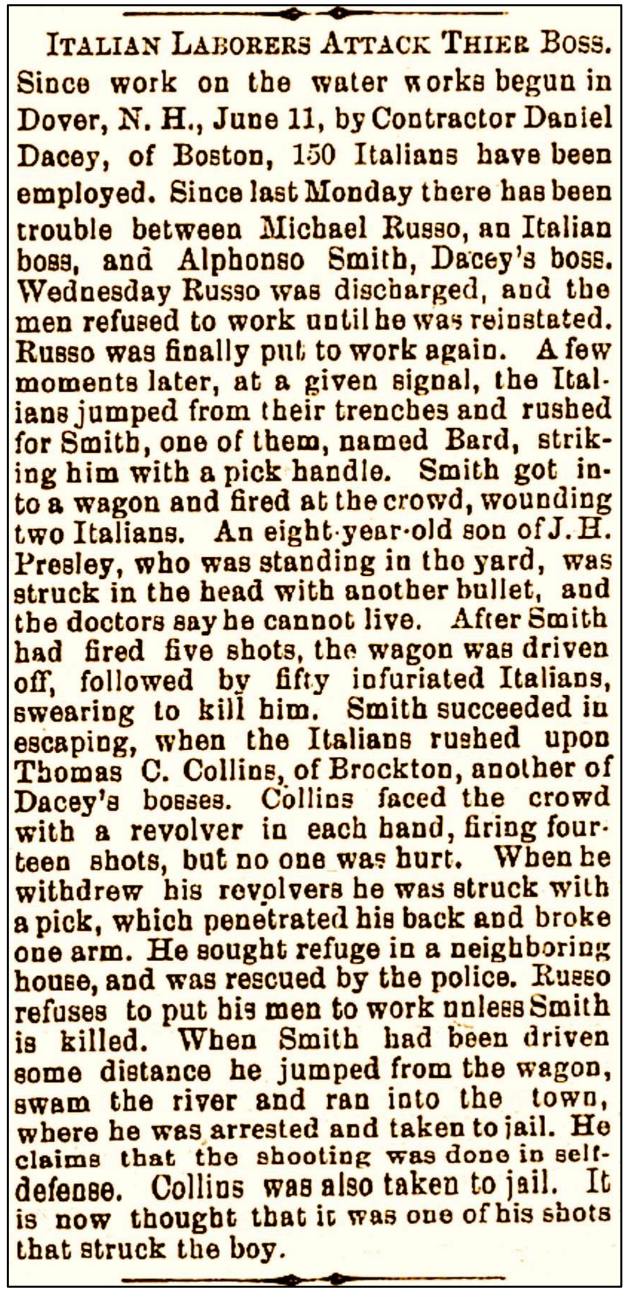
## 4. CITY OF DOVER WATER WORKS

On June 7, 1888, the City Council passed an ordinance creating the Board of Water Commissioners "for the purpose of constructing, managing and maintaining the system of water works."[13] Four days later the new mayor, George G. Lowell, broke ceremonial ground for a pipe trench on Hough Street. The main components of the system included two deep collecting wells known as the Hussey and Page wells, a stone-lined clear-water receiving basin, a pumping system housed in a brick Pumping Station building, an open reservoir atop Garrison Hill and a system of piping for the transport of the water between the wells, pumping station and reservoir and then through the city to fire hydrants, mills and businesses and eventually residences. Only the Pumping Station and perhaps some abandoned original underground piping still exist.

Contracts were immediately made with Camden Iron Works for piping, Eddy Valve Co. for valves, Ludlow Valve Co for hydrants, and George F. Blake Mfg. Co. for pumps and boilers. Daniel Dacey of Boston was given contracts for construction of the reservoir on Garrison Hill and for laying street mains and setting hydrants.

Dacey commenced work Monday June 11 with a crew of 150 Italians. Trouble soon brewed between "Michael Russo, an Italian boss and Alphonso Smith, Dacey's boss." On June 20th a fight with guns and pick axes erupted that "culminated in a shooting affair, in which 19 shots were fired, one which took effect in the heart of an 8-year old boy named Priestly."[14] Newspapers as far as Virginia covered the story (Figure 8).

Work resumed but was slowed by heavy rains during the summer which hampered the ditching and reservoir work and raised tensions among the workers. On the evening of Sunday, September 30, Hugh Mellon of the Irish work crew slapped Joseph Pratto of the Italian crew across the face triggering a clash among the men. "A general row ensued. Knives were freely used and many cuts inflicted."[15] Besides the labor unrest, Dacey was out of money and failed to make payroll the day after the knife fight. During October he fell further behind in his bills. Finally, on November 21, Dacey abandoned his contracts of $15,013 to lay pipes and $31,039 to build the reservoir.[16]



ITALIAN LABORERS ATTACK THIER BOSS. Since work on the water works begun in Dover, N. H., June 11, by Contractor Daniel Dacey, of Boston, 150 Italians have been employed. Since last Monday there has been trouble between Michael Russo, an Italian boss, and Alphonso Smith, Dacey's boss. Wednesday Russo was discharged, and the men refused to work until he was reinstated. Russo was finally put to work again. A few moments later, at a given signal, the Italians jumped from their trenches and rushed for Smith, one of them, named Bard, striking him with a pick handle. Smith got into a wagon and fired at the crowd, wounding two Italians. An eight-year-old son of J. H. Presley, who was standing in the yard, was struck in the head with another bullet, and the doctors say he cannot live. After Smith had fired five shots, the wagon was driven off, followed by fifty infuriated Italians, swearing to kill him. Smith succeeded in escaping, when the Italians rushed upon Thomas C. Collins, of Brockton, another of Dacey's bosses. Collins faced the crowd with a revolver in each hand, firing fourteen shots, but no one was hurt. When he withdrew his revolvers he was struck with a pick, which penetrated his back and broke one arm. He sought refuge in a neighboring house, and was rescued by the police. Russo refuses to put his men to work unless Smith is killed. When Smith had been driven some distance he jumped from the wagon, swam the river and ran into the town, where he was arrested and taken to jail. He claims that the shooting was done in self-defense. Collins was also taken to jail. It is now thought that it was one of his shots that struck the boy.

FIGURE 8: News article from Alexandria (Virginia) Gazette, June 22, 1888 (Newspapers.com).

"Owing to the failure of Daniel Dacey, a new contract was rendered necessary and one was made with Hiram F. Snow, to complete that part of the distribution piping left unfinished; also such extensions as were voted by the Commission. Mr. Snow commenced early in the season and completed the work called for by his contract early in August. Upon a test of the mains laid by him no leaks were found and the work was accepted by the Board."[17]

Meanwhile, construction of the Pumping Station by Tuttle, Brown & Bishop was proceeding nicely on property of the Dover Landing Aqueduct Co. known as Page's Field that included a spring. The building was completed in 1888 and the mechanical equipment it housed completed in 1889 (Figures 9, 10).


FIGURE 9: Dover Water Works Pumping Station. Woodcut made 1888, year of construction. See full graphic on cover (2nd Annual Water Commissioner's Report for 1889).

A detailed report by the engineer of the building of the water works is contained in the First and Second Annual Reports of the Water Commissioners for the year 1888 and 1889.

The purpose of the Pumping Station was house a large steam powered water pump and the coal-fired boilers that powered it. Separate rooms, each 30 x 36 feet were provided for the equipment. A coal shed with a capacity of 200 tons was built adjacent to the station.


FIGURE 10: Dover Water Works Pumping Station, in 2011. From top down: north side with main entrance set in arched opening; west side with round bay with conical roof; south side with entrance portico on paired columns (Historic Documentation Company, Inc.).

Water supply for the new system was derived from three sources: the Dover Landing Aqueduct Co. spring at Page's Field, the Cochecho Aqueduct Co. spring at Hussey Meadow, and from Willard Pond. Water from these sources was transported by gravity in a 12" cast iron "Conduit Line" to the one-million gallon Receiving Basin built at Page's field adjacent to the Pumping Station.

The water collected in the receiving basin – later called the clear water basin or settling basin – was piped into the pumping station where the high-capacity "Blake Mfg. Co. steam pump" (Figure 11) forced the water through a 14" main up to the Garrison Hill Reservoir, a vertical lift of 161.4 feet.

From the reservoir the water was distributed by cast iron mains through the city streets. A total of 21.3 miles of main was laid including more than two miles of 16" and 10" pipe, a half-mile of 14", 5.5 miles of 8" and 11 miles of 6", with the remainder 4" and 3" pipe.

The selection of the type of service pipe – the small pipe that branches off the main to deliver potable water to a building – was the subject of "careful investigation and consultation with managers of other water works in New England." Iron, lead, iron with tar lining and galvanized iron pipe were considered but rejected in favor of 1" cement-lined wrought iron pipe. Lead pipe was found "costly and considered unsafe for domestic use by many people." Galvanized pipe was rejected for the same reasons. Plain iron pipe rusts and clogs quickly and when given a tar lining lasts only slightly longer. Cement lined pipe in Worcester, Mass. was performing well after nineteen years of service, free of taste or rust and cost about six cents per foot. Over 60,000 feet of cement-lined service pipe was laid in 1888 and 1889.

Fire protection was the main priority that led taxpayers to approve the water works and as the mains were laid hydrants were installed. Upon completion of the system in 1889 a total of 146 fire hydrants had been set and connected to mains no smaller than six inches.

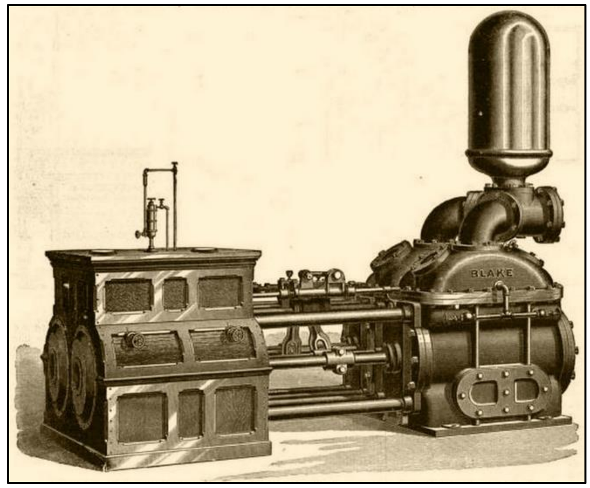



FIGURE 11: Blake's Improved Compound Duplex Steam Pumping Engine. Two 12" steam pistons (left) drove two 14" reciprocating water pumps (right) to move 1700 gallons of water per minute. It could fill the 2 million gallon capacity Garrison Hill Reservoir in 19 hours (Blake Mfg. Co., 1883, Patent No. 270,575).

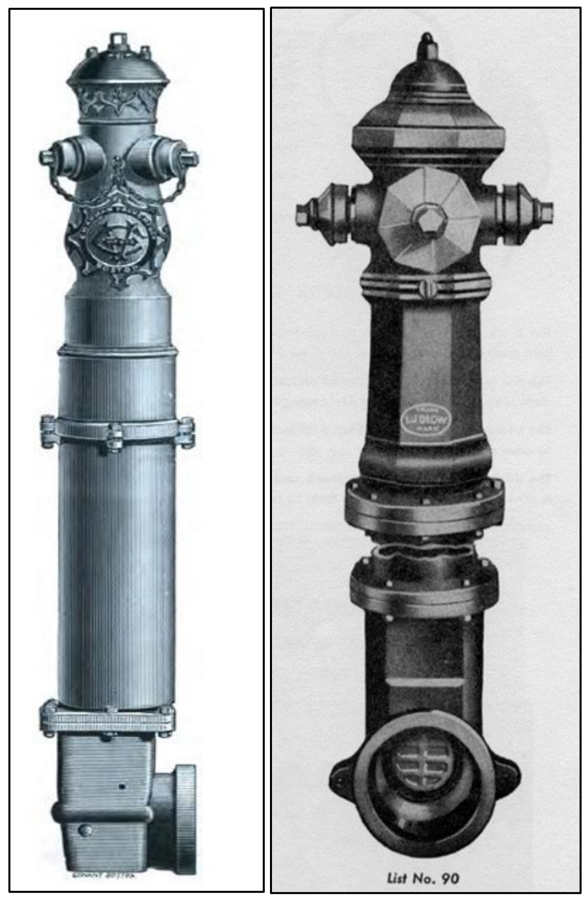


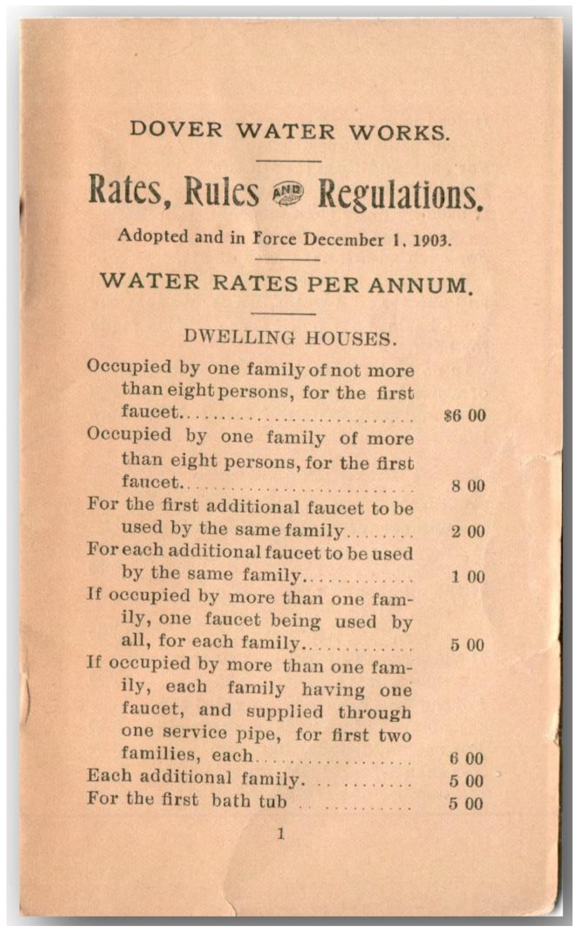

FIGURE 12: Fire hydrants manufactured by Chapman Mfg. Co. (left) and Ludlow Valve Co. (right) saw service in Dover prior to 1900. The city came to prefer the Ludlow-brand and the Chapmans eventually disappeared (Chapman 1888; L. M. Ramsey, 1897).

During the 1890s, Dover Water Works continued to expand and improve. Mains were extended to Sawyer Woolen Mills, Somersworth Machine Company and other businesses at high risk of fire and across the bridges spanning the Cocheco and Bellamy rivers. Demand for water increased and the city continued to develop new sources to keep up. A "collection gallery" was built at Hussey field consisting of a small reservoir into which the natural springs on the property were piped or directed. Protecting Willard Pond from contamination was a prime concern so the city secured passage of a state law prohibiting bathing and the leading of horses on the ice for any reason.

A drought that began in 1893 lowered the level of Willand Pond resulting in an unpleasnt taste in the water. The intake pipe was extended 1000 feet out into deeper water which solved the problem, but the lack of rain continued through 1894. When the water dropped to a point approaching the level of the gravity intake, the city moved quickly, purchasing a 5-inch rotary steam pump and a coal-fired boiler to power it. A wood frame building with a tin roof was erected around the equipment. Shortly after installation of the pump, the water level dropped below the intake and the pump was started and run continuously thru 1895 and 1896.

In 1896 an experiments artesian well was drilled at the pumnping station to a depth of 227 feet and proved a success at delivering 87 gallons per minute of "first-class quality" water and "proved an important factor in the water supply. But the drought continued and by 1899 the output of the springs feeding the system had fallen to a new low and Willard Pond was being increasingly relied upon. The 5" rotary pump installed at the pond four years earlier was too small to keep up with the demand and in 1899 a much higher capacity 7-inch centifugal pump with a 25 horsepower boiler replaced it. A brick "pump house" building with a slate roof was erected and the existing coal shed was moved alongside.

By the turn of the the 20th century Dover Water Works had proved itself as a sophisticated and nimble operation that could meet the needs of the city through a period of regional drought that had crippled other New England water systems. In spite of the lack of rainfall, the Water Commissioners and the Superintendent of the works had continued to make improvements and expanded service throughout the city while maintaining a balanced budget with little debt. In the decade since the initial system was completed in 1889, over 1,800 services to homes and businesses were installed requiring the laying of over 16 miles of 1" cement-lined pipe.


DOVER WATER WORKS.

Rates, Rules and Regulations.

Adopted and in Force December 1, 1903.

WATER RATES PER ANNUM.

DWELLING HOUSES.

| | |
|---|---|
| Occupied by one family of not more than eight persons, for the first faucet | $6 00 |
| Occupied by one family of more than eight persons, for the first faucet | 8 00 |
| For the first additional faucet to be used by the same family | 2 00 |
| For each additional faucet to be used by the same family | 1 00 |
| If occupied by more than one family, one faucet being used by all, for each family | 5 00 |
| If occupied by more than one family, each family having one faucet, and supplied through one service pipe, for first two families, each | 6 00 |
| Each additional family | 5 00 |
| For the first bath tub | 5 00 |

1

FIGURE 13: Dover Water Works Rules and Regulations, December 1, 1903. The city kept the basic water rate for a household at $6.00, but increased the number persons allowed to eight, a savings of $3.00 over the private aqueduct rates. Original 16-page document located in Dover Public Library special collections.

The problem of an adequate water supply continued to dog Dover Water Works into the early $20^{th}$ century as the city's demand began to outstrip the supplies. The average water consumption had increased from 440,000 gallons per day (gpd) in 1890 to over 753,000 gpd in 1903 while production from the existing sources had decreased. A new well was drilled near Hussey Springs in 1905 "at considerable expense" but although high in output it was also high in iron content to a degree that it was unsuitable for domestic use and could not be added to the system. In 1906 the drought continued, reaching a critical state; Willand Pond was down 17 feet – about one-quarter of its volume in 1888 – and continuing to fall at a rate of nearly 2" per week.

The city turned to William S. Johnson, "an expert sanitary and hydraulic engineer" from Boston, to assist in solving the diminishing water supply and iron contamination problems. Prior to engaging in the consulting business, Johnson served as Assistant State Sanitary Engineer for Massachusetts, and before that, Sanitary Engineer of the Health Department of Brooklyn, N. Y. Johnson built an experimental sand filter bed and aerator at Hussey Springs in 1907, which proved successful in removing the iron (Figure 14). With the successful demonstration of the sand filter, Johnson was engaged to design a filter plant with the capacity to filter all the water required by the city and prepare the necessary plans and specifications for bid.

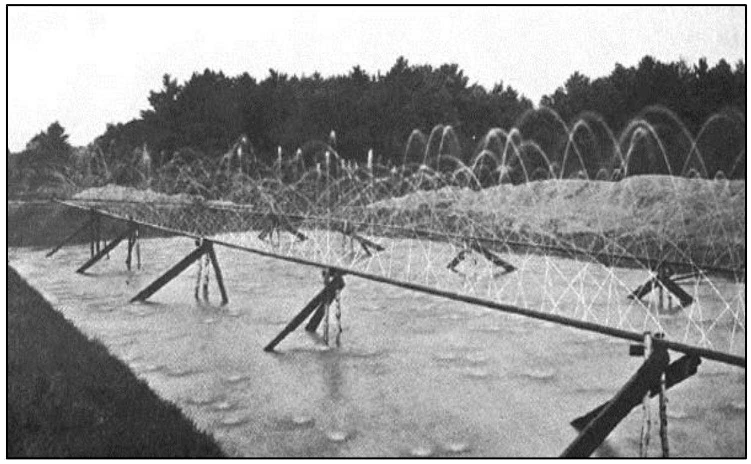


FIGURE 14: Experimental Sand Filter Bed and Aerator designed by engineering consultant William S. Johnson to eliminate iron from the water supply. The bed, built in 1907, measured 40 by 150 feet. Water was pumped through 2.5" perforated pipe and sprayed into the air and allowed to fall on the sand filter bed. The test was a complete success and led to the construction of a massive underground filter plant in 1909 (Water Commissioners Annual Report, 1907).

Meanwhile, a new primary pump was finally installed in the Pumping Station to replace the "Geo. F. Blake steam pump" that had provided 17 years of largely trouble-free service. The new pump was electrically powered, eliminating the expense of coal except for that kept on hand for the old pump that remained connected to the system as a backup. The new pump was supplied by Pratt Iron Works of Dayton Ohio and consisted of a General Electric 150 horsepower 14 x 12 inch Triplex reciprocating pump with a rating of 2.5 million gallons per 24 hour cycle.

Construction of the underground sand-filter was approved by the City Council in April 1908. Ryan Unmack Co. of New Haven, Conn. won the contract with a bid of $22,000 and began construction in July. The filter plant was completed and put into operation in February 1909 and consisted of a underground sand filter structure of concrete construction, approximately 100' by 200' by 15' high, (Figure 15), an adjacent underground settling basin of concrete, approximately 40' x 60', and a brick above-ground aerator building, approximately 25 feet square. None of these buildings or structures remain; the filter bed was demolished in 2012 as part of the Berry Brook restoration project.[18]

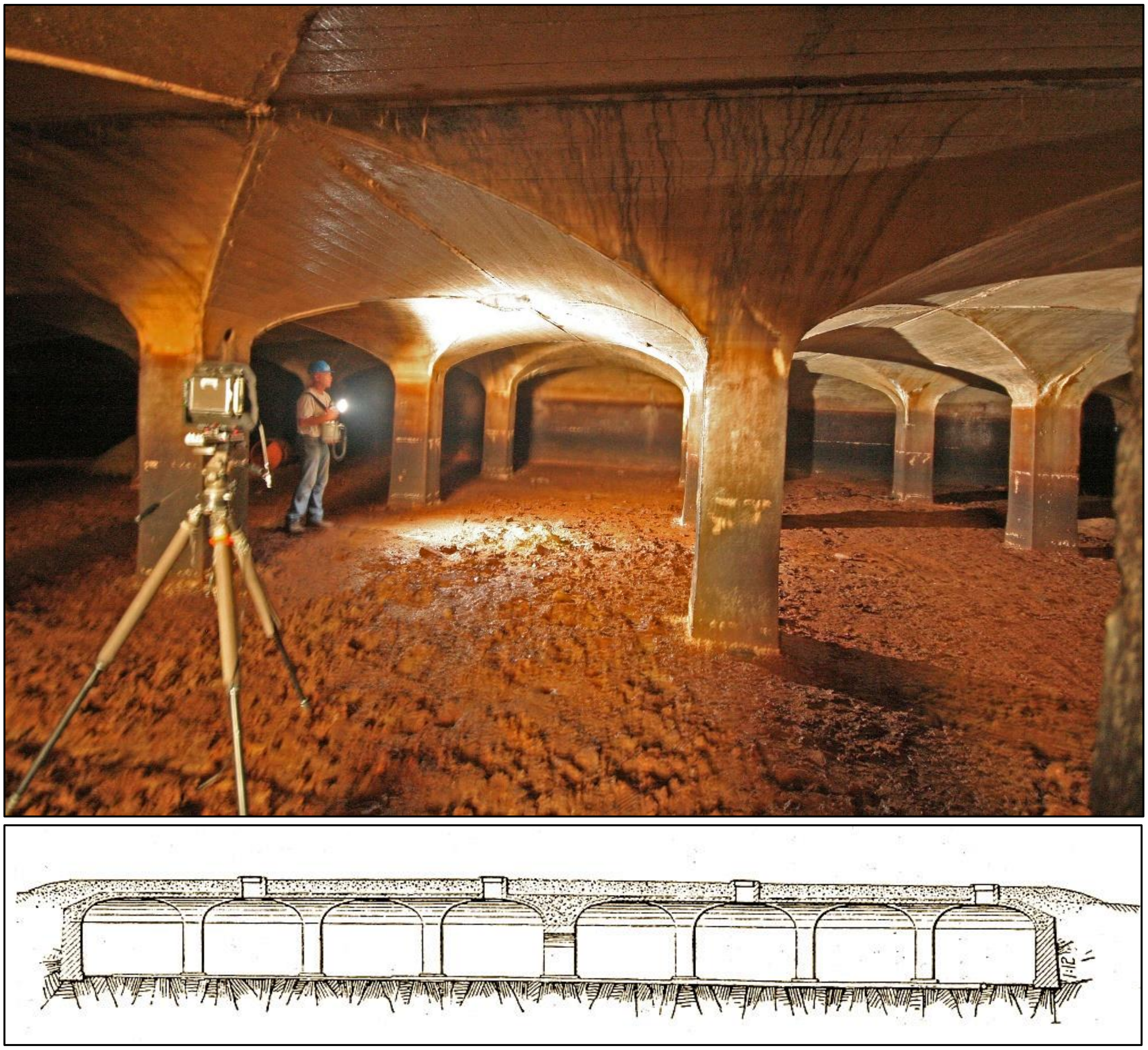


FIGURE 15: Photo shows Dover Water Works underground groined-arch sand filter bed, built 1909, during historic property documentation in 2011. The huge underground structure, abandoned in the 1950s and hidden by overgrowth, was discovered in 2011 during excavation for the Berry Brook Restoration project. The graphic shows the cross section of the nearly identical underground sand filter built in Somersworth, New Hampshire in 1898, the second groined arch structure of its type built in the U.S. by engineer William Wheeler of Boston, originator of system. The structure is still in use as a covered reservoir (Sources: Historic Documentation Co.; *Engineering News* 1898).

In 1910, the population of Dover roughly stabilized, reaching a peak of 12,247, a growth of only 457 people during the twenty years the Dover Water Works was in full operation. It would be another twenty years before Dover would being growing again and ninety years before the population in 1910 would be doubled. In 1910 the water system consisted of 27.3 miles of mains, 18 miles of service pipe connecting 1,884 services on which 1004 water meters were monitoring usage and more importantly, waste. Although demand for water had not dramatically increased over the previous decade, the costs to maintain the delivery of a steady supply of pure water during drought, diminishing sources and ageing equipment *was* increasing dramatically.

The issue of supply remained front and center. To curtail direct waste by consumers the city passed an ordinance requiring the installation of meters on all services having more than two tenements. The maintenance department was ordered to step-up efforts to quickly locate and fix burst pipes and underground leaks. In 1911, the city hired Leonard Metcalf of the firm Metcalf & Eddy, leaders in the field of water and wastewater engineering who literally "wrote the book on the subject" and would later be considered the founders of the field of environmental engineering. Metcalf's job was to assess Dover's water shortage and determine what to do about it. Two other consulting engineers, W. M. Ames and William S. Johnson (who designed the sand filters) had just completed independent studies of four potential additional sources: Reynor brook, Kelly springs, Bellamy river and Isinglass river. Metcalf was given the job of evaluating the recommendations of the prior studies and conducting additional measurements and studies as may be necessary to provide his own overarching conclusions and recommendations.

Metcalf found that the city's effort to curtail waste and enforce conservation had reduced water consumption during 1911 from roughly 700,000 to 500,000 gallons per day. He concluded that the existing sources of supply from Willand and Hussey springs were nearly equal to the demands of the city under average (non-drought) conditions and that the development of Reynor brook, offering a yield of 2 million gallons per day at a development cost of $25,000, was the prudent course of action for the future. Rainfall increased over the following years and by 1920 Willand pond returned to normal levels alleviating the threat of a critical water supply shortage.

In 1912 the General Electric Triplex pump failed again after repeated breakdowns over its measly five years of service and it was decided to replace it with a two-stage DeLaval centrifugal pump with the same 2.5 million gallon per day capacity. The original Blake steam pump, which was again called into backup duty, continued to "do good work."

The 1922 Water Commissioners Report gave the following account of the department's transition from horse to motor truck:

> On February 28, 1922, the department purchased a one and one-half ton Reo truck, to take the place of the horse and wagon formerly in use. The cost of up-keep for the remaining ten months of the year was $209.62, or at the rate of sixty-eight and five-tenths cents per day. This cost included several accessories, such as horn, curtains for the cab, etc. The total distance traveled was 4,725 miles. The stable account for our horse and wagon for the same period of time in 1921, was $441.50; for shoeing horse, repairs to wagon, harness, etc., $96.65; for veterinary service, $30.50; making a total cost of $568.65, or a rate of $1.85 per day.

FIGURE 16: Reo Speed Wagon, 1922 model, of the type bought by the Dover Water Works Commission. The truck cost $1,623.75 new. Two years later it was traded in for the 1924 model, with $625 given for the old truck on trade in (Source: American Truck Historical Society, 1973).

In 1925 the water department conducted a waste water survey of the entire water piping system to identify leaks and intentional wasting of water. The Pitometer Company of New York was hired to conduct the survey during the summer when wasting was historically the highest. Measurements were done with a portable pitometer which measured the flow in the pipe by means of a probe inserted into the pipe (Figure 17). The results provided accurate measurements of the total water consumption of the system, the accuracy of meters and drops in pipe flow rate due to scale build-up. The city was divided into districts and 24-hour measurements taken of consumption in each district. Large consumers were checked to detect unauthorized use of unmetered water. Measurements were also taken at night between 11 p.m. and 4 a.m. when the rate of use is at a minimum for comparison to day rates. The Commissioners reported that the survey showed the distribution system to be in excellent condition with a very low amount of leakage.

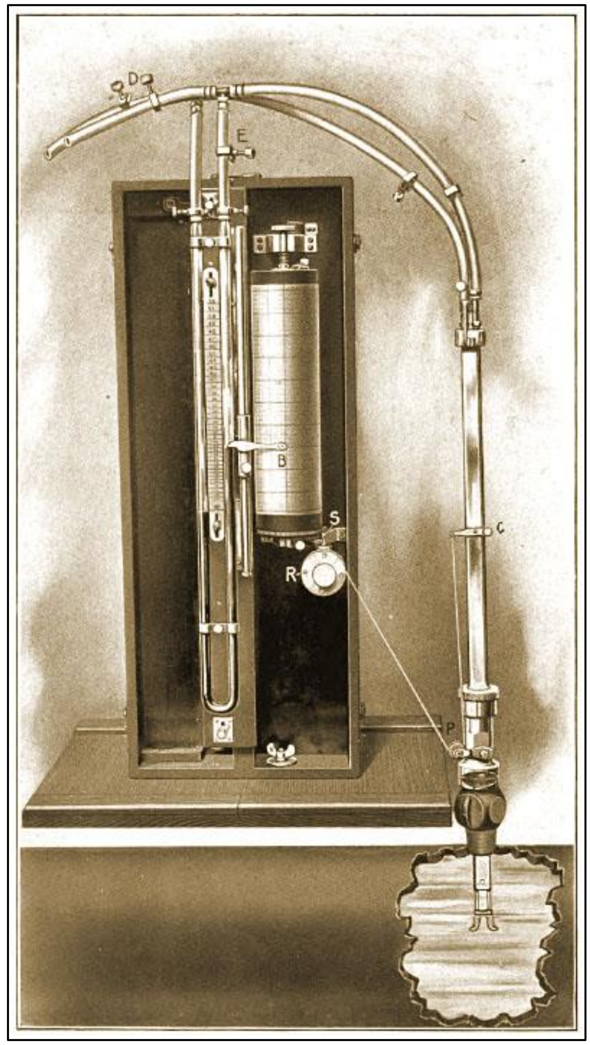


FIGURE 17: Portable pitometer manufactured and used by the Pitometer Co. to conduct a waste water survey of the Dover water system in 1925. The sampling probe, shown inserted in pipe in cutaway drawing at right, was inserted through a tap drilled in the pipe. The probe sampled both static and dynamic pressure at the center of the flow. The readings were recorded "topside" by a recording manometer and later entered into a formula with other coefficients to obtain the flow-rate in the pipe (Pitometer Company, 1909).

The severe drought of 1930 depleted Willand pond and caused a serious shortage in the city's water supply. The intake pipe had just been extended another 60 feet into deeper water but that was now looking insufficient. Then, in September, a proposal to develop new sources from wells was presented to the city by Layne & Sons of New York, a well-driller and water-supply delivery firm of national scope and recognition. Unlike the recommendations of the half dozen studies done for the city by other expert water supply engineers over the past decade, including one in 1928 by Weston & Sampson of Boston, a firm on par at the time with Metcalf & Eddy, Layne was offering a no cure-no pay contract to find a well with the output and water quality the city desired. All of the other engineers proposed development of surface waters – Weston and Sampson had recommended the Isinglass River – all of which required expensive piping, pumping and filtration. Seeing Layne's proposal as the most practical and economical solution to the water supple dilemma, a contract was quickly executed and in September 1930 the company began sinking of test wells in several locations.

The 1931 Water Commissioners Report gave the following account of the development of Layne well and its importance to the city:

> Several locations were tested with more or less success, water being found in each of these openings, but not of sufficient flow to warrant development, until they reached the Page pasture, where the second attempt proved highly encouraging. This well was enlarged according to the system adopted by the company, and it was found, upon completion, to be, as the company asserts, one of the best they ever installed."
>
> Fortunately for Dover the well had been completed and awaited connection with the system, when the alarm sounded for the Morrill block fire. During this emergency the new pumps were started, and for a period of twenty-two hours provided a continuous flow of nine hundred-twenty gallons of water per minute, or practically double the quantity ordinarily available, a supply which proved of inestimable value during that great conflagration. In this one instance the well fully paid the entire cost of installation, for with an inadequate supply of water it would have been impossible to confine the flames to the area occupied by the Morrill buildings. The loss which would have inevitably followed had the fire passed beyond control, is incalculable. Not only has the new well solved our water problem, but it has given us an adequate supply for the years to come, and of a quality which meets every requirement for domestic use. [19]

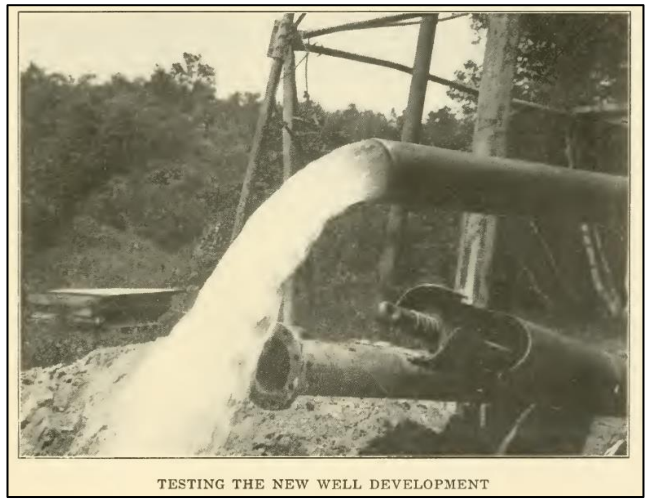



FIGURE 18: Testing Layne well at Page's pasture in 1930. The 18" well was drilled to 85 feet by Layne & Sons of New York. It delivered 920 gallons per minute or 1,300,000 gallons per day, roughly double the city's water supply needs at the time. The "excellent quality" water was pumped 3600 feet through a 12" force main to the aerator near the main Pump House (Dover Water Commissioners Report, 1931).

FIGURE 19: The Morrill Block fire, January 3, 1931 destroyed 26 businesses in Franklin Square. Fireman responded from as far away as Haverhill, Mass. The new Layne well had doubled the city's water supply and was credited with saving much of the downtown (Source: Dover Public Library special collections).

With a new well that doubled the city's water supply, several miles of new mains were added to the system. A 12" main was laid from Florence Street to Oak Street to the Reservoir, providing fire protection to the Kidder Press Company and the vicinity around it and another outlet to the Reservoir. Additional mains were extended along St. John Street, Durrell Street, Winter Street, Tolend Road, Mineral Street and Hough Street. The cost of the mains were offset by the increased revenue from new customers immediately connected, plus future revenue from property development along the extensions.

The greater flow through the system warranted the replenishment of the sand filter which had not been done in the thirty years since it was built. The old sand was removed and replaced with new filter sand "from Plum Island, Newbury, Mass., as recommended by the State Board of Health."

In 1936 the Water Department reported that they had finally accomplished "what they had been trying to do since 1904, namely, stop the willful waste of water by doing away with all former flat rate services." All customers were now purchasing water by the meter system. Also in 1936, a complete renovation of the Pump House was completed (Figure 20).

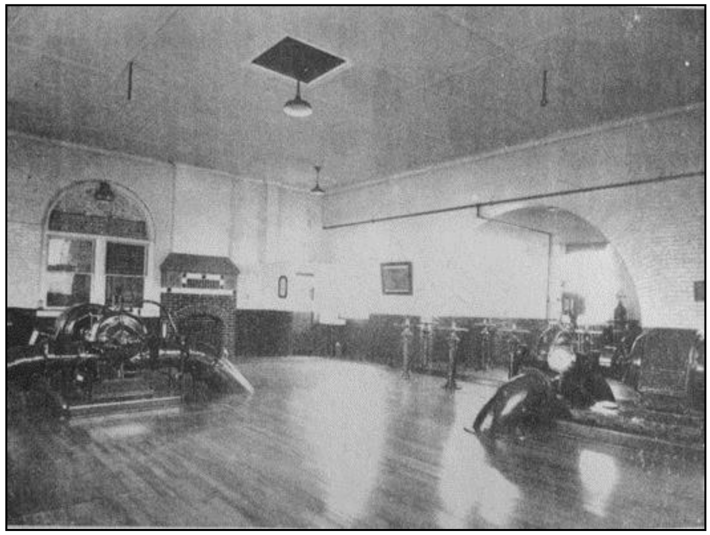


FIGURE 20: Interior view of Pump House after 1936 renovations that included the installation of a second electric centrifugal pump, a new heating system with a dropped ceiling to lower heating costs, new lighting and a polished hardwood floor (Source: *Fosters Daily Democrat*, 23 June 1973, p. 57).

The great success of the Layne well led the department to drill another well a short distance away. Well driller David R. Smith of Portsmouth NH was awarded the contract for $13,366.86. The well was completed, tested and approved in August 1940 (Figures 21-23). The Smith Well delivered over 1000 gallons per minute of water "of such high quality that it was pumped directly into the system without any treatment resulting in a considerable saving to the department."[20]

FIGURE 21: Testing Smith Well, August 15, 1940. See Figures 22, 23 for close up views (Source: Dover Community Services).

FIGURE 22: Testing Smith Well, August 15, 1940 (close up of Figure 21). The men inspecting the well are believed to include Mayor Samuel Blair, well-driller David Smith and some members of the Board of Water Commissioners. In 1940 the Board members were Samuel B. Blair, Philip C. Brown, John D. Grady, Cesaire Houde, and Frederick C. Smalley.

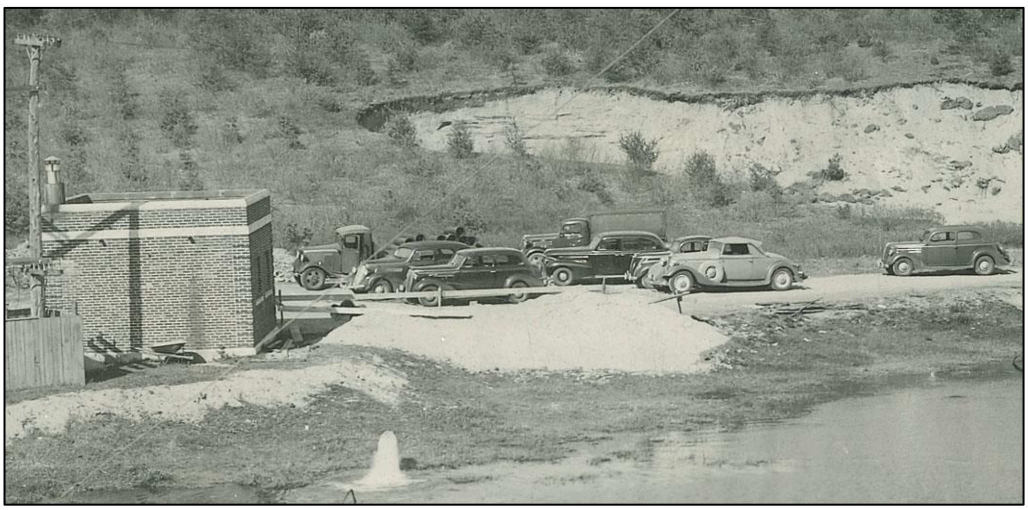


FIGURE 23: Close up of Figure 21 showing Layne well pump house built 1930. Note vintage cars and trucks presumably belonging to the Board of Water Commissioners and water department parked while inspecting the new Smith well across the pond.

During World War II, due to the shortage of labor and materials, nothing was done in the way of capital improvements; work was limited to repairs and the installation of service lines. In 1947 a new well of the gravel-wall type was completed near Barbadoes pond. The well proved capable of producing 2 million gallons per day of excellent quality water and was connected to the system with 2200 feet of new 12" main along Concord Road.

By mid-century, the system as a whole was suffering from an increasing number of age related problems. The water mains and distribution piping were no longer of sufficient capacity to meet flow requirements, a problem compounded by the reduced flow caused by corrosion and deposits in the pipes (Figure 24). In 1949 the Boston consulting firm of Chas. T. Main, Inc. (Main) was hired by the City to conduct a "comprehensive investigation of the water supply sources, water treatment facilities and distribution system."[21]

The Chas. Main study found the underground sand filter in need of extensive maintenance. He recommended repairs to the concrete, replacement of the filter sand and installation of a pre-chlorination system to assist in iron removal and prevent "iron bacterial slimes clogging the sand bed."[22] The sand filter work was one of ten items Main recommended in a comprehensive program of overhaul and new-construction of the system totaling $252,800.

FIGURE 24: In 1952 low water pressure in the Locust Street area prompted an investigation. A section of the main was cut open (shown above) revealing a buildup of scale and sludge reducing flow capacity by more than fifty percent. The successful cleaning of the main and return of normal pressure led to an extensive program of water-main cleaning in 1953 (Dover Annual Report, 1952).

The Main firm conducted two more studies, in 1951 and 1954 that further examined the water system and treatment needs. The second study addressed the sudden and severe contamination of the clear-water receiving basin in late 1953 with iron and highly acidic water. The pollutants were a result of the cleaning of the sand filters in 1952. The used, iron-laden sand had been dumped in the swamp above the basin and infiltrated the basin as runoff.[23]

Recommended improvements included the construction of a new chlorine treatment facilities, a new water treatment and pumping plant (Figures 26-28), a covered steel tank reservoir, wells and piping network. The improvements were undertaken in the following years, resulting in the abandonment of the slow sand filter system and discontinued use of the Pumping Station building as a functioning component of the water system.

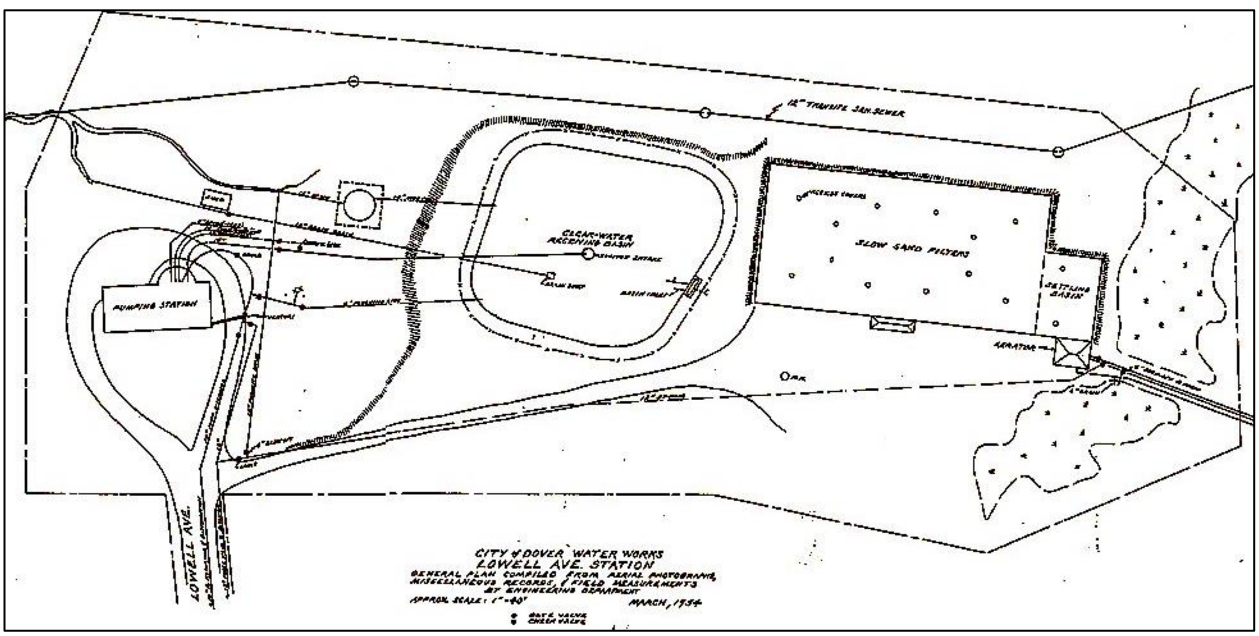



FIGURE 25: Plan of the Lowell Avenue Water Works property made by the Chas. T. Main Co. in March 1954 showing the components of the facility at that time, from left to right: the Pumping Station, Clear Water Receiving Basin, the Slow Sand Filters and Settling Basis (underground) and Aerator Chas. T. Main, Inc. 1954).

During the 1960s the expansion of Dover increased the city's water consumption from about 600 to 850 million gallons per day. In 1963, two surplus gravel-packed wells located at Pudding Hill off Mast Road were purchased from the Government Service Administration who had drilled them as a supply to Pease Air Force Base. One of the wells was connected with an 8" main from Durham Road, adding approximately one million gallons per day to the system. The "Crosstown Water Main" was completed in 1967 which solved the water pressure problem on the North side of the city and the discoloration of the water that was occurring.

FIGURE 26: Water Treatment Plant building built in 1955 at Lowell Avenue water works facility (Historic Documentation Co., 2011).

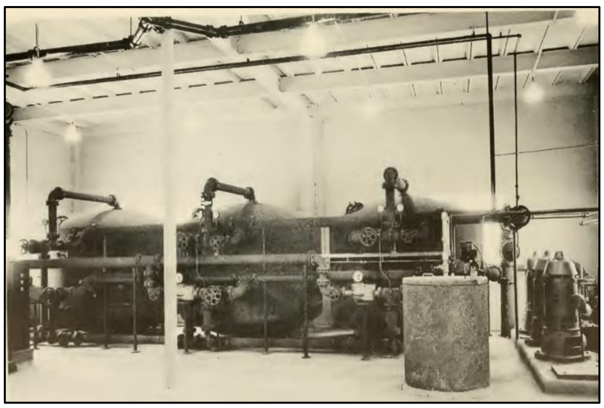


FIGURE 27: Interior of Water Treatment Plant after completion in 1955. Note three large large filter tanks, potassium permanganate feed tank in front of filters, and three 600 g.p.m. pumps at right (Dover Annual Report 1956).

FIGURE 28: Interior of Water Treatment Plant, 2016. Original piping and equipment functions remain in use but most equipment has undergone component rebuild or replacement (Historic Documentation Co., 2016).

FIGURE 29: New International; half-ton and one-ton trucks purchased for the Water Department in 1956 (Dover Annual Report 1956).

FIGURE 30: Water Department employees in front of Willand Pond Pump House in 1970. From left, Jim Printy, water superintendent Peter Bouchard, and foreman Bill Leahy (Dover Community Services).

## 4. PROJECT INFORMATION

This report was prepared by Richard M. Casella, Historic Documentation Company, Inc. Portsmouth, Rhode Island, for Underwood Engineers, Inc., Portsmouth, New Hampshire, and the City of Dover Community Services. The City of Dover is reconstructing the Lowell Avenue Water Treatment Plant (originally constructed in 1955) to accommodate health and safety, process, and energy and water efficiency improvements to the facility. The Lowell Avenue Water Treatment Plant is one of several important buildings at the National Register of Historic Places eligible Dover Water Works. The most noteworthy building on the property is the Pump Station, built 1888 (see Figure 10) which housed the primary pumping and valve equipment of the first municipal water works for the City and is representative of the late 19th century movement in the US to bring safe drinking water to the populace under the auspices of a public rather than private utility. The building exhibits a high degree of integrity, architectural quality and workmanship, representative of the Queen Anne style. It is a rare type. This History of the Dover Water Works was prepared to satisfy requirements contained in the Memorandum of Agreement between the City of Dover, the Environmental Protection Agency and the New Hampshire State Historic Preservation Office, dated February 24, 2016 for the project.

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[4] See, Morris A. Pierce, "Documentary History of American Water-works, 2018." Web document at www.waterworkshistory.us/NH/.

[5] Laws of New Hampshire, 1823, Chapter 45.

[6] Laws of New Hampshire, 1824, Chapter 22.

[7] *New Hampshire Patriot and State Gazette*, April 24, 1826.

[8] Laws of New Hampshire, 1832, Chapter 29. In 1851 a fourth company the Belknap Aqueduct was incorporated but no information regarding its makeup was obtained; see Laws of New Hampshire, 1851, Chapter 1190.

[9] http://www.dover.nh.gov/government/city-operations/library/history/a-history-of-fires-in-dover.html

[10] Dover Annual Report, 1888, p. 21.

[11] Dover Annual Report, 1889, p. 42.

[12] Water Commissioners' Report for 1889, p. 49-50.

[13] Water Commissioners' Report for 1888, p. 1.

[14] "Pistols and Picks. Serious Trouble with Italian Laborers at Dover, N.H." *Essex County Herald* (Guildhall Vermont) June 29, 1888, p. 1. The conflicting information in the news articles located were not resolved.

[15] "Italians and Irishmen." *New Hampshire Patriot and State Gazette* (Concord, NH), October 4, 1888, p. 5.

[16] "He Throws Up His Contracts." *The Burlington Free Press* (Vermont), November 22, 1888, p. 1.

[17] Dover Annual Report, 1889, p. 12.

[18] For more information regarding the underground sand filter and the Berry Brook Restoration project see: https://www.unh.edu/unhsc/berry-brook-project.

[19] Dover Annual Report, 1931, p. 151.

[20] Dover Annual Report, 1940, p. 144.

[21] Chas. T. Main, Inc. 1950, p. 1.

[22] Ibid., pp. 33, 60.

[23] Chas. T. Main, Inc. 1954, pp. 1, 9.