The Middlesex Canal

This pioneering engineering work proved that canals could serve as a practical and efficient means of transportation needed for a new and growing industrial nation.

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The Middlesex Canal was Massachusetts' first National Historic Civil Engineering Landmark (NHCEL). It was so designated in 1967, one of the first four NHCELs in the country. The other three were the Erie Canal and two bridges.

In addition to its importance as a pioneering engineering achievement, the Middlesex Canal has special significance to the engineering historian because the engineering papers of Loammi Baldwin (1745–1807), its builder, have survived. These records are part of the Baldwin Papers, a collection, or really three collections, that is included in the Inventory of Collections of Plans and Other Engineering Material of Historical Interest at The Engineering Center in Boston. These records give us a better understanding and appreciation of this great achievement and other notable projects of the Baldwins.

While Benjamin Wright, the engineer for the Erie Canal and later canals, has been called the "Father of American Civil Engineering," Massachusetts' Loammi Baldwin must be ranked high among the pioneers of our profession. The Middlesex Canal was his greatest achievement.

The Middlesex Canal was not the first extensive system of canal and river navigation works undertaken in the United States. This distinction belongs to the Potowmack Canal and Locks in Virginia. That canal was started in 1785 and completed in 1802. Surveys for the project were initiated by George Washington in 1749. However, it was the Middlesex Canal that proved, through low freight rates and expanded traffic, that canal transportation in the United States was practical and economical. With many pioneering features, it served as a precedent for many engineering aspects of the Erie Canal.

Origins

It was in 1793 that a group of Boston business leaders sought to improve the transportation of goods from the Merrimack River to Boston. At that time, goods were brought down the Merrimack from New Hampshire on river craft and then transferred to wagons or seagoing craft for the remainder of the trip to Boston. This mode of transportation was costly in time and money. The idea of a canal is believed to have originated with James Sullivan, a prominent Bostonian who later became Governor of the Commonwealth. The Middlesex Canal Company was chartered in 1793 with Sullivan as President. Chosen as superintendent of the canal project was Loammi Baldwin, of Woburn, Massachusetts. This self-educated surveyor and engineer also is known for developing a variety of apple — the Baldwin apple.

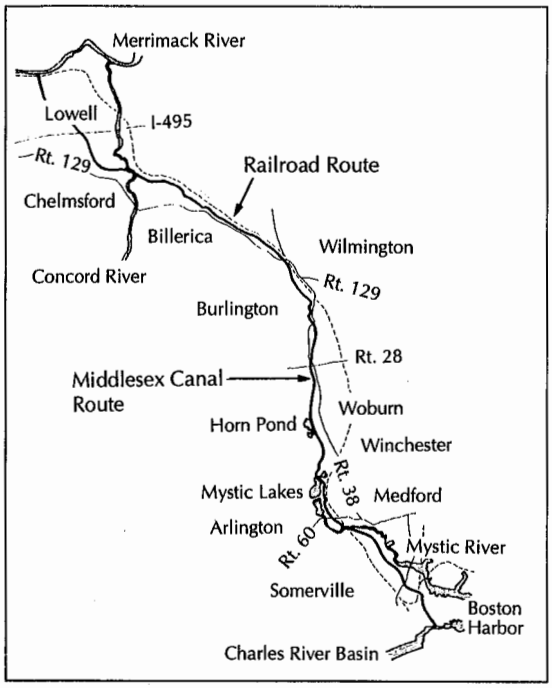

FIGURE 1. The route of the Middlesex Canal.

When he was selected to head the project, Loammi Baldwin had little knowledge of canal construction and lock operation. He studied what books on the subject were available in the Harvard College library. He had his first view of locks in 1794 when he visited the Potowmack Canal, which was then under construction. Baldwin knew his limitations and insisted that the directors of the canal company provide for the assistance that he needed.

It was with the help of the directors of the company and Samuel Thompson, of Woburn, that Baldwin began the survey for the selection of the canal route. The crude instruments available at that time for surveying resulted in such a high rate of error that Baldwin was convinced that the services of a qualified engineer were required. Sullivan and the company directors authorized Baldwin to seek the services of William Weston, the only person in the country qualified to undertake a reasonably accurate survey. Weston had recently arrived from England and was then engaged in work in Philadelphia. Responding to a lucrative offer, Weston agreed to work on the survey with Baldwin for three weeks. When in Philadelphia, Baldwin acquired an early form of the Wye level, the first accurate telescopic leveling instrument to be used in America. On the second of August 1794, Weston submitted his survey that consisted of two routes. One route was selected for the canal; the other was later selected for the route of the Boston & Lowell Railroad. Figure 1 shows the two routes. From that point on, Baldwin was on his own.

Canal Design

The canal bed was 20 feet wide at the bottom and 30.5 feet wide at the waterline with banks sloping 33 degrees. The design depth was 3.5 feet, but silting reduced it to about three feet. Between the locks it was graded for a steady flow of water. The banks extended one foot above the waterline with a ten-foot wide tow path on one side and a three-foot berm on the other where needed. Small brooks were carried under the canal bed in brick culverts; larger streams were carried over the canal by timber aqueducts. The largest of the eight aqueducts spanned the Shawsheen River. This structure was 188 feet long and was over 30 feet above the river. Visitors from afar came to view this impressive structure. In all, there were over fifty bridges across the canal. Many of them carried roads, while others were used by farmers whose property had been divided by the canal. An ingenious feature was the floating tow path that spanned the Billerica mill pond.

Construction was planned to start at the highest elevation along the canal route in Billerica. At that point, the canal was to cross, and be fed by, the Concord River. From the mill pond that was fed by the river, one flow of the canal would be directed northwest to the Merrimack River with a drop of 27 feet through three locks. The second flow would be to the southeast 21.5 miles to the Charles River in Charlestown, with a drop of more than 100 feet through thirteen locks. The total length of the canal was 27 miles and four more locks were required at the Merrimack, Concord, Charles and Mystic Rivers.

Canal Construction

While Sullivan and the company's board of directors were much involved and actively cooperative in the project, Baldwin was responsible for it down to the smallest detail. The hy-

draulic design was Baldwin's. He was the engineer for the design and construction of all canal structures including locks, aqueducts and bridges. For much of this work, he had little precedent to guide him.

In carrying the construction project through to completion, Baldwin exhibited a genius for meeting every challenge that confronted him. Few engineers have had to undertake some of the tasks that fell to him. One of these tasks entailed responsibility for operating a mill that the company had acquired along with the Billerica mill pond and land for the canal.

After Weston left, Baldwin completed what remained to be done with the surveying. The project started immediately after the survey with the purchase of land, the contracting for the work to be done and the gathering of materials. Much of the digging was done by small landowners whose property adjoined the canal route when manpower could be spared from farm work. The digging took place in many locations simultaneously under Baldwin's supervision.

Other work on the canal was contracted out. At times, Baldwin had 500 persons working on the project. Some of the laborers were housed in barracks provided by the company. Baldwin was responsible for providing fodder for several hundred horses and mules. In Billerica, the company operated a blacksmith shop with Baldwin in charge. All the tools and equipment needed for the project — from shovels to wheel barrows — were manufactured at this shop. Also at this shop, Sullivan and Baldwin invented the dump cart. It was Sullivan's idea, and Baldwin built several prototype models before settling on one that became standard.

In common with all early canals, obtaining water-tightness of the earth banks and bottom was a problem. Baldwin experimented with many methods of puddling, tamping and consolidating with reasonable, but not complete success.

The design and construction of the locks was a major engineering endeavor. The fine quality of the granite block stonework is proved by the fact that some of the stone structures are still standing.

Obtaining a good hydraulic cement that would harden under water was a real problem for Baldwin. At that time, hydraulic cement was made from granite dust and trass, a volcanic substance that had to be imported at great expense. In seeking a substitute, Baldwin learned of a volcanic ash that was used in the West Indies. The company immediately hired a sloop that brought back 40 tons of this new trass, along with instructions on how to mix it. Baldwin altered this procedure in a way that had a permanent influence on commercial cement manufacture in this country.

All of the locks on the canal were 12 feet wide and over 75 feet long. Canal boats were flat-bottomed, measured nine to 9.5 feet wide, were 40 to 75 feet long and had a capacity up to about 25 tons. Passenger canal boats also became very popular. In 1812, the company experimented with a steam engine in a canal boat — the first such endeavor in this country. However, the experiment was not a success that time.

Conclusions

After ten years in building, the completed Middlesex Canal was opened on December 31, 1803. It provided a cheaper means of transportation than had been known before. It justified the vision of James Sullivan and the other members of the Middlesex Canal Company, and established Loammi Baldwin as one of the great pioneer engineers in this country.

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