The mighty Merrimack River—a Clean Water Act success story

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ABSTRACT | In celebration of the 50th Anniversary of the Clean Water Act—*a job well done*—this article chronicles the history of northern New England's Merrimack River and its cleanup from one of the most polluted rivers in the country. The Merrimack River has been the center of life and commerce in New England since humans inhabited this land. It has also inspired generations who have seen and been touched by it; one of our country's first environmentalists, Henry David Thoreau, published *A Week on the Concord and Merrimack Rivers* in 1849, recounting his journey with his brother on this majestic waterway. Beatnik author and Lowell native, Jack Kerouac, reminisced about the river and its 1936 flood in his 1952 novel *Doctor Sax*. Several naval ships have been christened the USS Merrimack in honor of it.

This article is also about my journey as a 41-year water professional. I grew up about 1 mi (1.6 km) from the site of the wastewater treatment plant that I presently manage on the banks of the Merrimack River. The Merrimack has inspired me since I saw its roaring rapids as a child. I have a lifetime of river memories, and I take great pride in now being a trusted steward of it. This article will look at many of the historical, social, and economic factors that contributed to the river's pollution, cleanup, and revitalization.

KEYWORDS | Merrimack River, Clean Water Act, Industrial Revolution, legacy pollution

For centuries the Merrimack River was the lifeline of the Indigenous peoples of northern New England, providing them food, clean water, and transportation. Many tribes including the Agawam, Amoskeag, Pawtucket, and Pennacook lived on its riverbanks; in fact, the name "Merrimack" is derived from the Indigenous American name meaning "swift water place."

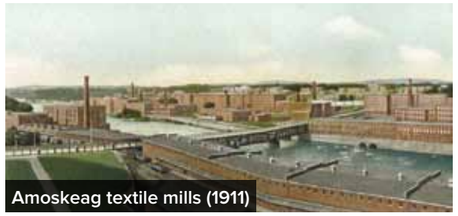
The first European to document the Merrimack River was the French explorer Samuel de Champlain in 1605. As more immigrants from Europe came to New England in the early 1700s, they settled along this river for the same reasons that the Indigenous people did—food, clean water, and transportation.

Late in the 1700s, the lower Merrimack Valley transformed quickly from an agrarian society to an industrial society. The Merrimack River soon became a chief means of commerce and to this day has been the economic engine for the Merrimack Valley. This quest for commerce led to the river's pollution and near-death. Ironically, this same quest has also led to its cleanup and revitalization.

INDUSTRIAL REVOLUTION

The Pawtucket Falls in Lowell offered a source of water power that enabled the construction of sawmills and gristmills in the early 1700s. The Merrimack Valley's rich fields of timber gave local merchants a bountiful harvest. Transporting the timber down to the sawmills and the cities via the river, however, was problematic due to a series of waterfalls. In 1792, the Proprietors of Locks and Canals Association was established by timber merchants from Newburyport. In 1796, they built the Pawtucket Canal to bring timber products around the Pawtucket Falls. This was followed in 1807 by the first lock and canal system in Manchester, New Hampshire, which navigated around the Amoskeag Waterfalls. These locks and canals were built without any environmental awareness or consideration, and the Merrimack River was forever altered.

In the early 1800s, at the dawn of the Industrial Revolution in England, textiles became one of the most dominant industries. The wealthy merchants on this side of the Atlantic, such as Francis Cabot Lowell and Benjamin Prichard, soon followed suit. The Merrimack Valley would transform over the next 100 years into a worldwide textile power led by the Amoskeag Mills, the world's largest single textile mill. The roaring flows of the mighty Merrimack River provided the power to drive this. The river was literally the engine that drove the textile industry into prosperity, and the river into pollution.



Amoskeag textile mills (1911)

The wealthy industrialists with their growing textile industry continued to control the river's destiny as they harnessed its hydraulic power. Starting in 1820 and over the next 28 years a series of dams were constructed on the river. In 1820, the Pawtucket Falls Dam was built in Lowell, providing 32 ft (10 m) of hydraulic power in the form of hydraulic head. In 1836, the Amoskeag Falls Dam was constructed in Manchester providing 50 ft (15 m) of hydraulic power. Last, in 1848, the Great Stone Dam was constructed in Lawrence providing 35 ft (10.7 m) of hydraulic power. In addition to these large-scale dams, canals were built in and around most mills, equipped with smaller dams with slide gates to control water release. Similar to the early locks, these dams and canals were constructed without environmental awareness or consideration. The slow killing of the Merrimack River continued.

Lowell mills (1910)

Huge textile mill complexes were constructed all along the riverbanks. From Franklin, New Hampshire, to Newburyport, Massachusetts, the Merrimack River powered the textile industry and New England's Industrial Revolution. By 1840 Lowell had grown to 32 textile factories employing almost 8,000 workers. The world's largest single textile mill grew along the river at Manchester's Amoskeag Manufacturing Company, which operated from 1810 to 1935. During its peak it employed over 17,000 workers spread over 40 buildings and 5.8 million ft² (0.54 million m²) of flow space. The mills produced everything from military uniforms to the denim for Levi Strauss jeans. In addition to textiles, the company's foundries produced everything from guns to locomotives to fire engines. The mid-1800s represented the peak of the textile industry in New England and along the banks of the Merrimack River.

The harnessing of the mighty river was a civil engineering marvel for its time. Every inch of hydraulic power was used by these pioneers. Mill buildings were constructed to maximize water use. Massive turbines were constructed to harness the river's energy. Networks of canals and gates were constructed to distribute the water and its energy

THE MERRIMACK RIVER WATERSHED

The 117 mi (188 km) long Merrimack River is one of the largest and most important rivers in northern New England. It starts in Franklin, New Hampshire, at the confluence of the Pemigewasset and Winnipesaukee rivers, and discharges into the Gulf of Maine in the Atlantic Ocean in Newburyport, Massachusetts. Its lower 22 mi (35 km) in Newburyport and Amesbury are considered tidal. A watershed of 5,010 mi² (12,980 km²) and 12 rivers contribute to its 4.8 billion gallons (18.2 billion liters) of flow per day. Several major cities sit along the river's banks, including Concord, Manchester, and Nashua in New Hampshire, and Lowell, Lawrence, and Haverhill in Massachusetts. Over two million people live in the river's watershed.

The Nashua River, a tributary of the Merrimack River, was severly polluted (left) circa 1960 and (right) before and after the CWA

throughout the mill complexes. This was truly a showplace of the golden age of civil engineering, constructed well before the birth of environmental engineering.

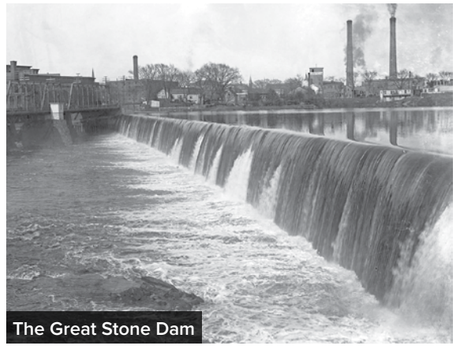
CONSEQUENCES OF THE INDUSTRIAL REVOLUTION

The Industrial Revolution was driven in the name of commerce by a relatively few wealthy industrialists and merchants. They realized most of the financial and social benefits of their work, but the rest of the Merrimack Valley's residents suffered the consequences for decades to come.

For centuries the river had been home to several species of diadromous fish that migrate between the ocean and freshwater. Shad, river herring, salmon, alewives, and eels served the river with several vital ecosystem functions throughout their life cycle. Diadromous fish transport nutrients from the ocean to inland ecosystems. During spawning migrations, they also provide a seasonal abundance of food for species living year-round in marine, freshwater, and transitional habitats. Eagles, ospreys, otters, and many others rely on these diadromous fish to feed their young.

Dam construction to fuel the Industrial Revolution all but killed the river's annual fish migration. The Great Stone Dam constructed just 30 mi (48 km) from the Atlantic Ocean in Lawrence created almost a complete barrier for diadromous fish that had fed Indigenous peoples for centuries. In addition to building dams, several "mill ponds" created stagnant water that further degraded the ecosystem supporting the river's aquatic life.

While the altering of the Merrimack River's natural course harmed its biology, the mill pollution further deteriorated the river. Dyes and bleaches from the mills were discharged to the river daily. One of the most damaging pollutants was the "wash water" from cleaning equipment that contained oils,



The Great Stone Dam

greases, and heavy metals. In addition to the textile mills, dozens of other industries such as foundries, tanneries, and paper mills contributed to the pollution. In Concord, New Hampshire, coal tar from the manufacture of coal gas to energize the city was stored in holding ponds within the river's floodplain.

Population growth also contributed to the pollution. Mill workers had to live within walking distance of work, creating dense urban populations within the river's immediate watershed. Judicious wastewater collection and treatment was still decades in the future, and domestic waste was discharged directly to the river. Stormwater runoff that also discharged into the river carried everything from horse manure to mill tailings to slaughterhouse waste, further deteriorating water quality.

The Merrimack River that had served generations of Indigenous peoples and early settlers became so polluted that it was an unsafe drinking water source. Waterborne diseases such as cholera, gastroenteritis, and giardiasis traveled downstream from one river city to another. In 1832, a cholera outbreak in Manchester killed 674 residents. In 1849, 149 residents of Lowell died from the disease. The river also no longer provided food, as the fish migrations had ended, and the water was so polluted that even

boating on it was a serious health risk. The river had become so odorous in some areas that it was a hardship to live adjacent to it. The mighty river that had served generations was now almost dead.

PERIOD OF INACTION AND FURTHER DEGRADATION

The decline of the textile industry started shortly after the Civil War. The increased cost to ship cotton north, heat buildings, and pay workers contributed to the industry's demise along the Merrimack River. Most of the mills closed during the Great Depression. Urban populations deserted the cities for the suburbs. By 1940 the vacant mills began a depressed era of inactivity.

During this period our nation faced three great challenges that would take all its focus and resources: World War I, the Great Depression, and World War II. Although it was an acknowledged and growing problem, the state or federal government had done little to address the environmental degradation and water pollution.

One of the first local laws to protect our waterways was enacted in 1878 when the Massachusetts General Court prohibited the discharge of refuse or any "polluting substances" into streams or public ponds. Commerce was again the priority, however, as lawmakers bowed to corporate pressure and exempted from this law the Connecticut and Merrimack rivers as well as the Concord River within Lowell.

In 1886, the Massachusetts Legislature required its board of health to adopt water pollution standards. This led to our engineering opening, with several notable activities taking place. In 1893, the Lawrence Experiment Station became home to groundbreaking wastewater engineering research. In 1899, the Rivers and Harbors Appropriation Act was passed, arguably our country's first federal environmental law. Ironically, this act addressed navigation of harbors but not the water quality. Once again, the law was driven by commerce; our harbors and adjacent waterways had become so full of solid waste that ships carrying goods could not navigate them.

In 1912, the federal government passed the Public Health Service Act to study problems of sanitation, sewage, and pollution. In 1917 Lowell prepared an engineering report recommending "the construction of proper sewerage facilities" along the Merrimack River. In 1929 our organization, NEWEA, was founded as the New England Sewage Works Association with 40 charter members. Environmental awareness was increasing, and small but positive steps were addressing the pollution of the Merrimack River.

Merrimack River as it flows from Haverhill to Newburyport, Massachusetts

With the end of World War II our nation could turn its attention to other challenges, including water pollution. In 1945, the surgeon general warned that over half of the U.S. population relied on drinking water supplies of "doubtful purity." In 1947, the New England Interstate Water Pollution Control Commission was created—one of several interstate water pollution control commissions created by Congress to address water pollution at the state level. By now the post-World War II generation recognized that water pollution was a national problem, and in 1948 the Federal Water Pollution Control Act was enacted. Although initially a weak law with no funding and little leadership, it was the foundation of the legislation that would ultimately enable the cleaning of the United States' waterways. The Federal Water Pollution Control Act was amended in 1956, 1961, 1965, and 1966, and each time it became stronger and more sustainable. Meanwhile, along the Merrimack River the Anadromous Fish Conservation Act of 1965—a joint state–federal effort to restore migratory fish such as salmon and shad—was enacted. Fish ladders and elevators were constructed around dams to facilitate the migration of these fish. Progress was slowly being made.

CLEAN WATER ACT

In the late 1960s, as a result of decades of inaction and continued raw wastewater discharges, the Merrimack River was named one of the 10 most polluted rivers in the country. However, the 1960s also brought change to our country. Social activism was bringing an end to an unpopular war in Vietnam. This same spirit of social activism embraced the environment. In 1970, the first Earth Day was held in support of environmental

Manchester, New Hampshire WWTP

protection. Also in 1970, EPA was created and at long last the United States' environmental leadership void began to be filled. Soon after, in the same year, the Clean Air Act was passed to address the smog choking our cities. Next up was water.

One of New England's own, Senator Edmund S. Muskie of Maine, championed clean water in the 1960s. Mr. Muskie grew up in Rumford, Maine, near the Androscoggin River, which received pollutants from paper mills, municipal sewers, and agricultural runoff. He knew firsthand that our nation's rivers were dying. In 1972, the U.S. House and Senate voted nearly unanimously to pass a set of sweeping amendments to the 1948 Federal Water Pollution Control Act; President Nixon, however, vetoed the bill. The Mr. Muskie-led environmental coalition quickly secured the votes for an override by the Senate and House, and the bill became law on October 17, 1972. The newly amended Federal Water Pollution Control Act, now strengthened, funded, and provided leadership by the EPA, would ever after be known as the Clean Water Act (CWA).

The CWA established environmental stewardship as one of our nation's priorities. It was also the catalyst for one of the most significant and successful engineering achievements over the past 100 years, the cleaning of our nation's waterways that had been polluted for over 200 years. The CWA established two key regulations to govern and protect our rivers: permits and water quality standards. The most important permit created was the National Pollutant Discharge Elimination System (NPDES), which regulates point sources discharging pollutants into U.S. waters. Water quality standards were generally left to the states because of the geographical, climatic, and aquatic life variations among them. These numerical criteria provided clear guidance to our industry for meeting the CWA's goals.

Most important to the CWA was federal funding. Many previous water projects suffered from lack of funding and lack of financial responsibility for the polluting industries. The CWA provided federal funding for construction of wastewater treatment plants WWTPs and collection systems nationwide, with the funding sources established at 90 percent federal, 5 percent state, and 5 percent local. With the water quality standards, permits, and funding in place, our industry was ready to go to work.

SUCCESS OF THE CWA

The Merrimack River communities began the construction of nine WWTPs, starting at the river's confluence in Franklin and ending at its discharge in Newburyport. These nine WWTPs were the most cost-effective investment to address the polluted waters of the Merrimack River. As plants started up in the mid-1970s, river water quality improved immediately.

As our nation embraced environmental stewardship, EPA determined that WWTPs were only a partial solution. Therefore, over the next 30 years EPA established several other programs under the CWA that further improved water quality. In 1981, the Industrial Pretreatment Program was established to prevent the introduction of pollutants to a WWTP. In 1990, the Municipal Separate Storm Sewer System (MS4) stormwater permit was issued to address polluted runoff affecting waterways. In 1994, EPA issued its Combined Sewer Overflow (CSO) Control Policy. This policy greatly affected the Merrimack River, as five large communities had combined sewer systems: Manchester, Nashua, Lowell, Lawrence, and Haverhill. These communities each established long-term control plans to mitigate CSO discharges, and collectively they have invested over $1 billion in addressing CSOs. As a result, "separated" collection systems now direct flows to WWTPs.

In the 2000s, EPA continued to improve water quality through NPDES permits by regulating dissolved pollutants such as nutrients including nitrogen and phosphorous. This multi-phase water pollution abatement approach over the past 50 years has restored the health and well-being of the Merrimack River, which is now the cleanest and healthiest it has been in almost 200 years. The river is the second largest surface drinking water source in New England, serving 600,000 people through five water treatment plants. Manchester is constructing its new $40 million, 7 mgd (26.5 ML) water treatment plant on the banks of the Merrimack River.

The reclaimed river has once again become the economic engine of the Merrimack Valley, but this time sustainably so. The river is still used to power our industries, but in a more environmentally responsible manner. Eight dams along the Merrimack furnish over 264,000 gps (1,000 M^3/s) of flow to turbines creating power in accordance with today's rules and regulations. The textile mill buildings along the river's banks are again thriving with high-tech companies, schools, and offices of several engineering firms contributing to our industry. While our nation's thirst for commerce and wealth has not subsided, we have recognized that this pursuit must be done environmentally, responsibly, and sustainably for our health and well-being.

In my youth I was in awe of the mighty Merrimack River with its white water rapids and raw power as it roared during spring snowmelt and rains. I fished the river and witnessed firsthand the pollution and devastation done to this great waterway. During the winters in the 1960s I watched city trucks dump, as was standard practice, all the snow full of roadway contaminants and solid waste into the river through the bridge grating. In my lifetime the river has gone from unsightly, not swimmable, and unsuitable for aquatic life to its cleanest and healthiest state in almost 200 years. Full recreational activities are offered on the northern portion, including swimming, boating, water skiing, and fishing. Salmon are stocked annually in the upper reaches. Many of the aquatic species that disappeared during the industrial revolution have slowly returned to their natural habitat. The river has once again become an inspiration to me and, I hope, to our next generations of environmentalists. The CWA was critical in achieving one of our nation's greatest engineering achievements in the past 100 years: the cleaning of the Merrimack River and the United States' waterways.

Merrimack River as it empties into the Atlantic Ocean

ABOUT THE AUTHOR

Frederick McNeill is the chief engineer of Manchester, New Hampshire's Environmental Protection Division, where he manages northern New England's largest wastewater utility. In addition to his current role as NEWEA president, Mr. McNeill is a member of the New Hampshire Rivers Management Advisory Committee and has been a NEIWPCC commissioner since 2007. A long-time industry advocate, Mr. McNeill has published/presented over 50 technical papers on a wide range of environmental engineering topics.