On the road to a sustainable infrastructure—Part 3: sustainability values in action

LAURA STOCK, P.Eng., SUEZ WTS, Oakville, Ontario
JENNIFER LAWRENCE, PhD, Tighe & Bond, Westwood, Massachusetts

ABSTRACT | The last in a three-part series, this article highlights four case studies in which the core values of sustainability—economic prosperity, environmental stewardship, and social well-being—were successfully balanced during the planning, design, and construction of clean water projects. Each project was previously featured in the *Journal*; here we bring a fresh eye toward the sustainable components. Through these examples, we reinforce the concepts discussed in parts 1 and 2 of this series ("Defining our Responsibilities," *Journal*, winter 2019, and "Integrating Sustainability in Planning, Design, and Construction," *Journal*, spring 2020). We also emphasize how these projects promote environmental justice, the principle that all people have a right to a clean and healthy environment.

KEYWORDS | Sustainability, economic prosperity, environmental stewardship, social well-being, environmental justice

POWER GENERATION THROUGH HEAT RECOVERY IN HARTFORD, CONNECTICUT

The Hartford Water Pollution Control Facility (HWPCF), operated by the Metropolitan District (MDC) in Hartford, Connecticut, is the state's largest wastewater treatment plant. It is permitted to treat 60 mgd (227 ML/d) through its secondary treatment processes, with a peak daily wet weather flow capacity of 200 mgd (757 ML/d). The HWPCF began incinerating its own sludge and sludge from several other water pollution control facilities across the district to manage disposal in the 1970s. In 2009, master planning determined that heat recovery from incineration would be economically viable and benefit the community. Shortly after, design of a heat recovery facility (HRF) began, and construction was completed in 2012. The HRF takes heat from the incinerator exhaust and turns it into steam in large boilers. The steam then spins a turbine that is connected to a generator and produces electricity that directly offsets the HWPCF's power costs.

Economic

Economics was a key driver of the HRF project. The MDC saw an opportunity to take waste heat from its incineration process and convert it into valuable energy. The HRF was designed to produce up to 40 percent of the HWPCF's energy needs, and its energy production has been trending upward since operation was turned over to operations staff in 2014. This positive trend is attributed to increased operational experience, equipment maintenance and overhauling, system optimization, and an enhanced understanding of and reliance on automation. In 2020, the HRF's energy production amounted to 10.6 million KWh (38.2 billion kJ), which equated to about $1.4 million.

The reduced baseline energy consumption for the HWPCF also benefits the MDC by reducing its electric utility fees. As a commercial user, the HWPCF is charged a fee based on its potential to use electricity. By reducing the plant's peak energy demand, the HWPCF can significantly reduce utility fees, which have historically been nearly

Ground level view of Hartford's two heat recovery boilers—the HRF takes heat from the incinerator exhaust and turns it into steam in large boilers

Hartford's Steam Turbine—the steam then spins a turbine that is connected to a generator and produces electricity that directly offsets HWPCF's power costs

half of its monthly power bill. Some of these savings are translated into reductions in the community's sewer service rates.

The MDC obtained grants and low-interest loans for more than 60 percent of the project cost through green stimulus funding. Combined with the power savings described above, this funding created an eight-year project payback for the HRF that, given the expected equipment life of 20 to 40 years, may generate decades of savings.

Environmental

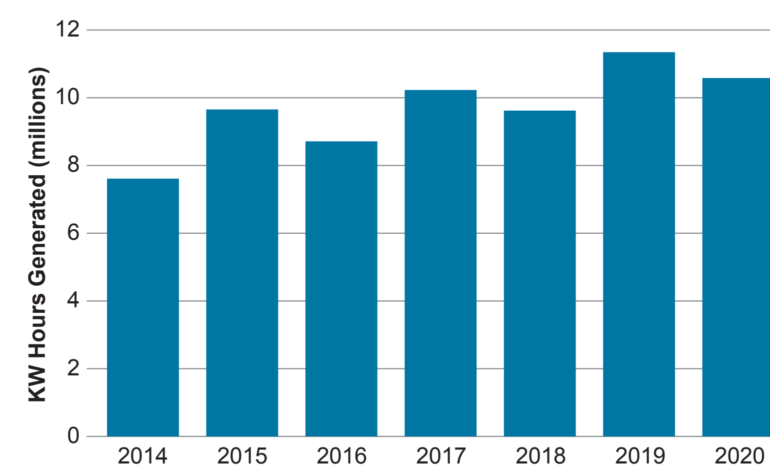
Heat recovery provides many benefits to the HWPCF. Waste heat is used in place of other valuable resources to create renewable energy from the biosolids incineration process. In turn, this reduces pollution emissions from conventional energy generation sources, as less power is produced to satisfy the HWPCF's electrical demand. The HRF system also reduces thermal waste to the environment, as the heat is now converted to electricity. Finally, onsite power reduces electrical line losses that would occur from power produced far from its point of use.

Social

At the HWPCF, the MDC is committed to community outreach and equitable education (MDC 2021). Education and engagement were key to the success of the HRF, with staff involvement at all project stages. Engagement started with reference facility site tours during planning and continued through design, construction, commissioning, and start-up. Each discipline was encouraged to provide input into the HRF design; this included maintenance staff weighing in on equipment accessibility, instrumentation and controls staff ensuring proper communication within the plant supervisory control and data acquisition (SCADA) system, and electricians ensuring consistency with power distribution standards. Staff took part in more than 20 equipment-specific and system-wide training sessions on the overall treatment process and how the equipment worked together to form a complete system. This approach enabled the HWPCF staff to learn new skills and take ownership of the HRF, in turn leading to high staff retention and high equipment uptimes.

Worker safety has also been integral to the project's success and was considered in every aspect. Every operator is authorized to implement an "emergency stop" to the facility at any time for any reason. The SCADA system monitors many different points within the facility and can automatically shut the system down or deliver alarms indicating an instance or trend requiring attention. To date, there have been zero reportable injuries at the facility.

The HRF project was part of the MDC's much larger Clean Water Project, which included upgrades to both the wastewater and stormwater collection systems and the wastewater treatment plant. At the onset of the Clean Water Project, the MDC formed a Citizens' Advisory Committee (CAC) to provide



HWPCF electricity production 2014–2020 (1 KWh = 3,600 kJ)

Lowell's restored flood pump station

community outreach and education. The CAC consisted of MDC customers, environmental groups, business groups, and environmental justice organizations, and acted as a bridge between the MDC and the communities it serves.

This project was originally published in the fall 2016 *Journal*: "It is all about energy—power generation through heat recovery in Hartford."

RESTORATION OF A FLOOD PUMP STATION IN LOWELL, MASSACHUSETTS

Part of Lowell, Massachusetts, located along the Merrimack River, lost its flood protection certification years ago because the city's West Street Flood pump station (WSFPS) was inoperable. This portion of the city, known as Centralville, is designated as an environmental justice population by Massachusetts due to the prevalence of minority households and the low median household income (mass.gov 2021). To restore flood protection to the area, the city rehabilitated two of the three 42 in. (107 cm) axial flow pumps and gate valves and reinstalled them with new right-angle gear drives and 475 hp (354 kW) diesel engines. The project also included structural and operational improvements to the pump station to mitigate operational issues from infrequent use. After the city completed construction in 2018, the Federal Emergency Management Agency (FEMA) and the U.S. Army Corps of Engineers (USACE) ran successful field tests. Given the promising results, FEMA re-accredited, and USACE re-certified, this critical component of the city's flood damage reduction system. The success of this rehabilitation project, combined with operational changes, could be repeated in other flood pump stations across the country that have similar maintenance issues due to infrequent use.

Pump station pre-restoration

Economic

Before embarking on this project, the city evaluated alternatives for restoring flood pumping capability. It did so by comparing the cost of rehabilitation of the existing flood pump station to the cost of constructing a new flood pump station at an alternative location. The project aptly integrated sustainability into the planning phase of the project life cycle to identify the most economically viable path forward. The evaluation revealed that rehabilitation of the pump station (constructed around 1940) was more cost-effective than decommissioning the station and starting anew. The rehabilitation of the pumps and the pump station saved the city about $1 million compared to the cost of replacing them.

Environmental

This project exemplifies the sustainable principle of "reuse." Instead of razing the entire pump station and building anew at a new location, the city identified the pump station components that could be salvaged and restored. These components included the structure, pumps, piping, and valves. Reusing materials saved them from being sent to a landfill and avoided wasting precious resources on manufacturing new materials. The city preserved the building superstructure and substructure by making minor, targeted concrete repairs. Finally, reuse of the site also allowed the city to preserve the alternate site that was considered for a new flood pump station. The alternate site remained as open space and in the future may be used for other wastewater needs.

During the planning process, the designers also considered the original reason for the pump station's disrepair and made sure the rehabilitated facility would not fail because of similar circumstances. The original pump station was activated only during a combined sewer overflow event that coincided with high river level, resulting in infrequent activation. The original design did not allow the pump station to be exercised during non-activation events. The lack of activations and inability to exercise the pump station led to its disrepair. In the redesign, the station was reconfigured with innovative features that enabled regular testing and system upkeep. The ability to exercise, maintain, and verify the readiness of the rehabilitated flood pump station will support not only the longevity of its lifespan but also flood resiliency in the neighboring environment.

Social

Prior to rehabilitation, the WSFPS had been inoperable for 30 years. Consequently, FEMA updated its flood zone mapping to include part of the Centralville neighborhood within high-risk flood zones. Homes and businesses in high-risk flood areas with mortgages from government-backed lenders must have flood insurance, so many residents within the neighborhood had to take on this costly expense (FEMA 2021). Flood insurance premiums can easily exceed $1,000 per year in Massachusetts, a possibly significant portion of household income in environmental justice communities such as Centralville (Moon 2019).

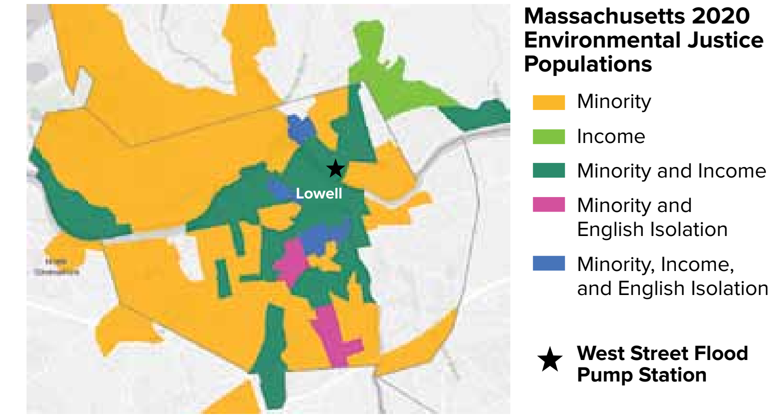
Removing these homes from high-risk flood zones was a priority. Not only would the properties be better protected from the damage caused by flooding, but also the burden of flood insurance would be removed from an environmental justice population. After the station was re-certified by the USACE and re-accredited by FEMA, FEMA updated its flood zone mapping to remove the same portion of the Centralville neighborhood from high-risk flood zones. This means that the neighborhood's low-income residents no longer have to pay for costly flood insurance premiums. Instead, they benefit from greater flood protection and lower homeownership costs.

This project was originally published in the spring 2019 *Journal*: "Restoring flood resiliency with a flood pump station rehabilitation in Lowell."

BIOSOLIDS CONVERSION TO COMPOST IN FAIRFIELD, CONNECTICUT

The Fairfield Water Pollution Control Facility (FWPCF) is home to the last remaining biosolids composting facility in Connecticut. It is also one of the oldest, continuously operating biosolids composting facilities in North America. The plant was constructed in 1950, and the composting facility was added in 1988. Other than replacement of the steel building in 1998 with a stainless-steel version, much of the equipment and infrastructure in the composting facility is original.

The FWPCF uses advanced secondary treatment to process a design average daily flow of 9 mgd (34 ML/d) and a peak daily flow of 24 mgd (91 ML/d). Biosolids are removed from the primary and secondary treatment processes and sent to anaerobic digesters for solids reduction and stabilization. Methane generated in digestion heats the digesters, and excess



Lowell environmental justice populations

methane is flared. Following digestion, solids are dewatered using a belt filter press and discharged into an agricultural mixing dump truck where they are combined with a similar mass of wood chips and mixed using the truck's internal equipment. The biosolids and wood chip material is then transferred into one of six bays in the main composting building. The bays are 220 ft (67 m) long with large agitators that mix and slowly move the compost material down the bay. Air is regularly blown through the composting material within the bays, and the plant's SCADA system monitors compost time and temperature to meet EPA requirements for pathogen and vector attraction reduction. This part of the composting process takes 28 days, after which 24 truckloads per week are loaded onto a truck and taken to another area for 30 days of storage. Following this storage period, the compost material is tested for fecal coliform prior to distribution.

Economic

The Town of Fairfield maintains contracts with two third-party contractors for composting-related activities. The first contract is for processing the town's yard waste and includes the supply of all

Fairfield—compost loaded onto a truck at the end of the 28-day agitation and aeration period


51 new trees along Somerville Avenue


Mulch placement at tree pits


Porous flexipave increases water retention

wood chips for composting, the supply of wood chips for the FWPCF's biofilters, and final storage and testing of the compost material. The second contract is for marketing, distribution, and assistance with submission of distribution planning documents to the Connecticut Department of Energy and Environmental Protection. The contracts provide a combined annual revenue of roughly $70,000 to the town. The town also saves around $300,000 per year by composting its biosolids instead of hauling them offsite and paying tipping fees for incineration.

Environmental

Creating compost from the FWPCF's biosolids and the town's yard waste is emblematic of a circular economy. Two products typically seen as waste are recognized for their value and combined to create a salable good. The composting practice provides for beneficial reuse of the biosolids, a reduction in the FWPCF's carbon footprint for biosolids management, and a reduction in the carbon footprint associated with production of soil amendments and fertilizers that the compost replaces. The FWPCF produces 5,250 yd^3 (4,010 m^3) per year of compost material.

Social

The FWPCF creates a Class B compost product that is used as a soil amendment for general landscaping, including tree planting and the construction or top-dressing of lawns and sports fields, for crops not directly consumed by humans, and as an ingredient in potting media. It is sold at an affordable rate to local customers, with 85 percent of the compost going to Connecticut and the remainder to New York.

The FWPCF also creates public awareness around what happens when a toilet is flushed. Prior to the pandemic, Fairfield regularly hosted site tours of the FWPCF and composting facility for groups including the Boy Scouts, junior high school, high school, and college classes. The tours provided insight into the different treatment steps, the type and purpose of upgrades made to the facility over time, and the important role facilities like the FWPCF play in protecting our environment.

This project was originally published in the spring 2018 *Journal*: "The last one standing—Fairfield, Connecticut's compost facility."

RESILIENT STORMWATER INFRASTRUCTURE IN SOMERVILLE, MASSACHUSETTS

Somerville, Massachusetts, is upgrading its infrastructure that will change how it manages much of its combined drainage system. The upgrades include macro improvements to stormwater conveyance, storage, and pumping as well as to green stormwater infrastructure in public and private developments. The new "gray" infrastructure will provide 860,000 gal (3,255,400 L) of stormwater storage. Additionally, the new green infrastructure will provide stormwater storage for 1.5 in. (3.8 cm) of runoff from the contributing drainage area, reduce impervious surfaces, expand the urban forest, and improve the quality of downstream waterbodies. The project is expected to be substantially complete and ready for use by the fall of 2021.

Economic

This project's improvements, developed through the city's comprehensive planning process, prioritize pedestrians and bicyclists by improving the amenities for these groups on the street, while minimizing the impacts of storm surge and sea level rise. By incorporating a grand vision into the planning and inception phases, the city has taken great steps to ensure that they are "doing the right project" and are "doing the project right," as outlined in Part 1 of this three-part sustainability series. By making the investments in the combined drainage system, the city expects to see returns via increased commercial activity and the associated tax revenue.

Environmental

This project addresses legacy flooding issues in and around Union Square. Incorporating green infrastructure to absorb stormwater runoff reduces flooding issues and creates urban ecosystems. As part of the project, the city is reintroducing native plant and tree species. These plant and tree selections will provide resiliency and enhance the urban ecosystem by creating food and habitat for butterflies, insects, birds, and other wildlife, while reducing irrigation needs. The improvements to the flooding issues will also help with area development.

Social

This holistic project was driven by the community-based Union Square Neighborhood Plan, Vision Zero, and SomerVision, with an aggressive plan to eliminate traffic-related deaths and serious injuries in Somerville (City of Somerville, 2020). Through these plans, Somerville strives to become the most walkable, bikeable, and transit-friendly city in America. The social well-being of the community is right at the heart of this clean water project.

Most of Somerville is designated as an environmental justice population due to its minority population. This can be traced to a historic "redline" map released by the federal government in 1930 that designated major parts of the city as "hazardous and undesirable" due to its relatively large minority and immigrant population. Redlining not only excluded people from owning, and potentially profiting, from home ownership, but confined them to areas of poverty and minimal investment. Though redlining is now outlawed, its effects on urban neighborhoods persist in many ways. One prominent example is the lack of green and open spaces, which are known to promote health and buffer stress (Lowell General Hospital, 2021). The city is providing more equitable access to green spaces through this project.

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ABOUT THE AUTHORS

- Laura Stock is a municipal sales manager with SUEZ Water Technologies & Solutions. Her nine years in the water and wastewater treatment industry have included roles in equipment commissioning, detailed design, and technical sales. Ms. Stock has been an active member of the NEWEA Sustainability Committee since January 2021.
- Jennifer Lawrence is a staff engineer at Tighe & Bond, where she applies her experience in identifying creative, sustainable solutions to water and wastewater quality challenges. Dr. Lawrence has been a member of the Sustainability Committee since January 2020.