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WASTEWATER TREATMENT AND COLLECTION SYSTEMS OPERATIONS

NEWEA

WORKING FOR WATER QUALITY

JOURNAL OF THE NEW ENGLAND WATER ENVIRONMENT ASSOCIATION

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Contents

On the cover: Manchester, New Hampshire Wastewater Treatment Facility—aeration piping and valves at center walkway between aeration tanks

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(page 16)
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NEWEA
WORKING FOR WATER QUALITY

OUR ASSOCIATION WAS ORGANIZED EIGHTY-EIGHT YEARS AGO in Hartford, Connecticut, on April 23, 1929, with the objectives of advancing the knowledge of design, construction, operation and management of waste treatment works and other water pollution control activities, and encouraging a friendly exchange of information and experience. From 40 charter members, the membership has steadily grown to more than 2,000 today. Membership is divided into the following classes:

Professional Member—shall be any individual involved or interested in water quality including any manager or other officer of a private waste treatment works; any person engaged in the design, construction, financing, operation or supervision of pollution control facilities, or in the sale or manufacture of waste treatment equipment.

Executive Member—shall be an upper level manager interested in water quality and who is interested in receiving an expanded suite of WEF products and services.

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Regulatory Member—this membership category is a NEWEA only membership reserved for New England Environmental Regulatory Agencies, including: USEPA Region 1, Connecticut Department of Energy and Environmental Protection, Maine Department of Environmental Protection, Massachusetts Department of Environmental Protection, New Hampshire Department of Environmental Services, Vermont Department of Environmental Conservation, and Rhode Island Department of Environmental Management.

Academic Member—shall be an instructor or professor interested in subjects related to water quality.

Young Professional Member—shall be any individual with five or fewer years of experience in the water quality industry and who is less than 35 years of age.

Professional Wastewater Operations Member (PWO)—shall be any individual who is actively involved on a day-to-day basis with the operation of a wastewater collection, treatment or laboratory facility, or for facilities with a daily flow of <1 million gallons per day. Membership is limited to those actually employed in treatment and collection facilities.

Student Member—shall be a student enrolled for a minimum of six credit hours in an accredited college or university.

WEF Utility Partnership Program (UPP)—NEWEA participates in the WEF Utility Partnership Program (UPP) that supports utilities to join WEF and NEWEA while creating a comprehensive membership package for designated employees. As a UPP a utility can consolidate all members within its organization onto one account and have the flexibility to tailor the appropriate value packages based on the designated employees' needs. Contact WEF for questions & enrollment (703-684-2400 x7213).

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Total paid and/or requested circulation		2,208	2,208
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Total distribution		2,208	2,208
Copies not distributed		292	292
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Percent paid and/or requested circulation		100	100

NEWEA
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President's Message

We are tied to the ocean. And when we go back to the sea, whether it is to sail or to watch, we are going back from whence we came.

– President John F. Kennedy, 1962

I have always considered myself fortunate to have spent virtually my entire life in New England. We especially enjoy our region's change of seasons; it helps us understand and appreciate the relevance and importance of the passage of time in our daily lives. My favorite season is late spring and summer; besides being baseball season, the days are warm and long, and we can take full advantage of water resources available to us throughout our six-state region. Our rivers, ponds, lakes, and ocean beaches provide us with recreational destinations and activities that are second to none. We are blessed with the advantages of these resources because of the work we all do every day to protect and keep them clean, fresh, and vibrant. For this reason, I thank each of you for your dedication, devotion, and commitment to serving as the stewards of our New England water resources.

As the seasons change, so do our NEWEA activities. As winter thaws and releases its grip, and spring slowly but triumphantly arrives, our NEWEA members rapidly begin to plan for and participate in our Affiliated State Association (ASA) legislative meetings, our Congressional Briefing in Washington, D.C., our ASA spring trade shows, training for Operations Challenge, our specialty conferences, and our Spring Meeting.

NEWEA co-sponsored successful and well-attended legislative outreach activities with our ASAs in Vermont in February, and in New Hampshire and Maine in March. We participated in the Vermont Local Government Day in Montpelier with representatives from NEWEA and the Green Mountain Water Environment Association. The event included presentations by state legislators, policy briefings on the state budget and Vermont Water Quality Act, and legislative committee meetings at the State House. The New Hampshire Water Pollution Control Association hosted its Legislative Breakfast in Concord. The program included remarks by Senator Jeanne Shaheen and Congresswoman Ann McLane Kuster, and a keynote address by Paula Tracy who is the *Escape Outside* Editor for ABC TV-affiliate WMUR. The Maine Water Environment Association hosted its Legislative Breakfast in Augusta that included presentations from House Leader Kenneth Fredette and Department of Environmental Protection Commissioner Paul Mercer, and a lively question and answer session with attendees.

"We relish our role as the protectors of the Atlantic Ocean and all our New England water resources so that we all can share in their benefits, now and for generations to come"

Race Point Beach, Provincetown, Massachusetts

Our legislative outreach is bearing fruit, and I am encouraged to hear our legislators speaking knowledgably about the critical need to support investments in our water infrastructure systems.

Our NEWEA Government Affairs Committee coordinated our annual Washington, D.C. Fly-in and Congressional Briefing in March. The event coincided with Water Week 2017 to communicate to our legislators the value of water to environmental protection, economic development, and job creation. We kicked off our activities with a lunch briefing that included remarks from NEWEA Government Affairs Chair Bob Fischer, Town of Livermore, Maine Town Manager Krystal Flagg, WEF board member Lynn Broaddus, and WEF Government Affairs Liaison Steve Dye. Our keynote speaker was our longstanding event sponsor, Massachusetts Congressman James McGovern. He noted that infrastructure is at the forefront of discussion in both the House and Senate, but it is competing with health care and tax reform priorities from the President. He anticipates that once these two items move through Congress, the focus will turn on shaping an infrastructure package. I was encouraged by the positive dialogue between our NEWEA members and our legislators and their aides during our meetings. Clearly, there is broad agreement on the need to address our infrastructure; the challenge is determining the funding levels, how it will be paid for, and its implementation throughout the nation to ensure long-term sustainability.

In April, Chair Travis Peaslee and the Operations Challenge Committee hosted a successful training day at the Holyoke Wastewater Treatment Facility for operators from throughout New England many of whom competed in our Operations Challenge event at the Spring Meeting, the winners of which will compete in September at WEFTEC. Training day activities included a tour of the WWTP, event descriptions, and hands-on training in the collection systems, process control, laboratory, safety and maintenance categories. I especially thank our sponsors for your longstanding support of this event.

Some of our ASAs have been active with their spring trade shows. while some hold their shows in the fall. Vice President Ray Vermette, President-elect Janine Burke-Wells, and I attended these events and participated in acknowledging NEWEA and WEF award winners from New Hampshire, Maine, and Connecticut. I especially enjoy the ASA trade shows as they provide opportunities to network with colleagues in a close-knit and relaxed setting to discuss the issues important in each state.

A Collection Systems and Sustainability Specialty Conference was held on May 1 featuring eight presentations and product exhibits by several of our NEWEA product representatives. A keynote address by Steve Estes-Smargiassi, who serves as the Massachusetts Water Resources Authority's (MWRA's) director of planning and sustainability, provided an excellent overview of the innovative ways the MWRA is managing its assets effectively and efficiently from a long-term sustainability perspective. The MWRA continues to be a leader in our industry, setting an example for other utilities and municipalities to follow. My thanks to Sustainability Chair Rob Montenegro, Collection Systems Chair Peter Garvey, Council Director John Digiacomo, and the committees for a job well done.

I greatly enjoyed our Spring Meeting, which was held June 4–7 at the Sea Crest Beach Hotel in North Falmouth. NEWEA staff and our Meeting Management Council prepared a program packed with exciting and thought-provoking activities. There is nothing better than spending time on our beloved Cape Cod. I truly believe that we experience a physical and spiritual metamorphosis when we travel over the Cape Cod Canal bridges and touch down on the Cape. As we listen to our favorite song, we roll the windows down to breathe and savor the ocean air, and a palpable sense of relaxation soothes our mind and body as we anticipate our seaside adventures. When we are by the ocean we are home, in a place that allows us to connect with and appreciate our planet's most important water resource. But equally important, the ocean connects us as people. Whether it is swimming, boating, fishing, or just relaxing on the beach, the sea provides us with a place of tranquility, optimism, and comfort. For these reasons, we relish our role as the protectors of the Atlantic Ocean and all our New England water resources so that we all can share in their benefits, now and for generations to come.

From the Editor

In keeping with the underlying Throwback theme for 2017 and the Wastewater Treatment and Collection Systems Operations theme specific to the summer edition of the *Journal*, I reviewed article titles from past *Journals* dating to the 1960s. Also, the American Society of Civil Engineers (ASCE) recently published its 2017 Infrastructure Report Card. Read on for my thoughts on these two interesting but unrelated topics.

Since its inception in the 1960s, more than 570 articles have been published in the *Journal*. Of those, about 30, or 6 percent, were related to wastewater treatment and collection system operations. If this seemingly low percentage accurately reflects the importance our industry places on this topic, much work is needed to place a higher priority on this critical function. Are the numbers skewed by few examples in the 1960s followed by a steady increase in recent years due to environmental awareness and regulations? For the answer, refer to the table below, a decade-by-decade approximation of the frequency of operations articles in the *Journal*.

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AECOM
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Frequency of *Journal* operations articles

Period	Total Articles	Operations Articles	Frequency
1967* – 1969	30	4	13.3%
1970 – 1979	108	6	5.6%
1980 – 1989	100	6	6.0%
1990 – 1999	133	7	5.3%
2000 – 2009	107	6	5.6%
2010 – 2017**	99	4	4.0%
Totals	**577**	**33**	**5.7%**

**Journal* inception; **Through Spring edition

As the table shows, though the data is limited in the early years, the percentage of operations articles started in double digits. If not an anomaly, this is an interesting finding given that modern environmental legislation was not passed until 1972 (Clean Water Act). In the decades that followed, the percentages subsequently dropped but stabilized in the 5 to 6 percent range, another interesting trend considering the timing of the Clean Water Act. For this decade, the percentage is about 4 percent, though a few years are still left to increase the numbers.

Whenever an analysis like this is completed, a quote attributable to British Prime Minister Benjamin Disraeli comes to mind: "There are three kinds of lies: lies, damned lies, and statistics." Personally, I believe our industry places a very high value on wastewater treatment and collection system operations, and those who do this work on a daily basis are under-represented in the table's statistics. For that reason, I call on operators to strongly consider contributing more articles to the *Journal*.

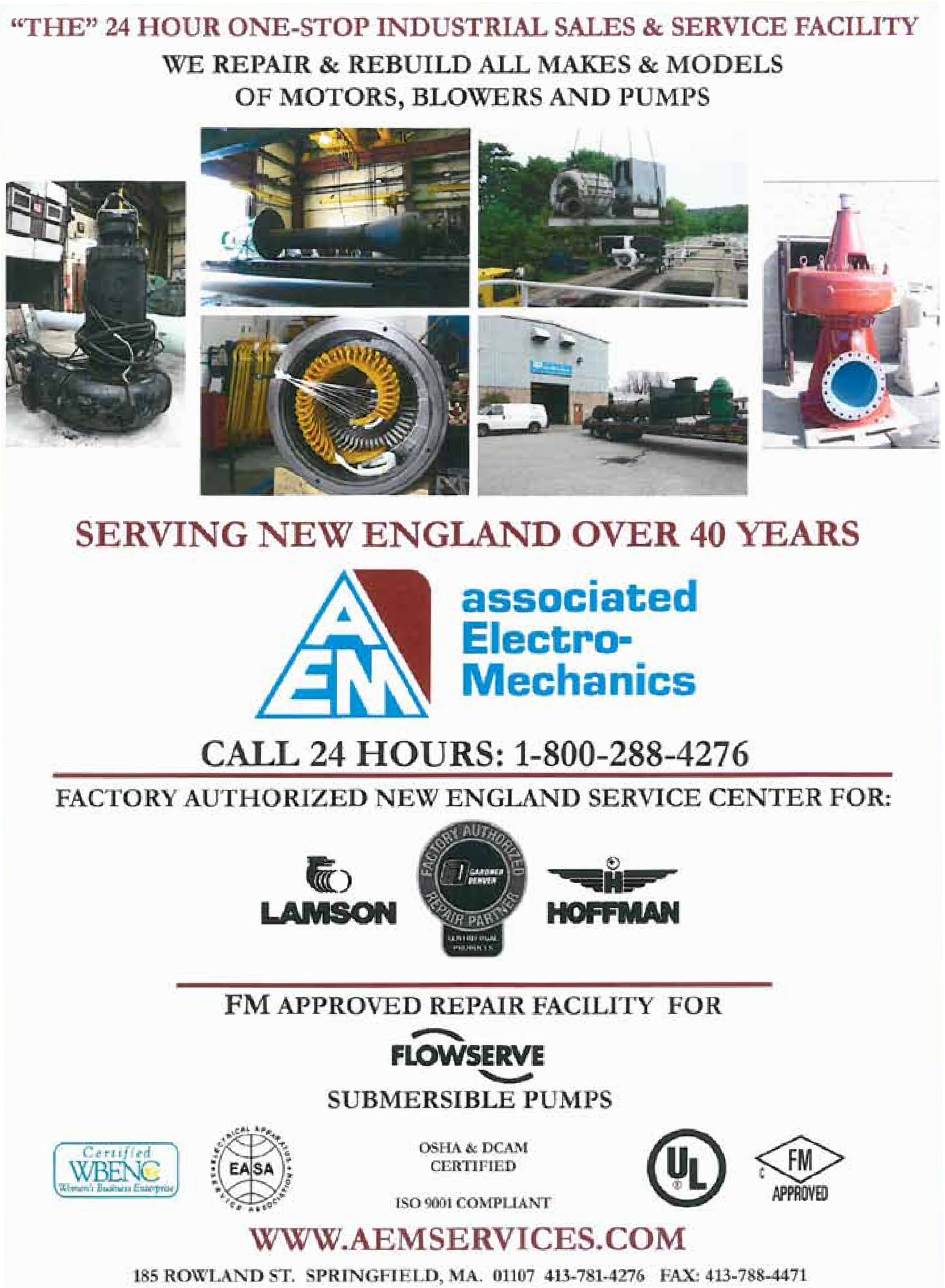
Speaking of numbers, or in this case letters, ASCE published its Infrastructure Report Card (infrastructurereportcard.org) this spring. Overall, infrastructure on a national level received a grade of D+. Wastewater followed the overall trend and received a grade of D+ also. On the one hand, there are reasons for optimism—after a downward trend that started in 1998, this is the third consecutive report showing improvement in the wastewater category. On the other hand, a grade of D+ is simply unacceptable.

ASCE uses a variety of criteria to develop each grade (capacity, condition, funding, future need, operation and maintenance, public safety, resilience, and innovation). It is not clear which criteria are driving the low grade, but I suspect it is a combination of all of them with perhaps the gap in funding being most concerning. According to ASCE's 2016 Failure to Act report, the funding gap for water/wastewater is expected to decrease from $11.3 billion to $10.5 billion through 2025, an encouraging sign, but it still highlights a substantial need. President Trump recently announced his administration's plans to rebuild America's infrastructure, but it does not include much to address this gap (visit whitehouse.gov; search for Infrastructure Initiative).

The current administration plan does not give rise to much optimism, but it does create resolve to raise political awareness about environmental issues and the need for financial assistance. In this regard, it underscores the importance of NEWEA's annual trips to Washington (for more on this topic, turn to page 58).

It is hard to believe that the summer is here and we are almost halfway through 2017; two editions of the *Journal* are now complete. If you are interested in submitting an article for a future edition, please refer to the table for each theme and the associated submission deadline.

2017 *Journal* themes & submission deadlines
Fall—**Municipal/Agency Topics** (June 30)
Winter—**National Issues of Regional Interest** (Sept. 29)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Industry News

WEF and AWWA have released a series of no-cost infographics to help respective members communicate about the value and importance of water.

Value of Water campaign begins rollout of outreach tools

– WEF News Release

The Water Environment Federation (WEF) and the American Water Works Association (AWWA) have released the first set of no-cost materials to help respective members communicate about the value and importance of water. The materials complement and work in collaboration with the national Value of Water campaign messaging and resources.

As two of the founding partners of the Value of Water campaign, WEF and AWWA are working together to provide supplementary tools and resources to further support WEF Member Associations, AWWA Sections, and utilities to educate and inform consumers, public officials, decision-makers, and stakeholders about the value of water, water and wastewater services, and the need for infrastructure investment.

This staggered rollout begins with a series of U.S. infographics. Additional materials will be added and released through June, including a communications plan to assist with implementing these materials according to specific needs and target audiences.

The materials are available at wef.org/value-of-water. For more information, contact Lori Harrison at WEF.

EPA awards $3.3 million in wetlands grants to help state and tribal wetland programs in New England

– EPA Region 1 News Release

EPA has awarded $3.3 million in grants to strengthen the capacity of states and tribes to protect and restore wetlands. The Wetland Program Development Grants provide interstate agencies, tribes, and nonprofit organizations with funding to develop and refine comprehensive state, tribal, and local wetlands programs. While monies for these projects came from 2015 and 2016 allotments, EPA will soon release a request for projects to be funded with 2017 and 2018 funding.

EPA believes these grants demonstrate our productive relationship with state partners, achieving meaningful environmental benefits for American communities by working collaboratively. Protecting wetlands helps communities take advantage cost-effectively of the significant benefits provided by healthy wetlands: buffering from storms and flooding, filtering stormwater, protecting habitat, and offering recreational enjoyment.

EPA has awarded funding for 15 projects to protect, manage, and restore wetlands. These grants assist state, tribal, and local government agencies in building wetland programs. Wetlands are vital to the health of our waterways and communities. Healthy wetlands perform important ecological functions, such as feeding downstream waters, trapping floodwaters, recharging groundwater supplies, removing pollution, and providing habitat for fish and wildlife. Wetlands also help our economy because of their key role in fishing, hunting, agriculture, and recreation. The funded grants are described below.

Connecticut

The Connecticut Department of Energy and Environmental Protection was awarded $289,000 to train and educate local decision-makers through a comprehensive online training course and continuing education workshops to promote wetland protection, connectivity, and resiliency through enhanced decision-making.

Massachusetts

The Massachusetts Department of Environmental Protection was awarded $360,000 to monitor and assess wetlands to provide recommendations on protection and restoration, create coastal hazard maps and policies for coastal resilience, and update wetland replication and delineation guidance. This will increase protection and restoration of Massachusetts wetlands and provide resiliency to impacts from climate change.

Massachusetts Coastal Zone Management was awarded $172,000 to develop a program to monitor and assess long-term impacts of climate change on tidal marshes through the application of cutting-edge image analysis and remote-sensing techniques at permanent monitoring stations.

The New England Interstate Water Pollution Control Commission was awarded $45,500 to improve and refine wetland monitoring and assessment methods by providing technical and logistical support to our state and federal partners, fostering the formation of joint state projects and technical transfer of scientific methods.

The University of Massachusetts (Amherst) was awarded $357,000 to fund scientists who will calculate and map an index of ecological integrity for New England by using a variety of landscape metrics that consider habitat quality, resilience, and connectivity. Previously developed under this grant program, the Conservation Assessment and Prioritization System (CAPS) tool can be used to compare ecological consequences of various land use scenarios or identify how to get the most ecological benefits from restoration projects. CAPS combines landscape ecology and conservation biology into a computer program that compiles spatial data and characterizes landscape conditions that can be used to help evaluate impacts from development projects.

Maine

The Maine Department of Environmental Protection (MEDEP) Biological Monitoring Program was awarded $490,000 to develop and refine indicators and wetland-specific aquatic life criteria (biocriteria) for various biological assemblages. This work will enhance MEDEP's ability to assess wetland conditions, and focus on tasks and products to develop and refine wetland-specific biological criteria supported by improved and expanded monitoring and assessment capability.

Protecting wetlands helps communities take advantage cost-effectively of the significant benefits provided by healthy wetlands: buffering from storms and flooding, filtering stormwater, protecting habitat, and offering recreational enjoyment

The Maine Natural Areas Program received funding for three projects totaling $298,000. The first will enhance the statewide wetlands monitoring and assessment strategy to identify the best wetland restoration and protection opportunities in Maine. A second project will focus on conservation planning for highly valued aquatic resources and integrated upland sites, particularly the western floodplain region of the state and south coastal areas. The third is geared toward protecting Maine wetlands from invasive plants by creating a centralized resource for invasive species information to support the efforts of land managers, state agencies, and private landowners in tracking and managing invasive species.

The town of Topsham, Maine, received $106,000 in funding to undertake a local vernal pool regulatory program that will complement federal and state oversight of vernal pools through the adoption of a vernal pool Special Area Management Plan being developed with federal, state, and other partners. This will ultimately result in the creation of a local vernal pool conservation program.

New Hampshire

The New Hampshire Department of Environmental Services (DES) was awarded $352,000 to develop a wetland monitoring and assessment program for implementing wetland-specific water quality standards. DES will investigate the development of numeric biocriteria thresholds for aquatic life use, evaluate historical wetland records for their applicability for use in environmental review, and support development of floristic quality assessment (FQA) thresholds for interpreting scores specific to wetland types in the state. FQA is a bioassessment method that uses characteristics of the plant community to derive an estimate of nativity or habitat quality.

A second grant to DES of $254,000 will be used to build resiliency to climate change throughout the state by prioritizing wetland and stream mitigation options. Technical resources and tools will assist municipalities in identifying and prioritizing areas vulnerable to threats from climate change.

Rhode Island

The Rhode Island Department of Environmental Management was awarded $255,000 to carry out a multi-year project to strengthen wetland monitoring and assessments of state programs to support adaptation of wetland protection and restoration programs to changing climate conditions, with an emphasis on coastal wetlands. The project will foster integration of freshwater and coastal wetland program activities that will improve effectiveness.

Vermont

The Vermont Department of Environmental Conservation (DEC) was awarded $287,000 to protect ecologically significant wetlands, create a permit compliance system, increase voluntary restoration of wetlands, and integrate wetland concerns into a plan to reduce phosphorus loads to Lake Champlain.

A second grant of $54,000 to the Vermont DEC will create a scientifically sound methodology for sampling the potential effects and stressors that solar farms have on wetlands. In recent years there has been a spate of small solar installations, mostly in agricultural wetlands. This project will result in a better understanding of impacts from solar projects and inform permitting decisions for the Vermont DEC, the solar community, and other regulatory agencies.

Dye study in Greenwich Harbor

– EPA Region 1 News Release

Scientists and engineers from the Connecticut Department of Agriculture's Bureau of Aquaculture (CT DABA) and EPA's New England regional laboratory, together with staff from the U.S. Food and Drug Administration (USFDA) Shellfish Sanitation Program conducted a hydrographic dye dilution study in Greenwich Harbor from April 3–7, 2017. The study tracked the flow and dispersion of wastewater discharging into Long Island Sound from the Greenwich Water Pollution Control Facility, located on Grass Island in Greenwich Harbor.

The Greenwich facility operates an advanced treatment process using ultraviolet disinfection, which has proven to be effective treatment against pathogenic bacteria and viruses contained in sewage, and does not require the introduction of chemicals into the waters of Long Island Sound.

Information collected during this study will be used by USFDA and CT DABA to evaluate the impact of wastewater discharges on shellfish-growing areas in Greenwich and will help scientists determine where shellfish may be safely harvested. The Greenwich facility operates an advanced treatment process using ultraviolet disinfection, which has proven to be effective treatment against pathogenic bacteria and viruses contained in sewage, and does not require the introduction of chemicals into the waters of Long Island Sound.

The coastal waters of Greenwich are home to some of Connecticut's most important natural eastern oyster and hard clam producing areas. The Greenwich Shellfish Commission has been engaged in projects to increase oyster production on existing natural beds and expand oyster populations in suitable areas within Greenwich waters. This is accomplished by selectively farming specific areas and permitting the controlled transplant of a portion of oyster resources to seed new shellfish bed locations.

The goals of the hydrographic dilution study are to protect public health and improve water quality in Greenwich waters while cultivating essential oyster habitat through science-based management. The study will support collaborative oyster resource enhancement projects developed by the Greenwich Shellfish Commission in cooperation with CT DABA and industry.

EPA awards $100 million to Michigan for Flint water infrastructure upgrades

– EPA Washington News Release

On March 17, 2017, EPA awarded a $100 million grant to the Michigan Department of Environmental Quality to fund drinking water infrastructure upgrades in Flint, Michigan. The funding, provided by the Water Infrastructure Improvements for the Nation Act of 2016, or WIIN, enables Flint to accelerate and expand its work to replace lead service lines and make other critical infrastructure improvements.

Marsh with oyster shells

"The people of Flint and all Americans deserve a more responsive federal government," said EPA Administrator Scott Pruitt. "EPA will especially focus on helping Michigan improve Flint's water infrastructure as part of our larger goal of improving America's water infrastructure."

"I appreciate the EPA approving this funding to assist with Flint's recovery," Michigan Governor Rick Snyder said. "Combined with the nearly $250 million in state funding already allocated, this will help keep Flint on a solid path forward. It's great to see federal, state, and local partners continuing to work together to help with infrastructure upgrades and pipe replacements for the people of Flint."

"We are excited and very grateful to receive these much-needed funds," said Flint Mayor Karen Weaver. "The city of Flint being awarded a grant of this magnitude in such a critical time of need will be a huge benefit. As we prepare to start the next phase of the FAST (Flint Action and Sustainability Team) Start pipe replacement program, these funds will give us what we need to reach our goal of replacing 6,000 pipes this year and make other needed infrastructure improvements. We look forward to the continued support of the EPA and federal government."

The WIIN funding supplements EPA's Drinking Water State Revolving Fund (SRF), a federal-state partnership. In addition to the federal funds announced today, the state of Michigan is providing the required 20 percent match of $20 million. Over the years, EPA has provided $32.5 billion to states for infrastructure upgrades through the Drinking Water SRF.

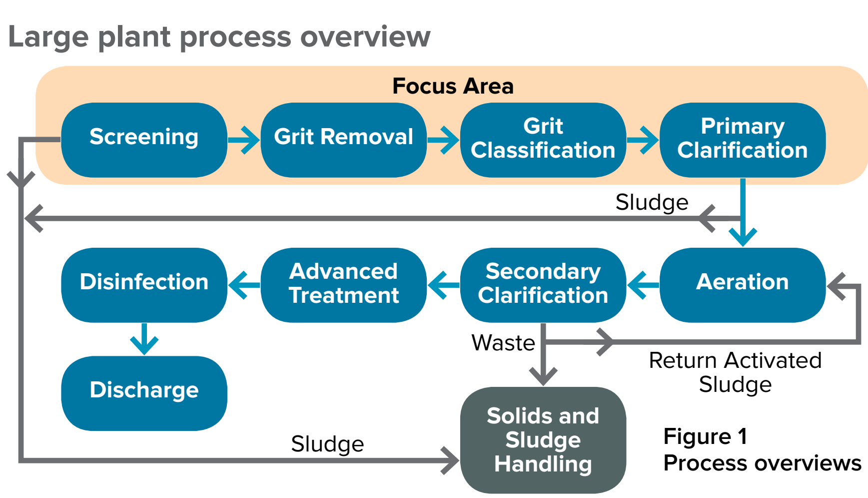
Under President Trump's budget blueprint, the SRF program remains fully funded, and the proposal provides robust funding for the Water Infrastructure Finance and Innovation Act program to finance critical drinking and wastewater infrastructure. For more information on the grant, go to epa.gov/flint.

Effects of flow fluctations on Cape Cod package plants

CHRISTOPHER HAYWARD, P.E., Whitewater, Inc., Charlton, Massachusetts

ABSTRACT | Small wastewater package treatment plants have unique flow and loading variations compared to larger treatment facilities; the former demand individualized approaches to overcome treatment system limitations, lack of redundancy, and site-specific characteristics. Given the often-limited presence at such facilities by operational and other staff to make the facilities affordable to operate, innovative operating procedures are often needed to enable the operator to anticipate influent variations and maximize treatment performance over the long term. This article presents an operator's perspective in overcoming these obstacles upon his experience with several Cape Cod packaged treatment facilities as a contract operator project manager.

KEYWORDS | Package plants, flow variations, septic tanks, system redundancy, elder-care, shopping-mall, schools, gated communities



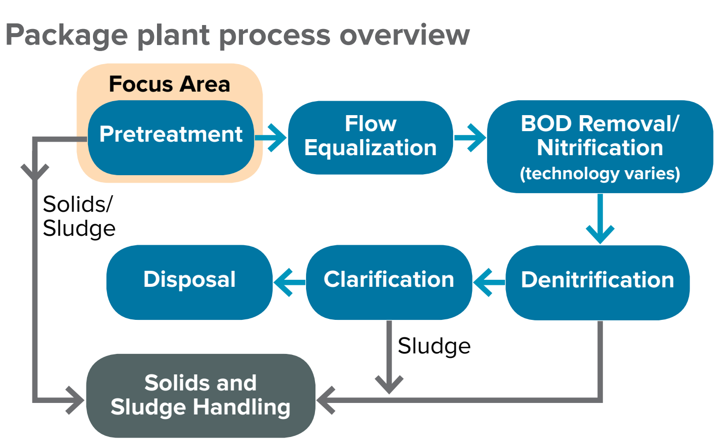


Figure 1 Process overviews

OPERATIONAL OVERVIEW

In direct proportion to the seasonal population of Cape Cod, sewage flow rises and falls throughout the year. A year-round population exists, and that population generates wastewater, some of which is treated by regional wastewater facilities or by private septic systems. Much of Cape Cod is dotted with "packaged" wastewater treatment plants, facilities that serve small communities, occupy small footprints, and use technologies capable of handling small, daily flows. Many of the packaged systems are modular and designed based upon stringent parameters and biokinetics. The volume of sewage produced by these small communities does not necessitate a large-scale activated-sludge plant, but it does require that the wastewater be treated in accordance with state requirements prior to its discharge.

Because of seasonal and other time-related variations, the Cape Cod wastewater operator is frequently faced with the dilemma of handling wide ranges of flow fluctuations. These changes are, at times, predictable, and to ensure operation within permitted limits, the operator must be keenly aware of what may change, and how to prepare for and react to such changes when they occur. Before discussing flow fluctuations, it may be helpful to review some of the unit processes and redundancies of larger and package-sized plants. By highlighting the differences between the two, the limitations of working at a package plant become evident.

The process overview diagrams in Figure 1 depict unit processes common to each plant size. Large plants have far more unit processes than do package plants. The equipment in a unit process at a large plant is typically more complex than the same unit process at a package plant.

Compare the unit processes in the focus areas on each diagram. The larger plant has several unit processes (screening, grit removal, grit classification, and primary treatment) at the front end of the plant that remove inorganic and organic solids from the waste stream. At a package plant, a septic tank (or tanks) serves as its only means of solids and sludge removal and storage. The simplicity of the package plant process comes with significant limitations. Package systems are constructed with as few as one septic tank or as many as five septic tanks, depending on the system's design flow. Plants with a single septic tank are susceptible to rapid accumulation of sludge and solids, especially during the high flow season. In some instances, the high flows could greatly impede influent water quality by flushing sludge and solids through the tank if sludge levels are not monitored and removed at an adequate frequency. If the structural integrity of the tank at a single-septic-tank plant were compromised, high pumping, hauling, and repair or replacement costs would result. Systems with the redundancy of multiple septic tanks have greater reliability and versatility but are rarely built with isolation valves, the absence of which complicates maintenance and repair and may require the use of less-reliable sand bags or test plugs to halt flow into the tank in question.

At small package plants, because of limited redundancy, the inoperability of a single piece of equipment often leads to a plant shutdown, during which time the operator must have wastewater hauled away—a rather costly and limiting tradeoff for process simplicity. Often, larger plants are designed with equipment ample enough to allow one or several items in a unit process to be taken out of service while other items remain online. To understand the redundancy limitations of package plants, we compare features between an activated sludge plant that New Englanders are familiar with, the Deer Island Treatment Plant (DITP), and a typical Cape Cod package plant (refer to Table 1).

DITP's redundancy is necessary because of its enormous capacity and complexity. A round-the-clock crew translates to an immediate response to a change in conditions. The DITP's collection system is expansive and can handle a wide range of flow conditions. Pump stations, with adequate backup pumps, are located throughout the 43 sewered communities that the DITP serves. It can produce a good-quality, primary effluent if six of its 48 primary clarifiers are offline. Similarly, four of the 54 secondary clarifiers can be taken out of service while producing an acceptable discharge. The anaerobic digesters provide a margin of redundancy greater than those of the clarifiers: only eight of the 12 digesters are required to operate at any one time.

A package plant clearly does not have the same redundancy as that of the DITP. Package plants are rarely supplied with spare pumps ready for installation. If a single pump in a duplex pump station were to fail, the package-plant operator will rely on the remaining pump while hoping for a quick repair or

Table 1. Treatment facility process comparison—large vs. small

Feature	Deer Island Treatment Plant	Typical Package Plant
Capacity	1.2 billion g/d (4.5 million m^3/d)[1] the equivalent of 1,817 Olympic-sized swimming pools	Capacities up to 300,000 g/d (1.1 ML/d). This volume is 1/4000th the capacity of the Deer Island TP.
Staff	24-hour, 7-day-a-week crew with multiple operators and maintenance personnel	One operator who visits for 2 hours per day, generally only 5 days per week
Collection system	Thousands of miles of pipe with some areas of combined sewers	Less than 25 miles (40 km) of pipe that primarily collect domestic waste only
Pump stations	Dozens of municipal pump stations that feed three main pump stations, each having a capacity between 360 mgd to 910 mgd (1.36 Mm^3/d to 3.4 Mm^3/d)[2]	From zero (for gravity systems) to 12, with capacities up to 0.2 mgd (0.76 ML/d). Two pumps per station
Primary treatment	Grit chambers followed by 48 primary clarifiers.[3]	One to five septic tanks, most ranging from 5,000 to 40,000 gal (19,000 to 150,000 L) in capacity. Bar screens are occasionally installed but effluent filters at the tank outlets are more common.
Secondary treatment	54 secondary clarifiers.	One to three rotating biological contactors or a single bioreactor
Sludge handling	Gravity and centrifuge thickeners followed by 12 anaerobic digesters[2, 3]	Pumped and hauled to activated-sludge plants or sludge processing facilities for additional treatment
Disinfection	Dual contact chambers with redundant pumps for sodium hypochlorite addition followed by dechlorination with sodium bisulfite.[3]	One or two ultraviolet-light disinfection units

[1] newea.org/wp-content/uploads/2015/10/CSO15_EWenger.pdf, pg. 3
[2] mwra.state.ma.us/03sewer/html/sewditp.htm
[3] newea.org/wp-content/uploads/2015/10/CSO15_EWenger.pdf, pg. 16

Much of Cape Cod is dotted with "packaged" wastewater treatment plants, facilities that serve small communities, occupy small footprints, and use technologies capable of handling small daily flows

replacement. The package plant typically has a single mechanism, such as a rotating biological contactor or bioreactor for secondary treatment. An inoperable secondary-treatment mechanism shuts down the plant until repair or replacement can be initiated, and performance may be severely impacted until sufficient biomass is re-established in the treatment system.

Staffing also affects system performance. An alarm condition often requires a rapid response, but because the package plant is not staffed full-time, a full response may not be immediate, but may be delayed several hours to as much as a day. A delayed response could lead to a more strained condition, such as a tank overflow. The response time for a non-alarm change in condition at a package plant could be as much as two days if the condition occurs just after the operator departs from the daily visit before a weekend.

Other important considerations for package plants are the communities that these plants serve, their inherent flow fluctuations, and the impact of these characteristics on operations. Several of the package plants discussed in this article serve elder-care facilities in southeastern Massachusetts and on Cape Cod. From an operator's perspective, the great advantage of this type of facility is its day-to-day consistency. The population of elder-care facilities is generally level throughout the year. Flow variations that result from tenancy changes are barely noticeable and have little effect on plant operation. Flow fluctuations that have the greatest effect in these facilities occur on holidays, when visits from family and friends drive up the daily flows. Ordinary flows at elder-care facilities contain high concentrations of organics in the form of biochemical oxygen demand (BOD). The higher, holiday-related flows typically drive up the influent ammonia concentration while leaving BOD unaffected. This spike in ammonia may require a change in recirculation rates or additional chemical dosing especially if the facility is a Total Nitrogen reduction or denitrifying facility. Although pharmaceutical uses and sanitizing cleaners can sometimes affect biological processes, suitable facility controls can make the wastewater characteristics at these facilities relatively uniform.

At shopping-mall package plants, on the other hand, several unique flow variations exist. Weekday flows are the lowest observed, are consistent, and are characterized by moderate levels of BOD and ammonia. Weekend flows can be as much as 150 percent of the weekday flow. Flows are also greatest during school vacations and long holiday weekends. Weather conditions can also influence flows, such as just prior to a nor'easter. The greater flows are most often accompanied by higher ammonia levels.

The flow rates and characteristics of wastewater discharged from schools are the inverse of those from shopping malls. Flows are greatest on weekdays during the school year and are greatly diminished during weekends and vacations. The challenge at schools, contrary to the challenge at other types of facilities, is how to handle lower flows with lower BOD contents especially during summer vacation. During this period, operators often must add food to the biological process to keep a healthy population of treatment bacteria. Sometimes area food processing facilities can supply a sustaining food source, and in some instances, a few bags of cheap dog food can offer operators an alternative to sustain the process.

As the populations of gated communities on Cape Cod rise and fall with the seasons, the wastewater flows fluctuate. Operators can set their watches to the rise in flow on Memorial Day, the monstrous surge on Independence Day, and a return to lower flows immediately after Labor Day. During the summer, flow fluctuations mimic those of shopping-mall plants, where weekday flows stay at moderate levels and weekend flows rise significantly. Not all residents in these communities are snow birds, so the flows between Labor Day and Memorial Day are generally sufficient in volume and organic loading to sustain adequate treatment year-round.

Wastewater treatment is a biological process that requires bacteria, organic and inorganic foods, and oxygen (and the absence thereof) to reduce waste concentrations below the permitted levels. The process functions most effectively when all those factors are consistent. Wide-ranging fluctuations of any of these factors could lead to inadequate treatment, a loss of bacteria, service disruption, or diminished treatment performance, potentially leading to a discharge exceedance.

Because Cape Cod package plants routinely experience inconsistencies of those factors, the operator must understand the fluctuations, their effects, and how to prepare for and react to them. As Memorial Day approaches, an operator must gear up for the first deluge of the season. Veterans advise the less experienced operators on techniques to attempt to prevent undesirable conditions and consequences. One such technique is to reduce the recirculation rate so that a greater percentage of the sewage flow is discharged. A higher recirculation rate could result in high tank levels. For plants with multiple, fixed-growth treatment units, such as rotating biological contactors, the operator would bring a second or third unit online several weeks in advance of the holiday to ensure mechanical functionality and to encourage sufficient bacterial growth (biomass establishment) on the units prior to flow increases. To provide the proper amount of sludge storage, the operator may have the primary-treatment (septic) tanks pumped out by mid-May to remove sludge and solids that have accumulated over the winter. Other flow restrictions, such as underperforming sand filters or partially fouled membrane systems, would be addressed long before May so that filtration meets the design parameters and an adequate backwash/backpulse/cleaning regimen is established. If membrane bioreactors are used, a thorough organic and inorganic cleaning may be needed to facilitate higher flow rates (flux rates) through the membranes.

During such periods of higher flows, the operator may find that treatment is less effective. A number of conditions could influence treatment. As noted above, the operator might have reduced the recirculation rate to improve throughput. Recirculation enhances treatment by returning thriving bacteria, unused nutrients, and alkalinity from secondary treatment to the head of the plant. Lowering the recirculation rate often reduces the concentration of bacteria (resulting in lower mixed-liquor suspended solids) in the process and requires the bacteria in the secondary processes to perform more work than in periods of higher recirculation. As flows increase, those same bacteria will also have less time to perform suitable treatment. The operator will need to more closely monitor nitrification when adjusting the recirculation rate. The change may also necessitate an increase in the feed rate for an alkalinity source, such as sodium bicarbonate, to promote nitrification. The same may also be true for the carbon-source feed rate for denitrification.

At the other end of the spectrum is the flow-rate reduction. The main concern during periods of lower flow is the loss of food, and the operator responds by reversing many of the changes made during the high-flow season. Recirculation is increased to retain more bacteria, nutrients, and alkalinity in the process. Chemical dosing rates are adjusted accordingly, and the operator closely monitors nitrification and denitrification to ensure effective treatment.

Flow fluctuations at plants that are exposed to only the seasonal type of variations can be anticipated and addressed more readily than at plants that experience more frequent flow shifts, such as those serving shopping malls. The sudden, high jump from weekday to weekend flows, especially during holiday weekends, is often the most difficult to address. It should be noted that small packaged plants are rarely visited on weekends, relying on remote monitoring or alarm notification, unless otherwise mandated by the facility's discharge permit; therefore, the operator must prepare the plant on Friday for the ensuing weekend flows, which are not predictable. The weekend flow could be a mere 10 percent higher than the weekday flow or as much as 50 percent higher. The proportionality of the Friday "preparation steps," which could include a reduction of the recirculation rate and/or an increase in chemical dosages, in relation to the actual weekend flows may be occasionally amiss, not yield the desired result, and not be realized until the following Monday. This challenge can be disheartening to the package-plant operator. In such instances, a modified operator work week may often be desirable, but this is generally not effectively implemented due to the site requirements and demands of other facilities under a contract operator's domain.

Cape Cod package-plant operators must become experts at handling sewage-flow fluctuations to best guarantee treatment performance. Diligence, experience, and dedication are the best friends of the package-plant operator. Possessing these, the operator, despite the simplified unit processes and low level of equipment redundancy, can learn to predict with reasonable accuracy the frequencies, durations, and effects of flow fluctuations. An operator's experience at such facilities cannot be overstated in these instances. With more exposure to these changes, the operator becomes better able to effectively plan an approach to reduce the ill effects of and appropriate responses to such fluctuations.

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20-year valve replacement at the Deer Island Treatment Plant

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ABSTRACT | The Massachusetts Water Resources Authority (MWRA) has begun replacing over 250 valves that are near the end of their useful life at its Deer Island Treatment Plant. MWRA awarded a $17 million contract to replace valves and piping throughout Deer Island. Many of these valves are critical isolation valves for North Main Pump Station (NMPS), the largest pump station at Deer Island, and the work required the isolation and dewatering of major wastewater conduits. MWRA determined that up to 62 shutdowns of NMPS would be necessary to complete this work. Modeling and experience indicated that during dry periods the wastewater could be "stored" in the MWRA-owned interceptors and community sewers during nighttime low-flow periods. Because 26 communities discharge into the northern collection system, this work requires substantial planning and extensive communication with the MWRA service communities affected. The project is about 85 percent complete, and there have been no permit violations, environmental mishaps, or wastewater service interruptions.

KEYWORDS | Valve, centrifugal pump, force main, CSO, SSO

Figure 1. MWRA service area

INTRODUCTION

The Massachusetts Water Resources Authority (MWRA) is a Massachusetts public authority created by the legislature in 1984. MWRA's mission is "to provide reliable, cost-effective, high-quality water and sewer services that protect public health, promote environmental stewardship, maintain customer confidence, and support a prosperous economy." MWRA has 1,150 employees and a budget of $700 million. MWRA provides drinking water and sewerage services to 2.55 million people in 61 communities in eastern Massachusetts. Of these 61 communities, 43 receive sewerage service (see Figure 1).

SEWER SYSTEM

The bulk of the wastewater from MWRA's service area is routed through interceptors to four headworks, which are equipped with bar screens to remove large objects from the wastewater, as well as grit chambers, to remove sand and other heavy material from the water. The wastewater then flows through three deep rock tunnels to the the Deer Island Treatment Plant in Boston, located just below the southern tip of the town of Winthrop. A small portion of the wastewater is routed through a large gravity sewer to a combined headworks and pump station at Deer Island itself, known as the Winthrop Terminal Facility. Flows from the northern collection system include stormwater from four combined sewer communities that can significantly increase flows during wet weather. Typical dry weather flows at Deer Island can increase from 350 mgd (1.325 Mm^3/d) average flow to 1,270 mgd (4.8 Mm^3/d) during major storm events.

The treatment plant itself consists of the pumping facilities, grit removal facilities, primary clarifiers, pure oxygen activated sludge secondary treatment processes, disinfection, sludge thickening facilities, and egg-shaped digesters. Biosolids are pumped through a five-mile tunnel and converted to pellets at a facility in Quincy, Massachusetts. North Main Pump Station (NMPS) houses 10 centrifugal pumps with a capacity of up to 150 mgd (568 ML/d) each. The South System Pump Station contains eight 67 mgd (254 ML/d) centrifugal pumps. The smaller Winthrop Terminal Facility houses six centrifugal pumps, each rated at 32 mgd (121 ML/d). See Figure 2.

NMPS with its 10 "giant" centrifugal pumps is perhaps the most critical facility in the entire MWRA sewer system. This station has a maximum capacity of 788 mgd (2.98 Mm^3/d). Owing to the combined sewers present in several of the member communities, as well as increased inflow and infiltration that occur during large rain events or wet periods of the year, the station can rapidly reach its full capacity. At this point, the operators at the headworks facilities need to throttle the gates and hold back the sewage in the interceptors upstream until the flow subsides. If the flow exceeds available storage in the interceptors and sewers, some flow will be released through designed combined sewer overflows (CSOs). The MWRA maintains several facilities to provide treatment to more than 90 percent of typical CSO flows. These facilities have screening facilities, storage and settling tanks, chlorination facilities, and dechlorination facilities to provide treatment to the stormwater and wastewater released at these points.

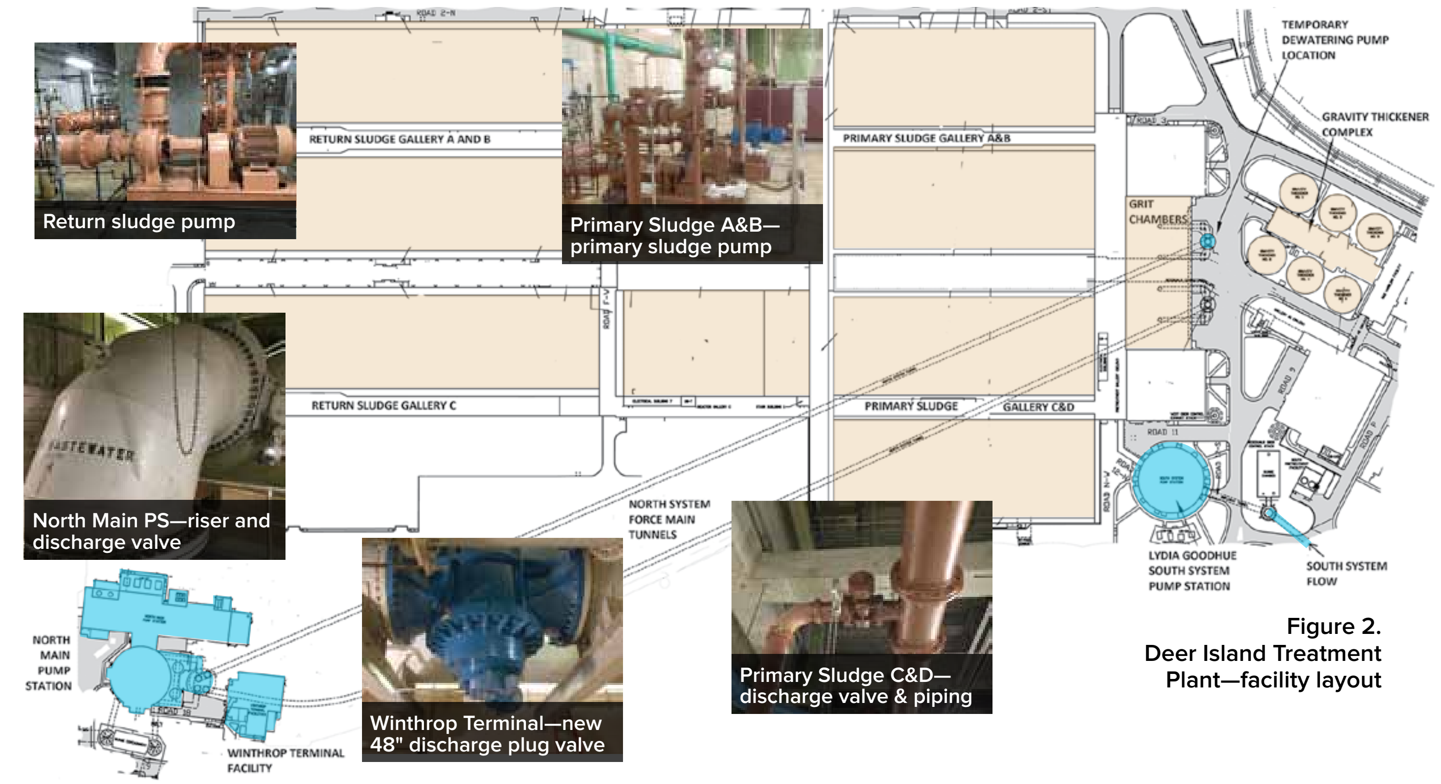

Figure 2. Deer Island Treatment Plant—facility layout

AGING INFRASTRUCTURE

The "new" Deer Island Treatment Plant was constructed in the 1990s. NMPS was one of the few buildings that was kept intact from the older plant constructed in the 1960s. Between 1992 and 1995 the old pumps that had pumped wastewater from the headworks facilities (also constructed in the 1960s) were removed and replaced with the centrifugal pumps in service today. In addition, new valves and piping were installed to control the wastewater and isolate the pumps for service when needed. These valves are now more than 20 years old, and many of them do not isolate completely, making maintenance on pumps difficult or impossible without major disruptions to the operation. When this became apparent, Deer Island management recommended that the valves be replaced in their entirety, because working on even one of the valves would require complete shutdown of significant portions of the wastewater transmission process. Rather than shutting down the process intermittently year after year to replace one or two valves at a time, it was decided to replace them all in one contract.

In addition to NMPS valves, the valves at the Winthrop Terminal facility also needed to be replaced. Because Winthrop Terminal serves an area linked to the area served by NMPS, it was logical to combine this work. While the design contract was being planned, it was discovered that large portions of the primary sludge lines had suffered severe crown corrosion and required replacement. These 12 in. (30.5 cm) lines and associated valves were added to the contract scope. Similarly, 81 return sludge valves, which are part of the secondary treatment process, also required replacement and were added to the contract. Finally, mechanical work was needed on the eight pumps in the Lydia Goodhue (South System) Pump Station, and this was added as well.

The sheer volume of the valve and piping work made it necessary to contract to outside companies. MWRA has approximately 150 maintenance staff on Deer Island, including pipefitters, plumbers, and mechanics. These employees are well-equipped and trained to change out valves less than 16 in. (42 cm) in diameter. However, the number and size—up to 48 in. (122 cm) in diameter—of the valves that required replacement made a contract necessary. Under Massachusetts General Law a project of this kind must be structured as design-bid-build—a professional services company must be hired (in accordance with applicable laws) to prepare design documents and draft construction specifications. Once this is complete, the MWRA makes the bid documents publically available and allows a certain time for general contractors to submit a bid price for the work. The Notice to Proceed to the winning qualified contractor was issued in June 2014 with a target substantial completion date of June 2017.

REGULATORY CHALLENGES

One of MWRA's biggest concerns about this project is the ability to meet the requirements of MWRA's Deer Island National Pollutant Discharge Elimination System (NPDES) permit while completing the work. The NPDES permit sets the limits on how MWRA can operate the treatment plant. Some of these limits are quantitative, such as the amount of concentration of suspended solids in the plant effluent. Of course, the MWRA is authorized to discharge wastewater only at certain points. This includes the Deer Island outfall, which is 9.5 mi (15 km) from Deer Island in Massachusetts Bay. Under certain conditions (such as high flows), discharge through CSOs is also permitted. If wastewater were to be discharged at some unpermitted point (for example a sewer manhole in the street), then this would be termed a sanitary sewer overflow (SSO) and potentially be subject to penalties and fines.

During design it was assumed that to replace the valves at NMPS and Winthrop Terminal, the contents of the entire pump discharge header would have to be drained, because isolation valves designed to separate the two sides of NMPS were observed to leak in the past. This would only be possible if all pumping from the North (Sewer) System were stopped. Given the large combined sewers tributary to the North System headworks facilities, the system benefits from significant storage capacity, making it possible to contain several hours of sewage in the interceptors and some town sewers. If the pumps were left off for too long, the rising level of sewage would eventually need to be released somewhere and would create a CSO or an SSO. MWRA therefore specified in the contract that the contractor would need to pump out the discharge header and that MWRA would provide approximately eight hours of downtime each night (when flow was lowest) to allow work on valves. This eight-hour period was estimated by calculating typical flow rates and estimated storage volumes in the interceptors. The specification allowed the contractor 62 shutdowns of the North System (NMPS and Winthrop Terminal) to complete the valve work at NMPS and Winthrop Terminal.

Table 1. Facility flow capacities (design)

Facility	Capacity (Mm^3/d)	Capacity (mgd)
Deer Island Treatment Plant	4.8	1,270
Deer Island Secondary Process	2.65	700
North Main Pump Station	2.98	788
Winthrop Terminal Facility	0.473	125
Lydia Goodhue Pump Station	1.51	400

The greatest concern for MWRA is that a valve is removed and the system is significantly delayed in resuming operation. In this case, MWRA would be faced with difficult choices between discharging significant amounts of wastewater into a river or even a neighborhood, or putting pumps back on in North Main with piping that is not sealed, potentially flooding the pump station. Though this is an unlikely possibility, MWRA still determined that the Massachusetts Department of Environmental Protection (MassDEP) and EPA should be thoroughly briefed on this work before the start of the project.

In addition to the challenges of changing the valves in the pump stations, the MWRA also needed to change valves in the return sludge headers of the secondary clarifiers. Deer Island can process 1270 mgd (4.8 Mm^3/d) of total flow, but only 700 mgd (2.65 Mm^3/d) can pass through secondary treatment. (see Table 1) When high flows occur due to heavy rain or snow melt, flow over the secondary limit receives primary treatment and then gets blended with secondary effluent before passing into the disinfection basin for chlorination. To accomplish the valve change, MWRA would need to take an entire secondary battery off-line. This would limit the secondary capacity of Deer Island to approximately 500 mgd (1.9 Mm^3/d) during downtime. Since MWRA is committed to avoiding blending under the process limit, MWRA initially directed the contractor to complete the replacement of 27 discharge valves in each battery within seven days; MassDEP and EPA were notified about this part of the work as well.

TEST SHUTDOWNS

Owing to the challenge of shutting down pumping for hours at a time, MWRA performed several "test" shutdowns of the pumping in NMPS and Winthrop Terminal. A test plan was developed by several departments, including Deer Island Operations, Wastewater Operations, and Engineering and Construction. This plan included procedures that would be used to shut down and restart the North System pumps, as well as procedures to inform towns and regulators of the testing. Finally, it included plans covering how the sewer system would be monitored to ensure that there were no SSOs.

To prepare for these shutdowns, MWRA staff used its wastewater hydraulic model of the northern collection system to predict the wastewater elevation during the proposed shutdowns. To run the model, an input flow had to be selected. This flow had to represent the flow through the system during most of the year but be low enough so that the system had enough storage to allow time for the valves to be changed. Use of nighttime flows was assumed, since this is the lowest flow period during any typical dry weather day. Given that wastewater was to be stored in the upstream system over the required eight-hour period, MWRA analyzed its extensive flow data from past years to determine when to stop flow conveyance. In the end, 207 mgd (784 ML/d) was input into the model as the average daily flow. Various model simulations were performed, activating and deactivating upstream facilities to optimize storage capabilities and establish contingency plans under differing dry weather flow conditions. Various comparisons were performed against historic wastewater elevations and ground surfaces (LIDAR data) to provide confidence that the predicted wastewater elevations would not result in SSOs, CSO discharges, or basement backups during the eight hours allotted to perform the valve replacement work. Model simulations and historic information were used to develop a monitoring plan that relies on field measurements, flow meters, and facility instrumentation. Significant field efforts were performed to ensure that the elevations of CSO weirs and low points were known and reflected accurately within the hydraulic model. Tools were then established to allow staff monitoring of the shutdown from the MWRA's Operations Center to continually compare actual measurements against model-predicted elevations during the shutdowns.

Table 2. Dates and durations of test shutdowns

Date	Facilities Off-line	Duration
5/20/15 – 5/21/15	Winthrop Terminal, Chelsea Creek	4 hours
6/10/15 – 6/11/15	Ward St, Columbus Park	4 hours
6/24/15 – 6/25/15	All	4 hours
7/22/15 – 7/23/15	All	8 hours

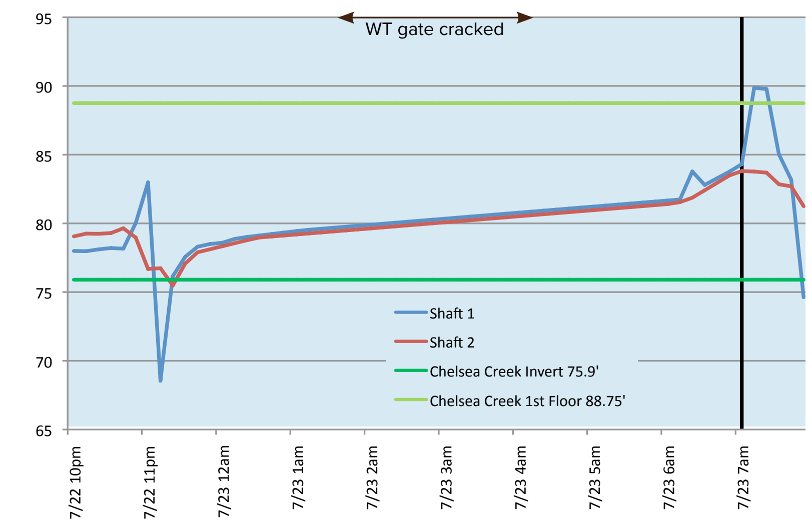

Figure 3. Rate of rise (in feet) at Chelsea Creek headworks for 7/23/15 shutdown

TEST SHUTDOWN RESULTS

The dates of the trial shutdowns are summarized in Table 2. The first two trials were only four hours long to give all involved the opportunity to learn their roles, verify that the hydraulic model was producing realistic results, and test the shutdown and reactivation procedures.

The trials went smoothly. Several issues came up during the trials, however, that were of interest. One initial concern was that when the shafts at the pump stations and headworks were dewatered after shutdown, they would fill back up with water and then the channels of the headworks facilities would begin to fill as well. This was partly due to leaks through Deer Island pump suction valves, which caused the wastewater to fill the lowest hydraulic points in the system (at Chelsea Creek headworks), and partly due to leakage in the system. This was a concern during the early shutdowns (which were only four hours long) because of unknown rates of rise. Fortunately, it became obvious that the rate of rise would be manageable after the results of the eight-hour shutdowns were analyzed (see Figure 3).

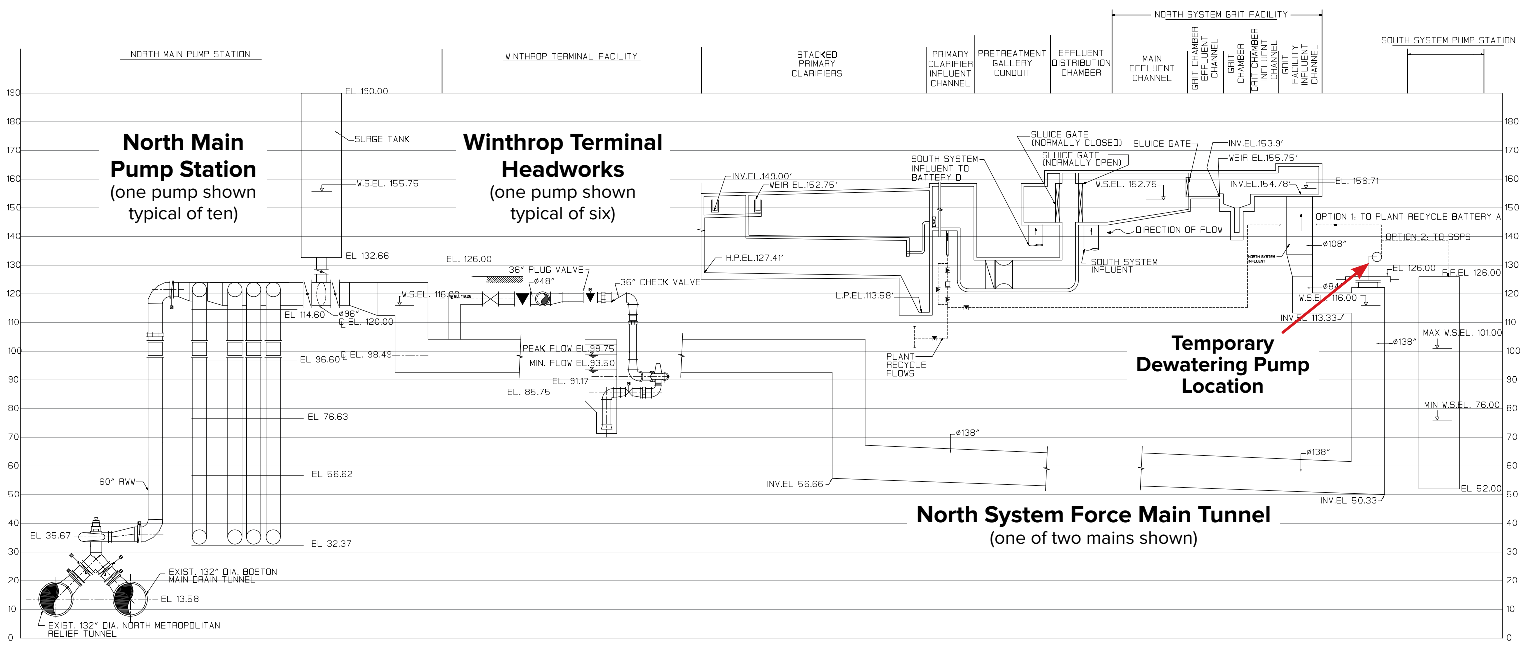

Figure 5. Hydraulic profile of North System pumping

During the second trial there appeared to be a strange discrepancy between the level transmitters at the Ward Street headworks and the level transmitter at Deer Island. This was traced back to a mismatch in the setting of the range of the Ward Street instrument in the Deer Island distributed control system. During the trial shutdowns staff refined their reactivation procedures, which proved to be a delicate operation. If the headworks gates were opened too quickly and without adequate pumping at the other end of the deep rock tunnels, with the estimated 15 to 20 ft (4.5 to 6 m) of wastewater upstream of the control gates, MWRA risked flooding the headworks. Conversely, if the gates were opened too slowly, the large pumps with a minimum capacity of 80 mgd (303 ML/d) would draw the shaft too low, resulting in pump trips due to excessive vibration. Re-establishing flows was further complicated because the headworks facilities use Parshall flumes, which, under flooded conditions, produce false flow measurements, rendering them useless upon startup. To overcome this obstacle, staff developed startup sequences and procedures for each of the headworks and NMPS. They also developed gate discharge equations to provide operations staff with guidelines on how much the gates needed to be opened to provide various flow rates at differing upstream levels. Through trials, post-shutdown coordination meetings, and data analysis, the staff continually improved upon the shutdown and startup procedures.

One key to the success of the shutdowns was MWRA's communication system. Because communication is important in effective incident management, MWRA uses incident command principles extensively in managing critical operations. When significant developments in operations occur that can affect other parts of the authority, an e-mail is sent to a company-wide list of managers, including the executive director and chief operating officer. This makes it far less likely that major problems will go undetected by senior management for hours or days. In addition, for emergencies or major events that require significant operational resources or include elevated risks, one or more emergency operational centers (EOCs) are activated. These centers are hubs for phone calls and questions to ensure that information is reaching upper management and other key stakeholders. Operational managers used these principles extensively during the test shutdowns, providing continual updates to staff and upper management from an EOC in Chelsea, Massachusetts, and a second one on Deer Island.

DEER ISLAND NORTH SYSTEM

It can be seen from the flow data in Table 1 that most of the flow to Deer Island passes through NMPS and Winthrop Terminal. Figure 5 shows the layout of the North System Pump Station hydraulics.

The flow from Winthrop Terminal and North Main is routed through two tunnels under Deer Island, before emerging at the entrance to the Grit Chambers. Although a series of valves separate the two sides of NMPS, preliminary testing showed that these valves did not seal completely. Thus, the only way to work on the isolation valves adjacent to the two tunnels was to stop flow and dewater them. This common force main was a big part of the technical challenge of the project design.

Before the contractor could begin work on the valves in Winthrop or NMPS, a temporary dewatering system had to be installed. This system would consist of several diesel-driven pumps installed in the riser shaft, immediately preceding the grit removal step of treatment. This point provides convenient access to the discharge portion of the pumps. For the contractor to install the system, MWRA needed to pump the wastewater level down several feet with smaller pumps. MWRA tested these pumps in advance and determined that they could dewater the system in a few hours, so it prepared a shutdown of the North System, similar to the previously described test shutdowns. Once the pumps were off, MWRA would dewater the header with the small pumps, and the contractor would install the dewatering pumps. This was done on the night of September 1–2, 2015.

The first valves to be installed were the three 48 in. (122 cm) plug valves that isolate the discharge of Winthrop Terminal from the discharge of NMPS. The contract constraints required the contractor to do these valves first to allow the greatest flexibility during the rest of the project. With these valves in place, the remaining valves in Winthrop Terminal could be replaced while NMPS continued operating. These valves were successfully installed in October and November 2015, during six nighttime shutdowns of the entire North System.

The contractor next installed the 18 valves and six flow meters in Winthrop Terminal. Since the flow feeding Winthrop Terminal passes through a large-diameter sewer with a high volume of storage, daytime shutdowns were a real possibility. To further improve the situation, wastewater operations staff proposed to divert some of the flow that would normally flow to Winthrop Terminal to the Chelsea Creek headworks instead. This dropped the flow to approximately 3 mgd (11 ML/d), an amount that could easily be stored for the eight-hour period necessary for the contractor to isolate a portion of the pump piping and replace the valves and flow meter.

The engineer's design called for the contractor to use the shutdown period to remove the discharge and suction valves on the first of the six pumps in Winthrop Terminal and then install "blind flanges" (circular metal plates) to close off the discharge header and suction pipe, which would be filled with wastewater when the pump station was placed back into service. The blind flanges also included 2-in (5-cm) drain ports. With the pump piping isolated, the pump station could be reactivated, and the contractor could then replace the check valve and flow meter. The discharge and suction valves would be installed during another shutdown, since this would require removal of the blind flanges. Therefore, two shutdowns were required for each of the six pumps.

The Winthrop work was completed between November 2015 and March 2016. When the contractor installed the suction valve on the first pump taken out of service, MWRA staff noticed inconsistencies in the valve configuration, and it was realized that the valve had been installed backward. The contractor removed the valve and reinstalled it correctly within two hours. Owing to the significant amount of time available because of the low flow through this part of the sewer system, this was not a problem. However, it was a lesson to apply to future work when extended shutdown time could be more problematic.

Another part of the contract included replacement of the primary sludge and scum piping as well as numerous isolation valves in these lines. Deer Island has four primary batteries of 12 stacked clarifiers, 48 stacked clarifiers in total. During dry weather flow (less than 396 mgd [1.5 Mm³/d]) two batteries can treat the wastewater. However, if rain is expected, operations staff will place additional batteries on-line as needed. Primary sludge is removed from each clarifier battery using centrifugal primary sludge pumps and is sent to the gravity thickeners for thickening. The contractor started work on these lines in the autumn of 2015, and the work is nearing completion at time of publication. The biggest challenge is that one of the four primary clarifier batteries had to be removed from service temporarily to make the connections to each of the 18 primary sludge pumps in each primary clarifier battery. The contractor had to make a temporary connection at the end of each day so that the battery could return to service if needed. However, the weather was relatively dry during this work, so in most cases the contractor was allowed to keep the battery disconnected overnight. This allowed the work to progress ahead of schedule and in no case did it affect the amount of wastewater treated by the plant.

Winthrop Terminal pump suction valve (left) and discharge valve (right)

North Main PS sewage pump—1 of 10 (left) and return sludge gallery, typical pump discharge valve (right)

| VALVE REPLACEMENT AT THE DEER ISLAND TREATMENT PLANT |

NORTH MAIN PUMP STATION

The replacement of the valves and flow meters in NMPS is likely the most critical phase of the project. NMPS houses 10 centrifugal pumps, each capable of pumping 150 mgd (568 ML/d) and equipped with a 3,500-hp (2,610-kW) motor. Each pump has four 60-in (152-cm) valves: a suction butterfly valve, a locally operated suction knife gate valve for isolation, a butterfly valve that acts as a check valve, and a discharge butterfly valve. The suction valves were not included, since the knife gate valves can still isolate the pumps if maintenance is needed. The discharge valves generally are not reliable, and, as a result, were scheduled for replacement under the contract. The flow meters were also being replaced since they were older than 20 years, and replacing them ensured that the latest equipment was placed into service during system shutdown.

Initially, the flow to NMPS and Winthrop Terminal was to be shut down, since the isolation valves designed to isolate the two force mains were not thought to be reliable. The contractor would then dewater the header with the temporary dewatering pumps and then remove the discharge valve on the first pump. To remove the valve, the elbow would have to be cut out, and then a blind flange would be needed to seal the header. This would need to be done within the eight-hour shutdown period. During this period, MWRA staff would monitor manholes and meters throughout the service area to ensure that levels in the sewer stayed at acceptable levels. Once the work was completed, pumping would be restored, and the contractor would proceed to install the butterfly check valve and the flow meter; the contractor would then fit-up the new 60-in (152-cm) discharge valve and, if possible, install it. However, the contract allows that additional work could be required to fit-up the valve, meaning a third shutdown could be necessary to install the valve after any modifications based on the findings of the fit-up during the second shutdown. Therefore, up to 30 shutdowns were planned for this work. To ensure low flow, this work had to be done between 11 PM and 7 AM in dry weather only, and only during periods meeting stringent dry weather flow limitations.

As the work at NMPS approached, management received good news. MWRA operations staff had been testing the giant 96-in (244-cm) isolation valves downstream of NMPS, hoping that they could demonstrate they could effectively isolate half the station. Word came back that they had succeeded, so instead of having to shut down all of the flow to work on the valves, flow could continue through half the station while work proceeded on the other half. Work could only take place in dry weather, of course, since wet-weather flows could require more pumps than the five pumps on one side of the station. To date, contractors have successfully replaced valves and flow meters on eight of the ten pumps without incident.

The final work required will be to replace the 81 discharge valves on the 81 return sludge pumps. The return sludge pumps remove settled sludge from the secondary clarifiers and pump most of it to the secondary reactor basins, with some sent to the waste sludge centrifuges, which thicken the sludge prior to digestion. Unfortunately, the discharge valves are all directly adjacent to the return sludge header, which serves an entire secondary battery of clarifiers. To replace any of these valves the sludge header for that battery must be drained and the battery removed from service. The contract was written to allow the contractor seven days to replace the 27 valves on each battery. It was also assumed that an additional seven days would be required to reconstitute the microbiology in each battery, since seven days without food would probably result in the complete loss of the biomass used to treat the wastewater. Therefore, regulators were notified that only 470 mgd (1.78 Mm^3/d) could be treated with the plant's secondary process. Normally, 700 mgd (2.65 Mm^3/d) can be treated with all three batteries operating.

However, MWRA had determined that keeping a battery out of service for 14 days would not be acceptable, and, as a result, the contractor was directed to complete the valve replacement in three days. MWRA believes it will be possible to keep sufficient organisms alive so that the biomass can be revived and used to treat the wastewater immediately after the three-day period. This is another lesson from the project. It is important that all stakeholders be kept closely informed during design and that they buy in to critical issues such as this so that change orders and additional costs can be avoided.

Two issues have emerged so far that must be overcome to complete the project. The first is that the valve manufacturer has had difficulty with the glass-lining process and shipped valves to the site that were not in compliance with MWRA specifications. These valves were rejected and sent back to the manufacturer to be relined. The manufacturer is developing a system that will improve the glass-lining process to ensure the valves comply with the contract documents. The glass-lined valves are required for the replacement of the 81 return sludge valves, and the contractor cannot start this work without this issue resolved. The second issue is with the coating of the 60 in. (152 cm) valves for NMPS. In this case, the contractor struggled to meet the valve coating specifications. Progress has been made on these issues, and the return sludge valve work will start in the summer of 2017, while the NMPS work is nearly complete.

REGULATORY COMPLIANCE

MWRA has been successful so far in continuing to meet the requirements of the Deer Island NPDES permit while managing this contract. A notification of MWRA intention to do this work was sent on August 25, 2014, and a meeting was held at Deer Island on September 10, 2014, to brief EPA and MassDEP on the project. While this notification met the permit requirements to notify the regulators, MWRA has provided courtesy notifications to regulators prior to any pumping shutdowns or significant work. There have been no SSOs or untreated wastewater releases as a result of this work.

As noted above, MWRA must always maintain a secondary process limit of 700 mgd (2.65 Mm^3/d) to comply with the permit-required prohibition on bypass. Thus, the flow entering Deer Island must be treated with the secondary process unless the flow increases over the secondary process limit, in which case flow greater than the limit may be treated with the primary process and then blended with the secondary effluent prior to the disinfection step. Also, blending is prohibited during dry weather. Blending is intended to be used only to handle high flows due to stormwater or possibly snow melt. This project presents a challenge to this prohibition when flow is started after a long shutdown. When the pumps that move wastewater out of the North System (NMPS and Winthrop Terminal) are shut down for an eight-hour period, it is necessary to pump out the sewer as quickly as possible to prevent any SSOs. The Deer Island operations group realized though that it had to be careful not to put on too many pumps too quickly, or it would quickly approach the secondary process limit and risk blending in dry weather. This was a new situation for the operators. Normally when pumping this much water, the only goal is to keep the pumps on-line. Having to carefully limit the flow was an additional challenge to the operations staff. There have been no blending events as a result of this project.

This project presents additional challenges to regulatory reporting, such as collecting regulatory samples during extremely low flow (during shutdown conditions, when only South System flow is passing through the outfall) or high flow (immediately after post-shutdown restart, when flow can be twice that of normal conditions). The Deer Island Process Control Department handles this case by case and carefully notes in the monthly report the impacts of the shutdown on the data. Finally, when flow is stopped from the North System, the Deer Island outfall tunnel becomes infiltrated with seawater, resulting in the undesirable effect of reducing the number of points of discharge at the end of the tunnel. This in turn reduces the factor of dilution as the effluent enters the ocean. The outfall purges itself when flow increases to about 660 mgd (2.5 Mm^3/d), but this can sometimes take weeks or months when there is little rainfall. MWRA is required to report the infiltration to the EPA and MassDEP, something that it does monthly.

CONCLUSION

Replacement of critical valves throughout the Deer Island Treatment Plant has presented the MWRA with a number of challenges. The success so far has been due to three factors. First, MWRA staff planned this project well in advance, and Deer Island operational staff discussed it thoroughly with senior management to obtain buy-in. Senior management exercised leadership, ensuring that the project received the resources it needed for success. Second, a genuine atmosphere of cooperation and communication existed among MWRA departments. Engineering, Wastewater Transport, Deer Island Operations and Maintenance, and Environmental Quality staff worked together to manage the project. Finally, the project team attempted to improve the strategies for handling the technical and operational challenges. The result has been a successful project thus far with no negative environmental or stakeholder impacts.

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Biosolids stabilization in Concord, New Hampshire—where does the city go from here?

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ABSTRACT | The Hall Street Wastewater Treatment Facility (WWTF) in Concord, New Hampshire, has performed biosolids dewatering and stabilization for more than 30 years. In 2014–2015, the WWTF performed a study to optimize biosolids dewatering and stabilization, and improve operating conditions. The study evaluated both long- and short-term stabilization options, including composting, Class A or B lime stabilization, anaerobic digestion, aerobic digestion, mechanical drying, solar drying, incineration, gasification, carbonization, and off-site disposal of non-conditioned biosolids. This article describes the evaluation of alternatives and the reasoning behind the city's final decision.

KEYWORDS | Biosolids stabilization, lime stabilization, odor control, beneficial use

Figure 1. Concord, New Hampshire Hall Street WWTF

INTRODUCTION

Optimizing biosolids dewatering and stabilization at the Hall Street Wastewater Treatment Facility (WWTF) has been a priority for the city of Concord, New Hampshire, ever since its first system, a simple plate and frame press followed by land spreading of Class B lime stabilized biosolids, was put into service three decades ago. Over the past 18 years, the city has conducted a series of evaluations in search of the best-fit technology for both the WWTF process and biosolids end-use goal of beneficial use.

The first biosolids stabilization evaluation was completed in 1999. This evaluation looked at many dewatering and biosolids stabilization alternatives. It resulted in the construction of the current dewatering system used at the WWTF to dewater a blend of primary and waste activated biological sludge. This system consists of dual two-meter belt filter presses (BFPs) and a heat and lime stabilization process. The technology meets Class A standards for biosolids use through adding sufficient lime and supplemental heat to achieve a temperature of 158°F (70°C) for 30 minutes and a pH of 12 for 24 hours. The Class A biosolids generated are primarily spread on agricultural land under a long-term contract with a private recycler.

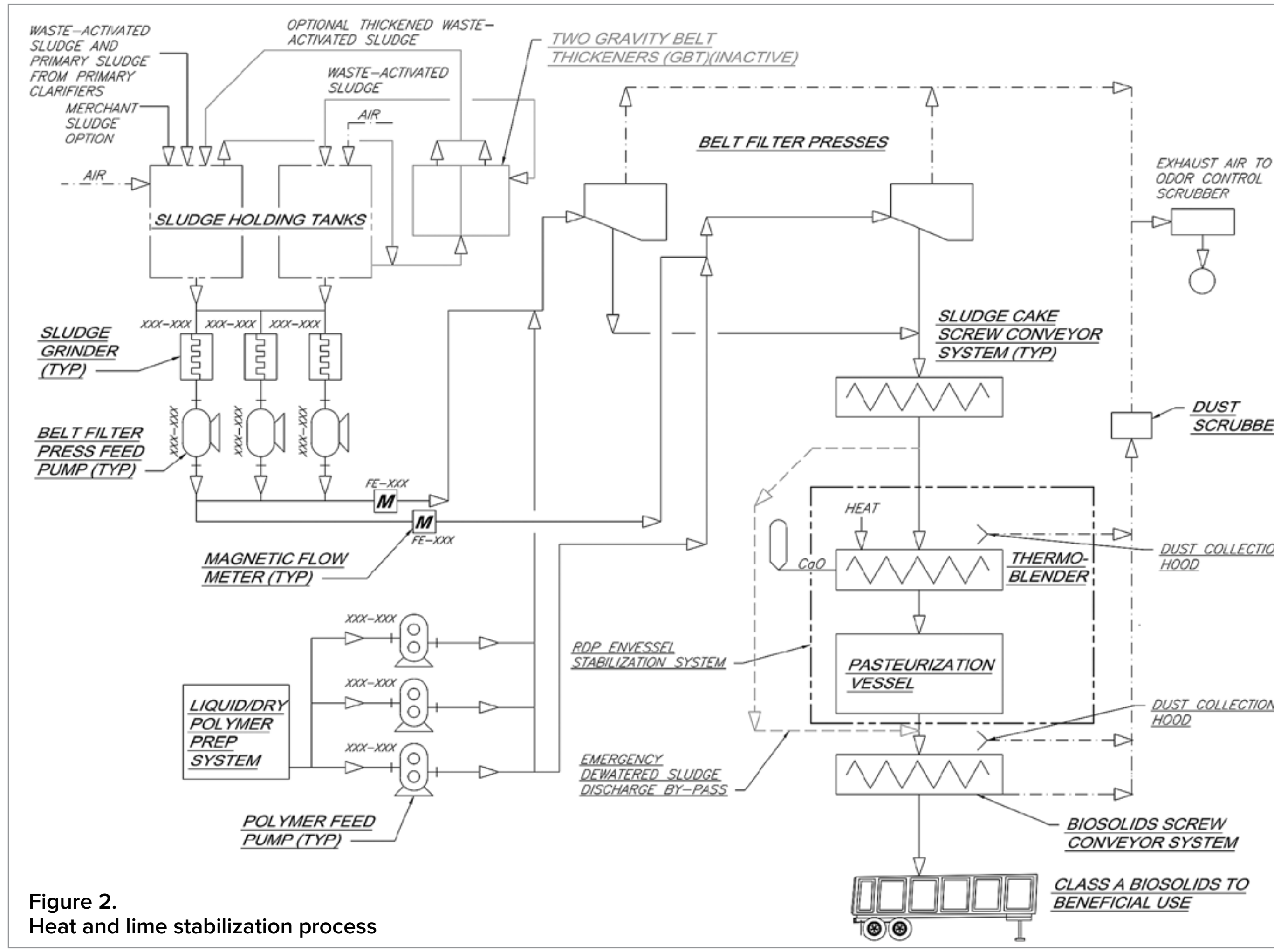

Figure 2.
Heat and lime stabilization process

SYSTEM ISSUES AND SOLUTIONS

Though the process is producing Class A biosolids for the city, several issues have prevented the city from being fully satisfied with the technology. Because of the variable sludge cake solids content and the difficulty of achieving mixing of the lime and sludge, meeting the Class A biosolids requirements was difficult during the early years. In addition, fugitive dust and odor emissions caused further problems, as the ventilation was insufficient in containment and treatment of the odorous gas, and the original dust and odor control systems were inappropriate for the system. For many years, conditions for WWTF staff were less than ideal due to unpleasant odors, dust, and gas emissions.

From 2008 through 2010, several studies of the ventilation, odor control, and conveyor and mixing system were completed to combat these issues. Various system components were upgraded during this time, including the following:

- Addition of a chemical odor control scrubber to treat the air from the BFPs, equipment, dewatering room, and truck-loading conveyors
- Addition of a Venturi-style wet scrubber to remove the lime dust from the air drawn from the equipment prior to the chemical scrubber
- Addition of operator platforms around the heat and lime stabilization equipment to provide operator and maintenance access to three sides of the thermoblender
- Reconfiguration of the polymer injection system
- Reconfiguration the dewatered sludge transport system
- Replacement of three of the four sludge screw conveyors with two flat belt conveyors to reduce the amount of reworking and plasticization of the dewatered sludge cake

The current iteration of the heat and lime stabilization system (see Figure 2) has been functioning well for the past five years because of these efforts.

REFINING THE FOCUS

Although the city has made much progress to optimize the heat and lime stabilization system at the WWTF, the system is not ideal. Thus, the city has commissioned several studies to evaluate a number of biosolids disposal and beneficial-use technologies, including composting, thermal drying, autothermal thermophilic aerobic digestion (ATAD), Class A lime stabilization, incineration, landfilling, mesophilic anaerobic digestion (MAD) before Class A lime stabilization, and thermal hydrolysis before mesophilic anaerobic digestion (THAD). In 2014, a comprehensive wastewater treatment facility evaluation was completed, recommending an in-depth evaluation of the system and a possible alternative technology, THAD, to finally resolve the issues.

This led the city to commission an assessment of the system and another comprehensive evaluation of long-term biosolids stabilization options in 2014–2015. Both long- and short-term options were considered in the evaluation to form a multi-faceted and realistic plan. The goals were to conduct a comprehensive evaluation of the current condition and life expectancy of the system, as well as a review of all possible short- and long-term biosolids processing and beneficial-use options available.

Long-term solutions focused on the period after the current beneficial-use contract ends in 2021. For short-term solutions, the system manufacturer and a consulting engineer looked more closely at the biosolids stabilization system, culminating in an evaluation report completed in late 2014. The report recommended reinvesting a limited amount of capital in the equipment to increase reliability of the Class A biosolids stabilization process. The extent of equipment replacement and upgrade modifications was recommended to be established by the city, based on alternatives presented within the report and based upon the city's budgetary constraints. Short-term, the report indicated that it was unlikely that any other Class A sludge stabilization system would be as cost-effective as the current one already in place. This finding was given further consideration in the 2014–2015 biosolids stabilization alternatives evaluation.

CONSIDERING ALTERNATIVES

To fully evaluate the performance of the Class A lime stabilization system and the needs for future upgrades, numerous alternatives were considered in the 2014–2015 evaluation. Consideration was given to the following biosolids stabilization alternatives, either as standalone technologies or a combination of two technologies:

- **Composting**. Composting stabilizes dewatered biosolids using heat from aerobic metabolism to provide pathogen kill, provides a valuable soil amendment, and is a proven process. Composting results in the largest volume of pasteurized Class A material to be disposed of due to the addition of the significant amount of bulking amendment to reduce sludge water content. The bulking amendment provides structure for air passage for drying as well as a carbon source.
- **Class A or B lime stabilization**. The city can continue using the current system, a proven process but with known issues, to provide Class A or Class B sludge. Other alternatives are also available to provide Class A lime stabilization.
- **Anaerobic digestion**. Anaerobic digestion is a proven process that reduces volatile content of sludge by converting some of it to methane gas, carbon dioxide, ammonia, hydrogen sulfide, water, and inert matter. Anaerobic digestion minimizes the size and cost of the digesters and provides proven pasteurization. Recent design trends of this process have been to use some form of pre-conditioning followed by the mesophilic gas production phase.
- **Aerobic digestion**. Aerobic digestion also is a proven process that reduces sludge volatile content and volume by aerobic bacterial metabolism, producing carbon dioxide, ammonia, and water. This is an extension of the secondary treatment process. Methane is not a metabolic byproduct. As such, no energy can be recovered from this process. This process is more effective at facilities that digest a blend of primary and secondary sludge. Aerobic digestion requires a high level of energy to mix the thickened sludge and aerate it effectively.
- **Mechanical drying**. Mechanical drying of municipal sludge is becoming more popular as a viable process for municipal WWTF sludge management. Sludge is dried to less than 10 percent moisture content, resulting in an EPA Class A sludge and significantly decreasing the volume of sludge for disposal. Drying of raw primary sludge can be problematic due to clogging of the dryer. However, drying can be used cost-effectively with standard single-phase mesophilic anaerobic digestion to achieve Class A sludge, and significantly reduce the volume of solids to be disposed of and lower operational costs.
- **Solar drying**. Solar drying uses greenhouses and mechanical agitation of the sludge to dry dewatered sludge to Class A or B biosolids. This technology significantly reduces total sludge disposal volume and is most feasible using aerobic secondary, or digested, dewatered sludge. This process requires a large footprint for greenhouse construction and has potential for odorous emissions.
- **Incineration**. Incineration is a standard biosolids destruction process. New incinerators use fluidized sand bed design using combustion of sludge to carbon dioxide, water, and ash in the presence of air, driving off all moisture. A sludge incinerator typically uses auxiliary fuel to initiate a burn and then subsequently operates autogenously from the fuel value in the sludge. The technology also requires high-energy blowers to fluidize the sand bed. The resulting ash is typically landfilled, but some ash is recycled into soils, cementitious products, and bituminous paving depending upon the heavy metal content.
- **Gasification**. Gasification reduces sludge to ash without air, producing low-grade combustible syngas comprising methane, hydrogen, and carbon monoxide. The resulting ash is disposed of at a landfill. This technology is still in the demonstration phase with limited full-scale installations.
- **Carbonization**. Carbonization can be achieved using a combination of dewatering, drying, and high-temperature carbonization producing dry product for fuel. This process requires mechanical dewatering to get 30 percent cake for fuel use. The dry fuel is used at power plants, and residual inorganics in the sludge become part of coal ash residual at power plants and are disposed of with coal ash. This technology is still in the demonstration phase with limited full-scale installations.
- **Off-site disposal of non-conditioned biosolids**. Dewatered sludge is hauled to a landfill for disposal. Some vendors can process the sludge at their own facilities to produce class A or B sludge for agricultural beneficial use for an additional fee. This option has a higher potential monetary risk related to the uncertainties of future disposal costs, with little, if any, beneficial recycling of the nutrient or energy value in the sludge.

NARROWING THE COMPETITION

Each of the alternative technologies considered underwent high-level initial screening to narrow down the competition (see Figure 3). The initial screening criteria used for Concord were as follows:

- **Has the technology been demonstrated?** Given the issues that the city faced with the process over many years, the city wanted the next biosolids stabilization system it considered to be operator-friendly and come with as few operational issues as possible.
- **Is the technology scalable to Concord's needs?** The Concord WWTF is a small- to medium-sized WWTF that treats approximately 4 million gallons (15 million liters) of wastewater per day and generates 1,800 dry tons (1630 dry tonnes) of biosolids per year. Not every technology would be the correct size or cost-effective for the WWTF.
- **Does the technology have a significant potential for off-site odors?** Given the proximity of the WWTF to residences, businesses, hotels, and a major highway, the city had previously expended significant capital to solve off-site odor issues and was unwilling to consider technologies in which off-site odors could not be effectively controlled.
- **What is the end-market for the resulting biosolids?** For any biosolids stabilization option, understanding the end markets for the product in the region is critical to the long-term success of the alternative.

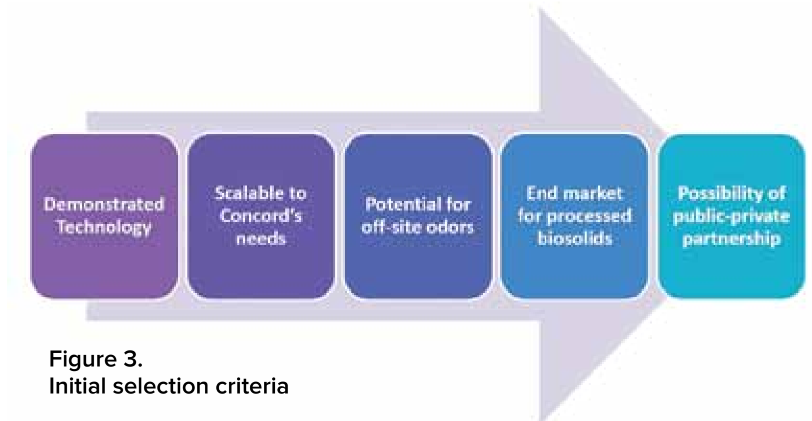

Figure 3.
Initial selection criteria

- **Is there a possibility for a public-private partnership?** Given the size of the Concord WWTF and that several past evaluations recommended biosolids stabilization options that might not be correctly sized for Concord, the possibility of a facility owned and operated by a private company was considered.

Using these criteria, the city removed several technologies from further consideration.

At the time of the evaluation, carbonization, gasification, and thermal hydrolysis before anaerobic digestion were determined not to be sufficiently demonstrated and were therefore eliminated. Incineration was also removed, as the technology is not scalable to Concord's needs and the associated sewage sludge incineration regulations are difficult and costly to satisfy in both the short- and long-term. Because of historical sensitivity to odors in Concord, composting and solar greenhouse drying also fell short of further consideration. Off-site landfilling was also eliminated as the city desired a technology that would result in beneficial use of the stabilized biosolids. Lastly, research into the possibility of a private–public partnership with the city being the host community for a regional biosolids stabilization facility was curtailed for now because of the potential issues with traffic, odors, and the stigma of being the regional dumping ground for sludge.

REMAINING ALTERNATIVES

With most of the alternatives removed from consideration, the city took an in-depth look at the six remaining technologies. Of the remaining technologies, three were Class A lime stabilization and three involved digestion of some type (temperature or two-phase anaerobic digestion (TPAD), mesophilic anaerobic digestion with drying (MADD), and ATAD.

The criteria considered for the intermediate round of technology selection were as follows:

- **Does the technology result in good indoor air quality for staff?** This criterion came from the experience of city staff enduring the existing process over the last 15 years.

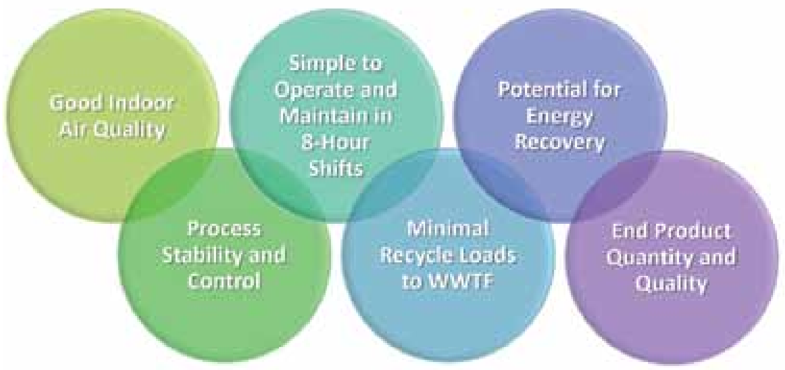

Figure 4. Intermediate selection criteria

- **How good is the process stability and control?** Because of the constant operator attention required to ensure a Class A product from the current system, process stability and control was important.
- **Is the technology simple to operate and maintain in eight-hour shifts?** The Concord WWTF operates based on an eight-hour shift and, ideally, the city wanted a system that could be run during an eight-hour shift or have sufficient instrumentation, control, and reliability to run unattended 16 hours per day and over the weekend.
- **Does the technology have minimal recycle loads to the WWTF?** The city's NPDES permit has a total phosphorus limit which, in time, could be ratcheted down to lower limits. The impact of recycle loads to the facility was important.
- **Is there a potential for energy recovery?** City-wide, Concord has undertaken many green initiatives, so energy recovery or energy reduction was important to consider.
- **What is the end-product quantity and quality?** The ability to effectively market the end-product is always a key evaluation criterion for any community.

The evaluation criteria table (Table 1) summarizes the advantages for each technology. Using these criteria, the six alternatives were ranked to allow easy comparison between technologies, the results of which are summarized in Figure 5. Two technologies with low intermediate rankings were dropped from further consideration for several reasons, including low-quality/high-quantity end products and high cost. Though the intermediate evaluation rankings suggested the existing technology should be dropped as well, it was kept because of the significant short-term cost savings for the city and the fact that it was already in place and operating. In addition to removing two from consideration, MADD was also dropped, due to the complexity of operation, high level of staff oversight required, and the need for two distinct technologies from two vendors to be coupled together for effective results. This left TPAD/2PAD and ATAD remaining after two rounds of screening for a long-term biosolids stabilization solution.

DECISION

After the rigorous evaluation and elimination process, the city selected both a short-term and a long-term biosolids stabilization technology. Short-term, the current biosolids stabilization technology was selected. It is still cost-effective and environmentally sound to continue with this method until at least the end of the current recycling contract in 2021. The disposal contract fees are low enough to allow the city to invest a planned $2 million in the current equipment and still be competitive with any other disposal option. The WWTF staff have overcome the significant issues inherent with lime stabilization of WWTF sludge and can consistently produce EPA 503 Class A biosolids. Various upgrades and improvements to the system are to be completed before the long-term solutions can be implemented, including:

- Replacement of the stainless steel thermoblender to extend the reliability of the system by 6 to 10 years
- Modification of the stabilized sludge discharge chute to prevent clogging
- Modifications to the duct work and odor collection hoods to improve dust and ammonia capture over the thermoblender and over the sludge trucks in the sludge garage

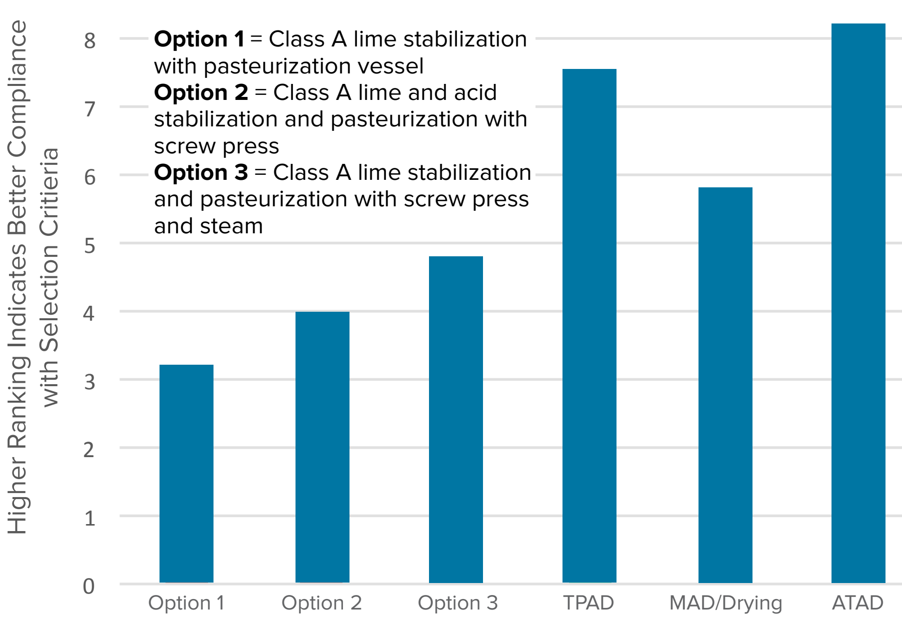

Figure 5. Sludge stabilization alternatives intermediate screening rankings

Table 1 . Intermediate evaluation criteria

	Option 1*	Option 2*	Option 3*	MAD w/drying	TPAD	ATAD
Simple to Operate	X	X	X			
No Post-Processing Required	X					
Limited Recycle Loads	X	X	X			X
Cost Effective	X					X
Significant Number of US Installations	X	X		X		X
Good Indoor Air Quality		X	X	X	X	
Limited Staffing Required		X			X	X
Good Process Control/Stability		X	X	X	X	X
Low End-Product Quantity				X	X	X
Quality End-Product	X			X	X	X
Good Energy Recovery				X	X	

*__Option 1__ = Class A lime stabilization with pasteurization vessel, **Option 2** = Class A lime and acid stabilization and pasteurization with screw press, **Option 3** = Class A lime stabilization and pasteurization with screw press and steam

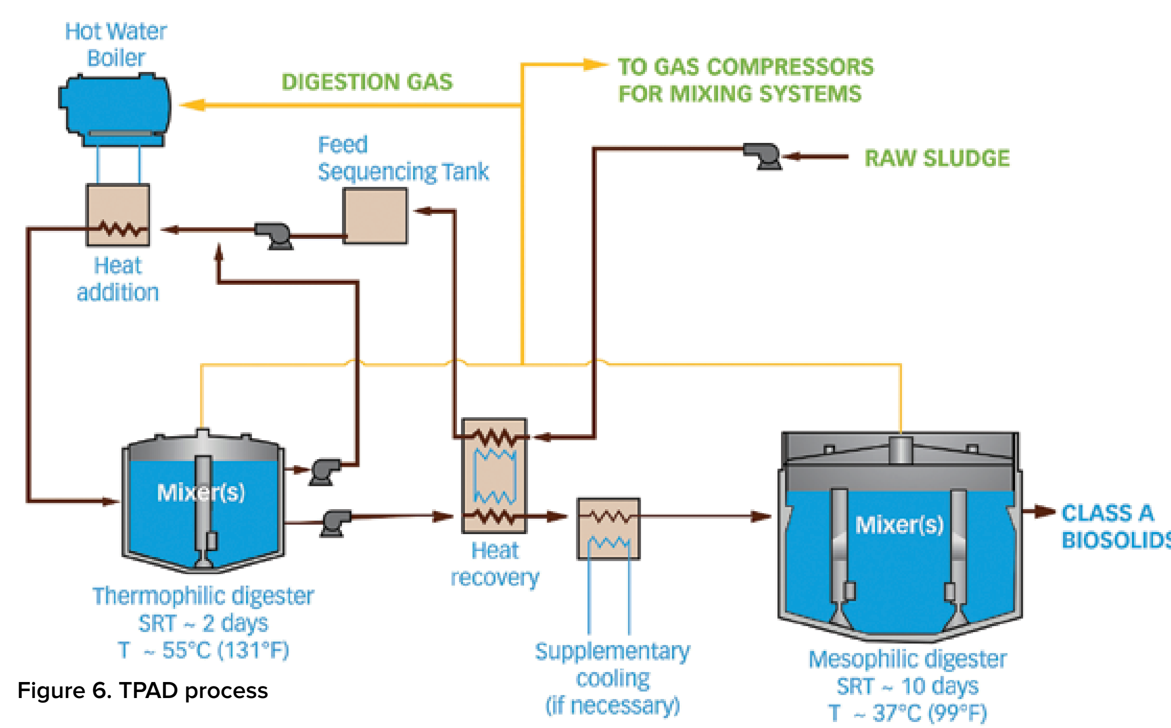

Figure 6. TPAD process

- Modification to the odor control system to allow the system to draw from the truck garage during loading and storage
- Modifications to the truck garage curtains to improve isolation of the sludge truck loading areas from the rest of the garage
- Replacement of the top covers of the truck loading conveyors

The long-term solution chosen was a "yet-to-be-determined" form of digestion. Though TPAD/2PAD has a lower lifecycle cost due to lower electric demand, there were only four installations in 2015 when the evaluation was completed. This lack of demonstrated performance in the United States made the city more comfortable with ATAD and and ultimately caused them to prefer this alternative for a long-term biosolids stabilization solution. The city has elected to postpone the decision on long-term biosolids stabilization for potentially 5 to 10 years.

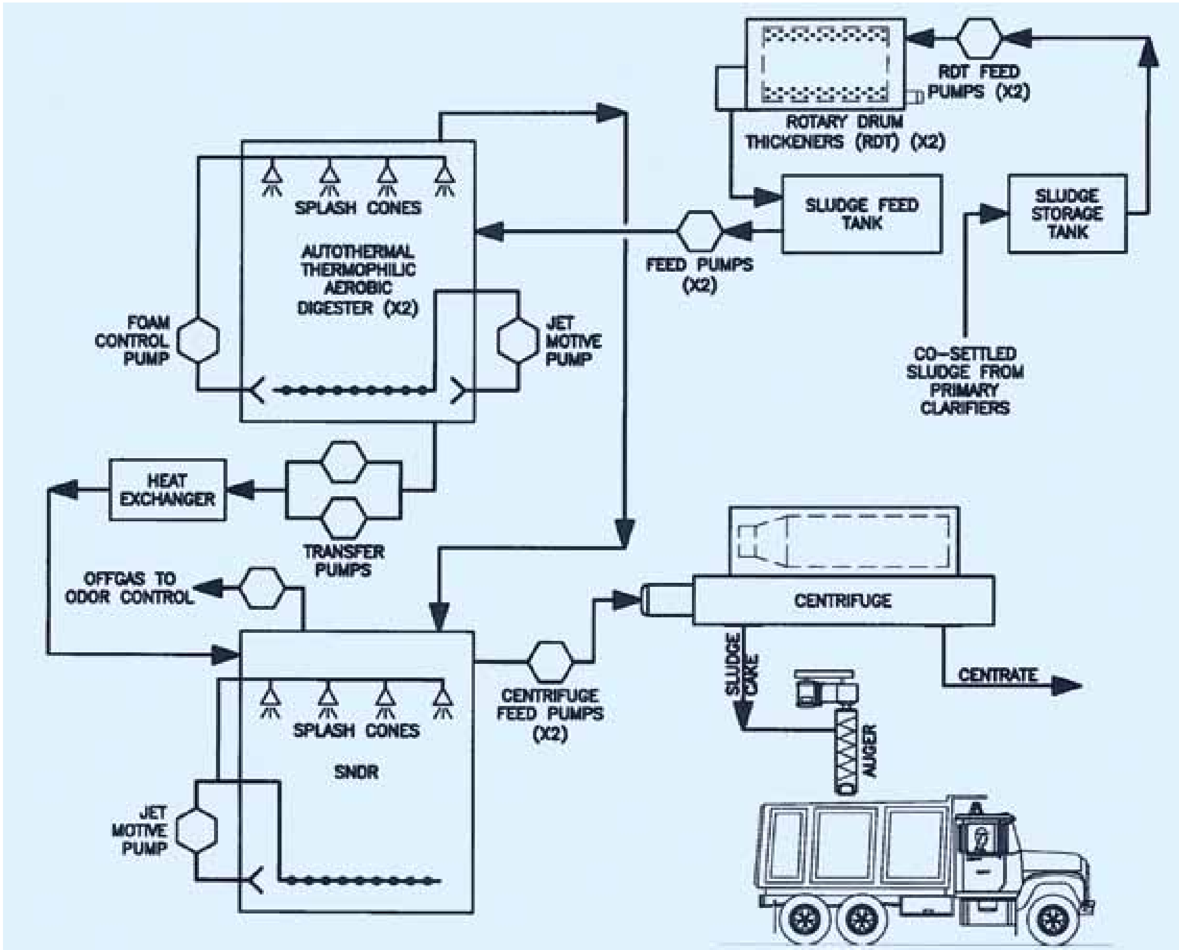

Figure 7. ATAD process

LOOKING INTO THE FUTURE

The city is under contract with a general contractor to upgrade the existing system, with startup expected in the fall of 2017. This upgrade allows time to further evaluate future advancements, refinements, and operational insights of TPAD/2PAD installations, and other variants to the digestion technology that are being developed and may be more viable in 5 to 10 years. The city has allowed for this future digestion project in its capital improvement plan. It envisions conducting preliminary design in the next few years, looking at the two digestion alternatives, with the hope that this process will yield more accurate cost estimates and aid in a decision on how to proceed. Also, energy alternatives for the facility may change with time, modifying the economic feasibility of alternatives. A merchant (privatized) facility for off-site processing in the area could also be established by the time of preliminary design, eliminating the need for an on-site processing system such as ATAD or TPAD/2PAD. With the groundwork laid for improving biosolids stabilization at the WWTF until at least 2021, the city can wait to see what changes in the biosolids stabilization market in central New Hampshire, in the United States, and worldwide.

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Achieving effluent total phosphorus of 0.12 mg/L with disc filtration

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ABSTRACT | The town of Cheshire, Connecticut Water Pollution Control Plant received a restrictive total phosphorus effluent limit of 0.12 mg/L as part of its 2012 National Pollutant Discharge Elimination System permit renewal. To meet this stringent limit, several proprietary treatment processes were considered and evaluated to select the process to be part of an upcoming plant upgrade. Disc filtration was the selected technology. Owing to the many differences between the available disc filter designs, vendor selection through a preselection process during design was implemented. This article describes the process equipment selection program, the advantages and disadvantages of a preselection program, the system's effluent total phosphorus performance for the first complete phosphorus removal season, and lessons learned.

KEYWORDS | Disc filter, disc filtration, phosphorus removal, preselection

INTRODUCTION

Cheshire, Connecticut, is a town of approximately 30,000 located in New Haven County, south of Hartford. In the denser, more heavily developed areas of town, the wastewater is collected and conveyed to an advanced water pollution control plant (WPCP) for treatment prior to discharge of treated effluent to the Quinnipiac River. The WPCP has an average daily flow capacity of 4.0 mgd (15 ML/d), and prior to the recent WPCP upgrade (Figure 1) the plant provided carbon oxidation and nitrification using the activated sludge process in a single-stage nitrification configuration, with denitrification accomplished in a downstream biological anoxic filter (BAF). Effluent was seasonally disinfected using sodium hypochlorite and dechlorinated with sodium bisulfite prior to discharge. Waste activated sludge and BAF residuals were co-settled in the primary settling tanks, anaerobically digested, and dewatered prior to offsite disposal at the incinerator in Waterbury, Connecticut. Figure 2 presents a process flow schematic of the treatment process prior to the recent WPCP upgrade.

The WPCP was constructed in phases beginning in 1971, with a major upgrade and expansion in 1992 and the addition of the denitrification BAF in 2006. In 2009, the town initiated planning for a needed WPCP upgrade to address worn and aging equipment.

AGGRESSIVE PHOSPHORUS LIMITS

According to EPA, nutrient enrichment has been identified as one of the most pressing water quality issues facing the nation. As a result, EPA increased pressure on all states to take aggressive action to limit the quantity of phosphorus discharged to surface waters. In Region 1, EPA mandated that all New England states establish limitations on phosphorus in all wastewater discharge permits where the potential exists for the discharge to contribute to eutrophication and impairment of designated uses in downstream waters.

In response to mandates by EPA Region 1 to establish phosphorus limitations where the potential exists for the discharge to contribute to eutrophication and impairment of designated uses in downstream waters, the Connecticut Department of Energy and Environmental Protection (DEEP) released its proposed *Phosphorus Reduction Strategy for Inland Non-Tidal Waters* in June 2009.

Figure 1. WPCP prior to the upgrade

This strategy included effluent phosphorus limits for 44 wastewater treatment plants in Connecticut discharging treated effluent to inland, non-tidal rivers and streams. The strategy assigned each of the 44 plants discharging to inland fresh water resources an average performance limit and seasonal (April through October) permit load. This seasonal load was based on a watershed analysis that identified the in-stream load needed to protect aquatic life throughout the watershed. Upon reissuance of the National Pollutant Discharge Elimination System (NPDES) permits, each plant affected will be required to implement measures to achieve the proposed seasonal load assigned to that facility. The permit limits vary widely, with 12 of the 44 plants required to achieve a stringent effluent total phosphorus concentration of 0.2 mg/L or lower. The Cheshire WPCP is one of 12 plants in the state receiving the stringent limits on total phosphorus.

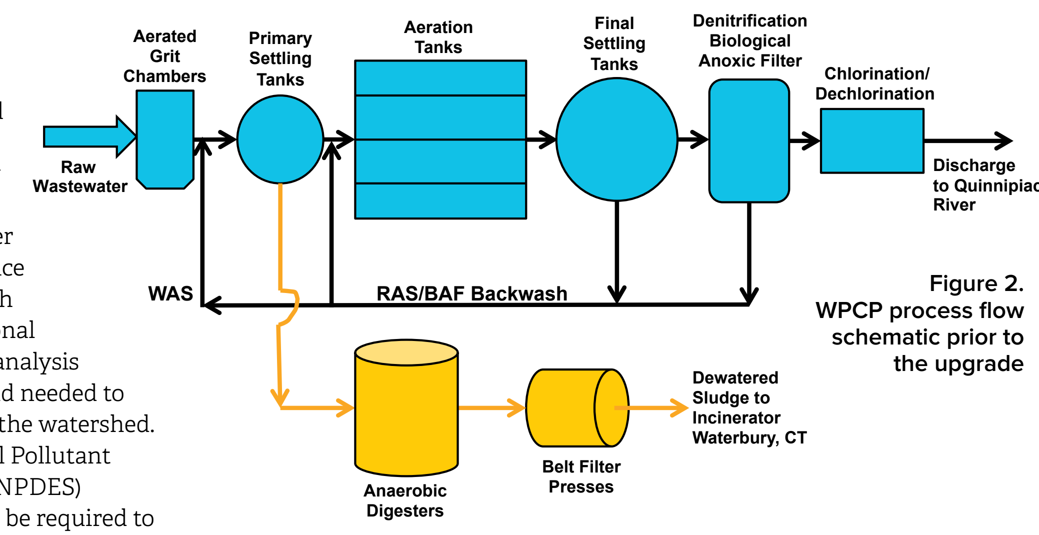

Figure 2. WPCP process flow schematic prior to the upgrade

The Cheshire WPCP's NPDES permit was renewed in 2012 and contained new effluent total phosphorus limits as well as a required compliance schedule to meet the new limits. The limits for the Cheshire WPCP apply from April 1 through October 31 of each year and have the following requirements:

- Seasonal Average Total Phosphorus: 4.06 lbs./d (1.85 kg/d) (equivalent to 0.12 mg/L at design flow of 4.0 mgd [15 ML/d])
- Monthly Average Total Phosphorus Concentration: 0.31 mg/L
- Daily Maximum Total Phosphorus Concentration: 0.62 mg/L

INITIAL TECHNOLOGY SELECTION

At the time DEEP proposed the phosphorus limits in 2009, the town had already initiated a wastewater facilities plan to identify needed improvements to the WPCP due to aging equipment and to improve operating and energy efficiency. A review of alternative approaches and the initial selection of the technology to meet the new phosphorus limits was completed as part of facilities planning.

To achieve the stringent total phosphorus limits for Cheshire, the project team concluded that chemical precipitation together with either an effluent filtration or ballasted flocculation process would be needed. The technologies considered for Cheshire were ballasted flocculation with magnetite, ballasted flocculation with micro-sand, disc filtration, and continuous backwash sand filtration. Each process was conceptually sited and sized to meet a target total phosphorus concentration of 0.1 mg/L (slightly

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Table 1. Wastewater facilities plan phosphorus removal technology comparison

Alternative	Estimated Capital Costs[1]	Estimated 20-year Present Worth O&M Costs	Estimated 20-year Life Cycle Costs
Disc Filtration and UV Disinfection	$7,900,000	$2,600,000	$10,500,000
Ballasted Flocculation with Magnetite and UV Disinfection	$12,800,000	$4,500,000	$17,300,000
Ballasted Flocculation with Micro-sand and UV Disinfection	$10,500,000	$3,300,000	$13,800,000
Continuously Backwashing Sand Filter and UV Disinfection	$9,000,000	$3,000,000	$12,000,000

[1] ENR Construction Cost Index: 8590

less than the required 0.12 mg/L at the design flow), and evaluated based on estimated capital and 20-year life cycle costs as well as non-monetary factors. Since the plant's disinfection system was to be upgraded to use ultraviolet (UV) disinfection as part of the proposed upgrade, and reuse of the chlorine contact tanks was possible, all the alternatives included the estimated cost for the conversion to UV disinfection. Table 1 presents the estimated capital, operation and maintenance, and 20-year life cycle costs for the four technologies.

Based on the evaluation, chemical precipitation (including coagulation and flocculation) with disc filtration was recommended for the plant upgrade. This technology had lower estimated capital and life cycle costs compared to the next-lowest-cost technology of more than $1 million and $1.5 million, respectively. Other benefits of the technology included the low head loss, which did not require the WPCP to pump its forward flow.

SELECTING THE DISC FILTER VENDOR/SUPPLIER

At the time of design, several equipment manufacturers provided disc filters for tertiary phosphorus removal that use surface filtration arranged in a vertical disc configuration. However, these systems differed in process configuration and characteristics. These systems differ in:

- Media type
- Flow path
- Head loss
- Backwash arrangement
- Depth of disc submergence
- Coagulation/flocculation and chemical dosing requirements

These differences made a single design to accommodate the different disc filter manufacturers' equipment and system configurations difficult and would have likely increased the construction costs.

As a result, the disc filter equipment supplier was preselected during conceptual design to identify the most beneficial disc filtration system. In 2012, the town prepared a request for proposals (RFP) for providing the disc filtration system, including any required ancillary equipment. Proposals were required to provide information on process configuration, phosphorus removal experience, and projected operation and maintenance requirements for the Cheshire installation, supported by operation and maintenance data from existing installations. They also had to have a defined scope of supply including design engineering, submittals to be provided, and equipment layouts, and details for the following:

- Disc filters, tanks, and covers
- Coagulant and flocculant dosing control systems
- Coagulation and flocculation mixers
- Disc filter/chemical cleaning system
- Online phosphate analyzer

The proposals were also required to provide pre-design performance verification testing as well as post-substantial completion performance testing. Finally, a fixed price for the scope of supply (supported by both bid and performance bonds) was to be included as a bid line item in the WPCP upgrade construction documents.

Evaluation of the proposals included estimated system construction costs based on information in the proposals including the equipment costs as well as the costs of the support systems (buildings, electrical loads, chemicals, etc.) based on vendor equipment sizes and configurations. Annual operation and maintenance costs were also developed based on information presented in the proposals supported by data from other installations. Based on the capital and operation and maintenance costs, life cycle costs were developed. Finally, other non-cost criteria (experience, proposal exceptions, etc.) were compared. Following these evaluations, a tentative selection of a supplier was made, after which, as required by the RFP, the supplier performed a validation test of its system at the WPCP on a portion of the flow. The validation testing was required to address project team concerns that the effluent phosphorus limit of 0.12 mg/L was potentially at the limit of the disc filter technology and few full-scale installations of disc filter systems were achieving these limits. Upon successful completion of the validation testing, a formal selection was made. The disc filter preselection processes described above also satisfied competitive equipment bidding requirements for these project elements to be eligible for grant and loan funding through DEEP's Clean Water Fund program. More information on the preselection process and performance validation testing can be found in a Spring 2014 *NEWEA Journal* article, "Pushing the Limit Without Breaking the Bank—Selection, Procurement, and Testing of a Phosphorus Removal Process."

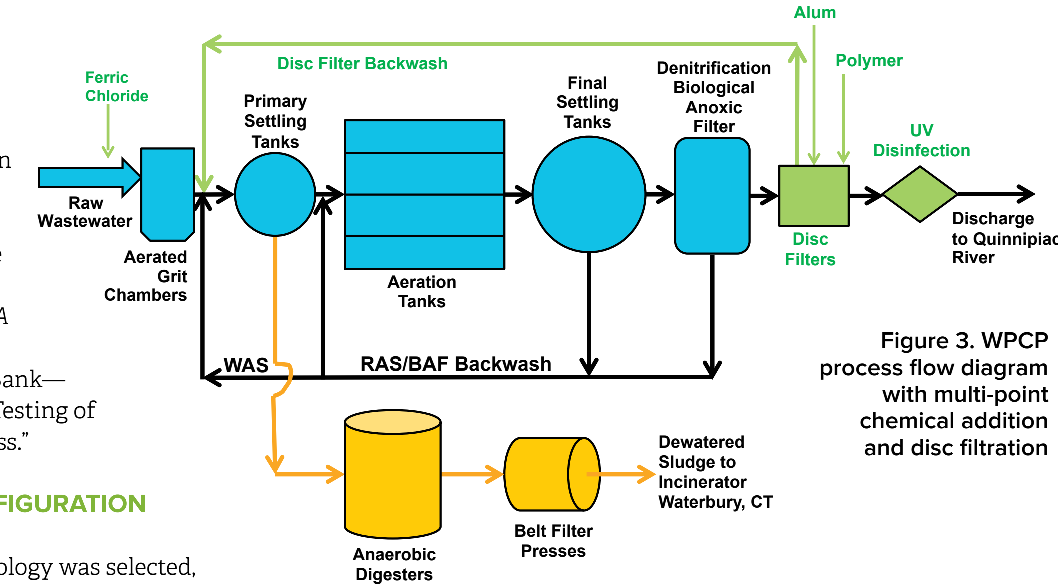

Figure 3. WPCP process flow diagram with multi-point chemical addition and disc filtration

UPGRADE PROCESS CONFIGURATION AND COMPONENTS

Once the disc filtration technology was selected, the project entered the design phase. Figure 3 illustrates the revised process flow diagram with the disc filtration system included. Multi-point chemical addition was to be used to precipitate and remove the phosphorus present in the wastewater. These two dosing locations, their solids removal process, and dosing control are described below.

Chemical Dosing Location No. 1—Pre-precipitation

To remove a portion of the phosphorus in the plant influent as well as a number of the plant recycle streams, ferric chloride is dosed in the aerated grit chambers where the air agitation mixes the ferric chloride with the incoming raw wastewater to precipitate phosphorus. The precipitated phosphorus is subsequently removed in the primary settling tanks. The total phosphorus concentrations in the WPCP influent average between 2.0 mg/L and 4.0 mg/L. The ferric addition dose is flow paced to the WPCP influent flow and trimmed to a target primary effluent phosphate concentration by an algorithm in the plant supervisory, control, and data acquisition (SCADA) system. The phosphate concentration in the WPCP influent and primary effluent is measured by an online phosphate analyzer. The phosphate analyzer measures the orthophosphate concentration of both the influent wastewater (used for chemical dose pacing) and the primary effluent for monitoring. These samples are pumped from their respective locations continuously to a common wet chemistry phosphate analyzer for independent sample analysis.

The phosphorus (or measured phosphate) in the primary effluent is controlled to allow for the passage of some phosphorus to the downstream biological processes. This is done to maintain the health of the biological populations in the aeration tanks and denitrification filters, while accounting for the removal of a portion of the phosphorus due to the biological activity of these processes. The ferric chloride dose is adjusted to produce a target primary effluent concentration of approximately 1.5 mg/L. This primary effluent concentration, and the subsequent phosphorus uptake in the aeration tanks and the denitrification filter allow the WPCP to achieve a target a denitrification filter effluent (tertiary phosphorus removal feed) concentration between 0.5 mg/L and 1.0 mg/L total phosphorus.

Chemical Dosing Location No. 2—Post-precipitation

Following the denitrification filters, aluminum sulfate is dosed and flash mixed upstream of the coagulation tanks. In the coagulation tanks the wastewater is slowly mixed and the remaining soluble orthophosphate is precipitated. From the coagulation tanks the flow is conveyed to flocculation tanks for additional low energy mixing and is dosed with polymer. The polymer and mixing increases the size of the precipitated phosphate floc for subsequent removal via surface filtration by three disc filters (two duty, one standby). The disc filters are sized for a peak hourly flow of 11 mgd (42 ML/d) and an average flow of 4 mgd (15 ML/d) with a target effluent total phosphorus concentration of 0.10 mg/L to meet the 0.12 mg/L total phosphorus seasonal average concentration at the average design flow. At these peak and average flow rates, the hydraulic loading rates of the filters are 4.84 gpm/ft^2 (197 Lpm/m^2) and 1.77 gpm/ft^2 (72 Lpm/m^2), respectively, with two filters in service. The filter backwash is directed to either a gravity thickener or to the plant drain for subsequent co-settling in the primary settling tanks. For both backwash discharge locations the residuals are subsequently digested and dewatered with the other WPCP residuals.

The dosing control of the aluminum sulfate and polymer are provided by the disc filter's programmable logic controller (PLC). The PLC uses an algorithm to control the chemical dosing based on the measured flow to the disc filters as well at the denitrification filter effluent phosphate concentration measured by an online phosphate analyzer. This phosphate analyzer measures the orthophosphate concentration of the denitrification filter effluent used for chemical dose pacing as well as the phosphate concentration of the final settling tank effluent and the disc filter effluent for process monitoring. These three samples are pumped from their respective locations continuously to a common phosphate analyzer for independent sample analysis.

PRESELECTION ADVANTAGES AND DISADVANTAGES

Preselection of the equipment supplier during design as described above can have advantages as well as disadvantages for a project or application. The engineer and owner should be aware of these advantages and disadvantages before deciding to proceed with a preselection. Some advantages and disadvantages are described below.

Preselection Advantages

Design tailored to one product. One benefit of preselection is identifying the system requirements before advancing the project into detailed design. This allows for design components such as building dimensions, the building foundation elevation(s), and the impact of the system on the upstream and downstream hydraulic profile to be known. Without the preselection process, the building and other support systems (electrical, I&C, pumping, etc.) may need to allow for the installation of more than one vendor's equipment. This may unnecessarily increase the footprint and foundation depth, and affect other systems that would add cost to the project.

Life cycle cost vendor selection. One significant advantage of preselection is that it allows for selection of the system to be supplied based on a life cycle cost of the equipment, construction, and operation to best serve the owner. Without a preselection the system supplied would most likely be determined by the construction contractor based on what is best for the contractor and not consider the operating cost of the system over its service life.

Early establishment of equipment price. Establishing the bid cost for the preselected equipment scope of supply through preselection early in design can aid in the control and planning of the project costs. The early establishment of the preselected equipment cost (often substantial) removes some of the owner's uncertainty of the project cost when developing its plan to finance the project.

Vendor "lessons learned" on other projects maximized. The preselection of the equipment vendor before the design allows the vendor to be certain of its project selection. This certainty has the benefit of improving the design. With the vendor essentially part of the design team, they are more willing to share their lessons learned on other projects with the engineer. This relationship with the engineer during design can result in suggestions to improve the value of the design through either the addition or reduction of project scope items related to its systems to best suit the owner's needs. For example, in Cheshire, a supplier recommended the use of passive overflow weirs and piping for each of their filter units which were not included in the original RFP scope that was sent to multiple vendors. These items were added during design (and to the selected vendor's scope of supply and fixed proposal cost), significantly improving the system reliability and reducing the risk of a system overflow at a relatively low cost. Under a conventional project this item would likely have not been included if it was not specified in the contract documents.

Equipment delivery possibly expedited. Another advantage of preselection is that it can expedite equipment delivery during construction. This expedited delivery can improve the project construction and start-up schedule once the contract has been awarded to a contractor. With the equipment vendor aware of the project details, and the bidding and construction schedule, the vendor has a much better sense of when the equipment will be procured by the contractor and can thus plan for the equipment production. Without the preselection, the vendor would start more or less from scratch when the project was advertised for bids and not be able to plan for the equipment production since it would not know if it would even "win" the bid with the contractor.

Preselection Disadvantages

Project schedule impacts. One disadvantage of the preselection process is that it adds time to the design schedule and ultimately extends the time until the project is bid and completed. The process to perform a preselection can include the following steps:

1. Development of an RFP from the system suppliers
2. Formal advertising of the RFP
3. Response to and clarification of RFP questions typically through formal addenda
4. Receipt of proposals
5. Evaluation of proposals related to completeness, development of construction and operation and maintenance (O&M) costs, and evaluation of exceptions or other non-financial considerations
6. Recommendation to tentatively select a proposer for award

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Figure 4. Cheshire WPCP upgrade progress and phosphorus removal components

7. Performance validation testing for the tentatively selected proposer (if deemed necessary)
8. Formal award

All these steps can add anywhere from five to nine months to the schedule before detailed design on the system can advance.

Project cost impacts. Another disadvantage is that preselection adds costs to the project. All the preselection steps noted above require an engineering effort, which increases the project design costs. In addition, the construction costs of the project may also increase due to the delay in bidding the project and the subsequent start of project construction. The costs of labor and materials are almost always increasing, so delays in bidding and construction can often increase the cost.

The overall impact on cost, however, may be greater or less with preselection. As noted in the advantages section, preselection has the positive financial impact of allowing for a life cycle cost selection of the technology as well as providing a technology-specific design (building and support system needs). It is believed that the overall project costs can be reduced by preselection if used for the right application. The engineer and owner need to be aware of the potential for additional costs when using preselection to determine if it is the right approach.

Need to negotiate terms and conditions. The terms and conditions of the equipment delivery, payment, material ownership, scope changes, indemnity, liquidated damages, passdowns (if applicable), and warranties are typically determined during the equipment procurement between the equipment supplier and the construction contractor. However, in a preselection these terms and conditions must be established ahead of design to obtain a fixed price from the equipment vendor to include in the construction bid documents. This may include negotiations of various performance and payment terms and conditions with the vendor during preselection.

PROJECT CONSTRUCTION

The design of the Cheshire WPCP upgrade, which included the disc filter system, was completed in the spring of 2013. Bids for construction were received in the fall of 2013, and a $28 million construction contract was awarded. Construction commenced in October 2013 and substantial completion was achieved in November 2015 as required by the contract documents. Figure 4 highlights the disc filter system components and the completed WPCP. Because substantial completion occurred outside the phosphorus removal season (April 1 to October 31), the first year of permitted phosphorus removal at the WPCP did not begin until calendar year 2016. The performance of the system during the 2016 phosphorus removal season is discussed in the following section.

2016 WPCP AND DISC FILTER PHOSPHORUS REMOVAL PERFORMANCE

Seasonal Performance Summary

The disc filter phosphorus removal system at the WPCP has been operational since the beginning of the 2016 permitted phosphorus removal season (April 1 to October 31). The total effluent phosphorus concentration data and effluent loading data are presented in Figure 5 for the 2016 total phosphorus removal season. The total phosphorus effluent results are also presented in Table 2.

Table 2. Disc filtration 2016 phosphorus removal season results

Permit Condition	Seasonal Results (April 1 – Oct. 31)	Permit Effluent Criteria
Average Total Phosphorus Effluent Load	1.93 lbs/d (0.88 kg/d)	4.06 lbs/d (1.85 kg/d)
Seasonal Average Total Phosphorus Effluent Concentration	0.12 mg/L	0.12 mg/L[1]
Monthly Average Total Phosphorus Concentration	0.17 mg/L[2]	0.31 mg/L
Daily Maximum Total Phosphorus Concentration	0.45 mg/L[3]	0.62 mg/L

[1] Required seasonal effluent concentration at design flow of 4.0 mgd (15 ML/d)
[2] October 2016, [3] First day of permit season (4/1/16)

During the first season of operation, the WPCP and the disc filter system met the required seasonal, monthly, and daily effluent total phosphorus concentrations and loads. The system achieved the target seasonal total phosphorus concentration of 0.12 mg/L, meeting that concentration or less for 66 percent of the samples collected and analyzed during the season. In addition, the system achieved a total phosphorus concentration of 0.05 mg/L or less for 21 percent of the samples collected and analyzed during the season. The average seasonal load from the WPCP during the 2016 season was 1.93 lbs/d (0.88 kg/d), well below the NPDES permitted seasonal load limit of 4.06 lbs/d (1.85 kg/d). The low seasonal loading is attributed to the dry weather and resulting low WPCP influent flows.

Disc filters

As shown in Figure 5, there were performance deviations with effluent total phosphorus concentrations greater than 0.12 mg/L. While the first deviation was attributed to the seasonal start-up period (early April), two performance deviations are of note. These occurred in late June 2016 and in late October 2016.

Performance Deviations

Late June. The high total phosphorus effluent concentration observed in the last week in June and first week in July were attributed to failure of the sample pump feeding denitrification effluent to the online phosphate analyzer. As noted, this online phosphate analyzer controls the alum and polymer addition upstream of the disc filters through an algorithm in the disc filter PLC. Upon failure of the sample pump, the chemical dosing was removed from automatic control and operated in manual. Once the sample pump was repaired and put back into service the system was returned to automatic control. As can be observed in the data, once the system was returned to the automatic mode, the effluent total phosphorus concentration was again reduced to below the target levels.

Late October. The high total phosphorus effluent concentrations observed in the last week in October were attributed to a failure of a circuit board in the phosphate analyzer measuring the WPCP influent and primary effluent. As noted, this online phosphorus analyzer is used to control the ferric chloride dosing to the aerated grit chambers through an algorithm in the WPCP SCADA system. The circuit board failure resulted in the WPCP running the ferric chloride chemical dosing in manual until the analyzer could be repaired and returned to automatic control. In manual the ferric chloride was intentionally operated at a reduced dose. This was due to concerns of overdosing the ferric chloride and creating phosphorus limiting conditions in the primary effluent that could have negative impacts in the downstream biological processes. The dose was also reduced because the WPCP was running well below the permitted seasonal total phosphorus effluent load, and the WPCP could have higher effluent concentrations for a short time without significantly affecting the ability to meet the effluent seasonal load mass limit. As expected, the reduced dosing at the grit chambers resulted in a total phosphorus concentration in the feed to the disc filters that was much higher than usual and resulted in the higher WPCP effluent total phosphorus concentrations.

Performance Without Deviations

With the removal of the data points related to the seasonal start-up and equipment issues that resulted in performance deviations noted above, the average total phosphorus effluent concentration for the 2016 season was 0.076 mg/L with a corresponding total phosphorus effluent load of 1.27 lbs/d (0.58 kg/d). This performance shows the ability of the technology to meet low total phosphorus effluent concentrations of lower than 0.1 mg/L at a much lower capital and operating cost than other tertiary phosphorus removal technologies (depth filtration and ballasted flocculation).

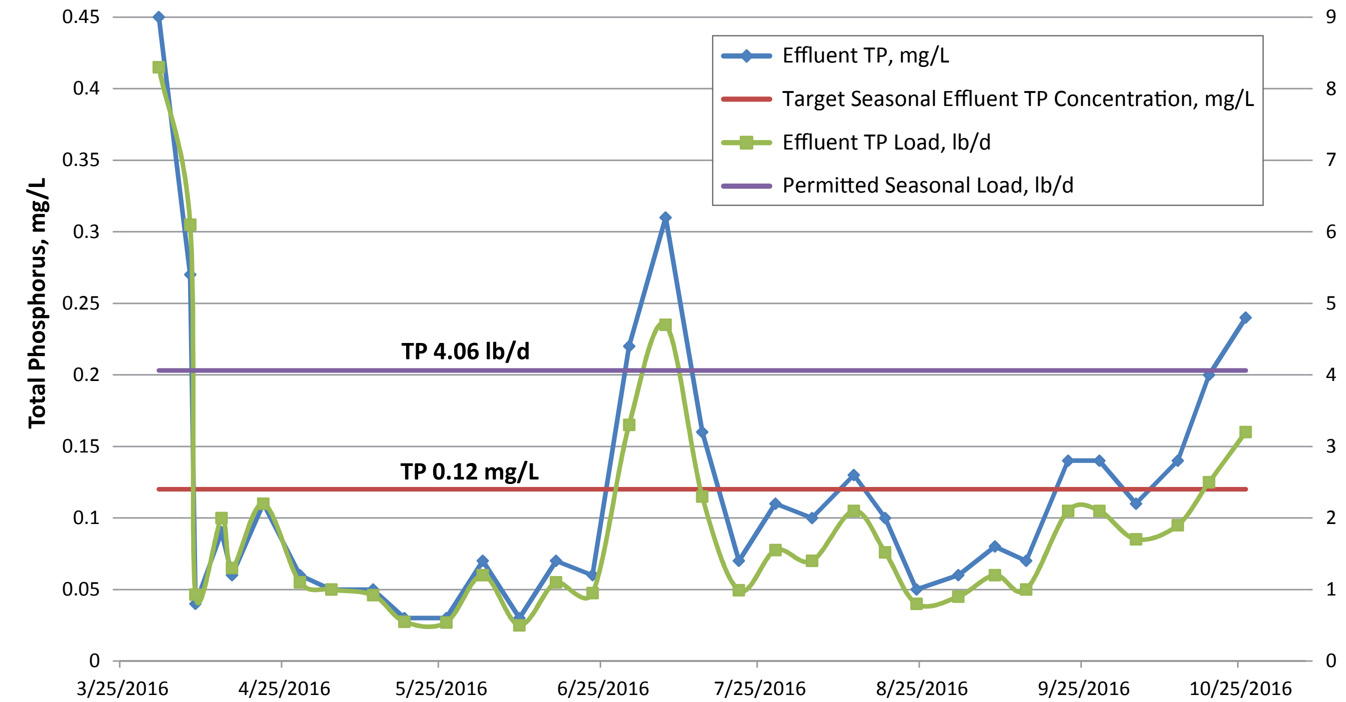

Figure 5. Cheshire WPCP 2016 phosphorus removal season data

LESSONS LEARNED

An important part of a WPCP upgrade project is to share some lessons learned. The following are some lessons learned from the project related to hydraulic surging and online sample collection and analysis.

Hydraulic Surge Potential

The design engineer and operators should consider hydraulic surge potential when implementing disc filters. In Cheshire, the desire was to install the tertiary disc filter system, including the upstream coagulation and flocculation tanks, as well as the new downstream UV disinfection system, without the need to pump the forward flow at the WPCP. As a result, reduction of headloss through these systems was evaluated and implemented in the design. One such item was the use of electric motor actuated weir gates at the downstream end of the UV system channels for water surface control. These actuated gates were installed downstream of the two new UV disinfection channels to control the UV system water surface elevation by reacting to the level in the channels as measured by ultrasonic level elements. The water elevation in UV channels is critical to UV performance. Too low a water level may result in the UV lamps being unsubmerged and potentially damaged. Too high a water level may result in reduced disinfection performance due to the top of the water being too far from the lamps to achieve effective disinfection. When headloss is not an issue, most UV disinfection systems use either a long fixed weir or an unactuated automatic water level control gate. The electric motor actuated weir gate was selected in Cheshire as it had the lowest head loss.

Like all filter systems, the disc filters need to be backwashed regularly to maintain their hydraulic throughput. The disc filter backwashes are triggered by headloss upstream of the disc filter measured by a level element (Cheshire preference) or by a timer. The backwash consists of spraying disc filter effluent through a backwash header of spray nozzles at the filter media in a direction counter current to the forward flow. This is done while the discs are rotated into the path of the spray header allowing the entire filter surface area to be backwashed. While the volume of backwash water is low, the frequency of backwashing in Cheshire is high with the filters backwashing every three to five minutes.

As a result of these backwashes, disc filter influent flow is effectively stored upstream of the filters as the head and water surface on the upstream side of the filters increase as the filter removes solids from the forward flow. Upon backwashing of the filters this "stored" water is released and causes surges in flow to the downstream UV disinfection system. This increase in flow results in the water elevation in the UV channel increasing rapidly following a disc filter backwash. The level element in the UV channel detects this increase in level, and the disc filter PLC actuates the weir gate to lower the level in the channel from the signal. Owing to the high efficiency of the disc filter backwashing system, the material collected on the filter is removed quickly. This reduces the upstream headloss, improving the filter throughput quickly but increasing the impact of the hydraulic surges. In Cheshire, these surges were significant enough that the UV weir gate could not react (lower) quickly enough to control the water surface elevation in the channel and resulted in a high-level alarm condition. In addition, as the disc filters backwash, the water level in the UV channel often drops quickly with the gate further open due to it lowering for the initial surge, resulting in the UV PLC reversing the direction of the gate (up) to increase the water level in the channel. Often the weir gate could not react quickly enough to these rapid changes in the measured UV channel level, resulting in a low water level condition in the UV channel.

To address this issue the control of the UV weir gates was modified. Instead of using the UV channel level to control the gates, the UV PLC was provided with signals from the disc filter PLC to let the UV system know when the disc filter PLC was going into or out of a backwash. These disc filter backwash status signals allowed the UV PLC to be predictive or proactive in response to disc filter backwashes and to start moving a UV weir gate going into or out of a disc filter backwash before the water surface elevation change could be observed in the UV channel. This predicted or proactive weir gate actuation addressed the issue and prevented the high and low water conditions previously encountered.

While the situation in Cheshire is unusual with the use of a downstream UV system with a motor actuated weir gate, awareness of this issue and other potential impacts from the disc filter hydraulic surges should be considered in a disc filter application. To address the potential hydraulic surge issues a few items could be implemented or considered, including use of the following:

- Faster actuator that can move the weir gate more rapidly
- Continuous duty actuator if conditions make the weir gate prone to frequent movement and affect the long-term reliability of the gate
- Actuated finger weir gate to increase the weir length and minimize the changes in water surface elevation due to hydraulic surges

Online Phosphate Sample Collection and Analysis

The performance of the phosphorus removal system is only as good as the weakest link. As noted, the chemical dosing control for both the upstream ferric chloride addition and the downstream alum and polymer addition were based on algorithms to pace the chemical doses based on the WPCP flow and disc filter influent flow for the two locations respectively, as well as phosphate measurements from their respective online phosphate analyzers. In Cheshire, automatic control of the chemical dosing was preferred to manual control due to the variability of the total phosphorus in the system (due to intermittent and high phosphorus concentration recycle streams [digester supernatant and dewatering filtrate of digested sludge]) as well as flow variability observed at the two chemical dosing locations. The variability in the influent was due to the impact of diurnal flows as well as the impact of recycle flows while the flow variability for the disc filter influent was a result of the impacts of the backwashes of the upstream denitrification filters. Because of the low total phosphorus limits required at the Cheshire WPCP (0.12 mg/L), the robustness of these control systems is critical. As noted in the performance section above, the two most significant deviations from the target total phosphorus effluent concentrations were attributed to, in one case, a sample pump failure and, in the other case, an analyzer failure. Suggestions to minimize the potential downtime of these systems include the following:

- Consider specifying the most robust sample pumps for the application. These pumps are critical components in the control of the system and are generally low in cost relative to the other phosphorus removal equipment. Also, the limited savings of specifying lower-quality sample pumps is not likely a good value due to the increase in the potential risk of losing the automatic control of your system for any period.
- Owing to the relatively low cost of the sample pumps versus the whole system, a hard-piped alternate pump or at least a shelf spare should be available in case of an issue with the sample pumps to minimize system downtime.
- Because of the higher cost of the phosphate analyzers and the complexity of replacing an entire analyzer, it is not reasonable to have a shelf spare. However, having sufficient spare parts on site is recommended with the intent to minimize downtime if there were an issue with the analyzer. Recommended spare parts include smaller value items such as fuses, filters/strainers, and batteries. However, stocking higher value spare parts such as valves, UV lamps, system pumps, circuit boards, network interface cards. or other potentially long-lead-time items should be considered.

CONCLUSION

To meet a stringent limit for effluent phosphorus at the Cheshire WPCP, multi-point chemical addition with disc filtration was selected as the lowest cost technology. Since the disc filter systems all differ, a preselection process was used to select the equipment vendor. To address concerns with using the disc filter system to reduce the effluent total phosphorus to such a low concentration with few full-scale similar installations, preselection included a requirement for an on-site performance verification test. This preselection approach allowed the town to select the vendor that provided the best value based on both capital and O&M costs, and confirmed that the full-scale system could achieve the required effluent total phosphorus levels.

The Cheshire water pollution control plant post-construction

For this application, the benefits of preselection, (including having the detailed design specific to one vendor, choosing the equipment supplier based on a life cycle cost analysis that included the construction cost of supporting systems, and applying lessons learned from the vendor during detailed design), far outweighed the longer schedule and additional costs to complete the design and construction. However, for other applications the engineer and owner should be aware of and discuss the advantages and disadvantages of preselection relative to their specific application before proceeding with that design approach.

Based on the results of the first permitted phosphorus removal season (April 1 to October 31, 2016), the WPCP and disc filter systems met all daily, monthly, and seasonal total phosphorus requirements and achieved a seasonal average effluent total phosphorus concentration of 0.12 mg/L with approximately two-thirds of the effluent samples collected with 0.12 mg/L or less. With the experience of the first full phosphorus removal season, operation and performance of the disc filter system is expected to be improved to provide an effluent with a lower total phosphorus concentration.

For other WPCPs facing similar permit limits, a disc filter system for total phosphorus removal could be a solution. For the Cheshire WPCP, the disc filter system met the seasonal limits at a lower capital and life cycle cost than the other total phosphorus removal technologies evaluated. If disc filters are implemented the impact of the hydraulic surges of backwashes on downstream processes should be considered. Finally, control of the chemical feed systems is critical to the performance of disc filter systems as well as any other tertiary phosphorus removal technology systems to achieve low-level-effluent phosphorus. Robust chemical feed control systems including sample pumps and analyzers are recommended along with complete shelf spares for selective components as well as sufficient selective spare parts to reduce the frequency or duration of downtime of these critical systems.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance and support provided by the Cheshire Water Pollution Control Department staff, the Cheshire Water Pollution Control Authority, and vendor staff.

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Manchester, New Hampshire retools its aeration system for the next generation

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ABSTRACT | The city of Manchester, New Hampshire, initiated a series of upgrades at its 40-year-old treatment facility to replace aged and failing aeration, provide greater operational flexibility and redundancy for the activated sludge process, increase secondary system and overall plant capacity, and enhance biological phosphorus removal as a first step toward addressing a phosphorous limit. Through tank reconfiguration, adding highly efficient fine bubble aeration, and enhancing biological phosphorus removal the treatment plant achieved all goals and realized a significant energy cost savings.

KEYWORDS | Manchester, ultra-high efficiency fine bubble aeration, enhanced biological phosphorus removal (EBPR), modified Johannesburg, energy savings

Figure 1. Manchester WWTF, December 2016

INTRODUCTION/BACKGROUND

The city of Manchester, New Hampshire, is the largest city north of Boston with 109,000 residents and has experienced significant growth and revitalization in the past 30 years. The Manchester Wastewater Treatment Facility (WWTF) was constructed in the 1970s and went into operation in 1975 with a capacity of 26 million gallons per day (mgd) (98 ML/d). The WWTF was upgraded in 1993 and expanded to 34 mgd (129 ML/d). Presently, the WWTF treats an annual average flow of 23.7 mgd (90 ML/d) from Manchester, Goffstown, Londonderry, and Bedford, New Hampshire, a combined population of 172,000. The city's 375 mile (603 km) collection system is about 55 percent combined resulting in high wet weather flows. The city has established goals for increasing both the peak wet weather flow capacity of the secondary system and the overall WWTF as part of a Facility Plan completed in 2010 and concurrent Revised Long-Term CSO Control Plan developed in 2010. The aeration system upgrade project was initiated in 2011 and had the following goals:

- Replace aged and failing aeration system with a more energy-efficient system
- Provide greater operational flexibility and redundancy for the activated sludge process
- Increase secondary system and overall plant capacity
- Enhance biological phosphorus removal as a first step toward addressing a phosphorous limit

Prior to the upgrade, the aeration system in Manchester consisted of a conventional activated sludge system with two parallel trains of six tanks in series. The activated sludge system was aerated via 12 two-speed mechanical surface aerators. Many of the aerators were installed when the Manchester plant was originally built and were more than 40 years old. The aerators were unreliable due to age, consistently failing, and frequent need of maintenance/repair.

The overall WWTF had a target peak capacity of 65 mgd (246 ML/d) with instantaneous flows as high as 78 mgd (295 ML/d). This flow was processed by directing a maximum of 35 mgd (132 ML/d) through the secondary system and the remainder through the secondary bypass system. The plant previously used one of its four primary effluent channels to carry secondary bypass flow to the bypass structure. During extremely high flow events when secondary bypass flows exceeded 35 mgd (132 ML/d), this system caused flow to back up to the primary clarifiers resulting in flooding of the scum troughs and effluent weirs.

The $22.4 million aeration system upgrade was substantially completed in 2015. The improvements included a new activated sludge process aeration tank configuration, aeration system and ancillary equipment, secondary bypass, major electrical upgrades including transformers, switchgear, and motor control centers (MCC), and instrumentation. Figure 1 shows an aerial view of the WWTF after the project was completed.

PROJECT GOALS

Increased Operational Flexibility and Redundancy

Manchester's old aeration process consisted of two parallel aeration trains of six aerated tanks in series as shown in Figure 2A. Typically, the facility operated with one train of six tanks in series. However, at times, two trains were needed to meet demand. Whenever two trains were needed, there were concerns about lack of backup if one of the mechanical surface aerators failed. To increase redundancy and flexibility, increasing the number of process trains was desired.

The aeration tank flow configuration was modified to allow operation of four parallel trains of three tanks in series as shown in Figure 2B (compare to Figure 2A, flow direction top to bottom). The new tank configuration included the following features:

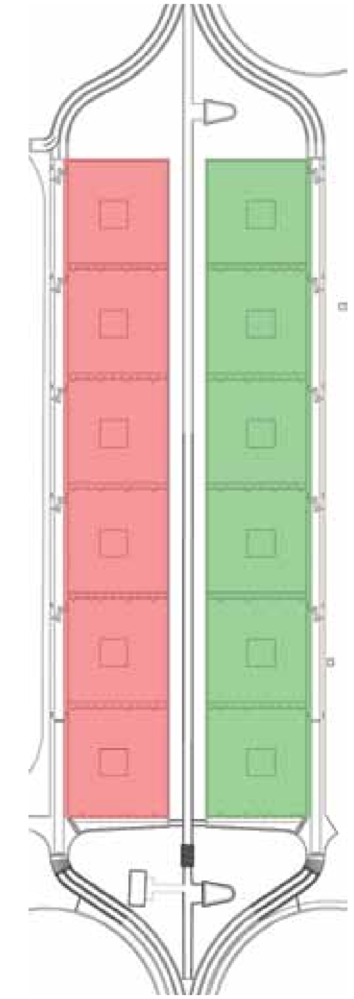

Figure 2a. Old configuration: two trains of six tanks each

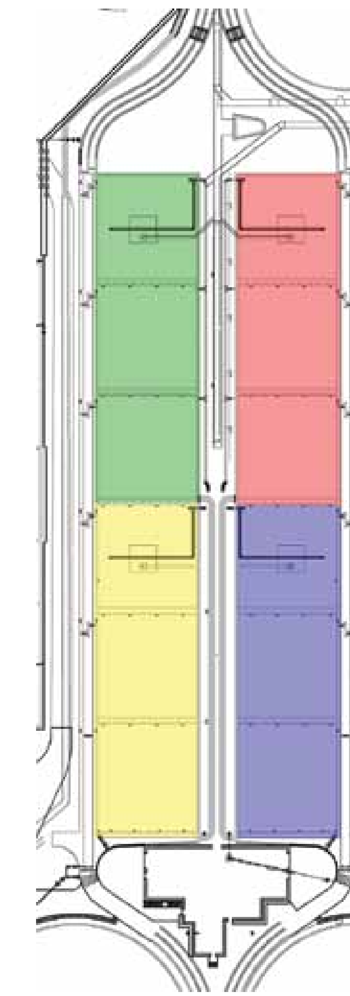

Figure 2b. New configuration: four trains of three tanks each

- New secondary bypass structure
- Four new Palmer Bowlus flumes in the aeration influent channels to induce head loss and provide a more equal flow split
- Two new aeration effluent troughs
- Working capacity increase of 13 percent in the aeration basins achieved by raising outlet weirs about 2 ft (0.6 m)
- Automated return activated sludge (RAS) flow splitting system with new pinch valves and splitter manifold that allows RAS from any of the three secondary clarifiers to flow to any on-line aeration train

The new tank configuration increased redundancy by allowing the WWTF to operate with two, three, or four trains on-line and reducing the portion of the tankage that needs to be off-line for maintenance to 25 percent.

Ultra-high-efficiency Aeration System

The city selected fine-bubble diffused aeration using first-in-class energy-efficient equipment for the aeration system upgrade. The new diffusers are ultra-high efficiency, urethane membrane, small

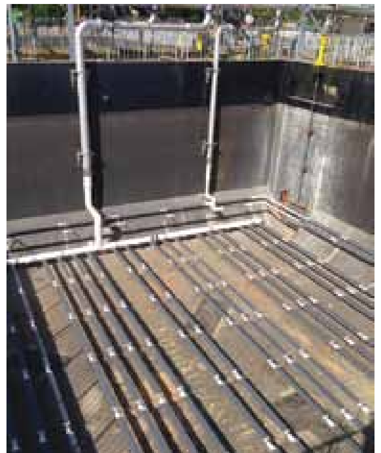

Figure 3. Ultra-high-efficiency fine bubble diffusers

Figure 4. Integrally geared aeration blowers

Figure 5. View of aeration piping and valves at center walkway between aeration tanks

panel type as shown in Figure 3, resulting in the least air flow required to meet oxygen requirements. The blowers are integrally geared, single-stage, centrifugal type as shown in Figure 4 that offered the highest available efficiency and provided better turn-down than turbo blowers. The four 300-hp (224-kw) blowers are housed in a new 4,300-sq-ft (400-sq-m) Blower Building.

Additional features of the new aeration system included the following:

- Each train consists of three tanks in series with one selector tank and two aerated contact tanks.
- Each of the eight aerated contact tanks was divided into two separate aeration zones, one zone on the main floor area of each tank and one zone midway up the perimeter fillets of each tank to account for the large tank area above the sloped fillets. The main floor area zone is adjusted based upon dissolved oxygen (DO) levels to account for fluctuations in process loading. The fillet zone maintains a constant air flow rate and prevents downward flow of the mixed liquor at the walls that would otherwise undermine oxygen transfer efficiency.
- DO monitoring was provided in each contact zone that feeds back to the programmable logic controller (PLC) and controls the total amount of air flow to each tank. The aeration pipe drop legs with control valves along the center walkway are shown in Figure 5.
- Aeration supply is controlled via pressure monitoring of the common air distribution header. The PLC automatically adjusts blower output and turns additional blowers on or off as necessary to meet the desired header pressure set point.

The DO control system allows for immediate aeration adjustments when loadings to the secondary system fluctuate to prevent under-aerating or over-aerating the process. The new aeration system was calculated to decrease aeration system energy usage by about 48 percent.

Upgraded Activated Sludge Process

The old system provided biological treatment via a conventional activated sludge process to remove biochemical oxygen demand (BOD) from the process flow. Enhanced settleability was critical to achieving the key goal of higher secondary system capacity and can be accomplished with either an anoxic or anaerobic selector. In addition, enhanced biological phosphorus removal (EBPR), another key goal, requires an anaerobic selector. The updated National Pollutant Discharge Elimination System (NPDES) permit included an effluent limit for total phosphorus. The seasonal mass-based limit is 236 lb/d (107 kg/d)—approximately 0.9 mg/L at permitted flow—for total phosphorus in the plant effluent. The new process, termed "variation of the modified Johannesburg," included a three-stage anaerobic selector and a separate RAS denitrifying zone, and is shown in Figure 6. These zones were incorporated into the first tank of each train.

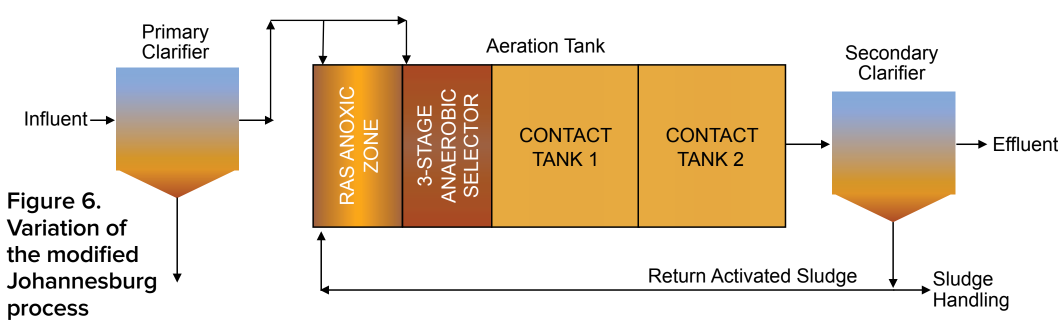

Figure 6. Variation of the modified Johannesburg process

The RAS anoxic zone is intended to help drive the EBPR by removing nitrates that would otherwise consume the volatile fatty acids, which are essential to EBPR. The RAS denitrifying zone (anoxic zone) and each stage of the anaerobic selector are mixed with separate hyperbolic mixers. The RAS denitrifying zone has the added flexibility to operate with diffused air when the process is not nitrifying. Oxidation-reduction potential monitoring was provided in this zone with feedback to the SCADA system to monitor RAS conditions.

The upgrade was predicted to increase peak secondary system capacity to greater than 48 mgd (182 ML/d). Process modeling indicated that the level of EBPR would not be sufficient to meet the pending permit limit under all conditions. Additional modifications would be needed that could include chemical addition and elimination of co-thickening of primary and secondary sludges.

Secondary Bypass

The project included a new secondary bypass structure adjacent to the primary effluent common channel. The new secondary bypass structure used a downward opening weir gate configuration that eliminated issues with flow backing up into the primary clarifiers and facilitated higher overall plant flows. The new secondary bypass simplifies control of the bypassed flow and increases secondary bypass flow capacity by more than 70 percent up to 60 mgd (227 ML/d). In combination with the increase in secondary system capacity, the upgrade was designed for total peak hourly flows of greater than 83 mgd (314 ML/d) consistent with the Revised Long-Term CSO Control Plan.

Blower Building

The change to fine bubble aeration resulted in the need for an enclosed space to house the blowers and new electrical gear. The identified building location was bounded by the aeration tanks to the north, the aeration effluent channels to the east and west, and the existing 1,200-ft-long (366 m), below grade, pipe tunnel. This new blower building location was ideal in limiting length of aeration piping and integrating access to the pipe tunnel, but it presented complex design and construction constraints. The building was sized to house four new 300 hp (224 kw) blowers, with space for two more blowers in the future. The building also included a new above-grade electrical room for electrical gear associated with the new aeration equipment as well as distribution switchgear and five MCC (previously located in the underground pipe tunnel) for the southern-half of the facility.

Revit 3D modeling software was used to model the new building and existing site, as shown in Figures 7 and 8. Finished photos of the blower building exterior are shown in Figures 9 and 10. The 3D Revit model checks conflicts of the new building and systems in a complex space and enables the owner and contractor to visualize the proposed building.

Figure 7. Blower building bounded by aeration tanks and aeration effluent channels

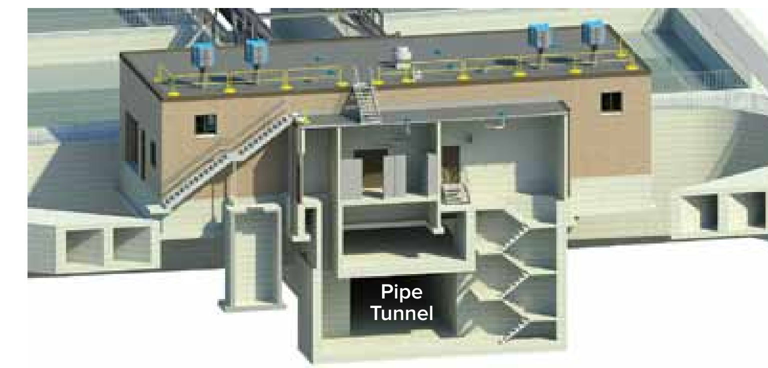

Figure 8. Blower building cross-section through electrical room, stairwell, and pipe tunnel

Figure 9. Blower building southwest view

Figure 10. Blower building northwest view

| MANCHESTER RETOOLS AERATION SYSTEM |

OPERATION

The first two aeration trains came on-line in June 2015, and the second two trains came on-line in December 2015. The performance to date has met and sometimes exceeded expectations.

BOD/TSS

The Manchester facility has maintained a history of excellent treatment performance, with single-digit final effluent results for both BOD and TSS annually. This performance has continued with the new aeration system as outlined in Table 1.

Table 1. BOD and TSS performance

	Before Upgrade 2012		After Upgrade 2016	
	TSS (mg/L)	CBOD (mg/L)	TSS (mg/L)	CBOD (mg/L)
Raw influent	142.7	111.1	193.7	146.0
Final effluent	5.2	5.0	6.4	5.5
Percent removal	96.4%	95.5%	96.5%	96.0%

Peak Flow Capacity

The secondary system has achieved an increase in both peak daily and peak hourly flow capacity of up to about 43 mgd (163 ML/d). Other plant modifications are needed to handle higher flows. This corresponds to a 28 percent increase in peak daily flow compared to 33.5 mgd (127 ML/d) for the old secondary system and a 23 percent increase in peak hourly flow compared to 35 mgd (132 ML/d) for the old system. State point analysis indicates the upgraded process should be able to achieve peak daily flows of 48 mgd (182 ML/d) and peak hourly flows up to 60 mgd (227 ML/d) once other bottlenecks at the WWTF are addressed (see opposite page for more information). The city must address other issues to be ready to trial peak flows of 83 mgd (314 ML/d) for the WWTF, but the secondary system and secondary bypass have the necessary capacity.

Phosphorus

As noted, process modeling indicated that EBPR alone would not consistently meet the new total phosphorus limit of 236 lbs/d (107 kg/d). The 2016 average BOD-to-phosphorous ratio is around 15-to-1, which is lower than the desired range of between 30-to-1 and 40-to-1 for EBPR. Effluent phosphorus results for 2016 are summarized in Figure 11, which shows that Manchester met the phosphorus limit for four of the seven permitted months with EBPR alone. Based on performance to date, future sludge handling improvements should bring the plant into full compliance. *(continued on page 56)*

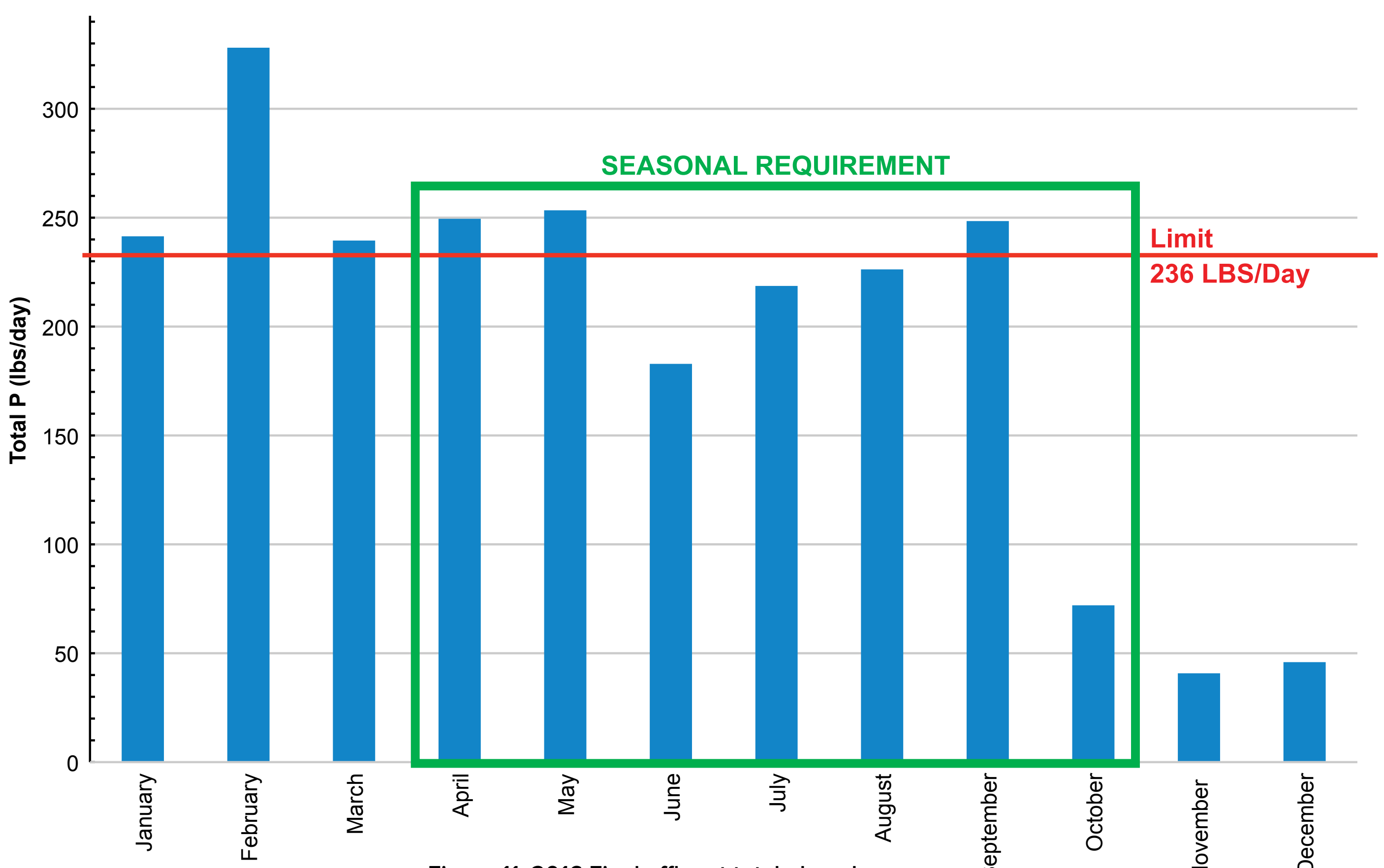

Figure 11. 2016 Final effluent total phosphorus

Manchester's Sludge Settling Velocity and State Point Analysis

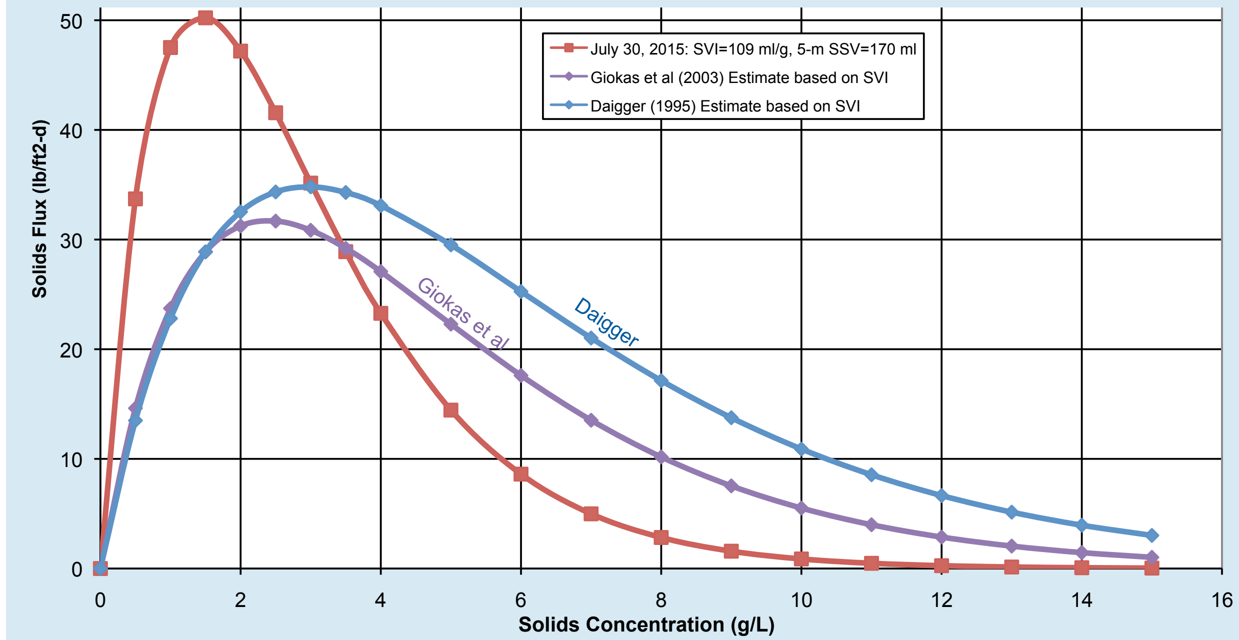

Figure A. Comparison of solids flux curves based on settling velocity testing for July 30, 2015, versus correlation equations for SVI

As part of the upgrade, state point analysis was used to predict maximum secondary system capacity. To use state point analysis, the solids flux curve must be determined either through settling velocity testing or by using correlation equations from literature based on analysis of data from many WWTFs. During the summer of 2015, settling velocity testing was conducted to develop site-specific data for Manchester's mixed liquor with the new selector zones in operation.

Compared to the most common correlation equations as reported by Giokas et al. (2003) and Daigger (1995), Manchester's sludge was found to settle more rapidly but have less "compactibility." As seen in Figure A, the solids flux curve for July 30, 2015 shows the correlation equations to be wider and shorter than Manchester's data. Flux curve width is indicative of thickening capacity, and the height indicates solids loading rate capacity. Since Manchester's mixed liquor appears to have less thickening capacity than the correlation equations, a key finding is that RAS pumping rates are critical to achieving higher secondary system capacity.

Because of the significant deviation from the typical correlation equations, additional settling velocity testing and a least squares fit analysis helped to develop a site-specific correlation equation to the sludge volume index (SVI), which is carried out daily at the Manchester WWTF. The current correlation equation used in Manchester is as follows:

Vo = 9.9372 + 0.053 * SVI, for Vo in m/hr

K = 0.1366 + 0.0043 * SVI, for K in L/g

The site-specific correlation equations are used in state point analysis to predict secondary system capacity during wet weather events. Figure B shows the state point analysis at 48 mgd (182 ML/d) secondary system flow for a mixed liquor suspended solids concentration of 1,600 mg/l, an SVI of 109 ml/g, and a RAS rate of 15.5 mgd (59 ML/d) (32 percent of secondary flow). At these parameters, the system still has about a 20 percent safety factor. As the flow increases, the underflow line approaches the settling flux curve, and the two lines become tangential at approximately 60 mgd (227 ML/d). On this basis, the secondary system should be able to achieve peak daily flows of up to 48 mgd (182 ML/d), and peak hourly flows of up to 60 mgd (227 ML/d).

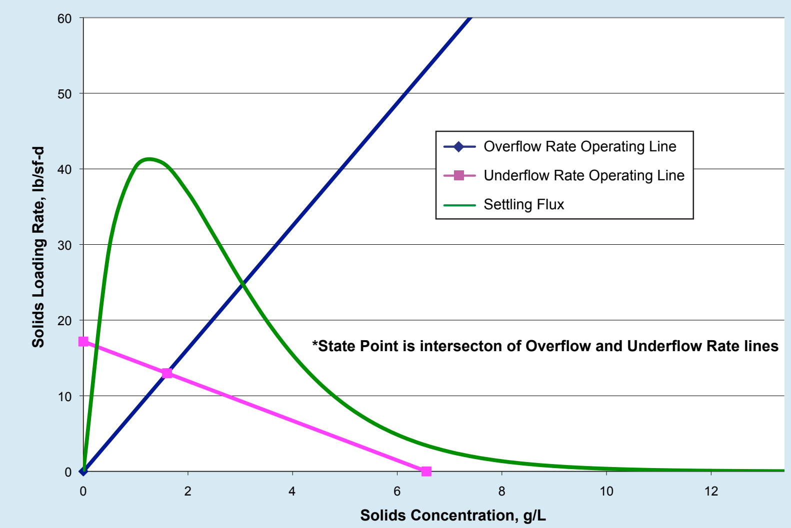

Figure B. State point analysis for 48 mgd (182 ML/d) and typical operating parameters for Manchester

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- Daigger, G.T., (1995) Development of Refined Clarifier Operating Diagrams Using an Updated Settling Characteristics Database, Water Environment Research, Vol. 67, No. 1, p. 95
- Giokas, D.L., G.T. Daigger, M. von Sperling, Y. Kim, P.A. Paraskevas, (2003) Comparison and Using a Unified Settling Characteristics Database, Water Research, Vol. 37, p. 3821

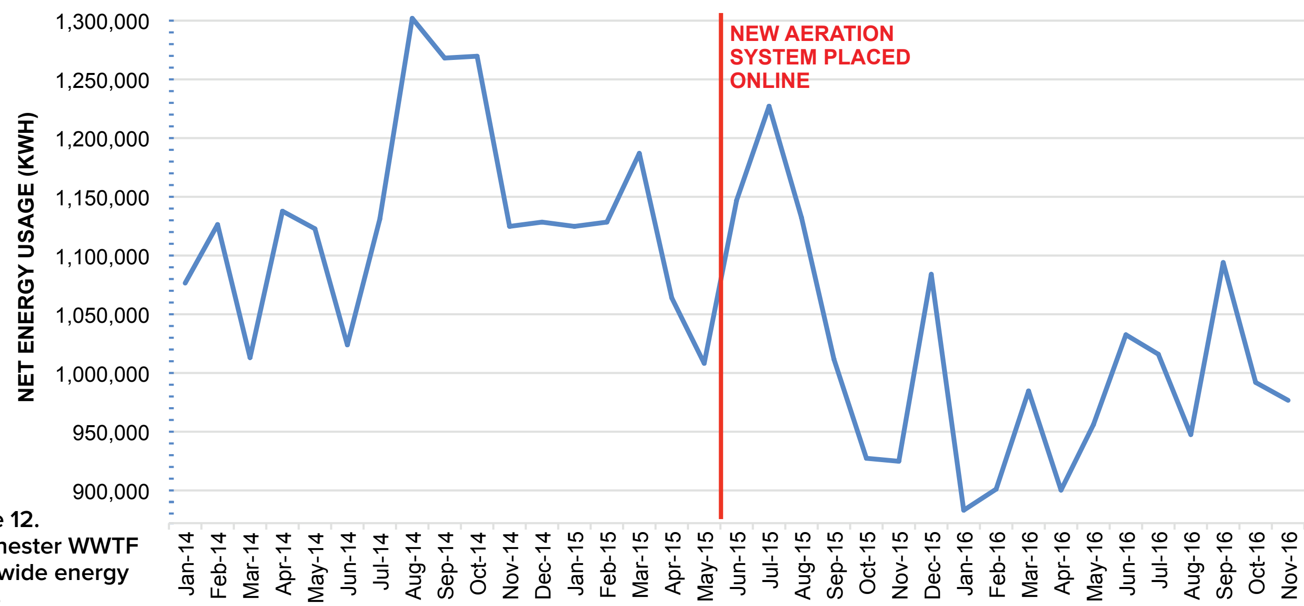

Figure 12. Manchester WWTF plant-wide energy usage

Energy Savings

During design, the new aeration system was calculated to achieve a 48 percent reduction in energy usage due to the ultra-high-efficiency aeration system. This calculated reduction, compared to Manchester's historical plant-wide energy usage, was 14 percent. Figure 12 shows overall monthly net energy usage at the Manchester facility from January 2014 through November 2016. Average net monthly usage totaled 1,132,000 kW/hr per month before the upgrade and 1,008,000 kW/hr per month after the upgrade, equating to a net energy savings of 124,000 kW/hr per month or an 11 percent reduction in plant energy usage. This provides approximately $225,000 in energy savings compared to previous years.

CONCLUSIONS

The key goals for the upgrade were all achieved, including the following:

- A new fine bubble diffused air system replaced the failing mechanical surface aerators to reduce maintenance requirements and provide reliable aeration.
- The secondary treatment system has more operational flexibility and redundancy through the conversion from two trains of six tanks in series to four trains of three tanks in series.
- The new aeration system uses significantly less energy, reducing electrical costs by 11 percent at the WWTF.
- The upgrade achieves enhanced biological phosphorus removal through a unique process configuration, achieving the first step toward meeting the NPDES permit limit for phosphorus.
- The improved sludge settleability of the mixed liquor has allowed a 28 percent increase in the peak daily flow capacity of the secondary system.

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National Water Policy Fly-in & Expo

by Bob Fischer, Chair, NEWEA Government Affairs Committee

NEWEA was well represented in Washington, D.C., at the National Water Policy Fly-in & Expo, which took place on March 21–23, 2017. The National Water Policy Fly-In is sponsored by the Water Environment Federation (WEF), National Association of Clean Water Agencies (NACWA), the Water Environment and Reuse Foundation (WERF), WateReuse, and the Water Research Foundation (WRF). The role of the attendees is to provide information to their

James Ehlers (GAC member Vermont), Vermont Senator Bernie Sanders, Ed McCormick (WEF California), and Bob Fischer

Congressional delegations that can then be used to make informed decisions. NEWEA has been going to Washington for this purpose for many years now, and it shows as senators, representatives, and their staff know NEWEA and increasingly use the participants as an important resource for facts about clean water in their states. Joining with the other organizations helped focus our efforts and gave us an even stronger platform to distribute information.

The NEWEA Government Affairs Committee produced "Talking Points," as per previous years and these were discussed along with other documents such as "Elevate Water as a National Priority," from the American Water Works Association and WEF, and documents from "The Value of Water Campaign," which were made available for reuse by the delegations. The NEWEA "Talking Points" emphasized four topics:

1. The need to fully finance the Clean Water State Revolving Fund (SRF) at $2.8 billion for FY 2018 and the Drinking Water SRF at $1.8 billion for FY 2018
2. The concerns, in the Northeast, that EPA reviewed the state-by-state allocations of the Clean Water SRF, in response to the 2014 Water Resources Development Act, and has recommended new allocations that would generally shift funding away from New England toward other states
3. The need to fund the Water Infrastructure Finance & Innovation Act (WIFIA) at $45 million for FY 2018
4. The potential elimination of the tax-exempt status of municipal bonds (as some have proposed) that would greatly affect the ability of water and wastewater utilities to fund capital projects. Tax-exempt municipal bonds play a vital role in financing clean water infrastructure and in maintaining rates at affordable levels as municipal bonds fund more than 80 percent of water infrastructure investments.

It is estimated that $655 billion is needed over the next 20 years to keep water infrastructure operational, and some believe that is an underestimate. And these costs do not consider improving the resiliency of our infrastructure in response to rising sea level and more severe weather events. The participants stressed that for every $1 in SRF spending, of which $0.23 is the federal contribution, the U.S. Treasury receives $0.93 in federal tax revenues and that for every $1 million in SRF spending, $2.95 million is created in the local economy and 16.5 jobs are created with an average salary of $60,000/yr. President Trump released his "Skinny Budget" on March 16, 2017, only five days before the Fly-in, and it included a modest increase in funding for the SRF programs as well as funding WIFIA. This covered two of our four talking points but also caused other

Shelagh Connelly at Rally for Water on Capitol Grounds

concerns, which were then relayed to the delegations. The largest requested reductions compared to the enacted FY 2016 budget, the last year for which a full-year appropriation was completed, were at EPA (31 percent) and the U.S. Department of Agriculture (29 percent). The President's budget request would eliminate the Rural Water and Wastewater Loan and Grant Program ($498 million), funding for regional water programs such as the Sea Grant Program, and geographic-based funding ($427 million). Nonpoint grants are zeroed out from $165 million in FY 2017, and EPA's Critical Infrastructure Protection Program is zeroed out (providing cybersecurity assistance for utilities). EPA's Research Budget, meanwhile, is reduced by 50 percent (loss of $235 million from FY 2017), and its Enforcement Budget is reduced by 20 percent (loss of $129 million from FY 2017). This is just a partial list.

One concern is that this proposal may create unfunded mandates for states who will still be required to meet specific federal standards set for those watersheds but without federal funding to help them do so. For municipalities, the costs of additional systems are often passed down to them as well as the operation and maintenance (O&M) costs that they will be forced to pay in perpetuity. Additionally, the rise in O&M costs has outpaced capital expenditures consistently for years. As the costs to live in the core service areas continue to increase, there is more incentive to build outside these areas, causing numerous environmental issues such as forest fragmentation, failing septic tanks, and increased road and driveway building causing stormwater issues. In Vermont, 54 percent of the population use septic tanks already.

The NEWEA Congressional Briefing Breakfast is the premier event for the Government Affairs Committee. This year it was moved to a lunch, and the main topic was preparing for the meetings on Capitol Hill. Speakers included Rep. James McGovern of Massachusetts, our event sponsor, and various WEF officials. Speakers covered major water developments in Washington and tips for effective Congressional meetings, and we reviewed NEWEA's talking points. It took place on March 21 in the Cannon House Office Building, Room 121, and was the kickoff event for the National Water Policy Fly-in & Expo. The room was packed. Attendees also noted that the water in the Cannon House was non-potable due to lead issues, highlighting issues with aging infrastructure.

Additional events that were attended by many of the NEWEA participants on March 21 included WEF/NACWA sessions and a WEF/NACWA Welcoming Reception along with our NEWEA arrival dinner at the Teddy and The Bully Bar. March 22 started with a WEF/NACWA Congressional Breakfast followed by the National Water Week Rally on the Capitol grounds and the Water Week Capitol Hill Reception that evening where various U.S. senators and representatives talked about various water quality issues. These events were interspersed with each New England state's NEWEA Government Affairs Committee members meeting with their respective delegations. This is where the real work takes place. Legislators that we spoke with were both engaged and candid on water issues that our industry faces today. Thank you to all who attended and arranged meetings with their legislators. The NEWEA Government Affairs Committee drafted a thank you letter to the legislators that contained links to the information that we dispersed. In Vermont, we have already reaped benefits of the meeting as Senator Bernie Sanders agreed during the meeting to follow up with a meeting on May 5 on "affordability" in Vermont with various municipal and state representatives as well as representatives from Senator Leahy. We updated the participants with recent information such as NACWA's "2016 Cost of Clean Water Index," which showed that for the 15th consecutive year, the increase in the cost of sewer services nationally has outpaced the rate of inflation.

The Fly-in is a fantastic opportunity to advance water quality issues at the federal level, and you are highly encouraged to attend next year.

Links to Resources

- "Talking Points," newea.org/wp-content/uploads/2014/03/Briefing-Information-Packets.pdf
- "Elevate Water as a National Priority," waterweek.us/wp-content/uploads/2017/03/elevate_water.pdf
- "The Value of Water Campaign," thevalueofwater.org/sites/default/files/Economic%20Impact%20of%20Investing%20in%20Water%20Infrastructure_VOW_FINAL_pages.pdf
- NACWA's "2016 Cost of Clean Water Index," nacwa.org/docs/default-source/news-publications/White-Papers/2017-05-18nacwa_index.pdf?sfvrsn=4&utm_source=Real%20Magnet&utm_medium=email&utm_campaign=112277622

This year's WEF Residuals & Biosolids Conference was held in Seattle, Washington, in early April

Notes from the 2017 WEF RBC

This year's WEF Residuals & Biosolids Conference (RBC) was held in Seattle, Washington, in early April. Northwest Biosolids was co-sponsor and local host of the conference, ensuring some clear mornings that allowed Mount Rainier to shine on the southeast horizon and clear visions for resource recovery through biosolids.

Like many conferences in the past several years, the 2017 RBC focused on anaerobic digestion and associated topics such as co-digestion, thermal hydrolysis, and biogas cleaning and use. Held in the Northwest, where high percentages of biosolids are recycled to soils in mature, stable, and diverse programs, there was plenty of information on land application.

In her plenary session, Professor Sally Brown of the University of Washington highlighted the growing focus on soil health and the role biosolids and other organics play. The "brown revolution" (brown referring to soil, not Ms. Brown, she said), involves food security, profitability for small farms (<1000 ac [400ha]), carbon (C) sequestration, ecosystem resilience, and other interrelated benefits. Restorative farming and regenerating soils involves things being done already: no till, varied cover crops, high-intensity short-term grazing, manure, composts, biosolids, and char. Biosolids are part of the solution for fixing soils. "You have one of the best tools out there to create healthy soils," Dr. Brown noted.

Big-picture policy carried over from the plenary session to sessions on biosolids management, facility planning, and communications. Jimmy Slaughter (Beveridge & Diamond PC) summarized recent major court decisions in favor of biosolids recycling (e.g., the Kern County case, and a decision by the Pennsylvania Supreme Court). He noted also, however, a new tort lawsuit in northeastern Pennsylvania, where neighbors to a farm have filed suit against a biosolids management company. Bob O'Dette, a state regulator, described biosolids trends in Tennessee, and several engineers described facility plans for improved biosolids processing and products. An example was Todd Williams' (CH2M) discussion of the new biosolids composting operation at Kodiak, Alaska.

An increasing number of biosolids generators are treating biosolids processing and management like a business, designing biosolids products and analyzing markets, as shown in the following examples:

- In King County, Washington, the "loop" biosolids marketing campaign has set a new high standard for biosolids promotion. Associated with that is advancing public understanding of the minimal risks posed by microconstituents—trace chemical compounds—in biosolids. Kate Kurtz of King County presented a recent risk assessment and communications effort regarding trace organic chemicals in biosolids.
- DC Water is designing, blending, and testing soil amendments made with its new thermal hydrolysis Class A biosolids, to find and develop markets in Washington, D.C.
- The U. S. Department of Energy staged a full session on "energy-positive water resource recovery," looking at research and demonstration projects aimed at assessing the potential, and maximizing energy efficiency and recovery from wet waste streams through, for example, biodiesel production.
- Denver Metro is upping its charge for biosolids applications to farms to $0.15/lb ($0.33/kg) of plant-available nitrogen (PAN) applied, about 30 percent of the cost of equivalent commercial fertilizer for farmers. The Metro-owned and -managed farm recovered 25 percent of the resource recovery department's expenditures in 2016. The discussion is, can biosolids pricing go even higher, given the benefits they provide to farmers? This recent price increase in Denver's program led some farmers to complain, but it appears no one stopped ordering biosolids; it is still a good deal.

Many of the conference presentations delved into the technical details of anaerobic digestion, co-digestion, dewatering, thermal processes, and biogas use. There was a full session on biomethane—renewable natural gas; this hot topic is getting ever more attention because it can be the most valuable use of biogas in some cases. In contrast to the gas clean-up required for that, another presentation stressed the simplicity of using minimally treated biogas to generate electricity by using a new generation Stirling engine.

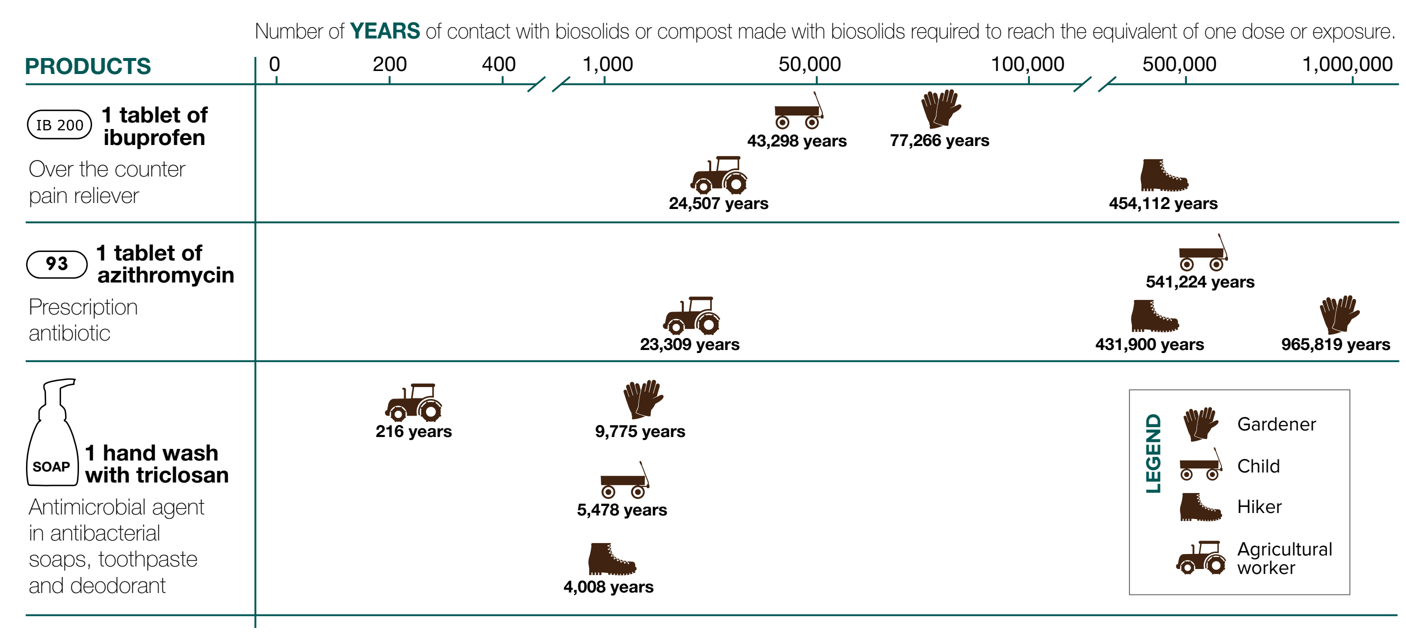
Gasification and pyrolysis remain a focus of biosolids energy generation efforts. A full-scale plant in Lebanon, Tennessee, is gasifying waste wood (~25 tons/d [23 tonnes/d]) with smaller amounts of biosolids (6 to 7 wet tons/d [5.4 to 6.4 wet tonnes/d]) and generating electricity with organic rankine cycle (ORC) engines, with a total carbon conversion efficiency of the system reported to be 90 percent. (To the best of the author's knowledge, this is the only full-scale biosolids gasification system operating in North America.) Meanwhile, lab research continues, as it has for many years, figuring out the ideal temperatures and pressures for obtaining just the right balance of syngas, bio-oil, and char from biosolids, for the best energy and reduced air emissions. Autocatalytic pyrolysis of biosolids looks hopeful, according to Professor Daniel Zitomer's team at Michigan; it can produce a little net energy, at least if the biosolids are mostly dried going into the process. But full-scale testing is some time off.

As usual, the committee meetings and networking offered a lot of value at the conference, as attendees learned about key developments in the field and what professionals are facing, for example:

- Recent changes in Washington and at EPA were reflected in discussions at the WEF Residuals and Biosolids Conference regarding the impacts of an executive order that would shake up the renewable identification markets, possibly inadvertently affecting biogas use projects.
- Retirements continue at a significant pace, drawing away decades of experience, such as upcoming retirements of two key leaders (Tom Granato, Dan Collins) of Chicago's massive biosolids program. In New England, Charlie Tyler, legendary leader at the Deer Island Treatment Plant in Boston and in state and regional associations (e.g. NEWEA), has retired.
- Privatization of biosolids management operations and public-private partnerships continue to be explored, as reflected, for example, in recent proposal requests from Jacksonville and several other cities in Florida.
- British Columbia continues its public debate of biosolids. A late-February two-day conference staged

Announcing: We Can Do It!
Managing Residuals in a Complex World
The Northeast Residuals & Biosolids Conference
Oct. 25–27, 2017 • Burlington, VT

NEBRA's annual conference.... with NEWEA's Residuals Management Committee, and, this year, Green Mountain Water Environment Association.... Full of info & fun in beautiful Burlington!



by concerned citizens and First Nations included David Lewis, formerly of EPA and a long-time critic, as well as representatives of biosolids programs of Metro Vancouver and Tacoma, Washington. Development of new provincial biosolids regulations is now delayed because of upcoming elections.

- Cities in the San Francisco Bay area are collaborating on developing biosolids management options in preparation for a likely phase-out of the use of biosolids as alternative daily cover, which is a common practice there in the wetter winter months. The change is being driven by a new California law aimed at reducing methane emissions from landfills.

In brief

Future of sludge—panel discussion

This discussion was held at the Connecticut Association of Water Pollution Control Authorities (CAWPCA) 2016 fall workshop and explored ideas on how Connecticut could diversify its wastewater solids management options. Currently, almost all Connecticut solids are incinerated. (Fairfield is the sole remaining biosolids compost facility.) With the new strict EPA air emissions regulations, the region's sewage sludge incinerators, many of which take outside solids, have had to limit their intake. There is growing awareness that having other options, such as anaerobic digestion, composting, and land application, could help the state's facilities be more resilient. Ensuring additional incineration capacity backup was also discussed. For example, the Hartford Metropolitan District has three incinerators but is only permitted to run two at a time; being allowed to run three in times of need, for example when another incinerator is down, would provide additional capacity. Brian Armet, former executive director of the Mattabassett District, moderated the panel, which included Melissa Hamkins (Wright-Pierce), Terry Szczesiul (Synagro Northeast), Roland Denny (Connecticut Department of Energy and Environmental Protection), and Ned Beecher (NEBRA). View the CAWPCA video of the panel discussion at cawpca.org/2016-fall-workshop-video-gallery.html.

Quebec publishes key biosolids reports

In 2016, the Quebec public health institute, the Quebec environment ministry, and RECYC-QUÉBEC released reports that advance biosolids and residuals recycling in the province.

One set of Frequently Asked Questions, released by the environment ministry, highlights a 2016 report (Samuels et al., 2016), which concluded that risks from chemicals and pathogens from biosolids applied in accordance with Quebec regulations are minimal and not that different from the risks from animal manure use. To mitigate risks, both require strict adherence to regulations and best management practices, which "should be maintained and amended in the light of new scientific knowledge."

Another ministry report provides information about the biosolid and other residuals that were recycled in Quebec in 2015. The report is comprehensive and a model of biosolids data compilation. In 2015, Quebec did the following:

- Diverted more than 1.5 million tonnes (1.65 million tons) of organic residuals from landfills
- Improved the soil of about 1,700 agricultural enterprises
- Recycled 42 percent of its municipal wastewater solids on 1.5 percent of its cultivated land

These efforts employed 30 firms and 60 agronomists.

RECYC-QUÉBEC and Solinov also recently released a "best practices" guide for recycling of municipal biosolids. According to the ministry, "The purpose of this guide is to assist municipal wastewater treatment plant managers in identifying key technical, administrative, and logistical aspects of establishing and maintaining a biosolids recycling program. It includes the information necessary for the planning and implementation of a recycling program, as well as a compilation of details to be included in program documents and contracts. It also includes case studies of five wastewater treatment plants that already recycle their biosolids; these are particularly interesting."

Ending a busy legislative season

This year, the legislative sessions in New Hampshire and Vermont were of greatest interest to residuals and biosolids programs. One bill would phase out land application of biosolids and septage in the Green Mountain state. It has been opposed by NEBRA and Green Mountain Water Environment Association, as well as by the Vermont Department of Environmental Conservation, and, after an initial hearing before the House Fish, Wildlife, and Natural Resources Committee, it has been retained for possible consideration next year. In New Hampshire, at press time, one bill continuing the land application of biosolids on certain farmlands near designated rivers seemed destined for passage. The New Hampshire legislature has approved the same thing every few years for the past couple of decades, and, this time, may make the law permanent.

Ned Beecher, Executive Director
Tamworth, N.H.
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For additional news or to subscribe to NEBRAMail, NEBRA's email newsletter visit nebiosolids.org

nebra
North East Biosolids & Residuals Association

Spotlight: **Killingly, Connecticut Water Pollution Control Facility**

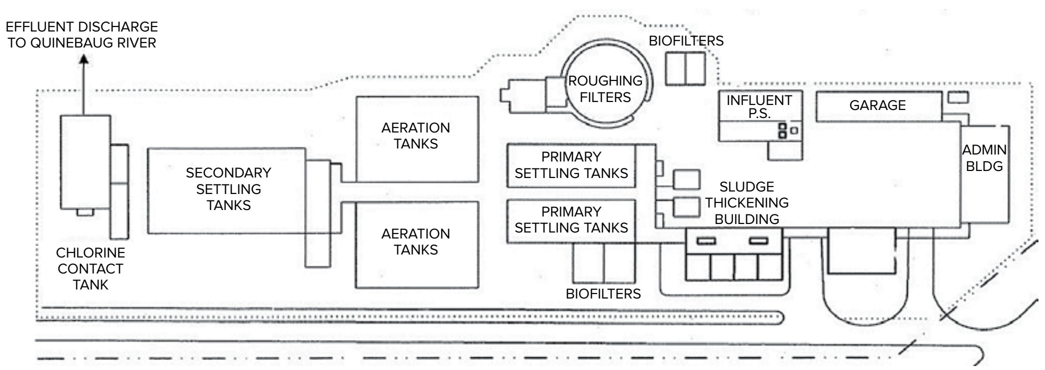
The Killingly Water Pollution Control Facility (WPCF) is publicly owned and has a design capacity of 8 mgd (30 ML/d), currently processing an average of 2.7 mgd (10.2 ML/d) that it discharges to the Quinebaug River. Built in 1975, the facility has evolved to meet the demand of its service area. The WPCF services the towns of Killingly and Brooklyn. Killingly, a community located in northeastern Connecticut, began around several mill villages that continue to function as active community centers. Killingly comprises the villages of Attawaugan, Ballouville, Dayville, East Killingly, Rogers, South Killingly, and the borough of Danielson. The Killingly area was originally a textile mill hub and one of the largest cotton producers in the state. Many of those historic mills have converted to businesses, shops, and restaurants, and the town has an industrial park and several commercial centers that also contribute wastewater flow. The WPCF serves an estimated population base of approximately 17,000 residents connected to the town's sanitary sewer system, which includes 14 lift stations, and around 60 miles (97 kilometers) of sanitary sewer and 1,200 manholes.

SUEZ Contract Operations

Suez Project Manager
Mark Cataldo

Consulting Engineer
Wright-Pierce

31 Wauregan Road
Danielson, Connecticut



The WPCF includes the following unit treatment processes: grit removal, primary sedimentation, a biofilter tower, activated sludge treatment with diffused aeration, secondary sedimentation, disinfection, and dechlorination. In 1979, the biofilter tower (trickling filter) was added at the facility to operate as a roughing filter prior to conventional aeration. The tower became necessary to accommodate the treatment demands of higher than normal organic loadings or biochemical oxygen demand (BOD) entering the facility. The influent is three times the strength of typical domestic wastewater due to high industrial flow content. The last major upgrade at the WPCF was in 2002.

Septage is received from 18 neighboring towns and typically represents 10 percent of the flow and 6 percent of the BOD loading. A new septage receiving facility, sized for an average flow of 30,000 gpd (114,000 L/d), was added to better handle the large septage volume. The new septage facility includes a septage screening unit that removes large solids from the septage and discharges the solids into a dumpster for disposal; an aerated septage holding tank that allows the septage to be metered into the plant during low BOD loading periods; odor control equipment consisting of chlorination equipment and biological filters; a septage receiving building; and a personal identification number (PIN) access system that allows septage haulers to activate the septage screening unit for discharge of septage while the unit records date, time, discharge volume, and other information for billing and record-keeping.

The WPCF has been operated by Suez since 1997 and has compiled numerous safety awards. A major upgrade is underway, estimated at $25.8 million. This upgrade will be for both the WPCF and the Rogers pump station. Construction has already commenced on the pump station and includes an electrical upgrade as well as flood-proofing to address new flood standards. The WPCF upgrade will refurbish the 42-year-old facility and add more advanced treatment systems to meet the more stringent state and federal guidelines for the removal of nitrogen and phosphorous. Around 40 enhancements are planned, including new influent screening facilities at the headworks, electrical upgrades throughout the facility, hazardous material removal, phosphorous removal treatment equipment, sludge dewatering facilities, and new emergency generators. Upgrade work is anticipated to commence in 2018.

WEF Delegate Report

NEWEA Leadership Shines at WEFMAX Puerto Rico

by Dan Bisson, Fred McNeill, and Susan Sullivan

NEWEA's leadership continues to shine nationally as our WEF delegates play a prominent role to help shape our industry's long-term goals and objectives. NEWEA is represented by three WEF delegates at the national level. The current delegates are Dan Bisson, Maine, Susan Sullivan, Massachusetts, and Fred McNeill, New Hampshire. Matt Formica, Massachusetts, is NEWEA's incoming delegate and will assume his duties this fall. In addition, Jennifer Lachmayr, Massachusetts, was appointed as one of WEF's national delegates-at-large. Finally, Howard Carter, Maine, was elected the 2017 speaker of the House of Delegates (HOD). Mr. Carter exemplifies a key contributor who has risen through local, regional, and national association ranks. Over the past 20 years he has served as president of the Maine's Water Environment Association and president of NEWEA, and is serving in a high-profile position within WEF.

WEFMAX

One responsibility of WEF delegates is participating in WEFMAX events. These WEF-sponsored three-day meetings offer industry leaders a forum to learn what is new from WEF, exchange member association (MA) information, and identify our industry's short- and long-term goals and objectives. MAs volunteer to jointly sponsor WEFMAX meetings with WEF. In 2017 WEFMAXs were held in San Juan, Puerto Rico, Cincinnati, Ohio, Austin, Texas, and Winnipeg, Manitoba.

wefmax
connecting ideas | inspiring leaders

At this year's first WEFMAX, in San Juan, Puerto Rico, the focus was on membership recruitment, retention, and engagement. Other topics included public communication and outreach, committee work, industry branding, and operator training. NEWEA was well represented and your delegates continued to take an active leadership role. Mr. Carter, as speaker of HOD, moderated the three days of sessions and meetings with about 80 attendees. Mr. Bisson, who serves on the Strategic Planning Work Group and Budget Committee, also attended WEFMAX. The Strategic Planning Work Group focused on working to bridge the gap between WEF and individual MAs to share knowledge and resources for conducting high-value and effective strategic planning initiatives that drive success and continuous improvement. The Budget Committee reviews the annual WEF budget, determines its consistency with the WEF Strategic Plan, and advises and directs WEF's senior leadership. Mr. Bisson presented on both subjects during WEFMAX.

At WEFMAX in San Juan, Puerto Rico: Anthony Giovannone discusses Young Professional activities, and Susan Sullivan presents on the work of the Outreach Committee

Ms. Sullivan serves as vice chair of the Outreach Committee. This committee is responsible for communicating HOD activities, progress, and work products to MA leadership. She presented the work of her committee during the second day of the WEFMAX. Ms. Sullivan also sits on the WEF Strategic Planning Committee and is a member of the WEF Awards Committee.

Mr. McNeill is NEWEA's newest WEF delegate and serves on the WEFMAX Events Committee. Future WEFMAXs are scheduled through 2020. Next year's locations are in Alaska, Arkansas, Indiana, and North Carolina. NEWEA last hosted a WEFMAX in 2010 in Providence, Rhode Island. There were initial discussions of NEWEA hosting a WEFMAX together with our spring meeting, which would expand that event to include a national perspective.

NEWEA was also represented by other members who attended the San Juan WEFMAX. Anthony Giovannone presented to the group on 10 years of the Young Professionals' highly successful service projects at WEF. Robert Domkowski, vice chair for WEFTEC vendors, also attended and added his expertise and input regarding WEF's largest and most successful event.

WEFTEC

WEFTEC 2017, WEF's 90th Technical Exhibition and Conference, is scheduled for September 30 to October 4 in Chicago. WEFTEC is recognized as the world's largest annual water quality exhibition; its massive show floor provides unparalleled access to the field's most cutting-edge technologies and services. Please consider joining your NEWEA colleagues at WEFTEC 2017 in Chicago.

Student Design Competition

by Annalisa Onnis-Hayden
Chair, Student Activities Committee

The winning team—Northeastern University's Erika Towne, Lindsey Carver, and Catherine Moskos

The second NEWEA Student Design Competition (SDC) organized by the Student Activity Committee was recently completed. This competition intended to promote "real world" design experience for students interested in pursuing an education and/or career in water engineering and sciences. The competition tasked teams of student members within NEWEA to design a project that they have worked on together. Student teams submitted written reports and presented their findings in front of judges during the SDC reception and presentation, held on April 27 at Northeastern University (NU) in Boston. The competing teams were from NU, University of Rhode Island (URI), and Massachusetts Institute of Technology (MIT).

The teams presented on the following:

- The NU team presented *Lions Gate Secondary Wastewater Treatment Plant: Design and Modeling*
- The MIT team presented *Infrastructure for Green Cities: Designing Urban Constructed Wetlands*
- The URI team presented *Nitrogen Recovery and Energy Saving Using Bioflocculation in Wastewater Plants*

The judges evaluated the technical aspects, the appearance and structure of the written submittal, and the content organization and effectiveness of the presentation. Following the evaluation, the NU team was selected as the winner.

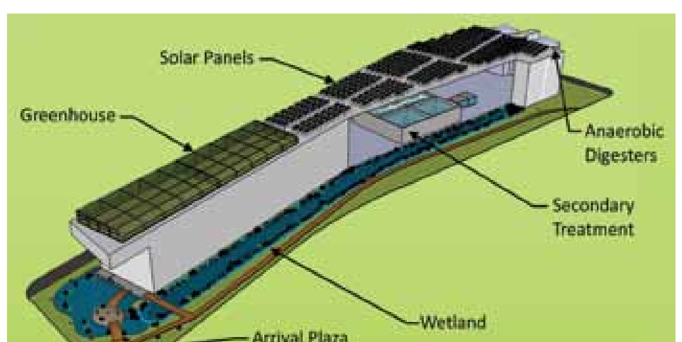
The NU project included the design and modeling of the Lions Gate Secondary Wastewater Treatment Plant (LGSWWTP) in North Vancouver, British Columbia. The preliminary design satisfies a new ammonia regulation for secondary treatment and addresses various sustainability goals, including resource recovery and community engagement. Ammonia removal is accomplished through the design of mainstream and sidestream treatment processes. The technology chosen for mainstream and sidestream treatment is integrated fixed film activated sludge and single reactor high activity ammonium removal over nitrite, respectively. The three resources that will be recovered at the site are stormwater, energy, and biosolids. These are recovered through design of a flow regulator tank and a wetland, production of biogas and biosolids in the anaerobic digesters, and placement of solar panels on the roof. Multiple features have been incorporated into the model of the LGSWWTP to promote community involvement, such as an arrival plaza, a pond, a greenhouse, public benches, public paths, and educational opportunities.

MEET THE WINNING TEAM

Erika Towne led the research and design of a stormwater management system for the plant. She analyzed the site's drainage area and existing characteristics to design a wetland. Ms. Towne also designed both a flow regulator tank and a broad crested weir and culvert to direct treated stormwater into a pond.

Lindsey Carver led the research and design of the sidestream secondary treatment of the plant. She modeled the sidestream treatment in BioWin and conducted a cost estimate for the project. Ms. Carver also calculated and optimized the amount of resources (such as biogas, biosolids, and solar energy) that could be recovered. Additionally, she created a 3D rendering of the plant design in SketchUp.

Catherine Moskos led the research and design of the mainstream secondary treatment. She focused on modeling in BioWin and optimizing the plant design. Ms. Moskos also designed components of the secondary treatment, such as the bioreactors, sidestream reactors, and anaerobic digesters.



The winning project

Competition judges were: Peter Lyons (Woodard and Curran), Nicholas Ellis (Hazen and Sawyer), Brian Tafe (Kleinfelder), Jerry Hopcroft (SAC and WIT), Vanessa Borkowski (Stantec), Ben Stoddard (Kleinfelder), Jim Barsanti (Town of Framingham, NEWEA), and Yuqi Wang (Kleinfelder).

The winning team will receive a $600 prize and allowance of up to $2,500 to travel to WEFTEC 2017 where the team will present its project at the WEF SDC.

One Water

NEWEA & NEWWA Explore Collaborative Training

by Janice Moran NEWEA Program Coordinator

The New England Water Environment Association (NEWEA) and New England Water Works Association (NEWWA) have a long-standing positive relationship for information sharing on topical issues as well as participating in joint programs where our initiatives converge.

Reflecting each organization's focus toward "Total Water Solutions" and the concept of "One Water," NEWEA and NEWWA have established a Joint Exploratory Group to develop a closer working relationship, investigate collaborative opportunities, and initiate specific programs to benefit the members of each organization. With officers, staff, and active members assigned to the working group from each organization, exciting and positive steps have been achieved to define opportunities and create programs consistent with this focus.

As the centerpiece of the continuing work by the Joint Exploratory Group, a Vision Statement was adopted—reflecting the group's priorities and to guide ongoing efforts:

Based on a wealth of common opportunities in the world of water, NEWEA and NEWWA are poised to work more closely together to benefit the members of both organizations. This enhanced collaborative effort will be a continuing goal focused on adopting the concept of "One Water."

An initial meeting was held in Holliston last November. Subsequent meetings were held in April and May with significant progress made to identify our initial collaborative programs. The discussions have been positive and productive with a structured process for assessing the value of initiatives to each organization and its members.

At the May meeting, the working group established the framework for our initial collaboration efforts, focusing on areas with shared priorities. The four topics proposed are:

- **Government Affairs**. Singular messages for investment in water infrastructure and rational environmental regulation will serve as more effective communications to federal and state governments. These efforts will be in coordination with each state's water organizations and their meetings with state legislators.
- **Training and Workshops**. There are numerous opportunities to provide training and education for topics of value common to both organizations. The intent with this effort is to focus on technology for utility management, specifically for Asset Management, and Cybersecurity. The goal will be to conduct a joint "IT Fair" in 2018.
- **Young Professionals**. Both organizations share a high priority to attract and retain students and young professionals to occupations in water. Both organizations have active programs to carry out these important efforts. The goal will be to expand joint NEWEA/NEWWA "YP" programs providing education on industry issues, networking opportunities, and association membership incentives.
- **Awards Program**. The group supports the establishment of a "New England One Water Award" to highlight innovation incorporating the concept of "One Water." The award will recognize individuals and organizations relative to total water solutions.

Additional information will be provided as the important work of this group continues.

Thank you
James R. Barsanti, President
Mary M. Barry, Executive Director

NEWEA WORKING FOR WATER QUALITY & New England Water Works Association a Section of the American Water Works Association

Specialty Conference, Webinar, and Training Proceedings

A team from Connecticut runs through the Collection Systems event at the Ops Challenge Training Day at the Holyoke, MA Wastewater Treatment Plant

SUSTAINABILITY & COLLECTION SYSTEMS CONFERENCE

The New England Water Environment Association's Sustainability & Collection Systems Committee held a joint specialty conference on May 1, 2017, at the Doubletree Hotel in Westborough, Massachusetts. Over 90 attendees participated in the specialty conference.

The specialty conference brought together the concepts of sustainability with design, construction and implementation of wastewater collection system infrastructure. The technical presentations commenced on Monday, May 1, 2017, with NEWEA President Jim Barsanti and NEWEA Sustainability Committee Chair Rob Montenegro providing the Welcome and Opening Remarks to meeting attendees.

In addition to the program, a keynote presentation was given by Stephen Estes-Smargiassi, director of planning, Massachusetts Water Resources Authority.

MORNING SESSION: MAINTENANCE AND PLANNING

Moderators:
- Ryan Wingard, Wright-Pierce
- Wayne Bates, Tighe & Bond

Improving Fat, Oil and Grease (FOG) Management in Urban Wastewater Sewer Networks Through Technology Integration –
- Michael O'Dwyer, SwiftComply

Sustainable Maintenance Practices –
- Joseph Buckley, City of Worcester, MA DPW
- Mark Hollis, City of Worcester, MA DPW

PACP® Asset Management –
- Laurie Perkins, Wright-Pierce

Taking it to the Next Level: Predictive Models Based on Over 500 Miles of Force Main Condition Assessment –
- Jeffrey Zdrojewski, Pure Technologies

AFTERNOON SESSION: PUMPS AND PIPING SYSTEMS

Moderators:
- Meredith Zona, Stantec
- Scott Naiva, Milliken

Intelligent Wastewater Pumps—The Next Pump Industry Breakthrough
- Bob Domkowski, Xylem

Utilizing Two Trenchless Rehabilitation Technologies to Reduce Wet Weather Flows in the Bear Brook Watershed—Saco, ME Case Study
- Matt Timberlake, Ted Berry Company, Inc.

Pumping Station Consolidation and Trenchless Installation Case Study—New River Street Pump Station Project
- Timothy McDonald, ARCADIS US, Inc.

Reviewing Stormwater Collection Projects through a Sustainability Lens
- Wayne Bates, Tighe & Bond
- Joseph Persechino, Tighe & Bond

EXHIBITORS

ADS Environmental
CSL Services, Inc.
CUES
Duke's Root Control Inc
F R Mahony & Associates Inc
Flow Assessment Services LLC
JWB Company/BAU Hopkins
Precision Trenchless, LLC
Pump Systems, Inc.
Scavin Equipment Company LLC

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ADS Environmental Services
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CDM Smith
Dewberry
Duke's Root Control
Environmental Partners Group
EST Associates
Flow Assessment Services
Fuss & O'Neill

SPONSORS (continued)

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Hayes Pump
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Hoyle, Tanner & Associates, Inc.
NASSCO
Tata & Howard
Ted Berry Company
Tighe & Bond
Vaidya Consultants
Weston & Sampson
Woodard & Curran
Wright-Pierce
WSP/Parsons Brinckerhoff

JOINT EFFECTIVE UTILITY MANAGEMENT WEBINAR

The EPA partnered with NEWEA and New England Water Works Association (NEWWA) to host an introductory webinar, *Effective Utility Management: Your Path to Sustainability*, on February 28, 2017.

OPERATIONS CHALLENGE FACILITY TOUR & TRAINING DAY

NEWEA's Operation Challenge Committee held a Facility Tour and Training Day on Friday, April 7, 2017, at the Holyoke, Massachusetts Wastewater Treatment Plant (WWTP). Forty-five attendees participated.

Attendees learned about Operations Challenge and the five competition events (Collection Systems, Process Control, Laboratory, Safety, and Maintenance). This event also included a facility tour of the Holyoke, Massachusetts WWTP and a barbecue luncheon.

SPONSORS

Aqua Solutions
Brown and Caldwell
David F. Sullivan & Associates
Dewberry
EJ Prescott
Flow Assessment Services
Kleinfelder
NASSCO
Suez
Tata & Howard
Ted Berry Company
The MAHER Corporation
Weston & Sampson
Woodard & Curran

Stephen Estes-Smargiassi delivers the keynote address at the Sustainability and Collection Systems Conference at the Doubletree Hotel in Westborough, Massachusetts

The MWRA's Cori Barrett, John Colbert, and, Anandan Navanandan (Nava) attend the Sustainability and Collection Systems Conference

Participants pose for a group photo at the Operations Challenge Training Day at the Holyoke, Massachusetts wastewater treatment plant

Upcoming Meetings & Events

JOINT NEWEA WATERSHED COMMITTEE, NEWWA, NEAPWA CLIMATE CHANGE CONFERENCE
July 12, 2017
UMass Lowell, Lowell, MA

POO & BREW AND STORMWATER TOO
July 13, 2017
South Portland WWTP, Portland, ME

NEWEA COMMITTEE APPRECIATION EVENT
July 27, 2017
Kimball Farms, Westford, MA

INDUSTRIAL WASTEWATER CONFERENCE & TOUR
September 13, 2017
RedHook Brewery, Portsmouth, NH

WEFTEC
September 30 – October 4, 2017
McCormick Place, Chicago, IL

GOLF CLASSIC BENEFIT
October 16, 2017
New Bedford Country Club
New Bedford, MA

JOINT STORMWATER CONFERENCE—MEWEA AND NE STORMWATER COLLABORATIVE
October 23 – 24, 2017
Holiday Inn, Portland, ME

NORTH EAST RESIDUALS & BIOSOLIDS CONFERENCE
October 25-27, 2017
Hilton, Burlington, VT

This is a partial list.
Please visit the state association websites and NEWEA.org for complete and current listings.

AFFILIATED STATE ASSOCIATIONS AND OTHER EVENTS

RI NWPCA TRADE SHOW & CLAMBAKE
September 8, 2017
Twelve Acres Banquet Facilty
Smithfield, RI

MWPCA TRADE SHOW
September 13, 2017
Wachusett Mountain
Princeton, MA

NHWPCA FALL MEETING
September 15, 2017
Manchester WWTF
Manchester, NH

NEWWA ANNUAL CONFERENCE
September 17 – 20, 2017
Ocean Edge Resort
Brewster, MA

MEWEA FALL CONFERENCE - 50TH
September 21 – 22, 2017
Sunday River, Newry, ME

BLUE TECH EDUCATION & INNOVATION EXPO
October 14, 2017
Sandwich, MA

GMWEA FALL TRADESHOW & CONFERENCE
November 9, 2017
Sheraton Conference Center, Burlington, VT

NHWPCA WINTER MEETING
December 8, 2017
Newmarket WWTF
Newmarket, NH

NEWEA invites you to join us for an evening reception at the historic Soldier Field during WEFTEC in Chicago, Illinois

The reception will be held at Soldier Field, a historic and elegant stadium located in downtown Chicago, exactly 1 mile from the Hilton Chicago hotel. Originally opened in 1924, the venue is the home field of the Chicago Bears and the oldest NFL football stadium in the country. In 2003, the Stadium was completely renovated but maintained its traditional external appearance. Soldier Field is the first NFL stadium to be declared LEED certified, and continues to set the standard for historic stadiums with a positive environmental impact.

Soldier Field is located in the scenic Museum Campus at 1410 Museum Campus Drive, It is one mile (20 minute walk) from the NEWEA hotel, the Hilton Chicago, and is also serviced by local buses and the "L" train.

EVENT DETAILS
The NEWEA Reception offers an evening of fun in the Skyline Room at Soldier Field to network with NEWEA leadership, and other NEWEA WEFTEC attendees!

Activities Include:
- Networking
- Hors d'Oeuvres & appetizers
- Spectacular views of Solider Field and Lake Michigan
- Cash bar

RSVP date—
Friday, September 22, 2017

New England Water Environment Association, Inc.

Statement of activities
For the years ended September 30, 2016 and 2015

Changes in unrestricted net assets:	**2016**	**2015**
Revenues and gains:		
Registration Fees	$570,419	$447,778
Exhibitor Fees	245,415	266,562
Membership Dues	42,174	10,388
Pass Through Dues	55,839	77,495
Advertising and Subscriptions	84,441	86,171
Sponsorships	72,059	72,015
Certification Fees	9,765	12,235
NEBRA Management revenue	–	–
Other Income	16,788	10,214
Total unrestricted revenues and gains	**1,096,900**	**982,858**
Total unrestricted revenues and gains and other support	**1,096,900**	**982,858**
Expenses:		
Program services	857,800	714,472
Management and general	264,722	245,343
Pass Through Dues	30,023	25,636
Total expenses	**1,152,545**	**985,451**
(Decrease) Increase in unrestricted net assets	(55,645)	(2,593)
Changes in temporarily restricted net assets:		
Endowment income	29,082	3,411
Scholarship expense	9,000	9,000
Increase (decrease) in temporarily restricted net assets	20,082	(5,589)
(Decrease) increase in net assets	**(35,563)**	**(8,181)**
Net assets, beginning of year	**664,455**	**672,637**
Net assets, end of year	**$628,892**	**$664,456**

New Members March – May 2017

David Acheson
Danville, NH (PWO)

David Comeau
Palmer, MA (PWO)

Kathryn Conoby
Acton, MA (YP)

Sarita S. Croce, Merrimack WTF,
Merrimack
NH (PWO)

Sean Dean
Fish & Richardson
Boston, MA (PRO)

Valarie Doerrer
Town of Concord
Concord, MA (PRO)

Nicholas Erickson
City of Fitchburg WWTF
Fitchburg, MA (YP)

Jessica Frackelton
ONSET Computer Corporation
Bourne, MA (PRO)

Alan George
Frederica, DE (PRO)

Tarun Gill
HDR Engineering Inc.
Boston, MA (PRO)

Rola Hassoun
CDM Smith
Providence, RI (YP)

Cameron Jenkins
Stoneham, MA (YP)

Myles Johnson
Saugus, MA (PRO)

Ziad Kary
Environmental Partners Group Inc.
Quincy, MA (PRO)

Ryan Kenney
PC Construction Company
Portland, ME (PRO)

Daniel Kramer
Woodard & Curran
Dedham, MA (YP)

Tabatha Lewis
Brookfield, CT (STU)

Jeffrey Liebowitz
Manhattan College
Wilton CT (YP)

Robert Marchesseault
North Reading, MA (PRO)

Reagan Masson
East Lyme, CT (STU)

Patrick Moran
Rowley, MA (STU)

Sean Naaykens
HACH Company
Loveland, CO (PRO)

Noah Palmer
Ludlow, MA (STU)

Laurie Ruszala
Town of Franklin DPW,
Franklin, MA (PWO)

William Sanderson
Town of Milton
Milton, VT (PWO)

Michael Supernant
Fiskdale, MA (PWO)

Luigi Tiberi
Ovivo, USA, LLC.
Salt Lake City, UT (PRO)

Michael Trotta
Town of Canton
Canton, MA (PRO)

Katherine Watkins
Cambridge Public Works
Cambridge, MA (PRO)

Jacob Weinrich
Tighe & Bond Consulting Engineers
Westfield, MA (YP)

Matthew Weisman
Town of Lexington
Lexington, MA (YP)

Patrick Wiley
Kennebunk, ME (PRO)

Chris Williams
South Essex Sewerage Dist.
Salem, MA (PWO)

Olivia Apergis
Bristol, CT (STU)

Dounia Elkhatib
East Greenwich, RI (STU)

Mike Hastings
Energy Systems Group
Greene, ME (PRO)

Laurie Horridge
Narragansett Bay Commission
Providence, RI (PRO)

Adam Moskal
Portsmouth, NH (PRO)

Kim Sandbach
Narragansett Bay Commission
Providence, RI (PRO)

William Smith
Weston & Sampson Engineers Inc.,
Chatham, MA (PRO)

Giovanni Amato
City of Newport
Newport, RI (PRO)

Mark Bukowski
Town of Windsor Locks WPCA
Windsor Locks, CT (PWO)

Cliff Germain
Greater New Haven WPCA
New Haven, CT (PWO)

Russell McGinnis
Narragassett Bay Commission
Providence RI (YP)

Isabella Schroeder
Greater New Haven WPCA
New Haven, CT (PRO)

Academic (ACAD)
Affiliate (AFF)
Complimentary (COMP)
Corporate (COR)
Dual (DUAL)
Executive (EXEC)
Honorary (HON)
Life (LIFE)
Professional (PRO)
Professional WW/OPS (PWO)
Student (STU)
Young Professional (YP)

Advertiser Index

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NEWEA/WEF* Membership Application 2017

Water Environment Federation – the water quality people · NEWEA – Working for Water Quality

Personal Information

Last name | M.I. | First Name | (jr. sr. etc)

Business Name (if applicable)

Street or P.O. Box (☐ Business Address ☐ Home Address)

City, State, Zip, Country

Home Phone Number | Mobile Phone Number | Business Phone number

Email Address | Date of birth (month/day/year)

☐ Please send me information on special offers, discounts, training, and educational events, and new product information to enhance my career ☐ by e-mail ☐ by fax

☐ Check here if renewing, please provide current member I.D.

***NEWEA is a member association of WEF (Water Environment Federation). By joining NEWEA, you also become a member of WEF.**

Employment Information (see back page for codes)

1. ORG Code: | Other (please specify): | 2. JOB Code: | Other (please specify):

3. Focus Area Codes: | Other (please specify:

Signature (required for all new memberships) | *Date*

Sponsorship Information

WEF Sponsor name (optional) | Sponsor I.D. Number | ACQ. Code for WEF use only | WEF 15

Membership Categories (select one only)

		Member Benefit Subscription	Dues
☐ **Professional Package**	Individuals involved in or interested in water quality	■ *WE&T* (including *Operations Forum*) ■ *WEF Highlights Online*	$185
☐ **Young Professional Package**	New members or formerly student members with 5 or less years of experience in the industry and less than 35 years of age. This package is available for 3 years.	■ *WE&T* (including *Operations Forum*) ■ *WEF Highlights Online*	$69
☐ **Professional Wastewater Operations (PWO) Package**	Individuals in the day-to-day operation of wastewater collection, treatment or laboratory facility, or for facilities with a daily flow of < 1 mgd or 40 L/sec.	■ WE&T (including *Operations Forum*) ■ *WEF Highlights Online*	$109
☐ **Academic Package**	Instructors/Professors interested in subjects related to water quality.	■ *WE&T* (including *Operations Forum*) ■ *WEF Highlights Online* ■ *Water Environment Research* (Online)	$181
☐ **Student Package**	Students enrolled for a minimum of six credit hours in an accredited college or university. Must provide written documentation on school letterhead verifying status, signed by an advisor or faculty member.	■ *WE&T* (including *Operations Forum*) ■ *WEF Highlights Online* ■ *Water Environment Research* (Online)	$10
☐ **Executive Package**	Upper level managers interested in an expanded suite of WEF products/services.	■ *WE&T* (including *Operations Forum*) ■ *WEF Highlights Online* ■ *World Water* ■ *Water Environment Research* (Online) ■ *Water Environment Regulation Watch*	$353
☐ **Dual**	If you are already a member of WEF and wish to join NEWEA		$40
☐ **Corporate Membership** (member benefits for one person)	Companies engaged in the design, construction, operation or management of water quality systems. Designate one membership contact.	■ *WE&T* (including *Operations Forum*) ■ *Water Environment Research* (Print) ■ *Water Environment Regulation Watch* ■ *WEF Highlights Online*	$411
☐ **New England Regulatory Membership**	This membership category is a NEWEA only membership reserved for New England Environmental Regulatory Agencies, including: USEPA Region 1, CT Department of Energy and Environmental Protection, ME Department of Environmental Protection, MA Department of Environmental Protection, NH Department of Environmental Services, VT Department of Environmental Conservation, and RI Department of Environmental Management		$50

WEF Utility Partnership Program (UPP): NEWEA participates in the WEF Utility Partnership Program (UPP) that supports utilities to join WEF and NEWEA while creating a comprehensive membership package for designated employees. As a UPP Utilities can consolidate all members within their organization onto one account and have the flexibility to tailor the appropriate value packages based on the designated employees' needs. Contact WEF for questions & enrollment (703-684-2400 x7213).

Payment

☐ **Check or money order enclosed** Made payable to NEWEA 10 Tower Office Park, Suite 601 Woburn, MA 01801 For more information: 781.939.0908 Fax 781.939.0907 NEWEA.org	**Charge** ☐ Visa ☐ American Express ☐ Master Card ☐ Discover	Card # | Security/CVC Signature | Exp. Date Daytime Phone	*Depending upon your membership level, $10 of your dues is allocated towards a subscription to the NEWEA Journal.*
Billing Address (☐ check here if same as above)	Street/PO Box	City, State, Zip	

NEWEA/WEF* Membership Application 2017

To help us serve you better, please complete the following:

(choose the one that most closely describes your organization and job function)

***NEWEA is a member association of WEF (Water Environment Federation). By joining NEWEA, you also become a member of WEF.**

What is the nature of your ORGANIZATION?

(circle one only) (ORG)

1 Municipal/district Water and Wastewater Plants and/or Systems

2 Municipal/district Wastewater Only Systems and/or Plants

3 Municipal/district Water Only Systems and/or Plants

4 Industrial Systems/Plants (Manufacturing, Processing, Extraction)

5 Consulting or Contracting Firm (e.g., Engineering, Contracting Environmental, Landscape Architecture)

6 Government Agency (e.g., U.S. EPA, State Agency, etc.)

7 Research or Analytical Laboratories

8 Educational Institution (Colleges and Universities, libraries, and other related organizations)

9 Manufacturer of Water/Wastewater Equipment or Products

10 Water/Wastewater Product Distributor or Manufacturer's Rep.

11 Stormwater (MS4) Program Only

12 Public Financing, Investment Banking

13 Non-profits (e.g., Trade, Association, NGO, Advocacy, etc.)

99 Other _____________ (please specify)

What is your Primary JOB FUNCTION?

(circle one only) (JOB)

1 1. Upper or Senior Management (e.g., President, Vice President, Owner, Director, Executive Director, General Manager, etc.)

2 Engineering, Laboratory and Operations Management (e.g., Superintendent, Manager, Section Head, Department Head, Chief Engineer, Division Head, Landscape Architect etc.,)

3 Engineering and Design Staff (e.g., Consulting Engineer, Civil Engineer, Mechanical Engineer, Chemical Engineer, Planning Engineer, Landscape Architect, Environmental/ Wetland Scientist etc.)

4 Scientific and Research Staff (e.g., Chemist, Biologist, Analyst, Lab Technician, Environmental/Wetland Scientist etc.)

5 Operations/Inspection & Maintenance (e.g., Shift Supervisor, Foreman, Plant Operator, Service Representative, Collection Systems Operator, BMP Inspector, Maintenance, etc.)

6 Purchasing/Marketing/Sales (e.g., Purchasing, Sales Person, Market Representative, Market Analyst, etc.)

7 Educator (e.g., Professor, Teacher, etc.)

8 Student

9 Elected or Appointed Public Official (Mayor, Commissioner, Board or Council Member)

10 Other _____________

What are your KEY FOCUS AREAS?

(circle all that apply) (FOC)

1 Collection Systems

2 Drinking Water

3 Industrial Water/Wastewater/ Process Water

4 Groundwater

5 Odor/Air Emissions

6 Land and Soil Systems

7 Legislation (Policy, Legislation, Regulation)

8 Public Education/Information

9 Residuals/Sludge/Biosolids/Solid Waste

10 Stormwater Management/ Floodplain Management/Wet Weather

11 Toxic and Hazardous Material

12 Utility Management and Environmental

13 Wastewater

14 Water Reuse and/or Recycle

15 Watershed/Surface Water Systems

16 Water/Wastewater Analysis and Health/ Safety Water Systems

17 Other _____________

Optional Items (OPT)

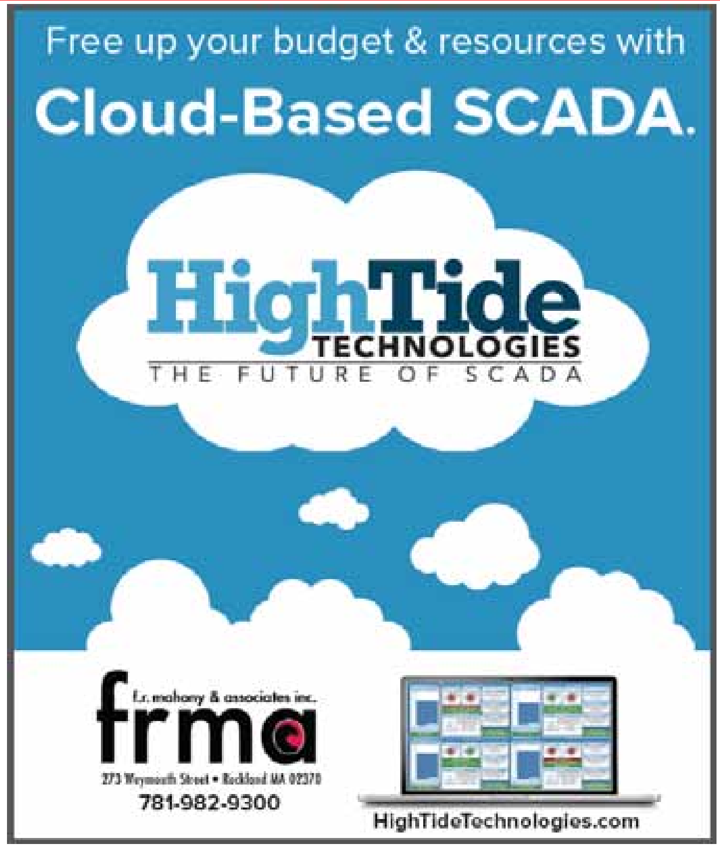
Years of industry employment? _______
1 (1 to 5) **2** (6 to 10) **3** (11 to 20)
4 (21 to 30) **5** (>30 years)

Gender? _______
1 Female **2** Male

Education level? (ED) _______
1 High School **2** Technical School
3 Some College **4** Associates Degree
5 Bachelors Degree
6 Masters Degree **7** JD **8** PhD

Education/Concentration Area(s) (CON) _____
1 Physical Sciences (Chemistry, Physics, etc.)
2 Biological Sciences **3** Engineering Sciences
4 Liberal Arts **5** Law **6** Business

Water quality professionals, with fewer than 5 years working experience and under the age of 35, are eligible to join WEF as an Active Member, while participating in the NEWEA/WEF Young Professionals Program. This program allows up to 50% off of the Active Member dues, valid for the first three years of membership. This program is available for new member applicants and Student Members.



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