JOURNAL OF THE NEW ENGLAND WATER ENVIRONMENT ASSOCIATION

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BIOSOLIDS AND OTHER WASTEWATER-DERIVED SOURCES

From 503 to infinity

From disposal to beneficial use—10 years of sustainable biosolids management at the Greater Lawrence Sanitary District

Two-phased anaerobic digestion makes New England debut in Vermont

Beneficial use of brown grease—a green source of petroleum-derived hydrocarbons

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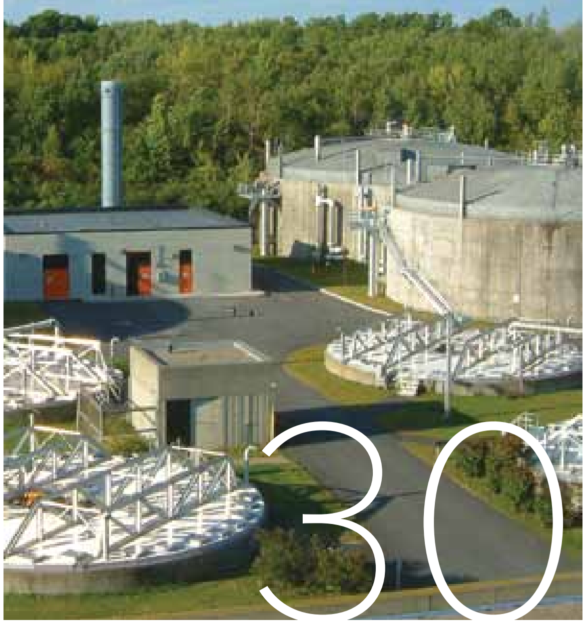

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On the cover: a farm tractor in Stowe Vt.; biosolids and other organic residuals are often used as soil amendments and fertilizers.

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Join us

OUR ASSOCIATION WAS ORGANIZED EIGHTY-FIVE 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:

A 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.

An 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.

A Corporate Member shall be a sewerage board, department or commission; sanitary district; or other body, corporation or organization engaged in the design, consultation, operation or management of water quality systems.

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A 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.

A 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.

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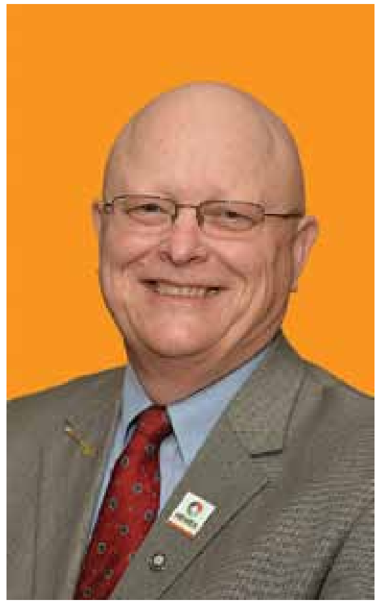

Bradley Moore
Superintendent
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President's message

Dear NEWEA Member,

Resources—no matter how we are associated with the water industry, we all need resources to work more productively. In today's secular atmosphere, most of us are stressed for time and searching for ways to do more with less. NEWEA's mission statement affirms, in part, that our organization will promote the "advancement of knowledge and technology of design, construction, and operation and maintenance of treatment works."

Our association, in accomplishing its stated mission, provides valuable resources that we can and should take advantage of. NEWEA's conferences and seminars provide timely information and networking opportunities. A good example is our spring conference, which was held on the Maine coast at the Samoset in Rockland this year. Many spring conference attendees approached me and commented on the quality of the technical sessions and spoke of how they could apply the information at their facilities. Another resource is our series of specialty conferences such as asset management, held in Portsmouth, N.H., which highlighted practical examples of asset management programs that the attendees could use. Breakout sessions provided hands-on activities, and a forthcoming asset management white paper will be useful for many of our members. An asset management community reunion is planned for the 2015 NEWEA Annual Conference in January—further evidence of the value of the specialty conferences for industry connectivity and camaraderie.

This *Journal* has for years been recognized for its quality and also as a valuable technical resource. For instance, two articles in this edition focus on sustainable approaches to biosolids management. Perhaps one could say that talk of sustainability and biosolids is nothing new, but the innovative approaches that these facilities took, viewing biosolids as a sustainable resource and eliciting up-front buy-in from customers, provides valuable information.

NEWEA's public education and outreach have been recognized by the Water Environment Federation, and in September we will receive the national Member Association Public Education Award. This well-deserved recognition for the hard work by many in NEWEA is an award of which we should be proud. The major basis for the award was the successful roll-out of our "NEWEA School Kit," a resource we all can use to help educate our communities, with the focus on schools. On our Web site, check out the President's Challenge to see how you can use this freely accessible kit to get our message out to school children. This is one more NEWEA resource that we can use to demonstrate the value of what we provide—clean water and protection of public health.

It is hard to believe that my presidency is approaching its halfway point. I have thoroughly enjoyed the opportunity to serve. It has been especially busy with the transition to our new executive director, Mary Barry, but she has assumed the position smoothly; please introduce yourself to her and let her know what NEWEA means to you. I look forward to Mary's leadership and help in moving our association toward continued pre-eminence as a resource in our industry. And whether you choose to become actively involved in the organization or just to improve your local outreach by using materials provided by NEWEA, I urge you to take advantage of the resources available in our active and healthy association.

From the Editor

The *Journal's* continued goal is to educate our membership and the public on waste stream topics. This quarter we focus on the beneficial use of biosolids and other wastewater by-products. As we look to continue to find effective uses for waste we must not harm the environment and we must always protect public health. Guest Editor Ned Beecher, executive director of NEBRA, presents a retrospective of the 503 Standards for Use or Disposal of Sewage Sludge. Interestingly, EPA has continued to refine this standard over the years from its beginnings in 1983. The goal of the refinements is to continue to investigate potential health and environmental issues as they relate to sewage sludge disposal and land application. This article discusses the creation of the standard and the environmental and human health risk modeling used to create and refine the standards over the years. I hope you find it interesting and share it with others who are concerned about the potential negative impacts of biosolids and land application.

Our second article charts the evolution of a 10-year program for sustainable biosolids management at the Greater Lawrence Sanitary District. This article provides a model for how wastewater utilities can make operations more sustainable by adopting biosolids as a resource. The community leveraged grant funding and a design-build-operate procurement process. Over the last 10 years the District's aggressive goals have paid off: virtually 100 percent of the biosolids have gone to beneficial-use applications, nearly 80 percent of the digester gas is used for process heat and building heat; contract operations are going well; and more than $1 million in annual savings have been realized.

The third article discusses energy as a by-product of the beneficial use of sewage sludge through anaerobic digestion as part of plant upgrades at the Brattleboro and South Burlington, Vt., wastewater treatment plants. The article focuses on residuals management and energy upgrades. Each plant converted their mesophilic anaerobic sludge digestion processes to two-phase anaerobic digestion for production of Class A biosolids and heat and power to reduce purchased grid power and heating-fuel costs.

Our last feature article is on the beneficial use of brown grease. This technical piece comes from research at Medgar Evers College of Brooklyn, N.Y., Fisk University in Nashville, Tenn., and the University of Connecticut, in Storrs, Conn. The research program is supported by grants from the National Science Foundation and Department of Energy. Brown grease samples for the testing came from Torrington, Conn., water pollution control facility and the Nashua, N.H., wastewater treatment facility. The initial research shows that brown grease appears to be promising as an energy resource. The ultimate goal of continuing this research is to develop a continuous process for brown grease conversion to fuel and determine whether other sources of FOG can be efficiently converted to fuel oil, either alone or in combination with brown grease. If successful, conversion of FOG, including brown grease, to fuels could have a major environmental and economic impact in the future.

Other items of note include WEF delegates highlighting the importance for membership outreach to the community to spread our message of "Water's Worth It" and highlights from the Samoset Summer Spring Meeting & Exhibit held in June.

Thanks to Ned Beecher for all the hard work and support on soliciting and review of the feature articles for this issue.

In closing, I would like to thank Elizabeth Cutone for all her years of support in the production of the *Journal*. NEWEA staff play an important role in the overall production of this quarterly publication. I welcome Mary Barry as NEWEA executive director and look forward to working with her. Please read our recent interview with both Elizabeth and Mary, starting on page 60. Elizabeth shares her 24-year perspective as retired executive director, and Mary shares her vision for the association as our new executive director.

Helen Gordon
Journal Committee Chair and Editor

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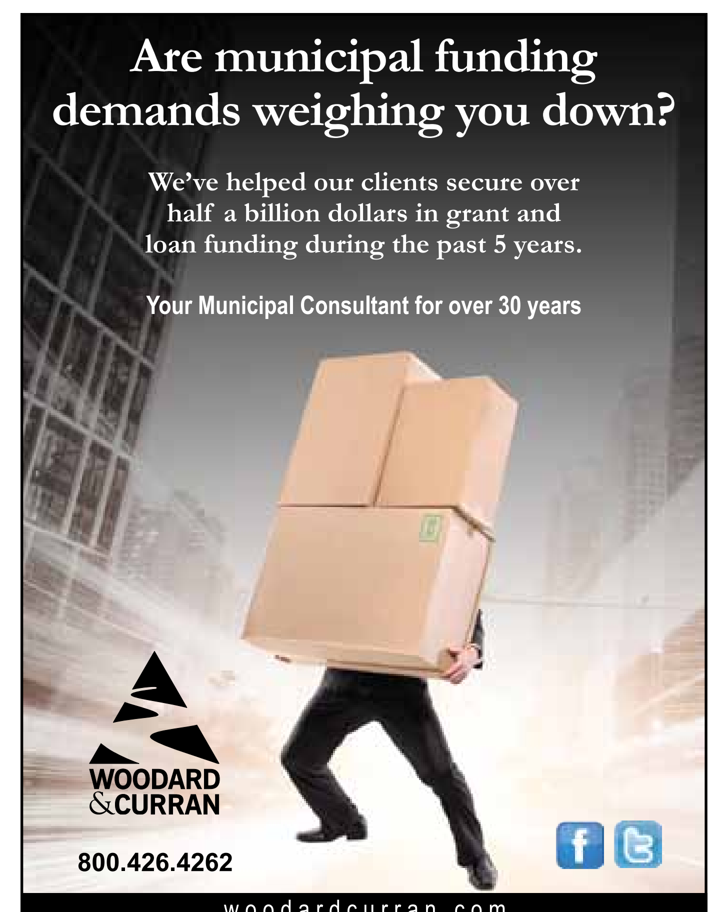

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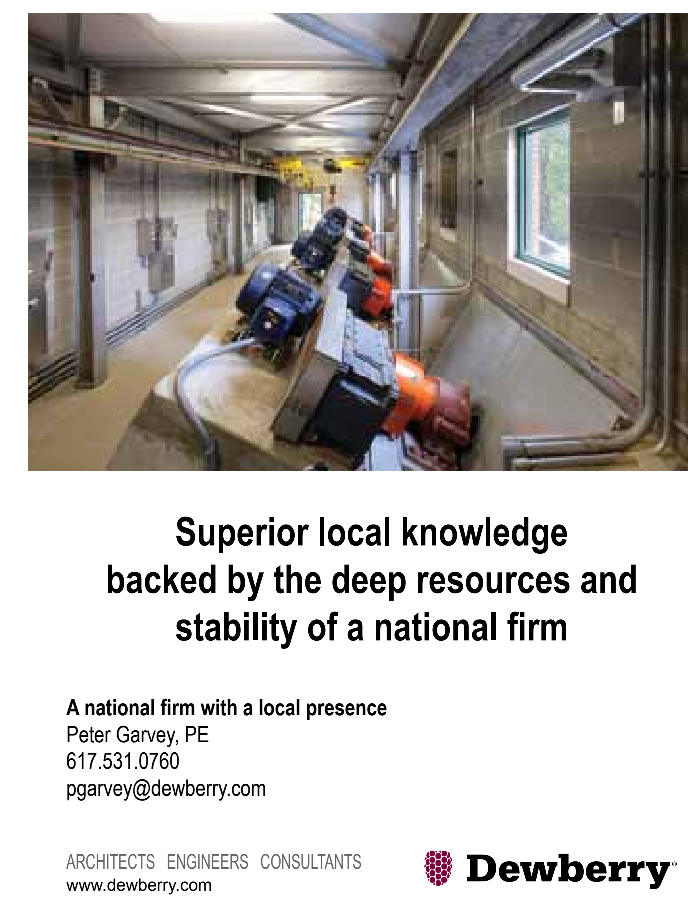

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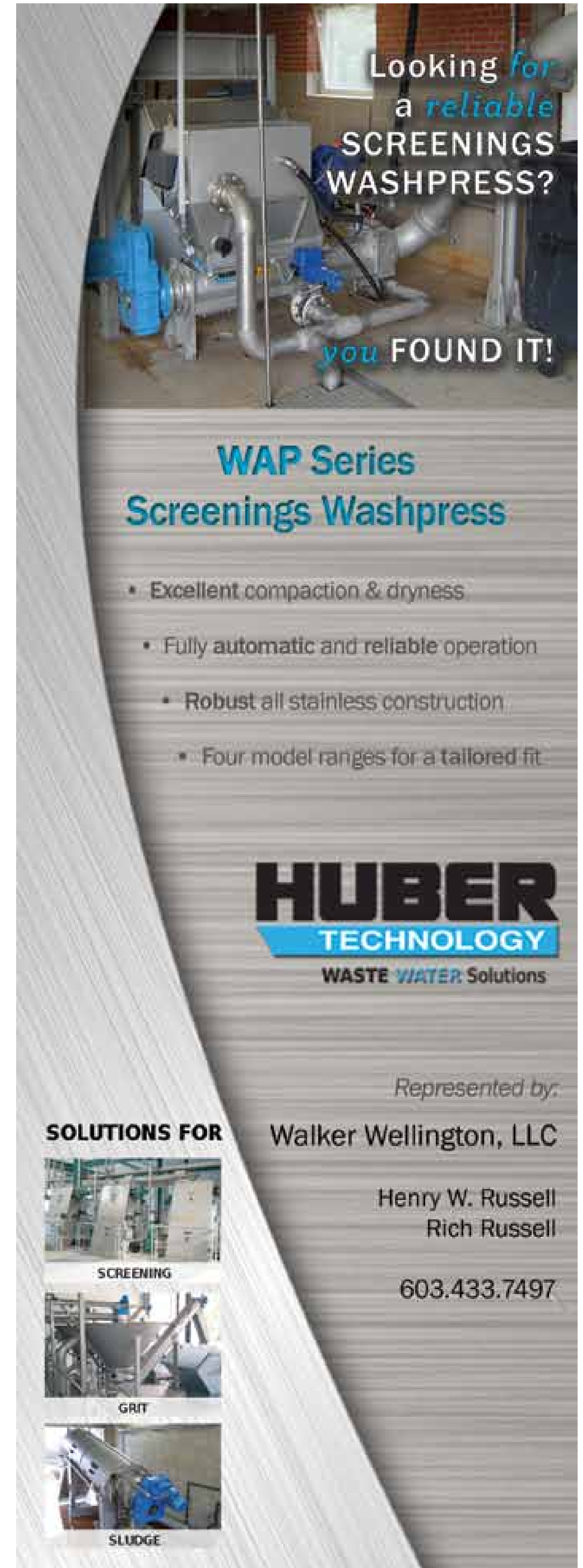
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Industry news

RUBBER DUCKS CONVEY STORMWATER POLLUTION MESSAGE IN MAINE

by Jennifer Fulcher
Water Environment Federation Highlights

Rubber ducks are not just for bath time anymore. A yellow rubber duck and red devil duck take center stage for stormwater educational messaging distributed throughout Maine. A group of 30 non-profits, state agencies, and municipalities have joined together through the Think Blue Maine campaign to educate state residents about polluted runoff.

"The goal is to get people to recognize that the water that falls on their property doesn't stay on their property, and that as it runs off, it picks up pollution and carries that directly into our water," said Jami Fitch, stormwater outreach manager for the Cumberland County Soil & Water Conservation District (Windham, Maine).

The rubber ducks in the campaign's hallmark public service announcements (PSAs) represent various types of stormwater pollution such as trash, pet waste, and lawn chemicals. "It's so hard to see nonpoint source pollution, so the rubber ducks created that visual image of the pollution," Fitch said.

Phase II of the U.S. EPA National Pollutant Discharge Elimination System includes Municipal Separate Storm Sewer System (MS4) permit requirements. The permits required development of statewide outreach plans to increase awareness of stormwater pollution. So in 2003, organizations throughout Maine formed Think Blue Maine as a way to accomplish more together than each could on its own, Fitch explained.

Participating organizations are divided into the four regional groups of Greater Bangor, Greater Lewiston/Auburn, Greater Portland, and Southern York County. All work both on a statewide media outreach campaign and on regional campaigns. Locally, many are working to change lawn-care behaviors, Fitch added.

After first forming Think Blue Maine, participating organizations coordinated a mass-media campaign centered on a yellow duck PSA, which had been created by Think Blue San Diego. Think Blue Maine received rights to alter the PSA, replacing the voice-over and logo to tie it to Maine. After airing the PSA on local television stations in 2004, the image and message stuck with residents, Fitch said.

To determine the tools and messages needed for effective outreach, the Maine Department of Environmental Protection surveyed residents in focus groups. Because focus group participants recalled the yellow duck PSA without prompting, a marketing group recommended that the campaign continue using the image. So Think Blue Maine began using the yellow duck on all of its stormwater-related materials and featured it on the campaign's logo, Fitch said.

In 2010, Think Blue Maine continued to build on its yellow duck PSA and complement local efforts by developing a devil duck PSA. For the video, devil ducks represent fertilizers and pesticides washed from lawns into storm drains and out into waterways.

In March 2014, Think Blue Maine launched a new television and online advertisement campaign. During the next 4 years, both PSAs will air on cable stations during the spring through fall. "We're doing a more targeted approach this time," Fitch said. To reach local, college-educated residents between the ages of 35 and 55, the duck videos will air on cable stations most likely to reach this audience.

Both types of ads direct residents to the Think Blue Maine Web site. Online, people will find information about how to reduce stormwater pollution coming from their property. The Web site also is a resource for stormwater managers and includes background on the campaign, information about stormwater pollution and regulations, listings for related organizations and information, and many free resources such as fact sheets, brochures, pamphlets, door hangers, stormwater drain stencils, PowerPoint presentations, logos, advertisements, and commercial transcripts.

In each region, organizations work to educate citizens and change behaviors through storm drain stenciling, community events, literature distribution, adult-education classes and events, and local business collaborations. The Greater-Portland area works with lawn-care and garden centers to educate staff so they can supply information to customers, distribute fact sheets and informational brochures, host healthy lawn-care classes, and tag preferred products with the duck logo.

FLUSHABLE WIPES CAMPAIGN NOMINATED FOR AWARD

Billy Hunter
Association of the Nonwoven Fabrics Industry

A public awareness campaign sponsored by the Association of the Nonwoven Fabrics Industry (INDA) and the Maine Water Environment Association (MeWEA) to educate consumers to not flush baby wipes down the toilet has been nominated for a 2014 EPA Environmental Merit Award.

Dave Rousse, INDA President, said: "This nomination for the 2014 EPA Environmental Merit Award is an honor and great recognition of a collaborative effort between the wipes industry members of INDA and the Maine Water Environment Association."

Benefits to the environment

The EPA Environmental Merit Award honors organizations that make outstanding contributions to improving a region's environment. The criteria include defining the environmental problem, addressing the problem, accomplishing the stated goals, measuring the benefits to the environment or public health, and collaborating with other organizations. Maine Commissioner Patricia W. Aho nominated the "Save Your Pipes: Don't Flush Baby Wipes" campaign for the New England regional award.

"Many products are flushed down the toilet that shouldn't be, including feminine hygiene products, paper towels, and non-flushable wipes like surface cleaning wipes," Rousse said. "Concern by wastewater entities about the inappropriate disposal of these items has engulfed those nonwoven wipe products that are designed to be flushed and pass our Flushability Assessment Guidelines. Our stewardship role on this issue is focused on building awareness of these two separate categories and the different proper disposal paths for each."

Building awareness

The campaign features various forms of media, including television commercials, print ads in newspapers, social media pushes, and direct mail pieces. The goal of the campaign is to reduce the costly burden that Maine wastewater treatment facilities experience due to items being flushed down the toilet that were never designed to be flushed.

The recipients of the 2014 EPA Environmental Merit Award were announced at a ceremony held in April in Boston.

NEW HAMPSHIRE STUDENT TO REPRESENT U.S. IN INTERNATIONAL STOCKHOLM JUNIOR WATER PRIZE COMPETITION

Lori Harrison
Water Environment Federation

Deepika Kurup from Nashua, N.H., was named the U.S. winner of the 2014 Stockholm Junior Water Prize (SJWP)—the most prestigious international competition for water-related research—during a ceremony at the Hilton Dulles Airport Hotel in Herndon, Va.

Kurup's project, "A Novel Photocatalytic Pervious Composite for Degrading Organics and Inactivating Bacteria in Wastewater" was selected from 48 state SJWP winners at the national competition, held on June 13–14. Her research offers options for safe, cost-effective, and eco-friendly wastewater treatment by integrating an enhanced photocatalytic advanced oxidation process with filtration using novel pervious composites.

"The water sector is an ever-evolving profession that continually seeks new and innovative approaches to sustainable water management," said Mohamed F. Dahab, chair of the SJWP review committee. "We were very impressed with the high caliber of research and creativity presented by Miss Kurup and all of the young men and women who participated in this year's competition."

Kurup received $10,000 and an all-expense paid trip to Stockholm, Sweden, where she will represent the U.S. at the international competition during World Water Week, Aug. 31–Sept. 5, 2014. The international winner will receive $15,000, which will be presented during a royal ceremony by the prize's Patron Crown Princess Victoria of Sweden.

Deepika Kurup, from Nashua, N.H., the U.S. winner of the 2014 Stockholm Junior Water Prize

Other competition winners included the two U.S. runners up, Bluyé DeMessie (Mason, Ohio) and Zachary Loeb (Melbourne, Fla.), who each received $1,000, as well as Jack Andraka (Crownsville, Md.) and Chloe Diggs (Glen Burnie, Md.), who were joint recipients of the Bjorn von Euler Innovation in Water Scholarship Award.

In the U.S., WEF and its Member Associations organize the national, state, and regional SJWP competitions with support from Xylem Inc., which also sponsors the international competition and the $1,000 Bjorn von Euler Innovation in Water Scholarship Award.


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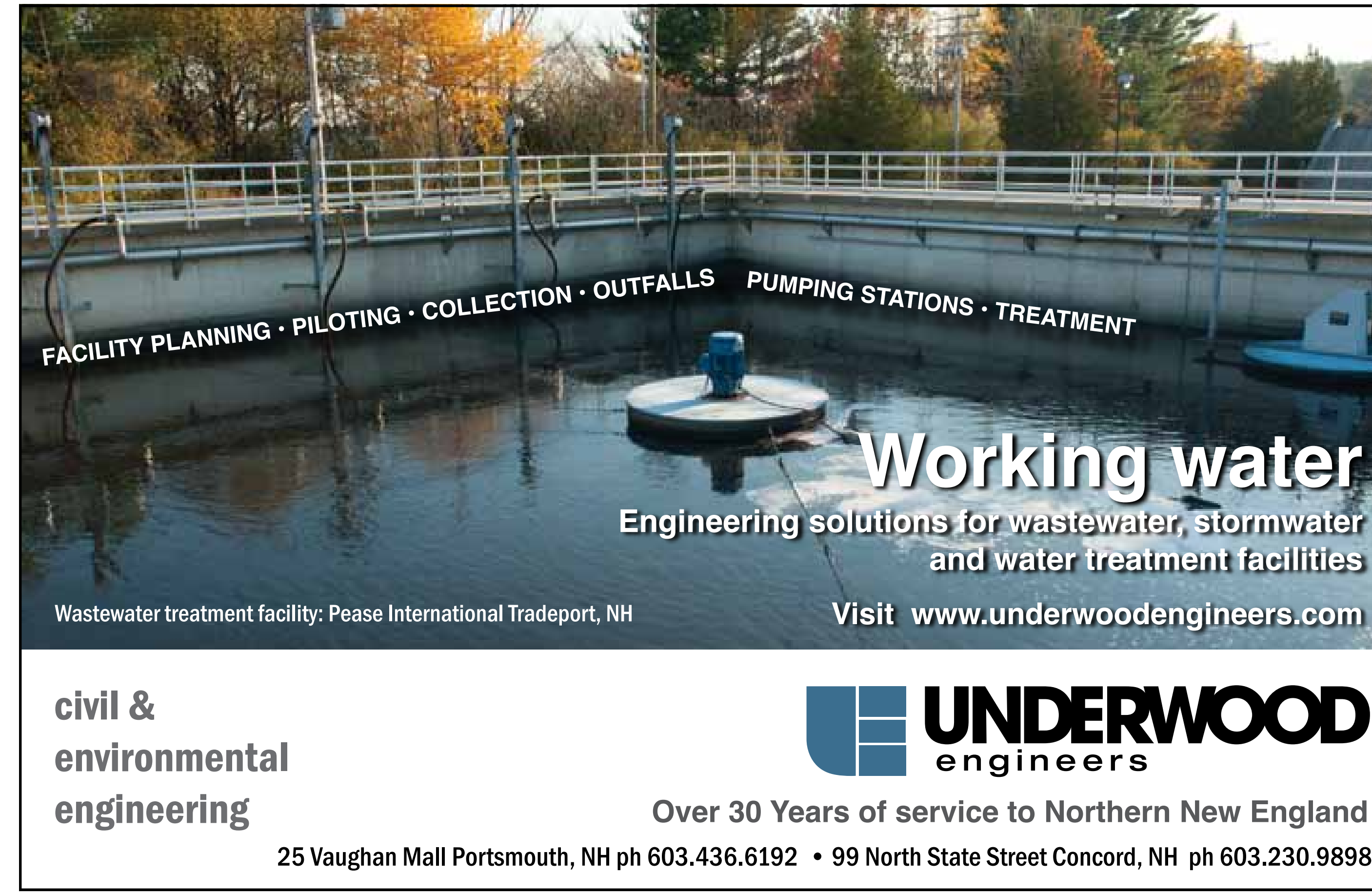
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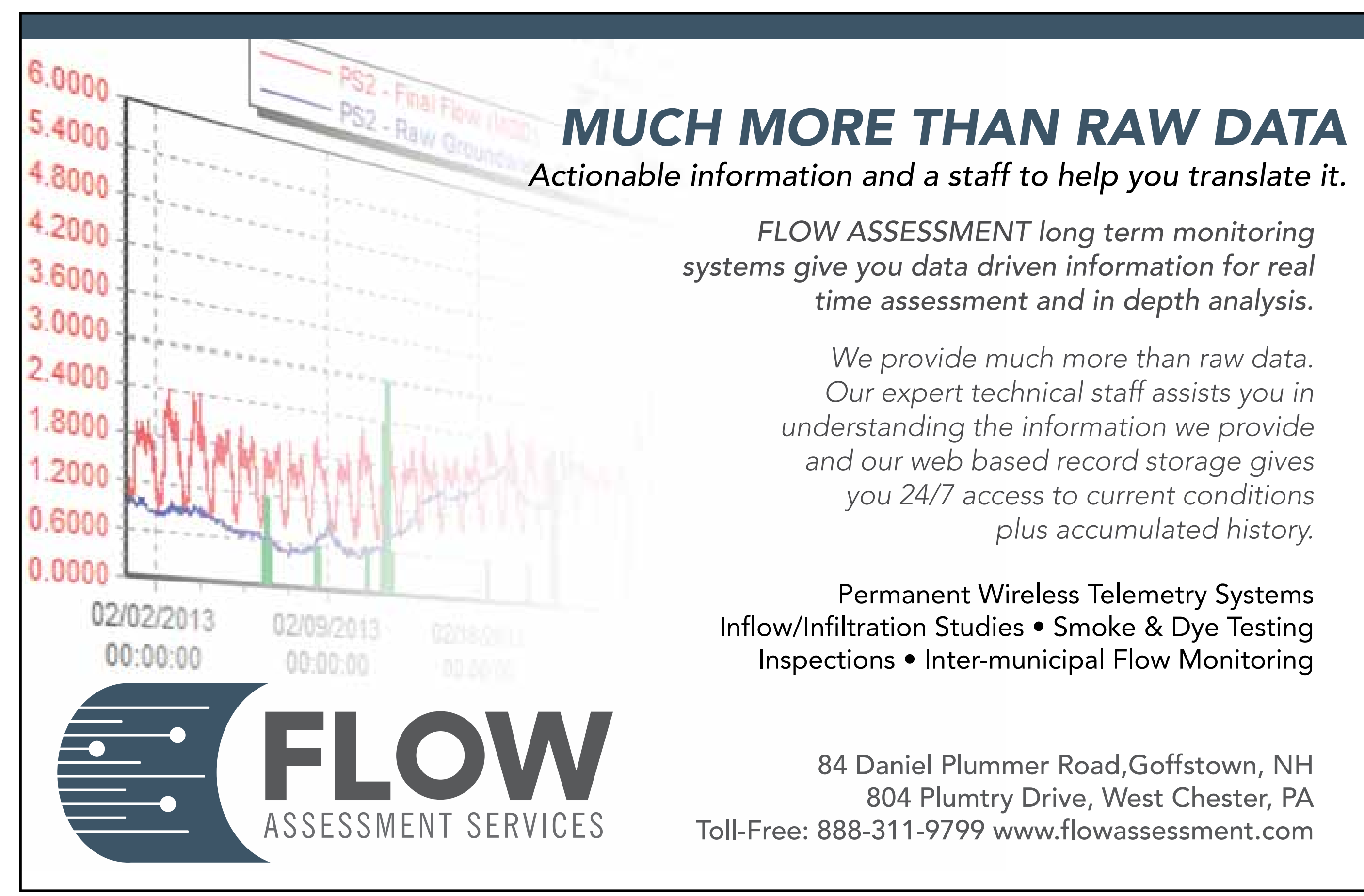
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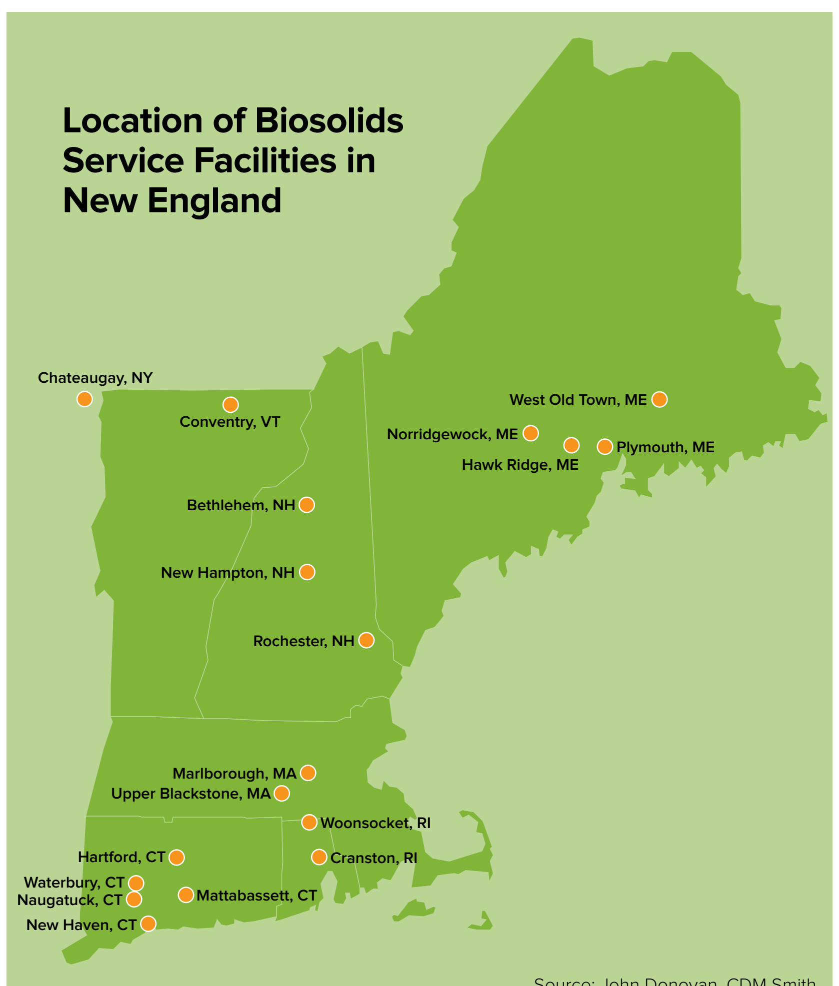
FEATURE

From 503 to infinity

NED BEECHER, North East Biosolids and Residuals Association, Tamworth, NH

ABSTRACT | The U. S. federal regulations at 40 CFR Part 503 were 20 years old in 2013. This article provides perspective on the history and impacts of the Part 503 rule on biosolids management over the past two decades, from the perspective of three scientists—Dr. Alan Rubin (U. S. EPA, retired), Dr. Rufus Chaney (U. S. Department of Agriculture), and Dr. James Smith (U. S. EPA, retired)—who contributed significantly to its development, as presented at the Northeast Residuals and Biosolids Conference on October 29, 2013. In addition to recounting some history of Part 503, the three scientists provided insights into the future of the rule and biosolids recycling to soils.

KEYWORDS | Biosolids, sewage sludge, wastewater solids, recycling, 40 CRF Part 503, regulation



Source: John Donovan, CDM Smith

Last year was the 20th anniversary of 40 CFR Part 503, the U. S. Environmental Protection Agency (EPA) biosolids rule. This event was marked at last fall's Northeast Residuals and Biosolids Conference, "From 503 to Infinity," co-sponsored by NEWEA and the North East Biosolids and Residuals Association (NEBRA).

Over two decades—and even before it became effective on March 22, 1993—Part 503 has seen controversy. But none of the challenges to the final rule, which have come from all sides, have done more than erode some minor details. Ten years after it became effective, a National Research Council expert peer review concluded, "There is no documented scientific evidence that the Part 503 rule has failed to protect public health," even as it noted that "additional scientific work is needed to reduce persistent uncertainty." Now, after another decade, Part 503 is widely regarded as a robust example of a risk-assessment-based regulation that has created a safe environment in which innovative resource recovery from biosolids can thrive. Despite continued public scrutiny, biosolids utilization has become the norm throughout much of North America, including much of New England. Biosolids products are diversifying and becoming more sophisticated (e.g. see loopforyoursoil.com). They are valued by farms, horticulture, and landscaping. They produce energy. They are tools that solve environmental problems. There are "unprecedented opportunities that now exist and are emerging for the organics, energy, and nutrients in biosolids" (National Biosolids Partnership, WERF, WEF, 2013: "Enabling the Future: Advancing Resource Recovery from Biosolids").

At last fall's conference three scientists—Dr. Alan Rubin, Dr. Rufus Chaney, and Dr. James Smith—central to the development of Part 503 reflected on its history and impacts and the future of biosolids management that it has catalyzed. Drs. Rubin, Chaney, and Smith were a few of the hundreds of scientists who, over decades, have created the body of science and policy that underpins Part 503, especially the standards for use of biosolids on land. However, in their positions in federal agencies, they played central, leading roles in ensuring the best available science was integrated into the regulations.

HISTORY

"In 1987, Congress amended section 405 (of the Clean Water Act) and for the first time set forth a comprehensive program for reducing the potential environmental risks and maximizing the beneficial use of sludge." (Federal Register, 58 FR 9248 | Rules and Regulations | Environmental Protection Agency 40 CFR Parts 257, 403, 503 Standards for Use or Disposal of Sewage Sludge | February 19, 1993). The rule was "to protect public health and the environment from any reasonably anticipated adverse effects of certain pollutants that may be present in sewage sludge."

Alan Rubin, PhD, entered U. S. EPA when the water program was expanding dramatically because of the Clean Water Act. From 1984 until his retirement from EPA in January 2005, he was the lead staff person to the EPA office of science and technology, health and ecological criteria division, in which he led the development of the Part 503 rule and its implementation. His responsibilities included refinement and implementation of multimedia/multi-pathway chemical risk assessments, development of microbial operational standards for the Part 503 rule, and communication of the Part 503 rule and its technical basis to the states and the general public to accelerate the rule's implementation.

Dr. Rubin was passionate about his work—and remains so in retirement. That passion runs to the very core of the science; for example, he once exclaimed excitedly: "The periodic table! It's so elegant, how it all fits together!" When he speaks about the Part 503 rule, his familiarity with every detail is evident. This was his life work. As Andrew Carpenter, president of NEBRA, noted during the conference, "even in contentious meetings, Alan was always eager to engage on this topic."

Alan Rubin: *I'm a boy from Brooklyn, N.Y. I wouldn't know a cow from a stalk of corn. Fortunately we have people like Dr. Chaney here to tell me a little about soil chemistry and soil analysis and risk assessment. And, of course, on the pathogen side, I had very little experience… and that's where we depended heavily on Dr. James Smith and his colleagues in the Cincinnati laboratories (of U. S. EPA)….I thank them for supporting me at (EPA) headquarters. My job was to develop the regulation…. as required under the Clean Water Act.*

In the early '80s, we began to get a sense of the scope of the rule and how it would work. Before Part 503, sewage sludge was something that was going to be regulated under the Resource Conservation and Recovery Act as a nonhazardous solid waste. You could put it on the land under a not-very-sophisticated rule.

My branch (at EPA) that was developing the rule started in 1984. We did the national sewage sludge survey in '89. We had to get a sense of what pollutants were in biosolids, and it didn't take a genius to figure out it depended on what was going into wastewater. From that we picked out 50 of the most probable compounds that we thought we'd find in biosolids, and, more importantly, those that we thought would have the most potential impact on human health and the environment. And then we did the risk assessment.

We put out the proposed rule in 1989; it was controversial. There were things that were wrong and things that were right…. And that's where Dr. Chaney and Dr. Smith and others came in and really helped guide the final development of the 503 rule, which we finally promulgated in 1993.

That initial effort was "Round one"—numerical standards and management practices for pollutants that we knew about. The Clean Water Act says that every two years EPA is supposed to go back and look at additional pollutants. We did a second round *and determined that we were not going to regulate dioxins: There was no need to, based on risk assessment. There is now a third round looking at some additional pollutants.*

503 for the first time clearly identified actions that must be followed. And it identifies who is responsible: the generator, (i.e. wastewater treatment plants), to the processor, to the transporter, to further treatment (e.g. compost), to the end use. In theory, a gardener… who uses Milorganite is on the hook for complying with Part 503. The rule covers everybody in the train.

QUANTITATIVE RISK ASSESSMENT—TRACE ELEMENTS

Part 503 regulates the use and disposal of sewage sludge (the legal term used by EPA) via landfill disposal, surface disposal, incineration, or application to land. It includes seven elements—general requirements, management practices, monitoring, record-keeping, reporting, and—most important—numeric limits on pollutants (e.g, potentially harmful elements/heavy metals and chemicals) and operational standards (which control pathogens).

Alan Rubin: *The numeric limits are standards based on risk assessment—maximum values of concentrations of elements that can be applied and the maximum pollutant loading rates. This allows for protection of human health and the environment because it is based on multi-pathway risk assessment. Cumulative pollutant loading rate (CPLR) is the gold standard of all the numerical limits…. The one that helped the industry the most were the "clean" numbers—concentrations of pollutants in biosolids that are low enough that if you place it on the land at 10 metric tons per hectare for 100 years, you would not exceed the CPLR. What that means is that if you get down to that clean number, you do not have to keep track of the accumulation on the land. That was the beginning of treating that kind of material (biosolids) as a regular fertilizer, where there are no requirements to track the CPLR. And that was important. The industry fought for that. Originally, at EPA, we were opposed to that, but eventually it made sense to us: If it is clean enough, why penalize biosolids; why not treat it just like regular fertilizer?*

The original risk assessment done for Part 503 used worst-case point values for every pathway. This was unrealistic; you can't pick out one facility from the 10,000 doing land application. So we used probabilistic (Monte Carlo) analysis looking at conditions (e.g. diets) throughout the United States. When you run these analyses, you get a distribution; the 100-percent number is the most stringent; that is not appropriate to use.

We eventually used the 95th percentile. This was a conservative, but realistic, approach. At one time we were toying with worst-case scenarios. Worst case means that every condition you put in the model is the absolute maximum in terms of giving someone a high exposure. It doesn't exist. I call it "the unicorn." There aren't real people like that in the world. So we chose the 95th percentile in establishing the numerical standards.

The numerical standards, along with the operational standards for pathogens, are what define the quality of biosolids. And, when you have biosolids that meet the EQ (exceptional quality—Class A and low metals) numbers, you now have a material that in effect becomes fertilizer. And a lot of the management practices and general requirements go away— it's treated. You've turned it into a material of sufficient value—have taken the time, effort, and expense—that we don't think you are going to abuse it—you're not going to pile the stuff on the land and create problems.

These standards for pollutants in biosolids and soils have been the driver for much of biosolids management research over the past 45 years, including a major part of Dr. Chaney's award-winning professional career.

Rufus Chaney, PhD, is a senior research agronomist in the environmental management and by-product utilization laboratory of the USDA-Agricultural Research Service at Beltsville, Md.

Rufus Chaney: *The original 1989 proposal would have prohibited biosolids use on land. There would have been none, if we hadn't had a peer review process where the industry and the (USDA) W-170 committee of researchers from the land grant schools did a scientific review and pointed out the problems. EPA withdrew the original 503 proposal. Then we corralled James Ryan at EPA and other experts to develop the pathways for risk assessment and the numerical standards. It was a remarkable process; we spent two to three years of our lives working half-time just on the 503 Rule.*

Some of the pathways that they had originally considered were flat wrong: for instance, the most limiting (standards for) copper and zinc and others were based on soluble salt metals added in pot studies, which we had shown in basic research was absolutely irrelevant. Now, 20 years later, data shows how even more wrong that was. We finally got the rule based on field applications of biosolids….

The PCB work was probably the funniest. One of the EPA contractors had found the highest uptake slope they could find for plant uptake of PCBs. Unfortunately, the compound in the paper they were citing was PCNB, which is a fungicide (intentionally applied to) and taken up by plants to make it work! Using that would not have allowed for any PCBs in land-applied biosolids, and all biosolids have some traces of PCBs. Now, the great reduction in uses of PCBs in society has made that a

non-issue. But, at the time, when the original rule was proposed, zero PCB would have been allowed in biosolids.

The most important part of the 503 rule—and why you in the profession need to read the (EPA) "Guide to the Risk Assessment"—is to understand the pathways. EPA is now using this kind of pathway approach for most compounds in the general environment, because we look at every known exposure—not just to humans but also to livestock and wildlife, soil organisms, and fish and so on, in receiving waters. We took realistic exposures that were, however, excessive—for instance, for the home garden pathway, we assumed that you are going to consume 60 percent of the garden vegetables that you've grown at home. We don't really find that that happens. People don't grow 100 percent of their vegetables. It was an overestimate. For soil ingestion, we used 200 mg/day, which came from Superfund; further research found that the geometric mean of young children's ingestion of soil is about 35 mgd/day for the median and 90 mg/day for the 95th percentile. So there, again, we were using an overestimate to make the rule. The same on the livestock pathways. We've looked at all the pathways—even earthworms living in those soils that are going to be eaten—they may biomagnify a compound, like cadmium or PCBs or DDT, and they are going to be eaten by shrews, which eat a third of their diet as earthworms. So we protected the shrews, as well as the children, as well as people who live and garden (with biosolids) for 70 years.

One of the points that I made (and everybody has since bought) is that in the natural environment elements are controlled by their chemistry and the chemistry of their soils. An example is the soil-plant barrier: Between binding in the soil and keeping in the roots, most elements never get into the edible part of plants. Insolubility and adsorption are so strong—chromium, lead, mercury—are so insoluble they don't enter plants. The next group of elements can have phytotoxicity under some worst-case conditions. But, when you have visible injury from these, such as at least 25-percent yield reduction due to the toxic element being taken up by the plant, (the plant) is still perfectly safe for 100 percent of the diet of livestock. So built-in phytotoxicity protects the rest of the environment. The exceptions to that protection are from soil ingestion: cadmium and selenium possibly for humans, and molybdenum, selenium, and cobalt possibly for ruminant livestock. Eating soil circumvents (the soil-plant barrier), and therefore iron, lead, arsenic, mercury, and fluoride could conceivably pose risk. But not at the levels of 503—the APL does not allow you to get that kind of issue.

(There) are all the different things that are known to bind metals in soil. We knew these back in 1989. They are the reason we never had toxicity in field trials, even though we were applying metals. In comparison, when you add soluble salts to a pot, it takes years before they reach the equilibrium, steady-state concentration. And, in the case of Ni and Zn, we form new compounds… and these elements become less and less available to plants or animals that would eat soil. It helps us understand why soluble salt studies were so wrong and irresponsible when they were used in the original 503 rule proposal.

In the original 503 proposal, PCB would have been allowed at .019 kg/ha. Copper: 46 kg/ha total, which is one application of an average sludge. Obviously, experience does not support that. Eventually, we abandoned that (original Part 503 risk assessment).

I want to point out the success of pretreatment. For example, Pennsylvania data from Rick Stehouwer over the period of 1978 to 2000 shows a remarkable reduction (in metals concentrations in biosolids). This data shows one city sludge I studied: It had 1,000 ppm (parts per million) cadmium. It was sludge given to farmers and gardeners. They eventually had to go back and take the soil from those gardens and do something to help those farms. But now, pretreatment and regulatory enforcement removes any high cadmium sludges, and now the median is 2 mg/kg (ppm)—in 2000. It is even better today. At Madison, Wis., there was cadmium as high as 30 or so (in the mid-1980s), and it's now down to 2 or 3. Zinc came down too. And the number I care about the most, the cadmium to zinc ratio, if it's above 0.015, theoretically, worst case, I could conceivably find somebody with too much cadmium; otherwise, high zinc kills plants, and zinc inhibits absorption of cadmium (in people and animals). In the newest targeted national sewage sludge survey, the cadmium/zinc ratio is well below 1 percent. So we don't have any in that survey that are failing the overwhelmingly protective goal that I provided….

There are some crazy things toxicologists are doing these days.... Some in EPA want to have soil arsenic standards that are lower than the background level of arsenic in soils in the U.S. California is pushing to regulate chromate in biosolids and soils even though there is no evidence that normal soils, and especially biosolids, are reducing environments (that would create the more toxic form of chromium—Cr(VI)). Iron—the only thing we see there is that ruminant livestock eating a large amount of biosolids could be iron poisoned, and we have high iron biosolids from using iron to remove phosphorus. Otherwise iron is a valuable component in biosolids. We have people who want zero emission of mercury from the soil, and so we're going to have some squabbles about that in the future perhaps.

Alan Rubin: *The risk assessment was looking at a modeled individual that I don't think exists. That's the way that EPA does risk assessment. It gives confidence that you are being very conservative. The individual modeled is a lifestyle farmer who is never going to leave the land, he'll eat all the food he raises and drink only the water from under the land, slaughter the animals, be exposed to runoff, eat fish from the farm pond, etc. The farmer is based on a combination of data from conditions throughout the U.S.—profiles of climates and soils, very complex. He's exposed for 365 days a year for 70 years. The 95th percentile data used in the risk assessment is for this person! What does that mean for you and me? We essentially have no exposure.*

The closest we ever got to an issue in the U.S. was back in the Wild West days before Part 503 when, for example, Chicago was putting out sewage sludge on farmland with 200 ppm cadmium. Even so, I don't think we wound up with any kidney issues from that, which would not be legal now because of Part 503.

Modern biosolids are hard to abuse with respect to metals. They can be abused based on nutrients if over-applied (nitrate in groundwater, as can happen with other fertilizers), or you can make someone sick (because of pathogens) if you put out raw sewage sludge (which is not legal because of Part 503). But the low levels of trace chemicals are not going to cause any issue.

QUANTITATIVE RISK ASSESSMENT—TRACE CHEMICALS

Besides containing elements of potential concern, biosolids also contain synthetic chemicals, including organic chemicals, of potential concern. These were also evaluated as part of the original multi-pathway risk assessment. And, in the second round of evaluation for Part 503 in the 2000s, EPA evaluated dioxins, furans, and co-planar PCBs. Dioxins are some of the most toxic chemical contaminants known, and they are ubiquitous in small amounts in various media. They are, therefore, excellent sentinel chemicals for understanding risks to human health and the environment from traces of persistent organic chemicals found in biosolids.

Alan Rubin: *(When it comes to risks from trace chemicals) the question is what level is ecologically or toxicologically relevant? About 80 percent (of a typical biosolids) is water. Contaminants of concern make up just micrograms that could potentially create any issue.*

For dioxins, we could not find a significant incremental increase in cancer or non-cancer risk from biosolids. The Office of Management and Budget said "you're not going to regulate this just to feel good." We couldn't show any benefits of regulating dioxin in biosolids, so we didn't. We also looked at PCBs and couldn't find risk there either. I'm confident that the trace organics are just not in biosolids at levels that pose any risk. If anything, we come in greater contact with many of these compounds in using the products that contain them.

Rufus Chaney: *The science behind the 503 standards applies also to PPCPs (pharmaceuticals and personal care products). Lipophilic compounds are concentrated in biosolids. Hydrophilic compounds mostly end up in the effluent. Applying the 503 risk assessment to these chemical compounds shows that the most sensitive pathways are likely direct biosolids or soil ingestion. But, if they were soluble, they stay with the effluent, and if they are not, they are bound to the organic matter and biosolids, so they are not taken up. People who have done tests on plant uptake have used artificial test systems that promote maximum plant uptake. The aging of these residues also makes them less available. We don't have any evidence of a problem with these in biosolids.*

And direct exposure in other ways is more significant. Colgate Total has 3,000 ppm triclosan; here we go worrying about what is in biosolids and we use soap with 1 percent triclosan. Human exposure from biosolids triclosan is trivial—beyond trivial.

However, POTWs need to know what's in your influent. If you know, then you can know what you need to do to protect the environment. Industrial pretreatment can protect most things. The Decatur, Ala. situation (in which perflourinated compounds (PFCs) were found in high levels in a land-applied biosolids) could have been prevented by industrial pretreatment. PFCs are slow to degrade; they are water soluble—a leaching risk. But they are not a risk to plants and animals. The research about organics applies to PFCs. Decatur is an extraordinary case.

ADDRESSING PATHOGENS AND STABILITY

In addition to potentially harmful levels of elements and chemicals, pathogens in wastewater solids present the other major concern for risk to human health and the environment. It is in this realm—microbiology—that James Smith, PhD, has spent his professional career.

Dr. Smith has worked in the environmental field since 1963 and has more than 140 presentations/ publications in the areas of residuals management, water and wastewater treatment, and hazardous waste management.

Jim Smith: *From the earliest times, fecal material has been beneficially used on land, and, perhaps surprisingly, so has the link between human health and what humans ingest, inhale, or come in contact with by some other means. We read in the Bible that people can get sick from drinking some waters and applying fecal material to agricultural land. Thus it suggests that water destined for drinking first either be exposed to the sunlight or boiled. For fecal material to be beneficially used and disease potential reduced, we see in ancient Egyptian records the suggestion that lime be added and in Roman records that composting be utilized.*

The early (EPA wastewater) regulations served to keep residuals out of waterways. As far as any kind of sludge/wastewater solids treatment, early 1900s texts simply noted that while stabilization by processes like aerobic or anaerobic digestion might be considered as a way to reduce sludge's odor, they mainly should be looked at as a way to reduce the mass and volume for any further solids processing.

Federal residuals management research earnestly began in the mid 1960s in the EPA Cincinnati laboratory with Bob Dean as chief. He quickly enhanced his staff with individuals like me, Joe Farrell, Ken Dotson, Mary Beth Kirkham, and Jim Ryan. Joe Farrell was concerned with incineration; I was responsible for stabilization research; and Ken Dotson, Mary Beth Kirkham, and Jim Ryan did land application research. Two early reports of the group pulled together what was then known about sludge management and presented information needed for process design. These documents were: "A Study of Sludge Handling and Disposal" (1968) and "Process Design Manual for Sludge Treatment and Disposal (1974)." These reports established the fact that residuals management was something that needed to be considered in planning the design of a wastewater treatment facility, and it was not just an arrow on a flow diagram going nowhere.

In the late 1970s, EPA's offices of solid waste and research and development cooperated in writing regulations for the landfilling of sewage sludge with solid wastes (40 CFR Part 258) and the management of sewage sludge by other means (40 CFR Part 257) including land application. Research work over the years clearly showed that wastewater, and thus sludges, very likely contained pathogenic bacteria, viruses, parasites, nematodes, etc. So it was no surprise that the 40 CFR Part 257 regulation contained requirements for control of pathogens and vectors; it was the origin of requiring the use of a process to significantly reduce pathogens (PSRP) or a process to further reduce pathogens (PFRP). The intent of the PSRP processes like aerobic digestion, anaerobic digestion, and lime stabilization was to reduce the pathogenic organisms like viruses, helminth ova, and Salmonella by one log and indicator organisms like fecal coliforms by 2 logs. In contrast, the intent of the PFRP processes like pasteurization, heat drying, and composting was to reduce pathogenic organisms to below the detection limits of available analytical processes. Since pathogens are likely to still be present with the employment of PSRP processes, it is essential that time be allowed for land-applied sludge to undergo further pathogen reduction by natural attenuation. Thus public access, crop harvesting, and grazing restrictions are applied.

| FROM 503 TO INFINITY |

Between the time the 40 CFR Part 257 and 40 CFR 503 regulations were issued, several activities occurred to bring together national experts and review the state of the art (what was known about the control of pathogens and vectors in sludge) and decide what research work was needed to resolve questions concerning: engineering, health effects due to chemical and microbial contaminants, analytical methodologies, and risk assessment. A 1983 conference in Denver pretty much confirmed the soundness of the approach taken by 40 CFR Part 257.

EPA's health effects laboratory in Cincinnati issued in 1985 a "reference" document on the health effects of the land application of municipal sludge, which discussed the various pathogenic organisms that may be found in sludge, the disinfectant processes available to control them, and their survivability on plants and on and in the soil. Numerous attempts were made in the 1980s and early 1990s to do a quantitative microbial risk assessment. All failed due to a lack of data, particularly with respect to humans and wastewater/sludge. Today, some successful attempts have been made by the British and the Water Environment Research Foundation at doing risk assessments for pathogens like Salmonella. In 1989, EPA's pathogen equivalency committee (PEC) put out the document "Control of Pathogens in Municipal Wastewater Sludge" (the "White House document"), which formally introduced the PEC and discussed how to get approval for using disinfection processes not listed in 40 CFR Part 257.

To get a better understanding of the public health concerns, it is helpful to look at what happens to fecal material from the time wastewater leaves your house and enters a treatment plant. At the plant the wastewater is treated, solids are settled out and given treatment, and the treated solids/biosolids may be land applied. Land application may occur in an area near where people live. What we see, in a situation like this and from a regulatory sense, is the need for some kind of barrier to be put in place. We have to ask the question, what can be done to prevent the movement of pathogens from fecal material to a human host? The answer is to apply some form of disinfection treatment such as pasteurization, heat drying, or thermophilic digestion. Or, in the case of using a PSRP process, combining the disinfection treatment with access restrictions.

Like Part 257, the Part 503 regulations contain the PSRP and PFRP disinfection processes. The public access and harvesting restrictions were only slightly changed.

Vector attraction reduction (VAR) was always viewed as a necessity. The methodologies for achieving it (reducing volatile solids, reducing oxygen uptake, desiccation, and employing injection or incorporation to place a barrier between the treated material and people) were initially more or less included in the PSRP and PFRP process descriptions. However, the options available for VAR implementation were not clearly identified and spelled out in regulatory language until 40 CFR Part 503 was adopted. This 1993 rule added alternatives for achieving disinfection and divided all the alternatives into Class A or Class B; separated out from the PSRP and PFRP descriptions the parts dealing with vector attractiveness; and established acceptable levels of pathogenic and/or indicator organisms for treated sludge intended for beneficial use (biosolids).

We, EPA, are often asked where we got the PSRP and PFRP processes and their definitions from (how they are supposed to work). I will now endeavor to answer that question with the kind of thinking we were doing in the 1970s. Aerobic digestion was best described by Jaworski as recorded in the Water Pollution Control Federation (WPCF) 1977 "Manual of Practice." Later work by Jewell and Kabrick at Cornell and Matsch and Drnevich at Union Carbide helped to formulate the best way to operate a thermophilic aerobic digestion process. Again we turned to the WPCF 1977 manual to come up with the best way to operate an anaerobic digester. This approach was confirmed by the work of Fair and Moore and by EPA (Farrell and Stern) research findings. Both methods of digestion had no difficulty in achieving a 38 percent reduction in volatile solids, and so that is what was expected. How to do lime stabilization of sludge was based on EPA's research work in the Cincinnati laboratory, at the Lebanon pilot plant, and in contract work with Burgess and Niple. Liquid sludge was treated with calcium hydroxide to produce a pH of 12 for up to two hours after the lime is added. This treatment gave a 1 log reduction of Salmonella, a 2 log reduction of fecal coliforms, and a 1 log reduction of viruses. The process was not effective in eliminating Helminth ova. The approach to air drying came out of work in Chicago by Baxter and some work by Joe Farrell in Cincinnati.

The PFRPs, which appeared in the 1979 regulations, addressed pasteurization, composting, heat drying, and thermophilic digestion. Pasteurization—heating the sludge to 70°C (158 F°) for 30 minutes—is based on research by Roediger in Germany and work by EPA's Laboratory in Cincinnati (Ward and Brandon). Requirements for within-vessel and windrow composting processes are largely the work of researchers at USDA's Beltsville research laboratory (Willson, Epstein, Parr, Horvath, Burge, etc.) in the 1970s. Some information was also gained from the composting efforts in Los Angeles.

A proper description for heat drying was easy to come by because of the work of Milwaukee, which had begun making heat dried solids in the 1920s. They had lots of performance data with their rotary kiln system. Samples of their product showed it to be largely sterile.

An area that has not had as much progress as we would like is that of developing improved analytical methods for the microorganisms in sludges and which are cited in the regulations. While we now do have much better methods for fecal coliforms and Salmonella, we still have some distance to go in getting them for enteric viruses and Helminth ova. In performing our analyses we can follow the lead of other countries like Canada and Australia and look at (analyze) larger quantities of sludge mass and thus improve upon a method's sensitivity. Obviously, this approach requires greater labor.

Alan Rubin: *We had a list—not that many—of approved technologies, and people asking if they could demonstrate meeting the performance standards with variations or with new technologies. EPA said, yes, they could, and the pathogen equivalency committee (PEC) was formed, and it's still active. It probably did more than anything else to free up the profession to go out and be innovative and create and hopefully save some money and land apply with a much greater degree of flexibility.*

MANAGING NUTRIENTS

Alan Rubin: *The only nutrient that Part 503 mentions is nitrogen (N). You must meet agronomic requirements of the crop and no more, to avoid nitrate leaching. Guidance documents provide support on making these calculations. There's not a requirement for maintaining soil pH.*

Phosphorus (P) is not included. But, today, phosphorus is often the limiting nutrient, and states—not EPA—are requiring nutrient management plans that focus on phosphorus. The phosphorus index and other requirements are coming for manure and biosolids both. It is unlikely there will be a federal rule controlling P in biosolids or animal manures. When we did the 503 rule—we knew we could prevent nitrogen leaching by using the agronomic rate—it was quantitative. But we did not know how to do that with phosphorus, because it is so site specific. Phosphorus is being regulated through nutrient management. Manure contains the most soluble form of phosphorus; biosolids much less so. But biosolids appliers are having to slow down application rates (in some states).

Rufus Chaney: *In some states, if you have a very high test of phosphorus, you can't apply. But what counts is not the amount you apply, but the amount that is soluble after you apply it.... We should regulate based on the water-soluble phosphorus. Most states are not yet doing that.*

(We asked the question): Is that non-available phosphorus available to plants? We did some experiments on 20- to 25-year plots, growing wheat. Total phosphorus measured up to 5,600 ppm in the soil. The water extractable phosphorus is down in the level of regulations. Is it plant available? The plants show comparably good growth. Because the plant roots change the environment around them, they can get all the phosphorus they want, even if it's bound to iron or aluminum.

TODAY

Alan Rubin: *The rule is self-implementing. EPA, even back then, when we were rich, didn't have enough people in the regions to go around and look at every site. So the rule was written to be self-implementing. So that means—don't expect to see EPA out here to check on you; but you have the responsibility to read the rule, understand it, and follow it. If you ever mess up... you're under regulatory and enforcement liability and maybe legal liability.*


Land application
Essex Junction, Vt

Part 503 is a base rule, which means that if you follow 503, no matter where you are, you will be protective of public health and the environment. For other reasons, states have become more stringent. Why? Sometimes they have a set of pollutants they're obsessing with, sometimes there's political pressure to put more in there, some want greater setbacks. EPA applied limited management practices—how you place it on the land; you can't place it on floodplain or on snow;... you can't put it within 10 meters (33-ft) of U.S. waters.

That's all okay—under federal standards, what the U. S. does not do is reserved to the states, and they have the ability to make something as stringent as they like. EPA has tried to have states take on responsibility for Part 503 through delegation. Several states have been given the authority to administer Part 503 as well as their own rules—delegation.

We originally had chromium (in the Part 503 rule), but it should never have been there. Fortunately biosolids is a great reducing medium; any hexavalent chromium that's originally present eventually winds up as trivalent chromium, which is relatively non-toxic. For molybdenum, we probably over-reached; the last number we had was 18 ppm. We withdrew all but the maximum

number, which is 75. EPA is on the hook to revise these numbers.

Land application of sewage sludge was fairly safe to begin with, but Part 503 has made it safer.... You're home free with respect to potential impact on public health and the environment.

As Dr. Rubin recounts Part 503 history, he emphasizes that how to manage wastewater solids is the choice of the local water resource recovery facility and the community it serves. *What this means has nothing to do with the receiving community: It does not apply to the host site where you are bringing the biosolids. This choice of use or disposal is for the generator only. Citizens cannot use this clause to stop a land application program.*

LOOKING FORWARD…

Drs. Rubin, Chaney, and Smith suggested the following on what they expect may happen with the rule and biosolids management in the coming years.

- Elimination of pathogen reduction Alternative 3 for Class A—testing for pathogens. Jim Smith: *If anyone asks my or the PEC's or some states' opinion, there would be no Class A Alternative 3 or 4. Why? What sense does it make to hunt for enteric virus or Helminth ova when you're unlikely to find any (in today's wastewater and solids)? It's Class A on arrival at the plant. That's the dilemma. If you're really concerned about public health, everything needs to be treated by a demonstrated process. Looking at Class B, it has a similar dilemma. I can't tell you how many sludges we have coming in that have less than 2 million fecal coliform. So they are Class B on arrival. Everything we have should be treated in some way.*
- Elimination of Alternative 4 for Class A—the one-time testing option. Dr. Smith makes the same argument about this as for Alternative 3. However, Dr. Rubin notes: *I don't know how else you deal with a pile of material that you want to manage unless you can test it for pathogens. Not sure I would take that out.*
- Adoption of a numerical standard for molybdenum. Alan Rubin: Fo*rty (ppm) is the recommended molybdenum number for concentration and cumulative loading rate (based on research); it is still not official.*
- Odor as an aesthetic and human health impact: Alan Rubin: *This is the only issue that can stop this industry.... EPA can't set an odor or aesthetic standard.... (Some states are trying to.) Public acceptance goes along with odors—the only thing that can stop you is enraging the citizenry out there.* Rufus Chaney: *Compost (or further stabilize in some other way), incorporate, or inject the biosolids (to avoid odor impacts).*

Rufus Chaney: *A problem I still point out: We used to have bad sludges that were given to farmers and gardeners. City 13 (one of the cities in one study) was pushing 100 ppm Cd. I went to biosolids fields, some were acid—5.7, some limed to 6.4. We grew crops and got cadmium concentrations in the plants grown on the acid soils of 70 ppm, compared to 0.5 ppm in the control. We really need to do something on these lands. There aren't many of these in the northeastern states, but Pennsylvania has a lot. I think we ought to do something. But I don't have any power to make it happen.*

Despite considerations of what *could* be addressed in changes and follow-up actions regarding the Part 503 rule, Dr. Rubin and others noted that EPA priorities and funding were unlikely to support many—if any—changes in the near future. The EPA office of water is completing the multiyear evaluation of nine elements, nutrients, and organic compounds as part of the required biennial evaluation of additional pollutants. This evaluation is being reviewed by a USDA committee.

Alan Rubin: *The reason round two (the dioxin risk assessment) was completed was because we had lawsuits. Today, there is no more pressure. The golden age of biosolids—where they gave us the resources—is gone, maybe forever. Add to that the new political climate. The agencies are trying to keep programs alive that they know are important, such as climate change. The good news on biosolids: it is now considered a "mature program..." which means, "We're outta here. We're outta here on enforcement, we're outta here on compliance... But don't screw up!"*

I would be surprised to see any changes in 503—even knowing these nine pollutants of round three are out there—it will be a very long time before we see any rule change. And they may find with those nine pollutants that it is not worth regulating them. In this required evaluation of new pollutants every two years, we see we don't have enough information to do the risk assessment.

Dr. Chaney says that for the current list of pollutants being evaluated, they shouldn't be wasting money on even looking at them. They do not present a risk. *However, EPA never did anything about iron, which could be a risk, when iron-rich biosolids are surface applied and ruminants directly ingest it. There are sludges with up to 14 percent iron.*

Surface application of biosolids remains a concern of Dr. Chaney. *Surface application of biosolids is a threat to the industry. The British government decided to prohibit surface application.*

Dr. Smith notes that there continue to be many developments in the science of pathogen reduction and stabilization:

- *I'm sure you've been monitoring work done at Bucknell by Matt Higgins and others, indicating that if you anaerobically digest the sludge and high-speed centrifuge it, you may have problems with what appears to be inadequate kill of fecal coliforms.*
- *Work by Sudhir Murthy and others—limited work—suggests we may need to do more than 70°C (158°F) for 30 minutes for lime stabilization. Mark Meckes and others in Cincinnati have also done work on this, and the jury's out.*
- *We've had problems with thermophilic AD because engineers and operators like to operate them continuously. The microbiologists go crazy with continuous systems because you're taking something out and then adding in something that hasn't been there very long. They want to see a batch system.*
- *We've done work on quantitative microbial risk assessment with WERF. We'd like to bring these methodologies together with (the EPA) office of water. You could certainly finish up the Helminth ova pretty fast. We've been doing some work on extraction of viruses from sludge.*
- *What about "emerging" pathogens? Work by Suresh Pillai and Mark Meckes and Chicago has been looking at what is in raw sludge in terms of indicators and pathogens. Work that Pat Millner and I have done concluded that our present PFRP Class A treatment methods are adequate to eliminate all of the newly identified emerging pathogens.*

We have to demonstrate that we're achieving pathogen reduction. And what is stability? Have we done the best job we can? What can we do to make sure there is no odor?

We have the information we need to do a risk assessment for Salmonella and enteric viruses. The difficulty is getting EPA to do that. We did it with WERF successfully; we had EPA office of water (Rick Stevens) participating and people from the environmental assessment staff in Cincinnati.... For a long time, we've had our parasitologist in Cincinnati and others in agreement on methodology. What's needed is for the EPA Office of Water to follow up on this work. Virus risk assessment is farther away. We've done work on extraction of virus from sludge. Pretty good agreement on methodology. May need to do more DNA work on that.

It's important to note that, even as we look more and are able to detect more, it doesn't change the risk. The risk stays the same. The organisms are there and have been there.

Is 503 protective with regards to pathogens? Absolutely. And that came out of a workshop that we had (BioCycle published the findings of that workshop).

TO INFINITY…

Today, 20 years after Part 503, biosolids have become widely accepted tools in agriculture, turfgrass production, landscaping, horticulture, gardening, forestry, and land reclamation. By creating standards for making safe products, Part 503 has allowed for increasingly innovative and helpful uses of biosolids. Reclamation of damaged sites and disturbed soils may be the most environmentally significant way in which biosolids and other organic residuals are used today.

Rufus Chaney: *It's not that we have things about biosolids that we have to fix; we now have biosolids that can fix societal problems. We all know the benefits of growing with biosolids: improve the fertility and organic matter and soil microbes and you get better crops. And when it goes into a period of drought, the control field will wilt and the sludge-treated field will thrive.*

I took that knowledge and worked with EPA at Superfund sites. Since 1989, we have known that we can use combinations of iron and phosphate to bind metals and form lead pyromorphite, which ends up making lead not bioavailable to organisms that eat the soil or plants (grown on the soil).

So, with today's biosolids, if we have mine waste that is pH 2.5, we have to add enough limestone to bring it up to a reasonable pH. And then I prefer to use biosolids or biosolids compost. I've done this in numerous locations in the western U.S. We've even shown that there is leaching of limestone equivalence down into the soil in a way that doesn't happen if you just apply calcium carbonate without applying organic matter. Lots of these mine wastes have been so toxic that there has been no microbial population (before reclamation happened). We can do this one shot, tailor-made biosolids or compost mixture in remediation..... Use the biosolids to solve the toxicity.

For example, look at Palmerton, Pa. We studied it starting in 1979. Just before the smelter closed, the 800-acre (324-hectare) parcel adjacent, owned by the company, was dead. Logs that had fallen 30 years before were not degrading, because there were no organisms *in the soil. A colleague from the NRCS worked out a mixture of fly ash, limestone and digested sludge and seeded it with somewhat metal-tolerant little bluestem and lespedeza. There was a dramatic difference between the biosolids-treated and untreated areas which persists over 20 years later..*

A picture showing the re-vegetated site is charming (a barren area bordering lush green new vegetation on the remediated site). That barren area is the Appalachian trail. They (the land reclamation project) weren't allowed to apply biosolids within 100 yards (91.5 meters) of the trail. So we have a perfect control—the barren land along the trail!

Actually, those kinds of (barren) sites are getting worse, because naturally acidic rainfall is acidifying the part that wasn't killed; higher zinc uptake results and the number of seedlings declines. Palmerton was built around the smelters: Some of the soils had 1.5-percent zinc. (There was) 160 ppm cadmium in the typical vegetable garden in the area. People gardened all kinds of crops, using manure and limestone. It shows how contaminated they were, yet with compost addition they were okay. Soil amendment alkalinity and organic matter knocked the cadmium bioavailability down.

The goal of this kind of reclamation project is to raise the pH and increase metal adsorption. Higher iron and phosphate in biosolids or manures is critical. Leaf compost doesn't do as well, because it doesn't have these. We want to increase metal sorption. In the long term, remediated soils must support legumes. By giving organic nitrogen to get it started, and making it so diverse vegetation can grow on the treated soil, we end up with legumes maintaining the diverse plant cover (by fixing nitrogen). With biosolids compost, (we found that) pH change reached a depth of a meter; without it, the deep acidity restricts rooting depth.

At Belvidere Mountain, Vt., (there is a) potential Superfund site, where asbestos mining wastes were piled up. There are 300 acres (121.4 hectares) of serpentinite rock tailings that they washed and blew the asbestos out of. Wind and water erosion were very significant. EPA took emergency action to stop the water erosion. To an agronomist, we know that it will take centuries for this to grow anything. It hasn't happened since 1950. Serpentinite rock is magnesium silicate, so it's severally deficient in phosphorus and calcium. It also contains 2,000 ppm nickel and about that much chromium, but its pH is 8, so none of that is toxic; it's just intensely infertile. We tested different plants, we used compost, and fertilizers. We made a mixture of gypsum (because we need calcium), limestone (to prevent it from becoming acidified in the surface-applied layer), and manure-yard debris compost manufactured nearby. We installed replicated plots. The second year into the study, in 2011, showed diverse grasses and legume with roots going down nine inches. Calcium was migrating down (into the soil) too. The rooting zone and fertility were right for this part of Vermont, and the plants thrived. We had left over compost and gypsum, so we applied it to a steep slope. (That slope) still has highly effective vegetative cover and no movement, even with rainfalls they have in northern Vermont.

What's the logic? First, we did the agronomic evaluation of the soil. We knew what we had to address calcium, phosphorus, infertility, nitrogen, potassium, and even boron. We did greenhouse tests to demonstrate to EPA that it would work. And then we installed test plots at the site. The reason we applied the limestone is that, over time, legume growth generates acidity. You don't want the surface to become acid. It may not have mattered, but the limestone was some insurance. I put in gypsum (fluidized bed gypsum). This site was unusual in needing calcium to achieve revitalization..

CONCLUSIONS

Rufus Chaney: *I'd like to stress that 503 is a highly defensible rule. The pathways, the highly exposed individual basis for it, and this incredible "worst case" loading of 1,000 tons per hectare (406 tons per acre).... We couldn't say 200 tons per hectare (81 tons per acre). We had to be very conservative. That's what you have to do with a regulation like this. But, on the other side, we put in 1,000; that's a big number. We can hardly get there. You're talking about hundreds of years. So even if we have something wrong, we have 100, 200, 300 years at fertilizer application rates to figure it out. We felt we were being overwhelmingly protective.*

The more we look at phytotoxicity, and the experience around the country, we almost have never had toxicity problems after we had 503.

If we look long enough, we may find something of potential danger. But I don't know of anything yet. Lot of money being spent, lot of philosophically important things to ask, but I don't see any great risk. EPA is focusing on arsenic below background levels. I've been working on arsenic in rice. In normal soils, you can't have rice grown that doesn't have arsenic in it. Do you stop eating rice? Or do you decide that it was never toxic at these levels in native soil and rice in the first place?

503 works because it is based on a quantitative risk assessment. The soil-plant barrier is real. Phytoavailability was measured for field-applied biosolids to give the correct constants for determining regulations. We have found important ways to use biosolids for remediation and other important environmental problems that society faces. And I think we can be proud that biosolids does this. You can solve problems using biosolids and limestone and whatever other amendments are needed. Consider the value....not only were biosolids not a problem, they fixed a problem. One million dollars an acre (0.4 hectare) to carry away a polluted soil versus a few thousand dollars to apply biosolids—seems like a pretty obvious choice....

After all those painful years of fighting with Alan (Rubin) in 1989 to 1993 with a team of highly respected biosolids and agronomy scientists... I think we did the right thing. It provides the tools that states need, that regulators need, and that users need.

Jim Smith: The bottom line seems to rest on public acceptance. They need to understand what's being done for pathogen reduction, what's being done for stabilization. And we have to have a low odor potential in our products! Maybe something like north of the border; in Quebec, they have an odor scale.... If you have odors, you know that can kill a program. In the U.K., they have eliminated surface application.

The take-home message: Keep the public satisfied, happy. Not a technical issue. We can't put something out that stinks or attracts vectors. We have to have high-quality products that look nice.

POSTSCRIPT

In New England, many biosolids management programs have been routine for years. Some have shifted from disposal to beneficial use or vice-versa. Many wastewater solids are managed by private contractors. John Donovan (CDM Smith) presented an overview of current biosolids management in New England at the NEWEA spring conference in June, reviewing the current "network" of biosolids management facilities around the region. He suggests that likely changes in New England biosolids management in this region in the next decade will be improvements in Class A biosolids processes and products. "But there is no silver bullet technology," Donovan noted.

Resource recovery will continue to be a focus—with more digestion and co-digestion with food waste and other organic residuals and improved fertilizer products. Meanwhile, Class B land application is likely to continue its decline. Many New England wastewater facilities will continue to have their solids processed by "the network," while MWRA and some northern New England facilities continue to manage their own solids via in-house or contracted recycling programs. "Biosolids management decisions are still based on costs, not sustainability," Donovan says. But with more private-public partnerships, there continues to be more flexibility in how the costs are allocated.

Where wastewater solids management is today is due to the foundation laid by the Part 503 Rule. The 20th anniversary of that rule has refreshed memories about the extensive research and history behind it and a chance to honor those who were instrumental in its creation, including Drs. Rubin, Chaney, and Smith.

ACKNOWLEDGEMENTS

- Statements by Drs. Alan Rubin, Rufus Chaney, and James Smith and others were transcribed from recordings made at the Northeast Residuals and Biosolids Conference, October 29, 2013, and reviewed by the scientists. Facts were checked by—and any errors are the responsibility of—the author.
- Dr. Alan Rubin received four EPA Bronze Medals, including two for his work on the Part 503 rule. He has been a presenter at many state, regional, national, and international conferences and meetings on biosolids. Prior to 1984 at EPA, Dr. Rubin worked on the development of the Clean Water Act Section 307 ambient water quality criteria, water quality standards, and regulations for the incineration of chemical wastes at sea.
- Dr. Rufus Chaney conducts research on the fate, food-chain transfer, and potential effects of soil microelements at the USDA—Agricultural Research Service at Beltsville, Md. Since beginning his career in 1969, Dr. Chaney has 450 published papers (300 peer reviewed) and 285 published abstracts on related topics.
- Dr. James Smith's career has included managing a research laboratory in the investigation of improved methods for wastewater solids disinfection, stabilization and dewatering; chairing EPA's pathogen equivalency committee; and working for the World Health Organization's division of environmental health in Geneva, Switzerland, where he directed marine and fresh water quality, drinking water and wastewater treatment studies.

ABOUT THE AUTHOR

Ned Beecher is executive director of NEBRA, tracking research, legislation, and regulations and providing information to members and the public. He edits and contributes to NEBRA's email newsletter, NEBRAMail, and NEBRA Highlights in the *NEWEA Journal*, and has been the lead author on various biosolids documents.

FEATURE

From disposal to beneficial use—10 years of sustainable biosolids management at the Greater Lawrence Sanitary District

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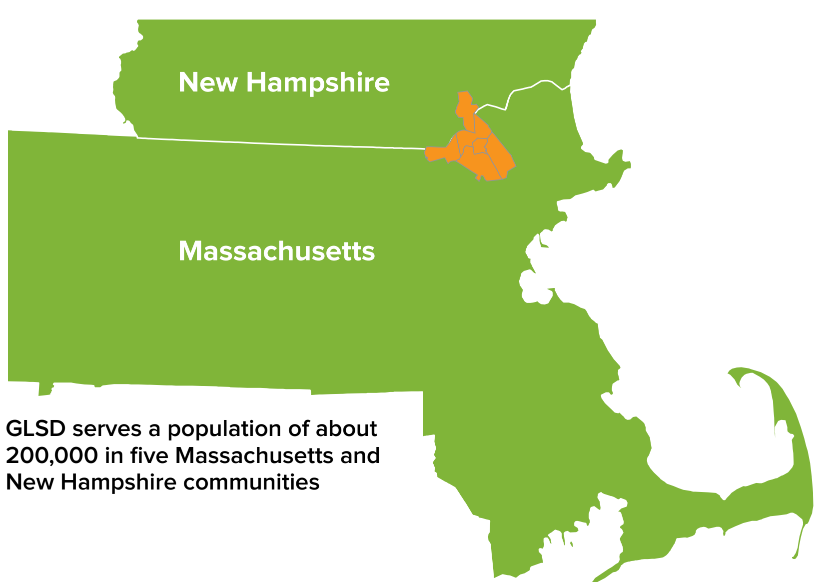
ABSTRACT | The Greater Lawrence Sanitary District (GLSD) owns and operates a 197 ML/day (52-mgd) secondary wastewater treatment facility that serves a population of about 200,000 in five Massachusetts and New Hampshire communities. As was typical of 1970s-era facilities, the original GLSD facility design was based on the premise that sludge is a waste by-product from the liquid treatment process and that the goal of sludge management is to provide reliable disposal of this waste product. Over the nearly 40 years since the GLSD facility began operation, major industry trends have steadily moved toward more sustainable approaches to biosolids management, with emphasis on biosolids beneficial use rather than sludge disposal, energy recovery and efficiency, and creative applications of innovative technologies to achieve sustainable results.
The GLSD facility demonstrates this evolution of biosolids management in our industry and serves as a model for how wastewater utilities can make their operations more sustainable by adopting biosolids management practices founded on the premise that biosolids are a resource rather than a waste product.

KEYWORDS | Biosolids, resource recovery, thermal drying, beneficial use, alternative delivery



GLSD serves a population of about 200,000 in five Massachusetts and New Hampshire communities

INTRODUCTION

In managing sludge/biosolids at the GLSD facility, the District has moved from sludge incineration (1977 to 1988) to sludge trucking/off-site disposal (1988 to 2002) to thermal drying with beneficial use of the dried pellet product (2002 to current day operation). In making these transitions, the District has not only used innovative technology, it has also brought innovation to the procurement and operation of new assets by leveraging public-private partnerships to implement major capital projects and applying specialty private sector skills as appropriate to ensure operational reliability and efficiency. This evolution serves as a model for wastewater utilities to make their operations more sustainable by adopting effective biosolids management practices.

HISTORY OF SLUDGE/BIOSOLIDS MANAGEMENT AT GLSD

Like many plants constructed in the 1970s, the GLSD facility has modified solids handling over the years to reflect changes in technology, environmental regulations, and public attitudes towards biosolids management and associated community impacts. The original GLSD facility included gravity thickening of primary sludge, dissolved air flotation (DAF) thickening of secondary sludge, and dewatering of the blended sludges using vacuum filters with lime and ferric chloride conditioning. Dewatered cake was conveyed to a multiple-hearth incineration system, with an on-site landfill used for ash disposal.


The GLSD facility

The first modifications to the original solids train were completed in the early to mid-1980s. During this period, the District discontinued operation of the DAF units and began to return secondary sludge to the primary clarifiers for co-settling followed by co-thickening in the gravity thickeners. This modification reduced power requirements and simplified plant operation and maintenance. Additionally, the District replaced the original vacuum filters with belt filter press (BFP) units. Installation of the BFPs reduced both chemical and power requirements while improving dewatering performance.

The District continued to operate the multiple hearth incineration system until 1988, when public and regulatory concerns regarding furnace emissions resulted in the shutdown of the furnaces. The District needed to quickly implement an alternative means of sludge processing/disposal, and contracted a private company to construct and operate an on-site chemical stabilization system. The private company also transported and disposed of the chemically stabilized sludge. This process was costly, as the District's annual operations budget increased from $3.1 million in 1987 to more than $12 million in 1991, with most of the cost increase attributed to the change from incineration to chemical stabilization and off-site disposal.

After four years, the District discontinued chemical stabilization, opting instead to transport unstabilized liquid (thickened) and dewatered sludge off-site for further treatment and/or disposal. As with previous operations, the District maintained responsibility for operation of sludge thickening and dewatering systems, with private contractors used for sludge transport and disposal. Sludge was transported from the site in both liquid and cake form to increase operational flexibility and the number of possible sludge disposal outlets. During this period, the District produced approximately 31.7 metric tons per day (35 dry tons per day) of sludge, with about two-thirds conveyed off-site as a liquid and about one-third conveyed as a cake. Liquid sludge was transported to regional public and private facilities for further treatment (generally incineration), and sludge cake was transported to landfills in Maine, New York, and New Hampshire for disposal.

While the District operated successfully for more than 10 years with reliance on off-site sludge disposal, this practice became precarious as the number of available outlets for off-site disposal dwindled and the demand for such services increased. Additionally, off-site disposal was costly and unreliable, as many regional sludge processing facilities imposed restrictions on acceptance of outside sludges due to odor, traffic, or other community concerns. Consequently, the District initiated planning for an upgraded solids train that would provide secure, cost-effective, and sustainable biosolids processing over the long term.

PLANNING FOR A NEW ERA IN BIOSOLIDS MANAGEMENT

In 1996, the District and CDM Smith initiated a facilities plan that evaluated 10 solids processing alternatives. Technologies considered included belt filter press and centrifugal dewatering, anaerobic digestion, thermal drying, and alkaline stabilization, with technologies organized into solids trains. The evaluation recommended that new sludge thickening, anaerobic digestion, centrifugal dewatering, and thermal drying facilities be constructed. This alternative was found to have the lowest life cycle cost and provided non-cost benefits such as reduced truck traffic, operational independence, and creation of a marketable beneficial-use biosolids product.

A major part of this evaluation compared drying alternatives with and without anaerobic digestion. From a process perspective, the inclusion of anaerobic digestion in a thermal drying train is preferred to avoid raw sludge "product odors" and therefore create a more marketable final product. However, anaerobic digestion is often difficult to justify economically due to its capital-intensive nature. In this case, the economic comparison of alternatives was significantly influenced by two factors:

- Grant funding. The commonwealth of Massachusetts committed approximately $22 million in grant funding to the project. These grants were originally awarded to the District to support proposed incineration upgrade projects in the late 1980s. For a number of reasons, these projects were never implemented. However, the commonwealth honored its grant commitment and made these unused grants available for the new biosolids project.
- Energy sharing. The proposed digestion/drying alternatives included extensive sharing of energy between the anaerobic digestion and thermal drying systems, with digester gas serving as the primary fuel source for the thermal dryers. It was estimated that this energy optimization would reduce the District's annual cost for auxiliary fuel by about $600,000. To our knowledge, this was the first facility in the U.S. to implement such a sharing of energy between a digestion system and a drying system.

The availability of grant funding combined with significant savings in energy costs offset the capital cost of digestion, thereby making the recommended digestion and drying alternative more cost-effective than drying alternatives without digestion.

Other components of the recommended solids train included the following:

- New gravity belt thickeners for processing of secondary sludge, with an option for processing of combined primary and secondary sludges
- Continued use of existing gravity thickeners for processing primary sludge
- New high-solids dewatering centrifuges
- A new biofilter to treat exhaust gases from covered gravity thickeners, the gravity belt thickener enclosures, the centrifuges, and all sludge storage tanks

Sizing of the recommended train was based on a projected design year sludge production of approximately 36.3 metric tons per day (40 dry tons per day).

BLENDING THE BEST OF PUBLIC AND PRIVATE

Like most public agencies, the District is under continuous pressure to improve the efficiency of traditional construction procurement and operations. In response to this pressure and to the general trend in the industry toward private-sector operations, the District investigated a number of privatization options as part of facilities planning. Options considered were sale of all District facilities to a private contractor and private contract operation of some or all of the District facilities. These options were evaluated using a variety of methods, including release of a request for proposals (RFP) for the design/build/operation (DBO) of a new sludge processing facility and an RFP for 20-year privatized operations of the entire treatment works.

After careful consideration, the District decided to maintain ownership of all facilities and to continue District operation of the liquid train and new sludge thickening, digestion, and dewatering facilities. However, the District implemented the thermal drying portion of the project under a DBO contract arrangement, with the DBO contractor assuming complete responsibility for marketing and distribution of the biosolids product. This decision was based on the recognition that a private contractor may better manage the risks of constructing and operating a new or an innovative technology. Furthermore, a private contractor would have greater access to established product distribution outlets and better manage the risks in introducing a new biosolids product to an increasingly competitive beneficial-use market.

By considering the components of the solids train individually, a recommended plan was developed that allowed the District to maintain control and ownership of its facilities while making appropriate use of private-sector innovation and risk-management skills. This unique approach to project delivery blended the best elements of the public and private sector approaches to project implementation and operations.

THE DBO PROCUREMENT PROCESS

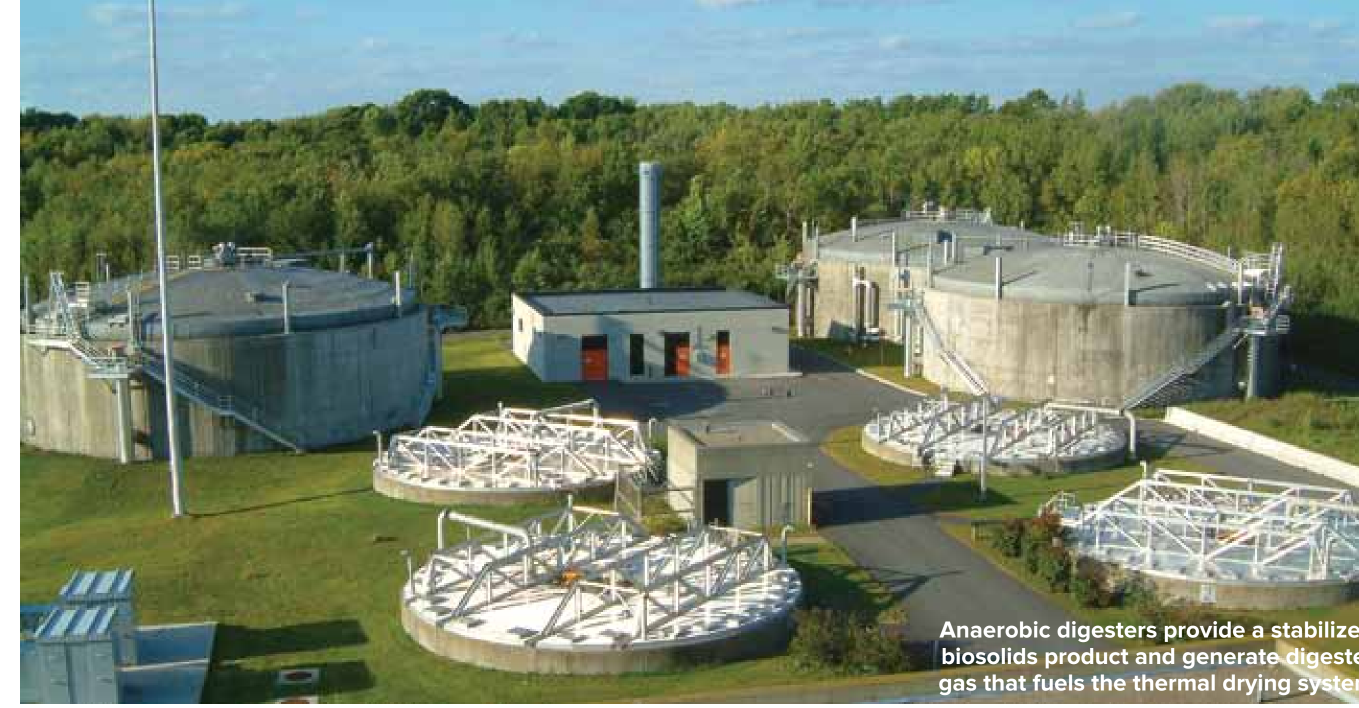
DBO procurement has not been widely used in Massachusetts because of conflicts with the commonwealth's procurement laws. To address these conflicts, the District requested that the Massachusetts legislature approve special legislation to authorize the District to proceed with a DBO approach for this project. The special legislation was detailed and described how the project was to be bid and executed.

The DBO procurement process used by the District is described broadly as follows:

- RFP preparation. Procurement proceeded in parallel with the evaluation of alternative sludge processing technologies. Therefore, when the RFP was advertised, a digestion/drying alternative still had not been chosen. Consequently, the RFP allowed the proposer to put forward alternative sludge processing technologies. However, the RFP did establish clear sizing criteria for the technical proposals and described the selection criteria that would be used to evaluate the proposals. Additionally, the RFP outlined the major conditions of the contract for the project, although a draft contract was not included in the RFP.
- Proposal evaluation. Proposals were separately evaluated for cost and non-cost factors. The cost evaluation included both capital and annual operating costs, and non-cost criteria included technical feasibility, environmental effectiveness, technology experience, and the qualifications and financial strength of the proposer.
- Contract negotiations. Upon selection of a successful proposer, the District entered into detailed negotiations regarding the terms and conditions of the DBO agreement. While the key contract provisions were outlined at the RFP stage, the negotiations were required to reach agreement regarding DBO contractor obligations and guarantees, risk-sharing provisions, and performance standards.

All the above activities were carried out under the umbrella of the special authorizing legislation.

In practice, the District received six DBO proposals from five companies. Four of the proposals were based on thermal drying technology and one proposal was based on alkaline stabilization technology. A thermal drying proposal was selected as the most advantageous proposal based on both cost and non-cost considerations. The District subsequently entered into detailed negotiations with that proposer, resulting in execution of a DBO agreement in February 1999. Under the terms of the agreement, the selected contractor constructed an independent building that houses two thermal drying trains (each with a capacity of 17.2 metric tons per day [19 dry tons per day]) and associated materials conveyance equipment. The system also included a regenerative thermal oxidizer (RTO) for emissions control. Under the terms of the agreement, the contractor is responsible for distribution and marketing of all pellet product and, if market or quality issues prevent beneficial use, for pellet/biosolids disposal.



Anaerobic digesters provide a stabilized biosolids product and generate digester gas that fuels the thermal drying system

COMMITMENT TO PROJECT COST CONTROLS

The District proceeded with the biosolids improvement project under difficult financial constraints imposed by its rate-paying communities and Proposition 2½ restrictions on increases to user fees. The estimated capital cost was $32 million. The capital cost for the thermal drying portion was established as a result of the DBO procurement. Thickening, digestion, and dewatering were implemented under a traditional design/bid/build approach, and a capital budget was established at the planning-level stage and adhered to throughout the design phase. The project was projected to save the District $1 million annually in total (amortized capital and operation and maintenance) sludge disposal costs.

Detailed cost estimates were prepared for the new sludge thickening, digestion, and dewatering facilities at the preliminary, 60-percent, and 90-percent design stages. Additionally, an intensive value engineering exercise was conducted following preliminary design. Throughout both the preliminary and final design stages, funding priorities were established and tradeoffs among capital cost, operating cost, and system operability were evaluated. This joint commitment to


In more than 10 years of operation, virtually all the thermally dried pellets produced at the GLSD facility have been sent to a beneficial-use outlet

cost control allowed the District to stay within its funding constraints while focusing expenditure on areas of greatest importance to District operations and maintenance personnel.

COOPERATION WITH REGULATORS AND THE COMMUNITY

During the late 1980s, the District received negative publicity in the local community for odor and traffic issues. Additionally, public concern about incineration emissions had been a contributing factor to the shutdown of the multiple hearth incineration system in 1988. Therefore, when planning a new approach to biosolids management, the District sought to re-establish credibility with the public and alleviate any public fears that the thermal drying process was a veiled attempt to reinstate a sludge incineration system. Furthermore, the District recognized that regulatory "buy in" to the project was critical to the project's approval and acceptance and included regulatory agencies in the project development process.

Throughout both the planning and design stages, the District held monthly progress meetings with regulatory authorities and periodic public meetings. These meetings identified important issues to the regulators and the public and addressed them during project development. The District also published a periodic Issues & Answers bulletin that provided descriptive project information and answers to commonly asked questions about sludge processing in general and the proposed project in particular. The District's cooperative approach to these relationships built consensus and support for the project and helped the District project a positive public image to the local community.

10 YEARS OF SUCCESSFUL BIOSOLIDS MANAGEMENT

The District established aggressive goals for the biosolids improvement project and, over the past 10 years, these goals have largely been met. Since the new biosolids thickening, digestion, dewatering and thermal drying systems began operation in 2002, the District has demonstrated that a sustainable approach to biosolids management not only provides environmental and resource conservation benefits but can save money and address community concerns. Highlights of this new era in biosolids management include:

- Virtually 100 percent of GLSD biosolids have been sent to beneficial-use applications. Initially, most of the thermally dried pellets were land applied in Florida. Currently, pellets are land applied in Massachusetts (primarily for growing hay), with distribution of the product managed by an outside company. No bagged product is sold.
- More than 80 percent of digester gas produced fuels the thermal drying system, and much of the remaining gas provides process heat for the digestion system or building heat. This digester gas utilization saves approximately $800,000 annually in fuel costs.
- The public/private partnership has proven successful, as the initial contract operations period has been extended from 5 to 15 years. During this period, no significant contract disputes have arisen, and the contractor's processing costs have remained stable. Furthermore, the contractor has found beneficial-use outlets for the biosolids pellet product produced at the GLSD facility.
- Community relations have been excellent, with virtually no odor or trucking complaints or public concerns regarding facility emissions. The District has maintained a strong record of regulatory compliance and cooperation as well.
- Projections of $1 million in annual savings have been exceeded and long-term price stability has been achieved. Additionally, operation of the biosolids processing systems has been highly reliable and predictable, allowing the District to manage facility operations with confidence.

Sustainable solutions are often described as the intersection of economic, environmental, and social considerations. By this definition, the last decade of operation at the GLSD facility has proven that sustainable biosolids management is possible, as the upgraded biosolids processing systems have reduced operating costs (economic) while maximizing the nutrient and energy value of the biosolids (environmental) and eliminating the adverse community impacts of previous sludge management practices (social).

LOOKING TO THE FUTURE

While the last 10 years of operation have been highly successful, the District continues to look to improve the current system by applying new technologies or process enhancements that may increase energy recovery or otherwise make the system more efficient.

The Massachusetts Department of Environmental Protection (MassDEP) has proposed a ban on the disposal of source-separated organics (SSO) generated from commercial operations in landfills and incinerators. Regulations resulting from this ban are expected to be implemented in the fall of 2014, at which time approximately 1,000 wet tons (907 metric tons) per day (wtpd) of SSO will be diverted from landfills and incinerators across Massachusetts to recycling/reuse facilities such as anaerobic digestion or composting facilities. The District has studied the viability of accepting some of this organic waste, which would largely be generated by large-scale food processing facilities such as hotels, university cafeterias, and supermarkets. Acceptance of additional organic loading to the District's anaerobic digesters would produce additional digester gas, which could be an energy source through the use of a biogas-fired combined heat and power (CHP) system. The ability to accept new organics for treatment would also provide a new source of revenue to support the District. While the details and economics of such an operation require further study, the District is viewing this change in regulations as a possible opportunity to increase energy generation at the facility and further reduce the need to purchase energy from off-site sources (utilities).

Additional improvements being implemented include repairs to aging equipment and measures to control/contain periodic episodes of foaming at the digester tanks. To address the foaming issue, the District is experimenting with de-foaming agents and constructing a containment system around the perimeter of the tank to capture the foam. The District is also implementing new process controls to better mitigate the causes of these occasional foaming incidents.

SUMMARY

The goals and operating constraints placed on sludge/biosolids management have changed dramatically over the past 40 years, as the narrow 1970s-era goal of achieving cost-effective sludge disposal has given way to the broader goal of providing sustainable biosolids treatment that is cost-effective and treats the biosolids as a resource rather than a waste product. The District's story shows that this physical and philosophical transformation is possible, as the District has moved from three decades of reliance on landfill disposal of ash, chemically stabilized sludge, and raw sludge to beneficial use of an anaerobically digested, thermally dried fertilizer product. Benefits of this transformation include:

- Savings of approximately $1 million annually in sludge processing costs, compared to previous off-site disposal operations
- Improved system reliability, as the District no longer relies on short-term contracts with outside parties for sludge processing and disposal
- Community benefits in reduced potential for nuisance odors associated with previous sludge processing systems and elimination of community concern regarding emissions from sludge incineration
- A strong record of regulatory compliance and support for the current operation
- Recovery and reuse of energy from the biosolids to reduce both cost and reliance on off-site fuel sources (i.e. power and natural gas purchased from utilities)
- Generation of a beneficial-use biosolid product that, in keeping with the principals of sustainability, recycles the nutrient content of the biosolids as a fertilizer product rather than sending it to a landfill as a waste product

In many respects, the District's operation is a model for biosolids management in the 21st century, founded on innovative application of beneficial-use technologies, a blend of public and private operations and project delivery skills, a partnership approach to regulatory and community relationships, and strong commitment to the sustainable goals of energy and resource conservation. This unique approach to biosolids management can be a model for other communities that are under pressure to re-tool outdated solids processing systems to meet the new environmental, regulatory, community, and economic requirements facing our industry today.

ABOUT THE AUTHORS

- Cheri Cousens is the executive director of the Greater Lawrence Sanitary District. Before joining the GLSD in 2014, Ms. Cousens was the executive director of the Charles River Pollution Control District in Medway, Mass., from 2010-2014 and, prior to that, was the District engineer/industrial pretreatment program coordinator for 11 years. Before joining the District, she worked as an environmental engineer for CDM Smith.
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- Michael Walsh is a vice president and client service manager with CDM Smith. He has over 25 years of experience in the planning and implementation of wastewater and biosolids projects both in New England and overseas.

NEWEA
WORKING FOR WATER QUALITY

Two-Phased Anaerobic Digestion Makes New England Debut in Vermont

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ABSTRACT | Plant upgrades at Brattleboro and South Burlington, Vt., converted anaerobic digesters to phased thermophilic-mesophilic digestion systems to produce Class A biosolids. They also installed combined heat and power (CHP) systems to generate power and heat for plant operations. This case study provides an overview of the two upgrades and focuses on the residuals management and energy upgrades at each plant, including engineering, construction, operation, lessons learned, and performance results.

KEYWORDS | Biosolids, digester, sludge, solids, two-phase anaerobic digestion (2PAD)

INTRODUCTION

The city of South Burlington is in northwestern Vermont, and the town of Brattleboro is in southeastern Vermont. South Burlington is an employment, trade and housing center of northwestern Vermont. It has substantial natural resources, including 12,000 (3,658 m) feet of shoreline on Lake Champlain. Brattleboro is a regional employment center, with walkable neighborhoods, a vibrant downtown, and a strong sense of community.

In recent years, these two communities embarked on major upgrades to their wastewater treatment facilities. South Burlington's Airport Parkway wastewater treatment facility (WWTF) was upgraded to handle an average daily flow of 3.3 mgd (12.5 MLD), and the Brattleboro facility was refurbished with capacity to handle an average daily flow of 3 mgd (11 MLD). Both facilities converted their mesophilic anaerobic sludge digestion processes to two-phase anaerobic digestion (2PAD), an acid/gas configuration. Each facility also added a 65-kW microturbine and heat recovery unit to produce CHP.

PROCESS DESCRIPTION

The 2PAD process includes a thermophilic phase and a mesophilic phase. During the thermophilic, or acid phase, acidogenic bacteria consume organics, producing soluble compounds and volatile fatty acids. The thermophilic digester operates at a temperature of 130°F to 140°F (54°C to 60°C), and the goal is to destroy pathogens to meet Class A biosolids standards. During the mesophilic, or gas phase, acetogenic bacteria consume organics, producing acetic acid, and methanogenic

Figure 1. South Burlington Airport Parkway WWTF— A new, combined heat and power system has been installed, including a 65-KW microturbine, biogas treatment to remove moisture and siloxanes, and a heat recovery unit.

bacteria consume soluble material, producing biogas. The mesophilic digester operates at 99°F (37°C), and the goal is to convert organic mass to biogas mass.

2PAD SYSTEM ADVANTAGES

Advantages of the 2PAD system include:

- A low solids retention time of 12½ days; this allows for a smaller digester capacity
- Pathogen destruction to meet Class A biosolids standards
- Reduced foaming problems
- Elimination of odors
- A high level of volatile solids destruction, which reduces biosolids hauling costs
- CHP production that reduces purchased grid power and heating fuel costs

2PAD AUTOMATIC CONTROL SYSTEM

The 2PAD control system is fully automated. The plant programmable logic controller (PLC) controls the timed pumping of raw sludge from the main plant flow to the 2PAD pre-feed sequencing tank. The 2PAD PLC controls the pumping of raw sludge from the pre-feed sequencing tank through the 2PAD system to the digested sludge storage tank. The 2PAD controls the three batch-feed cycles per day, including the sludge pumping from tank to tank. It opens and closes automated valves and controls sludge pumping to prevent tank overfill and to prevent dry pumping from an empty tank.

AIRPORT PARKWAY WWTF— 2PAD SYSTEM UPGRADE

The February 2004 facilities planning report for the Airport Parkway WWTF evaluated four preliminary engineering alternatives for sludge digestion. A present worth analysis of the two most promising alternatives indicated the following 25-year total present worth:

- Increase existing process capacity: $6.4 million
- Renovate the existing process as 2PAD: $5.5 million

South Burlington selected to renovate the existing process as a 2PAD process due to the lowest 25-year total present worth cost, which was largely driven by lower anticipated costs associated with final disposition of Class A biosolids and improved volatile solids destruction.

Construction of the Airport Parkway WWTF was completed in June 2012. The 2PAD system upgrade included a new thermophilic digester with an 18-ft (5.49m) side liquid depth and a 30-ft. (9.14m) diameter. It operates at a temperature of 131°F (55°C) and has a solids retention time of 2.1 days. The thermophilic digester is mixed with a confined gas-injection "bubble" mixer. The upgrade also refurbished the three existing mesophilic digesters with new confined gas-injection "bubble" mixers and refurbished gasholder covers. The refurbished mesophillc digesters have a combined solids retention time of 10.5 days and an operating temperature of 99°F (37°C). A raw sludge holding tank has been repurposed as a digested sludge storage tank to hold Class A biosolids. It has a 1-MG (3.8 ML) capacity, which can equalize Class A biosolids for approximately 40 days at the 2PAD system design capacity. A raw sludge holding tank has been repurposed as the new dewatering building, including a rotary drum thickener for waste-activated sludge and a centrifuge with capacity to dewater sludge to 25 percent total solids. A new CHP system has been installed, including a 65-kW microturbine, biogas treatment to remove moisture and siloxanes, and a heat recovery unit. The 2PAD system has a total mass loading capacity of 9,450 lbs/day (4,286 kg/day). It is designed for a raw sludge feed, volatile solids concentration of 80 percent and total solids of 4.5 percent. It has a hydraulic capacity of 25,332 gpd (95,892 Lpd) raw sludge. Figure 1 shows some of the main features of the Airport Parkway WWTF upgrade.

AIRPORT PARKWAY WWTF—2PAD SYSTEM SCHEMATIC STEPS

Figure 2 shows the major 2PAD system process components schematic, including the pre-feed sequencing tank, feed sequencing tank, thermophilic digester, mesophilic digesters, and digested sludge storage tank. Figure 2 also shows the sludge pumps and heat exchangers.

As previously indicated, the 2PAD system process has hydraulic capacity for up to 25,332 gpd (95,892 Lpd). The 2PAD automatic control system feeds the daily volume in three 8-hour batches. At design capacity, each 8-hour batch would be approximately 8,444 gallons (31,964 L). After the 2PAD system has been started up and has reached normal operation, during the first step in each 8-hour batch, the 2PAD system first discharges the batch-digested sludge volume from the mesophilic digesters to the digested sludge storage tank to make room for the next batch volume of sludge to be fed into the 2PAD system. This sludge movement is depicted in red shading in Figure 2.

Next, the thermophilic digester sludge, at 131°F (55°C), is discharged from the thermophilic digester to the mesophilic digesters. The 2PAD system automatic control system splits the batch volume in thirds to feed each of the mesophilic digesters. This sludge movement is depicted in orange shading in Figure 3. As it is pumped to the mesophilic digesters, it flows through the recovery heat exchangers (RHXs). At the same time, cool, raw sludge is pumped from the PFST, through the RHXs, to the FST. This sludge movement is depicted in yellow shading in Figure 3. As these two sludge feeds, one hot and one cold, are pumped through the RHX, the cold raw sludge recovers the heat from the hot thermophilic sludge, and the thermophilic sludge is cooled to mesophilic temperature.

Next, the sludge located in the FST, which has been pre-heated by the thermophilic sludge in the RHX during the previous batch, is pumped into the thermophilic digester. This sludge movement is depicted in green shading in Figure 4.

Finally, the thermophillic digester recirculates the thermophilic digester sludge through a heat exchanger where heat is added from either the microturbine heat recovery unit or the plant boiler to maintain the thermophilic digester temperature of 131°F (55°C). This sludge movement is depicted in blue shading in Figure 5.

AIRPORT PARKWAY WWTF—2PAD SYSTEM RESULTS

After the 2PAD system was constructed and started up, performance testing was completed to demonstrate system performance. Performance testing included digester mixing, pathogen sampling, analytical testing and sampling, and volatile solids destruction analysis.

Good digester mixing improves overall conversion of volatile solids to biogas. A temperature profile test was completed to demonstrate the effectiveness of the confined gas-injection "bubble" mixers. The test was completed by lowering a temperature probe through the digester covers and reading the temperature at eight elevations within the digesters. The construction contract required that temperature readings be within 0.9°F (0.5°C) standard deviation to demonstrate mixing performance. The thermophilic digester results indicated a standard deviation of 0.23°F (0.13°C), and the mesophilic digester results indicated a standard deviation of 0.324°F (0.18°C). These results indicate adequate digester mixing.

To demonstrate the quality of the biosolids produced by the 2PAD system, samples of digested sludge were collected and analyzed in a laboratory. The fecal coliform analysis indicated 147 most probable number (MPN) per gram total solids. The enteric virus and viable helminth ova analysis indicated less than 1 plaque forming unit (PFU) per 4 grams of total solids. These results meet the Class A biosolids limits of the solid waste management facility certification issued to the city by the state of Vermont.

During December 2013, the raw and digested solids analysis indicated that raw sludge fed into the 2PAD system had an average total solids concentration of 3.4-percent total solids. The raw sludge had an average volatile solids concentration of 79.3-percent volatile solids. During the month of December, the average volatile solids destruction rate was 56.3 percent.

The schedule of construction costs values indicates that the 2PAD system scope of equipment supply cost $2.8 million. This excludes costs associated with contractor general conditions, piping, civil, architectural, mechanical, and electrical aspects of the digestion complex renovation. The final cost data attributed explicitly to the 2PAD system is not readily available because this cost data is embedded with other cost data associated with the overall Airport Parkway WWTF upgrade.

| TWO-PHASED ANAEROBIC DIGESTION MAKES NEW ENGLAND DEBUT IN VERMONT |

Figure 2

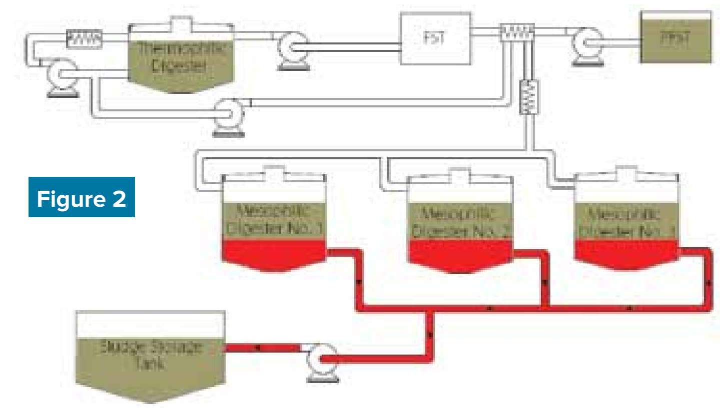


Figure 3

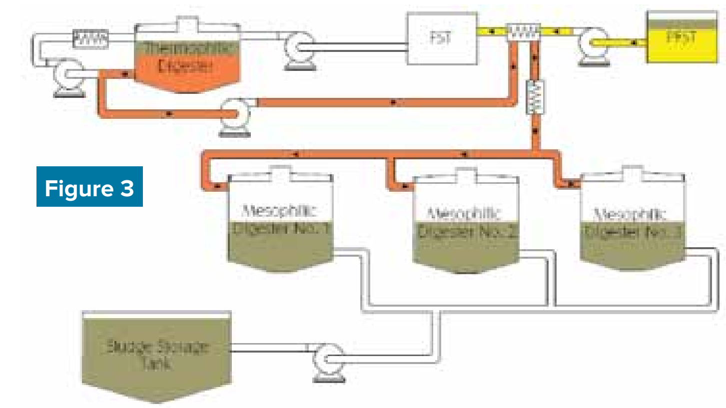


Figure 4

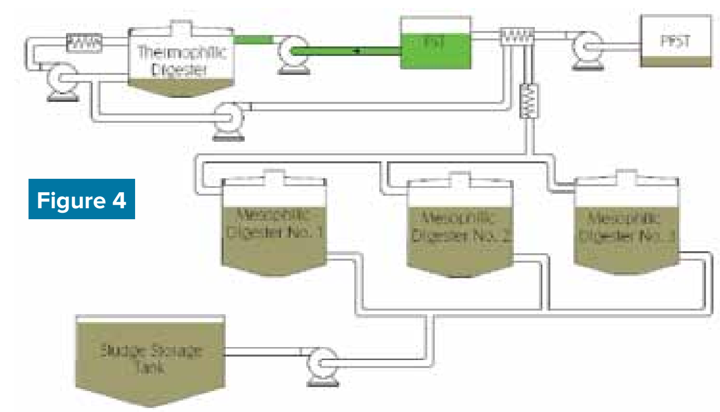
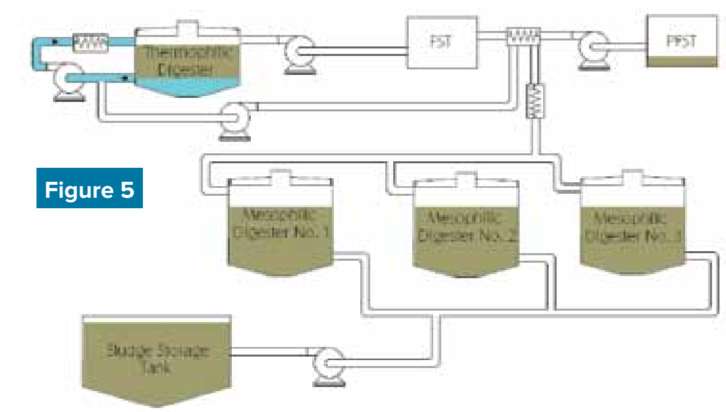


Figure 5



Figures 2 – 5. Airport Parkway WWTF—Two phase anaerobic digestion sludge schematic steps

Figure 2. During the first step, in each 8-hour batch, the 2PAD system, discharges the batch sludge volume, from the mesophilic digesters, to the digested sludge storage tank, to make room, for the next batch volume of sludge.

Figure 4. Next, the feed sequencing tank sludge, which has been pre-heated by the thermophilic sludge, in the recovery heat exchanger, is pumped to the thermophilic digester.

Figure 5. Finally, the thermophilic digester, recirculates the thermophilic digester sludge, through a heat exchanger, where heat is added, from either the microturbine heat recovery unit, or the plant boiler, to maintain, the thermophillic digester temperature, of 131°F (55°C).

The city of South Burlington is part of an agreement with the Chittenden Solid Waste District (CSWD), which manages the biosolids from treatment plants throughout the county. For this service, CSWD subcontracts with a private waste management company. Under the agreement, the cost to manage untreated biosolids disposal at a landfill is $86 to $89 per wet ton. In contrast, the District charges approximately $40 per wet ton to market and distribute Class A biosolids. This saves South Burlington of approximately $47 per wet ton. Simultaneously, the microturbine also produces approximately 45 kW of electricity, plus building and process heat, to reduce purchased grid power and heating fuel.

AIRPORT PARKWAY WWTF—2PAD SYSTEM—LESSONS LEARNED

This project had lessons learned from the construction of the 2PAD and CHP system. The Airport Parkway facility produces only 12,000 to 13,000 gpd (45,000 to 49,000 Lpd) of sludge, which uses approximately 50 percent of the 2PAD system capacity of 25,332 gpd (95,892 Lpd). The city realized during the early design years that they could haul raw sludge from its other WWTF (Bartlett Bay) to the Airport Parkway WWTF and feed it into the 2PAD system. It is hauling approximately 5,000 gpd (18,900 Lpd) of raw sludge from the Bartlett Bay WWTF and feeding it into the 2PAD system to produce Class A biosolids instead of paying a subcontractor to haul, dewater, and landfill untreated solids. This reduces the city's biosolids management costs. It also stretches staff resources; however, staff are balancing priorities of meeting plant permit limits while minimizing biosolids management costs.

BRATTLEBORO WWTF—PAST AND PRESENT

The Brattleboro WWTF is on the Connecticut River and was constructed as a 1.6-mgd (6.1 MLD) primary plant in 1967 (Figure 6). The facility was upgraded to a

3.0-mgd (11 MLD) secondary plant with rotating biological contactors (RBCs) and intermediary pumping. The facility is in the final stages of a $25.5 million comprehensive upgrade that began in late 2010. The new 2PAD system is in startup as of the spring of 2014.

The facility upgrade included construction of a new headworks to co-locate new fine screening, grit removal, septage, and high-strength waste receiving and raw wastewater pumping. Two new circular primary clarifiers were also constructed, and a wet well has been converted into a selector. The RBC media was also replaced. The secondary clarifiers were converted to a center-feed configuration, and the chlorine contact tank was refurbished—including replacement of its monitoring components. The mesophilic anaerobic sludge digestion system was replaced with a new 2PAD system, including a new thermophilic digester, and the dewatering equipment was replaced with two new rotary presses. Construction also included major control building renovations.

BRATTLEBORO WWTF—SUSTAINABLE DESIGN APPROACH

From the conceptual engineering phase and through the preliminary and final engineering phases, sustainable design concepts and approaches were prominent, including minimizing energy consumption, capitalizing on supply side energy resources, reusing existing structures, reducing operating costs, using life-cycle cost analyses, improving reliability, and allowing economic growth in the community.

BRATTLEBORO WWTF—SOLIDS TREATMENT

As part of the upgrade and conversion to 2PAD solids treatment, the rectangular primary settling basins, which are cast-in-place concrete tankage, were reconstructed as three new sequencing tanks—a pre-feed sequencing tank, a feed sequencing tank, and a heating tank. A new pump gallery was also installed. This reuse of concrete tankage, including the existing pile foundation, significantly reduced the capital construction cost associated with this upgraded plant infrastructure.

The new pump gallery associated with these reallocated tanks houses the new sludge pumping systems, including double-disc, positive displacement, rotary lobe, and chopper-type pumps. The pump gallery also is home to the new spiral sludge-to-sludge heat exchangers, which include three new recovery heat exchangers and one new heat addition heat exchanger that receives hot water supply from either the dual fuel boiler (No. 2 oil or biogas) or the mircoturbine heat recovery unit.

A new septage receiving plant provides capacity to accept and store fats, oils, and grease (FOG) in three new mixed holding tanks. From these tanks, the FOG is pumped into the 2PAD system to boost biogas fuel production, resulting in additional CHP energy output.

The plant co-thickens secondary clarifier waste sludge in the primary clarifiers. The plant control system controls the primary clarifier waste pumps to periodically pump the co-thickened primary and secondary waste sludge to the 2PAD system pre-feed sequencing tank, which equalizes the sludge feedstock prior to being fed into the 2PAD system.

The new solids treatment upgrade also included construction of a new thermophilic digester, refurbishing of two mesophilic digesters, and conversion of a third mesophilic digester to a digested sludge storage tank.

Two new rotary press dewatering units dewater digested sludge, and a new shaftless screw conveyor moves the dewatered sludge cake from the rotary press discharge to a 30-ton (27.2-tonne) tri-axle trailer used to haul the Class A biosolids cake off site.

2PAD SLUDGE AND BIOGAS IMPROVEMENTS

The town selected the 2PAD system for sludge treatment because of the anticipated increase in volatile solids destruction and the resulting increase in biogas fuel production. In addition, the town anticipated reduced sludge disposal costs by producing Class A biosolids. While the construction costs for the 2PAD system were greater than a conventional anaerobic sludge digestion system, an analysis during conceptual design showed that it provided a lower total life-cycle cost. Further, there were other non-economic factors considered, including use of biogas and treated biosolids. These factors were strongly aligned with the town's sustainable project initiatives.

MICROTURBINE CHP—BASIS OF DESIGN

Prior to the upgrade, the Brattleboro WWTF had two heat exchanger/boilers for sludge heating that were originally designed to be run on either digester biogas or No. 2 fuel oil. In addition, the facility had a biogas-driven engine for power generation. The generator was reportedly damaged by a power surge and taken out of service in 1997. Since then, biogas from the digester had been flared.

The town realized the potential value of using the biogas, and, as part of the recent upgrade, renewed its commitment to this onsite energy source. Untreated digester biogas contains hydrogen sulfide, siloxanes, and other compounds, which need to be filtered and removed prior use in the microturbine. With proper treatment, biogas can be used in a reciprocating engine, microturbine, or fuel cell to produce CHP. The town installed a 65-kW microturbine because, in comparison to an engine generator, it is expected to provide higher sulfur tolerance, lower emissions, lower noise, lower maintenance demands, compact size, grid-ready interconnection, and remote control.

BRATTLEBORO WWTF—2PAD SYSTEM SCHEMATIC STEPS

The Brattleboro 2PAD system process has a hydraulic capacity for up to 37,500 gpd (142,000 Lpd) of sludge. The automatic control system feeds the daily volume in three 8-hour batches. At design capacity, each 8-hour batch would be approximately 12,500 gallons (47,000 L). After the 2PAD system has been started up and reached normal operation, during the first step in each 8-hour batch, the 2PAD system first discharges the batch digested sludge volume from the mesophilic digesters to the digested sludge storage tank. This makes room for the next batch volume of sludge to be fed into the 2PAD system.

Next, the thermophilic digester sludge, at 139°F (59°C), is discharged from the thermophilic digester to the mesophilic digesters. The 2PAD automatic control system splits the batch volume into sludge volumes proportional to each of the mesophilic digester operating volumes. As the hot thermophilic sludge is pumped to the mesophilic digesters, it flows through the recovery heat exchangers (RHXs). At the same time, cool raw sludge is pumped from the pre-feed sequence tank through the RHXs to the feed sequencing tank. As these two sludge feeds are pumped through the RHXs, the raw cool sludge recovers the heat from the hot thermophilic sludge, and the thermophilic sludge is cooled to mesophilic temperature.

Next, the heating tank sludge, which has been pre-heated to the thermophilic temperature of 139°F (59°C) from the previous batch, is pumped to the thermophilic digester. Next, the feed sequencing tank sludge, which has been pre-heated by the thermophilic sludge in the RHX, is pumped to the heating tank. Finally, the heating tank sludge is pumped through a heat exchanger, where heat is added by hot water supply from either the microturbine heat recovery unit or the boiler to bring the sludge to 139°F (59°C) so that the sludge is at thermophilic temperature when pumped into the thermophilic digester during the next batch.

BRATTLEBORO WWTF—2PAD SYSTEM RESULTS

After the 2PAD system was constructed and started up, performance testing was completed to demonstrate performance. As at the South Burlington Airport Parkway WWTF, performance testing included digester mixing, pathogen sampling, analytical testing and sampling, and volatile solids destruction analysis.

The same temperature profile test that was completed on the Airport Parkway digesters was also completed on the Brattleboro digesters to demonstrate digester mixing performance. Similar to the Airport Parkway test requirements, the contract required that temperature readings be within 0.9°F (0.5°C) standard deviation to demonstrate mixing performance. At Brattleboro, the thermophilic digester results indicated a standard deviation of 0.193°F (0.107°C), and the mesophilic digester results indicated a standard deviation of 0.047°F. (0.026°C) standard deviation. These results indicate adequate digester mixing.

To demonstrate the quality of the biosolids produced by the 2PAD system, samples of digested sludge were collected and analyzed. The results of fecal coliform analysis indicated 147 MPN per gram, and the results of both enteric virus and viable helminth ova analysis indicate less than 1 PFU per 4 grams of total solids. These results meet the Class A biosolids limits of the solid waste management facility certification issued to the town by the state of Vermont.

The 2PAD system equipment supply invoice submitted to the construction contractor indicates a cost of $2.7 million. This excludes costs associated with contractor general conditions, piping, and civil, architectural, mechanical, and electrical aspects of the digestion complex renovation. The final cost data attributed explicitly to the 2PAD system is not readily available because this cost data is embedded with other cost data associated with the Brattleboro WWTF upgrade.

As the Brattleboro WWTF upgrade construction reaches final completion, additional 2PAD performance results will become available.


Figure 6. The Brattleboro WWTF

BRATTLEBORO 2PAD SYSTEM—DIGESTION PROCESS STARTUP CHALLENGES

Challenges during design, construction, and startup include:

- Repurposing of structures was a sustainable design concept emphasized throughout this project. Repurposing of structures allows for cost savings by not having to build new infrastructure. However, repurposing represents design challenges:
  - Use of the former primary settling tank for the 2PAD

system pump gallery resulted in close quarters between piping and equipment, which reduces ease of maintenance.
  - The 2PAD system includes three sludge feed sequencing tanks. During startup, the automatic control system faulted out of automatic control and stalled the batching progression. Troubleshooting identified the need for improved mixing of the sludge in the feed sequencing tanks to allow the automatic control system to remain in automatic.
  - Results of raw sludge sampling and analysis indicate lower than anticipated sludge quality and quantity, resulting in reduced volatile solids destruction in the 2PAD system. Low volatile solids destruction has resulted in low initial biogas fuel production and low microturbine power and heat production.
- The 2PAD system automatic control software was designed to operate using both mesophilic digester No. 1 and mesophilic digester No. 2 simultaneously. The operator has identified the need for additional flexibility to allow for independent operation of mesophilic digesters Nos. 1 and 2. This flexibility is needed for two reasons:
  - The current sludge feedstock quantity is low, and so operation of only one mesophilic digester would reduce operating costs.
  - To allow for one mesophilic digester to be taken out of service for maintenance. Providing the flexibility to allow for independent operation of the mesophilic digesters will require additional software programing of the 2PAD automatic control system.
- Maintenance requirements for both the microturbine unit and the biogas treatment skid are more intensive and costly than anticipated. The town is working with the supplier to identify maintenance tasks that treatment facility employees can perform to reduce maintenance costs.
- The thermophilic digester and the two mesophilic digesters were specified with an 8-in. (200 mm)-thick spray-applied polyurethane foam insulation and coating system to reduce heat loss. This system required foam application in maximum 1-in. (25 mm) thick lifts. This requirement was an apparent challenge for the spray foam applicator to provide for a smooth and uniform surface and resulted in an aesthetic issue that has been managed by spot repair and acceptance of a monetary credit and warranty extension.

CONCLUSIONS

These two WWTF upgrades demonstrate the success of using two-phase anaerobic digestion to produce Class A biosolids and CHP. Both facilities have overcome and are overcoming the many challenges of designing, constructing, starting up, and operating this kind of advanced digestion system with CHP. Test results from both facilities show adequate digester mixing to ensure process efficiency and reduce future maintenance costs. Pathogen analytical testing indicates that the digested sludge meets Class A biosolids standards. The town of Brattleboro will soon realize more of the benefits that the city of South Burlington is realizing, as it reaches final construction completion. The Airport Parkway WWTF is also producing up to 45 kW of electricity with its microturbine, which offsets purchased grid power, and it is producing building and process heat that offsets purchased heating fuel. The city of South Burlington is also realizing significant cost savings in managing final disposition of its biosolids. In addition, it is diverting biosolids from the landfill to agronomic utilization of the biosolids nutrients.

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- Sudhakar Viswanathan, Infilco Degremont, Inc.
- PCC Construction, Inc.

ABOUT THE AUTHORS

- John D. Reilly, P.E., has more than 20 years of experience in managing civil, environmental, and water infrastructure projects, including planning, designing, and construction of municipal WWTF with anaerobic sludge digestion to produce Class A bioslids and combined heat and power.
- Michael V. Schramm, P.E., LEED-AP, associate and senior project manager, has managed many wastewater treatment and collection projects in addition to numerous stormwater projects, energy development and efficiency projects, and site monitoring, assessment and remediation projects.

Beneficial Use of Brown Grease— A Green Source of Petroleum-Derived Hydrocarbons

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IMAN NOSHADI, RICHARD PARNAS and ANTHONY PROVATAS, University of Connecticut, Storrs, CT

ABSTRACT | Brown grease, formed as cooking oils and food fats, entering sewage systems is a major urban problem. We have shown that brown grease can be converted to a mixture of aliphatic hydrocarbons by heating under relatively mild conditions. This mixture contains primarily n-alkanes and 1-alkenes with between 8 and 30 carbon atoms in the chain. Furthermore, this conversion occurs without addition of a catalyst, which is significant because the water and impurities in brown grease would destroy or deactivate many metal or metal oxide catalysts that have been used in model systems.

KEYWORDS | Brown grease, interceptor grease, hydrocarbon fuel, pyrolysis, fatty acid

INTRODUCTION

Grease buildup in sewer lines is caused as fats, oils, and greases (FOG) are disposed in the sewer system. Even with proper care not to pour grease down the drain, small amounts of grease accumulate over time from washing dishes. Restaurants in some locations are required to have grease traps installed downstream from the dishwasher and sinks. Those traps require periodic maintenance and vary in effectiveness. The result is that sewer lines need to periodically be cleaned of this grease buildup. Grease buildup can cause odor, fouling of equipment, blockages, and sanitary sewer overflows (SSOs)—discharges of untreated sewage into the environment leading to fines and public health hazards. Brown grease has an odor similar to that of untreated sewage, which is greatly reduced or eliminated in the process described below. Conversion of this brown grease nuisance to a commodity will offset the cost of removal and support a reduction in SSOs.

Triglycerides are the major constituents in vegetable oils and animal fats. Waste products from the food and wastewater industries, such as yellow and brown grease, comprise mainly triglycerides and free fatty acids (FFA), as well as various other contaminants from the cooking and disposal processes.

Yellow grease is a higher grade of waste oil consisting primarily of triglycerides, and smaller amounts of FFA and water. The primary source of yellow grease is used vegetable oil. It was once considered a waste product or low-value commodity for soap production. Because of the rising popularity of biodiesel, it is now a higher-value commodity, although biodiesel from that material can meet less than one percent of America's needs. The value of yellow grease for biodiesel production is due to its low FFA and water content. It is easily converted via a simple base catalyzed process preceded by a mild acid catalyzed pretreatment [1].

In contrast, brown grease consists of FFA, solids, and water, with smaller amounts of triglycerides. Brown grease contains between 50- and 100-percent FFA, in addition to the non-oil components of solids and water [2]. Because of the high FFA content, conversion of brown grease to biodiesel requires a more difficult and more energy intensive acid catalyzed pretreatment process. As an alternative to traditional biodiesel, brown grease is shown to be a source of aliphatic hydrocarbons, similar to those derived from petroleum.

Brown grease is a low-value byproduct of sewage treatment. Its major components of palmitic, oleic, and stearic acids have heats of combustion of 2.4, 2.6, and 2.7 kJ/Kg (1.03, 1.12, and 1.16 BTU/lb), respectively. Brown grease is used as a fuel for sludge incineration and anaerobic digesters. Unfortunately current digester capacity is only a small fraction of what would be needed to treat the organic material available for digestion from municipal solid waste. The acidity of brown grease fatty acids increases with temperature, making them corrosive and unsuitable as fuels in many applications. The hydrocarbon products described here are chemically similar to petroleum diesel, and this technology, when fully developed, is likely to convert this nuisance material into a high-value commodity. Sale of brown grease may soon partially offset the cost of sewage treatment.

Petroleum consists of low molecular weight alkanes (naptha), cycloalkanes (napthenes), aromatic compounds, and aliphatic and aromatic compounds containing oxygen, nitrogen, sulfur, and other elements [3]. Petroleum usually also contains dissolved natural gas. During refining, the methane, ethane, propane, and butane is processed as liquefied petroleum gas (LPG). Straight run gasoline is a low-octane fuel with mostly straight chain and C2-methyl substituted alkanes from C_7H_{16} to about $C_{11}H_{24}$. The boiling range of gasoline varies by season, but it is generally in the 70° to 180°C (158 to 356°F) range. The next fraction is kerosene, a major component of jet fuel. Kerosene boils in the 150° to 275°C (302° to 527°F) range, and consists of alkanes in the $C_{11}H_{24}$ to $C_{15}H_{32}$ range, together with aromatics and cycloalkanes. Kerosene typically has an aromatic content of between 10 and 40 percent. Gas oil is a heavier fraction of petroleum and a major component of diesel fuel. Gas oils boil between 270° and 400°C (518 to 752°F), and consist of alkanes with 15 to 25 carbon atoms, in addition to cyclic, bicyclic, and tricyclic aromatics and cycloalkane systems. Heavier fractions are used as lubricating oils or cracked to lower molar mass compounds for fuels.

Alkanes are the most valuable components of petroleum for fuel production. Aromatic compounds, particularly the polycyclic aromatics, are more refractory to cracking, and lead to the formation of coke in addition to the cracking products. A source of oil consisting primarily of alkanes will therefore be desirable for fuel production. Although alkenes are less stable to oxidation and burn less cleanly than alkanes, they are easily converted to alkanes by catalytic hydrogenation. As described below, the controlled pyrolysis of brown grease, or other fats, oils and greases, produces alkanes and 1-alkenes as the major products, with smaller amounts of char.

Several new processes are in development to produce hydrocarbon fuels from renewable resources such as algae, and these processes will also require the application of decarboxylation and cracking reactions, as well as various separation strategies. The components of renewable feedstocks, such as algae that are converted to jet fuels, fall under fats, oils, and greases noted above. Brown grease is one of these feedstocks, and an estimated 1 billion gallons (3.78 billion liters) of dewatered brown grease is produced annually in the U.S. alone. The dewatered material still contains significant amounts of water, which is separated or distilled off in the process described in this paper. Examples of current state-of-the-art research are given in [4-10], where special catalysts are used to decarboxylate fats, oils and greases. FFA can be deoxygenated via decarboxylation, which produces paraffinic hydrocarbon via the removal of the carboxyl group with release of carbon dioxide [11]:

$$C_{17}H_{35}COOH \rightarrow n\text{-}C_{17}H_{36} + CO_2$$

Decarboxylation was first demonstrated in liquid phase with the conversion of stearic acid over a metal catalyst supported by carbon. Carbon-supported metal catalysts have been shown to catalyze decarboxylation reaction at temperatures of 300° to 360°C (572° to 680°F) and high pressures to maintain reactants such as saturated and unsaturated FFA in liquid phase [12]. Decarboxylation of the latter leads to saturated diesel fuel range products, and n-heptadecane and N-pentadecane with fairly good selectivity [13, 14]. The gaseous effluents indicated deoxygenation pathways described above [15, 16]. A carbon-supported palladium catalyst, Pd/C, with 5-percent Pd content, exhibited the highest initial decarboxylation rate, which deteriorated because of reduction in catalyst pore size due to decarbonylation switchover [11, 17]. Catalyst deactivation has been investigated in a fed-batch process [17] or continuous systems [18, 19] with both downward and upward flow. In fed-batch systems, catalyst deactivation was reduced by lower H_2 and CO partial pressures and cessation of the FFA feed. In continuous systems, catalyst deactivation was worsened by reduced residence times and high feed rates, which, however, enhanced high n-alkane selectivity [18, 19]. Higher temperatures enhanced conversion without being conducive to n-alkane selectivity [19-26]. Other published methods have major drawbacks when applied to brown grease and similar substrates.

Careful preparation of the catalyst is required, and many of the catalysts are subject to possible contamination from the numerous impurities in the FOG. Some of the catalytic systems require use of the precious metals platinum and palladium; a hydrogen atmosphere is also sometimes required [27, 29]. Those catalysts are susceptible to deactivation by some metals, nitrogen compounds, and sulfur compounds, which are likely to be present in brown grease. In other cases, a cheaper nickel catalyst is used, but careful preparation and pretreatment with hydrogen are required [29, 30]. In those systems a range of hydrocarbons were produced from pure feedstocks. Transition metal oxides have catalyzed pyrolysis of C_{17} fatty acids to C_{16} hydrocarbons, but supercritical water was required [31]. Catalysts based on group II metals have been developed for decarboxylation to remove naphthenic acids from petroleum [32, 33]. Again, those catalysts require careful preparation at temperatures of up to 800°C (1,472°F). Because of the significant water solubility of group II metal oxides and the significant amount of water in brown grease, those catalytic systems would not be expected to survive long under the actual reaction conditions. Even when the brown grease is dried at 80°C (176°F) under vacuum, water is formed during pyrolysis. Whether the brown grease holds the water tightly or water is produced during the pyrolysis reactions remains uncertain. In either case, a water sensitive catalyst is unsuitable for this system. Radical, cationic, and anionic mechanisms have all been proposed for metal catalyzed decarboxylation reactions [34]. That some reactions referenced above generate a single or very few hydrocarbon products while others generate a homologous series suggests that more than one mechanism may be operative, and this is a fertile field for additional research. In related oxidative decarboxylation and decarboxylation/coupling reactions of carboxylic acids, copper and manganese species have been implicated as catalysts [35-37].

To our knowledge, the work described here is the first example of hydrocarbon fuel production from waste oil at low temperatures without an added catalyst.

MATERIALS AND METHODS

The experiments were performed in two sets. Initially, qualitative experiments were performed to define the parameter space and estimate the product ratios and conditions to be optimized. Next, the experiments were repeated under carefully controlled conditions to examine the effects of moisture and presence of air.

Samples of dewatered brown grease containing variable amounts of water and solids were obtained from Onsite Environmental in Nashville, Tenn., the Nashua wastewater treatment facility, in Nashua, N.H.; and the Torrington, Conn., water pollution control facility. Onsite Environmental samples were removed from sewer lines, and the samples from the Torrington facility were recovered from oily material at the top of the sewage undergoing treatment. The primary difference was the amount of solids and water, most of which was removed by heating and decantation. The dewatered brown grease was first heated to roughly 65°C (149°F) in a beaker to allow most of the remaining water and the solids to settle to the bottom, and the upper liquid oil fraction was decanted into a separate container. In these initial experiments, heating rate, pre-drying, simple or fractional product distillation, and other parameters were tested. Oil samples were heated in a round bottom flask with a condenser and receiving flask. Some oil samples were also initially heated to approximately 95°C (200°F) and held at pressures less than 0.5 atm for several hours to remove the remaining water. Once the basic reaction parameters were worked out, each reaction was heated according to a specific temperature profile.

The temperature of the heating mantle was increased to its maximum setting with two timing protocols, and the oil temperature reached maximum values in the range of 300° to 350°C (572° to 662°F). In one protocol, the heating mantle was turned to its maximum setting at the start of the reaction, resulting in visible free fatty acids subliming from the reaction flask. In the other protocol, the temperature was increased to the maximum value over a about 6 hours, resulting in less fatty acid sublimation. Insertion of a packed column between the reaction flask and condenser reduced the fatty acid levels, but the column had to be removed to collect the heavy oil fraction.

After this qualitative determination of the reaction conditions and product distribution, experiments recorded the oil temperature as a function of the heating mantle setting. After collecting all of the oil that distilled at atmospheric pressure (light oil fraction), the flask was cooled and connected to a vacuum, and distillation was resumed until no more oil was obtained (heavy oil fraction).

Distillate components were obtained by gas chromatography-mass spectrometry (GC/MS). The analysis used gas chromatograph/mass spectrometers in scan mode. The injector was heated to 280°C (536°F) in split mode, with a split ratio of 20:1. The chromatography column was 30m (98.4-ft), 0.25mm (9.8 mil) i.d., 0.25um (.0098 mil) phase thickness Restek Rxi-5Sil MS fused-silica capillary column. The carrier gas was helium, with flow rate of 1.2 ml/min (.0025 scfh). The column temperature program was: initial temperature of 50°C (122°F), hold for 3 min, increase to 280°C at 12°C (536°F at 21.6°F) and hold for 10 min. Total ion current was monitored using electron-impact ionization (70 eV). The components of the distillate were identified using the NIST mass spectral library, version 2.0 (2008). Because long chain hydrocarbons easily fragment in the mass spectrometer, the identification by matching with the computer database has some uncertainty. Therefore, a combination of computer matching and the pattern of the homologous series in the gas chromatogram were used for identification with

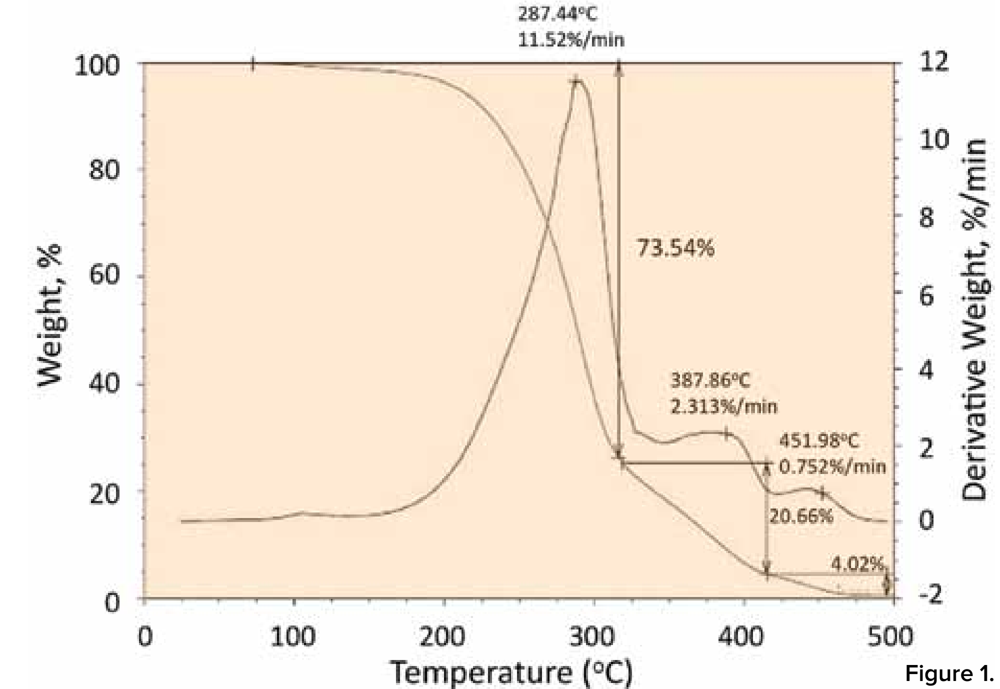

Figure 1. TGA analysis on a brown grease sample obtained from the Torrington, Conn. wastewater facility

a high degree of confidence. The approximate quantities of each component were estimated from the peak areas using the total ion concentration.

RESULTS

Brown grease oil characterization

Several samples of the brown grease oil were characterized by titration with KOH to determine a free fatty acid content that was consistently between 89 and 90 percent by mass. Gas chromatography indicated that the remaining material was predominantly triglycerides. The fatty acid profile was determined by converting a brown grease oil sample to the methyl esters by refluxing for 24 hours with methanol in the presence of a sulfuric acid catalyst. The product composition was analyzed by GC/MS. The major products were the methyl ester of palmitic acid and saturated, mono-unsaturated, and di-unsaturated C_{18} fatty acid methyl esters. A smaller amount of methyl tetradecanoate, and traces of other fatty acid methyl esters were also present. Comparison of the fatty acid profile of the starting material with the composition of the pyrolysis products presented below provides insight to the reaction mechanisms.

A micro-pyrolysis experiment conducted by thermogravimetric analysis (TGA) in inert atmosphere indicated the temperatures expected to cause sample degradation and volatilization (Figure 1). Mass loss begins at about 100°C (212°F), likely from loss of water. Most of the mass loss occurs between 225° and 325°C (437° and 617°F), perhaps due to degradation of the fatty acids and formation of volatile hydrocarbons. Mass loss is slower above 325°C (617°F), as most of the lighter oils have been lost at that point, and the heavier hydrocarbons crack to lower molar mass compounds. By 500°C (932°F), all of the volatile organic material has vaporized, leaving about 4 percent of the original mass as ash and char.

Pyrolysis product composition

Hydrocarbon mixtures were distilled from the reaction flask at atmospheric pressure (light oil) and under vacuum (heavy oil). Mass spectral analysis of the light and heavy oil fractions indicate that the slow brown grease pyrolysis produced a homologous series on n-alkanes from C_8 to as high as C_{30}, possibly from decarboxylation of fatty acids,

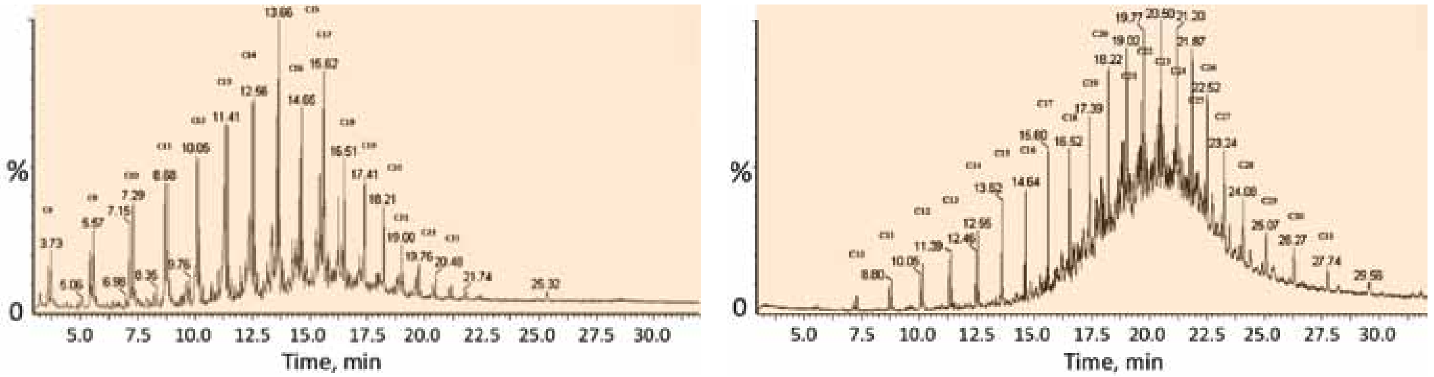

Figure 2. Gas chromatograms of the light (left) and heavy oil fractions

followed by rearrangement and coupling of the resulting radicals. Ketones and other compounds were observed during the reaction, suggesting the possibility of mechanisms other than single-step decarboxylation of the fatty acids. In addition, 1-alkenes were produced from C8 to C15, with the amount of alkene decreasing in relation to the corresponding alkane after C11, with only a small amount of 1-pentadecene being produced. Small amounts of fatty acids and internal alkenes were also observed as minor components of the distillate. Representative gas chromatograms are shown in Figure 2.

Pyrolysis yields

The experiments were conducted with 40- to 45-g (1.4 to 1.5 oz.) samples of brown grease placed in a round bottom flask equipped with a distillation head, condenser, and a thermometer immersed in the brown grease to monitor its temperature during the pyrolysis reaction. The flask was placed in a heating mantle and the power was set at No. 4 (out of 10), corresponding to an oil temperature of about 180°C (356°F). The temperature was gradually increased to a setting of 7 (out of 10) over 5 hours, and held overnight for approximately 18 hours. The brown grease temperature was monitored as a function of reaction time. The next morning, the power setting on the heating mantle was increased to the maximum setting of 10, and the volatile components were distilled from the mixture. The remaining components were distilled under vacuum until only char and a small amount of tar and heavy oils remained.

The water content in brown grease samples can vary considerably. In these experiments, the raw dewatered brown grease was heated on a steam bath to allow the water and biosolids to settle to the bottom, and the grease was decanted into the reaction flask prior to the reaction. No special measures were taken to remove the remaining water. Five trials of the pyrolysis were performed, and the results are presented in Table 1.

There was only a slight sample-to-sample variation in the quantities of light oil, heavy oil, and total oil obtained, and the average oil yield was 66 percent by mass. Work is in progress to determine the mechanisms and intermediates in this reaction. Direct decarboxylation is not the only possible mechanism, as long-chain ketone and other intermediates have been detected in the reaction mixture by CG/MS. A control experiment, described below, with pure palmitic acid showed that large quantities of dipentadecyl ketone are formed prior to hydrocarbon formation, but only trace amounts of that compound are formed with brown grease. The mechanistic work in progress examines the fatty acid components of brown grease alone and in combination, with and without added metal salts.

Figure 3 shows a typical profile of the oil temperature as a function of reaction time as the heating mantle settings were increased from No. 4 to No. 7 out of 10 over 5 hours, increasing the setting by 0.2 units every 20 minutes. The final oil temperature of about 340°C (644°F) was maintained overnight (approximately 18 hours) to allow the reaction to go to completion, before finishing the product distillation the following day.

Table 1. Yields (grams) of brown grease pyrolysis products

Trial	Sample mass	Light Oil	Heavy Oil	Total Oil	Water	Tar, Char and Ash
1	41.424	23.424	1.042	24.466	1.990	1.851
2	41.472	25.762	3.852	29.614	1.751	2.379
3	40.995	24.805	1.746	26.551	3.223	2.483
4	40.958	25.719	2.906	28.625	3.833	2.688
5	42.904	26.120	2.555	28.675	3.728	3.569
Average	41.551	25.166	2.420	27.586 66% yield	2.905	2.594
Std. Dev.	0.793	1.088	1.079	1.854	0.976	0.627

Sources: Nashua, N.H. and Torrington, Conn. wastewater facilities

The effect of water on oil yields

Brown grease, as it arrives at the wastewater treatment plant, is typically more than 90-percent water. Dewatering systems remove over half this water, generating a material known as dewatered brown grease, which is typically 25- to 50-percent water, and has the consistency of thick mud at room temperature. Dewatered brown grease was the starting material. The dewatered brown grease was further separated into an oil layer and a water/solids layer on a steam bath. If the dewatered brown grease was heated directly on the hot plate, a very wet oil layer resulted from the boiling water at the bottom rising and mixing with the oil. This very wet brown grease was used for the next trials to determine the effect of excess water on the oil yields. Table 2 shows the mass fraction yields from five pyrolysis runs with this material. The total average oil yield from the very wet grease was 49 percent based on total mass, but 65 percent based on mass of dry oil.

In the next trials, the melted brown grease was centrifuged at 3,000 rpm for 5 minutes to remove suspended water and solid material. The oil yields are shown in Table 3. The average total oil yield was 68 percent, only slightly higher than from the gravity-separated brown grease. From these three sets of experiments residual water appears to have only a small effect on the total oil yields from brown grease.

The pyrolysis was also performed on raw dewatered brown grease without separating the water and solids. The yields varied considerably as this raw material was not homogeneous. The average oil yield was only 44 percent with much higher quantities of tar, char, and ash apparently formed from the solids that do not contribute to the yield of oil. Table 4 summarizes these results.

Effect of inert atmosphere on pyrolysis

Pyrolysis refers to heating in the absence of air. Three trials were performed under an argon flow of 15 mL per minute (.03 scfh), after degassing the melted brown grease with argon for 5 minutes. The total oil yield was 64 percent, which is not significantly different from the yield under air. If an inert atmosphere were required for pyrolysis of brown grease, the cost of a commercial process would increase greatly, and the positive environmental impact

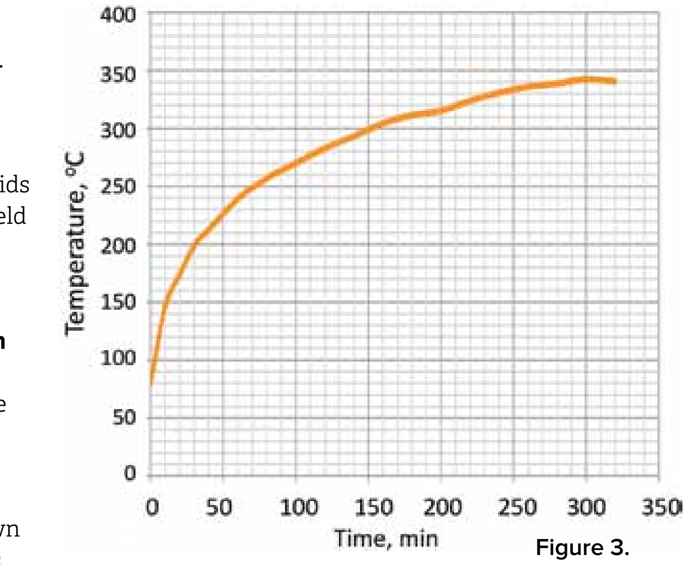

Figure 3. Temperature profile of brown grease pyrolysis

Table 2. Yields (grams) of very wet brown grease pyrolysis products

Trial	Sample mass	Light Oil	Heavy Oil	Total Oil	Water	Tar, Char and Ash
1	47.070	22.845	1.011	23.856	13.500	4.736
2	41.588	16.568	2.848	19.416	10.711	3.143
3	41.813	13.054	3.014	16.068	12.191	2.725
4	41.589	21.863	1.625	23.488	5.772	3.684
5	41.781	21.193	1.087	22.280	9.003	3.834
Average	42.768	19.105	1.917	21.022 49% yield	10.235	3.624
Std. Dev.	2.407	4.153	0.957	2.93	3.006	0.762

Sources: Nashua, N.H. and Torrington, Conn. wastewater facilities

Table 3. Yields (grams) of centrifuged brown grease pyrolysis products

Trial	Sample mass	Light Oil	Heavy Oil	Total Oil	Water	Tar, Char and Ash
1	42.451	24.982	1.738	26.720	2.718	2.724
2	41.654	28.343	2.088	30.431	2.232	3.915
3	41.290	23.963	5.008	28.971	2.387	1.660
4	42.772	25.772	2.084	27.856	2.258	2.801
5	41.941	26.884	1.893	28.675	2.481	2.643
Average	42.022	25.989	2.562	28.531 68% yield	2.415	2.749
Std. Dev.	0.597	1.696	1.375	1.230	0.197	0.800

Sources: Nashua, N.H. and Torrington, Conn. wastewater facilities

Table 4. Yields (grams) of unseparated (with water and biosolids) brown grease pyrolysis products

Trial	Sample mass	Light Oil	Heavy Oil	Total Oil	Water	Tar, Char and Ash
1	45.420	11.438	8.381	19.819	3.209	11.410
2	45.455	6.973	5.502	12.475	3.602	22.202
3	45.011	8.765	4.984	13.749	3.126	21.836
4	44.427	25.133	3.453	28.586	1.355	5.364
5	45.406	23.238	0.627	23.865	2.115	4.349
Average	45.144	15.109	4.589	19.699 44% yield	2.681	13.032
Std. Dev.	0.597	1.696	1.375	1.230	0.197	0.800

Sources: Nashua, N.H. and Torrington, Conn. wastewater facilities

Table 5. Yields (grams) of brown grease pyrolysis products under argon atmosphere

Trial	Sample mass	Light Oil	Heavy Oil	Total Oil	Water	Tar, Char and Ash
1	41.220	21.335	5.195	26.530	3.566	3.888
2	42.477	19.869	6.337	26.206	3.024	4.934
3	42.451	25.488	2.659	28.147	3.444	3.604
Average	42.049	22.231	4.730	26.961 64% yield	3.445	4.142
Std. Dev.	0.718	2.915	1.882	1.040	0.284	0.700

Sources: Nashua, N.H. and Torrington, Conn. wastewater facilities

would be reduced, as energy is required to produce inert gases. That air does not appear to inhibit the process or reduce the yield has great significance concerning the capital costs of building the facilities as well as the cost of the process itself.

Model compound control experiment

The unusually low decarboxylation temperature of the brown grease led to the hypothesis that traces of metals and/or reactive oxygen species of biological origin catalyze this reaction. To test that hypothesis, a sample of "artificial brown grease" was prepared from 8.9-percent soy oil, 25.0-percent palmitic acid, 10.5-percent stearic acid, and 55.5-percent oleic acid by mass, to simulate the distribution of major components in the real brown grease. This fatty acid content, which varies from sample to sample, was similar to that analyzed by GC-MS from the Torrington facility, with 6.1-percent stearic acid, 68.3-percent oleic acid, 28.6-percent palmitic acid, and less than 2 percent each of tetradecanoic acid and hexadecenoic acids. The power setting of the heating mantle was increased according to the same schedule as used for the real brown grease to produce the temperature profile shown in Figure 4. The temperature profile in Figure 4 is not identical to that in Figure 2, and the temperature only reached 300°C (572°F) within 5.5 hours for the artificial brown grease rather than 350°C (662°F) in the case of the real brown grease. After continuing to heat the artificial brown grease overnight, the temperature reached 340°C (644°F) but only about 7 percent of the mass was lost to reaction or sublimation, leaving 93.1 percent of the mass in the reaction flask. Subsequent experiments showed that pure palmitic acid is converted to dipentadecyl ketone, which also sublimes with unreacted palmitic acid. The ketone is apparently converted to hydrocarbons over several days. With the real brown grease, only a small trace of the ketone is observed throughout the reaction.

DISCUSSION

Initial experiments where brown grease was heated rapidly resulted in significant amounts of carboxylic acids. In contrast, smaller amounts are formed when the temperature is gradually increased, as in the experiments described above. The FFA content can be further reduced by placing a short ceramic packed column between the reaction flask and the distillation head. The absence of any significant amount of C14 and higher carboxylic acids in the pyrolysis products indicates that decarboxylation is a net result of the reaction. However, if it was the only major reaction, the pyrolysis products would consist primarily of pentadecane, heptadecane, and heptadecenes. Our work indicates that a one-step decarboxylation is not the only possible reaction mechanism. The presence of C_6-C_{10} carboxylic acids indicates that some chain cleavage occurs at a rate comparable to the decarboxylation reactions, and those acids distill out of the reaction mixture unless the pyrolysis takes place slowly. Thermal cracking of petroleum occurs primarily by radical mechanisms, and radicals are more easily formed by bond cleavage at a carbon adjacent to a double bond. Radical formation and recombination is consistent with the formation of hydrocarbons in the C_8-C_{21} range in the pyrolysis products.

The formation of hydrocarbons greater than C_{17} could also occur by a coupling mechanism. Traces of transition metals were found in the brown grease, which could potentially catalyze coupling reactions. That potential mechanism will be the subject of further investigation.

Thermal cracking of petroleum occurs at temperatures above 500°C (932°F), which is significantly higher than the temperatures used in this work. The artificial brown grease system heated under the same conditions generated no detectable pyrolysis products. On the other hand, the real brown grease contains metal ions, described above, that may catalyze the pyrolysis by an as-yet-undetermined mechanism. It is also likely that the real brown grease contains alkene oxidization products from the unsaturated fatty acids, which could potentially catalyze the reaction.

We have performed preliminary work on pyrolysis of other carbon-rich substrates, such as polyethylene, polypropylene, polystyrene, and yellow grease. With the used plastics, the ease of pyrolysis follows the ease of radical formation, and branched chains pyrolyze easier than high-density polyethylene. Polystyrene pyrolysis yielded a mixture of toluene, ethylbenzene, isopropylbenzene, styrene, and α-methylstyrene, with traces of other compounds. Petroleum diesel fuel can contain up to 35-percent aromatics, so these compounds may be suitable for blending with petroleum diesel, biodiesel, or the green diesel described in this paper. Yellow grease can also undergo pyrolysis, although early results indicate it is more difficult than brown grease. Once the brown grease mechanisms and catalytic species are better understood, that knowledge can be applied to fuel oil synthesis from other substrates.

Brown grease from sewage scum and that removed from sewer systems have similar compositions of the oily organic component. Thus, the substrates appear to be interchangeable for fuel production.

A previously untapped source of fuel oil is municipal solid waste (MSW). Its FFA content is intermediate between that of yellow and brown grease, and it is a potentially useful and plentiful substrate for fuel oil production. The commercial potential for MSW oil extraction is being investigated in our laboratory.

Conversion of various FOGs, including brown grease, to fuels could have a major environmental and economic impact. Any grease kept out of landfills helps the environment by reducing the amount of methane produced. Methane is about 25 times as powerful as carbon dioxide as a greenhouse gas. The same applies to grease extracted from MSW. Although carbon dioxide is still produced when the fuel is burned, it avoids use of fossil fuels and is closer to carbon-neutral. Many experts believe the world has already reached peak oil production, or will do so soon. In contrast to petroleum, brown and yellow greases are renewable. It is not yet known how much petroleum can be replaced by oil extracted from MSW, but even replacement of a few percent of petroleum by renewable sources can significantly affect fuel prices.

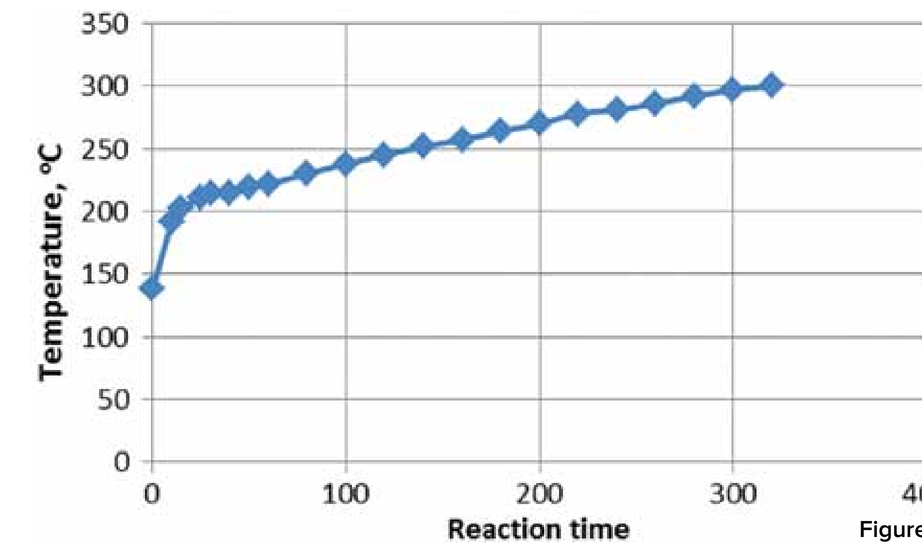

Figure 4. Artificial brown grease temperature as a function of time during pyrolysis

The future direction of this research will be to better understand the reaction mechanisms and catalytic species, develop a continuous process for brown grease conversion to fuel based on these results, and determine whether other sources of FOG can be efficiently converted to fuel oil, either alone or in combination with brown grease. Finally, we are working with colleagues in developing countries to use this technology to solve energy and environmental problems there.

CONCLUSIONS

Pyrolysis of brown grease generates a mixture of alkanes in the C8-C30 range, with smaller amounts of 1-alkenes in the C8-C15 range, and traces of higher alkanes and other compounds. This product distribution is different from the C15 and C17 major products that would be expected if decarboxylation were the only pyrolysis reaction. In addition to occurring at significantly lower temperatures than petroleum thermal cracking, this pyrolysis occurs without any added catalyst, being catalyzed by as yet undetermined species already in the feedstock. The pyrolysis occurs in the presence of air and does not require inert atmosphere, thus greatly reducing the potential costs of a commercial process. The reaction mechanisms are under investigation, and several possible mechanisms can likely contribute to the observed products. Furthermore, other carbon-rich substrates, including yellow grease, oil extracted from MSW, and used plastics can also be converted to hydrocarbons under sufficiently vigorous conditions. Once the reaction mechanisms and catalytic species are better understood, that knowledge can be applied to other systems.

ACKNOWLEDGMENTS

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PERSPECTIVE

Executive directors

As NEWEA grows as an organization, it is important to reflect on where we have come from and what is in store for the future. To do so, we spoke with Elizabeth Cutone, recently retired executive director of NEWEA, to discuss her thoughts on where we have come from, and then with NEWEA's new executive director, Mary Barry, to learn where she sees us going.

A conversation with Elizabeth Cutone

Elizabeth Cutone's 24 years as NEWEA executive director saw dramatic changes in the water quality industry, including new and increased standards for arsenic, radon, nutrients, a greater focus and higher costs to manage combined sewer overflows and polluted stormwater runoff, and the list goes on. Throughout that time, Elizabeth's consistent focus on empowering NEWEA members to lead through broader technical reach, expanded educational programs, and public outreach has helped bring about the dynamic, influential organization that exists today.

How did you come to NEWEA?
Before I started at NEWEA I was just out of college, working at an organization that provided "supported employment" opportunities to at-risk young adults with behavioral and developmental challenges. We found real life work experience for people and provided enough support to help them succeed in the work place with the goal of helping them become truly independent. A key part of that work is guiding people through situations that they might find intimidating and helping them see the value of their contribution, showing them that what they do and their work matters and is meaningful.

After that, I moved to Boston and literally answered an ad in the paper for a support role at NEWEA (NEWPCA at the time). I am very thankful to have worked with then-Director Al Peloquin for 2 years prior to his retirement and I sponged up as much of his wisdom as possible—giving me the edge to develop the knowledge and skills necessary to lead a dynamic association like NEWEA. Al was very generous with sharing his experience and knowledge, and at the same time willing to let me grow as a professional.

A conversation with Mary Barry

Mary Barry understands the depth and breadth of the wastewater and water professions. She has led marketing, strategy, partnering, and communications programs for national and international environmental and engineering consulting firms, working closely with engineers, scientists, operators, constructors, and state and municipal officials to implement some of the largest water treatment projects in the eastern U.S. Her knowledge of the technical challenges of the business are coupled with a keen understanding of how to effectively communicate both with well-informed stakeholders and with the general public to build consensus. As executive director of NEWEA, she will provide the vision and leadership to guide the organization through the next phase of its development.

How does your background influence your thinking about NEWEA and the wastewater industry?
Throughout my career I have worked to help bridge the gap between the technical side of what we do and the public side. So much of the work of NEWEA is about education, both within the industry but also in helping people outside the industry understand the importance of what we do. I believe that knowledge is power and that the more people know about our work the more supportive they will be, and that is good for all of us—the industry, the public, future generations, and the environment.

How do you think NEWEA will change in the coming years?
I believe the organization will continue to grow and become stronger with the diversity of its members. I also believe there will be continued focus on sustainability and water resources throughout our lives, driving our need for legislative and public

A conversation with Elizabeth Cutone (continued)

How has the organization evolved during your tenure?
Interestingly, our membership numbers have remained about the same over the last 25 years, but our operating budget has more than quadrupled. This means we have been able to provide more services and opportunities, more technical conferences, joint strategy sessions and educational events with other environmental organizations. Our reach is much broader. At one time we were considered to be a predominately technical association for engineers. We have grown to where, not only do we continue to provide a forum for exchange of highly regarded technical expertise, we now have strong public education and outreach programs, have gained traction in the government arena and have made strides influencing proposed legislation.

Over the last 25 years the leadership of this organization has also put strong emphasis on developing productive and mutually beneficial relationships with other environmental and related groups—specifically our six affiliated state associations, New England Water Works, New England Public Works Association, and the New York Water Environment Association (NYWEA). We now hold a regular joint Spring Meeting with NYWEA every 5 years. Our progressiveness and emphasis on relationship building is a testament to the vision of NEWEA's current and past leadership—understanding that water knows no boundaries nor should the organizations that exist solely to speak for it.

As NEWEA services and programs have evolved so as has the membership. NEWEA is a dynamic, diverse mix of engineers, scientists, operators, regulators, educators, researchers and community leaders—a powerful network of committed professionals all sharing a common goal of a universally valued and sustainable water infrastructure for now and generations to come.

What are you most proud of when you look back at your years leading the organization?
I feel like after 24 years of this work I've had 50 years of rewards. I am really proud to have been part of this special organization for so many years. I would like to think that I have done my best to relate and develop connections with members over the years. On that theme, one of my goals throughout my career with NEWEA has been to act as a catalyst for developing relationships among our members. At every event, meeting, and function I made a conscious effort to assist in making connections with and between our members and non-members alike. I was always looking around the room and strategizing at every event seeing the connections that could be made. This was especially true when I would see someone new to the organization or just starting his or her career; I knew that having someone to help navigate those first experiences with a new group can make all the difference. It may seem simplistic, but a friendly smile and one person to connect with is all someone needs to really feel a part of the group. Members may join for the technical exchanges, but they stay for the community.

Where do you think the organization and industry will be 25 years from now? Do you foresee any significant challenges?
That's a very hard question to answer, but I would like to think that there's opportunity for more cooperation between related organizations. Does it make sense to keep thinking of water and wastewater and related issues as separately entities?

One challenge that I think will persist is helping people understand the true value of water. Wars have been fought over water throughout our history, and as a society we really don't value water appropriately. I see us and our members playing a much more visible role in promoting the value of our infrastructure. Nursing associations don't need to promote the importance of their profession, but so much of what we do is unseen. Maybe the time is finally ripe, and governments will pay the kind of attention to our infrastructure that it deserves.

There's no one who knows water like we do. I was recently thinking about that line from the Dr. Seuss book "The Lorax": He keeps repeating that he "speaks for the trees." In an important sense, we speak for the water because it has no voice of its own. We have an intimate relationship with this beautiful natural resource. We know its power, its frailty, its beauty, and its importance. And we have to keep speaking for it so that the public understands what we understand.

A conversation with Mary Barry (continued)

partnering. Working with and providing information to policy and decision makers at the public, state, and national level is critical. There are also growing opportunities for us to do more with our sister organizations with common goals, through partnerships and joint projects on issues where our missions overlap.

What do you see on the horizon that might represent a major change or challenge for NEWEA?
Our generation is going to have to continue to focus not just on the immediate issue at hand but also on the implications to future generations. There will be more and more emphasis on sustainable solutions and creative technology, and our industry and members will have to keep innovating and developing new solutions to complex issues. We will also have to engage more than ever with all kinds of organizations and stakeholders, to increase the collaboration both in support and technology among the public and private sector, universities, utilities, and advocacy organizations.

I think a great strength of NEWEA is the belief that the mission is more important than any one person, and that will guide us through any challenge.

NEWEA
WORKING FOR WATER QUALITY

WEF delegate report

Since our last WEF delegate article Howard Carter and Jenn Lachmayr have been working on various House of Delegates (HOD) work group assignments. Jenn leads the leadership development work group, which provides leadership development tools that will be useful for all WEF members. Currently, the group is developing Webcasts, starting with the Membership Recruitment/ Retention Guidebook (4th edition, dated January 2014). The topic for development of leadership training materials was selected based on input from all Member Associations (MAs), and the concepts were vetted at the WEFMAX meetings. The goal is to have a product ready in late September, in time for WEFTEC 2014.

Howard is chairing the HOD nominating committee. Nominations were due by July 31 for WEF officer approval and appointment at WEFTEC 2014. Howard is also active on the non-dispersibles committee. The committee has turned its findings over to the WEF-NACWA-INDA task group, and an update will likely come in the fall of 2014.

Howard, Jenn, and other NEWEA members attended the first 2014 WEFMAX meeting in Weehawken, N.J., in March. The meeting was well attended, with the following topics covered: MA development of operator programs, membership value, retention and benefits, effective MA communication, and "whats" and "hows" of successful MA public outreach programs. Other WEFMAX venues this year included Whitefish, Mont., Grand Rapids, Mich., and Charleston, S.C.

Phyllis Arnold Rand, our most recently elected delegate, resigned her position effective April 2014. Michael Wilson was nominated at the NEWEA spring conference to serve the rest of her term, which runs through October 2016.

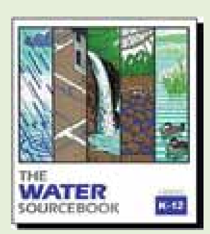
Mike has pledged to support sustainable action to further our mission, which is, in his words, to enable the rebirth of the water cycle, viewing ourselves at the beginning rather than at the end of the water story. He feels that association and community involvement and information are keys to sustaining our effectiveness. According to Mike, "The most important thing you can do is to get involved and give something back. Whether it's leading a WEFMAX gathering or talking to sixth graders about what you do, please find a way to give back and be a part of the rebirth of the water cycle." For the next couple of years, he'll be doing his part as our newest WEF delegate, and we look forward to working with him.

WEF has announced new nominations for vice president (Rick Warner – Nevada), board of trustees (Jackie Jarrell – North Carolina and Jenny Hartfelder – Colorado), and delegates at large, including Jenn who will be migrating from WEF NEWEA delegate to WEF delegate-at-large for a new 3-year term starting in October 2014 and running through 2017. Congratulations to Jenn and the other WEF officer nominees.

WEF Delegates: Michael Wilson, Jenn Lachmayr and Howard Carter

WEF items of interest

WEF offers no-cost Webcasts throughout the year on topics from utility management to collection systems to water advocacy—and more. Visit wef.org/webcasts to access all upcoming Webcasts, including April's: "Full-Plant Deammonification for Energy Positive Nitrogen Removal," which will also be featured on WEF's YouTube channel.



The Water Sourcebook CD-ROM K–12 is a comprehensive guide for teachers and water quality professionals. The CD-ROM teaches youth the importance of preserving and enhancing water resources. It is free except for shipping and handling at news.wef.org/free-wef-education-tool. Some of the contents are free to download at wef.org/PublicInformation/page.aspx?id=143.

NEBRA Highlights

Solids management research leading to the future

Research on the use of biosolids and other organic residuals as soil amendments and fertilizers has been ongoing at land grant universities around the U. S. for decades. Such research is found today at the University of Washington, Colorado State, Virginia Tech, and other universities near major agricultural areas where biosolids are routinely used in crop production.

In the past, all the New England land grant universities also contributed some research in biosolids use on soils. Today, this region sees continued use of bulk biosolids in agriculture. However, that use has been diminishing over the past decade, and there is more use of highly treated Class A biosolids products in landscaping and horticulture. Also, use of renewable energy is increasing.

These shifts in biosolids uses are mirrored by shifts in the focus of this region's biosolids research. For example, Dr. Rebecca Brown at the University of Rhode Island continues research to enhance sustainable production of vegetables, fruits, and turf grasses through using various kinds of recycled residuals such as food waste composts and Class A biosolids (see *NEWEA Journal*, Fall 2012).

Below are highlights of current research on biosolids as specialized soil amendments and for energy production that hint at how wastewater solids will be managed in the future.

Incinerator Ash as Phosphorus Fertilizer—Université Laval, Quebec

Quebec is an important agricultural region, and the province has policies—including a $20/ton disposal fee on landfilled biosolids—encouraging energy recovery from wastewater solids and land application of the resulting biosolids. Quebec environmental policy discourages incineration of wastewater solids but will allow it to continue under its future organic residuals recycling requirements if the ash is used productively, the incinerators are

New Haven, Conn. sewage sludge incinerator

operated to avoid significant nitrous oxide (greenhouse gas) emissions, and energy is recovered.

Nearby New England is home to the largest concentration of wastewater solids incinerators in North America, with Connecticut and Rhode Island relying heavily on this technology for solids management.

This summer, scientists at Université Laval in Quebec City are evaluating the efficacy of using the ash from wastewater solids incineration as a phosphorus fertilizer. The project, led by Professor Lotfi Khiari and intern Hatem Farhat, is instigated and funded largely by the Quebec environment ministry. The project analyzes ashes from 10 incineration facilities and tests the effects of different rates of application on ryegrass growth in greenhouse potted soil studies.

In Quebec, 48 percent of the wastewater solids produced in the province are processed at three large incineration facilities—Quebec City, Montreal, and Longueil. The current research project uses ash samples from two of these facilities, as well as two Ontario incinerators. NEBRA has helped facilitate the additional involvement of four New England incinerators. The research results are expected to be published next winter.

There has already been land application of Manchester wastewater solids incinerator ash in New Hampshire. And, according to the Laval research team, its use has been approved in Germany and other parts of Europe. But research on the bioavailability of ash phosphorus and impacts of using this ash in agriculture in this region will be useful in informing decisions about its further use here and determining best management practices.

This summer's research began with analysis of the ash samples for phosphorus content and other constituents. The researchers then set up random replications of each ash applied at different P application rates to two kinds of soil (coarse-textured and fine-textured). Controls consist of the same two soils fertilized with triple superphosphate fertilizer. Ryegrass is growing in all of the pots of soil; in late summer, it will be harvested and analyzed for total plant mass, nutrient content, and other parameters.

If the current greenhouse trials indicate value in this use of wastewater solids incinerator ash, the research team will likely conduct field studies next year.

MWRA Co-digestion—University of Massachusetts/Amherst

At the University of Massachusetts/Amherst, graduate student Wenye Camilla Kuo-Dahab and other students working with Dr. Chul Park continue laboratory testing of co-digestion of food waste and biosolids for the Massachusetts Water Resource Authority (MWRA). The anaerobic digestion facilities at the Deer Island Treatment Plant (DITP) are seen as a significant part of the solution for managing food waste that the commonwealth of Massachusetts is targeting for diversion from landfills. In a presentation at WEF's residuals and biosolids conference in Austin, Texas, in May, the research team, including Parviz Amirhor and Meredith Zona of Fay, Spofford & Thorndike and David Duest of MWRA, reported:

- VSR based on VS loadings increased from approximately 66 to 76.4 percent (2 to 18 percent over control digesters) as the ratio of food waste in the feed sludge increased from 0 to 50 percent. All co-digestion tests showed higher gas production than the digesters processing only wastewater solids.
- Cumulative biogas production during the 150-day study increased as the ratio of food waste to feed sludge increased from approximately 22 to 97 percent, compared to control [solids-only] digesters.
- The highest biogas yield was obtained in the reactors with a food waste to feed sludge ratio of 10 to 20 percent.
- All co-digesters...did not show negative effects on the system stability.
- The addition of food waste to the anaerobic digestion process has little impact on sidestream nitrogen and phosphorus loadings. However, the addition of food waste increases the COD loadings of the sidestream.
- Comparisons of this study to research at East Bay Municipal Utility District in California found similar results and conclusions, including that "food waste is a highly desirable substrate for co-digestion with sewage sludge...with regards to increased biodegradability and methane yield and content, while maintaining digester stability and not increasing total soluble nitrogen and soluble phosphate to the sidestream loading."

In related work, MWRA is evaluating harvesting struvite for reducing maintenance issues caused by this and related minerals and producing another valuable product from wastewater management. Currently, ferric chloride is added to the digesters to inhibit struvite formation by precipitating vivianite (iron phosphate) to reduce the available phosphorus. This method reduces both the formation of struvite and hydrogen sulfide in the biogas, but it is a major chemical cost for ferric chloride, according to Eric Spargimino (CDM Smith), who will present information on struvite harvesting at the annual northeastern residuals and biosolids conference in South Portland, Maine, October 22–23, 2014.


HRSD A-stage pilot

MAXIMIZING THE CAPTURE OF CARBON FOR ANAEROBIC DIGESTION AND ENERGY PRODUCTION

At the NEWEA Annual Conference in January 2014, Ed Kobylinski (Black & Veatch) stressed that "primary treatment is the key to attaining energy neutrality." He noted that the average electricity consumption for wastewater treatment ranges from 950 to 1,900 kWh/million gallons (250 to 500 kWh/million liters) treated. The goal today should be to minimize net energy consumption: "minimize energy use on the liquid side and increase potential for harvesting energy from solids processes." He explains that to do this requires capturing as much biological oxygen demand (BOD) as possible in the primary treatment process and minimizing the sludge retention time (SRT) in liquid treatment processes to conserve carbon for energy recovery. In short, "make more primary sludge; make less waste-activated sludge (WAS)." This rule applies to both anaerobic digestion and thermal conversion (incineration with energy recovery). In both cases solids removed in primary processes have more energy than WAS, and removing them early in the liquid process reduces energy demand in secondary treatment. He points to alternative primary treatment processes that can help capture not just easily settled suspended solids, but others as well. These include chemically enhanced primary treatment (CEPT), Co-Mag (a proprietary process), compressible media filters as primary treatment, Actiflo as primary treatment, and Salsnes filters.

Jason Turgeon of EPA Region 1 has also championed the idea of shunting carbon to anaerobic digestion and energy recovery as efficiently as possible in the primary treatment process.

One challenge in maximizing primary sludge production is that some carbon is needed in biological nutrient removal processes in the liquid stream. Therefore, a balance is needed. In collaboration with the Hampton Roads Sanitation District (HRSD) in Virginia, Virginia Tech graduate student Mark Miller is looking at how best to capture and use the energy in wastewater while also efficiently meeting strict effluent nutrient limits. Dr. Charles Bott, research and development manager at HRSD, is helping spearhead this research, collaborating with researchers and operators in Europe and the U. S. Bott was a keynote presenter at NEWEA's "Moving Toward Sustainability" energy and nutrients conference in Sturbridge, Mass., in May. Miller describes the HRSD research on increased capture of carbon for digestion:

"Several processes (e.g., primary sedimentation) can redirect organic carbon; however, they are generally limited to particulate matter, require external chemical addition, or mineralize a large fraction of the influent carbon. One process that has been successfully used for carbon redirection is the adsorption-style high-rate activated sludge (HRAS) process commonly referred to as the A-stage process. The A-stage (A/B process) was originally developed by Böhnke and Diering (1980) as a cost-effective biological buffer against nitrification inhibition at plants with high industrial inputs. The A-stage was designed to remove only a portion of the organic carbon so that the nutrient removal goals of the B-stage could still be met. Recently, the A-stage has been used to redirect organic carbon to anaerobic digestion for biogas production. The need for a controlled influent COD to nitrogen (C/N) ratio has also generated a renewed interest in the A-stage prior to short-cut nitrogen removal technologies, such as mainstream nitritation-denitritation and anaerobic ammonia oxidation (anammox).

"The high-rate operation of the A-stage (<1 day SRT, ~30 min HRT, <1 mg/L DO) results in concentrating the influent particulate, colloidal, and soluble COD (chemical oxygen demand) to a waste solids stream with minimal energy input in a small footprint by maximizing sludge production (i.e., yield), bacterial storage, and bioflocculation. This concentrated stream is then redirected to an energy recovery process like anaerobic digestion or incineration. By redirecting carbon to anaerobic digestion, the A-stage at a facility in Rotterdam, Netherlands, can produce 0.5 kg methane/kg (0.5 lb/lb) COD removed (Jetten et al., 1997). Maximizing yield in the A-stage also results in maximizing nitrogen and phosphorus removal by assimilation (Jetten et al., 1997). The sludge produced by an A-stage has better digestion characteristics compared to normal secondary sludge, which results in a lower overall sludge production when compared to a single-sludge nutrient removal process preceded by primary sedimentation (van Loosdrecht et al., 1997). It was shown that the required specific aeration tank volume of an A/B process can be reduced to 65 L/PE (17 gal/PE) (population equivalent), compared to 150 to 200 L/PE (40 to 53 gal/PE) for single-stage processes, which is a 57- to 68-percent reduction in the specific aeration volume required (Müller-Rechberger et al., 2001).

"The A-stage process can cost-effectively redirect organic carbon without significant energy input and does not require external chemical addition, as in the case of traditional chemically enhanced primary treatment (CEPT). Despite the advantages of the A-stage, there is relatively little knowledge on controlling carbon redirection and mineralization. It is the objective of this work to present what is already known about full-scale A-stages and continue to expand the knowledge base so facilities can obtain energy self-sufficiency through carbon redirection and recovery. HRSD is piloting an A-stage as part of a mainstream nitritation-denitritation process followed by tertiary anammox polishing."

ANOTHER WASTEWATER RESOURCE TO BE RECOGNIZED AND RECOVERED—BROWN GREASE

"A year ago, Richard Parnas had never heard of brown grease: stick,y stinky remnants of sludge sucked from grease traps at restaurants, bars and commercial kitchens. The glop for years has been considered useless, a common clog-inducer at sewage treatment plants, often burned as costly waste." So begins a 2012 industry news article (fuelfix.com/blog/2012/11/26/uconn-professor-seeks-to-turn-grease-into-fuel).

This year, research on converting brown grease to biodiesel is shifting to a pilot unit at the wastewater treatment plant in Torrington, Conn.

For the past few years, Dr. Parnas of the University of Connecticut has continued to work with researchers around the region to better understand the chemistry and potential of brown grease as a fuel. This year, his research on converting brown grease to biodiesel is shifting to a pilot unit at the wastewater treatment plant in Torrington, Conn. Funding is being provided by a Connecticut Innovations grant. Initial results from the pilot are expected this fall. His hope is to develop a "plug and play unit that fits in two shipping containers," he explained in a recent phone interview.

Others have been interested in this challenge. Of course, yellow grease—used cooking oils—is already widely used in biodiesel production; but it is far purer and has less water than brown grease. Brown grease is being used as a valuable, high-energy addition to anaerobic digesters, where it generates copious biogas. Creating a fuel, however, would be a higher and more valuable use of brown grease. A few companies have pioneered biodiesel production from brown grease over the past decade, with limited success. According to Dr. Parnas, one particular biodiesel product from brown grease is having difficulty meeting the ASTM standard for sulfur content.


Brown grease: sticky, stinky remnants of sludge sucked from grease traps at restaurants, bars and commercial kitchens

One challenge for the economic feasibility of converting brown grease to valuable fuel is figuring out how to minimize the time needed for the chemical reactions involved. Slower reactions make for longer processing times, more energy use, and the need for larger processing capacity. One alternative, using catalysts, requires additional costly inputs. Therefore, Dr. Parnas is interested in the work of Dr. Lawrence Pratt, a chemist at Medgar Evars College in Brooklyn. Pratt and his team of students have been conducting detailed laboratory tests to figure out how to convert brown grease to energy-rich oils as efficiently as possible. The research paper (beginning on page 44) provides the latest on this research. In time, such research may help determine how this challenging waste can become yet another valuable wastewater-derived resource.

The feature article—*Beneficial Use of Brown Grease…* begins on page 44

Ned Beecher, Executive Director
Tamworth, N.H.
603-323-7654 | info@nebiosolids.org

For more information or to subscribe to NEBRAMail, NEBRA's email newsletter visit nebiosolids.org

EVENTS

Specialty conferences & educational series proceedings

Attendees participated in various work groups and discussions during the two-day asset management workshop

WORKSHOP

ASSET MANAGEMENT

Hosted by NEWEA's Asset Management Committee

June 25 & 26, 2014
Cataqua Publick House,
Portsmouth, New Hampshire

The workshop had 60 participants. The technical presentations commenced on Wednesday, June 25, 2014, with NEWEA President Brad Moore and NEWEA Asset Management Committee Chair John Jackman providing the Welcome and Opening Remarks to meeting attendees.

In addition to the workshop, a networking reception and dinner event was held on Wednesday.

TECHNICAL PRESENTATIONS
Wednesday, June 25, 2014

Asset Management at Columbus DPU -
- Kevin Campanella, City of Columbus, OH

Asset Management at Narragansett Bay Commission
- Joe LaPlante, Narragansett Bay Commission, Providence, RI

Asset Management at City of Bangor
- Brad Moore, City of Bangor, ME WWTP

TECHNICAL PRESENTATIONS
Thursday, June 26, 2014

NHDES Funding Options for Asset Management
- Sharon Rivard and Luis Adorno, NHDES

Attendees participated in workgroups supported and advised by experienced AM practitioners, discussing asset management actions and how they can be implemented at least cost and for the greatest benefit and value. As a result from the workgroups, the NEWEA Asset Management Committee published a white paper focused on right-sizing a practical AM implementation.

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WEBINAR SERIES

INDUSTRIAL WASTEWATER

Hosted by NEWEA's Industrial Wastewater Committee

A three-part webinar series on November 13, December 11, 2013 and January 9, 2014

Wednesday, November 13, 2013
Overcoming Challenges with pH Control for Industrial Water—Pulp & Paper
- Matt DeMarco, ARCADIS

Fundamentals of Coagulation and Flocculation in Industrial Wastewater Treatment
- Hugh Tozer, Woodard & Curran

Wednesday, December 11, 2013
Complying with Whole Effluent Toxicity (WET) Requirements of NPDES Permits
- Dr. John Cooney, Aquatic Toxicology Consultant

Approaching Complex Toxicity Identification and Toxicity Reduction Evaluations (TIEs and TREs)
- Dr. Jerry Diamond, TetraTech

Thursday, January 9, 2014
Introduction to the Federal Pretreatment Program Regulations and Standards
- Jay Pimpare, EPA Region 1

SEMINAR

NUTRIENT REGULATIONS Removal and Monitoring—A Small Community Perspective

Hosted by NEWEA's Small Community and Laboratory Practice Committees

November 14, 2013
Crowne Plaza Hotel,
Cromwell, Connecticut

The seminar had 54 attendees.

The technical presentations commenced with NEWEA President Michael Bonomo and NEWEA Small Community Chair Jeff Gregg providing the Welcome and Opening Remarks to meeting attendees.

TECHNICAL PRESENTATIONS

Regulations—Nutrient Removal
- Iliana Raffa and Mary Becker, CT DEEP

Case Study—Old Saybrook, CT WPCA
- Kurt Mailman, Fuss & O'Neill, Inc.

NPDES and Phosphorus Implementation
- Rowland Denny, CT DEEP

What Small Communities Can Learn From Stamford, CT's Experience
- Mary Lee Santoro, City of Stamford, CT

Case Study—Southbridge, MA WWTF
- Paul Kransnecky, Southbridge, MA WWTF

Case Study—Sturbridge, MA WWTF
- Ian Catlow, Tighe & Bond

Case Study—City of Shelton, CT WWTP
- Matt Jermine, Fuss & O'Neill, Inc.

Case Study—Jewett City, CT WWTP
- Jon Pearson, AECOM

Making Effective Use of th e Myriad of In-House Phosphorus Testing Methods
- Justin Skelly, Tighe & Bond

Nitrogen Testing—Correlating Data with Online Instrumentation
- Mary Lee Santoro, City of Stamford, CT

CONFERENCES

RISK MANAGEMENT, EMERGENCY PREPAREDNESS, AND BUSINESS CONTINUITY Planning for Water and Wastewater Utilities—Critical to Operations in these Demanding Times

Hosted by NEWEA's Utility Management Committee, Safety Committee and New England Water Works Association (NEWWA)

September 25, 2013
Best Western Royal Plaza Hotel
Marlborough, Massachusetts.

Over 100 attendees participated in this conference.

The specialty conference focused on risk assessment, emergency preparedness and business continuity planning. The technical presentations commenced on Wednesday, September 25, 2013, with NEWEA President, Mike Bonomo and NEWWA President, David Harris providing the Welcome and Opening Remarks to meeting attendees.

In addition to the conference, two concurrent technical sessions and a facility tour to MWRA's John J. Carroll Water Treatment Plant was offered.

KEYNOTE
The Water Sector's Role in Securing the Nation
- Kevin Morley, Security & Preparedness Program Manager for the American Water Works Association

TECHNICAL PRESENTATIONS

Why Are We Here? Aging Infrastructure, Doing More with Less, Climate Change Facing the "New Normal"
- Marian Long, Principal, Gradient Planning

Community Engagement and Benefit-Cost Analysis to Create Water/Wastewater Infrastructure Resiliency
- Sam Merrill, Associate Research Professor, University of Southern Maine

Case Study—The Benefits of Emergency Planning – Mass Water Resources Authority Aqueduct Failure
- Marcis Kempe, Director of Operations, MWRA

The Benefits of Business Continuity Planning—Regional Water Authority, New Haven, CT
- Kate Novick, President, Gradient Planning and Jim Flynn, Regional Water Authority

Cyber Security & Homeland Security
- Mike Leking, Cyber Security Advisor, U.S. Department of Homeland Security

CONCURRENT SESSION
FEMA FUNDING

An Ounce of Prevention—Accessing FEMA Funding for Hazard Mitigation Work
- Mary Kristin Ivanovich, Vice President and Mary McCrann, Woodard & Curran

Lessons Learned to Improve Disaster Management
- Jamia McDonald, RIEMA Acting Executive Director and Janine Burke, Executive Director, Warwick Sewer Authority

CONCURRENT SESSION
DEVELOPING A PLAN

CT's Public Water Systems Emergency Preparedness—Small Community Water Systems
- Lori Mathieu, CT's Drinking Water Administrator & Section Chief of the CT Department of Public Health's Drinking Water Section

Crisis Communications in a 140 Character World
- Andrea Obston, President, Andrea Obston Marketing Communications, LLC

CONCURRENT SESSION
MWRA'S MARLBORO FACILITY TOUR
Tour Coordinator: Marcis Kempe, MWRA

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CSO/WET WEATHER ISSUES, STORMWATER & WATERSHED MANAGEMENT

Hosted by NEWEA's CSO/Wet Weather Issues Committee and Stormwater and Watershed Management Committees

October 23 & 24, 2013
Biltmore Hotel, Providence, Rhode Island

Meeting registrants included: 161 attendees and 17 exhibit displays for a total of 178 registrants.

The technical presentations commenced on Wednesday with NEWEA CSO/Wet Weather Issues Committee Chair James Drake; NEWEA President Michael Bonomo, and The Honorable Angel Taveras, Mayor of Providence, Rhode Island providing the Welcome and Opening Remarks to meeting attendees.

In addition to the conference, two optional concurrent facility tours were offered; NBC's Fields Point WWTF & CSO Abatement Tunnel Project and

Green Infrastructure Tour of Eastern Narragansett Bay were held on Thursday,. A meet and greet reception was also held in the exhibit area on Wednesday,

TECHNICAL PRESENTATIONS
Wednesday, October 23, 2013

GENERAL SESSION
Moderator:
- James Drake, CDM Smith

Update on National Wet Weather Issues
- Deborah Nagle and Mark Pollins, US EPA; Thelma Murphy, US EPA Region 1

Panel Discussion: Integrated Wet Weather Approach
Moderator:
- William Taylor, Pierce Atwood LLP
- Pinar Balci, Director, Bureau of Environmental Planning and Analysis, NYC DEP
- John Sullivan, Chief Engineer, BWSC
- Robert Moylan, Commissioner, Worcester, MA DPW & Parks
- Raymond Marshall, Executive Director, Narragansett Bay Commission

CONCURRENT SESSION
IS INTEGRATION THE KEY TO SUCCESS?
Moderators:
- Matt St. Pierre, Tata & Howard
- Chris Feeney, Louis Berger Group

Water Resource Management Drives Integrated Stormwater, Wastewater and Drinking Water Integrated Plan
- Bethany Leavitt and Sarah Bounty, CH2M HILL

Integrating the Latest Industry Trends into "Age-Old" Projects
- Patricia Passariello, Weston & Sampson

Integrated Wet Weather Planning Programmatic and Financial Considerations
- Leah Gaffney and Prabha Kumar, Black & Veatch

Why Do An Integrated Plan?
- Fredric Andes, Barnes & Thornburg

Why Spring and Fall Storms Tell only Half of the Story; An Integrated Solution to Flood Mitigation and CSO Control
- Matthew Gamache, CDM Smith

CONCURRENT SESSION
CORNUCOPIA OF STORMWATER AND FUNDING ISSUES
Moderator:
• Virgil Lloyd, Fuss & O'Neill, Inc.
• Mike Wilson, CH2M HILL

The New Phase II—A Coming Event
• M. James Riordan, Fuss & O'Neill, Inc.
• Nisha Patel, CT DEEP
• Eric Beck, RIDEM

Update on Northampton's Stormwater and Flood Control Utility Project
• James Laurila, City of Northampton Public Works
• Virginia Roach, CDM Smith

Mystic River Watershed Association Engages Town of Arlington in Rain Garden Planning, Design and Construction
• Meredith Zona, Fay, Spofford & Thorndike

A Tale of Two Cities
• Amy Corriveau, CDM Smith

Town & City—Planning for a Regional Stormwater Utility in the Upper Narragansett Bay Area
• Sheila Dormody, City of Providence, RI
• M. James Riordan, Fuss & O'Neill, Inc.

TECHNICAL PRESENTATIONS
Thursday, October 24, 2013

Two Concurrent Sessions were held.

CONCURRENT SESSION
MIXING GREEN AND GRAY OFFERS BETTER CSO CONTROL
Moderators:
• Laurie Perkins, Wright-Pierce
• Rita Fordiani, CH2M HILL

Construction Assessment of Right-of-Way Bioswales in NYC
• Karen Appell, AECOM

Green Infrastructure Construction and Technology Choices
• Zachary Monge and Sean Skehan, CH2M HILL

Greening the Bronx for CSO Control
• Walid Harrouch, NYC DEP
• Michael Dodson, CDM Smith

Green Redevelopment Reduces CSOs in New Haven
• Tom Sgroi, Greater New Haven WPCA
• Bruce Kirkland, Greater New Haven WPCA

Using Stormwater Detention Facilities To Mitigate CSOs, Upper Granby Road Sewer Separation Project, Chicopee, MA
• David Partridge, Tighe & Bond, Inc.

Cambridge Stormwater Outfall and Wetland Basin Project
• Owen O'Riordan, Cambridge, MA DPW

CONCURRENT SESSION
INTEGRATED APPROACH IN PRACTICE AND PLANNING
Moderators:
• Mike Wilson, CH2M HILL
• Phil Forzley, Fuss & O'Neill, Inc.

CSO Compliance as a Benefit, Not a Goal—Springfield Water and Sewer Commission's Development of an Integrated Plan
• Thomas Ritchie, Kleinfelder

Green Solutions for CSO Abatement in Fall River, MA
• Cynthia Baumann, CDM Smith
• Terrance Sullivan, City of Fall River

Integrated Permit Approach for the Town of Durham and the University of New Hampshire
• David Cedarholm, Town of Durham, NH

I Love That Dirty Water: Water Quality in Boston's Drainage System
• Mitchell Heineman, CDM Smith

Baltimore's Solution to Integrated Wet Weather Issues
• Rudolph Chow, Baltimore City DPW
• Arthur Jones-Dove, Louis Berger

Integrated Tunnel System Leads to Optimized Sizing for the Hartford MDC to Achieve Required Control Levels
• Scott Craig, CDM Smith

EXHIBITORS
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ANNUAL NORTH EAST RESIDUALS & BIOSOLIDS

From 503 to Infinity! Biosolids Resource Recovery Takes Off...

Hosted by NEWEA's Residuals Management Committee and NEBRA

October 29 & 30, 2013
Grappone Conference Center, Concord, New Hampshire

Meeting registrants included: 94 attendees and 11 exhibitors for a total of 105 registrants. The two-day conference was held jointly with the North East Biosolids & Residuals Association (NEBRA).

The technical presentations commenced on Tuesday, October 29, 2013, with NEWEA President Michael Bonomo and NEWEA Residuals Management Committee Chair Jonathan Keaney providing the Welcome and Opening Remarks to meeting attendees.

In addition to the conference, an optional facility tour to the Manchester, N.H. Incinerator Upgrades and Land Application Demonstration was held on Tuesday, October 29. A meet and greet reception was also held in the exhibit area on Tuesday, October 29.

TECHNICAL PRESENTATIONS
Tuesday, October 29, 2013

SESSION 1
503... 20 YEARS LATER
Moderator:
• Charlie Alix, Stantec

Reflections of a Federal Biosolids Regulator—Tweny Years After the Adoption of Part 503
• Alan Rubin, U. S. EPA (retired)

The Research: Metal & Chemical Standards & Risk Assessment
• Rufus Chaney, USDA

Review of U.S. Guidance and Regulations for Sludge Disinfection and Stabilization, Including a Future Projection
• Jim Smith, U. S. EPA (retired)

SESSION 2
503... TODAY
Moderator:
• Elaine Sistare, CDM Smith

Getting it Hot and Doing it Fast: Upgrading a Fluidized Bed Sludge Incinerator in Manchester, NH
• Matthew Formica, AECOM
• Fred McNeill, City of Manchester, NH

Extractive Nutrient Recovery as a Green Option for Managing Phosphorus in Sidestreams and Biosolids
• Wendell Khunjar, Hazen & Sawyer

Operational Efficiencies in Biosolids Transportation and Processing to Reduce Carbon Impact
• Jen McDonnell, Casella Organics

GROUP DISCUSSION: 503 FORWARD
Moderator:
• Andrew Carpenter, Northern Tilth
Speakers:
• Alan Rubin, Rufus Chaney, and Jim Smith discussed their perspective on 503.

TECHNICAL PRESENTATIONS
Wednesday, October 30, 2013

WELCOME & OPENING REMARKS
• Andrew Carpenter, NEBRA President

SESSION 3
TO INFINITY...ADVANCING DIGESTION & ENERGY
Moderator:
• Deb Mahoney, Hazen and Sawyer

Utilizing Excess Anaerobic Digester Capacity to Process Source Separated Organics—Two Case Studies
• Anastasia Rudenko, GHD

Investigating Anaerobic Co-Digestion of Sewage Sludge and Food Waste Using a Bench-Scale Pilot Study
• Wenye Camilla Kuo-Dahab, Univ. of MA

Co-Digestion at Deer Island Treatment Plant
• John Donovan, CDM Smith
• David Duest, MWRA

Taking WAS Out of the Waste: Sludge Pretreatment for Beneficial Uses
• Matthew Van Horne, Hazen & Sawyer

CONCURRENT SESSION WITH NHWWA
Using Water Treatment Residuals as Soil Amendments
• Andrew Carpenter, Northern Tilth
• Gavin MacDonald, Resource Management
• Ian Rohrbacher, Somersworth Water Dept.

CONCURRENT SESSION 4B
Moderator:
• Tom Schwartz, Woodard & Curran

Beneficially Reusing Industrial Wastewaters & Waste By-Products
• Wes Ripple, NH Dept. of Environmental Services

Wastewater Anaerobic Digestion Comes to Maine—Mac Richardson, Lewiston Auburn WPCA

Using Residuals to Improve New England Soils
• Shelagh Connelly, and
• Charley Hanson, Resource Management Inc.

SESSION 5
TO INFINITY AND BEYOND
Moderator:
• Donald Song, Wright-Pierce

Keynote: Biosolids as a Tool for Solving Others' Challenges
• Mike Van Ham, Sylvis Environmental

Consistency & Transparency
• Kevin Litwiller, Lystek International Inc.

Technology & Hubris vs. Common Sense
• Charlie Alix, Stantec

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ENERGY & SUSTAINABILITY SPECIALTY CONFERENCE

Hosted by NEWEA's Energy and Sustainability Committee

May 7 & 8, 2014
Publick House Inn, Sturbridge, MA

Meeting registrants included: 77 attendees and 8 exhibit displays for a total of 85 registrants.

The technical presentations commenced on Wednesday with NEWEA Energy Committee Chair Tom Schwartz and NEWEA Vice President Ray Willis providing the Welcome and Opening Remarks to meeting attendees.

In addition to the conference, an optional facility tour to the Sturbridge wastewater treatment plant was held on Wednesday. A meet and greet reception was also held in the exhibit area on Wednesday.

TECHNICAL PRESENTATIONS
Wednesday, May 7, 2014

SESSION 1
Plant Upgrades for Nutrient Removal
Moderator:
• Tilo Stahl, Biochem Technology Inc.

Aeration Upgrades for Permit Renewal and Energy Consequences
• Tom Ciolfi, Narragansett Bay Commission, Providence, RI

Lagoon Cold Weather Nitrification using a BAF
• Philip Pedros, AECOM, Washington, DC

KEYNOTE
Roadmap to Sustainability—Imagine if...
• Matt Ries, Chief Technical Officer WEF, Alexandria, VA

KEYNOTE
The Energy Roadmap
• Ed McCormick, WEF President-Elect

SESSION 2
Optimizing What You Have for Nutrient Control
Moderator:
• Cynthia Castellon, Tighe & Bond

Low Cost Retrofits for Nitrogen Removal at Wastewater Treatment Plants in the Upper Long Island Sound
• Jeanette Brown, Consultant, Stamford, CT

Nitrogen Removal at Bargain Cost
• Grant Weaver, The Water Planet Company, New London, CT

Optimizing BNR Process Control for Nutrient Removal and Energy Efficiency
• Tilo Stahl, Biochem Technology, Inc., King of Prussia, PA

ROUNDTABLE DISCUSSION
The Next Frontier for Resource Recovery Facilities
Moderator:
• Elizabeth Watson, United Water
Speakers:
• Ed McCormick, Matt Ries, Charles Bott, Jeanette Brown

TECHNICAL PRESENTATIONS
Thursday, May 8, 2014

The technical presentations continued on Thursday with NEWEA Sustainability Committee Chair Elizabeth Watson providing the Welcome and Opening Remarks to meeting attendees.

SESSION 3
Phosphorus Recovery
Moderator:
• Tom Schwartz, Woodard & Curran, Inc.

Impact of SRT on Enhanced Biological Phosphorus Removal
• Yueyun Li, Northeastern University, Boston, MA

Evaluating Biological Phosphorus Removal Capacity
• Yuqi Wang, Northeastern University, Boston, MA

Innovative Approaches to Phosphorus Recovery
• Mark Greene, O'Brien & Gere, Albany, NY

SESSION 4
Sustainability Considerations in Plant Design
Moderator:
• Ken Maltese, Maltese and Associates, LLC

Sustainability Assessment of Advanced Nutrient Removal Processes using Life Cycle Assessment
• Sheikh Rahman, Northeastern University, Boston, MA

Sustainability Considerations in Process Selection for Biological Nutrient Removal
• Courtney Eaton, Carollo Engineers, Danvers, MA

Sustainable Nutrient Removal—Upper Blackstone Water Pollution Abatement District
• Maureen Neville, CDM Smith, Cambridge, MA

KEYNOTE
Advances in Point Source Nitrogen Removal Technologies—Transitioning from Version 1.0 to 3.0
• Charles Bott, Hampton Roads Sanitation District, Virginia Beach, VA
Moderator:
• Jason Turgeon, USEPA Region 1, Boston, MA

SESSION 5
Leading Edge Technologies
Moderator:
• Denise Breiteneicher, MWRA

The DEMON® Process: Resource Savings Through Sidestream Centrate Treatment
• Andrea Nifong, World Water Works, Oklahoma City, OK

Microbial Fuel Cell Latrine for Decentralized and Developing Countries and Decentralized Applications
• Cynthia Castro, University of Massachusetts, Amherst, MA

Ecovolt: The World's First Bioelectric Treatment Process
Justin Buck, Antenna Group

NEWEA Energy Committee Vice Chair Denise Breiteneicher gave the closing remarks.

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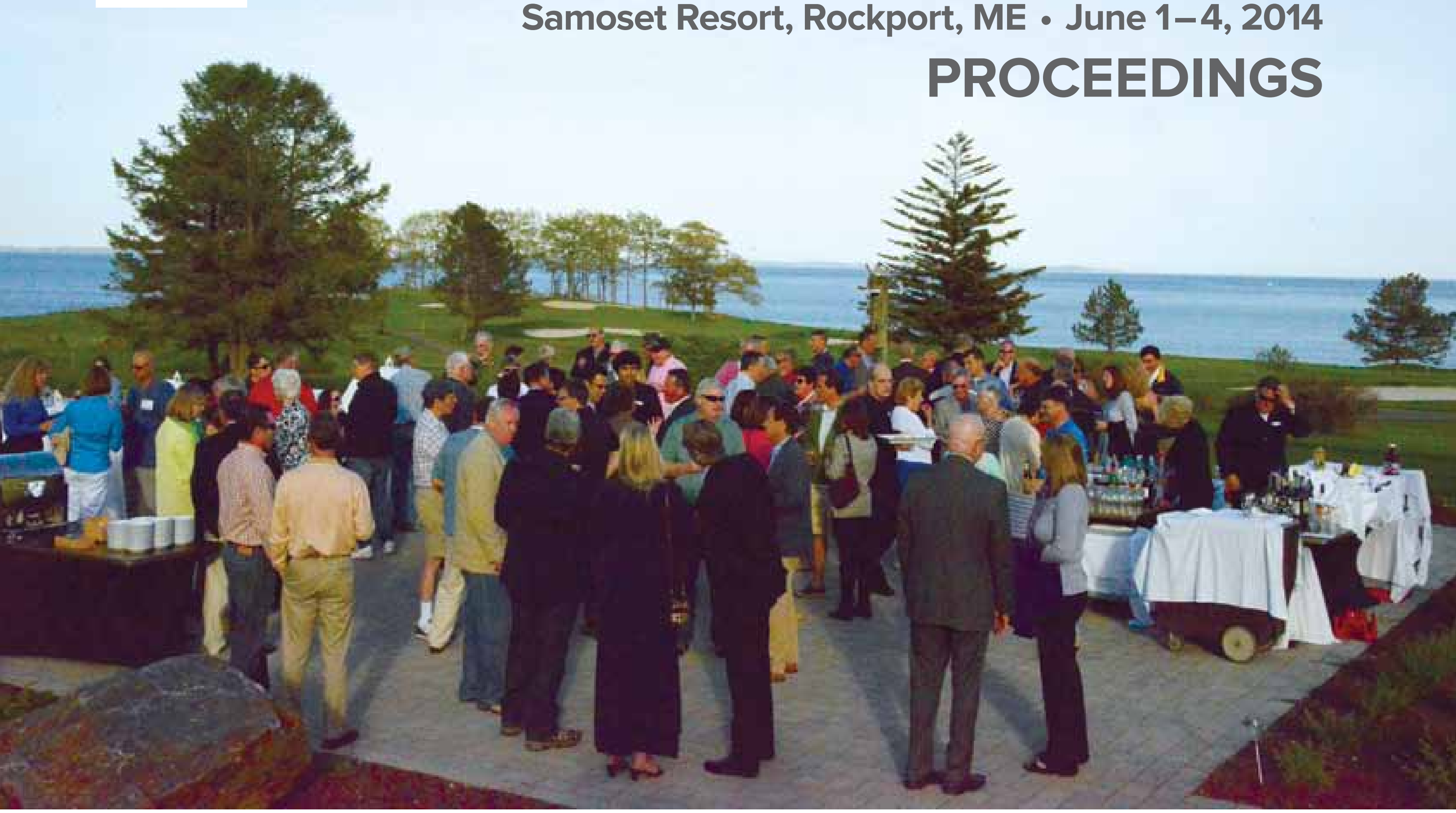
(10/14)

EVENT

2014 Spring Meeting & Exhibit

Samoset Resort, Rockport, ME • June 1–4, 2014

PROCEEDINGS



(opposite page) The president's reception **1.** President Brad Moore and his family **2.** Past President Jim Courchaine, Executive Director Mary Barry, and Conference Arrangements Chair Ron Tiberi **3.** New Hampshire Director Fred McNeill and WERF Program Director Lola Olabode **4.** The tour of Fisher Engineering production facility and pretreatment system

The New England Water Environment Association (NEWEA) held its Annual Spring Meeting on June 1–4, 2014 at the Samoset Resort in Rockport, Maine. Meeting registrants totaled 172. Registrants included 124 members, 5 non-members, 15 Operations Challenge participants, and 16 guests. The meeting also featured 12 exhibit booths.

A full NEWEA Executive Committee meeting with Committee Chairs was held on Sunday, June 1, 2014, with NEWEA President Bradley Moore presiding.

In addition to the Opening Session, there were nine technical sessions and one tour.

BREAKFAST AND GENERAL OPENING SESSION

Moderator:
- Susan Guswa, Tighe & Bond, Inc.

Welcome:
- Bradley Moore, NEWEA President

Featured Speaker:
- Bob Crowley, Maine Native and 2008 Season Winner of "Survivor"

SESSION 1
Operator Focus

Moderators:
- Peter Goodwin, Woodard & Curran
- Patricia Passariello, Weston & Sampson

The Nashua WWTF Upgrade from the Operators' Perspective
- John Adie, City of Nashua, NH

Reflections on My Operator Exchange Experiences
- Phil Ryan, City of Haverhill, MA

Experiences in Maine's Management Candidate School
- Michael Courtenay, Warren Sanitary District and
- Michael Janczura, Thomaston Water Pollution Control

Maine's New Intrastate Exchange Program
- André Brousseau, Sanford Sewerage District

SESSION 2
Watershed Management and Ocean Acidification

Moderators:
- Adam Yanulis, Tighe and Bond, Inc.
- Maria Rose, City of Newton, MA

Navigating Impaired Waters—What Are TMDL's and How to Deal with Them
- Bethany Leavitt, CH2M HILL
- Aubrey Strause, Verdant Water

WERF—Nutrient Model Toolbox
- Lola Olabode, WERF Program Director
- Clifton Bell, Brown and Caldwell

Panel Discussion: Ocean Acidification Science, Monitoring, Research and Regulatory Efforts

Panel Moderator:
- Aubrey Strause, Verdant Water

Panelists:
- Emily Bird, NEIWPCC
- John Bucci, University of New Hampshire
- Susie Arnold, PhD, Island Institute
- Leland Arras, Town of Freeport, ME

SESSION 3
Looking to the Future

Moderators:
- Jessica Cajigas, Comprehensive Environmental
- Michael Emond, Town of Manchester, CT

What is Value Management and What Can it do for You?
- Edward Rushbrook, Process Analysts

Redundant Thinking—The Changing Status of Treatment Facility Redundancy Operations and Management
- Alan Wells, Kleinfelder

WEF/WERF Leaders Innovation Forum for Technology (LIFT)
- Lola Olabode, WERF Program Director

Municipal In-Conduit Hydropower Generation
- Celeste Fay, Gregory Allen, Kevin Bastien and William Fay, Alden Research Laboratory

SESSION 4
Stormwater A to Z

Moderators:
- Ginny Roach, CDM Smith
- Tim Vadney, Wright-Pierce

Industrial Stormwater Discharge—It's a Piece of the Stormwater Puzzle!
- David Horowitz, Tighe & Bond

Is Your Road a Stormwater BMP?
- David Nyman, Comprehensive Environmental Inc.

Philadelphia Water Department Green City Clean Waters Case Study—Cobbs Creek Restoration, Floodplain Wetlands and Green Stormwater Infrastructure Improvements
- Thomas Graupensperger and Antonio Federici, Dewberry

Practical Approaches in the Face of a Residual Designation Authority (RDA)
- Robert "Brutus" Cantoreggi, Town of Franklin, MA

1. Past and current presidents at the president's breakfast: Charles Tyler, Al Schiff, Brad Moore, Erin Mosley, Howard Carter, Phyllis Rand, Dennis Keschl, and Jim Courchaine 2. Guests at the president's suite try their hand at a "life-sized" Jenga game 3. Hardy souls head off for the Tuesday morning bicycle ride, led by Adam Yanulis

SESSION 5

Case Studies in Making the Most of Treatment Assets

Moderators:
- Kate Goyette, Kleinfelder
- Charles Wilson, Hazen and Sawyer

Biological Treatment of Fats, Oils, & Grease (FOG) in Sanitary Sewer System
- Bulbul Ahmed, In-Pipe Technology Company, Inc.

Testing the Waters—Piloting High Rate Treatment Technologies for Secondary Treatment and Total Nitrogen Removal Process Selection
- Terry Desmarais, AECOM
- Paula Anania, City of Portsmouth, NH
- Peter Rice, City of Portsmouth, NH
- Jon Pearson, AECOM
- Donald Chelton, AECOM
- Erik Grotton, Blueleaf, Inc.

Relocating a Wastewater Treatment Facility and Meeting the Increased Capacity Demands for a Growing Region
- Robert Polys, Woodard & Curran
- Michael Harris, City of Ellsworth, ME

Cost Effective Metals Removal When You Only Have Nickel Left
- Doug Urquhart, CHA Consulting, Inc.

SESSION 6

The Next Generation Biosolids Management

Moderators:
- Ken Maltese, Maltese and Associates
- Steven Perdios, Dewberry

Biosolids Management in New England: The Next Ten Years
- John Donovan, CDM Smith

To Digest or Incinerate Sludge—That is the Question
- Mark Greene, O'Brien & Gere

How to Create a Self-Funding Co-Digestion Project Starting From Nothing?
- David Wrightsman, Energy Systems Group

SESSION 7

Maine Ice Storm of 2013—Perspectives on Emergency Preparedness

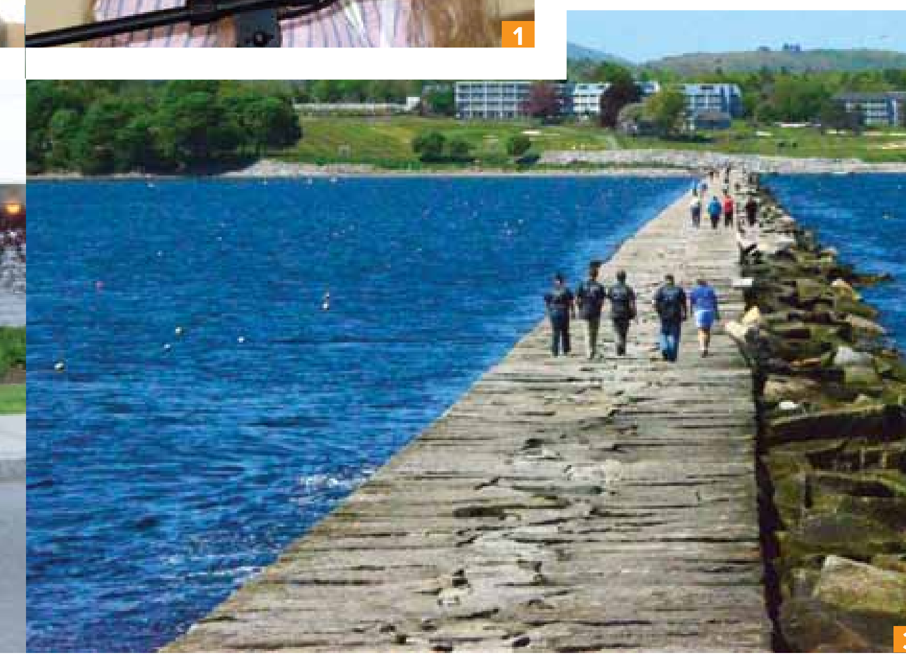
Moderators:
- Georgine Grissop, CDM Smith
- Marian Long, Gradient Planning LLC

Icemas 2013
- Andrew Sankey, Emergency Management Director, Hancock County, Maine

An Update on MEWARN
- Tom Bahun, Maine Rural Water Association

Planning for Extreme Weather Events and Beyond
- Marian Long, Gradient Planning LLC

Panel Discussion—Q&A



1. Celeste Fay of Alden Labs presents a paper on hydropower generation 2. A secondary treatment session presented by Terry Desmarais was well attended 3. A view toward the resort from the lighthouse end of the Samoset breakwater 4. President Brad Moore addresses guests during the Tuesday reception and dinner

SESSION 8

Collection System Rehabilitation and Management

Moderators:
- Frank Occhipinti, Weston & Sampson
- Ken Carlson, Woodard & Curran

Inflow and Infiltration Investigations—A New Approach
- Sebastian Amenta, Comprehensive Environmental, Inc;
- Mark Moriarty and Robert Trottier, City of New Britain, CT

$350K Cost Savings Achieved Through Detailed Modeling And Innovative Design for a CSO Storage Facility in Nashua, NH
- Charles Wilson, Hazen and Sawyer
- Frank Ayotte, Hazen and Sawyer
- Amy Prouty Gill, City of Nashua, NH
- Jeanne Walker, City of Nashua, NH

Sewer Service Lateral Rehabilitation Update 2014
- Charlie Gore, Stantec

How A CMOM Program Can Work For You
- Robert Robinson, City of Manchester, NH—Environmental Protection Division

Framingham's Infrastructure Renaissance—The Unique Regulatory, Permitting, Funding, and Outreach Challenges of Transforming Framingham's Wastewater Collection System for Future Generations
- James Barsanti, Town of Framingham, MA DPW

TOUR

Fisher Engineering Production Facility and Pretreatment System

Coordinator:
- Ray Vermette, City of Dover, NH

OPERATIONS CHALLENGE

Operations Challenge Committee Chair: Michael Burke

Operations Challenge was held on Tuesday, June 3, 2014. Three teams participated in the competition.

Maine Force Maine:
Alex Buechner (Captain), Ian Carter
Dan Laflamme (Coach), Scott Lausier
Stacy Thompson

Massachusetts MASSerators:
Mike Baker, Tim DeGuglielmo
Sean Kehoe (Coach), Patty Passariello (Captain), Kris Smith

Rhode Island Ocean State Alliance:
Mike Ceasrine, Joe Crosby (Coach), Edward Davies, Vincent Russo, Mike Spring (Captain)

The Operations Challenge Awards Reception was on Tuesday, June 3, 2014, at 4:00 PM. Committee Chair Mike Burke and each event coordinator, assisted by NEWEA President Brad Moore, presented trophies to the winning teams of each

1. Lab event judges scrutinize a team's work 2. The MASSerators compete in the safety event 3. Session speakers chat during the speakers' breakfast 4. Laboratory pro Alex Buechner shows off his two-fisted pipetting technique

1. Alex Buechner prepares to enter the "manhole" in the safety event 2. Force Maine competes during the collection systems event 3. Team Force Maine accepts the first place over all trophy 4. The MASSerators pose with their safety event trophy 5. The Ocean State Alliance team shows off their hardware

event and to the overall first, second, and third place winning teams. The results of the competition are reported as follows:

First Place Individual Events:
- Process Control—Maine
- Safety—Maine
- Collection Systems—Rhode Island
- Laboratory—Maine
- Pump Maintenance—Maine

Overall Competition:
- Third Place—Rhode Island
- Second Place—Massachusetts
- First Place—Maine

During the reception, it was announced that NEWEA would support the first-, second-, and third-place teams in the 2014 WEF National Operations Challenge competition to be held in New Orleans, Louisiana in September.

Event and Equipment Coordinators:
- Process Control—Paul Dombrowski, Michael Harris
- Safety—James Laliberte, André Brousseau
- Collection Systems—EJP, Lenox Tools, Michael Smith
- Laboratory—YSI, MaryLee Santoro, Dennis Palumbo
- Pump Maintenance—Xylem-USA, Brian Farmer

Scorekeeping:
- Overall—Jane Brooks

Judges:
- Process Control—Operations Challenge Committee
- Safety—André Brousseau, Jane Brooks
- Collection Systems—Ray Willis, Mike Smith, Frank Occhipinti
- Laboratory—Andy Fish, MaryLee Santoro, Phyllis Rand, Linda Staponites, Peter Sherwood
- Pump Maintenance—John Trofatter, Travis Peaslee John Lord, Dennis Palumbo

Miscellaneous:
- Trophies—Joseph Kruzel, Michael Burke
- Shirts—Norton True

MEETING PLANNERS
- Conference Arrangements—Ron Tiberi
- Program—Susan Guswa
- Registration—Kate Biedron
- Operations Challenge—Michael Burke
- Guest Program—Joy Lord
- Golf Tournament—Peter Kibble

MEETING MANAGEMENT
- Director—Meg Tabacsko
- Sponsors—Paul P. Casey

SELECT SOCIETY OF SANITARY SLUDGE SHOVELERS
During the Monday evening reception, Influent Integrator Charles Tyler inducted five new members into the Select Society of Sanitary Sludge Shovelers:
- André Brousseau
- Susan Guswa
- Jennifer Lachmayr
- Mickey Nowak
- George Vercelli

MISCELLANEOUS
A variety of committee meetings were held throughout the Spring Meeting. The Tuesday evening reception and dinner was held at the Samoset Resort. The Annual Spring Meeting Golf Tournament was held at the Samoset Resort. Attending spouses and guests enjoyed a number of recreational and social activities during the meeting.

EXHIBITORS
ADS Environmental Services
Aqua Solutions, Inc.
BLD Services, LLC
CUES
Duke's Root Control, Inc.
EST Associates, Inc.
Flow Assessment Services, LLC
Hamilton Kent
Hanna Instruments
Landtech Consultants
Mechanical Solutions
Ted Berry Company, Inc.

SPONSORS
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BETA Group
Brown and Caldwell
CDM Smith
CH2M HILL
David F. Sullivan & Assoc., Inc.
Dewberry
Duke's Root Control, Inc.
Environmental Partners Group, Inc.
EST Associates, Inc.
Fay, Spofford & Thorndike
Flow Assessment Services, LLC
Fuss & O'Neill, Inc.
Green Mountain Pipeline Services
Hayes Pump, Inc.
Hazen and Sawyer, PC
Hoyle, Tanner & Associates
Kleinfelder
The MAHER Corporation
NEFCO
Martinez Couch & Associates
R.H. White Construction Co.
Synagro Northeast LLC
Tighe & Bond, Inc.
Underwood Engineers
United Water
Weston & Sampson
Woodard & Curran
Wright-Pierce

Upcoming meetings & events

OPERATIONS CHALLENGE GOLF TOURNAMENT
September 8, 2014
Stow Acres, Stow, MA

COLLECTION SYSTEMS SEMINAR AND EXHIBIT
September 10, 2014
Westford Regency Inn, Westford, MA

EXECUTIVE COMMITTEE MEETING
September 10, 2014
Westford Regency Inn, Westford, MA

WEFTEC ANNUAL CONFERENCE
September 27 – October 1
New Orleans, LA

WATERSHED MANAGEMENT AND STORMWATER SEMINAR
October 16
Marriott Mystic Hotel, Mystic, CT

ANNUAL NORTH EAST RESIDUALS AND BIOSOLIDS CONFERENCE AND EXHIBIT
October 22 – 23, 2014
Marriott Sable Oaks, Portland, ME

MICROCONSTITUENTS SPECIALTY SEMINAR
October, 29, 2014
Bentley University, Waltham, MA

SMALL COMMUNITIES/PLANT OPS SPECIALTY CONFERENCE
November 5, 2014

EXECUTIVE COMMITTEE MEETING WITH SELECT CHAIRS
November 12, 2014
NEWEA Office, Woburn, MA

NEWEA ANNUAL CONFERENCE
January 25 – 28, 2015
Boston Marriott Copley Place Hotel, Boston, MA

NEWEA SPRING MEETING AND EXHIBIT
June, 7 – 10, 2015
Mt. Washington Resort, Bretton Woods, NH

AFFILIATED STATE ASSOCIATIONS AND OTHER ASSOCIATION MEETINGS

NARRAGANSETT WPCA CLAMBAKE AND EXHIBITION
September 12, 2014
Twelve Acres, Smithfield, RI

MWWCA (MEWEA) FALL CONVENTION, GOLF TOURNAMENT AND TRADE SHOW
September 17 – 19, 2014
Sunday River Resort. Newry, ME

MWPCA TRADE SHOW
September 24, 2014
Wachusett Mountain Resort, Princeton, MA

NEW HAMPSHIRE WPCA FALL MEETING
October 10, 2014
Sunapee WWTF, lunch at Mount Sunapee Ski Resort

GMWEA FALL TRADE SHOW AND CONFERENCE
November 6, 2014
Sheraton, Burlington, MA

NEW HAMPSHIRE WPCA WINTER MEETING
December 12, 2014
Ashworth by the Sea, Hampton, NH

New England Water Environment Association, Inc.

Statement of activities
For the years ended September 30, 2013 and 2012

Changes in unrestricted net assets:	**2013**	**2012**
Revenues and gains:		
Registration Fees	$374,707	$399,255
Exhibitor Fees	389,332	236,540
Membership Dues	64,222	64,193
Pass Through Dues	9,561	14,448
Advertising and Subscriptions	10,800	73,548
Sponsorships	56,055	56,580
Certification Fees	8,495	10,125
NEBRA Management revenue	46,014	59,856
Other Income	37,182	27,705
Total unrestricted revenues and gains	**996,368**	**942,250**
Net assets released from restriction:		
Expiration of time and program restrictions	9,000	9,000
Total unrestricted revenues, gains and other support	1,005,368	951,250
Expenses:		
Program services	710,521	616,433
Management and general	210,913	173,220
Pass Through Dues	9,740	13,563
NEBRA Management expense	48,795	62,479
Total expenses	**979,969**	**865,695**
Increase in unrestricted net assets	25,399	85,555
Changes in permanently restricted net assets:		
Endowment income	-2,703	10,297
Net assets released from restrictions	-9,000	-9,000
Total permanently restricted contributions	-11,703	1,297
Change in permanently restricted net assets	-11,703	1,297
Increase in net assets	**13,696**	**86,852**
Net assets, beginning of year	**848,144**	**761,292**
Net assets, end of year	**$861,840**	**$848,144**

NEWEA
WORKING FOR WATER QUALITY

New members
July 2013 – May 2014

Janet J Butler
Davies Career Technical High School (ACAD)

Andrew Ramsburg
Tufts University (ACAD)

James Houle
University of New Hampshire Stormwater Center (ACAD)

Tom Mason
Brunswick Sewer District (COMP)

Jason Prout
Brunswick Sewer District (COMP)

Joanna Williams
City of Westfield (COMP)

Rodney L Warrington
Queensbury Wastewater Dept (COMP)

Patrick Scheidel
Village of Essex Junction (COMP)

Scott Avedisian
Warwick Sewer Authority (COMP)

Lynn Owens
Warwick Sewer Authority (COMP)

Jack Caplan
Marlborough, CT (COMP)

Ydelfonso De La Cruz
Bridgeport, CT (COMP)

Nathan Dee
Bangor, ME (COMP)

Melissa Franco
Cumberland, RI (COMP)

Alec Gelfenbein
South Burlington, VT (COMP)

Ellyn Golden P
ortland, ME (COMP)

Vivian Huang
South Burlington, VT (COMP)

Wesley Kocurek
Shelton, CT (COMP)

Amy Kopec
Princeton, MA (COMP)

Deepika Kurup
Nashua, NH (COMP)

Gabrielle Liflander
Riverside, CT (COMP)

Anne Merrill
Old Greenwich, CT (COMP)

Andrew Sandweiss
Bangor, ME (COMP)

Erika Wilson
Princeton, MA (COMP)

Mary Butler
Bangor, ME (COMP)

Richard A Claytor
Horsley & Witten Inc (COR)

Daniel Imig
City of Alexandria (DUAL)

Phil Kline
Hisco Pump Inc (DUAL)

Jim Gallmann
Baton Rouge, LA (DUAL)

Addison “Tad” David
Corvias Group (EXEC)

Saleh Mohammed Al-Muzaini
EAEO (EXEC)

Scott Henry
Flood Lakeland Ventures Development (EXEC)

Songheng Li
Alden Research Laboratory, Inc. (PRO)

Auster Jennie
Aldrich Elliott (PRO)

Derek Francis
Alfa Laval Inc (PRO)

Kerry Reed
AMEC (PRO)

Corinne Marie Tuozzoli
ARCADIS (PRO)

Samuel Boyarsky
Associated Engineers Inc (PRO)

Rico Biasetti
Biogenic Reagents (PRO)

Demetrios G Vidalis
Boston Water & Sewer Commission (PRO)

Adriana Cillo
Boston Water & Sewer Commission (PRO)

Robert M Da Silva
Boston Water & Sewer Commission (PRO)

Weston D Silva
Boston Water & Sewer Commission (PRO)

Derek Etkin
CDM Smith (PRO)

Matthew David Pitta
CDM Smith Inc (PRO)

Jeffrey L. Allen
City of Bangor (PRO)

Keefe C Cyr
City of Bangor (PRO)

Sean Currier
City of Bangor WWTP (PRO)

Megan Moir
City of Burlington—
Dept. of Public Works (PRO)

Stephen J Gagnon
City of Methuen (PRO)

Nicholas Caneira
City of New Bedford (PRO)

Diane C Rossini
City of Northampton MA (PRO)

Carlos A Esguerra
CT Dept of Energy and Environmental Protection (PRO)

Antonio F Federici
Dewberry-Goodkind Inc (PRO)

Dwayne Dischert
Dupont Water Technologies (PRO)

George A Bianco
EBI Consulting (PRO)

Peter Michael Hanrahan
Everett J. Prescott, Inc. (PRO)

Michael Sparks
F R Mahony & Assoc (PRO)

Kevin P Klein
Fay Spofford & Thorndike Inc (PRO)

Anthony Capo
Fiberglass Fabricators (PRO)

Eugene Chuang
Garg Consulting Services Inc (PRO)

Tom M Barrett
GIS Inc (PRO)

Russell B Parkman
GZA Geoenvironmental Inc (PRO)

Carmine Iacuone
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Innovative Engineering Solutions (PRO)

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Rafael Castro
Jacobs Associates (PRO)

Rosa Maria Castro-Krawiec
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Sonii Kollie
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MDC (PRO)

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Turbocam Inc (PRO)

Ray Hebert
Turbocam Inc (PRO)

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Veolia Water North America (PRO)

Angela L Brodeur
Veolia Water, NA (PRO)

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Jeffery Lee
Pepperell Wastewater Treatment Plant (PWO)

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Town of Westport (PWO)

Karen Goffe
Veolia Environment (PWO)

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Warwick Sewer Authority (PWO)

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York Sewer District (PWO)

Michael Tibbetts
York Sewer District (PWO)

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Eric Ellison
Glastonbury, CT (STU)

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Monica Kaprzyh
NEIWPCC (YP)

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Stantec Consulting (YP)

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Tighe & Bond Inc (YP)

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Weston & Sampson Engineers Inc (YP)

Justin D Motta
Wright Pierce (YP)

Erik Drukovskis
Coventry, RI (YP)

Karyn Lynn Bienia
Pittsfield, MA (YP)

Michael Julian Votruba
Jefferson, MA (YP)

Christopher P Cox
Graniteville, VT (YP)

Joseph S Hart
Charlestown, NH (YP)

Michael David Perkins
Abington, MA (YP)

Bonnie Bielec
Norwood, MA (YP)

Matt Hross
Groton, CT (YP)

Affiliate (AFF)
Complimentary (COMP)
Corporate (COR)
Dual (DUAL)
Executive (EXEC)
Honorary (HON)
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Professional (PRO)
Professional WW/OPS. Division (PWO)
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NEWEA Membership Application 2014

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 Business Phone Number Fax number

E-Mail Address

☐ 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 Member I.D. (please provide)

**By joining NEWEA you also become a member of the Water Environmental Federation (NEWEA is a member Association 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 13

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*	$139
☐ **Young Professional Package**	New WEF members or formerly WEF 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*	$66
☐ **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*	$86
☐ **Academic Package**	Instructors/Professors interested in subjects related to water quality.	■ *WE&T* (including *Operations Forum*) ■ *WEF Highlights Online* ■ *Water Environment Research* (Online)	$139
☐ **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*	$10
☐ **Executive Package**	Upper level managers interested in an expanded suite of WEF products/services.	■ *WE&T* (including *Operations Forum*) ■ *World Water* ■ *Water Environment Research* (Online) ■ *Water Environment Regulation Watch*	$335
☐ **Dual**	If you are already a member of WEF and wish to join NEWEA		$38
☐ **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*	$390

Additional Subscriptions

Consider including additional WEF resources in your membership package! Check the appropriate subscription and include the subscription cost in your payment.
NOTE: prices listed reflect a substantial member discount!

*Water Environment Research Premium includes WER Online, plus online archives of all WER issues from 1928 – 2004.

☐ *WE&T* (including Operations Forum)	$55	$______
☐ *World Water*	$75	$______
☐ *World Water: Water Reuse & Desalination*	$55	$______
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☐ *Water Environment Research Online*	$80	$______
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☐ *Water Environment Research Print*	$105	$______
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Total Due

Dependant upon your membership level, $10 dollars of your membership dues is allocated towards a subscription to the NEWEA Journal.

NEWEA Membership Codes 2014

To help us serve you better, please complete the following:
(choose the one that most closely describes your organization and job function)

What is the nature of your ORGANIZATION?

(circle one only) (ORG)

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

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 and Environmental)

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
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, etc.,)

3
Engineering and Design Staff (e.g., Consulting Engineer, Civil Engineer, Mechanical Engineer, Chemical Engineer, Planning Engineer, etc.)

4
Scientific And Research Staff (e.g., Chemist, Biologist, Analyst, Lab Technician, etc.)

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

1
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)

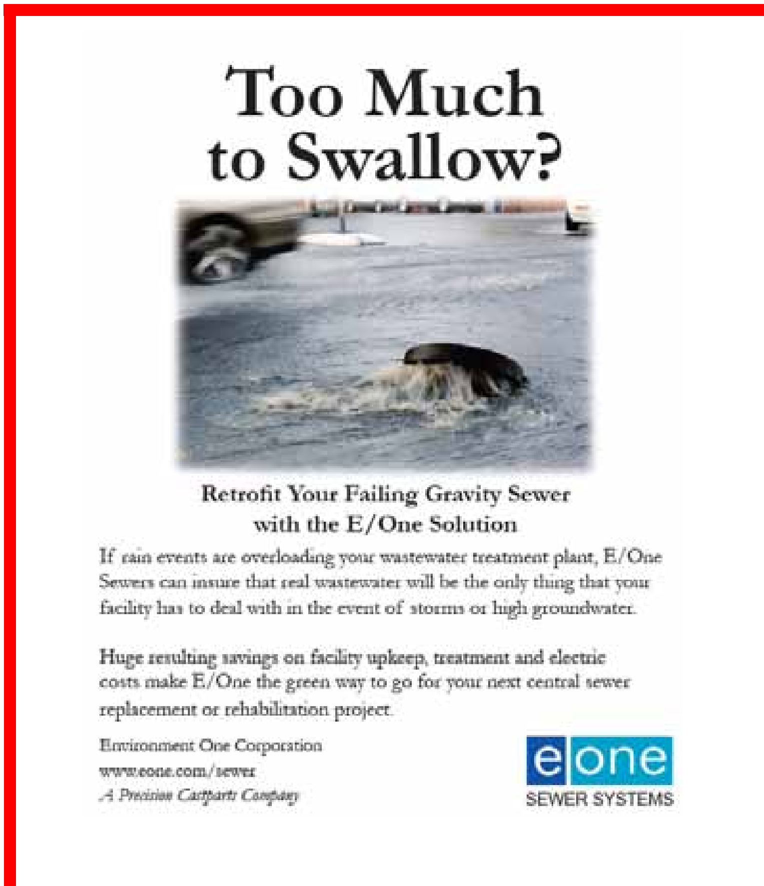
Year of birth? _______

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 are 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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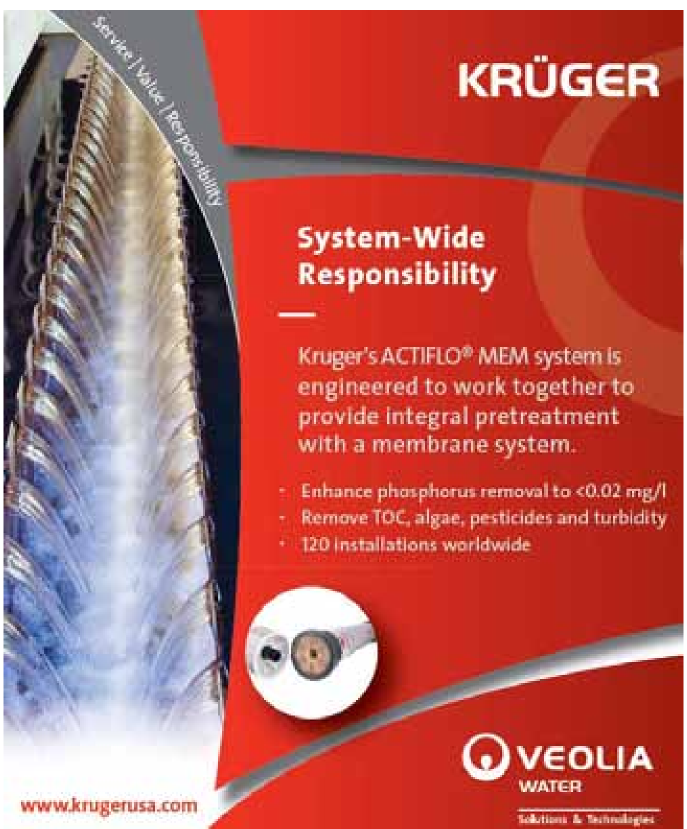
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4-Liter Bench Scale Digester Reactors at UMass Amherst Laboratory

Digester Gas Capacity Analysis for Deer Island Treatment Plant

Digester Gas Compressors

Upgrades to Anaerobic Digesters at Clinton, MA Wastewater Treatment Plant

Digester Floating Cover

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