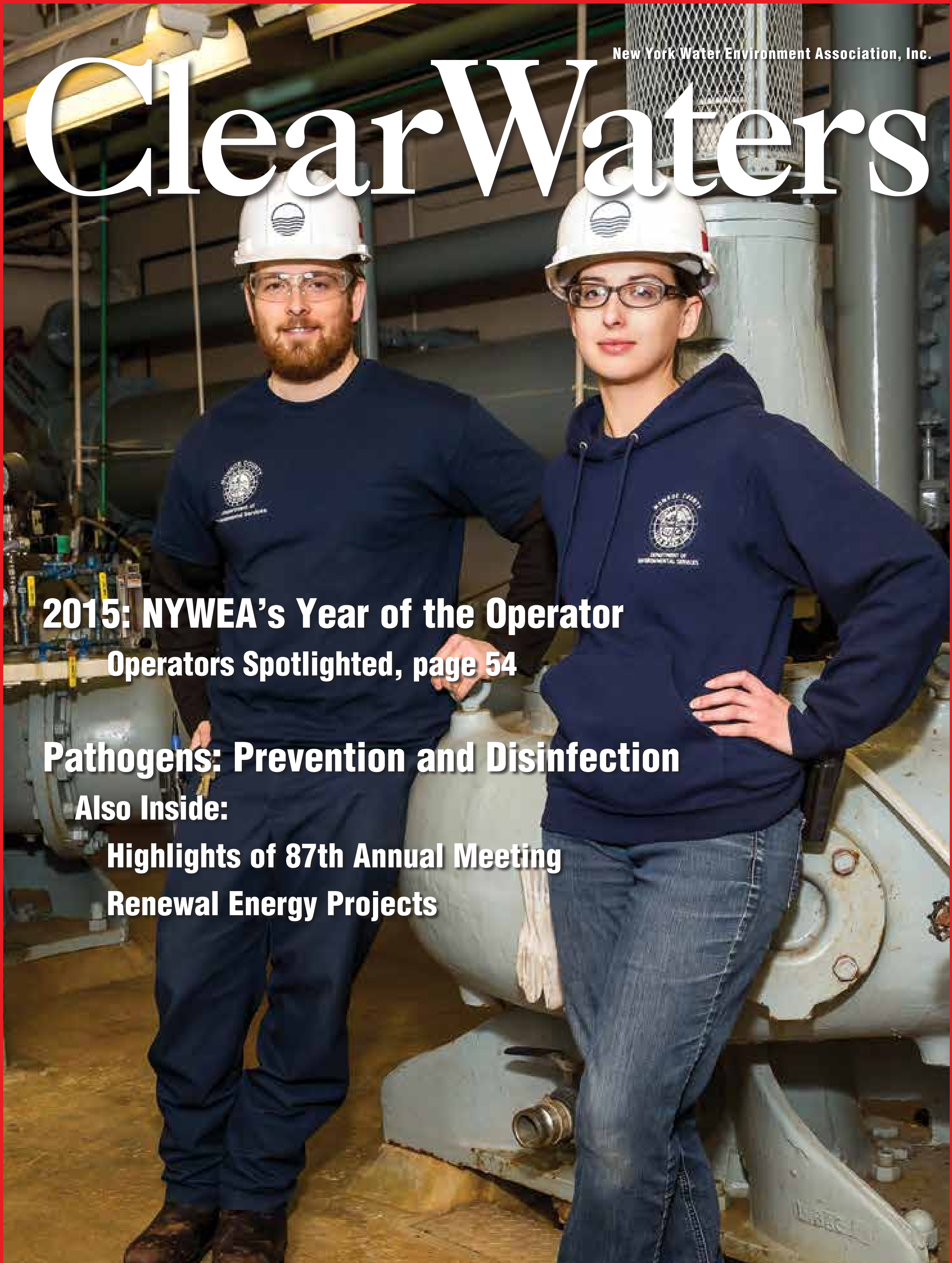
Spring 2015, Vol. 45, No. 1

New York Water Environment Association, Inc.

ClearWaters



2015: NYWEA's Year of the Operator

Operators Spotlighted, page 54

Pathogens: Prevention and Disinfection

Also Inside:

Highlights of 87th Annual Meeting

Renewal Energy Projects

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Spring 2015, Vol. 45, No. 1

Clear Waters

New York Water Environment Association, Inc.

President's Message 4
Michael J. Garland

Executive Director's Message 5
Patricia Cerro-Reehil

87th Annual Meeting Highlights 6–7, 59

Water Views 9
James Tierney

Focus on Safety 9
Eileen Reynolds

A History of Pathogen Control Discoveries 10
Ashley Waldron

Waterborne Pathogens and Safeguards Against Them 13
Eileen Reynolds

Overview of Pathogens and Wastewater Disinfectants 18
Christopher Somerlot and Daniel Davis

Operator Facts – Chemistry of Chlorine Disinfection 28
Rich Malaczynski

Total Residual Chlorine Going Down, Down, Down 31
Frank DeOrio and Darcy Sachs

Interim Guidance for Managers and Workers Handling Untreated Sewage from Individuals with Ebola in the United States 36
CDC Reprint

Small Water System's Recovery from Natural Disaster: Case Study on the Village of Horseheads 41
Michael W. Wymer, Brian Sibiga, Andrew Casolini Dal Bo and Christine Birmingham

Developing Better Indicators for Pathogen Presence in Sewage Sludges 45
Suresh D. Pillai, Mark C. Meckes, Sudhir N. Murthy and John Willis

Renewable Energy Technology Project Completed at Ithaca's Wastewater Treatment Plant 50
Alex Wright

Facility Turnaround: Wastewater Treatment Plant in Compliance – And Off the Grid 52
Marsha Johnston [Reprint from BioCycle]

NYWEA Declares 2015 "Year of the Operator" 54

Operator's Quiz No. 107 Formula Exam 56

Help with Ammonia Criteria Implementation: Tools to be Developed for Utilities 58
Claudio H. Ternieden

Changes the Midterm Election Will Bring to US Congress 59
Steve Dye

Cover Image: Wastewater treatment plant licensed operators Justin Slentz and Alison Perez are seen by one of the 26 recirculation pumps in the Recirculation Pumping Station at the Frank E. VanLare WWTP in Rochester, NY. See the Operator Spotlight story, page 54.

Photo by Trent Wellott, T Wellott Photography, http://twphoto.us

Correction Note: Certain images in the article titled, "Peracetic Acid as an Alternative Disinfectant," which appeared in the Winter 2014 edition of *Clear Waters* were not given complete attribution. Their credits should have read: *Courtesy of PERAGreen Solutions, LLC, and Solvay Chemicals.*

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♻ **Clear Waters** *is printed on recycled paper, using soy-based ink.*

President's Message | Spring 2015

Year of the Operator!

It was a great honor and privilege to accept the gavel from Immediate Past President and Water Ambassador, Steve Fangmann, at the annual awards luncheon on February 4th. Shortly after the gavel was passed, I announced that the focus of my term as President will be on the New York Water Environment Association's core constituent and fundamental building block – the operator. By operator, I'm referring to both state-licensed water resource recovery facility operators, as well as NYWEA-certified collection system operators. Partly to this end, for the rest of the year, the covers of *Clear Waters* magazine and conference programs will prominently feature operators in recognition of the great work they do day in and day out. Each edition will celebrate the dedication and diversity of the men and women that operate our great water resource recovery facilities and collection systems throughout the state.

There is, and will continue to be, much discussion about the "Utility of the Future," but we also need to understand what is the "Operator of the Future." We are building tomorrow's utilities, but will we have the licensed operators to run them? To that end, I would like to create a task force to explore and understand the needs of the operator of the future. I want to understand what we can do to attract and retain the men and women we need to operate our future utilities. In addition, I'd like to create scholarship opportunities for operators to broaden their skills, knowledge and understanding.

Annual and Spring Meetings

Despite the wintry weather, the 87th Annual Meeting held in New York City was an overwhelming success with tremendous attendance. I was pleased to participate in the opening session panel dialogue on the 50th Anniversary of New York's Pure Waters Program. We were fortunate to have many distinguished panelists including Mark Klotz (NYSDEC), Phil DeGaetano (formerly of NYSDEC), John Petito (NYCDEP), Joe Fiegl (Erie County) and Paul Bowen (WEF President–Elect). I was impressed with the content and variety of our well attended technical sessions. The expanded exhibit hall was at capacity with new and returning vendors eager to share information and engage in discussion.

As the snow falls, I can't help but think ahead to a warm and sunny spring meeting from June 1–3 at the beautiful Sagamore Resort on Lake George. The meeting will provide relevant technical sessions, convenient networking opportunities and relaxing Adirondack activities. This year, we'll be hosting the 2nd Annual Regional Operations Challenge where out-of-state teams will compete shoulder-to-shoulder with our four talented operator teams.

A Look Ahead

While this year's focus will be on our operators, there are a number of key initiatives and activities that I will be engaged in:

- **Outreach and Collaboration:** I will work to strengthen and maintain our relationships with NYSDEC, NYSEFC, NYSERDA, NYCDEP, NYSAWWA and the NY Rural Water Association, as well as forge new relationships with the NY Federation of Solid Waste Associations and NYS Association of Counties.
- **Utility Executive Committee (UEC):** The UEC has enabled our utilities across the state to present a unified front and speak with one voice. I will continue in my involvement with the UEC and steadfast advocacy for utilities across the state.
- **Wastewater Infrastructure Funding:** I will work to elevate wastewater infrastructure funding to the forefront of state and national discussions on infrastructure needs rather than taking a back seat to above ground infrastructure, like roads and bridges. The state Legislative Dialogue on May 5 and the WEF Fly-In to Washington DC from April 13–15 will be ideal opportunities to carry the message to our state and federal legislators.
- **WEFMAX:** I'll be attending WEFMAX in Quebec City on May 27–29 where we'll have the opportunity to share NYWEA's financial management success as well as take away great ideas from our counterpart WEF state Member Associations.
- **CHAPEX:** The second annual CHAPEX meeting will be held on August 5. With the success of last year's meeting, I expect increased Chapter representation and information exchange.
- **Strategic Plan:** This year, I will initiate the 2017–2021 Strategic Plan that will establish NYWEA's roadmap of priorities.

My Personal Thanks

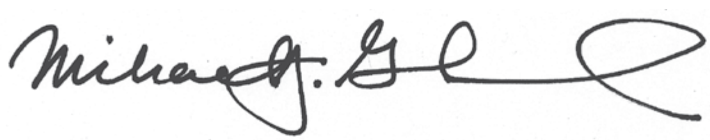
I would like to extend a debt of gratitude to Immediate Past President Steve Fangmann for the guidance, support and friendship he has shown me since I joined the Executive Committee. As a four-decade member, Steve's contribution to NYWEA is immeasurable. As President, he left a lasting legacy of accomplishments. Steve presided over more conferences and meetings than any other Past President in NYWEA history! I would also like to thank the other Water Ambassadors I've had the pleasure of working with, namely, past presidents Mark Koester, Rich Lyons and Tony DellaValle.

There is much work to be done in the year ahead and we are blessed to have an all-star team of dedicated and talented professionals on the Executive Committee, including President–Elect Joe Fiegl, Vice President Paul McGarvey and Vice President–Elect Geoff Baldwin.

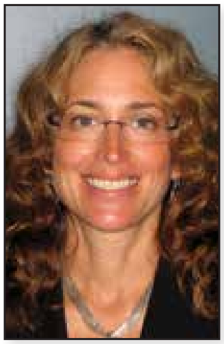
What holds our great association together and keeps it moving forward is our Executive Director Patricia Cerro-Reehil and her dedicated and talented team of Maggie Hoose, Maureen Kozel, Tanya Jennings, Rebecca Martin and Theresa Baker. Patricia and her team make a very difficult job look easy and they do it with grace and style!

Nominate!

Lastly, I would like to again congratulate all of the well-deserving individuals and utilities that received awards at the annual awards luncheon. If you have never made a nomination before for either a WEF or NYWEA award, I would encourage you to consider doing so this year. The impact to an award recipient is permanent and profound!



Michael J. Garland, PE
NYWEA President



Teaming Up for Grassroots Advocacy

NYWEA members who volunteer give their time and attention to whatever committee or chapter activity that appeals to them. Gifted members come from every chapter, every sector and because of what they give they are helping to mold the organization into a stronger, more robust and interesting environmental nonprofit. A recent case in point: at the suggestion of Libby Ford, a longtime Government Affairs Committee member, during the legislative session break members of NYWEA met with elected officials to discuss three important topics – infrastructure funding, harmful algal blooms and climate change.

Central New York members, Bob Kukenberger, Geoff Miller, Dave Miller and I, met with Senator John DeFrancisco, chair of the Finance Committee, to discuss these three topics, emphasizing strongly the need for water infrastructure funding. When we asked Senator DeFrancisco how we could help in this effort, he responded that we could testify at hearings, and he asked if we could get a listing of the infrastructure needs (drinking and wastewater) by NYSDEC region. The senator also thought it would be helpful if all proponents of water infrastructure could speak with one voice. We did just that by sending him a letter on the critical importance of infrastructure funding that was co-signed by six organizations, including NYWEA, the NY Section American Water Works Association, NY Rural Water Association, Association of Towns, NY Conference of Mayors, and American Public Works Association. Collectively, these organizations represent approximately 8,000 members. The letter, which was also sent to the governor, can be found on the NYWEA website.

As a follow-up to the senator's direct request, I'm pleased to report that Chretien Voerg, Town of Colonie Pure Waters Superintendent and member of NYWEA's Utility Executives Committee, testified at the Senate Economic Development Hearing held on February 9 on the importance of wastewater infrastructure and its connection to economic development. A copy of his testimony and a link to the live video are also on NYWEA's website (www.nywea.org). Additionally, Richard J. Lyons, NYWEA Water Ambassador and co-chair of the Utility Executives Committee, submitted testimony on behalf of Albany County and NYWEA for two hearings- the Environmental Conservation Hearing on January 28, and the Local Government Hearing held on March 4.

NYWEA Executive Director Patricia Cerro-Reehil meeting with Geoff Miller, NYSAWWA Water Utility Council member; Senator DeFrancisco; Robert Kukenberger, NYWEA Water Ambassador and member of the Government Affairs Committee; and Dave Miller, NYWEA Legislative Liaison. Photo taken at Senator DeFrancisco's office in Syracuse, NY.

During the holiday session break, our downstate members led by Boris Rukovets, chair of the Government Affairs Committee, also scheduled meetings with elected officials in Long Island and NYC. President Steve Fangmann, Rukovets, Nicholas Bartilucci and Ben Wright met with Steve Englebright, who is the Assembly's new chair of the Environmental Conservation Committee. In addition, they sat down with Senators Carl Marcellino, chair of Infrastructure and Capital Investment Committee and Diane Savino (joined by NYWEA Water Ambassador and Executive Committee member, Anthony DellaValle) again covering the three topics while reinforcing the critical message for infrastructure funding.

> *According to a Harris Poll, three in four US adults, or 74 percent, agree that "protecting the environment is so important that requirements and standards cannot be too high, and continuing environmental improvements must be made regardless of cost."*

Strengthening our Voice

In January, Executive Director of the Hudson Riverkeeper Paul Gallay had reached out to us, proposing to work together with several advocacy environmental nonprofits in communicating to elected officials about infrastructure funding. On a number of fronts, we have done that, communicating the same message with different partners, strengthening our collective voice to make sure we are heard. All together these seven advocacy groups and NYWEA represent approximately 250,000 New Yorkers.

We have built up an optimism that the arrival of spring brings. Here's to that same optimism transferring to the elected leaders in New York State as they listen to our voices, now unified, and include a request for $800 million or more for new clean water infrastructure grants in the coming year.

In this Issue – Pathogens

Stemming from the Ebola outbreak this fall, we dedicated this issue of *Clear Waters* to pathogens, as these microorganisms are one more issue wastewater operations specialists have to deal with at their utilities. It is our hope that this issue will be a resource for you and help make the message crystal clear to elected officials that continual maintenance and upgrades that are expensive are necessary to address the complex issues associated with water resource recovery utilities from pathogens to pumping stations and everything (literally) in between.

Patricia Cerro-Reehil
pcr@nywea.org

Marriott Marquis, New York City

Highlights of 87th Annual Meeting

WEF President–Elect Paul Bowen (left), Conference Management Chair Joyette Tyler and President Steven Fangmann officially kick off the 87th Annual Meeting.

(L–r) President Fangmann inducts Benjamin Wright, Walter P. Saukin and David Ellis into the NYWEA Hall of Fame.

Long Standing Members Recognized: (L–r) President Steven Fangmann for his 40 years of continuous membership; Henry Chlupsa and Jerry Lastihenos for their 50 years of supporting membership! They must have joined when they were 12!

President Steven Fangmann presents Lauren Livermore with the Young Professionals Service Award.

Nicholas Benevento receives the Uhl T. Mann Award.

Steven Carroll receives the Uhl T. Mann Award.

Stephen McTarnaghan with his Uhl T. Mann Award

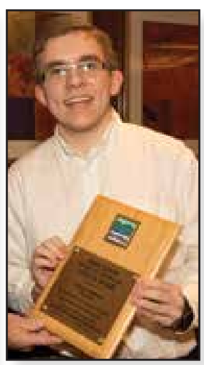
Gregory Smith receives the Milton T. Hill Award.

L–r: Joyette Tyler, Randall Long, owner/CEO of Brunel Corporation–the Gold Status Long Standing Exhibitor, and Steven Fangmann

Tyler Masick, Gloversville/Johnstown WWTP, accepts Sustainability Award.

Karis Manning receives the Emmeline Moore Award.

Cinar Akman receives the Robert M. MacCrea Award.



Shane Holmes, Manhattan College graduate, receives the Association's Student Chapter Service Award.

Madison Quinn accepts the Public Education Award for the Onondaga County Save the Rain at Rosamond Gifford Zoo project.

George Bevington receives the Water Hero Award.

Libby Ford receives the Public Education Award.

OJ McFoy (left), Roberta Gaiek and Dave Comerford accept the Municipal Achievement Award for the Buffalo Sewer Authority.

L–r: Service Awards were presented to William Grandner, William Nylic and Kathleen O'Connor.

WEF President–Elect Paul Bowen (right), recognizes Dale W. Grudier as a member of WEF Quarter Century Operators Club.

L–r: Courtnay Anderson receives WEF's William D. Hatfield Award; NYCDEP's Zainool Ali receives the Uhl T. Mann Award; Chris Laudando receives the Collection System Operator Award; Diane Hammerman; and NYCDEP's John McCabe receives the Uhl T. Mann Award.

Thomas Lauro gives the invocation.

President–Elect Mike Garland, director of Monroe County DES, addresses members about county's experiences.

Rich Isleib of HDR speaks about the challenges of *Enterococci* compliance.

President Steven Fangmann passes the gavel to President–Elect Michael Garland.

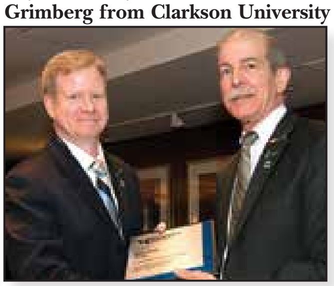
Steve Lawitts, First Deputy Commissioner of NYCDEP, gives NYWEA members an update on New York City's water and wastewater programs.

Taylor Lenney and Stefan Grimberg from Clarkson University

Steven Fangmann recognizes 20 year members Greg Jager (center) and Tom Wilson.

NYWEA Officers, l–r, Joe Fiegl, Geoff Baldwin, Mike Garland and Paul McGarvey

Steve Fangmann recognized 30 year members, Terry Heneveld (left) and Dick Pope.



WEF President–Elect Paul Bowen (right), recognizes Bruce Munn for his delegate work. Paul McGarvey accepts plaque.

L–r: Edward Balsley; Bill Davis, Pradeep Jangbari of NYSDEC; and Newark Mayor Peter Blandino (recipient of the Frank E. Van Lare Award)

L–r: Nat Federici, President Steven Fangmann, Amanda Bauner, James Pynn and Robert Ivers receive the Kenneth Allen Memorial Award for their paper entitled "Newtown Creek WWTP Central Residuals Building Project – Total Project Management Gone Right!"

The "Fun" Club

(L–r) Khris Dodson, Bill and Melissa Nylic

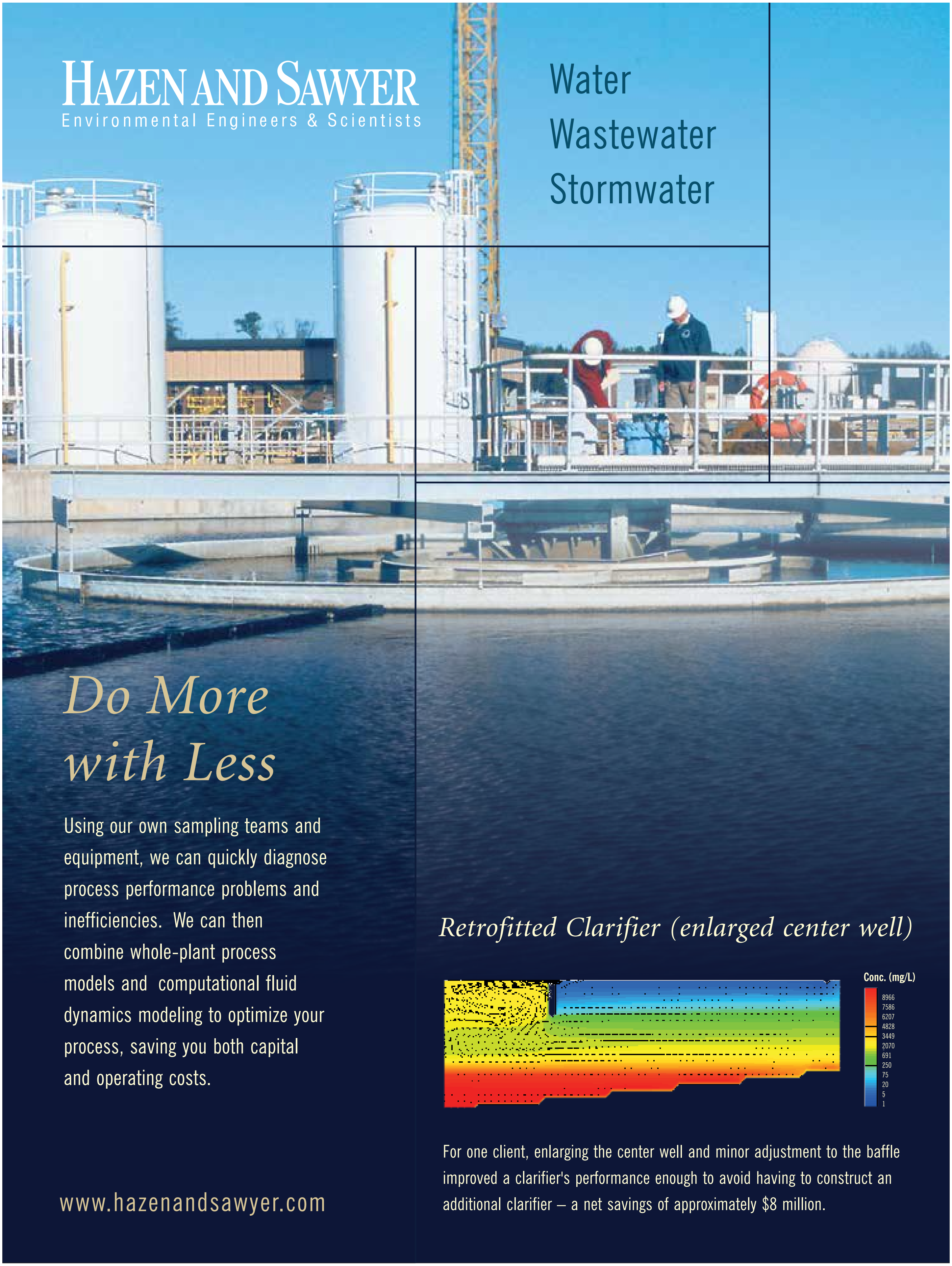
Above: Conference Management Floor Managers John Ruggiero, left, and Larry Brincat

Tim O'Brien (left) of Xero, Inc. and David Niblett of JASH USA

NYWEA President Fangmann awards Steven Effler of the Upstate Freshwater Institute the Environmental Science Award.

Left: Joyette Tyler and President Fangmann present Bob Bendlin, center, of Bendlin, Inc. with the Long Standing Exhibitor Award.

Photos continued on page 59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4828
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1
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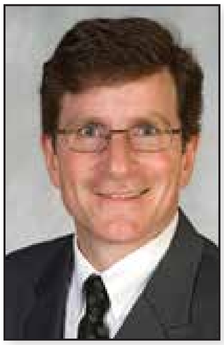


Celebrating 50th of Pure Waters Act

Many thousands of children around the globe die each year from drinking water that is contaminated with human and/or animal waste. Thankfully, such deaths are very rare in this country. This is not luck; it is due to many years of building, maintaining and improving our drinking water and wastewater infrastructure.

This year we celebrate the 50th anniversary of the 1965 Pure Waters Bond Act. In 1965, Governor Rockefeller proposed a $1 *billion* bond act, and a major element of the program was the construction of municipal wastewater treatment facilities. New Yorkers overwhelmingly voted in favor of the bond act. The result was, for that time, the largest and most comprehensive water pollution control program in the world.

The passage of New York's Pure Waters Bond Act helped lay the groundwork for the federal Clean Water Act. A key element of the Clean Water Act was federal infrastructure funding. Another was the goal of all waters being swimmable and fishable.

Facing Remaining Problems

Today we are working with many communities to address the remaining problems, such as sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs) which, when they overflow, are a major source of pathogens for waterways. Across the state, a number of communities are working hard to address their overflows. For example, the six Albany area communities prepared a Long Term Control Plan which outlines significant wastewater infrastructure investments to stop most of the CSOs that are impacting the water quality of the Hudson River. The plan makes a commitment that after most rain storms the Hudson River near Albany will be swimmable within 10 hours.

While New York has invested significant dollars over the years to improve and maintain sewage treatment facilities, more work is needed to ensure protection of public health and safety. For example, there are about 147 treatment facilities (out of 610) that do not disinfect their treated effluent. The NYSDEC is encouraging these wastewater treatment facilities to disinfect their effluent. There was a time when poor water quality discouraged recreation in our waters. Now that waters are cleaner, disinfection of municipal wastewater effluent is increasingly necessary to protect people who recreate in the waterbodies. Citizens coming in contact with non-disinfected discharges can be sickened. Researchers have even found antibiotic resistant bacteria in New York's waterways linked to municipal sewage discharges.

Looking forward, NYSDEC is also cooperatively formulating an asset management policy and pilot program to better maintain wastewater infrastructure for the long term. This initiative protects the public health and environment by recognizing the substantial investment of public funds and the necessity to properly operate and maintain – and periodically re-invest – in wastewater infrastructure. The NYSDEC's asset management policy will insure that municipal wastewater infrastructure is operated and maintained in a state of good repair.

The high quality of our state's waters is no accident. It is the result of visionary thinking that started 50 years ago, steady efforts today, and planning and investment in the future

– James Tierney, Assistant Commissioner for Water Resources
NYS Department of Environmental Conservation

Focus on Safety | Spring 2015

Long Ago, but Close to Home

This edition's topic on pathogens is a bit déjà vu for me. A few years ago, I was asked by a longtime friend of my parents to nose around and see if I could discover where the father of his shirt-tail relation was buried. I was interested because I knew this relation when I was much younger and, coincidentally, as I write this, I am sitting in the chair that he had passed away in at my great aunt's home. (It has been reupholstered since then.) The end of the story is that the father was buried 135 years ago in a small cemetery at the end of the road in an unmarked grave. It is the middle of the story that is curious.

The legend of his death was that he died while driving logs on the Black River and was drowned. By uncovering his death records, I found that legend wasn't entirely factual, but just as interesting. He was, indeed, a lumberman in the north country who came over from Canada with his brothers. However, it turns out that he did not drown but died of typhoid fever. Typhoid fever – also known simply as typhoid – is a common worldwide bacterial disease transmitted by the ingestion of food or water contaminated with the feces of an infected person, which contain the bacterium, *Salmonella Typhi.* It was quite common in the US prior to water sanitation practices and infrastructure.

The causes of death for others who died that year listed diarrhea, acute diarrhea, dysentery, and a host of other sad maladies, but no others for typhoid fever. At least there wasn't an epidemic. But how does a single person way out in the woods die of typhoid without any others that entire year? Perhaps he really did fall into the river and contacted the typhoid bacteria while in the water. Living conditions were bound to be very basic, with outhouses as the norm and no running water. It is difficult to say that he contracted it at his home, no matter how primitive, as no one else in the household succumbed to it. Perhaps it wasn't really typhoid but another gastrointestinal illness with similar symptoms. Whatever the cause, he left a very young wife with young children, one of whom was six months old at the time of his father's death. This infant was the one who eventually passed away in my chair at a ripe old age.

If it was typhoid, his death puts him in good company with some well known personalities: Wilbur Wright of the Wright brothers, Abigail Adams, Louisa May Alcott (who survived), the infamous Typhoid Mary (Mary Mallon), Roger Sherman (signer of the Declaration of Independence), the composer Franz Shubert, inventor of the Ferris wheel, George Ferris, Theodore Roosevelt's mother Martha, and little Willie Lincoln (son of Abraham Lincoln). These are just some of the more recognized victims of privilege, but there were many more who suffered and died in obscurity of a feared pathogen in the course of American history.

– Eileen M. Reynolds, Certified Safety Professional
Owner, Coracle Safety Management

A History of Pathogen Control Discoveries

by Ashley Waldron

Recent advancements in water treatment and their positive impacts on public health have made it difficult to remember the time when waterborne diseases were one of the primary public health concerns. Around the turn of the 20th century, waterborne diseases were rampant and, as a result, the average life expectancy was merely 47 years old due to a high infant mortality rate *(McGuire 2013)*. For example, in 1900, eight US cities had more than 300 infant deaths per 1,000 births *(McGuire 2013)*. During this era, constant outbreaks of cholera, typhoid fever, dysentery, and other diarrheal diseases afflicted the population, particularly in densely populated areas *(Haines 2001)*. Because the industrial revolution had caused rapid urbanization (the percent of the United States population in cities grew from 6 percent to 40 percent between 1800 and 1900), the transmission of disease became a growing issue as crowded cities became more prevalent. The effect of congestion was so severe that a study conducted on mortality rates between the years of 1800 and 1940 found that in 1900, for example, white males in rural areas enjoyed a 10-year excess life expectancy than their counterparts in urban areas *(Haines 2001)*.

Photo by Ashley Waldron

Source water contamination once led to widespread epidemics of waterborne diseases.

Waterborne Epidemics

Concern over widespread waterborne disease epidemics was due not only to their frequency but also to the abruptness and severity of their symptoms. Although the incubation period for cholera was typically a few days, its onset was rapid and accounts from the time describe cholera victims as "feeling well in the morning and dead when the sun went down" and suffering up to a 50 percent fatality rate *(McGuire 2013)*. Victims experienced phases of symptoms, which typically started with a seemingly insignificant level of discomfort and upset stomach, then progressed to violent vomiting and diarrhea among other symptoms, and finally exhausted the sufferer to a point where life was barely detectable *(Vinten-Johansen 2003)*.

Typhoid fever was another common waterborne illness in the United States, and its effects were prolonged compared to other diseases. The incubation period varied between one and two weeks and most victims initially felt general discomfort and suffered from flu-like symptoms, such as headaches, pain in the abdomen, nausea, diarrhea, and chills *(Chowdhury et al. 2014)*. By the second week, the afflicted experienced a fever during the night (up to 104°F) and a decrease in temperature during the day. In some cases, the symptoms could last for up to five weeks and it was during the third week that pulmonary illnesses could develop as well. It has been reported that up to two-thirds of the fatalities from typhoid fever resulted from complications, such as pneumonia, rather than the actual disease *(McGuire 2013)*.

Miasma Theory

One of primary reasons for these outbreaks was that there was little understanding of how diseases were spread. During the late 1800s, germ theory was in the early stages of acceptance by the general public, and the heavily rooted belief of disease transmission was called the miasma theory *(Rosen 1993)*. According to sources, infectious disease outbreaks were thought to be caused by "atmospheric conditions" *(McGuire 2013)* and it was believed that "certain gases or certain exhalations produced by living matter" could cause diseases in humans *(Barnes 2006)*. Following this line of thought, epidemics were blamed on weather conditions, for example, attributing a cholera outbreak to a dry summer or cloudy winter *(Rosen 1993)*. The terrible smells induced by harmful gases, such as hydrogen sulfide, mistakenly led to a generalized belief that all displeasing smells, such as those from the degradation of organic matter, were in themselves harmful. In addition, dirt was believed to release harmful gases and any sign of filth was considered dangerous and poisonous *(Rosen 1993)*. Dennis Dantic states "although miasma theory correctly teaches that disease is a result of poor sanitation, it was based upon the prevailing theory of spontaneous generation" *(Dantic)*. Numerous books and stories were written on miasma and its effect on humans, including a short story by Edgar Allen Poe called, "The Fall of the House of Usher," which discussed the unfortunate impacts of miasma arising from potable water sources on a nearby resident *(Poe 1839)*. Occasionally, construction projects were delayed or rescheduled in order to reduce human exposure to disagreeable gases and miasmas in the soil. The miasma theory gradually became less accepted, but still persevered decades after opposing scientific theories, such as germ theory, were established *(McGuire 2013)*.

Sewer Systems

Apprehension created by the growing frequency of epidemics led governing bodies to pursue mitigation efforts to minimize outbreaks in cities. Sanitary engineers implemented sand filtration to treat water supplies and built sewer systems to divert wastewater away from city water supplies. These efforts were believed to alleviate potential human exposure to miasmas and disease *(Barnes 2006)*; however, the conveyance systems built by sanitary engineers only created a more efficient method of polluting downstream water supplies *(McGuire 2013)*. Cities would dispose of their wastewater into a nearby water source, and the frequency of waterborne disease cases followed a tidal wave pattern down rivers and watersheds. Michael McGuire has called this compounding effect the "death spiral" *(McGuire 2013)*.

John Snow and the Broad Street Pump

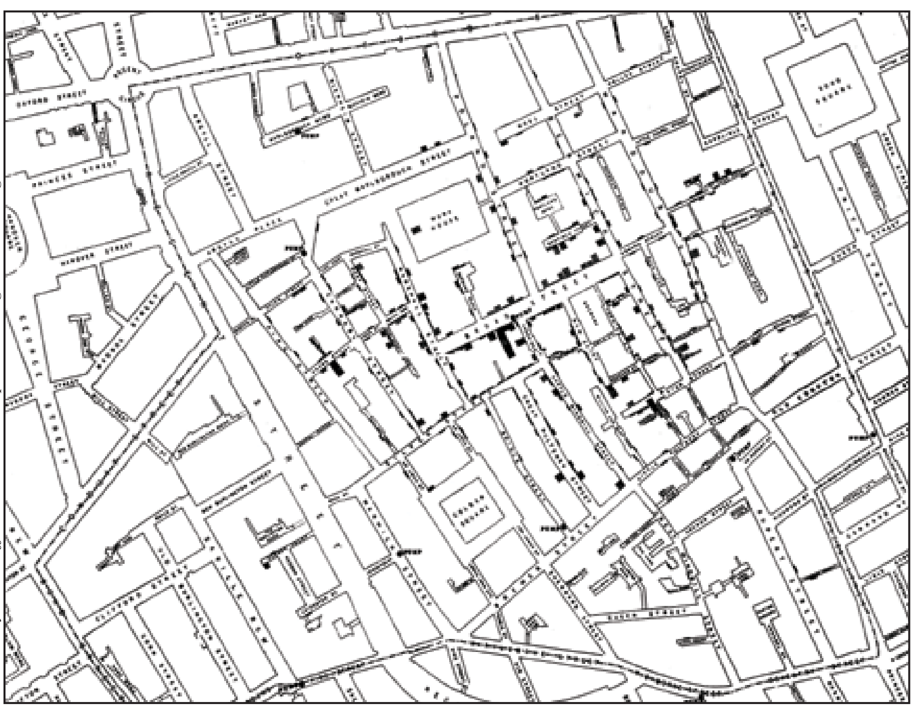
Research and application efforts of physicians (such as John Snow), public health officers (such as John L. Leal), and sanitary engineers (such as George Warren Fuller) led to the concept of using disinfecting compounds to kill harmful pathogens during drinking water management applications. John Snow is famously known for tracing the cause of the cholera outbreak in London to a contaminated well *(Dantic)*. He was able to convince local authorities in the 1850s that it was not miasma causing the epidemic, as many believed at the time, but rather, that it was due to a specific water pump on Broad Street *(map)*. Snow wrote that he "found that nearly all the deaths had taken place within a short distance of the [Broad Street] pump" *(Snow 1854)*.

Microbiology and the Path Forward

Other famous contributors include the chemist Louis Pasteur who extensively researched the germ theory of fermentation. Anton van Leeuwenhock and Joseph Jackson Lister studied lenses and aided the advancement of microscope technology that allowed future generations to better understand microbiology *(McGuire 2013)*. Richard Petri improved the methods and apparatus that Robert Koch originally created for measuring bacterial growth *(McGuire 2013)*.

Although less famous, George Warren Fuller and John L. Leal contributed greatly to the efforts to fine-tune sanitary water management and provide safe drinking water. In 1904, Jersey City, NJ was in dire need for an adequate drinking water supply because its current source (Boonton Reservoir) was heavily polluted with pathogens. The city sued the company who built the reservoir and pushed for a resolution calling for the installation of a new costly sewer system *(Water Quality and Health Council 2015)*. However, an advisory water company, which included both Fuller and Leal, suggested otherwise; they explained to the judge during litigation that a chlorination system would reduce the bacterial populations in the city's water *(Water Quality and Health Council 2015)*. Although treating water with a chemical that was considered a poison at the time was a highly divisive issue, the judge overhearing the court case gave them the opportunity to design and build a water treatment system that would produce a "pure and wholesome water supply" for Jersey City *(McGuire 2013)*. As a result, Leal and Fuller were the first in US history to successfully integrate a chlorination system into a water treatment facility.

The use of chlorine disinfection for municipal drinking water treatment became vital for the inactivation of harmful pathogens *(McGuire 2013)*. Since the first implementation of chlorine to disinfect drinking water, chlorination systems have led to reductions of reported cases of dysentery, typhoid fever, and cholera by 50, 80, and 90 percent, respectively *(Richardson et al. 2007)*. The use of chlorine became widely adopted and, by 1941, over 80 percent of treatment plants utilized chlorine for disinfection *(Water Quality and Health Council 2015)*. This major advancement resulting from the hard work of a few individuals was a significant step toward protecting public health and improving the quality of life in America.



Published by C.F. Cheffins, Lith, Southhampton Buildings, London, England, 1854.

John Snow developed a map depicting the outbreak of cholera near the Broad Street pump in London. Cholera cases are highlighted in black boxes and these households were serviced by the contaminated water source.

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Waterborne Pathogens and Safeguards Against Them

by Eileen Reynolds

Waterborne pathogens are disease causing organisms, usually microscopic, and a concern all around the world. They are not just a third world concern. Even domestic water treatment facilities must be concerned with waterborne pathogens when ingested or contacted by humans, as they may cause serious disease or other health issues. The water treatment facility must provide waters that are safe for discharge – either as a treated effluent or as drinking water. The safety of treated drinking water is important as it goes to the community's taps for either drinking or washing foods which are then ingested. The safety of treated effluent is also important to prevent the contamination of surface waters used for recreation or as a water supply.

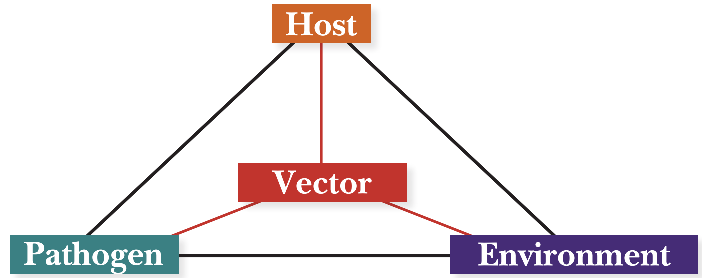
The most common of the diseases caused by waterborne pathogens is gastroenteritis. This is the more formal name for diarrheal illnesses, sometimes in combination with vomiting. If the specific pathogen is known, then the gastroenteritis is better known for the pathogen, such as typhoid or cholera. For most of the population, a bout of diarrhea is an unwelcome inconvenience, with a fairly short recovery time, even if it may seem a long time. For others, it is a fatal condition. Susceptible populations, such as the very young, old, or those with compromised immune systems, may develop diseases from these micro-organisms/pathogens that the "normal" population would not.

Disinfection and Pathogen Types

Fortunately, the survival of these pathogens in treated water is low due to very available disinfection means. Water treatment facilities commonly use chlorination as the means of disinfection. Additionally, ultraviolet light radiation and ozonation will also reduce pathogen populations in wastewater. In some waters, it may even be possible to have actual and permit limits that are lower than the waters into which the treated wastewater is discharged! However, upsets, equipment problems and human error occur, so treatment facilities may still be a source and a discharger of contaminated water. Sterilization, through heating or other means, will kill all organisms, but it is impractical and unnecessary. Customers of water treatment facilities must understand that even though their water is not sterile, it is safe. It is up to the water treatment facility to keep it so.

The pathogens of primary concern include bacteria, viruses and protozoa. The greatest concern, and greatest disease vector, is the ingestion of these pathogens. However, inhalation of contaminated aerosolized water and skin contact with contaminated waters may also result in illnesses of the respiratory tract, skin, eyes and other biological systems. Diseases of organs other than the gastrointestinal tract are not as easily traced back to contaminated water as they may be attributed to other causes, or the length of time until symptoms appear may be sufficiently long to obscure a direct line relationship. By far, the illnesses or diseases of the gastrointestinal tract are the most common and well known. There have been well documented outbreaks for millennia. It should be remembered that many micro-organisms live very happily in gastrointestinal tracts, cause no trouble at all or are even beneficial.

The Centers for Disease Control and World Health Organization have identified the pathogens that are expected to be the most responsible for the vast majority of non-food illnesses. The list is short, and includes *Campylobacter jejuni (Campylobacter), Salmonella enterica (Salmonella),* rotavirus, adenovirus, *Cryptosporidium spp., Giardia lamblia (Giardia),* norovirus, and *Escherichia coli (E.coli)* O157:H7. There are other pathogens that also cause illnesses, but are responsible for far fewer. The infectious dose of each category of pathogen (virus, bacteria, protozoa) varies greatly. Protozoa and the viruses that cause gastrointestinal disease only need a nominal number of the organisms to cause disease. On the other hand, bacteria need many more. So, statistically, one could have contact with just a single viral or protozoan pathogen and become ill. Realistically, the probability of contracting an illness will depend upon the presence of a *pathogen,* a *route of entry* (the vector and host), and having a *sufficient concentration* (environment) of that specific pathogen to create a disease response. Eliminating any one of these three legs *(pathogen triangle)* will stop a disease in its tracks.



Pathogen Triangle

Viruses: Viruses are not an organism as typically thought, but infectious particles with DNA or RNA covered with a protein coat. They need a host organism to reproduce. Without a host, they just exist, but they remain infectious. Luckily, they are host-specific. Only a few cause life threatening conditions, with the remainder producing mild symptoms in generally healthy humans. They are also tricky to diagnose correctly as the gastroenteritis symptoms that enteric viruses produce (watery diarrhea and vomiting) are common to several conditions.

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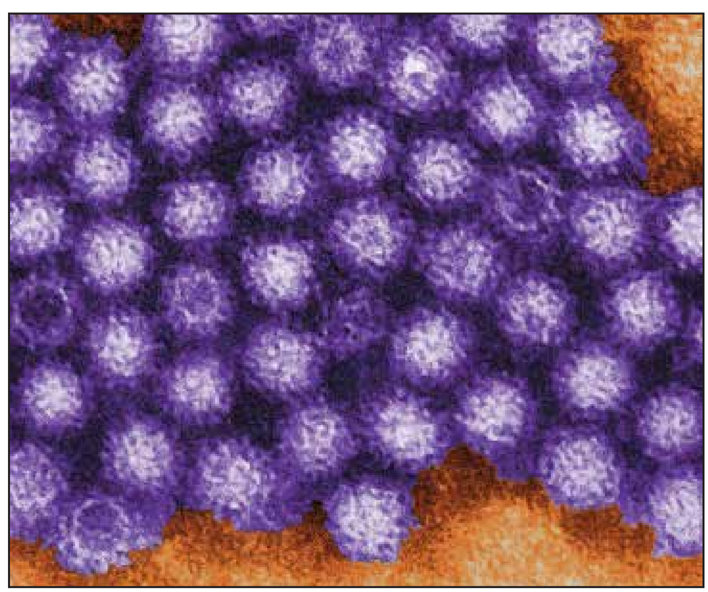

Image courtesy of CDC

Norovirus

continued from page 13

Bacteria: Pathogenic bacteria in water systems are generally linked to human or animal feces. *Salmonella* and *Campylobacter* are very common causes of gastroenteritis. There are many different species of *Salmonella* and many are infectious in humans. The presence of *Salmonella* in water, however, does not necessarily mean human waste contamination because *Salmonella* is also a food-borne pathogen and many other species can carry *Salmonella. E. coli* O157:H7 is a pathogenic strain of the very common *E. coli,* a generally harmless intestinal bacterium. Persons infected with *Campylobacter, Salmonella,* or *E. coli* O157:H7, develop gastroenteritis, with its characteristic diarrhea and vomiting. Non-gastrointestinal bacterial illnesses (non-enteric) include pneumonia from *Legionella* and various skin and eye infections from *Staphylococcus* (staph) and *Pseudomonas.* Not all bacteria are harmful. *Lactobacillus* is a non-pathogenic bacteria found in the human gut and urinary tract, as well as in yogurts, sauerkraut, beer and other common foods. Interestingly, *Lactobacillus* is used in therapy for those suffering from the diarrhea from rotavirus and infections from *Helicobacter pylori.*

Protozoa: *Giardia and Cryptosporidium* are the two infectious protozoa related to contaminated water. Like some bacteria, they are present in both humans and animals. *Crypto* is a common infection in cattle/dairy and may be found in runoff or lagoon failure. Unfortunately, *Crypto* oocysts may exist in the environment and remain infectious for significant periods of time. *Giardia* is more related to wild animals and is the impetus behind not drinking untreated lake or river waters.

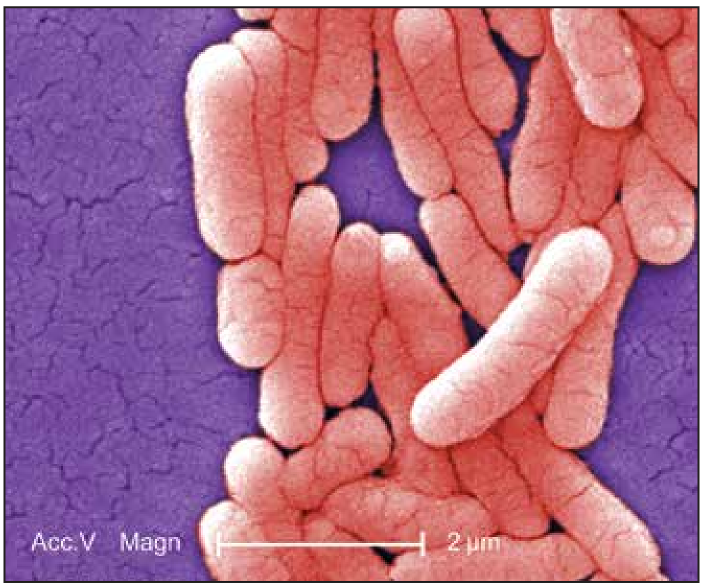

Image courtesy of CDC

***Salmonella typhimurium*, a cause of typhoid**

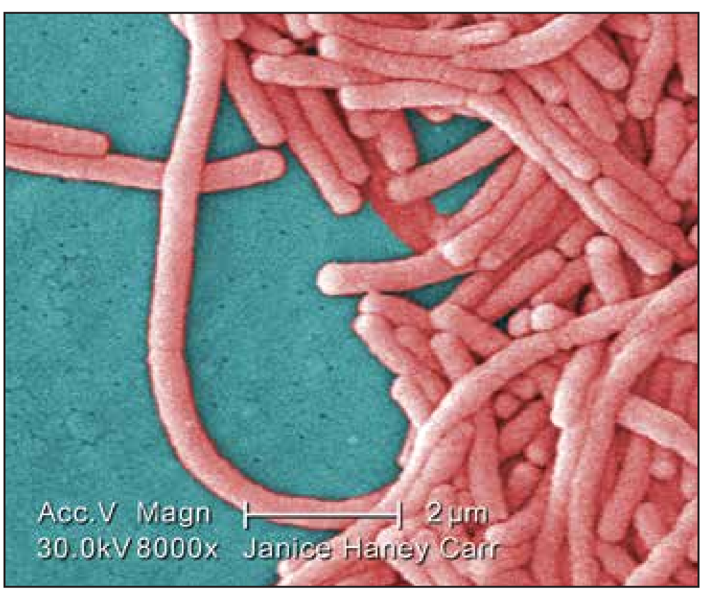

Image courtesy of CDC

***Legionella pneumophila*, a non-enteric bacteria**

Protection Against Pathogens at WWTPs

As mentioned previously, many of the waterborne pathogens are controlled by chlorination or other forms of disinfection. However, as detection methods improve, other pathogens are bound to be detected in wastewater samples and drinking water samples. Perhaps the illness symptoms that are presented have been previously credited to one of the common pathogens. Disease or illness symptoms may be attributed to other illnesses and not investigated further. These diseases/illnesses may have been around for years but "flying under the radar." With the enteric pathogens, so many of them cause gastroenteritis that it is difficult, without lab testing, to determine the true cause.

After reading all the potential health effects of waterborne pathogens, water treatment technicians may be naturally worried about their own health. With proper work procedures, training, awareness and personal hygiene, technicians may be assured that they are protected from the diseases associated with waterborne pathogens. Workers in a water treatment facility have the potential exposure to pathogens by inadvertent ingestion, inhalation of aerosols or skin contact. Technicians should have the mindset that pathogens do exist in the waste stream in their facility. To deny the existence of these pathogens is foolhardy, even in the smallest facility in a remote location. This is the time to have all proper procedures in place and to ensure that all employees follow those procedures each and every time. They will have a higher exposure potential but, with adherence to the safety rules and work procedures, their risk of developing a disease or illness is low and could be eliminated entirely.

Personal Hygiene: Workers must practice excellent personal hygiene habits in both the treatment area and the lab. As many of the potential diseases or illnesses are gastrointestinal in nature, workers must ensure that untreated water does not enter their mouths. This is not to say that workers are intentionally drinking untreated water but are exposed in non-traditional ways — water can splash during treatment, mists or aerosols may be inhaled, and hands get dirty. People have a tendency to touch their faces and put their hands in their mouths without thinking about the consequences. In the case of these pathogens, however, this hand-to-mouth contact could result in the transmission of disease. The simple prevention activity of frequent hand washing will minimize this path. Workers must wash their hands with soap and water before drinking, eating or smoking (if allowed), after using the lavatory and at the end of their work shifts. If showers are available onsite, it is a good practice to shower at the end of the day. Related to personal hand washing is the cleaning of any tools that have had contact with wastewater or sludge. Wounds, including simple lacerations and abrasions, must be promptly and thoroughly cleaned.

The prohibition of eating, drinking, smoking, chewing tobacco or gum, or applying cosmetics is required for many other contaminants in the workplace (asbestos, cadmium and lead are examples) and should be employed in water treatment facilities. Each of these actions provides a potential exposure to a pathogen. The action of applying cosmetics includes applying chapped lip balm, sunscreen, skin lotions, and other normally innocuous substances.

Table: Common Waterborne Pathogens and Symptoms

	VECTOR	PATHOGEN	DISEASE	SYMPTOM
Bacteria	Ingestion	*Helicobacter pylori*	Gastroenteritis	Ulcers
		Salmonella typhii	Typhoid fever	Diarrhea
		Campylobacter jejuni	Gastroenteritis	Diarrhea
		E. coli	Gastroenteritis	Diarrhea
		Shigella spp.	Bacterial dysentery	Bloody diarrhea
		Vibria cholera	Cholera	Acute diarrhea
	Respiratory	*Legionella pneumophila*	Legionnaires' Disease (pneumonia)	Pneumonia
Virus	Ingestion	Adenovirus	Various symptoms	Respiratory infection
		Calicivirus	Gastroenteritis	Diarrhea
		Coxsackievirus	Hand/foot/ mouth disease, Meningitis	Blisters/skin ulcers, brain infection
		Echovirus	Various symptoms including Gastroenteritis	Dependent upon strain
		Hepatitis A, E viruses	Hepatitis A, Hepatitis E	Liver infection
		Rotavirus	Gastroenteritis	Diarrhea
		Norovirus/Norwalk virus	Gastroenteritis	Diarrhea
Protozoa	Ingestion	*Cryptosporidium spp.*	Gastroenteritis	Diarrhea
		Cyclospora cavetanensis	Cyclosporiasis	Diarrhea
		Giardia lamblia	Gastroenteritis	Diarrhea
		Entamoeba histolytica	Amoebic dysentery	Severe diarrhea
	Skin contact/ Respiratory	*Naegleria fowleri*	Meningoencephalitis	Brain infection

Work Clothes: Many facilities provide a uniform service for their employees where the employer both provides the uniforms and their laundering through a vendor. This is a great practice and prevents any contamination from leaving the facility and entering the employee's home. In the absence of a uniform service, work clothes should not be mixed into the other personal laundry at home. The habit of separating the work clothes, washing in strong detergent, and cleaning the washing machine afterwards may seem excessive, but these actions prevent the possibility of cross contamination.

Personal Protective Equipment: Personal protective equipment (PPE) is the last line of defense from contact with wastewater. Impervious gloves of latex or nitrile must be made easily available and used conscientiously. Mucus membranes are also a potential exposure path. The use of goggles will protect eyes from splashes, while masks or face shields will protect both the eyes and mouth. Rubber boots (or equivalent) that can be cleaned are recommended, as opposed to leather boots which could absorb water on which pathogens may survive for a surprisingly long period.

Any PPE must be cleaned after use even if there is no suspected contamination. The proper use of PPE will minimize or eliminate the risk of disease transmission to the worker. However, it must be recognized that PPE is the last line of defense and many other processes and procedures must be in place. While PPE complements those procedures, they are not the replacement for them.

Lab Practices: Safety practices in the lab need to include prohibitions on mouth pipetting and of handling sharps to prevent lacerations or puncture wounds; and the consistent sterilization of equipment to prevent cross contamination of samples.

It is a good practice for employees to have a current tetanus shot. The general rule is a booster every ten years. However, if an employee has a significant wound and it is more than five years since the last booster, another tetanus shot is recommended. No other vaccinations or immunizations are routinely recommended.

Training and Mechanical Design: Training for hazard communications, hazardous waste handling, blood-borne pathogens, first aid, and PPE is recommended for all employees in a facility. Additionally, the other hazards native to the facility and its operations are not to be forgotten. Electrical safety, confined spaces, lockout tagout, fall protection and other site specific training programs are equally important to the well organized facility.

Engineering can be the technician's friend – in other words, incorporating a prevention-through-design mentality. The mechanical layout of a facility can work for exposure reduction by having sampling ports, remote monitoring, and simple covers. Proper drawings for the major systems, especially those carrying wastewater and clean water, will help prevent mishaps from crossed lines.

The topic of pathogens in water reminds one of the Samuel Taylor Coleridge poem, "The Rime of the Ancient Mariner," when the sailor laments: "Water, water, everywhere, and all the boards did shrink; Water, water, everywhere, Nor any drop to drink." Water is all around us and yet for many, even if water is plentiful, there is not a safe drop to drink. Our country is very fortunate to have a good wastewater and drinking water infrastructure and a skilled workforce. The job of the water treatment facility technician is critically important – to disinfect incoming waters, allowing their discharge at a safe, healthy quality to help ensure the health of the community.

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Overview of Pathogens and Wastewater Disinfectants

by Christopher Somerlot and Daniel Davis

Pathogens are a subset of the microorganism biosphere which cause disease, and act as a natural mechanism to limit population density in any ecosystem. Disinfection technology is one of the core infrastructure components that have allowed humanity to overcome this ecological limitation. Indeed, it was not until the advances in epidemiology and chemistry that led to the invention of municipal disinfection infrastructure that we were historically able to overcome severe diseases such as the bubonic plague, typhoid fever, cholera and, more recently, parasites such as *Giardia* and *E. Coli (CDC 2012)*.

This article will provide an overview of the technologies in use for wastewater disinfection, and some operational and maintenance considerations for the different disinfectants most commonly used in this application.

Disinfection Kinetics

Conventional disinfection is governed by the relationship:

Kill = c x t
Where: **c** = concentration of disinfectant
t = time of contact (within a contained volume)

The effectiveness of a specific disinfectant for a specific wastewater source is typically determined by bench scale or pilot scale measurements of this relationship. From these tests, dose-kill curves at various concentrations and contact times can be computed. These dose-kill curves can be used to design a system to optimize disinfection while minimizing the formation of disinfection byproducts. An example dose-kill curve, where the log-scale count of colony forming units is on the Y axis and contact time is on the X axis, is shown below in ***Figure 1***.

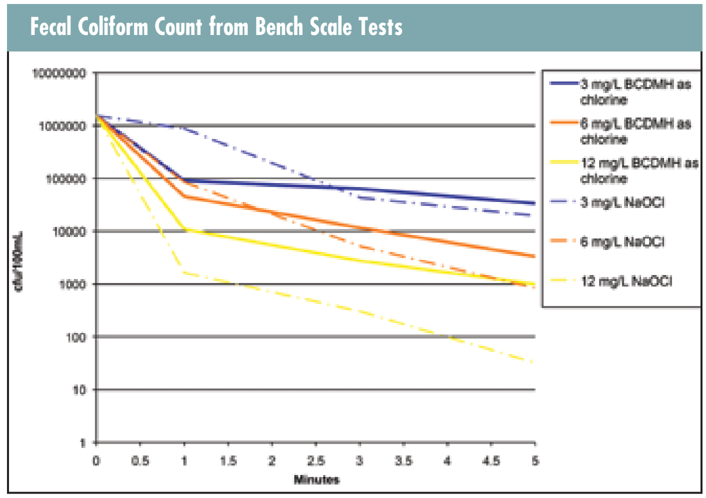

Figure 1. Example dose-kill curve of Fecal Coliforms from bench tests of a bromine-based and a chlorine-based disinfectant

Description of Disinfectants

Chlorine has long been the disinfectant of choice for most wastewater disinfection systems. It offers reliable reduction of pathogenic microorganisms at reasonable operating costs. Alternatives to chlorine have been developed and evaluated for disinfection of wastewater discharges to small streams or sensitive water bodies, including:

- sodium hypochlorite
- calcium hypochlorite
- chlorine dioxide
- ozone
- bromine
- peracetic acid
- ultraviolet radiation (UV)

Chlorination/Dechlorination: Chlorine has been the most widely used disinfectant for wastewater and potable water in the United States due to its low cost, reliable disinfection effectiveness, and adequate supply. Chlorine is available in many forms including chlorine gas and chlorine products such as sodium and calcium hypochlorite. Gaseous chlorine is not recommended for disinfection facilities that may be unmanned due to safety concerns of chlorine gas leaks. This section and ***Table 1*** only include descriptions of liquid sodium hypochlorite.

Sodium Hypochlorite (NaOCl): Liquid sodium hypochlorite has become widely used for wastewater disinfection due to its reliability and relative ease of handling. Sodium hypochlorite can be purchased in bulk forms of 10 to 15 percent available chlorine or can be manufactured on site. At this point in time, NaOCl is the predominate chlorine disinfectant employed for wastewater treatment

Typical sodium hypochlorite has limited shelf life and is subject to loss of available chlorine content by decay. Decay may be caused by low pH, catalysts like metal salts, and high temperatures. As discussed below, some manufactures can produce a cleaner sodium hypochlorite product, which can extend the shelf life. Decay rates of typically 10 percent and 15 percent NaOCl solutions are presented in ***Table 1***.

Table 1. Chlorine Strength vs. Days of Storage

Days of Storage	Strength at 15%	Strength at 10%
Day 0	15%	10%
Day 20	13%	9%
Day 60	10%	8%
Day 120	8%	7%

One way to minimize the effects of chlorine strength decay is to store smaller volume and have more frequent deliveries. Another is to dilute the solution using onsite storage to a lower solution strength such as 5–7 percent.

Chlorination serves primarily to destroy or deactivate disease-producing microorganisms. Generally, bacteria are more susceptible to chlorination than viruses. The disinfection effectiveness is largely a function of the chemical form of the disinfecting species. Chlorine is applied to the waste stream in molecular (Cl_2) or hypochlorite (OCl^-) form. Chlorine initially undergoes hydrolysis to form "free" chlorine consisting of hypochlorous acid (HOCl) and hydrochloric acid (HCl):

$$Cl_2 + H_2O \longrightarrow HOCl + HCl$$

Hypochlorous acid can further dissociate depending upon pH and temperature to hypochlorite:

$$HOCl \longrightarrow OCl^- + H^+$$

A combination of hypochlorous acid and hypochlorite ion (i.e., "free" chlorine) exists at a neutral pH. Both contribute to the disinfection process; however, hypochlorous acid is the more effective disinfectant given a limited contact time. Further reactions can occur if ammonia nitrogen is present in the wastewater to form compounds called chloramines. Formation of chloramines occurs under the following ordered processes:

$NH_3 + HOCl \longrightarrow NH_2Cl + H_2O$ **Monochloramine**

$NH_2Cl + HOCl \longrightarrow NHCl_2 + H_2O$ **Dichloramine**

$NHCl_2 + HOCl \longrightarrow NCl_3 + H_2O$ **Trichloramine**

These reactions are complex and the products can vary with time, ammonia present, and chlorine added. Additionally, chloramine formation is strongly influenced by pH. Under neutral and alkaline conditions, monochloramines dominate, while significant amounts of dichloramine are present under acidic conditions. Chloramines contribute to the disinfection process, but the disinfection process for chloramines is less rapid than for free chlorine. Collectively, chloramines are referred to as combined chlorine residual. The sum of free residual and combined residual chlorine is referred to as total residual chlorine (TRC), representing all forms of chlorine that contribute to the disinfection process and can represent toxicity to the receiving water.

Calcium Hypochlorite ($CaOCl_2$): Calcium hypochlorite is a relatively stable compound of chlorine in terms of maintaining product strength, and is commercially packaged either as a coarse powder or in tablet form, or in wet form. The most commonly used calcium hypochlorites will yield 70 percent available chlorine by weight. In dry form, it maintains its strength longer than sodium hypochlorite, allowing long term storage. It loses 3 to 5 percent available chlorine every year. Like sodium hypochlorite, it loses its strength with exposure to air and should be stored properly to retain its strength. More importantly, proper storage can prevent the decomposition of calcium hypochlorite, which is exothermic and can occur very rapidly in the presence of heat and moisture. It can decompose so rapidly as to auto-combust or ignite packaging material.

Dechlorination: Free chlorine and combined chlorine residuals are toxic to aquatic life at certain concentrations. Intermittent discharges of total residual chlorine have been recommended not to exceed 0.2 milligrams per liter for a period of two hours per day where more resistant species of fish are known to live, or 0.04 milligrams per liter for a period of two hours per day for trout or salmon *(Brungs 1973)*. It is, therefore, sometime necessary to dechlorinate (i.e., reduce chlorine compounds) the chlorinated effluent before it is discharged into a receiving water.

Dechlorination may be accomplished through injection of any suitable reductant, such as a solution of sodium bisulfite ($NaHSO_3$) or sulfur dioxide (SO_2) into the process flow, following the chlorination process. The dechlorination process is nearly an instantaneous reaction. A potential problem with dechlorination is the possible depletion of dissolved oxygen by excess sulfite ion, thus requiring oxygenation prior to discharge.

The ***advantages*** of chlorination disinfection are:

- widely used and accepted for many areas of disinfection
- requires minimal operator attention
- relatively low cost

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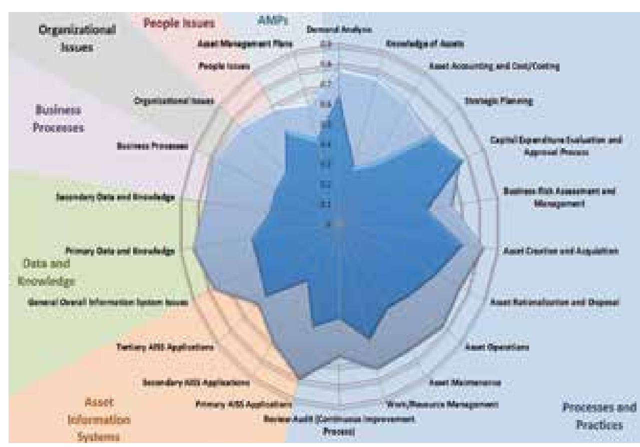

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The ***disadvantages*** of chlorination disinfection are:

- produces disinfection byproducts
- reacts with ammonia to form chloramines
- corrosive nature of chlorine
- limited shelf-life of sodium hypochlorite
- disinfection effectiveness is pH dependent and is reduced at pH 8 or greater
- possible dissolved oxygen depletion of dechlorinated effluent
- safety considerations associated with chemical storage

Chlorine Dioxide

Chlorine dioxide (ClO_2) historically has proven its capabilities as an outstanding bactericide and viricide *(White 1999)*. ClO_2 is a yellowish gas at room temperature, but it is most often produced and used in an aqueous solution. ClO_2 is ten times more soluble in water than chlorine. Due to the highly reactive nature of ClO_2, it must be generated onsite on an as needed basis. In contrast to chlorine, ClO_2 does not react with ammonia and other nitrogenous compounds to form chlorinated organics as chlorine does and its disinfection efficiency is high over a wider pH range than chlorine. These can be the most important issues.

ClO_2 may be generated onsite by one of the following processes:

- acid/sodium chlorate generation
- acid/ sodium chlorite generation
- chlorine/sodium chlorite generation
  - a) solution generators
  - b) gas-solid generators
- UV radiation/sodium chlorite generation

The acid/sodium chlorate process is only appropriate for large-scale production, such as in industrial paper bleaching operations. It is not cost effective for small-scale production, such as required by water and wastewater disinfection. The acid/sodium chlorite process is generally inefficient and is primarily used for generating ClO_2 on a laboratory scale. While this process has been used at some water treatment plants in Europe *(White 1999)*, it is generally not popular as the yield of ClO_2 is quite low (e.g., less than 50 percent). By far, the most prevalent method of ClO_2 generation for water and wastewater treatment is the chlorine/sodium chlorite process. The chlorine/sodium chlorite process can be further broken down into two types of generators – solution and gas-solid generators. The typical reaction of the chlorine/sodium chlorite solution generation is as follows:

$$\mathbf{Cl_2(gas) + Sodium\ Chlorite(solution) \longrightarrow ClO_2(solution) + Sodium\ Chlorite + Chlorate\ Ion}$$

There are two important points to note in this reaction. The first is that the reaction is carried out in the presence of excess chlorine in order to achieve high conversion (82–90 percent) of chlorite to ClO_2. However, excess chlorine favors chemical reactions that result in the formation of the chlorate ion in the final ClO_2 product. The second is that unreacted sodium chlorite remains as a byproduct of the reaction. Chlorine dioxide, chlorite and chlorate ions can be toxic to aquatic life at certain concentrations. However, when chlorine gas is allowed to react directly with an excess of moist solid sodium chlorite, chlorine dioxide gas that is free of chlorine, chlorate ion, and chlorite ion are produced *(CDG Technology Inc. 1995)*. This is the gas-solid generator as described by the following equation:

$$\mathbf{Cl_2(gas) + 2NaClO_2(solid) \longrightarrow 2ClO_2(gas) + 2NaCl\ (solid)}$$

Using an excess of sodium chlorite favors the production of ClO_2 over chlorate ion and minimizes the possibility of chlorine impurities in the ClO_2 product. Since the ClO_2 produced is in the gas phase, neither chlorate ion nor chlorite ion are present. The gas-solid generator provides an actual ClO_2 yield of 95 to 98 percent *(A.R. Pitochelli 1995)*. The one disadvantage to this ClO_2 generation process is that it employs chlorine gas as a feedstock. Restrictions on the transportation and use of chlorine gas limit the application of this generation process. As an alternative, the chlorine gas used in this generation process could be produced onsite either electrolytically or by the reaction of acid with sodium hypochlorite.

A recent advance involving a process of ultraviolet radiation of a single chemical, sodium chlorite ($NaClO_2$), has emerged as a new and innovative technology for ClO_2 generation. ClO_2 is produced by this method through the disassociation of chlorite, a process that requires very little energy in the generation process. Under proper control and intensity, UV radiation of aqueous sodium chlorite can generate ClO_2, by the following reactions *(UVD Inc. 1996):*

$$\mathbf{NaClO_2 + UV\ radiation \longrightarrow Na^+ + ClO_2}$$
$$\mathbf{Na^+ + H_2O \longrightarrow NaOH}$$

The primary benefit of this generation method compared to conventional ClO_2 generation methods is that chlorine gas is not used in the generation process. This technology was developed in several bench-scale facilities. The first full-scale pilot of the UV-ClO_2 generation process was operated at the Meadowbrook-Limestone POTW, Onondaga County, NY. This system was also operated as part of an alternative disinfection study for the Onondaga County Department of Drainage and Sanitation in 1999.

The role of ClO_2 as an oxidizing agent in water involves three steps:

1. ClO_2 gains one electron to form chlorite (ClO_2^-):

$$\mathbf{ClO_2 + 1e^- = ClO_2^-}$$

2. Chlorite gains four electrons to form chloride (Cl^-):

$$\mathbf{ClO_2^- + 2H_20 + 4e^- = Cl^- + 4OH}$$

3. Under alkaline conditions, ClO_2 can more readily degrade to form chlorate (ClO_3^-) and chlorite (ClO_2^-):

$$\mathbf{2ClO_2 + 2OH^- = H_2O + ClO_2^- + ClO_3^-}$$

The first step to form chlorite can usually occur in a pH range normally found in wastewater. The second step does not occur as readily; hence, the overall five-electron transfer for complete reaction through the first two steps is not often available. The third step does not occur to an appreciable extent at a pH less than 8; however, the rate of degradation is influenced by the ClO_2 concentration. Higher rates of degradation occur at higher concentrations of ClO_2.

The ***advantages*** of high-rate ClO_2 disinfection include:

- ten times greater aqueous solubility than chlorine
- effective over a broader pH range than chlorine
- does not react with ammonia
- more effective bactericide and viricide than chlorine at comparable doses
- requires less contact time than chlorine
- no production of trihalomethanes (THMs)

The ***disadvantages*** of ClO_2 disinfection are:

- requires onsite generation
- conventional method of generation requires use of gaseous chlorine

continued on page 22

continued from page 20

- corrosive nature of ClO_2
- safety considerations associated with ClO_2 disinfection systems
- ClO_2 strength degrades readily unless refrigerated

Ultraviolet Radiation (UV)

The use of UV for disinfection of secondary effluent is an established technology with over 1,000 systems in operation throughout the United States and Canada. These systems range in magnitude from 10^4 to 10^8 gallons per day flow capacity

Ultraviolet light irradiation is a physical process offering short detention times, typically five to seven seconds, that does not involve the addition of chemicals. The UV disinfection does not produce known toxic residuals or byproducts that are a risk to humans or aquatic systems. Some concerns have been raised regarding the development of organism mutations, but no conclusive data exists. The UV technology works on the principle that all microorganisms that contain nucleic acids are susceptible to damage through the absorption of radiation in the UV energy range. The extent of damage, mutation, or death will depend upon the organism's resistance to radiation penetration. This depends on several factors, including cell wall composition and thickness. The UV disinfection is accomplished by electromagnetic radiation at specific wavelengths ranging from 100 to 400 nanometers (nm). Optimum disinfection is achieved at a wavelength of 253.7 nm.

The intensity of UV light produced is described in terms of energy per unit area with the most common units of milliwatts per square centimeter (mW/cm^2). The UV dose is computed by multiplying this intensity by the exposure time and is represented in units of $mW\text{-}sec/cm^2$. The UV dosage requirements depend upon several parameters, including the frequency and intensity of the UV radiation, the number and configuration of the UV lamps, the distance between the lamp surface and the waste stream, the chamber turbulence, and the wastewater's absorption coefficient and exposure times. Systems with UV disinfection also vary by lamp technologies.

Lamp technologies are categorized as follows:

Lamp Type	Operating Pressure (torr)
• Low pressure, low intensity	10^{-3} to 10^{-2}
• Low pressure, high intensity	10^{-1} to 10^{-2}
• Medium pressure, high intensity	10^2 to 10^2

Low pressure lamps result in 85 percent of their output being monochromatic at a wavelength of 253.7 nm. The UV disinfection facilities have historically been designed using low pressure, low intensity UV lamps. The low output of these systems limited their use to drinking water and wastewater following secondary treatment.

Medium pressure, high intensity lamps differ substantially in terms of the output spectrum of the lamps. The radiation from these lamps is emitted over a large fraction of the UV spectrum. Only a small fraction of the UV output is in the germicidal wavelength of 254 nm. However, the higher UV light intensity produced by these lamps provides a higher intensity within the reactor with fewer lamps as compared to low pressure, low intensity systems. The advent of medium pressure, high intensity lamps has redefined the suitability of UV disinfection in the wastewater arena. A significant amount of the lamp input energy for medium pressure lamps is lost as thermal energy to the surrounding water. As a result, power consumption is significantly greater than for low pressure technology.

Low pressure, high intensity UV lamps are a recent development in lamp technology. Manufacturers of these systems claim that they can achieve the high intensities of medium pressure lamps at the higher energy efficiency of low pressure lamps. This technology promises high disinfection efficiency while offering reduced operational costs. At the present, there are only a few manufacturers offering this technology and there is limited data on the performance of these systems.

Ultraviolet disinfection systems vary in reactor geometry, lamp type, orientation and arrangement, and lamp power. These factors dictate how the electromagnetic energy is delivered to the wastewater. When UV systems are used for disinfection of wastewater of poor quality, an operational concern arises over the potential for lamp fouling. The medium pressure, high intensity lamps are operated at high temperature to provide the necessary energy required for disinfection. The high temperature can result in fouling of the lamps with a glaze-like film. This film acts to reduce the energy transferred from the lamps to the wastewater. To alleviate this problem, elaborate systems have been devised to provide a mechanism for cleaning the quartz lamp sleeves. These consist of mechanical and mechanical/chemical-wiping systems, sonic cleaning and chemical baths for removal of accumulated material on the quartz sleeves.

The ***advantages*** of UV disinfection include:

- no disinfectant chemicals are required
- no byproducts
- short contact time
- ability to deactivate wide range of pathogens
- more effective protozoan deactivation than chlorine
- potential for simple control (on-off), especially with respect to intermittent operation

The ***disadvantages*** of UV disinfection are:

- sensitivity to high solids concentrations and transmissivity to achieve comparable bacteria reductions as chemical disinfectants
- fouling of UV lamps by wastewater and associated operation and maintenance costs
- high energy demand

Bromine

Bromine disinfection has the advantage of providing a more reactive disinfectant species namely, hypobromous acid, than the chlorine counterpart, hypochlorous acid. However, there have been conflicting reports on the toxicity of organobromines relative to organochloramines. Most studies of bromine have been performed on drinking water and therefore organobromines have not been a major issue. Studies by Hohfeld, et al. of Dow Chemical reported that reaction products of bromine chloride are less toxic to fish than those produced from chlorine. This is attributed to the rapid breakdown of bromamines. However, certain organobromines are more toxic than organochloramines *(White 1999)*. Some organobromines may be more toxic than organochloramines, but they are generally found in lower concentrations due to the lower dosage of bromine than chlorine that is required as a bactericide. This may explain the conflicting results of these studies.

Many forms of bromine are available for disinfection, such as pure bromine, bromine chloride, sodium bromide and bromochlorodimethylhydantoin (BCDMH). Pure bromine and bromine chloride are liquids at normal atmospheric conditions, but are highly volatile. These forms of bromine are stored in sealed containers and generally introduced into the wastewater as a vapor using the similar equipment as used for gaseous chlorine. Sodium bromide is a liquid form at normal atmospheric conditions, but is not as volatile as pure bromine and bromine chloride. Owing to the inert nature of the sodium bromide, sodium hypochlorite is used to react with the sodium bromide to form hypobromous acid.

The ***advantages*** of sodium bromine disinfection include the following:
• more reactive disinfectant than chlorine
• three times more soluble than chlorine
• residuals are less persistent than chlorine

The ***disadvantages*** of sodium bromine disinfection are:
• limited availability of sodium bromine
• corrosive nature of bromine
• production of disinfection byproducts
• safety considerations associated with chemical storage

Ozone

Ozone is a chemical oxidizing agent that has been widely used for disinfection of drinking water systems and bleaching in the pulp and paper industry. Ozone gas is an extremely strong oxidant and is well established for its powerful antibacterial and antiviral properties. Ozone is a rapid disinfectant, requiring substantially less contact time than conventional chlorination disinfection systems to achieve the similar inactivation of bacteria at comparable doses. Based upon research performed by the US Environmental Protection Agency (USEPA) in the 1970s and early 1980s, ozone was considered to be one of the most feasible disinfection alternatives to chlorination. However, there presently are few operating facilities using ozone for disinfection of municipal wastewater. This may be attributable to the relatively high initial capital costs associated with ozone generation equipment and the poor operating records of previous generations of ozone generators. Ozone readily gases out of solution and contactor efficiency is therefore very important *(White 1999)*.

Since ozone is unstable, it must be generated onsite. The corona discharge process is the most commonly used method of ozone generation. Ozone is produced when oxygen is subjected to a high-voltage electrical current. The voltages used in this process range from 7,500 to 30,000 volts. Passing air or oxygen through this high voltage electrical field produces ozone. Air preparation is required if oxygen is not used as the feed source. Oxygen may be purchased as liquid oxygen or generated onsite using pressure swing adsorption, vacuum-assisted pressure swing adsorption, or cryogenic air separation technology. Commercial ozone generators can produce 1 to 4 percent ozone using air as the feed gas and 6-14 percent ozone, by weight using oxygen as the feed gas. In present day ozone generators, only approximately 10 percent of the applied energy goes toward the generation of ozone *(White 1999)*. Most of this energy is dissipated as heat.

The major components of an ozone generator include:
• feed gas preparation
• electrical power supply
• high voltage and ground electrodes with dielectric material forming the discharge gap
• cooling system to remove heat generated

Gaseous ozone is dissolved in the wastewater by injecting the ozone gas into the process stream in an ozone reactor or contactor. The most common ozone dissolution systems include fine bubble diffusers and injectors. A baffled retention tank is commonly used to allow residual ozone to continue to react with the process water. Ozone is relatively volatile and is easily stripped from water. Dissolved ozone residual is reasonably stable in clean water. However, in the presence of oxidizable organic and inorganic matter, any residual ozone is rapidly consumed. A benefit of ozone disinfection is that dissolved oxygen is formed from the decomposition of ozone which can elevate oxygen levels in treated water. If insufficient detention time is provided or if ozone dose exceeds demand and decay, chemical quenching of excess ozone residual may be needed to remove any residual ozone. Quenching agents include hydrogen peroxide, sodium bisulfite, sodium metabisulfite and sulfur dioxide.

Byproducts from the reaction of ozone with wastewater have been identified. In general, the reaction of organic molecules with ozone leads to destruction of the original molecule, often forming a more biodegradable product; however, more research relating to the byproducts of wastewater ozonation is needed. Ozone byproducts include bromate, aldehydes, ketones, acids, and other rapidly biodegradable organic compounds.

Ozone is a toxic and corrosive gas requiring proper safety precautions in design and operation. The major issues that must be addressed during design are:
• need for watertight, gas-tight contactor (ozone reactor)
• need for collection of off-gas and ozone destruction (typically using thermal/catalytic off-gas destruction) prior to atmospheric discharge
• monitoring, alarm and ventilation systems
• corrosion resistant construction materials

The ***advantages*** of ozone disinfection are:
• high oxidation potential and more reactive disinfectant than chlorine
• more effective bactericide and viricide than chlorine at comparable doses
• residuals are far less persistent than chlorine
• fewer disinfection byproduct concerns than chlorine

The ***disadvantages*** of ozone disinfection are:
• high capital costs
• high operation and maintenance costs
• corrosive nature of ozone
• safety considerations associated with ozone disinfection systems
• high ozone consumption due to reaction with organic material in wastewater

Peracetic Acid

Peracetic acid (CH3COOOH) (PAA), also known as ethaneperoxoic acid, peroxyacetic acid, or actyl hydroxide, is a strong oxidant. PAA has received a good deal of attention over recent years due to its increasing commercial availability and its advantages noted below. There are currently a number of locations where PAA is being tested in a variety of applications in the wastewater industry. Initial results suggest PAA can be very effective at disinfection and there should be additional data available soon to further consider its relative effectiveness compared with other disinfectants.

The ***advantages*** of disinfection with PAA include:
• fast acting disinfection
• non-tainting to wastewater
• it produces safe, innocuous decomposition products that are non-polluting

The ***disadvantages*** of disinfection with PAA include:
• need to mix two chemicals which requires stoichiometric control onsite

continued on page 25

continued from page 23

Table 2. Comparison of Disinfection Technologies

CRITERIA	Chlorine (NaOCl)	Chlorine Dioxide	Ultraviolet Radiation	Ozone	Bromine (NaBr)	Peracetic Acid
Effectiveness	High	Moderate	Moderate – High	Moderate	High	High
Occupational Safety Reguirements	Moderate – High	High	Low	Moderate – High	Moderate	High
Number of Installations	High	Low	Moderate – Low	Low	Low	Low
Ease of Operation	Simple	Simple – Moderate	Simple	Moderate – Complex	Simple – Moderate	Simple – Moderate
Generation Equipment Required	No	Yes	Yes	Yes	No	No
Persistent Residuals	Yes	Yes	No	No	Yes	No
Power Requirements	Low	Low	Moderate – High	High	Low	Low
Present Worth Cost	Low	Low – Moderate	High	High	Moderate	Low

- reduced effectiveness at higher suspended solids concentrations
- highly corrosive, unstable and explosive
- byproducts can exert an oxygen demand

Summary

Table 2 presents a summary of the disinfection technologies and comparative rankings for specific criteria. The disinfection technologies are listed across the top of each column and the rankings are listed below for each criteria. The rankings are for comparative purposes only for each criteria.

The disinfection technologies presented in ***Table 2*** represent technologies used for wastewater disinfection *(White, 1999)* and major assumptions are briefly identified below. More detailed descriptions of these technologies follow here:

- **Chlorine** includes sodium hypochlorite and calcium chlorite. Gaseous chlorine is not commonly used in disinfection facilities due to health and safety issues.
- **Chlorine dioxide** is generated onsite from gaseous chlorine. Commercially available chlorine dioxide generators often use gaseous chlorine.
- **Ultraviolet light** includes the use of medium pressure, high intensity bulbs within a closed chamber or open channel.
- **Ozone** is generated onsite using a corona type generator. Industrial grade oxygen can be generated onsite or delivered to the site.
- **Bromine** includes sodium bromide. Other forms of bromine exist for disinfection, such as pure bromine, bromine chloride and BCDMH
- **Peracetic Acid** is generated onsite by combining glacial acetic acid, hydrogen peroxide and water.

The disinfection technologies presented in ***Table 2*** are compared to one another based on specific criteria. The criteria are described below.

- **Effectiveness** is the disinfectants ability to inactivate indicator organisms at dosages deemed by equipment suppliers and design engineers.
- **Occupational Safety Requirements** reflects the quantity and complexity of safety barriers required to maintain operator safety.
- **Generation Equipment Required** denotes whether the disinfectant needs to be generated onsite. Because UV bulbs and controls are significant pieces of equipment, they are considered generators.
- **Persistent Residuals** is a measure of the disinfectant that remains as a residual after the disinfection process is complete. This also includes disinfection byproducts.
- **Power Requirement** reflects the amount of electric power required to operate the disinfection technology.
- **Present Worth Cost** includes capital and annual operational and maintenance costs.

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Operator Facts – Chemistry of Chlorine Disinfection

by Rich Malaczynski

This is reprinted from NYSDEC's "Operator Facts" newsletter, Winter 2002 edition.

The disinfecting agents hypochlorousacid, (HOCl), and hypochloriteion, (OCl^-), are equally distributed at a pH of about 7.5 which is a typical range for conventional wastewaters. These compounds are referred to as "free available chlorine." A third disinfecting compound is formed when hypochlorous acid, (HOCl), reacts with ammonianitrogen (NH_3) to form a chloramine which is referred to as "combined chlorine." Ammonia (NH_3) is a common constituent of wastewater that forms the ammonium ion (NH_4^+) within the normal pH range of most domestic wastewater. The combination of hypochlorous acid (HOCl) with the ammonium ion forms the disinfecting agent monochloramine. Dichloramine and trichloramine may also be formed, but their presence is rare due to the low pH ranges and hypochlorous acid concentrations required for their formation. The hierarchy of strengths of disinfecting agents from strongest to weakest is hypochlorous acid (HOCl), hypochlorite ion (OCl^-), and monochloramine (NH_2Cl).

The success of chlorine as a disinfecting agent is dependent on many chemical variables. Typical chlorine disinfection problems encountered by operators addressed in this article include fluctuating organic-N levels, overdosing and losing the chlorine residual, partial nitrification and industrial discharges. The use of chlorine as a disinfection agent is linked to its powerful oxidizing nature. Distinct chemical properties of elemental chlorine include the third highest electronegativity (attraction capacity for electrons), and its vigorous reactivity at 25°C which is about room temperature. The tendency to attract electrons with a negative charge is characteristic of an oxidizing agent. It is believed that electron transfer is the mechanism that chlorine disinfects. By disrupting the chemical cytoplasm of pathogens, chlorine has the ability to impede their replication, and to inactivate pathogens.

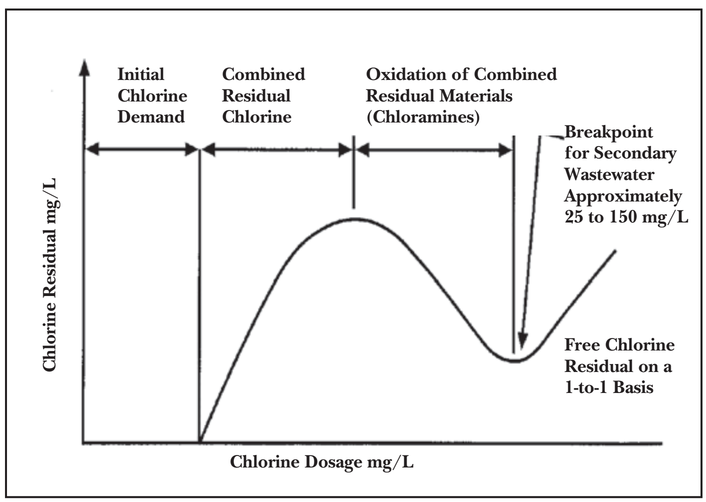
The two predominant chlorine agents, compressed liquid chlorine or a hypochlorite, follow similar initial reactions. The first reaction that occurs is ***hydrolysis,*** where chemical bonds are broken in the presence of water, and new chemical compounds are formed. The second reaction is ***dissociation,*** where a chemical compound can split apart and form back together.

The Chemistry of Chlorine Disinfection

Chlorine Gas (Cl_2)
hydrolysis **$Cl_2 + H_2O$ HOCl + H^+ + OCl** ***dissociation***
HOCl $H^+ + OCl^-$

Sodium Hypochlorite (NaOCl)
hydrolysis **NaOCl + H_2O NaOH + HOCl**
dissociation **HOCl $H^+ + OCl^-$**

The disinfecting agents hypochlorous acid, (HOCl), and hypochlorite ion, (OCl^-), are equally distributed at a pH of about 7.5 which is a typical range for conventional wastewaters. These compounds are referred to as *"free available chlorine"*. A third disinfecting compound is formed when hypochlorous acid, (HOCl), reacts with ammonianitrogen (NH_3) to form a chloramine, which is referred to as *"combined chlorine."* Ammonia (NH_3) is a common constituent of wastewater that forms the ammonium ion (NH_4^+) within the normal pH range of most domestic wastewater. The combination of hypochlorous acid (HOCl) with the ammonium ion forms the disinfecting agent monochloramine. Dichloramine and trichloramine may also be formed, but their presence is rare due to the low pH ranges and hypochlorous acid concentrations required for their formation. The hierarchy of strengths of disinfecting agents from strongest to weakest is hypochlorous acid (HOCl), hypochlorite ion (OCl^-), and monochloramine (NH_2Cl). "Free available chlorine" is a stronger disinfecting agent than "combined available chlorine". This strength characteristic is a negative attribute for disinfection purposes. Chemical constituencies of wastewater will react with "free available chlorine" in side reactions which ultimately reduce the total amount available for disinfection. Monochloramine will also react with these same compounds, but at a much slower reaction rate leaving a greater amount for disinfection. A perfect example of this phenomena is the reactions that occur with Total Kjeldahl Nitrogen (TKN). The TKN for a wastewater is the sum of the ammonia nitrogen and the organic nitrogen. The instantaneous reaction of "free available chlorine" with organic nitrogen forms a compound known as an organochloramine. This compound has the unique distinction of titrating as a dichloramine fraction for chlorine residual measurement, yet it is a non-germicidal, impotent, disinfecting agent. Without an accurate assessment of the organic nitrogen fraction, the wastewater operator may be fooled into thinking the chlorine residual is adequate, while a lab analysis returns fecal coliform violations.



A second interesting phenomena regarding the role of nitrogen in chlorine disinfection is Breakpoint Chlorination. The plot above shows the chlorine residual with increasing dosage. At the peak of the ascending curve, the residual reaches a pinnacle. Just left of this peak is optimal. Additional chlorine dosage beyond this point begins to oxidize the "combined available chlorine" chloramines. This is characterized on the plot by the descending segment to the "Breakpoint." The "Breakpoint" indicates the lowest residual for the highest dose. Continued dosage beyond this point will raise the

Photo provided by NYSDEC

A chlorine tank that is well monitored

residual on a one-to-one basis. Operators need to monitor the influent ammonia-N concentrations so chlorine dosage does not start to reduce the residual, causing fecal violations. When this occurs, it is natural to raise the dose, which only compounds the residual reduction until the breakpoint is passed.

A third phenomena of nitrogen impacting chlorination concerns partial nitrification. When ammonia-N is partially nitrified to nitrite, it creates a chlorine demand of 5 mg/L of chlorine for the reduction of 1 mg/L of nitrite to nitrate. The operator can easily monitor this condition with a simple color-matching test kit for ammonia, nitrite and nitrate.

A fourth phenomena that can dramatically impact chlorine disinfection is industrial discharges. This influent typically has a different chemical constituency than conventional domestic wastewater. It can generate huge chlorine demands, and adverse disinfection results. As an example, phenols and other compounds generally associated with them can generate a chlorine demand of 20 mg/L to destroy 1 mg/L of phenol. For successful disinfection, good initial mixing is required so that the monochloramine (combined chlorine) species is formed. Second, periodic test-kit monitoring is important to keep abreast of the concentration of nitrogen species through the plant and to maintain an optimal position on the Breakpoint Chlorination curve. Industrial dischargers have to be closely monitored so that abrupt changes in pH and slug discharges do not upset the treatment process and the chemistry of chlorination.

Finally, the operator needs to use an EPA-approved method to monitor chlorine residuals to dictate chlorine dosages. Elevated organic nitrogen (identified in a laboratory TKN test) will form non-germicidal organochloramines. An "impotent" chlorine residual could lead to baffling fecal coliform violations.

This article was written by Rich Malaczynski, PE, an Engineer II, formerly with the Facility Operations Assistance Section of NYSDEC's Bureau of Water Compliance. He currently works in the department's New York City Municipal Compliance Section. (The "Operator Facts" newsletter, in which this article originally appeared, no longer is published nor is it available to reference from the NYSDEC website.)

Total Residual Chlorine is Going Down, Down, Down

by Frank DeOrio and Darcy Sachs

Recently, the New York State Department of Environmental Conservation (NYSDEC) has been implementing a lower enforceable compliance level or daily maximum limit for total residual chlorine (TRC) in State Pollutant Discharge Elimination System (SPDES) permits. These permits are issued to sewage treatment plants (STPs) and industrial wastewater treatment plant dischargers that release directly into a water body.

The limit reduction is being accomplished by using a lower practical quantitation limit (PQL)[1] for total residual chlorine (TRC) using Standard Methods 4500-Cl-G. This lower PQL can significantly reduce the effluent TRC daily maximum limit or enforceable compliance level for many SPDES dischargers, particularly if discharging to a lake or smaller water body.

The NYSDEC has been reaching out to dischargers to inform them of pending changes. Generally, lower limits are implemented when a SPDES permit is up for renewal or modification. In some cases, the discharger is granted time to complete an engineering study to prove that the existing system can comply with the lower limits. If the existing system cannot be proven to be in compliance then the lower limits can result in changes for STP and industrial WWTP operations and equipment, new outfall/diffuser arrangements, better mixing technologies, dechlorination or alternate disinfection methods (e.g., UV, or a chemical disinfectant generating less or no residual).

Chlorination

Chlorine is used to disinfect sanitary wastewater to kill pathogens, or disease causing micro-organisms. The TRC is the portion of chlorine that is still reactive in the wastewater at the point of discharge. Because residual chlorine is needed to confirm disinfection is effective, some measurable residual needs to be present in the effluent. If the remaining chlorine is too high, however, harm to aquatic life, such as fish, can occur.

Harm can occur at very low concentrations – in the low parts per billion (ppb or ug/L) range – depending on the organism and ability to move into unchlorinated waters. This has resulted in many states establishing ambient water quality standards and guidance values (AWQS) for TRC or similar active chlorine measurement at low ppb levels. Often these standards are below USEPA approved analytical methods' respective reproducible measurement level – the method PQLs.

New York State's AWQS for total residual chlorine is provided in ***Table 1***.

TRC Analytical Methods

While there are a number of USEPA[2] approved analytical methods for TRC (***Table 2***), Standard Methods 4500-Cl G as the compliance method is most often specified. This is because 4500-Cl G has been found to have fewer interferences in a wastewater matrix, as well as one of the lowest analytical PQLs.

Testing for TRC requires it be performed within a short timeframe (15 minutes), to provide an accurate test result. Given the short timeframe required between sample collection and testing, is often performed by treatment plant operators and sampling technicians. While quality checks and control procedures should be performed and recorded in operator and sampling log books, independent verification of in-field testing accuracy and precision is not typically performed. In 2012, New York State Department of Health (NYSDOH) stopped reviewing for Analyze Immediately On Site (AIOS) filed parameters, which included TRC.

Inline Instrumentation and Monitoring

Continuous inline chlorine monitoring is used extensively at the point of distribution for potable water systems, and at the effluent discharge for wastewater treatment plants to ensure disinfection and regulatory compliance. The two most common methods for inline chlorine analysis are amperometric and colorimetric detection methods. The amperometric method (SM 4500 Cl D) is an electrochemical technique that measures the change in current resulting from chemical reactions as a function of concentrations of reactants. Several of the interferences identified in ***Table 2*** can present limitations when amperometric sensors are used for continuous inline process measurements. In addition to those limitations, other variables can interfere with amperometric measurements based on sample and sampling environments, pH, temperature, sample flow and pressure. In contrast, the USEPA approved DPD colorimetric method (SM 4500G) is independent of temperature, pH, and sample flow/pressure fluctuations and is considered the standard analytical approach for the inline measurement.

Most of all inline DPD analyzers typically use a series of small valves and pumps to deliver defined volumes of process water, DPD reagent and buffer solution to the measuring cell. This allows the chemistry to proceed. The required sample flow to the analyzer is generally > 200 ml/minute. Discharge from the analyzer is directed to a drain. There are concerns that the waste stream generated may be harmful to the environment but, in general, these are at very low concentrations and below maximum contamination levels (MCL). The typical operating range for online DPD analyzers is in the same range as the laboratory performed procedure and capable of measuring 0-5 ppm free (or total) chlorine, with accuracy ±5 percent or 0.03 ppm, whichever is greater. The DPD method has a drawback and suffers from interferences of certain iron and manganese species. This could present a problem if a wastewater utility utilizes iron salts for phosphorus removal.

continued on page 32

Table 1: NYS Ambient Water Quality Standards for TRC

State	Receiving Water Standard (µg/L)		Water Best Use Classifications
	Fresh Water	Saline Waters	
Chronic – Fish Propagation	5	7.5	A, B, C and SA, SB, SC
Acute – Fish Survival	19	13	D or SD

Notes:

1. *Chronic criteria is presented. Acute criteria for protection of aquatic life is significantly higher, and is not often used. Technical and Operational Guidance Series 1.1.1, Ambient Water Quality Standards and Guidance Values and Groundwater Limits*
2. *Classes A, B and C are fresh waters. Classes SA, SB or SC are saline waters.*

continued from page 31

The USEPA requires that inline DPD analyzers be calibrated onsite using either a standard solution, or can be process calibrated by adjusting the reading to match an external secondary, lab performed test.

Standard maintenance of the DPD colorimetric analyzers is as simple as replacing bottles of reagent and buffer solutions typically on a monthly basis. Pump tubing needs to be replaced periodically and all other tubing in the analyzer should be inspected monthly for wear. There are many other small fittings and parts within the analyzers will fail over time and require replacement. Most units are better serviced by the supplier as these systems often require special tools. It is typical when monitoring wastewater effluent to install an upstream filter as the small diameter tubing can become clogged with particulate typical of treated effluents.

SPDES Effluent Limits – Enforceable Concentration and Daily Maximum Limits

Generally, NYSDEC develops SPDES permit limits as the more stringent of:

- A technology based limit, **or**
- Water quality-based effluent limit (WQBEL).[3]

The technology based limit for TRC is 2 mg/L, and in recent practice is as low as 0.5 mg/L.[4] A WQBEL for TRC can be as low as 0.005 mg/L, depending on the receiving water and mixing zone available.

In establishing a WQBEL, regulations allow the assimilative capacity of the receiving water to be counted. This is done by applying a mixing zone factor (i.e., dilution factor). This factor may be based on:

- Modeling and/or diffuser mixing calculations and studies
- The statistical low flow for the flowing water body (e.g., 7Q10 flow)
- Regulatory requirement (e.g., the Niagara River maximum factor is 100x)
- General best professional judgment practice (e.g., 10x for discharge to a lake)

When the mixing zone factor is small, the allowable TRC effluent concentration can be calculated to be less than the analytical PQL of 0.02 mg/L.

A hypothetical example is as follows:

The municipal STP discharges 1 mgd to a small river that has low summer flows. The receiving stream has 7 day/10 year statistical (7Q10) low flow of 1 mgd. The river is a Class B water, and the TRC AWQS is 0.005 mg/L.

1 MGD + 1 MGD = 2 MGD or a 2x dilution factor
0.005 mg TRC/L AWQS x 2 = 0.010 mg/L
(This is the calculated SPDES discharge limit)

Given that the PQL for TRC analysis as defined by NYSDEC is 0.020 mg/L,[5] the permit could contain a new compliance level of 0.020 mg/L, down from an older compliance level of 0.1 to 0.5 mg/L. If this occurs, the discharger may have to reduce the concentration of TRC in its effluent.

More specific information regarding limit establishment can be found in NYSDEC in the following Technical and Operational Guidance Series (TOGS):

- 1.2.1 Industrial Permit Writing, 1998 Edition.
- 1.3.1E Amendment – Permit Limit Development for Certain Parameters, July 1996
- 1.3.3 SPDES Permit Development for POTWs, February 1998 Edition.

Little Mixing Zone - Permit Limits

Historically, for dischargers with little mixing available, NYSDEC has typically set the TRC enforceable limit at a PQL between 0.1 to 0.5 mg/L. Currently, renewed SPDES permits with little mixing have an enforceable compliance level as low as 0.02 mg/L. These renewed permits may also include an interim limit while the discharger finds ways to address the lowered TRC limit. In some cases, a schedule of submittals may also be included in the new permit.

Challenges

Given every SPDES discharge situation is unique, there are a number of implications to a reduced TRC limit or enforceable compliance level. These challenges may be addressed in some of the following ways:

- Permit negotiation
- Demonstrate site-specific method quantification or detection levels

Table 2: USEPA Approved TRC Analytical Methods

Name	Analytical Methods (1)		Minimum Detectable Concentrations and Interferences
	USEPA	Standard Methods	
Iodometric Direct Method I	330.3	4500-Cl B	1 mg Cl/L using starch iodide endpoint, or 0.040 mg Cl/L is a 1,000 ml sample and 0.01N Sodium Sulfate used
Iodometric Method II Back titration either end -point	330.2	4500-Cl C	Interferences from oxide forms of manganese and other oxidizing agents.
Amperometric Titration, direct	330.1	4500-Cl D	Interferences from nitrogen trichloride, chlorine dioxide, chloroamines, copper.
DPD – Ferrous Titrimetric Method	330.4	4500-Cl F	0.018 mg Cl/L, normal working detection limits typically higher.
DPD – Colorimetric Method (Spectrophotometric DPD)	330.5	4500-Cl G	0.010 mg Cl/L, normal working detection limits typically higher.
Electrode (e.g., Orion 97-70 chlorine specific ion)	–	–	0.2 mg Cl/L 0.01 mg Cl/L with blank correction

Key:
DPD = N,N-diethyl-p-phenylenediamine
Blue highlights are Standard Method recommended WW methods.
Note:
1. Standard Methods for the Examination of Water and Wastewater, 22nd Edition. 2012.

- Mixing zone analysis
- Diffuser studies or ambient monitoring studies
- Inline monitoring for TRC
- Process design and construction of dechlorination systems, or alternative disinfectant
- Design, modification or construction of a diffuser
- Process design and construction of UV disinfection systems.

The NYSDEC is working hard to let potentially affected dischargers know that improved TRC analytical method sensitivity may decrease the allowable discharge concentration.

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References

1. Now described as the Method Reporting Level (ML) in new or recently renewed SPDES permits.
For compliance, the USEPA approved method with the lowest possible detection limit (40 CFR Part 136) for the measurement of the parameter is generally selected.
ML: The ML is a quantification term defined by the USEPA as: "The concentration at which the entire analytical system must give a recognizable signal and acceptable calibration point. The ML is the concentration in a sample that is equivalent to the concentration of the lowest calibration standard analyzed by a specific analytical procedure, assuming that all of the method-specified sample weights, volumes, and processing steps have been followed. The ML concept and how it is calculated have evolved over time. MLs have been either calculated as 3.18 times the MDL, or set equal to the lowest calibration standard. The factor of 3.18 is derived from another quantification term, the LOQ.
PQL: The PQL is the "lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions…" 50 FR 46906.
2. US Code 40 CFR Part 136 "Guidelines Establishing Test Procedures for the Analysis of Pollutants, as amended 2007.
3. There are at times exceptions to this approach.
4. Based on TOGS 1.2.1 Industrial Permit Writing, Appendix C for dechlorination.
5. Based on Standard Methods and test kit manufacturers 0.010 mg/L method detection limit for Method 4500-Cl G, and is able to achieve a PQL of 0.02 mg/L in wastewater. This PQL is calculated using USEPA 2010 guidance for determining analytical methods quantitation levels.

Interim Guidance for Managers and Workers Handling Untreated Sewage from Individuals with Ebola in the United States

Reprinted from CDC public domain material

November 20, 2014

Who this is for: Workers who handle untreated sewage that comes from hospitals, medical facilities, and other facilities with confirmed individuals with Ebola.

What this is for: To provide recommendations for workers on the types of personal protective equipment (PPE) to be used and proper hygiene for the safe handling of untreated sewage that may contain Ebola virus.

How to use: Use this document to reduce the workers' risk of exposure to infectious agents including Ebola virus when working with untreated sewage.

See also: Frequently Asked Questions on Interim Guidance for Managers and Workers Handling Untreated Sewage from Suspected or Confirmed Individuals with Ebola in the U.S.

Key Points

- Ebola virus is more fragile than many enteric viruses that cause diarrheal disease or hepatitis.
- The envelope that covers Ebola makes it more susceptible to environmental stresses and to chemical germicides than non-enveloped viruses, such as hepatitis A, poliovirus, and norovirus.
- To protect workers against Ebola:
  - o Educate them on
    - What PPE to use to protect broken skin and mucous membranes and
    - How to properly use the PPE, including how to put it on and take it off.
  - o Develop and fully implement routine protocols that ensure workers are protected against potential exposures (i.e., prevent contact with broken skin, eyes, nose or mouth) when handling untreated sewage.
  - o Ensure all workers always practice good personal hygiene, including frequent hand washing to reduce potential exposures to any of the pathogens in sewage.

This guidance is based on current knowledge of Ebola virus, including detailed information on Ebola virus transmission, recommendations from the World Health Organization (WHO), and scientific studies of wastewater treatment and workers who handle wastewater.[1,2,3] Updates will be posted as needed on the CDC Ebola webpage at *http://www.cdc.gov/vhf/ebola/*.

Some workers come in contact with untreated sewage before it enters the wastewater treatment plant and could be at very low risk of exposure to Ebola virus. These workers include:

- Plumbers in hospitals that are currently treating an Ebola patient
- Sewer maintenance workers working on the active sewer lines serving the hospital with an Ebola patient
- Construction workers who repair or replace active sewer lines serving the hospital with an Ebola patient

Transmission

Ebola virus is transmitted through:

- Direct, unprotected contact (i.e., with broken skin, eyes, nose or mouth) with blood or other body fluids (e.g., , feces, vomit, urine, saliva, sweat, breast milk, tears, vaginal fluid, and semen) of an infected patient who is actively ill
- Needle stick injuries from needles and syringes that have been contaminated with infected blood or other body fluids and tissue from an infected patient who is actively ill
- Unprotected contact with medical equipment contaminated with blood or body fluids from an infected patient who is actively ill
- Direct, unprotected contact with the body of someone who has died from Ebola

The World Health Organization recommends that human wastes, including waste from Ebola patients such as vomitus and feces, be either disposed of through a sanitary sewer or be buried in a pit toilet or latrine with no additional contact or treatment.[4,5,6] There has been no evidence to date that Ebola can be transmitted via exposure to sewage.[7] The WHO has established guidelines for hygiene and PPE to prevent exposure to potential pathogens when working with untreated sewage.[4,5] In the United States,

continued on page 38

Source: CDC

continued from page 36

human waste (i.e., excreta), blood, and other potentially infectious materials are routinely released into sanitary sewers. Wastewater handling processes in the United States are designed to inactivate and remove pathogens, such as Ebola. Workers should follow the guidelines below to prevent exposure to human pathogens, including Ebola virus, when working with untreated wastewater.

Personal Protective Equipment (PPE)

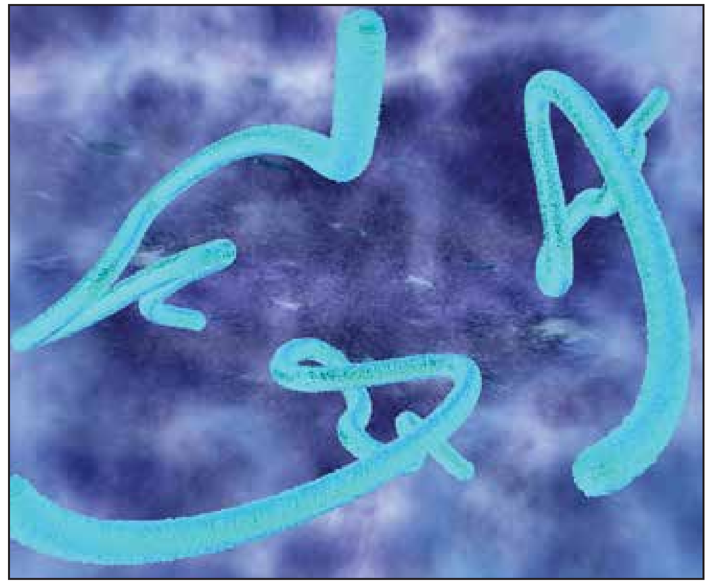
Workers handling human waste or sewage should be provided hand washing facilities at the worksite, PPE (described below), and training on how to use this PPE. The training should specifically address methods for the correct and safe removal of PPE to prevent workers from contaminating themselves or others during its removal. Trained workers should demonstrate both knowledge of the appropriate PPE they will be expected to wear and proficiency in its use. If using a respirator, the worker should be part of a respiratory protection program that includes medical clearance and fit-testing under OSHA's PPE standard (29 CFR 1910.132). Workers should wash hands with soap and water immediately after removing PPE. Leak-proof infectious waste containers should be provided for discarding used PPE. Guidelines for dealing with potentially infectious waste can be found at *http://www.cdc.gov/vhf/ebola/hcp/medical-waste-management.html* and *https://www.osha.gov/Publications/OSHA_FS-3756.pdf*

The following PPE is recommended for workers handling untreated sewage:

- Goggles or face shield: to protect eyes from splashes of untreated sewage
- Face mask (e.g., surgical mask): to protect nose and mouth from splashes of human waste. If undertaking cleaning processes that generate aerosols, a NIOSH-approved N-95 respirator should be used.
- Impermeable or fluid-resistant coveralls: to keep untreated sewage off clothing
- Waterproof gloves (such as heavy-duty rubber outer gloves with nitrile inner gloves) to prevent exposure of hands to untreated sewage
- Rubber boots: to prevent exposure of feet to untreated sewage

Basic Hygiene Practices

- Wash skin with soap and water immediately after handling sewage, or any materials that have been in contact with sewage.
- Avoid touching face, mouth, eyes, nose, or open sores and cuts while handling sewage, or any materials that have been in contact with sewage.
- Wash hands with soap and water before eating or drinking after handling sewage.
- Remove soiled work clothes and do not take home to launder. Launder clothing at work or use a uniform service.
- Eat in designated areas away from untreated sewage.
- Do not smoke or chew tobacco or gum while handling human waste or sewage, or any materials that have been in contact with human waste or sewage.
- Cover open sores, cuts, and wounds with clean, dry bandages.



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Ebola virus

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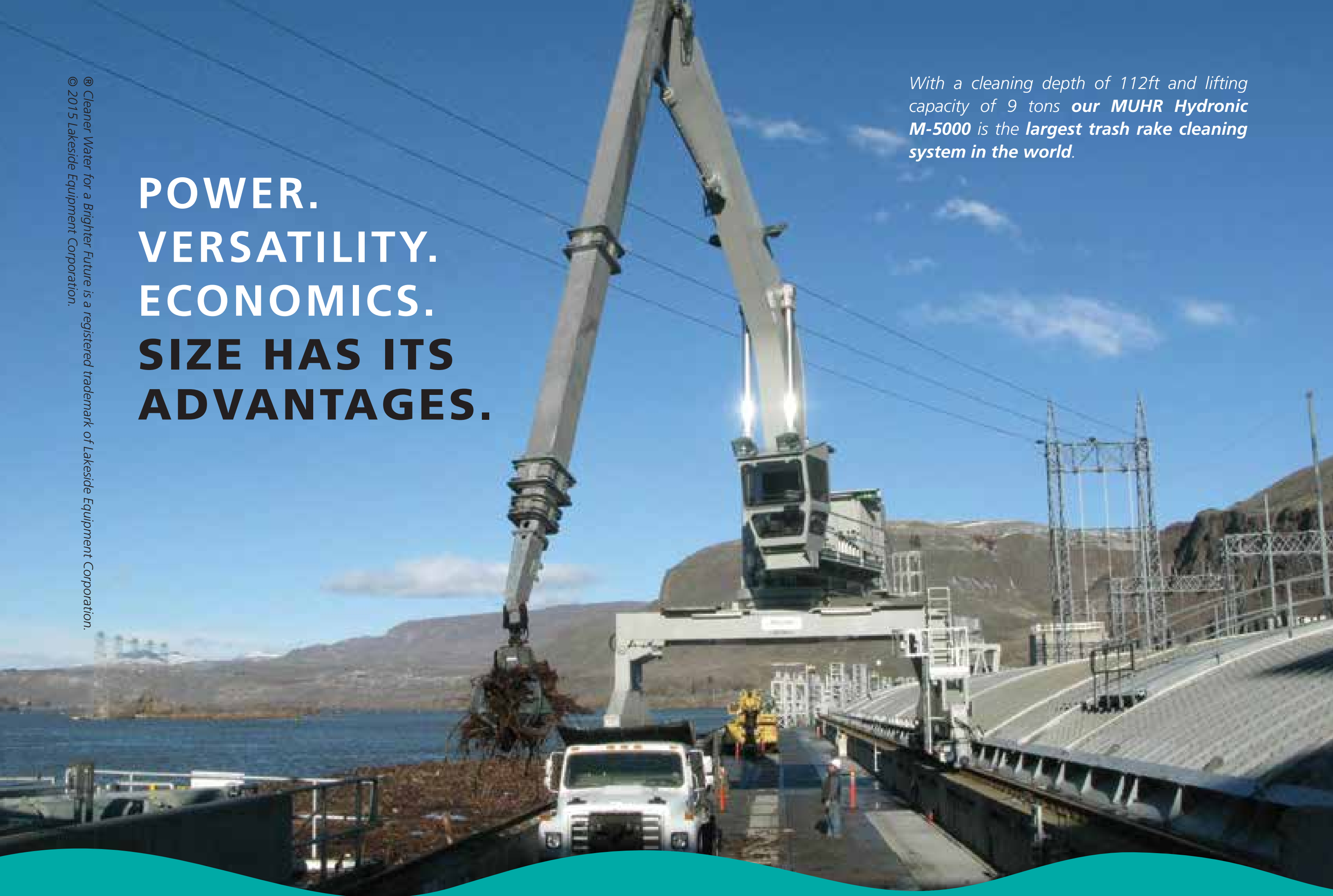

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Small Water System's Recovery from Natural Disaster: Case Study on the Village of Horseheads

by Michael W. Wymer, Brian Sibiga, Andrew Casolini Dal Bo and Christine Birmingham

The Village of Horseheads, located in Chemung County, NY, owns, operates, and maintains a water system which serves approximately 15,000 people. The average demand of the water system is approximately two million gallons per day. Well 5, the largest groundwater well in the system has provided approximately 60 percent of the potable water required by the village for over 25 years.

When the one-two punch of Tropical Storms Irene and Lee hit in Fall 2011, the area around Well 5 was inundated due to its close proximity to Newtown Creek, and water quality in the well was compromised. As a result, the well was re-classified as groundwater under the direct influence of surface water (GWUDI), meaning the source was considered at permanent risk of contamination from pathogens such as *Giardia lamblia, Cryptosporidium,* and viruses. Shortly afterward, the NYS Department of Health (NYSDOH), requiring additional treatment, issued a consent order.

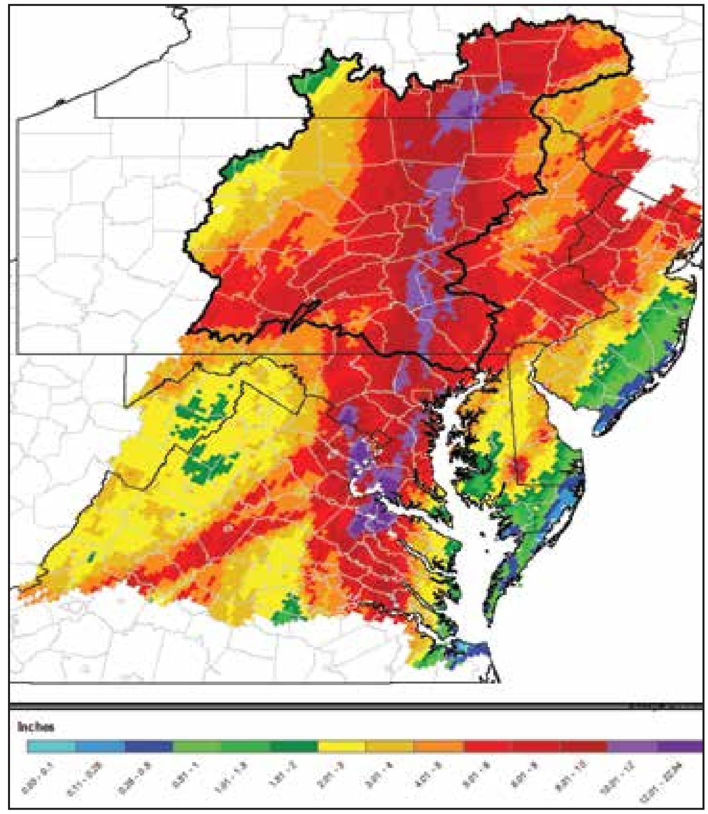
Courtesy of Wendel

The existing Well No. 5 is in close proximity to Newtown Creek. When Tropical Storm Lee hit, the area was flooded and the well water was compromised. The water was re-classified as groundwater under the direct influence of surface water (GWUDI), which means any water beneath the surface of the ground is now considered at risk of contamination from pathogens such as *Giardia lamblia*, *Cryptosporidium,* and viruses, and thus, requires additional treatment.

Regulatory Requirements

The New York State Public Law Part 5, Subpart 5-1.30 states that the minimum treatment for surface water sources (or ground water sources, like Well 5, which are directly influenced by surface water) shall be filtration and disinfection techniques capable of 99 percent removal (2 log) of *Cryptosporidium oocysts*, 99.9 percent removal and/or inactivation (3 log) of *Giardia lamblia* cysts and 99.99 percent removal and/or inactivation (4 log) of viruses, unless the NYSDOH determines that the supplier of water can meet specific avoidance criteria.

A study was commissioned by the village that evaluated multiple compliance alternatives including upflow filtration, microfiltration, connection to a neighboring water system, and development of a new groundwater supply. Upflow filtration emerged as the preferred compliance alternative due to its potential to meet all treatment goals, compact footprint, low operating cost, and operational flexibility. The selection of upflow filtration provided an integrated solution for the village that interlaced all environmental media:



NOAA, National Weather Service, Eastern Region

Heavy rainfall amounts from Tropical Storm Lee – shown from September 5 through September 9, 2011 – sock the Southern Tier.

- Air – An energy analysis conducted as part of the study indicated the selection of upflow filtration over microfiltration resulted in a net annual environmental savings (from electrical use reduction) of 122,000 pounds of carbon dioxide, 500 pounds of sulfur dioxide and 141 pounds of nitrous oxide.
- Water – The excellent well water quality allowed for a modification of the upflow filtration backwash process from continuous to intermittent operation, reducing the overall volume of backwash water produced and, therefore, reducing the amount of backwash water discharged into Newtown Creek.
- Land – The compact design of the upflow filtration units permitted construction of the new treatment works without disturbance of the adjoining wetlands (no fill was brought to the site). The design also incorporated the existing Well 5 structure into the treatment process, further reducing site disturbance.

Originality and Innovation

The treatment system consists of a Parkson DynaSand intermittently backwashed, upflow filter system followed by chlorine disinfection. Sixteen individual filtration modules, 50 square feet each, were constructed, arranged in four trains of four filter modules (two modules for the first stage and two modules for the second stage in each train). The filtration system produces an average flow of 2.0 mgd at an average filter loading rate of 3.6 gallons per minute per square foot of filter area.

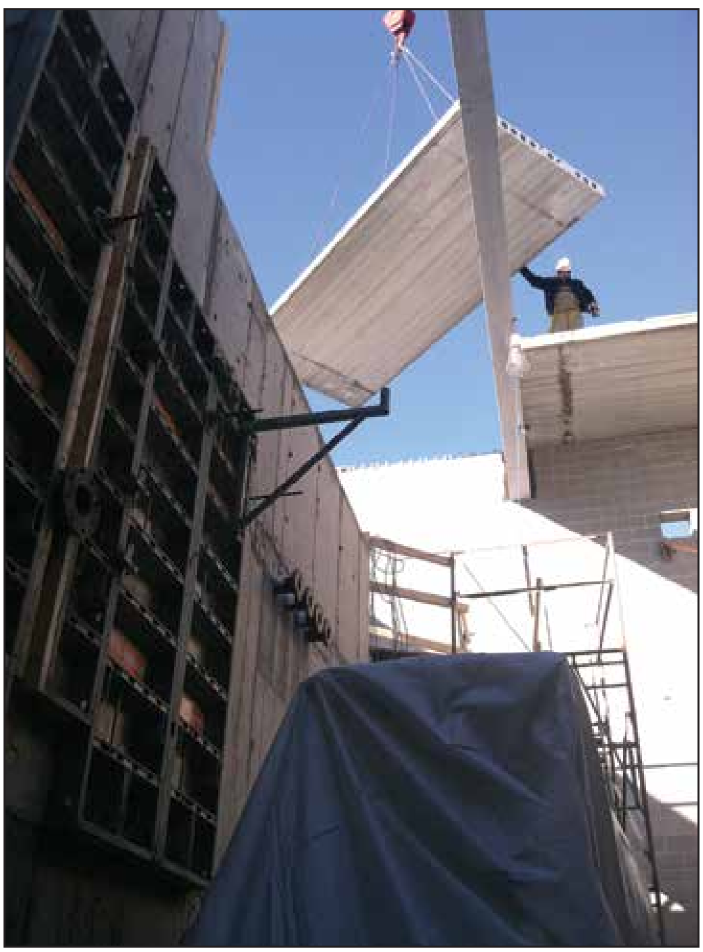
The filtration equipment in each module is installed in a

continued on page 42

continued from page 41

Graphic courtesy of the Parkson Corporation

Workers prepare for the installation of the first filter component. The shape of the FRP cone enhances the movement of the filtered water up through the sand.



Courtesy of Wendel

The upflow filtration system provides a compact design resulting in a smaller footprint while minimizing energy requirements for backwashing. The design also allows the filter to continue to operate during the cleaning sequence resulting in lower capital costs due to reduction in redundancy.

concrete tank; the total dimensions of the installed unit in feet are approximately 32x32x20. A new building, approximately 48x60x32 feet tall, was constructed to include the filter units, as well as a new pump suction/finished water wet well, two finished water pumps, chemical room, operations area, and an electrical room.

Polyaluminum chloride (PACl) is applied proportionally to flow as a coagulant chemical to enhance the turbidity and organics removal of the filtration system. The basis of design for PACl chemical selection and initial dosage selection was based on the operational experience of similar Parkson installations.

A new 60,000 gallon wet well, located adjacent to the filtration system, receives filtered water by gravity from the filtration system effluent channel. The wet well, combined with existing transmission piping, provides the necessary disinfection contact time prior to the first customer.

The upflow sand filtration and disinfection system was approved by the NYSDOH as meeting all pathogen removal/inactivation requirements. The filter manufacturer provided numerous supporting references documenting filter performance including New York City Department of Environmental Protection (NYCDEP) microfiltration equivalency studies, which reported average pathogen removals up to 7 log (NYCDEP Division of Drinking Water Quality Control and Delaware Engineering, Village of Stamford/ NYCDEP Tertiary Wastewater Treatment Demonstration Project Comparing Continuously Backwashed Upflow Dual Sand Filtration and Microfiltration Technologies, May 2000). A 1997 NYSDOH approved pilot study conducted at the Village of Stamford, NY reported 4.5 to 4.9 log removal of *Cryptosporidium* and *Giardia lamblia* in spike challenge testing (Wright, P. and M. Moreau, Dual Filters and Coagulant Aids Were Equivalent to Microfiltration in Pilot Studies, *Environmental Science and Engineering Magazine,* January 2000).

Typically, upflow filtration has been applied to wastewater treatment or quality challenged drinking water sources, requiring a continuous backwash flow; however, this intermittent type of filtration system has been installed at eight similarly sized water supplies in New York State. Well 5 has excellent raw water quality characteristics, low in turbidity and organics, allowing optimization of the backwash process to reduce the volume of backwash generated each day. The use of variable frequency drives on all pumps provides the flexibility to refine treatment schemes and match seasonal demand fluctuations.

Proactively, the design of the treatment facility includes additional treatment capacity to accept groundwater from the Well 4 facility, a groundwater source adjacent to Newtown Creek, located approximately 2,000 feet south of Well 5. If a similar reclassification of Well 4 should occur, the village is prepared with a treatment solution.

Complexity

Several physical, operational, and economic challenges were addressed during the design process. As noted, the solution had to incorporate an efficient footprint to allow construction on the existing elevated area above the 100- year flood elevation and surrounding wetlands.

Prior to construction, Well 5 operated as an on/off system based on the high/low level settings of the village's finished water reservoirs. This operating scheme does not fit operation of a filter system, which prefers an uninterrupted flow through the filters. Through the use of variable frequency drives on the raw and finished water pumps, coupled with remote level readings transmitted through a

The two-stage filter system consists of four filter trains, each with two filter units. Each filter is covered by a solid-surface aluminum deck panel. The influent channel distributes water pumped from Well 5 to the first stage filters (background) which include 80 inches of filter sand. Water then flows by gravity to the second stage filters that have 40 inches of sand. Each filter has a dedicated air panel controlling the backwash processes. A central control panel (left) manages and reports on filter operation and backwash activities.

renewed Programmable Logic Controller/Supervisory Control and Data Acquisition (PLC/SCADA) system, a new operating scheme in which the rate of pumping automatically adjusts to system demand was implemented. This not only provided the continuous flow required by the filters, but also a more stable pressure and chlorine residual throughout the entire distribution system.

Economic challenges focused on the financial sustainability of the treatment process. Prior to the Well 5 reclassification, the major expenses associated with operation involved the cost of chlorine, fluoride, and electricity for pumping. Major additional operation costs associated with the new plant included application of the coagulant chemical, an additional stage of pumping, and the disposal of waste backwash water. The impact of these costs was lessened through optimization of coagulant dose, intermittent filter backwashing, and provision to obtain a NYSDEC permit for direct backwash discharge to the creek. Also, the use of variable frequency drives described above allowed for a more energy efficient operation of Well 5 and finished water pumps. Light emitting diode (LED) lighting further reduced utility costs.

Economic and Social Advancement

Construction of the Well 5 treatment system, coupled with the future ability to treat Well 4, provides the Village of Horseheads with a stable, cost effective water supply to meet current and future water demands of its customers. This effectively enhanced the economic growth of the residential, commercial and industrial base of the area.

The project was funded largely through a grant provided by FEMA and the New York State Emergency Management Office. The final cost for the project is projected to be approximately $4.3 million, falling under the limit of the grant award.

Through sensible cost control throughout the Well 5 project, the village was able to enhance the safety and reliability of the entire water system. At Well 5, the existing chlorine and fluoride facilities were modified to allow remote communication and control in proportion to finished water flow. Improvements to the outdated system-wide SCADA system provided further control and alarm dependability between Wells 1, 2, 4 and 5, the village's two reservoirs, and operator command centers located at the Water Department building and Village Hall.

The village acted in a highly transparent manner during the project, engaging the public throughout the entire process. Upon acknowledgment of the need to upgrade the Well 5 facility, the village immediately developed a process to communicate the progress of the treatment project with its customers, utilizing broadcast media, direct mail and the village website. The village also established a 24-hour customer hotline to receive public inquiries. The public perception of the overall project – based on public tours, information sessions for the public and feedback from the client – is of a treatment facility that meets all treatment requirements with a budget set by the village and operational expectations by the water department staff.

Quality

The owner was an integral part of the development and implementation of the project as a stakeholder in the design process, regulatory meetings, funding/financing and public engagement. During construction, the owner provided full-time resident observation services. Despite an aggressive initial schedule and extraordinary cold winter/wet spring, the plant was constructed and available for operation by the dates identified in the consent order.

At the ribbon cutting ceremony in December 2014, Village Manager Walter Herbst praised the merits of the project: "The solution exactly met the total goals of the village. The treatment plant surpasses all water quality requirements of the NYSDOH, was built under budget and within the consent order schedule. Village residents can look forward to a safe, economically-smart water supply for many years to come."

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Developing Better Indicators for Pathogen Presence in Sewage Sludges

by Suresh D. Pillai, Mark C. Meckes, Sudhir N. Murthy and John Willis

Abstract

The ability to detect the presence of microbial pathogens and the resulting health risks in biosolids is a significant issue confronting the wastewater industry. Ideally, wastewater treatment plants should be able to monitor for specific pathogens in biosolids. Since it is almost impossible to detect and quantify the presence of all possible pathogens in waste matrices, there is a compelling need to identify a suite of indicators that can be used to predict the presence of pathogenic microorganisms in biosolids. The overall objective of this project was to identify those pathogens and surrogate indicator organisms that are at the highest density in raw (untreated) sewage sludge across the United States, and determine the time-temperature relationship under controlled laboratory conditions. The results provide information about the concentrations of an extensive selection of raw sewage-associated organisms across warm and cool seasons and from locations across the United States. Additionally, the 16S pyrosequencing (non-culture based) analysis allowed for the compilation of a list of bacterial DNA sequences that were present in the raw wastewater samples. The second part of this study compared the time-temperature relationships of a subset of commonly used wastewater indicators and pathogens.

The untreated sewage sludge samples were obtained from seven different U.S. locations (Illinois, Ohio, Wisconsin, California, Texas, Georgia, and the District of Columbia). Four samples were obtained from each location. Two samples were collected during the warm season (August–September, 2009), and two samples were collected during the cool season (January–February, 2010). Overall, all locations had relatively similar levels of organisms within ± 1-2 log units. There were no seasonal differences in the levels of total coliforms, fecal coliforms, *E.coli, C. perfringens* spores, *Salmonella spp., Aeromonas spp.,* or Adenovirus. However, *Shigella spp.,* enterococci, somatic coliphages, male-specific coliphages and culturable enteric viruses were higher in the warmer season than in the cooler season. *Legionella spp.* were higher in the cooler season as compared to the warmer season. In terms of relative abundance, there were greater numbers of indicator organisms such as fecal coliforms (10_8 MPN/g), *E. coli* (10_6 MPN/g), and enterococci (10_6 MPN/g) as compared to the traditional U.S. EPA 503 target pathogens, *Salmonella spp.* (< 8 MPN/g), culturable enteric viruses (< 1 PFU/g), and helminth ova (< 1 ova/g) in the raw sewage samples as compared to fecal coliforms (10_8 MPN/g), *E.coli* (10_6 MPN/g), and enterococci (10_6 MPN/g). Known pathogens, such as *Shigella spp.* (25 MPN/g), *Legionella spp.* (10_8 CFU/g), *Aeromonas spp.* (10_8 CFU/g), MacConkey sorbitol-negative *E. coli* populations (10_4 MPN/g) were, however, present in larger numbers. When real-time PCR-based methods were used, the presence of genetic sequences indicative of pathogens such as Adenovirus (10_7 gene copies/g), *Giardia spp.* (10_5 gene copies/g) was also evident. Aerobic spores (106_6 CFU/g), *Cl. perfringens* spores (10_6 CFU/g), somatic coliphages (10_5 PFU/g) and male-specific coliphages (10_5 PFU/g) were also present. This suggests that traditional indicators such as fecal coliforms and *E.coli,* along with other organisms such as coliphages and enterococci, should be included in sewage monitoring studies. The presence of *Aeromonas spp.* and *Legionella spp.* in high numbers in the samples suggest that these target organisms should also be included in the suite of organisms that are screened for if monitoring for sewage contamination. More than 400 different bacterial genera were detected in the raw sewage sample based on 16S sequencing of bacterial genomes obtained from the sewage samples. Gene (16S) sequences from 22 different genera were detected across all sewage sludge sample that were collected. The relative prevalence of these sequences ranged from 0.20 percent *(Rhodobacter spp.)* to 12.54 percent *(Arcobacter spp.)*. Sequences representing known pathogens such as *Clostridium sp., Brucella sp., Coxiella sp., Rickettsia sp., Vibrio sp.* were also detected by 16S sequencing.

The time-temperature studies focused on fecal coliforms, a cocktail of three different *E. coli* strains, a cocktail of three *Salmonella* serovars., somatic coliphages, male-specific coliphages (MS2 as the prototypical male-specific coliphage), and enteric viruses (using Poliovirus Type 1 as the prototypical enteric virus). Of all the organisms studied, somatic coliphages were the most tolerant to temperature stress over other bacterial and viral indicators that were studied. They were relatively resistant to temperature with approximately 40 percent of the original population surviving even when exposed to 60°C for 120 minutes. Neither somatic nor male-specific coliphages were detected in any sewage samples once the samples were exposed to 70°C.

This study provides new information of the concentrations of different organisms that are present in raw sewage sludge across different regions in the United States during the warm and cool seasons of the year. Additionally, the results from the time-temperature studies provide useful information about the choice of indicator organisms and pathogens that can be used to evaluate temperature-based treatment technologies.

Benefits

- Provides new information about the diversity and density of microorganisms in raw sewage samples from the U.S.
- Identifies sewage-related indicator organisms suitable for wastewater screening.
- Identifies indicator organisms suitable for screening temperature-based wastewater treatment processes.
- Provides information on the time-temperature relationships of indicator organisms and microbial pathogens.
- Provides information that can be used to assess pathogen kill predictions for temperature-based treatment technologies.

Executive Summary

The overall objective of this project was to identify those pathogens and surrogate indicator organisms that are at the highest density in raw sewage sludge across the United States, and determine their time-temperature relationships under controlled laboratory conditions. The untreated sewage sludge samples were obtained from seven different U.S. locations (Illinois, Ohio, Wisconsin, California, Texas, Georgia, and the District of Columbia). Four samples were obtained from each location. Two samples were collected during the warm season (August- September, 2009), and two

continued on page 46

continued from page 45

Table 1. Prevalence of Indicator Organisms in Samplings 1 and 2

Sampling	Sample Location	Anerobic Heterotrophs log_{10}(CFU/*)	Aerobic Aerobic Spores log_{10}(CFU/*)	*C. perfringens* log_{10}(CFU/*)	Total Coliforms[a] log_{10}(MPN/*)	Fecal Coliforms log_{10}(MPN/*)	Coliforms Colilert-EPA[a] log_{10}(MPN/*)	Generic *E. coli*[b] log_{10}(MPN/*)	E.coli Colilert-EPA[b] log_{10}(MPN/*)	Enterococci log_{10}(MPN/*)	Somatic S. Coliphage log_{10}(PFU/*)	Male-specific MS Coliphage log_{10}(PFU/*)
Sampling 1	Illinois	10.736	6.394	6.465	8.704	7.977	8.690	7.977	7.634	7.039	7.789	5.342
	Ohio	10.458	6.030	6.254	8.603	7.510	9.486	6.935	7.917	6.392	5.370	3.888
	Georgia	10.902	8.802	5.887	8.338	7.856	9.369	7.856	7.591	6.427	6.194	5.357
	Texas	10.190	6.470	6.380	7.365	6.811	7.847	6.702	6.880	6.448	7.847	6.880
	Wisconsin	10.779	7.704	5.948	≥8.623	7.109	8.776	7.109	7.445	6.707	7.337	5.733
	California	9.693	6.545	5.913	8.428	7.158	8.625	7.158	7.507	6.206	6.338	2.017
	Dist. of Columbia	10.387	8.563	6.127	8.866	8.030	8.853	7.576	7.832	4.285	5.636	4.733
Sampling 2	Illinois	10.938	7.336	7.099	9.017	8.154	10.227	8.154	8.711	6.630	5.969	5.638
	Ohio	9.509	6.955	5.835	8.005	6.981	9.458	6.002	7.489	6.536	5.634	5.422
	Georgia	10.695	6.741	6.519	8.697	7.852	9.234	7.656	8.223	7.077	5.971	5.745
	Texas	10.066	6.230	6.442	7.499	6.622	8.365	6.622	7.514	6.423	6.309	4.402
	Wisconsin	10.054	7.168	5.802	8.089	7.254	9.073	7.254	7.591	6.271	5.682	5.507
	California	10.006	6.503	6.018	7.906	7.610	8.673	7.610	6.682	6.700	5.331	4.939
	Dist. of Columbia	10.364	7.046	6.352	8.429	6.125	9.449	6.125	7.943	4.265	5.010	5.147

***All results listed per dry gram a) Some groups of organisms were measured by multiple research groups using different methods. The Texas A&M laboratory analyzed total coliforms by the EPA multiple-tube method, while the EPA laboratory analyzed coliforms using the Colilert© packets and protocol. Both results are included here. b) The Texas A&M laboratory analyzed generic *E. coli* using an extension of the EPA multiple-tube method on EC-MUG. The EPA laboratory analyzed *E. coli* using the Colilert© packets and protocol. Both results are included here.**

samples were collected during the cool season (January–February, 2010). Overall, all locations had relatively similar levels of organisms within ± 1-2 log units. There were, however, differences in the relative abundance of the different organisms during the warm and cooler months of sampling.

There were low numbers of culturable enteric viruses (median values shown) (< 1 PFU/g), *Salmonella spp.* (< 8 MPN/g), and helminth ova (< 1 ova/g) in the untreated sewage samples. Other pathogens, such as *Shigella spp.* (25 MPN/g), *Legionella spp.* (10_8 CFU/g), *Aeromonas spp.* (10_8 CFU/g), MacConkey sorbitol-negative *E. coli* populations (10_4 MPN/g) were, however, present in larger numbers. When PCR-based methods were used, the presence of gene sequences indicative of pathogens such as Adenovirus (10_7 gene copies/g), *Giardia spp.* (10_5 gene copies/g) was evident. Other organisms such as aerobic spores (10_6 CFU/g), *Cl. perfringens* spores (10_6 CFU/g), fecal coliforms (10_8 MPN/g), *E. coli* (10_6 MPN/g), enterococci (10_6 MPN/g), somatic coliphages (10_5 PFU/g) and male-specific coliphages (10_5 PFU/g) were present in larger numbers. Overall, there were greater numbers of indicator organisms such as fecal coliforms and *E. coli* as compared to the traditional USEPA 503 target pathogen, *Salmonella spp.* This suggests that traditional indicators such as fecal coliforms and *E.coli* should continue to be included in sewage monitoring studies. The abundance of other organisms such as coliphages, enterococci suggest that these organisms should now be included in monitoring studies. The presence of *Aeromonas spp.* and *Legionella spp.* in high numbers in the samples suggest that these target organisms should also be included in the suite of organisms that are monitored if checking for sewage contamination. More than 400 different bacterial genera were detected in the raw sewage sample based on 16S rDNA sequencing of bacterial genomes. Sequences from 22 different genera were detected in every sewage sludge sample, ranging in average prevalence from 0.20 percent *(Rhodobacter spp.)* to 12.54 percent *(Arcobacter spp.)*. Sequences representing known pathogens such as *Clostridium sp., Brucella sp., Coxiella sp., Rickettsia sp., Vibrio sp.* were detected by 16S sequencing.

Time-temperature studies were performed for a suite of organisms which included fecal coliforms, *E. coli, Salmonella spp.*, somatic coliphages, male-specific coliphages, and poliovirus. Compared to fecal coliforms, and *Salmonella spp.*, *E.coli* appeared to be the most heat-resistant showing only approximately 4 log reduction after 30 minutes at 60°C. Of all organisms (including both bacterial and viral) tested, coliphages were the most tolerant to heat exposure. They were relatively resistant to temperature with approximately 40 percent of the original population ES-2 surviving even when exposed to 60°C for 120 minutes. Significant decline in somatic coliphages numbers occurred only when they were exposed to 55°C for 120 minutes. Neither somatic nor male-specific coliphages were detected in any samples once they were exposed to 70°C. These results point to the superior value of coliphages as conservative indicators of microbial inactivation in temperature-based treatment processes

Conclusion

The microbial survey of the raw sewage samples conducted in the initial part of this project was important in that it provided an overview of the concentrations that many indicator and pathogens present in untreated sewage sludge and variations in concentrations between samplings and seasons. The next-generation 16S sequencing analysis provided an unprecedented look at the vast diversity of bacterial populations in municipal waste streams including a variety of expected and unexpected pathogens. The phylogenetic profiles similarity across sludge samples indicates the dominance of certain groups of organisms possibly due to high input number or their ecological robustness in municipal waste streams. However, conserved differences in locations across samplings and seasons also indicates that certain municipalities, (for example in the Texas sample), could have certain unique features (e.g., waste input characteristics, collection system engineering design) that could be influencing the microbial diversity in such samples which for the most part were not evident in other locations.

This study also highlights the impact of inherent differences in microbial enumeration protocols. As was shown, total coliforms and *E. coli* counts obtained by one method gave slightly higher concentrations than the same organisms analyzed by another method. These differences may not be large, however, industry personnel need to be aware of these differences when choosing protocols for detection and enumeration of microorganisms in wastewaters and sludge samples. One needs to have a clear understanding of the protocols when comparing or analyzing microbiological results from different laboratories. Another issue encountered was the quantification of *E. coli* O157 in sewage. No published protocol currently exists for *E. coli* O157:H7 in sewage sludge, and so a laboratory protocol had to be developed for this study.

Certain organisms, including *Proteus spp.*, can appear phenotypically similarly to *E. coli* O157 on Sorbitol MacConkey media. It is possible that that the high concentrations of *E.coli* O157:H7 in the initial two sampling could have been the result of the non-specificity of the test medium. However, the continued detection of these organisms in the subsequent samples highlight the importance for the wastewater industry to support the development of a robust and validated protocol for the enumeration of *E. coli* O157 for the wastewater industry. The results of this study also illustrate the discrepancies between results generated by traditional culture-based methods and molecular methods such as the next-generation sequencing. For example, *Aeromonas spp.* were detected at high levels by both pyrosequencing and culture. However, *E. coli* were detected at high levels in every sample by culture methods but only in a handful of fall samples by pyrosequencing. This discrepancy was quite unexpected and this cause is still unclear. Compared to other organisms it was evident that *E.coli* sequences were not as abundant. It is possible that the massive amount of other bacterial DNA present in the extracted sludge made the *E. coli* DNA fall below the analytical method's detection limit.

Time-temperature studies were performed for a suite of organisms which included fecal coliforms, *E. coli, Salmonella spp.,* somatic coliphages, male-specific coliphages, and poliovirus. The time-temperature study was significant in that it demonstrated significant differences in how microorganisms respond to a combination of temperature and exposure times. The choice to spike many of the organisms directly into the pre-heated sludge likely did cause the organisms to experience heat-shock effect. However, this was determined to be the best option to evaluate time-temperature response of the organisms. Exposing the organisms to gradual increases to the set temperature can also cause physiological changes in these organisms. Sub-lethal heating of organisms causes differential gene expression patterns which result in enhanced temperature resistance. Compared to fecal coliforms, and *Salmonella spp., E.coli* appeared to be the most heat-resistant showing only approximately 4 log reduction after 30 minutes at 60°C. Of all organisms (including both bacterial and viral) tested, coliphages were the most tolerant to heat exposure. They were relatively resistant to temperature with approximately 40 percent of the original population surviving even when exposed to 60°C for 120 minutes. Significant decline in somatic coliphages numbers occurred only when they were exposed to 55°C for 120 minutes. Neither somatic nor male-specific coliphages were detected in any samples once they were exposed to 70°C. These results point to the superior value of coliphages as conservative indicators of microbial inactivation in temperature-based treatment processes. Overall, the data has helped identify a suite of microbial indicators that could be used to evaluate temperature-based treatment processes.

Table 2: Detection Limits of Survey Organisms in Sewage Sludge Samples

	per mL	per dry gram (Average)
Anaerobic Heterotrophs	<10	<907.87
Aerobic Spores	<10	<907.87
C. perfringens	<1	<90.79
Total Coliforms	<0.1803	<16.37
Fecal Coliforms	<0.1803	<16.37
Coliforms – EPA	<0.01	0.91
Generic *E. coli*	<0.1803	<16.37
***E. coli* – EPA**	<0.01	0.91
Enterococci	<0.01	0.91
Somatic Coliphage	<10*	
Male-Specific Coliphage	<10*	
Soribitol MacConkey	<0.1803	<16.37
Salmonella spp.	<0.0065	<0.59
Shigella spp.	<0.1803	<16.37
Enteric Virus	<3.3*	
Adenovirus	<909.1	<8.25E+04
Aeromonas spp.	Unknown	Unknown
Legionella spp.	Unknown	Unknown
Giardia	<1938.2	<1.76E+05
Helminth Ova	N/A	<0.25

** of extract*

Significance and Recommendations for Wastewater Industry

This study has shown (based on conventional microbiological analyses) that the seven different regions across the United States seem to have fairly uniform levels (within ± 1-2 log units) of microorganisms in their raw (untreated) wastewater sludges. Moreover, the study has shown that except for enterococci and *Shigella spp.,* season does not seem to influence microbial numbers diversity in raw wastewater sludges. This information was generated using conventional culture based methods, PCR-based amplification methods as well as the state of the science 16S deep sequencing methods. This information can help guide the choice of organisms to screen for or performing microbial risk assessments. Those organisms that are repeatedly conserved in high numbers across multiple locations and multiple sampling are good candidates to be chosen as target organisms. Their presence in waste effluent and biosolids could be used as sentinels for evaluating treatment processes. The results from this project can assist in the identification of a suite of indicator organisms that the wastewater industry could use for screening for sewage contamination or for evaluating microbial kill in temperature-based treatment processes. Overall, this study provides a glimpse into the incredible diversity of organisms present in sewage sludges and highlights the challenges of choosing indicator organisms that can accurately represent such a complex and dynamic microbial community. This study provides a useful comparison of the concentrations of common pathogens and indicator organisms in sludges, as well as the response of typical sewage-associated organisms to heat exposure. Additionally, the immense quantity of data and interesting results obtained by the pyrosequencing analysis demonstrates the importance of investigating next-generation technologies for applications in the wastewater industry.

Traditional indicators such as fecal coliforms and *E.coli* should continue to be included in sewage monitoring studies. The abundance of other organisms such as coliphages and enterococci suggest that these organisms should also be included in monitoring

continued on page 48

continued from page 47

studies. The abundance of *Aeromonas spp.* (in both culture-based and molecular analyses) and *Legionella spp.* in high numbers in the samples suggest that these target organisms should now be included in the suite of microorganisms that need to be monitored if checking for sewage contamination.

Somatic coliphages were the most tolerant to temperature stress over other bacterial and viral indicators that were studied. They were relatively resistant to temperature with approximately 40 percent of the original population surviving even when exposed to 60°C for 120 minutes. Neither somatic nor male-specific coliphages were detected in any sewage samples once the samples were exposed to 70°C. This suggests that somatic coliphages should be used as conservative indicators of microbial pathogen kill in temperature-based treatment processes. Presumptive *E.coli* O157:H7 was repeatedly detected in the raw sludge samples. However, unfortunately today there are no robust round-robin validated protocols for the detection, confirmation and enumeration of this toxigenic *E.coli* in sewage sludge samples. The wastewater industry should support the development of robust culture-based laboratory methods for detecting, confirming and enumerating *E.coli* O157:H7. These results also prompt several recommendations for further research in this area.

The wastewater industry should continue to invest in promoting next-generation 16S sequencing, functional genomics, and bioinformatics tools to better understand microbial processes occurring in the wastewater streams as well as during wastewater treatment processes. A metagenome-based approach, building upon the data generated here, would provide the wastewater industry to assign "functionality" to the different microbial populations, as well as help optimize the functioning of selected microbial populations to enhance the efficiency of treatment processes.

Suresh D. Pillai is with Texas A&M University; Mark C. Meckes with the U.S. Environmental Protection Agency; Sudhir N. Murthy is with DC Water; and John Willis is with Brown & Caldwell.

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Excerpt is from the Water Environment Research Foundation (WERF) 2011 report: Developing Better Indicators for Pathogen Presence in Sewage Sludges, WERF Project #U1R08. Reprinted by permission of the Water Environment Research Foundation, based in Alexandria, VA (www.werf.org).

Renewable Energy Technology Project Completed at Ithaca's Wastewater Treatment Plant

by Alex Wright

A demonstration project of an enhanced primary treatment (EPT) technology by ClearCove Systems, a Rochester, NY company, was recently completed at the Ithaca Area Wastewater Treatment Facility (IAWWTF). The project was funded under a New York State Research and Development Authority's (NYSERDA) "Towards Net-Zero Energy in Wastewater" program grant. The NYSERDA program supports demonstration projects of technologies that enable wastewater treatment plants to satisfy their energy demands from onsite renewable sources. The project's advisory committee included members from the US Environmental Protection Agency, Water Environment Research Foundation, Albany County Sewer Authority, Black & Veatch and AECOM.

EPT Technology Project Overview

Beginning in March and concluding in October 2014, the project involved the operation of the EPT (enhanced primary treatment) pilot unit and sludge classifying press (SCP) supplied and run by ClearCove Systems, in conjunction with four pilot-scale anaerobic digestion units designed and built by O'Brien & Gere Engineers. The energy experiment and mass balance energy data assessments and conclusions were completed by Mark Greene of O'Brien & Gere. The biogas generation from the four pilot digesters was continuously monitored and recorded utilizing biogas flow meters connected to a PLC (programmable logic controller) outside of the digester room. This was done to compare the generation rate of the EPT sludge versus the sludge captured by the conventional primary clarifier. The sludge types fed to each pilot digester were analyzed for volatile solids content on a daily basis to ensure that the pilot digesters were fed at the same rate as the IAWWTF full-scale digester. The digesters were constantly measured and maintained for optimum temperature of 95-98 degrees F and a PH level of 6.9 to 7.1. The digesters were fed these four different feedstocks:

1. Control feedstock, or thickened sludge of the plant currently fed into the full-scale digester
2. Primary sludge as collected by the plant
3. EPT-collected sludge
4. EPT-collected sludge but at double the loading rate of the full-scale digester

The purpose of doing this was to ensure that the pilot digesters mimicked the operation of the full-scale digester to ensure that they would provide scalable results using a control and with the variable "enhanced" feedstocks. Biochemical methane potential testing was also performed alongside the pilot digesters to provide supplemental, back up and corroborating biogas data.

The EPT technology removes the majority of organics and solids at the head of the wastewater treatment plant through a physical-chemical process. This results in significant energy savings due to the reduced load on the activated sludge process. The EPT technology performs enhanced primary clarification, and through pumped flow, SCADA automation controls enable flow equalization, bar screening, coarse screening, fine screening, fiber and grit removal – all in a single process and piece of equipment. Raw sewage enters the system at either ends of the tank and is settled and decanted. Solids and organics are separated from the water using gravity and a non-fouling 50-micron (.05 mm) screen. One-hundred percent of the grit and fiber are removed prior to decanting to the secondary process. The settled organics and solids

Courtesy of IAWWTF

The Ithaca Area Wastewater Treatment Facility where an enhanced primary treatment technology was piloted through a NYSERDA grant. The boxed building shows where the EPT pilot was placed for testing.

are removed from the bottom of the tank, thickened using a sludge classifying press (SCP) or thickener, and sent to an anaerobic digester for energy generation. The screened water is sent to downstream processes. The EPT operates with at least two tanks; while one tank is filling, the other tank is settled and then decanted.

By capturing these organics early in the wastewater treatment process, the EPT also provides a high energy potential sludge to the anaerobic digester which results in increased biogas generation. By both reducing the facility's energy consumption and increasing its energy generation, the EPT can enable a facility to achieve net-zero, or even net-positive, energy operation. The sludge captured in the EPT has a higher methane yield than the primary sludge captured in conventional primary clarification. Unlike primary clarifiers which have a constant forward velocity, the EPT stops the flow of wastewater and allows the lighter, colloidal organics to settle to the bottom of the tank. These organics would typically flow out of a conventional primary clarifier and contribute to the increase biogas yield of the EPT sludge.

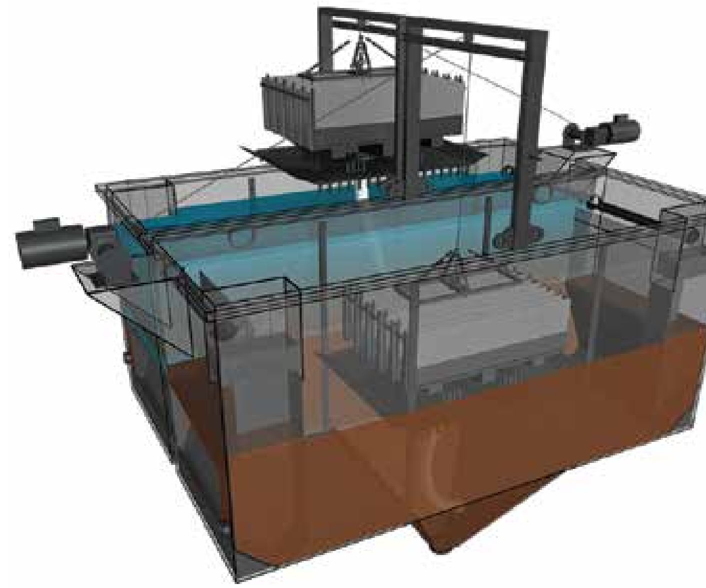
The EPT pilot unit was placed at the influent building of the IAWWTF and received raw wastewater prior to any treatment or chemical addition while the pilot digesters were placed in the digester room of the IAWWTF. The effluent of the EPT was tested for a number of parameters to help determine the plant-wide effects of the system if it were to be installed at full scale. The sludge captured in the EPT was run through the SCP technology. The SCP removes the inorganics, such as plastics, fibers, grit or rags, from the sludge while at the same time shearing the encased organics to increase the organic concentration of the sludge.

The study found that if installed at the IAWWTF, the EPT sludge could generate up to 400 percent more methane than that of the plant's current primary treatment. In addition, by capturing these organics in the primary treatment stage, aeration energy consumption would be reduced by 62 percent.

The reason for the increased biogas generation is twofold – an increased capture of organics and colloidal material in the primary treatment stage leading to higher biogas yield from these organics. Prior studies have shown that primary sludge, especially the suspended colloidal material, has a greater methane yield than the thickened sludge produced from the activated sludge process. The EPT achieves greater organics and solids removal than that of conventional primary treatment, increasing the ratio of primary to secondary sludge. This means that a wastewater treatment plant would then produce a higher volume of the high energy value primary sludge and less of the lower energy value secondary sludge.

Conventional primary clarifiers capture approximately 30 percent of the biochemical oxygen demand (BOD), allowing for the majority to move downstream to the activated sludge process where a significant amount of energy is consumed through aeration – sometimes up to 80 percent of the facility's total usage on treatment. The EPT demonstrated at the IAWWTF an average BOD removal rate of 67 percent, which would reduce the BOD load to the activated sludge process and thus decrease its energy consumption. In addition, the EPT also achieved 84 percent total suspended solids removal, 85 percent volatile suspended solids removal, and 72 percent total phosphorus removal.

It is expected that no incremental chemical costs would be required with the installation of the EPT. The IAWWTF currently adds chemical in its Actiflo process for phosphorus removal at the end of the plant. This chemical addition is expected to shift from the back of the plant to the front of the plant with the EPT.



Courtesy of ClearCove Systems

The enhanced primary treatment technology unit by ClearCove Systems, which captures organics at the head of the wastewater plant

The combination of these two benefits – increased methane production and decreased aeration energy consumption – would allow the IAWWTF to generate more energy than it consumes, and become a renewable energy resource for the community.

"We feel this technology will help us to reach our goal of becoming a renewable energy provider for our community. This is very positive news for our plant and the Ithaca area" said Dan Ramer, chief operator of the Ithaca Area Wastewater Treatment Facility.

More to Come

In January 2015, ClearCove commenced its second NYSERDA project at the Nott Road Wastewater Treatment Plant in Guilderland, NY to demonstrate how a facility without an anaerobic digester can still capitalize on the renewable energy benefits of the EPT's enhanced primary sludge through the use of the "hub and spoke" model. The hub and spoke is the concept of installing the EPT at facilities without anaerobic digesters, or "spokes." Such facilities would send their enhanced primary sludge to nearby "hub" facilities with anaerobic digesters for energy generation. The spokes receive the economic advantage of no longer hauling their sludge to a landfill and the hubs receive the benefits of increased energy generation from the additional fuel. The project in Nott Road was expected to be completed in late February/early March with results from the project being published sometime this spring.

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Wastewater Treatment Plant in Compliance – And Off the Grid

Partnership between the City of Wooster, Ohio and an anaerobic digester developer to retrofit WWTP solids handling is already yielding positive results.

by Marsha Johnston

Retrofits to three anaerobic digesters (domed structures) at the Wooster WWTP included adding a steel ring to each tank to increase volume to each tank by 100,000 gallons/tank, and to add mixers and heat exchangers.

In early 2013, the City of Wooster (pop. ~26,300) in northeastern Ohio found itself in a bind: Despite having spent $25 million in 2007 to upgrade its wastewater treatment plant processes, its discharges were not compliant with environmental regulations. The plant has a designed daily flow capacity of 7.5 million gallons/day (mgd); daily flow is actually 3.5 mgd. "The process upgrades were supposed to reduce the amount of solids and save on power consumption," explains Kevin Givins, Wooster's utilities manager. "The project ended in 2007, but by 2011 we were under findings and orders from Ohio EPA to investigate the issues and fix them." Notably, the plant was not in compliance for suspended solids, ammonia, and Biochemical Oxygen Demand (BOD). In fact, the Ohio EPA told the city it needed to reduce the solids in its effluent into the Killbuck Creek almost immediately after the 2007 upgrades to the plant were completed.

The 2007 project did not upgrade any of the plant's anaerobic digesters, two of which were built in the 1940s, two in the 1960s and one in 1980. "We would have been looking at another $5 million to fix the digesters," adds Givins, "but after we spent $25 million, there wasn't a lot left over to do additional projects."

The City of Wooster issued a Request for Proposals in 2013 to upgrade the solids handling portions of its WWTP. It received two proposals — one from quasar energy group and one from a joint venture between Agri-Sludge and Swedish Biogas. Quasar energy group, based in Cleveland, Ohio, proposed a public-private partnership where it would pay for the upgrades to the treatment plant's solids handling, and Wooster would pay a tipping fee to quasar to process the solids as well as purchase electricity generated by the anaerobic digesters.

The City awarded the 20-year contract to quasar to retrofit, operate and monitor the plant's anaerobic digesters, as well as manage the biosolids. All upgrades had to fit within the existing footprint of the WWTP. The contract marked the first time that

A biomass equalization tank is used to mix the treatment plant solids with other substrates, such as food wastes, prior to loading into the digesters.

quasar, which began in 2006 as Schmack Bioenergy, would retrofit an existing plant, notes Clemens Halene, chief operating officer, although it had done work on municipal facilities in Akron and North Ridgeville, Ohio previously. Quasar already had an AD plant, along with a laboratory and engineering facility, at Ohio State University's Ohio Agricultural Research and Development Center (OARDC) campus located in Wooster.

Under the Wooster contract, quasar provided approximately 90 percent of the capital for the $7.1 million project, while the city spent $1.5 million. Due to the need to meet compliance deadlines, quasar had only 14 weeks to retrofit the three digesters, build the biomass (hydrolysis) tank and a building and receiving station, and install a 1,100 kW Caterpillar generator. The city was responsible for making the required wet stream improvements to manage the ammonia and BOD levels (at a cost of about $4 million). The city's project also included installing a septage receiving station, which it hadn't been able to do previously because of challenges managing its own solids.

Facility Retrofits

Quasar's responsibilities at the WWTP start with receiving the primary and waste activated stream from primary treatment, which is operated by the city. "The solids are pumped from the settling tanks and we take it from there," explains Halene. "We are responsible for the digestion, effluent solution and energy solution to provide electricity back to the plant."

Three of the WWTP's existing digesters were expanded by adding a steel ring to each tank (increasing volume by 100,000 gallons/tank). Mixers and heat exchangers were installed. "We could have built all new tanks, but it was easier to upgrade them to 2014 standards, with increased size and higher sides," he notes. "We put new gas storage shells on top, which provides tremendous biogas storage." To avoid service disruption during the 14-week construction period, quasar installed a temporary gravity belt thickener to increase the solids content from 1.5 to 8 percent, and transported the thickened slurry to its digester on the OARDC campus, 1.5 miles away. "It required five tanker truck trips a day," says Halene. "After digestion, we would bring the material back to the treatment plant's lagoons."

Incoming WWTP solids arrive at 1.5 to 2 percent solids; a gravity belt thickener raises the solids content to 8 percent. Quasar built a biomass equalization tank to macerate, mix and store feedstocks prior to anaerobic digestion. Using the tank helps to control odors from incoming feedstocks. In addition to the WWTP solids, quasar sources food waste and other organics streams, both locally and from the Cleveland and Columbus areas. "We get the tipping fees for that material," adds Halene. "The City of Wooster also can source feedstocks and in turn, it receives a percentage of the tipping fee for what it brokers. Our goal is to source all additional organics from a 10 to 20 mile radius of Wooster."

The streams are pumped into the biomass tank, mixed for three days and pumped into one of the three digester tanks, where they remain for between 18 to 30 days. The new system can handle up to 14 percent solids versus only 2 percent previously. The city's solids utilize about one-third the capacity of the retrofitted digesters, with the remaining two-thirds available for additional feedstocks, especially those with higher energy content.

Energy Production, Nutrient Recovery

Biogas from the digesters is fed to a 1,100 kW CHP unit on site that converts it to electricity; the plant uses 600 kW and 500 kW is sold to the grid. "Wooster is exporting almost the same amount of electricity it is consuming," notes Halene. Taking the Wooster plant off grid is saving the city between $300,000 and $400,000 a year, as the plant's electric bill has been chopped from over $32,000 a month to just over $300, according to Givens. Quasar is planning to install a biogas upgrade system in the next 12 months to be able to sell renewable CNG vehicle fuel.

The increase in plant capacity has also opened the door for Wooster to accommodate more industry. Daisy brand dairy products, based in Garland, Texas, is building a new dairy processing plant in Wooster, closer to East Coast markets. "Because we were in violation of our permit, we wouldn't have been able to take a significant industrial load if we didn't deal with some of the issues," explains Givins. "I would venture to say that, if not for quasar, we would not have gotten the Daisy project, and that they would probably have located somewhere else."

Quasar has a proprietary full-scale nutrient resource recovery system at the wastewater treatment plant that operated for about three months on a testing basis. The company is scaling nutrient recovery back over the winter months, and plans to go into full-scale operation of the equipment in 2015. "Essentially, our process treats the digested effluent by recovering the nutrients — primarily nitrogen," says Halene. Nutrient removal enables the treated wastewater to be discharged into the nearby creek. Currently, the effluent is stored in lagoons. Quasar's goal is to dewater digested effluent to 25 percent solids and recover nutrients from the 75 percent liquid stream. Biosolids are used on reclamation sites or land applied on farms.

The City of Wooster is excited about the changes at its wastewater treatment plant. "There was a lot of concern in the community as to what was going on, with numerous articles in the paper that didn't shed a positive light on us," notes Givins. "But that's all turned around now, the facility is in compliance, and the plant is off the grid, generating more power than we can use."

Marsha Johnston is a Contributing Writer to BioCycle.

This article was reprinted with permission from BioCycle magazine (December 2014). The original version may be viewed at: http://www.biocycle.net/2014/12/17/wastewater-treatment-plant-in-compliance-and-off-the-grid/.

NYWEA Declares 2015 "Year of the Operator"

by Lois Hickey

Upon accepting the President's gavel of the New York Water Environment Association (NYWEA) during the annual meeting this February, Michael Garland of Pittsford, NY, director of Environmental Services for Monroe County, declared 2015, "The Year of the Operator."

"It is high time special recognition is given to clean water operators, NYWEA's core constituent, when the highly referenced 'Utilities of the Future' need 'Operators of the Future,'" Garland said. The water and wastewater treatment industry needs state licensed operators who can meet the widening knowledge base required to work with advanced technologies, renewable energy resources, biology, chemistry, math and mechanics. At the same time, while communities continue to expand and build more wastewater treatment plants or water resource recovery facilities, the industry is losing a large segment of the experienced operator workforce to retirement, or a "graying of the profession." Filling this widening gap, according to Garland, means creating opportunities for job growth and rewards in order to recruit and retain these needed environmental professionals.

Water/wastewater treatment plant and system operators typically need a high school diploma and a state license to work, and also undergo on-the-job training. More and more operators are entering the field with the preferred two or four year college degree.

To explore and understand the needs of the operator of the future, Garland is convening the NYWEA Operator of the Future Task Force. The group will include about a dozen, mainly plant operators, but also collection system operators, utility executives and regulators from the statewide NYWEA board membership. Its first product will be a white paper that outlines findings on how to attract people to such water careers and what NYWEA members and the utilities that employ them can do to help.

NYWEA continues to work to support those already in the profession through training, education and recognition. In addition to providing training for state operator certification and educational technical programs, NYWEA also offers a major scholarship program for those pursuing college degrees in environmental sciences. Garland is also pushing to create new scholarship opportunities for working operators to help broaden their skills and knowledge.

As a part of the special recognition effort, *Clear Waters* is running cover stories devoted to operators in its 2015 editions. This issue provides a profile of two young operators *(seen right)* who work for Monroe County's wastewater treatment plants. While they both can be considered exceptional young role models for their profession, they are also typical in many ways of the new operator workforce. Future editions will place a focus on the Operators Challenge competition, collection systems work, and operator classroom training.

In a recent national interview with TPO *(Treatment Plant Operator, 2-21-15),* Garland said: "It takes special people who understand the value of the work, who enjoy the sciences and the technology, yet aren't afraid to get dirty and do what it takes to operate a facility in compliance with state and federal regulations."

New York State operators, such as those profiled here, are up to the challenge!

Spotlight:

Photo by Trent Wellott, T Wellott Photography, @http://twphoto.us

Licensed operators Justin Slentz and Alison Perez, shown reviewing the centrifuge operator panel at the Frank E. VanLare WWTP, a 135 mgd facility operated by Monroe County Department of Environmental Services

Getting to Know Two Young Professionals

Alison Perez and Justin Slentz from Upstate New York are representatives of today's young wastewater treatment system operator – college educated and desiring advanced operator certification, dedicated and environmentally conscious.

Alison Perez, 28, has two years as a pump and process operator at Rochester's Frank E. VanLare Wastewater Treatment Plant and Northwest Quadrant WWTP. She holds a BA in biology with a minor in environmental science from Alfred University. She is a grade 3A licensed wastewater treatment operator. Alison pursued a career, she says, that would allow her to be outdoors and active. Her first job as a field technician for a chemical company gave her exposure to the Monroe County water collection system.

"I really enjoyed my environmental courses in college and after graduation I began working for a chemical supplier that provided odor abatement to the collection system and the two treatment plants in Monroe County." It was during this time Alison learned about wastewater treatment and what the work of an operator entailed.

"I felt like this was the kind of job I had been looking for, and I applied."

Justin Slentz, 25, also a pump and process operator at Rochester's VanLare plant, has worked there more than two and a half years. Prior to this, he was a paid intern for 18 months while earning his bachelor's degree at RIT in civil engineering technology.

"I chose a career in wastewater treatment because while in the co-op I had some exposure to the field and I found it fascinating. So, I took a full-time position here and have been doing it since."

Justin obtained his grade 3A certification as well.

The most rewarding part of the job, Justin says, "is knowing that the water is being treated properly and the lake is being protected for people and wildlife."

Another bonus is the variety promised in each work day. "I enjoy that every day is something different – you never know what to expect and it keeps you on your toes."

Alison enjoys both the mental and physical aspects her work provides. "No two days are ever the same. We are consistently being presented with new challenges, working together and thinking creatively to solve them."

Generally, the public and even some of their family and friends may not realize what they do as operators, or their importance to their municipality's clean water system.

"It's one of those things people don't consider as long as [the water/sewer infrastructure] is working properly," commented Alison. "People are really surprised when they come for a tour or I tell them just how much goes into wastewater treatment. Luckily, I think this trend is changing. We do a lot of public outreach here through tours and open houses. I've also noticed much more media attention on some of the wastewater treatment challenges municipalities are facing on a broader scale, such as xenobiotics, the increased use of disposables, and microbeads."

"While the public is aware that there is a process in treating water and wastewater," Justin commented, "the public might not know the complexity of it or everything that goes into it. I also feel that if people were more aware of what went on inside here, they might be a little more careful of what they dump into the sewers or flush down the toilet."

What is their advice to those considering the field or who are new to the job?

"Take the opportunity to learn everything you can from those who are long-term employees," said Alison. "With an aging workforce and many retirements in the near future, it is critical for us to gather as much of the knowledge and experiences veteran operators have to pass on. I would encourage any new operator to get involved in as many projects as possible and never stop asking questions."

"This is an ever-growing field, so keep an open mind and take in everything you can," added Justin. "Anybody who enjoys working outside and wants to protect the environment, this is a good field for you. Also there is good job security because people are always going to need one of their most valuable resources – clean water."

Justin and his wife, Katie, have one daughter, Leah, and are expecting their second child's arrival in October. Justin says he hopes to take his 4A certification exam soon, "and keep expanding my knowledge of the wastewater field."

"I'll be testing for my 4A license this year," noted Alison. "I plan on continuing on at Monroe County and focusing on advancing my skill sets as an operator."

The future appears bright for them, and the Rochester community is fortunate to have operators such as these – and who NYWEA knows are typical to wastewater treatment facilities across New York State – working diligently each day to uphold our water quality standards.

Lois Hickey is editor for Clear Waters magazine. She extends thanks to Alison Perez and Justin Slentz for taking personal time to provide information about their careers as operators. Both are NYWEA Genesee Valley Chapter members.

Know an Outstanding Operator to Spotlight?

If you know an operator you think is a professional role model for us to profile in an upcoming *Clear Waters* magazine, please send information as to why, including the operator's name, title, utility, and how to contact, to: Lois Hickey, editor, at: clearwaters525@aol.com.

Operator Quiz Test No. 107 – Formula Exam

The following questions are designed for trainees as they prepare to take the ABC wastewater operator test. It is also designed for existing operators to test their knowledge. Each issue of *Clear Waters* will have more questions from a different section of wastewater treatment. Good Luck!

1. If the concentration of total suspended solids is 44 mg/L and the flow is 170,000 gallons per day, calculate the pounds per day of total suspended solids.
   a. 94.6 lbs./day
   b. 62.38 lbs./day
   c. 122.07 lbs./day
   d. 9.46 lbs./day

2. Calculate the BOD_5 using the following:
   Initial DO = 7.4 mg/L
   Final DO = 4.5 mg/L
   Sample = 15 mL
   a. 43.5 mg/L
   b. 4.35 mg/L
   c. 77.65 mg/L
   d. 58.0 mg/L

3. What is the chlorine demand in mg/L of wastewater under the following conditions:
   Flow = 5.0 mgd
   Feed Rate = 90 lbs. /day
   Chlorine Residual = 0.5 mg/L
   a. 1.66 mg/L
   b. 1.39 mg/L
   c. 2.22 mg/L
   d. 0.96 mg/L

4. A tank that is 25 ft. wide, 100 ft. long, 12 ft. deep and has a flow through it of 2 mgd will have a detention time of what?
   a. 2.7 hours
   b. 20.1 hours
   c. 4.5 hours
   d. 4.5 hours

5. What is the food/microorganism ratio given the following conditions:
   MLSS = 2500 mg/L
   Influent BOD_5 = 210 mg/L
   Aeration Tank Volume = 125,000 gallons
   Primary Effluent BOD_5 = 102 mg/L
   Flow = 235,000 gallons per day
   Mixed Liquor is 75% volatile
   a. 0.3
   b. 0.2
   c. 0.05
   d. 0.1

6. What is the percent removal of total suspended solids given the following information:
   Influent TSS = 170 mg/L
   Effluent TSS = 14 mg/L
   Effluent BOD_5 = 21 mg/L
   Flow = 3.7 mgd
   a. 98.1%
   b. 91.8%
   c. 95.6%
   d. 92.8%

Answer the following questions based on the plant information below. The secondary system consists of 2 rectangular aeration tanks and 2 circular clarifiers.

Parameter	Values
Raw Waste Water Flow	4MGD
Influent TSS	180 mg/L
Influent BOD	200 mg/L
Primary Effluent BOD	180 mg/L
Primary Clarifier Dimensions	Diameter = 60' Depth = 12'
Aeration Tank Dimension	100' x 15' x 20'
Each Secondary Clarifier Volume	1,500 cu.ft.
Aeration MLVSS	2800 mg/L
Aeration MLSS	3500 mg/L
30 Min Settling Test Volume	200 ml/L
WAS Flow	.025 mgd
WAS TSS	4500 mg/L
Effluent TSS	2.5 mg/L
Effluent BOD	5 mg/L

7. What is the sludge volume index (SVI) of the plant aeration system?
   a. 85.6
   b. 50.1
   c. 57.1
   d. 157.1

8. What is the mean cell residence time (MCRT) of the aeration system?
   a. 8.5 days
   b. 9.8 days
   c. 13.5 days
   d. 12.8 days

9. What is the percent removal of BOD?
   a. 97.5%
   b. 95.7%
   c. 99.2%
   d. 89.7%

10. What is the Food to Mass ratio (F/M)?
    a. 0.75
    b. 1.22
    c. 0.65
    d. 0.57

11. What is the total suspended solids percent removal?
    a. 96.8%
    b. 92.5%
    c. 89.6%
    d. 98.6%

12. What is the detention time in the primary clarifier?
    a. 1.52 hours
    b. 2.75 hours
    c. 3.55 hours
    d. 1.75 hours

Answers on page 62.

For those who have questions concerning operator certification requirements and scheduling, please contact Tanya May Jennings at 315-422-7811 ext. 4, tmj@nywea.org, or visit www.nywea.org/OpCert.

Thank You.

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Help with Ammonia Criteria Implementation: Tools to be Developed for Utilities

by Claudio H. Ternieden

Utilities seeking help implementing ammonia criteria revised by the US Environmental Protection Agency (USEPA) will have several tools resulting from an experts workshop held last fall that discussed how to help reduce the burden for permittees.

The workshop, which took place in Arlington, Va., from October 28 to 29, was hosted by the Water Environment Federation (WEF; Alexandria, Va.), National Association of Clean Water Agencies (NACWA; Washington, D.C.), and Water Environment Research Foundation (WERF; Alexandria, Va.).

The USEPA published final national recommended water quality criteria for protection of aquatic life from the toxic effects of ammonia in freshwater in 2013. The criteria reflect new data on sensitive freshwater mussels and snails, incorporate scientific views the USEPA received on its draft 2009 criteria, and supersede the USEPA's previously recommended 1999 ammonia criteria.

Experts from WEF and NACWA as well as WERF subscribers and state water quality professionals led the workshop. The USEPA technical staff also provided the agency's perspectives and updates on implementation efforts.

The workshop objectives included the following:

- Identify what tools and projects are needed to fill the information gaps or respond to the flexibility discussed in the USEPA's guidance.
- Identify data and information gaps needed for implementation of the revised criteria – what details pertaining to implementation in permits and other flexibilities are known now or that will be needed.
- Propose a framework and provide clear guidance for implementation – based on a common set of principles.
- Produce a final report (prepared by WEF, NACWA and WERF) on the outcome of the workshop to serve as a path to implementation.

Recommendations from the workshop participants are listed in ***Table 1***.

Table 1. Recommendations from Workshop Participants

• Decision trees for mussels present/absent determinations and related permitting decisions
• Role of use attainability analysis and use sub-categorization/ tiered aquatic life uses
• Possible use water-effects ratio for applying the ammonia criteria
• Better definition of mixing zones policies applicable to ammonia
• Additional studies on the fate of ammonia in receiving waters
• Potential use of in-stream studies to evaluate discharger impacts
• Better understanding and definition of the consequences of pH, temperature, and upstream background concentration specifications
• Better understanding of the scope of the problem: How many site-specific criteria needed? Is it principally a small plant discharging to small stream and/or arid west problem?
• Assess water quality standards attainment options: adaptive/flexible implementation to make significant, step-wise improvements that may fall short of full attainment
• Determine effective implementation timeframe that accounts for complexity of issues, including relationship to triennial review process
• Model multi-discharger variance for lagoon and other types of systems (e.g., small package plants) that cannot meet the criteria
• Assess applicability of stochastic or probabilistic analysis in permit derivation
• Holistic approaches for facilities required to meet both ammonia and nutrient limits – compatibility of treatment options and sequencing of implementation to cost-effectively achieve compliance
• Methodology for assessing the benefits of achieving ammonia limits
• Public education to promote understanding of the importance of maintaining mussel populations as means of gaining support for funding projects

Key Elements of the Criteria

The 2013 final freshwater aquatic life criteria for ammonia are pH- and temperature-dependent, and expressed as total ammonia nitrogen (TAN). The new criteria are more restrictive than the 1999 criteria — see ***Table 2*** for an example.

Table 2. Freshwater Aquatic Live Criteria (20°C, pH 7 s.u.)

Criterion	2013	1999
Acute[a]	17 mg/L TAN	24 mg/L TAN
Chronic	1.9 mg/L TAN	4.5 mg/L TAN

[a]*Salmonids present*

The criteria and related materials can be found at http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/ammonia/index.cfm . The USEPA's key contact for questions related to ammonia criteria derivation and implementation in National Pollution Discharge Elimination System permits is Lisa Huff (huff.lisa@epa.gov).

In addition, the EPA published several factsheets and support documents related to criteria implementation and derivation of site-specific criteria. The most important documents in addition to the criteria publication (EPA 822-R-13-001) are:

- Revised Deletion Process for the Site-Specific Recalculation Procedure for Aquatic Life Criteria (EPA 823-R-13-001).
- Flexibilities for States Applying EPA's Ammonia Criteria Recommendations (EPA 820-F-13-001).
- Technical Support Document for Conducting and Reviewing Freshwater Mussel Occurrence Surveys for Development of Site-specific Water Quality Criteria for Ammonia (EPA 800-R-13-003).

The final proceedings for the workshop is available since mid-February from WEF. WEF, NACWA and WERF are working with USEPA to help implement the recommendations from this workshop.

Claudio H. Ternieden is Director of Regulatory Affairs at the Water Environment Federation (Alexandria, Va.). He can be reached at cternieden@wef.org.

Changes the Midterm Election Will Bring to US Congress

by Steve Dye

The 2014 midterm election will bring changes large and small, with the biggest change being US Senate control by Republicans who will appoint new committee chairs and set the legislative agenda. The Senate Committee on Environment and Public Works will now be led by Senator James Inhofe (R-Okla.). After an eight-year hiatus as chairman while Democrats controlled the Senate, Inhofe has overall seniority on the committee and reclaimed the chairmanship as the committee addresses major regulatory differences the Republicans have with the Obama administration.

In the House, Republicans gained 13 seats, increasing their majority to 242 – 174 over Democrats. Both US Representatives Nick Rahall (D-W.VA.) and Tim Bishop (D-NY) lost their reelection bids, which vacate the ranking member seats for the House Transportation and Infrastructure Committee and Water Resources and Environment Subcommittee.

US Rep. Peter DeFazio (D-Ore.) is the new ranking member of the committee, and US Rep. Grace Napolitano (D-Calif.) is expected to become the new ranking member of the Water Resources Subcommittee. There were no changes for Republican leadership of the full committee or subcommittee.

Agenda for Bills and Policies Affecting Water

Legislatively, Republicans will control the process in both congressional bodies and will likely push forward with several significant water-related bills and policies. The Water Environment Federation (WEF) Government Affairs believes there will be legislative action to restrict the Obama administration's Waters of the United States (WOTUS) rule, expected to be finalized in Spring 2015.

The annual appropriations bills also will be wholly written by the Republicans. WEF Government Affairs believes these bills likely will reflect the Republican agenda for spending and federal policies, such as possible additional spending cuts to USEPA programs and restrictions on implementation of the WOTUS rule and amendments to the Clean Air Act.

Additionally, efforts to move tax reform legislation will likely begin again, which previously have raised concerns over possible changes to tax-exempt municipal bonds. A tax reform bill potentially will include lifting or removing the cap on private capital investments though private activity bonds.

Steve Dye is president of Nexus Government Relations and supports the Water Environment Federation's (Alexandria, Va.) legislative efforts in Washington, DC.

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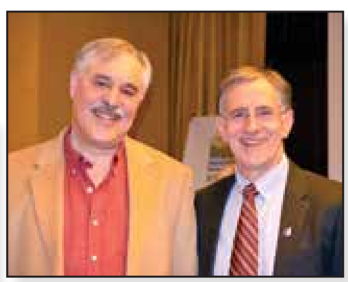
continued from page 7

Highlights of 87th Annual Meeting continued

Adam Zabinski (left) and Stefan Grimberg

(L–r): Phil DeGaetano, Joe DiMura, Micah Fish-Gertz, Jim Mueller and Bob Adamski



Gerry Moscinski (left) and Robert Kukenberger

Gabriel Novac of GNA

(L–r): Lauren Livermore, Adam Cummings and William Nylic

Rodney Hunt/Fontaine exhibitors Paul Brunelle (left) and Gene Darin

Steve and Lucia Fangmann

Above: (L–r) Letty Butterworth, Janice Jijina and Kathleen (Lauro) O'Connor

Left: Will Stradling shares a laugh with table mates.

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More opportunities at nywea.org/jobs

Wastewater Treatment Plant Supervisor, the Village of Watkins Glen, NY

To both direct current plant staff of three members and actively participate in the operation of the Village's 0.7 MGD Activated Sludge Wastewater Plant, nine remote pumping stations and gravity collection system at the southern end of Seneca Lake in New York State Wine Country. Applicants need to demonstrate:

- Possession of a valid New State 3A or higher classification Wastewater Treatment Operator Certification
- At least 2 years experience as a municipal WWTP Plant Operator
- At least 2 years track record of supervisory experience at a comparable plant
- The ability to operate and maintain associated wastewater plant equipment, and instrumentation
- The ability to direct and perform routine laboratory analyses associated with the plant
- Prepare electronic SPDES DMR and other required report forms
- The ability to interact with the public, elected officials, professional consultants, NYSDEC and NYSDOH regulatory officials, and vendors.
- Successfully pass a competitive Civil Service Examination for the position

It is the intent of the Village to hire a highly motivated individual who could assume the Chief Operator (WWTP Supervisor) position at a future 1.2 MGD Regional WWTP that will serve the Watkins Glen/Montour Falls area within the next 3 to 5 years. This new plant is currently in the Planning/Preliminary Engineering phase. Additional roles/responsibilities of the Regional WWTP Supervisor will include:

- Obtaining a Grade 4A certification for activated sludge/tertiary limits
- Participate in Preliminary and Final design development for the WWTP with the Village's Consultant, and be involved in its construction, start-up and testing
- Supervise WWTP staff, and potentially Joint Collection System O&M staff
- Report monthly to the Joint Project Committee (JPC), the administrating body for the Regional WWTP, on such things as status of operations, maintenance and repairs, capital improvement needs, staffing issues, etc.
- Serve as the WWTP budget officer and prepare annual capital and O&M budgets for the Regional WWTP/collection system(s)
- Regularly monitor and assess Excess Capacity, and review/make recommendation for approval of new sewer connections
- Develop, with assistance from the Village's Consultant, an Asset Management Plan (AMP) for the new WWTP in support of annual CIPs, O&M budgets, etc.

The Village offers an excellent benefit package including health insurance, paid vacation, holidays, and sick days. You may pick up an application at 303 N. Franklin St. Watkins Glen, NY 14891 or download an employment application from our website *www.watkinsglen.us*. Donna J. Beardsley, Clerk/Treasurer, 303 N. Franklin Street, Watkins Glen, NY 14891, P: 607.535.2736, Fx: 607.535.7314

Senior Wastewater Manager – Environmental Engineering

With more than 8,500 people around the globe, GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation.

With the flexibility to be based in our White Plains, NY, or Cazenovia, NY, office, we are currently seeking an experienced **Wastewater/Water Engineer** to pursue work on, and manage a wide range of water and wastewater related projects. Recognized as a leader in your field, this position is responsible for the plan, design and construction of water and wastewater infrastructure for municipal clients, as well as helping to mentor and develop technical staff. You will also be responsible to develop master plans, facility plans and sewer systems evaluations. You will manage project budgets, delegate project tasks and respond to project issues. One of your key roles will be client development and management as a Client Relations Manager.

Our White Plains and Cazenovia offices are made up of a group of dynamic individuals, who enjoy the diversity of their projects and camaraderie of their co-workers. This in turn has led to a positive culture, fostering an environment of Teamwork, Respect and Integrity.

Qualifications:

- BS Degree in Environmental Engineering or similar field.
- MS Degree is desirable
- Current PE.

Key Requirements

- Minimum of 8-15+ years of relevant industry related experience, with a strong emphasis on water and wastewater infrastructure (e.g. pipelines, pump stations and treatment facilities) projects across the public sector. Candidates with a strong portfolio of work across the greater New York area will be highly regarded.
- Strong client development and client service skills
- Strong production design capability
- Strong project management skills, managing multi-disciplinary projects on time and within budget
- Strong analytical skills and sound technical judgment
- Good communication skills, both written and oral, including report-writing and preparation of competitive proposals
- Experience supervising groups of technical staff.
- High ethical standards, committed to producing high quality work

As a multicultural organization, we encourage individual achievement and recognize the strength of a diverse workforce. GHD is an Equal Opportunity and Affirmative Action Employer–minorities, females, individuals with disabilities and veterans.

To apply, please attach your resume and covering letter via *http://www.ghd.com*. For a confidential discussion you may call Trish Fernandez, People Advisor on +1 949 585 5209.

MRB Group Engineering, Architecture & Surveying, P.C.
recruiting for several positions to join our growing team:

Team Leader/Project Manager: Candidate will be responsible for client and project development, client interaction, and client meetings. Individual will represent the firm in meetings and conferences with clients, regulatory agencies, and officials of other organizations. Candidate must have experience and background with civil engineering disciplines and especially water and wastewater conveyance and treatment. Team Leader/Project Manager will develop projects with clients and then will be involved in the oversight and management of the design and construction of those projects while maintaining client contact. Only candidates with the ability to apply advanced engineering techniques and demonstrate exceptional problem solving and communication skills will be considered. Public speaking and interactions with clients, politicians, and municipal officials will expected. Licensure is required with a minimum of 10 years of experience.

Civil Engineers to plan, design, direct, oversee and execute civil engineering projects in our water/wastewater group. Minimum qualifications include a B.S. degree with 1–3 years of experience (for Civil Engineer I), 3–5 years of experience (for Civil Engineer II) or 5–7 years of experience (for Civil Engineer III). Water/wastewater experience desired. P.E. license preferred. Successful candidates will be self-starters with good communication skills and the ability to work well in a team environment.

Seasonal Construction Observers to oversee the construction of various utilities and site improvements. Minimum qualifications include 3–5 years of utility and site construction experience. The successful candidate will be familiar with construction documents and will be responsible to ensure that the construction conforms to the information presented in these documents. Knowledge of the Phase II stormwater requirements is a plus. Building and water/ wastewater process experience also helpful. Excellent written and oral communication skills a must.

MRB Group has offices in Rochester, Watertown, Saratoga Springs, Seneca Falls, and Elmira, New York. Please e-mail your resume to: *resume@mrbgroup.com* or mail a copy to The Culver Road Armory, 145 Culver Road, Suite 160, Rochester, NY 14620

Engineer I - Civil/Environmental
Rockland County Sewer District No. 1, Orangeburg, NY

F/T permanent position for a variety of duties including planning, design and inspection of wastewater collection and treatment projects.

Minimum Qualifications: A Bachelor's Degree in Engineering, which included or was supplemented by at least 15 semester hours in civil engineering or comparable curriculum. **Starting Salary:** $60,687.30 per year with full benefits. Mail resume to: RCSD#1, 4 Route 340, Orangeburg, NY, Attn: Jean Langan or email resume to *langanj@co.rockland.ny.us*

Chief Operator
Rockland County Sewer District No. 1, Orangeburg, NY

F/T permanent position for the operation and maintenance of a grade 4 wastewater treatment facility. **Minimum Qualifications:** A Bachelor's Degree or higher in Civil, Sanitary, Environmental Engineering, or comparable curriculum and five years of experiences in the operation of wastewater treatment plants, one (1) year of which must have substantially involved supervisory and /or managerial responsibilities. **Special Requirements:** Possession of a valid Grade 4 WWTP Operator certificate issued by the NYSDEC. **Starting Salary:** $98,316.00 per year with full benefits. Mail resume to RCSD#1, 4 Route 340, Orangeburg, NY, Attn: Jean Langan or email resume to *langanj@co.rockland.ny.us*

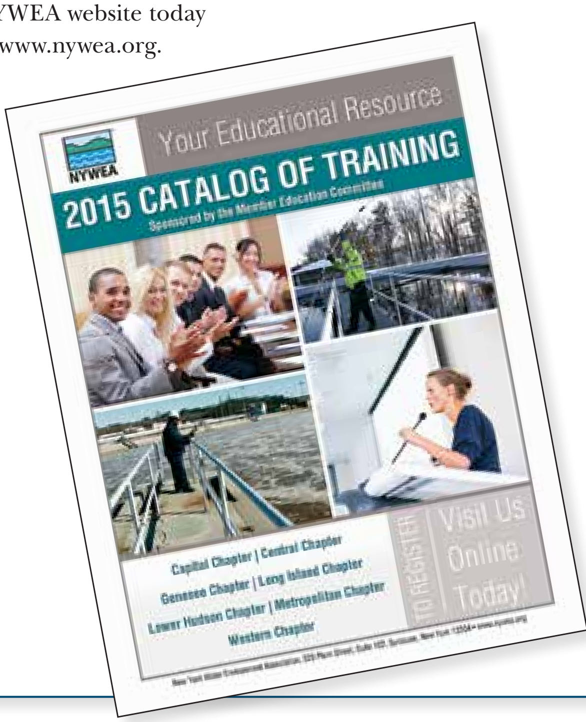
Resources

To advertise or to become a member, contact Rebecca Martin at 315-422-7811 ext. 5 or e-mail her at rebecca@nywea.org.

Visit www.nywea.org for information or see us on Facebook.

The 2015 Training Catalog Has Arrived!

NYWEA exists to enrich the lives of its members through educational training opportunities that include the added benefit of networking with peers and others interested in the profession. The 2015 Training Catalog includes 19 events scheduled throughout the year. To view the catalog, visit the NYWEA website today at www.nywea.org.



Spring 2015, Vol. 45, No. 1

Clear Waters

New York Water Environment Association, Inc.

ADVERTISERS	PAGE
AECOM	24
Aftek, Inc.	30
Aqua-Aerobic Systems	21
ARCADIS–US	39
Barton & Loguidice, D.P.C.	19
Bond, Schoeneck & King, PLLC	12
C & S Companies	29
CDM Smith	17
D&B Engineers and Architects, P.C.	17
Eco-Rental Solutions.	61
Franklin Miller	61
G.P. Jager & Associates	16, 27, 44
GA Fleet	34
Gannett Fleming	61
Greeley & Hansen	26
H2M architects + engineers	29
Harper Control Solutions Inc.	49
Hatch Mott MacDonald	35
Hazen and Sawyer Environmental Engineers & Scientists	8
HDR	35
Holland Company, Inc.	62
J. Andrew Lange Inc.	48
Koester Associates, Inc.	Inside Front Cover
Lakeside Equipment Corporation	40
Mixing Systems, Inc.	Inside Back Cover
O'Brien & Gere	12
Pumping Services, Inc.	37
Savin Engineers, P.C.	12
Siewert Equipment Co.	Back Cover
Smith & Loveless, Inc.	26
Sprayroq	33
Statewide Aquastore, Inc.	61

Answers from page 56: 1 B, 2 D, 3 A, 4 A, 5 D, 6 B, 7 C, 8 C, 9 A, 10 D, 11 D, 12 A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