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WATER & WASTES DIGEST

2020 FORECAST

WEF, WWEMA, AWWA & NACWA present 2020 regulatory briefs, p. 10

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WATER & WASTES DIGEST

JANUARY 2020
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On the Cover

Industry associations relay key talking points going into 2020, *See page 10.*

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MADE IN THE USA

By Bob Crossen

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New Year Momentum

It can be difficult to start the New Year off strong. It delineates a capsule of time to reflect upon, but it also is simply a continuation of things already in motion. For me, a new year is an opportunity to rebuild or carry momentum into the future. To further one's aims and goals rather than start over on new ones.

There were some new things introduced to the industry this year, and based on the work industry associations are doing and their regulatory briefs on page 10 in this issue, it would seem they too are eager to carry that momentum into 2020 to encourage important change.

Being heard in Washington, D.C., amid the noise—the U.S. House of Representatives Impeachment Articles against President Donald J. Trump, the lead up to the Democratic Primary Election, and of course the General Election—can be a monumental challenge. But the leadership of water industry associations have never been more unified behind the message for water's future, especially regarding water infrastructure measures.

This collective voice is one we encourage everyone to use. Get involved with local, regional and national associations. Attend committee meetings or work toward sitting on those committees. Raise your voice and those of your colleagues so we can work toward a brighter water future.

We'll stand there shouting with you.

Bob Crossen | Senior Managing Editor | bcrossen@sgcmail.com

WEB EXCLUSIVE: NUTRIENT LOADING IN THE GULF OF MEXICO

Did you know the Gulf of Mexico Dead Zone at the detla of the Mississippi River is measured at nearly 7,000 square miles, larger than the states of Connecticut and Rhode Island combined? Learn how regulators in Iowa are taking measures to reduce nutrient loading and improve the Gulf of Mexico in a WWD Web Exclusive series by Tyler Marshall at bit.ly/nutrientseries.

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WATER & WASTES DIGEST
3030 W. Salt Creek Lane | Suite 201
Arlington Heights, IL 60005-5025
847.298.6622 | F: 847.390.0408 | www.wwdmag.com

EDITORIAL STAFF
Senior Managing Editor Bob Crossen
Associate Editor Lauren Del Ciello
Associate Editor Katie Johns
Associate Editor Cristina Tuser
Designer Jason Kenny

ADVERTISING & SALES
Integrated Media Advisor John Huff
jhuff@sgcmail.com | 847.954.7986
Integrated Media Advisor Wendy Posey
wposey@sgcmail.com | 847.391.1055
Storefront Coordinator Frankie Corrado
fcorrado@sgcmail.com | 847.954.7940
Print Coordinator Adrienne Miller
amiller@sgcmail.com | 847.391.1036
List Rental Contact Claude Marada
claude.marada@infogroup.com | 402.836.6274
List Rental Contact Bart Piccirillo
bart.piccirillo@infogroup.com | 402.836.6283
Advertising Coordinator Erica Rivera
erivera@sgcmail.com | 847.391.1049

MANAGEMENT
Sr. Vice President/Group Publisher Ryan Hanson
rhanson@sgcmail.com | 847.391.1059
Associate Publisher Greg Tres
gtres@sgcmail.com | 847.306.6692
Director of Custom Media & Strategic Product Development John Atwood
Data & Audience Development Manager Matt Ohlson

Subscription Inquiries
Water & Wastes Digest
P.O. Box 300
Lincolnshire, IL. 60069-0300
wwd@omeda.com
Toll-Free: 877.501.7540
Local: 847.763.4933

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Water & Wastes Digest (WWD) is published exclusively for the 80,000+ decision makers in the municipal and industrial water, wastewater and water pollution industries. These individuals actively design, specify, buy, operate and maintain the equipment, chemicals and services used for water treatment. Editorial content in this audited publication highlights new products and technologies concerning the supply, collection, treatment and distribution of drinking water; the collection, treatment and disposal of wastewater; and hazardous waste pollution control. A product directory is included in the annual June Buyer's Guide.

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Mitigation Through Harmony

By Gerry Feldmeier & Nicole George

Specifying the right solution for harmonic mitigating solutions

A lot happens in a day at a water treatment facility. Millions of gallons of water run through the plant each day, placing an enormous responsibility on the operations and maintenance teams to ensure the process proceeds without disruption. Keeping the plant running smoothly is a top priority and resources spent troubleshooting problems, repairing equipment or paying penalties for power quality concerns is not only inefficient but risks water output; a critical requirement to keep a municipality functional.

While eliminating all potential setbacks is not possible, it is possible to simplify some of the decision-making that impacts the plant operations. One of these decisions is selecting the appropriate harmonic mitigating solution for the plant's variable frequency drive (VFD) applications. Harmonics are distorted electrical waveforms that introduce inefficiencies into the electrical system causing inefficiencies in the power distribution system, damage to transformers, possible interference of monitoring devices and incurred fees from the local utility.

The Institute of Electrical and Electronics Engineers (IEEE) established the IEEE-519 guideline written from the point of view of electrical utilities, and this guideline establishes the level at which electrical energy is determined "clean," so not to pollute the utility power or affect other users of that power. Designing and selecting the right harmonic mitigating products to meet IEEE5-19 can be confusing, and often the solution procured is over-designed for the application resulting in added hardware costs that could have been avoided.

Selecting the right harmonic mitigating solution can be simplified to the power range of the VFD and the type of input power. Simply put, IEEE-519 can be achieved using various technologies, including inductive reactors with a 6-pulse drive, passive filters, multi-phase converters and active front end (AFE) drives.

Sometimes where the plant is located will dictate the type of mitigation that should be used. If the plant is in a remote location where unstable or poor power quality can be expected, then using a multi-phase drive is desirable because the solution is more robust and able to withstand more disturbances than other solutions. Multi-phase solutions also are better suited for applications where standby generation is required and the VFDs represent a large percentage of the load. Passive filter and active front end drives would be better suited for applications where the power is extremely stable and the VFDs represent a smaller percentage of the overall load.

The tables below provide a rule of thumb reference for selecting and specifying the right harmonic mitigating solutions for the application based on motor size and power considerations.

Understanding harmonic mitigation solutions does not need to be intimidating. When specifying the right variable frequency drive solution for the application, remember H.I.P: horsepower and input power. Applying these guidelines will help to narrow down the options and reduce the total cost of ownership on the plant. WWD

Gerry Feldmeier is regional drives sales manager for Eaton. Nicole George is product manager of pumping variable frequency drives - industrial controls division for Eaton. Feldmeier and George can be reached at eatoncpcd@eaton.com.

Nominal HP	Technology	Power Considerations	Reason
<=40HP	6 Pulse	N/A	Represents a small amount of total load; an additional 3% input reactance may be added for additional mitigation and to make the VFD less susceptible to power disturbances.
>40HP	18 Pulse	Poor quality input or standby generation	Most robust solution that will provide the greatest stability when on standby generation or poor power quality exists.
>40HP	Passive Filter	Reliable power quality	Most cost-effective solution where there is a lot of other non VFD loads and the power quality is considered good.

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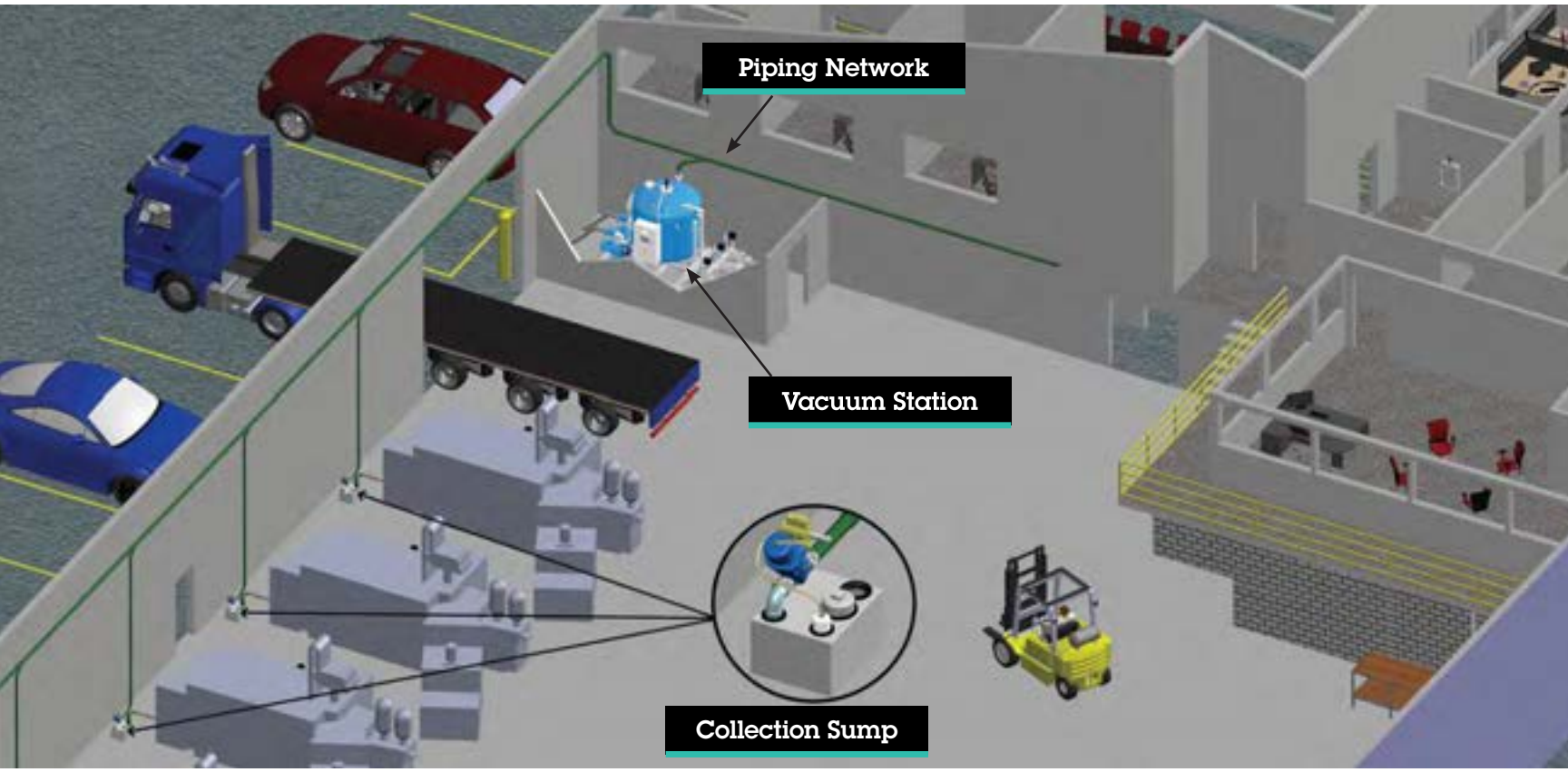

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ASSOCIATION FORECAST

Compiled by Bob Crossen

Industry associations forecast critical talking points & issues for 2020

Tracy Mehan
Executive Director of Government Affairs
AWWA

Chris Moody
Regulatory Technical Manager
AWWA

2019 was witness to large moves in the water industry. From revisions to the Lead and Copper Rule and the release of the U.S. EPA National Water Reuse action plan, the industry has developed plans with purpose and achievable goals. But there are a multitude of other issues facing the industry, some revolve around funding and financing, while others are changes to regulations and legislation—both federally and at the state level. To better understand the largest talking points of 2020, Water & Wastes Digest (WWD) asked four associations—American Water Works Association (AWWA), Water & Wastewater Equipment Manufacturer's Association (WWEMA), National Association of Clean Water Agencies (NACWA) and Water Environment Federation (WEF)—to submit briefs on the issues most important to them and their memberships in the coming year. Below are summaries from leadership at those associations.

Regulatory Forecast for Drinking Water

By Tracy Mehan & Chris Moody

Last year saw a flurry of drinking water regulatory and legislative activities. Despite this, we would wager that there will be more to come for 2020. The upcoming election will likely lead the current administration to push out as much as possible prior to this time next year in case of unfavorable election results. Much of the anticipated activity for this year is expected to be related to tying off loose ends.

In 2019, several drinking water regulations were proposed by the U.S. Environmental Protection Agency (EPA). The first major piece of regulation for 2019 was for perchlorate, which proposed either setting a maximum contaminant level (MCL) or reversing the prior positive regulatory determination, which AWWA has supported due to the lack of evidence for meaningful opportunity to protect public health. In November the EPA proposed revisions to the Lead and Copper Rule (LCR), which included broad changes to the rule such as new precautionary requirements for systems based on exceeding a new lead trigger level. The rule also includes requirements for systems to develop lead service line (LSL) inventories and to implement a LSL replacement program upon exceedance of the lead trigger or action level. The revisions to LCR also include extensive public outreach and risk communication practices as well as mandated lead testing in schools. AWWA expects the EPA to propose final rules for perchlorate and the revisions to the LCR later this year.

Additionally, 2019 marked a year of frustration for environmental advocates and the regulated community alike concerning per- and polyfluoroalkyl substances (PFAS). While the EPA has been working to better understand PFAS through research, Congress worked tirelessly during 2019 to mandate further action by the EPA to address PFAS as a class. This is likely to continue through 2020. AWWA is also anticipating the EPA will include a suite of PFAS in its proposed Fifth Unregulated Contaminant Monitoring Rule this summer.

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Vanessa M. Leiby,
Executive Director,
WWEMA

To Regulate or Not to Regulate – That is the Question

By Vanessa M. Leiby

The Trump Administration has made it clear in its words, Executive Orders and actions that a key priority of this administration is the reduction in size of the federal government and the reduction/elimination of various regulations that it perceives hinder business, commerce, and/or job creation in the U.S. With regard to the EPA, the administration announced Nov. 21 that it had taken 48 deregulatory actions, which the agency projects has saved U.S. citizens more than $5 billion in regulatory costs.

Against this backdrop of rollback and deregulation are extent and substantial environmental and public health threats that have risen to the national stage over the last three years. These include lead, perchlorate, and PFAS to name a few. The public, as well as communities, utilities, and states are demanding action and setting their own standards in the face of inaction at the federal level. Congress also has actively weighed in on many of these contaminants, trying to compel EPA to take action outside of the regulatory structures created by statutes such as the Safe Drinking Water Act (SDWA).

For those of us who were actively involved in helping develop and pass the 1996 Amendments to the SDWA, we recognize and appreciate this difficult challenge. Prior to 1996, EPA often regulated contaminants based on pressure from Congress and the public but without clear scientific rationale. In fact, one of the primary purposes of the 1996 Amendments to the SDWA emphasized sound science and risk-based standard setting to require that EPA create a rational and scientific processes for identifying, researching, and ultimately regulating contaminants of greatest health and environmental concern. This process is being tested today as EPA faces mounting pressure to take action. The Fall 2019 Unified Agenda of Regulatory and Deregulatory Actions, published Nov. 20, offers a glimpse into these answers about regulating contaminants.

Let's start with PFAS, which saw significant public and Congressional outcry in 2019. PFAS are a group of ubiquitous and persistent man-made chemicals manufactured and used in a variety of industries around the globe, including in the U. S., since the 1940s. PFAS can be found in food packaging, non-stick Teflon products, fire retardants, and stain- and water-repellent fabrics to name a few.

Perfluorooctanic acid (PFOA) and perfluorooctanesulfate (PFOS) are two of the PFAS contaminants on the fourth Contaminant Candidate List for which EPA must make a regulatory determination by the end of 2019. This determination, which begins the rulemaking process to develop a National Primary Drinking Water Regulation (NPDWR), is based on three criteria: 1) health risk; 2) high occurrence; and 3) potential for risk reduction. EPA can determine if a contaminant should drop off the list, be further studied, or move down the path for regulation. This determination is published in the Federal Register for public comments.

EPA also consults with states and other Federal Agencies. Once this process is completed, it reviews and considers all the comments and recommendations and publishes a final notice in the Federal Register. According to the agenda, the publication of the final determination (not a rule) will be made by January 2021. Of note, EPA has already announced a delay in the assessment of draft toxicity values for PFAS until Q1 2020.

Shifting gears, the Regulatory Revisions for the Lead and Copper Rule, which have been years in the making, continue to move forward. The Notice of Proposed Rulemaking (NPRM) was published in the Federal Register on Nov. 13. Comments must be received by Jan. 13. The proposed changes focus on six key areas: identifying areas most impacted; strengthening treatment requirements; replacing lead service lines; increasing sampling reliability; improving risk communication; and protecting children in schools. One key question will be the cost of implementing the rule since the Trump Administration requires that for every rule an Agency promulgates, additional rules of equal or greater cost must be taken off the books. This may be particularly challenging in light of the cost for lead service line replacement.

Perchlorate is another contaminant EPA has been wrestling with for a number of years. A recent Consent Decree filed against EPA mandated the agency finalize a NPDWR with a maximum contaminant level goal (MCLG) by Dec. 19. That, however has now been delayed until June 2020 due to an overwhelming number of comments. The agency's proposed options range from three levels of MCLs and MCLGs to deciding not to regulate perchlorate at all – quite a range of options.

Finally, a rulemaking that is of interest to a number of WWEMA members is the Peak Flows Management Rule to address sanitary sewer overflows due to wet weather events. Although listed as deregulatory in nature, this rule will seek to ensure a consistent national approach for permitting Publicly Owned Treatment Works that allow for efficient plant operation while protecting the public from adverse health effects related to inadequately treated wastewater. A NPRM is expected in December 2019, although that timetable may be optimistic.

Kristina Surfus
Legislative Director
NACWA

Emily Remmel
Director of
Regulatory Affairs
NACWA

Modernizing the Outdated Affordability Framework

By Kristina Surfus & Emily Remmel

As the clean water sector looks ahead to the 50th anniversary of the Clean Water Act (CWA) in 2022, there are significant achievements to be celebrated, and yet more work to do. One significant regulatory and legislative priority that remains outstanding is modernizing the outdated affordability framework to reflect the real affordability challenges facing local utilities.

Aging infrastructure, regulatory drivers, and the diminution of federal dollars have left local governments holding the bag to fund capital improvements and ongoing operation and maintenance to meet today's needs at rates that are not beyond the reach of the households they serve. As these challenges grow, it is imperative the EPA revise its outdated affordability guidance.

EPA's existing 1997 guidance—Combined Sewer Overflows: Guidance for Financial Capability Assessment and Schedule Development—has serious, known flaws, including reliance on the 2% Median Household Income (MHI) threshold, which is a poor indicator of economic distress and fails to capture impacts across diverse populations within a community. The existing methodology does not look holistically at drinking water, wastewater, and storm water, nor does it account for other non-discretionary household costs which can exacerbate affordability challenges for individuals.

Echoing many of the water sectors concerns over affordability, the National Academy of Public Administration (NAPA) recommended major changes to EPA's procedure for evaluating ratepayer affordability and utility financial capability. However, the recommendations did not provide a new methodology or path forward for EPA.

NACWA, AWWA, and WEF released a report in April 2019 titled Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector. This report builds upon the recommendations in the NAPA report and provides EPA with an adoption-ready, updated framework and methodology for household affordability and financial capability assessment. Working with EPA to update its affordability guidance in line with these recommendations will be a central regulatory priority for NACWA in 2020.

An updated water affordability methodology is only one element of ensuring access to clean and safe water services. The other legislative element NACWA will pursue is advancing legislation to establish a federal financial assistance program for water and wastewater services. Unlike other similar life-critical programs—such as supplemental food and heating assistance—no federal low-income assistance program for water and wastewater exists. This missing piece, combined with rising water and wastewater bills is further exasperated by growing income inequality, meaning too many households are at risk of loss of service. It also means public utilities, working to avoid shutoffs at all costs, must deal with growing numbers of delinquent accounts and lost revenue. Neither situation is sustainable.

As we look to the next 50 years of the CWA, ensuring access to water service and that utilities are resilient and sustainable is paramount. NACWA looks forward to continuing to work on these critical issues.

Steve Dye, Director
of Legislative Affairs,
WEF

Congress Taking Hard Look at PFAS

By Steve Dye

Over the last year, Congress has taken a hard look at what the federal government can or should do to help address PFAS in our environment. EPA has also started a process to take some regulatory actions in the coming months. WEF has been closely monitoring these activities and directly involved with some of the policy proposals under consideration. WEF's members also recently provided a groundswell of grassroots outreach by sending more than 1,000 letters to Congress when it was considering, including provision in the 2020 National Defense Authorization Act (NDAA).

PFAS is a huge concern for the sector, and we want to find technical and regulatory solutions to remediate it in treatment works and biosolids management. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund, has been proposed as a possible regulatory avenue, but the wastewater sector has concerns about using that path without assurances that wastewater utilities and biosolids management programs will not be held liable. According to legal reviews of the statute, utilities could be held liable as a potential responsible party (PRP) although they are not the producers of the PFAS. Wastewater utilities are "receivers", not "producers" or "users" of PFAS, and therefore should not be considered a PRP under CERCLA.

The final NDAA dropped a provision that would have included PFAS in CERCLA, but it is expected that Congress will consider including CERCLA and other regulatory statues in legislation in 2020.

Additionally, on Dec. 3, the EPA transmitted to the White House Office of Management and Budget a proposed regulatory determination for PFOS and PFOA in drinking water under the SDWA. This step sets in motion the process of adding PFAS to fourt4h Contaminant Candidate List (CCL4) of SDWA.

As any legislative or regulatory actions moves forward, WEF will be communicating with the public and policy makers how the clean water sector may be impacted. PFAS is a serious concern to communities nationwide and the clean water sector wants to be a partner in remediating this challenge. WWD

Bob Crossen is senior managing editor for WWD. Crossen can be reached at bcrossen@sgcmail.com.

RICHTER RESILIENCE

By Greg Womble

Oregon water treatment plant expansion includes seismic resiliency elements

How do you design a water-delivery pipeline for an area that has averaged nearly one earthquake per week during the past year? Very carefully.

Most agree that Oregon, with its breathtaking mountains and rugged coastline, is a scenic wonder. Yet the geologic forces that make it so spectacular also make it one of the most earthquake-prone spots in the country.

Take, for example, the Hillsboro, Oregon, area. Located a half-hour drive from Portland, it has been the scene of 49 recorded earthquakes from August 2018 to August 2019. Most measure less than a 2-inch magnitude, but the fact remains: any new construction requires innovative planning, design and implementation to remain resilient in the midst of regular seismic activity that has become common to the area.

This was the challenge for Oregon's Joint Water Commission (JWC), which is owned in partnership by the cities of Hillsboro, Forest Grove, Beaverton, and the Tualatin Valley Water District. JWC currently treats, transmits and stores drinking water for more than 365,000 customers and operates the largest conventional water treatment plant in Oregon. However, due to population growth, JWC needed to strengthen the water plant infrastructure and increase capacity from 75 million gallons per day (mgd) to 85 mgd, while factoring in a potential future capacity of 105 mgd.

To meet the challenge, American Cast Iron Pipe Co. sales engineers, along with distribution partner Ferguson Waterworks,

worked closely with project engineering firm Jacobs (formerly CH2M), general contractor Slayden Constructors Inc.—a subsidiary of MWH Constructors—and JWC to design a ductile iron pipe system to achieve the the water commission's aggressive goals.

The state of Oregon requires new and retrofitted construction to meet rigorous seismic safety standards, so this project set a precedent for earthquake-resistant treatment plants in the Pacific Northwest.

"We provided a variety of 24-inch to 48-inch Flex-Ring pipe and fittings," said Jeff Blakely, American senior sales engineer. "The design we helped develop is capable of withstanding 22 inches of permanent ground deformation due to liquefaction (a destabilization that occurs when saturated soil loses its firmness) during a seismic event."

Robert Montgomery is senior project manager for Slayden Constructors Inc. He noted the relationship between the pipe company and engineering firm prior to the project helped meet goals.

"American came out and did a class for our installation people because the earthquake-resistant system is such a new thing," he said. "That was very helpful. Jeff Blakely and his team have been very responsive."

The project was completed via an alternative delivery model known as construction manager/general contractor. This method allows the owner to engage a construction manager during the design process to provide construction feasibility input. According to the U.S. Federal Highway Administration, this allows the construction manager to "provide input regarding scheduling, pricing, phasing and other input that helps the owner design a more constructible project" during the design phase. Between 60% and 90% design completion, the owner and construction manger then negotiate a guaranteed maximum price for the project based on scope and schedule.

The project was scheduled for completion in October 2019, but ran into some delays. It is now expected to be completed in January 2020. According to JWC's October update, the filter structure underdrain was completed, and the filter media, specifically anthracite and sand, were installed. Ongoing aspects of the project include the installation of the communication network and electrical equipment as well as the installation of the final filter structure architectural details.

Despite the delay, the drinking water produced by the JWC Water Treatment Plant continues to meet and exceed all compliance standards set by the U.S. EPA Safe Drinking Water Act. WWD

- To learn more about this project, visit bit.ly/JWCWaterExpansion.
- Oregon earthquake data can be found at https://earthquaketrack.com/us-or-hillsboro/recent.

Greg Womble is a freelance writer for American Cast Iron Pipe Co. Womble can be reached at gregwomble@gmail.com.

Struvite Strife In Bethlehem

By Jack Lawrence

Pennsylvania water treatment plant battles struvite deposits in internal distribution pipe

Sometimes, the efficient operation of a wastewater treatment facility comes down to a few pipes. If the flow in those pipes is reduced by a buildup of minerals like struvite, the operation suffers.

Such was the case at the Bethlehem (PA) Wastewater Treatment Plant (WWTP). Struvite had accumulated inside the three 8-inch, ductile iron overflow pipes between the three primary digesters and the secondary digester, choking the flow in the gravity-fed over a 25-foot run. This created operational headaches, continuously clogged the pipes and created backups. It became a daily challenge to keep the digested sludge flowing.

Struvite: A Challenging Adversary

Struvite buildups are a common problem. This crystalline structure composed of magnesium, ammonium and phosphate is a natural byproduct of wastewater treatment. Over time, struvite can accumulate in pipes, valves and pumps, creating a thick buildup as hard as concrete—and almost as stubborn to remove. Similar buildups can occur with other minerals, including vivianite (hydrated iron phosphate) and limestone (calcium carbonate). Typical areas for struvite to form include anaerobic digesters and associated pipes, valves, pumps and mixers; dewatering equipment; filtrate and centrate piping, valves and pumps; plant centrifuges; and heat exchangers. Over time, these buildups can dramatically reduce plant efficiency, increase unplanned downtime, shorten equipment life spans and increase energy use. They also resist removal using traditional maintenance methods.

The location of the pipes at Bethlehem's digesters added to the challenge. Installed when the plant originally was constructed in the 1950s, the pipes were cemented into the structure, making replacement difficult. While the digesters had undergone major upgrades in 2017, these original pipes were not part of the project. A cost estimate to replace the three pipes came in at more than $80,000 and would have taken each primary digester out of service for up to a month. Not only was this cost and timeline not feasible, but there was no guarantee the replacement pipes would no longer experience the same struvite buildups.

The Struvite Fights Back

In an effort to keep the struvite at bay, Bethlehem contracted with an outside "Rooter" vendor to attack the buildup with high-pressure water jets at a cost of about $1,500 a visit. Over the course of a year, the facility spent about $20,000 on these

services attempting to unclog the pipes. But the struvite continued to build up, making the pipe openings narrower and narrower.

The maintenance staff even tried to remove the struvite by using a length of steel conduit to chisel it out of the pipe, with little success. "The stuff is like cement," said Maintenance Supervisor Drew Buskirk. Not only is the struvite hard, but it adheres to whatever is put in the pipe, so staff had to be careful not to end up with a piece of conduit stuck in the pipe, making matters worse.

When the staff decided to try mechanically drilling out the bottom of the pipes, two floors below, it was the facility's and operator's first look at just how extreme the struvite buildup had become. While the opening at the top was constricted by a few inches, the bottom of the pipe was about 90% blocked with an opening of about 1 inch in the worst case. This was a real wake-up call. The struvite was gradually blocking the pipes and no attempts to remove it seemed to work. Bethlehem needed a different approach, and management was willing to consider just about anything.

Chemical-based Approach

Workers heard about a new method of struvite removal by an industry salesperson, who mentioned a company in New Jersey called Grignard Company. This company had developed a proprietary chemical-based process that purported to remove struvite quickly and effectively. The documentation provided looked promising, so facility managers met with Grignard to learn more.

The process employs a proprietary chemical that binds with the magnesium ions in the struvite, breaking the molecular bonds of the struvite, removing it in solution and capturing it for proper disposal off-site. While other chemical methods have been used to remove struvite, such as ferric chloride (inorganic metal acid), these are not always effective and introduce hazardous, corrosive materials into the digesters, potentially impacting sludge quality and damaging equipment. The Grignard Company chemistry is non-corrosive, non-toxic, non-flammable and operator safe, with no hazardous fumes.

Struvite is a crystalline structure of magnesium, ammonium and phosphate that commonly builds up in pipe networks and is resistant to traditional maintenance methods for removal.

The chemical-based process for removing struvite in pipe has been successful for the Bethlehem Wastewater Treatment Plant's internal distribution lines.

Methodical Process

Bethlehem managers gave the Grignard team the go-ahead and scheduled the project. The first step was a thorough inspection by the team to plan the project, which was estimated to take five days, cleaning one pipe at time to minimize disruptions to regular operations. The pH of the sludge was tested to assess the mineral composition and determine the dosing rate of the "struvicide" product and to establish a baseline to assess progress during the process.

The set-up for the work was straightforward. Bethlehem WWTP provided a balloon inlet cap for introducing the product at the top of the pipe and a flange at the bottom of the pipe with a 2-inch connection to facilitate recirculation back up to the top. Three 275-gallon totes of the struvicide product and a pump, supplied by the contractor, were placed by crane on the roof at the top of the pipe run.

Once everything was in place, the Grignard team introduced the product into the first pipe, recirculating it for eight hours. At the end of the day, the pipe was allowed to soak overnight. The following day, the pipe was flushed, and the contents pumped back into the tote for disposal. This process was repeated for the other two pipes in turn, so that the plant always had two pipes operational during the project. Throughout the process, we could see that the color of the liquid in the tote was changing, as the struvite in solution was recirculated into the tote. The pH was measured during the process, allowing the contractor to determine when the process was complete.

Free of Struvite

At the end of the project, Bethlehem inspected the pipes and found they were now approximately 99% clean of the struvite. To see the pipe restored to almost new condition so quickly and with little impact on operational efficiency satisfied the WWTP.

The next concern was how to avoid future struvite problems. Here, too, Grignard had a solution: a struvicide formula designed for preventive maintenance use. This nontoxic product is fed directly into the digester sludge feed line on a daily basis to prevent buildups of struvite and scale. It is formulated to go through the plant process and has had no impact on the sludge nor on dewatering in the centrifuges. Operators continue to inspect the pipes and the struvite accumulation seems to be under control.

Since performing the removal, the Bethlehem WWTP has experienced no backups or foaming issues or rags clogging in the pipe—all common occurrences before the project. With a proven strategy for winning the struvite battle, operators and workers can focus time and energy on its core mission: meeting the wastewater treatment needs of the Bethlehem community efficiently and cost-effectively. WWD

Jack Lawrence is the superintendent for Bethlehem, Pennsylvania Wastewater Treatment Plant. Lawrence can be reached at jlawrence@bethlehem-pa.gov.

Top: Pipe clogged by struvite.
Bottom: Pipe after struvite chemical treatment.

ALARMING SUPPLY IN THE ARCTIC

By Steve Cooper

Miles of new pipe brings freshwater to the arctic

Alaska's Department of Environmental Conservation discovery of sulfolane and per- and polyfluoroalkyls (PFAS) in the local drinking water wells of North Pole, Alaska, led to two new wells being dug outside of the 2-mile by 3-mile underground water plume.

To deliver the fresh water to the nearly 2,200 inhabitants of the city 14 miles southeast of Fairbanks, a high-density polyethylene (HDPE) potable water pipeline was installed. The 181,000 feet of PE 4710 IPS DR 11 HDPE pipe with a pressure rating of 200 psi in various diameters from Pipeline Plastics LLC provides a leak-free, seismic-resistant supply line. The project included both open cut as well as boring to install the 6-, 8-, 10-, 12- and 16-inch diameter pipe. To ensure uninterrupted water service even during Alaska's harsh winters, the HDPE pipe was pre-insulated with polyurethane foam.

In all, the $52.1 million project will consist of 35 miles of pipe, expansion of the North Pole water treatment plant and a 750,000-gallon potable water reservoir. Service connections at nearly 700 homes and businesses will be added once the system becomes operational. Two of the four zones had been completed by June 2019 and all work is expected to be done during 2020.

The effort won the Project of the Year Award for the Plastics Pipe Institute Inc.'s (PPI) Municipal and Industrial Division. PPI is the major North American trade association representing all segments of the plastics pipe industry. The North Pole project team also included Wolseley Industrial Group/Ferguson (Distributor), Stantec (Design Engineer), Arctic Insulation (Fittings, Accessories) and Exclusive Paving of Fairbanks (Contractor).

"The North Pole water distribution project went through a few iterations prior to the formal tender," said Matt Theilken, national sales manager of Thermacor Process, Inc., the pre-insulator of the HDPE pipe. "We looked at a range of carrier pipe materials, but in the end, HDPE made the most sense for the project.

To provide a reliable water source for North Pole, Alaska, the city installed 35 miles of pipe as well as a 750,000-gallon reservoir totalling $52.1 million.

When looking at the life expectancy of a system, HDPE provides the best value and the longevity one would expect from such a large capital expenditure. The goal of the project was to build and install the pipeline from Fairbanks to North Pole and have 3 inches of insulation and jacketing around it. This would protect the pipe and keep the water from freezing as it's transferred from Fairbanks."

HDPE pipe is corrosion-resistant, which contributes to its long useful life. Theilken said he and the team added insulation and freeze protection for this application due to the conditions the pipe would endure. For this, the team used a high-density polyethylene jacket that had been manufactured from the same resin as the pressure pipe, PE 4710.

"The pipe is preheated prior to the spray application of the polyurethane foam," he said. "It's a reaction process, which makes the bonding of the foam to the pipe and jacket permanent. We use a side-head extruder to put the jacket directly on to the foam."

A 10- to 12-inch cut back is left at the end of each stick of the pipe during manufacturing at the factory. Then at the site, crew members can clamp one end with the jacket, which has a compressive strength of 40 to 50 psi so as not to damage the insulation. The join closure kit then is used to seal the joint shut.

Despite being buried, the pipe could endure temperatures as low as -30ºF. Thermal expansion and contraction are concerns that are mitigated by the burial because of the bonding of the jacket to the foam insulation and that insulation bond to the pipe.

"The integrity of the fused joint is critical in a situation where groundwater contamination is present and has shaken the confidence of the city's inhabitants," explained Camille George Rubeiz, P.E., F. ASCE, senior director of engineering, Municipal and Industrial Division for PPI. "The harshness of the weather with temperatures way below zero required a material that could provide a long service life even in this rugged Alaskan environment. The pipe is PE 4710, which is the highest performance classification of HDPE piping material for water applications. It is tough, durable and flexible, plus it meets AWWA C906 and ASTM F714 standards. PE 4710 HDPE pipes provide zero-leakage, conserving water and preventing infiltration

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Linda County Water District, Olivehurst, CA

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To accommodate freezing conditions, workers wrapped in a 3-inch insulation jacket around the high-density polyethylene pipe installed in North Pole, Alaska. Seismic activity also is a regular occurrence and despite more than 200 quakes registering 1.5 magnitude or greater, the pipe continues to function as intended.

of contaminated water as was found at the North Pole."

The strong heat-fused joint between the 50-foot lengths of pipe plus the flexibility of the PE 4710 pipe protects the entire pipeline from natural disasters, seismic activity and even earthquakes with enough magnitude to register on the Richter scale.

On May 29, 2019, a 2.6 magnitude earthquake hit the area, some 60 miles from North Pole, Alaska. During the past 365 days, the area has had 232 earthquakes registering 1.5 magnitude or greater.

"With nearly 34 miles of pipe being installed, it was imperative that each and every foot be able to withstand any seismic shift here at the North Pole," Rubeiz stated.

Tony Radoszewski reiterated the extreme conditions in which this pipe was installed and the importance of this project for delivering potable water to the community.

"The City of North Pole, Alaska is in a sparsely populated, rugged environment with severe temperature swings, and unfortunately, contaminated water," offered Tony Radoszewski, CAE, president of PPI. "When both groundwater and the local lake test positive for action level contaminats, the community is in trouble. But the new HDPE pipeline system will provide complete isolation from the contaminates at the North Pole, insulate the water from the temperature and environment, be able to survive the annual freeze and thaw cycle of the ground, and even provide uninterrupted service after occasional seismic activity that is frequent in the area." WWD

Steve Cooper is a writer for SCA Communications. Cooper can be reached at steve@scacommunications.com.

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MISSION COMMUNICATIONS

DISINFECTION BYPRODUCT FILTRATION

By Christy Bostardi

Installing granular activated carbon today to prevent regulatory issues in the future

In 2010, Shelby County Water Services (SCWS) was planning for the future. With new regulations on the horizon, SCWS determined the Talladega/Shelby Water Treatment Plant (WTP) in Shelby County, Alabama, needed more effective removal of disinfection byproducts (DBPs). Specifically, the treatment plant needed help complying with the new U.S. EPA Stage 2 Disinfection Byproduct Rule (DBPR).

SCWS serves both retail and wholesale customers. The active wholesale customers, Alabaster, Pelham and Sterrett-Vandiver, sell significant amounts of water from SCWS to their customers. The number of SCWS retail customers, primarily located in Westover, Chelsea and the subdivisions of Eagle Point, Greystone, Forrest Park, Forrest Lakes, Mt. Laurel, Regent Park, Villas Belvedere and Highland Village, grew from about 3,200 in 2001 to more than 10,500 in 2010. Part of that increase was attributed to the acquisition of customers from the former Westover Water Authority, which merged with SCWS in 2007.

SCWS gets water from Lay Lake on the Coosa River and treats the water in two facilities: Talladega/Shelby WTP and Shelby County South WTP. The Shelby County South

plant near Wilsonville is owned and operated by Shelby County and began production of drinking water treated with granular activated carbon (GAC) for DBP removal in 2008.

Over the course of the following year, SCWS considered GAC and ion exchange for use at the Talladega/Shelby plant to ensure compliance with Stage 2 DBPR regulations. Based on its analysis, the county concluded the cost and performance of a GAC system would be similar to the other options, assuming the carbon lasted at least one year before requiring reactivation.

Another consideration in the analysis was the location of the Talladega/Shelby plant because the remote location and lack of septic sewers favored a technology that resulted in minimal waste. Waste from the plant flows through a series of settlement lagoons and eventually is discharged into the Coosa River. These waste lagoons were not designed to treat high levels of color, total dissolved solids or salt, which can be typical of ion exchange waste. Furthermore, the Alabama Department of Environmental Management indicated a concentrated waste discharge would require special permits and significant testing for compliance. For these reasons, SCWS was drawn toward the GAC system, which characteristically results in little waste.

The county's cost analysis showed the GAC filter design necessary to effectively remove DBPs for a full year before requiring reactivation. Calgon Carbon proposed its newest and largest GAC adsorption system, the Model-14. This system, equipped with two vessels that hold 60,000 pounds of GAC each, was developed as SCWS evaluated how best to upgrade the plant. Birmingham-based Municipal Consultants Inc., who played a large role in the design process for the plant, took notice of the new system.

"When Calgon Carbon released the 60,000-pound vessels, we were able to reduce the number of vessels we needed down to four," said Chris Cousins, president of Municipal Consultants. "This saves money because with the larger size, we only have to reactivate two of them every fiscal year."

In the end, the plant installed four of the 14-ft diameter Model-14 pressure vessels over a 10-month period. Filtered water is pumped through the GAC to remove the natural organic matter (NOM) from the source of water before disinfection, preventing the formation of DBPs. The system is designed to allow plant operators to pump either all or part of the filtered water through the vessels in either parallel or series operation.

Approximately every year, the county sends the spent GAC from two vessels to Calgon Carbon for custom reactivation. The spent GAC is transported to one of Calgon Carbon's custom reactivation facilities, where it is thermally reactivated to remove adsorbed contaminants and restore its adsorption capacity. The filtration media company then returns and installs the reactivated carbon (including a small amount of virgin GAC to make up for losses in reactivation) into the Talladega/Shelby vessels. The entire reactivation process is performed according to the latest NSF and AWWA standards governing the reactivation of

Shelby County Water Services selected granular activated carbon vessels that hold 60,000 pounds of granular activated carbon each to treat its water and comply with U.S. EPA Stage 2 DBPR standards

GAC used for drinking water treatment.

Ultimately, GAC was a wise selection of the treatment options that were considered because GAC is an effective removal technology that accomplishes more than just DBP compliance. GAC not only removes targeted contaminants of concern, such as natural organic matter (NOM) and DBPs, but it also acts as a defense barrier against accidental contamination by unregulated compounds like perfluorinated compounds (PFCs), pesticides and a number of other contaminants listed on the U.S. EPA's Contaminant Candidate List 4 (CCL4).

Since the installation of the Model-14 vessels with GAC at the Talladega/Shelby plant, DBP levels throughout the distribution system have remained in compliance. Installation of the GAC systems preempted the impact of the Stage 2 DBPR, ensuring Shelby County's water was in continuous compliance during the transition from Stage 1 to the more stringent Stage 2.

The affordability of the proposed solution,

the availability of custom reactivation services and the large vessel design all were factors in SCWS's choice to work with Calgon Carbon, according to Michael Cain, manager of water services for Shelby County.

"This was supplied as a complete system: carbon, vessels, pipes, pressure vessels and all," Cain said. "Calgon Carbon has proven to be the right choice."

What are DBPs & Why Are They Regulated?

Disinfecting water using chemical agents, such as chlorine is an essential part of public health, because it protects consumers from disease-carrying microorganisms. However, disinfectants react with NOM in the water to form compounds called DBPs. DBPs have been linked to a number of human health concerns and have been regulated by the U.S. EPA.

Some alternative disinfectants, such as chloramines and ozonation, do reduce the level of regulated DBPs but result in new, currently unregulated and still toxic DBPs. Many municipal water providers are taking the step of removing NOM from water before adding disinfectant chemicals, preventing the formation of both regulated and unregulated DBPs. Granular activated carbon (GAC) is one of the most commonly applied technologies used to remove NOM from water.

The U.S. EPA's Stage 2 DBPR requires water systems meet disinfection maximum contaminant levels at each monitoring site in a distribution system.

What is Custom Reactivation?

Calgon Carbon has a dedicated NSF-approved reactivation plant in North Tonawanda, New York, that serves customers east of the Mississippi River.

This facility is used for custom municipal reactivation, meaning every customer's carbon is segregated and processed separately from other customers' carbon. During the reactivation process, organic compounds captured by GAC are destroyed when subjected to high temperatures that, at the same time, restore the GAC to a near-virgin state. This resulting reactivated product results in a cost savings. The reactivation/recycling process also is better for the environment, with a reduced CO_2 footprint compared to the manufacture of virgin-activated carbon.

Not only is granular activated carbon effective at removing disinfection byproducts, but it also removes natural organic matter, pesticides and perflourinated compounds.

Model 14 Adsorption Vessels

Calgon Carbon's Model-14 adsorption system uses GAC to remove dissolved organic contaminants, such as DBPs and NOM, from liquids. These vessels can hold up to 60,000 pounds of GAC providing the additional contact time to remove either compounds at low concentrations or poorly adsorbing compounds.

It is designed with one GAC fill line and three GAC discharge lines positioned to extract 20,000 pounds of spent carbon each. The arrangement of the discharge lines facilitates efficient GAC exchanges in three easily removed increments. In addition, three nozzles along the straight side of the vessel can be fitted with in-bed sample assemblies to allow the operator to monitor the mass transfer zone of the adsorbate through the bed.

The standard system is a single vessel, and typical designs include several single vessels operated in parallel. However, two vessel systems can also be provided for lead-lag operation. WWD

Christy Bostardi is marketing manager of drinking water solutions for Calgon Carbon. Bostardi can be reached at cbostardi@calgoncarbon.com.

NO FOUL PLAY

By Nik Mehta

Field performance of low-fouling reverse osmosis membranes

As global water demand rises and discharge regulations tighten across many industries, water treatment through membrane desalination is becoming increasingly more common. While developments in membrane treatment capabilities continue to allow for more difficult feedwaters to be purified using membranes, these feed streams can pose a unique challenge for operators: membrane fouling. Membrane fouling occurs when particulate in the feed stream is deposited onto the membrane surface, leading to permeate flux decline. This translates to increased system downtime for membrane cleaning and more frequent membrane replacements due to shorter lifetime.

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In 1977, John Cadotte developed and patented the first fully aromatic cross-linked polyamide RO membrane... Compared to previous RO membrane designs, such as asymmetric cellulose acetate membranes and early composite RO membranes, the fully aromatic cross-linked polyamide RO membrane marked a major step forward and quickly became the industry-standard for RO desalination.

membrane lifetime on challenging feed waters, companies like Microdyn-Nadir offer low-fouling polymeric brackish-water reverse osmosis (RO) membranes with proprietary membrane chemistry. While most commercially available RO membranes use a polyamide thin-film barrier layer as the final membrane layer, the TRISEP X-20 low-fouling RO membrane has a polyamide-urea barrier layer that exhibits low-fouling properties. This membrane is not only different when compared to standard polyamide RO membranes, but is also differs from most other low-fouling RO membranes on the market today. This is because X-20 uses a custom synthesized monomer in the make-up of the membrane surface, as opposed to a simple treatment or surface coating that is common to most other low-fouling membranes.

Membrane Development & Chemistry

In 1977, John Cadotte developed and patented the first fully aromatic cross-linked polyamide RO membrane. This membrane demonstrated both mechanical and chemical durability and exhibited very high flux and rejection rates. Compared to previous RO membrane designs, such as asymmetric cellulose acetate membranes and early composite RO membranes, the fully aromatic cross-linked polyamide RO membrane marked a major step forward and quickly became the industry-standard for RO desalination. Nearly all RO membranes commercially available today use the membrane chemistry developed by Cadotte as a basis. While significant improvements to rejection and flux performance have been made over the years, the standard polyamide RO chemistry remains susceptible to irreversible fouling from organic material, scale, and particulate matter in the RO feed stream.

After a relentless development effort, X-20 low-fouling RO membrane was commercialized by TriSep Corp. (later acquired by Microdyn-Nadir). This membrane not only achieves 99.5+% NaCl rejection and high permeate flux, but also exhibits low-fouling properties. While the backbone of X-20 membrane is still a fully aromatic polyamide polymer, the surface chemistry of the membrane is made using a custom synthesized monomer that is quite different from the acid chloride monomer used in standard polyamide RO membranes, thus dubbing it a polyamide-urea membrane layer. Amino functional groups are present on the membrane surface instead of carboxylic acid groups. Within its wide operating pH range, these amino groups on the X-20 membrane surface are neutral, while the carboxylic acid groups on

Parameter	Description
Design Recovery	78% System (81.7% Overall)
RO Permeate Flow	5.2 mgd (19,500 m³/day)
Blended Permeate Flow	6.5 mgd (24,500 m³/day)
Feed TDS	2,201 mg/L
RO Permeate TDS	34 mg/L
Operating Flux	10.1 gfd (17.2 lmh)
RO Membrane Element Lifetime	11+ Years

Table 1 – Valencia Tertiary Treatment Plant RO System Parameters

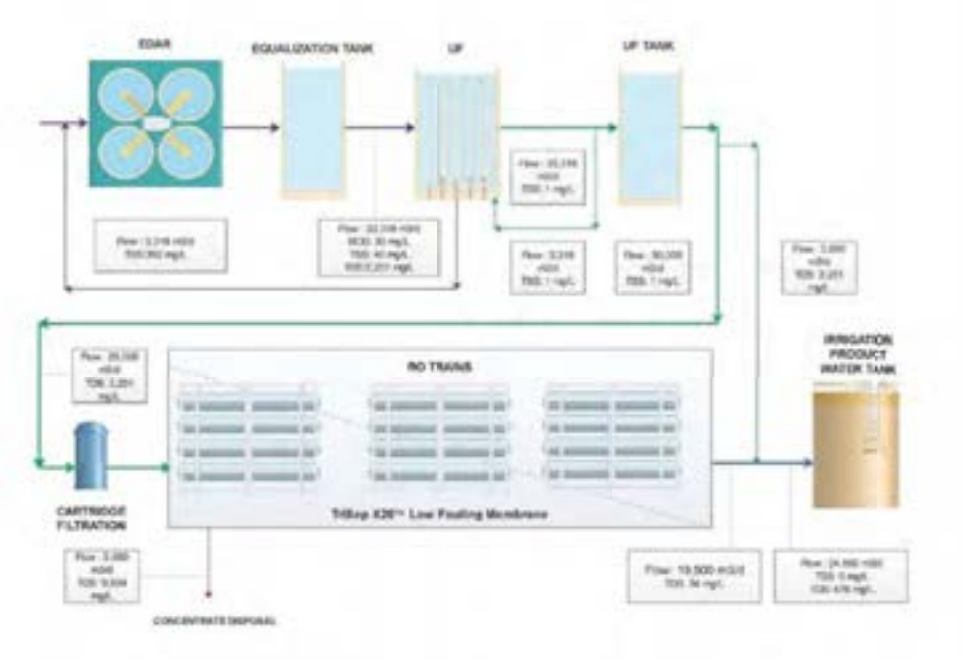

Figure 1 – Process flow diagram of the Valencia tertiary treatment plant.

Parameter	Description
Design Recovery	75% System (83.3% Overall)
RO Permeate Flow	5.9 mgd (22,500 m³/day)
Blended Permeate Flow	6.6 mgd (25,000 m³/day)
Operating Flux	11.1 gfd (18.8 lmh)
Feed Conductivity	2,800 µS/cm
RO Permeate Conductivity	< 100 µS/cm
RO Membrane Element Lifetime	4 Years

Table 2 - Operating Parameters of the Alicante Tertiary Plant RO System

A bird's eye view of the Alicante tertiary treatment facility in Spain. The reverse osmosis membranes were selected as they would better handle the solids passing through the ultrafiltration membranes.

standard polyamide RO membranes are negatively charged. Foulants are significantly less likely to adhere to the neutral X-20 membrane surface than the negatively charged standard polyamide RO membrane surface.

Most membrane manufacturers market low-fouling membranes, however there is a significant difference between X-20 and competitive fouling resistant membranes. Most competitive low-fouling RO membranes are comprised of a standard polyamide polymer that has been treated or surface coated with a secondary chemical - this secondary coating gives these membranes their low-fouling characteristics. In these membranes, there is minimal bonding between the polyamide polymer and the chemical coating. While this coating may temporarily affect the fouling nature of the membrane, there is potential for the coating to be removed due to frequent and aggressive membrane cleaning in high-fouling applications. X-20 membrane instead obtains its permanent low-fouling characteristics from its fully cross-linked co-polymer backbone composition that cannot be removed over time due to membrane cleanings.

Valencia, Spain – Wastewater Treatment Plant

A major municipality in the community of Valencia, Spain, has been a pioneer in the treatment and reuse of effluents with its wastewater treatment plant. The effluent plant has increased in size over the years, with the incorporation of a tertiary membrane treatment plant.

Prior to it, product water conductivities in excess of 2,000 microSiemens per centimeter (µS/cm) affected the reuse objective (crop yields), resulting in diminishing effluent reuse quotas. The objective of the membrane plant is to guarantee a consistent permeate flow and quality suitable for irrigation. Secondary effluent sent to the membrane plant is first fed to an equalization tank and is then treated by ultrafiltration. Following cartridge filters, the RO system purifies and desalinates the water, which then is blended with ultrafiltration (UF) permeate for reuse. Table 1 and Figure 1 (page 32) show the details of the membrane system.

The low-fouling membrane elements were selected for the RO treatment system downstream of the UF system. The two-stage RO system operates at a flux of 10.1 gallons per square foot per day (gfd) and a recovery of 78%, with a total permeate flow of 5.2 million gallons per day (mgd). The system consistently produces permeate with a salinity of approximately 34 milligrams per liter (mg/L) and a conductivity of less than 60 µS/cm. The original membrane elements have been in continuous operation for more than 11 years without being replaced.

These elements produce consistent permeate flow and quality with limited cleanings, and the cleanings that are performed are mainly due to seasonal water quality changes. RO membrane elements typically represent 20 to 30% of the RO equipment capital cost. The X-20 elements in this system have lasted more than twice the standard lifetime that architectural and engineering consultants typically account for in RO tertiary treatment plants.

Alicante, Spain – Wastewater Treatment Plant

Increased growth in the region of Alicante, Spain, lead to the implementation of a plan to develop and reuse the region's water resources. A tertiary treatment facility was constructed at the wastewater treatment plant of a major municipality that incorporates a lamella clarifier, ultrafiltration (UF) membrane system, and an RO system. The treated municipal water from the RO system is blended with UF permeate and used for irrigation water for produce in the l'Alcantí and

Reverse Osmosis (RO) System	Parameter	Description
Main RO System	Design Recovery	75.0%
	RO Permeate Flow	3.3 mgd (12,600 m3/day)
	Operating Flux	11.3 gfd (19.2 LMH)
	Feed TDS	1,120 mg/L
	RO Permeate TDS	10 – 30 mg/L
Brine Recovery RO System	Design Recovery	60.0%
	RO Permeate Flow	0.57 mgd (2,160 m3/day)
	Operating Flux	10.9 gfd (18.4 LMH)
	Feed TDS	5,800 mg/L
	RO Permeate TDS	100 - 130 mg/L

Table 3 - Operating Parameters of the Boiler Water Plant RO Systems

Pilot testing of reverse osmosis membranes at an oil refinery in the southeast of Spain compared salt rejection and permeate flux. Ultimately the facility chose the X-20 membrane for its low-fouling properties.

Medio Vinalopó areas. Table 2 (left) shows the operating parameters for the RO system at this plant.

X-20 membrane elements were chosen for this system in part due to reports of solids passage through the UF (fiber breakages), causing RO cartridge filters to require replacement on a frequent basis. Early on, these solids breakthroughs to the RO led to frequent membrane cleanings. Despite these initial pretreatment issues, the X-20 membrane elements recovered flow and operate at 11.1 gfd with 75% recovery and consistently produce permeate with a conductivity less than 100 µS/cm. The unique surface chemistry of X-20 membrane leads to less overall fouling of the membrane elements and better flow recovery following cleaning. The tertiary treatment plant, including robust desalination with X-20 membrane, continues to provide the region with high quality water for irrigation.

Southeast Spain – Oil Refinery Boiler Water Production Plant

In an effort to increase the processing capacity of crude oil and reduce costs at a major oil refinery in Southeast Spain, the refinery proceeded with an expansion project which included construction of a boiler water production plant. Canal water is mixed with wastewater from the refinery's effluent plant and undergoes clarification, sand filtration, RO, ion exchange, and polishing for use in the refinery's boilers. The brine from the initial reverse osmosis system is fed to a brine recovery RO system for additional water recovery. Table 3 (above) shows the system details of the main RO and brine RO system.

To select the most effective RO membrane element for use in the RO system, an extensive pilot testing phase was conducted, comparing the salt rejection and permeate flux of multiple manufacturer's membrane elements. X-20 membrane elements were selected for this system because they showed the best combination of high salt rejection and continuous high permeate flow for the duration of the study, with the least decline in permeate flow over time on the high-fouling feed water.

The main RO system is fed with effluent from the sand filtration step. This system takes the 3.3 mgd feed with a salinity of 1,120 mg/L and recovers 75% of the water with a permeate salinity of 10 to 30 mg/L. The 5,800 mg/L salinity brine from the main RO system is then fed to a second RO system that is able to recover an additional 60% of the brine.

The permeate from the RO systems is sent to ion exchange and further polishing for use in the refinery's boilers. The consistent high quality permeate from both the main RO system and brine RO system demonstrate the ability of X-20 membrane elements to perform in high-fouling industrial wastewater applications.

Conclusion

The low-fouling RO membrane was developed to solve one of the major pitfalls of standard polyamide RO membranes: susceptibility to irreversible fouling from organic material, scale, and particulate matter in the RO feed stream. While there are many low-fouling membranes that are a standard polyamide membrane with a surface coating available, the low-fouling characteristics of X-20 membrane are different, as they come from the fully cross-linked co-polymer backbone composition that cannot be washed away from aggressive cleanings.

This membrane has showed success treating high-fouling wastewaters at the Valencia WWTP, the Alicante WWTP, the refinery in southeast Spain, and other locations. These membrane elements are in operation across the world in RO systems ranging in size from one to thousands of membrane elements. The considerable operational savings from greater uptime and lower replacement costs due to the durability of X-20 membrane elements make them an excellent choice for both municipal and industrial wastewater treatment applications. WWD

Nik Mehta is technical service manager for Microdyn-Nadir US Inc. Mehta can be reached at n.mehta@microdyn-nadir.com.

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MITIGATING MINING WATER LOSS

By Arjan Boogaards

Water reduction & water use strategies in private industry applications

With a growing, more prosperous population, the world needs more things. Things are made of basic materials, and many of those materials are mined. However, the world also needs more water, a finite commodity, which is becoming scarcer, because it, too, is needed to provide food, sanitation, goods and services for a larger and richer world population.

That is why industries around the world are learning to do more with less water, and mining is no exception. Fortunately, the technology is available to extract basic materials while cutting down on water use and protecting the environment, all while operating in an economically viable way.

Competing Demands

Water has a host of applications in mining, including mineral processing, material handling and tailings management. Increasingly, with the growing demand for mineral resources and exhaustion of more easily accessible reserves, much of today's mining activity takes place in inhospitable regions near communities and environmentally sensitive water sources. That is just one of many demands that make sustainable water management a more urgent and more challenging proposition for mining companies.

Water scarcity is becoming the new normal around the world. Already, two billion people live in water-stressed regions, and that number is expected to rise. If global society keeps using water at the same rate, the world will see a 40% freshwater shortfall by 2030, according to United Nations projects. That reality demands increasing attention to water—and how to use less of it—from every industry, including one as fundamental as mining.

Meanwhile, regulators pressure mining companies to improve sustainable operations and mitigate environmental risk. In the age of social media and increased access to mass communications for all, communities are more vocal about their gripes with neighboring industries. By its very nature, the mining sector is a large, inviting target.

Increasingly, investors, too, are showing concerns about sustainability. For now, profitability is generally top-of-mind, but a mine that sees its license to operate threatened by sustainability concerns is not a profitable enterprise in the long run. Subsequently, environmental stewardship, public health and social equity are gaining importance in long-term governance for mining operations.

Water plays a key role in all these instances. When there is less of it to go around, all users must rethink how they

Mining is an industry reliant on a heavy consumption of water. For instance, a mine in Chile required 2.5 cubic meters (660.5 gallons) of water to produce 1 ton of ore. That is the equivalent of 38.4 average-length showers in the U.S, according to Home Water Works, a project of the Alliance for Water Efficiency.

Water scarcity is not just about a lacking quantity of water that can be used for a specified purpose, it also could relate to the quality of that water failing to meet the needs for its specified purpose.

manage their water resources. Pollution issues can lead to clashes with regulators and communities. Besides the potential of stalled operations and lost revenue, the potential reputation damage and tarnished brands that come with water issues may cause investors to think twice about allocating their resources to the mining industry.

Unsurprisingly, the International Council on Mining and Metals warns, "Water is one of the most significant issues facing the mining and metals industry and is a critical resource not only for all our members' operations but also for other industries, communities and the natural environment."

Helping Mines Manage Water

Naperville, Illinois-based Nalco Water, an Ecolab company, works with hundreds of mining and minerals processing customers around the world to improve water management, reduce costs and lower risks associated with water. For more than 50 years, the company has served mining companies around the world in all segments of the industry.

The company delivers its mining solutions through a combination of holistic site audits that identify and remedy challenges and breakdowns along the production process, a broad line of technologies that improve efficiency, sustainability and profitability and customized, on-site service by experienced engineers.

That model bore fruit at a copper mine in northern Chile, where improved water management delivered a $12 million profitability increase while decreasing freshwater usage by 1 million cubic meters or 264 million gallons.

Chile, which essentially is a 2,700-mile ribbon of land between the Andes mountains and the Pacific Ocean, is increasingly water-stressed. Traditionally dependent on glacier meltwater from the Andes, the country's vulnerability to water scarcity is accelerating as snow-packs and glaciers in the high mountains recede due to climate change.

But Chile also is one of the world's largest copper mining countries—an industry that requires significant amounts of water. At one specific copper mine, approximately 2.5 cubic meters (660.5 gallons) of water is required to produce 1 ton of ore. This meant it had to recirculate 300,000 cubic meters (87 million

gallons) of water per day. However, changes in water management led to increased levels of suspended solids in the process water, which in turn caused scale formations that blocked the pipes.

With critical parts of the process threatening to clog up, mine management turned to Nalco Water, which conducted a full plant audit and fed the resulting data into its Mining Optimizer software, which models how water, solids and processing chemistries interact inside water systems.

Nalco Water found that, even though the correct anti-scalant was used, the water mix was ineffective. It addressed the problem by adding or altering dosage points at strategic locations throughout the process to ensure a better water mix throughout the system. These actions were completed with live digital monitoring to keep tabs on changes in the system water and enable corrective changes in real-time, along with a new service plan to manage the changes over the longer term.

As a result, the mine upped its ability to keep scale formation in check, leading to nearly $4 million in reduced maintenance cost and a 3,000-ton growth in annual copper production. This resulted in $8.5 million in added annual revenue. The 1 million cubic meters of water saved in the process is equivalent to the annual drinking water needs of 913,000 people.

Reducing Environmental Impacts

Water scarcity is a function of water quantity and quality. You may find yourself surrounded by water, but if that water is not good enough to use or consume, your predicament is effectively identical to having no water available. For example, think of a shipwreck survivor caught out on the open ocean in a lifeboat.

This is why, for industries that use water, water quality is not just a matter of regulatory compliance. It also is part of their overall water stewardship approach: ensuring sufficient, quality water for the surrounding communities, other industrial facilities, agriculture and the natural environment.

That was the case for an open-pit copper mine in Spain, where heavy rainfall created high flows of wastewater that required constant management. The mine had already had its share of run-ins with the community over water quality concerns prior to the start of its relationship with Nalco Water a decade ago. It was specifically interested in controlling heavy metals and other contaminants in its water flows to maximize water efficiency, minimize discharge water and be maximally self-sufficient for its water needs.

After a thorough site audit, the Nalco Water team developed an action plan with a range of process optimizations and technologies. The plan included placing a full-time Nalco Water expert on-site to assist the company with monitoring and water management protocols, and a mind-set change from seeing the ponds where raw process water is gathered as regulation and equalization elements instead of just holding reservoirs. With these more effective treatments, the mine was able to remove larger amounts of solid contaminants at critical stages of the process.

Furthermore, sand filters were introduced to protect the site's ultrafiltration systems from severe fouling. More efficient membranes were installed to reduce energy consumption. Flexible monitoring protocols were adopted to account for seasonal variations, such as increasing analysis frequency in rainy periods and adding treatment programs to protect membranes in dryer seasons.

This holistic approach reduced the mine's water discharge by 40%, lowered its energy usage by 22%, extended its filtration membranes' life spans by two years and saved more than 1.1 million euros ($1.23 million USD) annually.

On top of these efficiency gains and cost savings, the mine has reduced its environmental impact and lowered its regulatory risk, which will allow it to exist in harmony with the surrounding community and safeguard its license to operate as it continues to supply society's basic materials, even in a more water-scarce world. WWD

Arjan Boogaards is senior vice president of global mining for Nalco Water. Boogaards can be reached at gmcommunications@ecolab.com.

Industrial IoT Networking

By Reno Moccia & Ray Sojka

Wireless networking in industrial IoT applications

As digital transformation continues to drive change in the mining industry, private LTE networks have emerged as the wireless technology of choice to deliver robust, reliable and secure mobile communications. According to Harbor Research, private LTE for industrial and business markets will grow more than three-fold between now and 2023, reaching nearly $70 billion in estimated annual revenue.

The Internet of Things (IoT), cloud computing, artificial intelligence (AI), predictive analytics and automation all are playing key roles in this paradigm shift towards smart mining operations with an objective to increase productivity, reduce costs and improve safety. Now more than ever, the mining environment demands wireless networks with high-availability, seamless mobility and guaranteed Quality of Service (QoS), along with the ability to support multiple applications and services simultaneously.

Private LTE networks were first adopted by the mining and utilities sectors due to the secure and reliable digital connectivity offered for IoT devices in remote areas. Essentially, a private LTE network leverages micro tower and small cells, similar to an on-site WiFi access point, to replicate the larger public network. Private LTE networks can use licensed, unlicensed or shared spectrum,

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Private LTE networks are a reliable and effective means for transmitting data and communicating information over vast distances. They can be used in safety monitoring solutions, transportation logistics system, and other machine-to-machine applications.

delivering higher quality performance and coverage than Wi-Fi. They are also more affordable to maintain, more secure and faster to deploy than Wi-Fi networks since they don't require testing and certification by a mobile network operator.

Safety monitoring, transport systems, CCTV cameras and machine-to-machine applications all are well suited for private LTE networks across a wide range of use cases. Among these are remote locations and temporary sites such as mines, power plants, water and wastewater operations and offshore oil rigs where connectivity for these environments can be challenging.

While standalone wireless networks to serve devices and users within a localized area have significantly improved performance and reliability, the rapid growth of industrial automation, especially IoT devices and autonomous vehicles, brings new challenges and opportunities for these private networks.

Massive Multiple Input Multiple Output & 3D Beamforming Advantages

In mining operations, private LTE networks enhance automation at the site and can connect personnel to vehicles and sensors,

thereby improving safety. There is no industry more vigilantly safety-conscious than mining. The high throughput and low latency offered by private LTE networks allow staff in open pit and underground mines to monitor and control critical equipment without interruption. Vehicles and heavy equipment, such as trucks, bulldozers, drills and excavators can be connected over private LTE, which offers significant performance improvements in network reliability and availability.

Even so, mining and other businesses operating in the most mission-critical, demanding and dynamic environments are striving to become an automated industry able to support a plug-and-play private LTE/5G ecosystem that can exploit the full capabilities of industrial IoT applications. Moreover, the proliferation of private LTE/5G networks due to the availability of the unlicensed Citizens Broadband Radio Service (CBRS) spectrum is set to further accelerate demand for agile networks.

In 2015, the Federal Communications Commission (FCC) opened previously protected spectrum used by the U.S. Navy and other agencies at the U.S. Department of Defense when it authorized the use of the 3.5 GHz band (3550 MHz to 3700 MHz) for shared wireless access.

The deployment of 5G network infrastructure is sure to invoke its own challenges, not least of which is the need for significantly greater capacity. Increasing spectrum efficiency is a major consideration when planning a 5G network capable of supporting connected devices and applications.

All 5G networks are expected to leverage massive multiple input multiple output (MIMO) antenna arrays and beamforming. Today, 4G networks employ MIMO capability with either two or four antennas. These create multiple radio paths between the receiver and transmitter thereby improving radio link reliability and data carrying capacity. The advances in the field have now made it possible to cost-effectively deploy larger numbers of antenna elements to further improve the radio link for capacity and reduced latency. This capability in 5G networks is referred to as massive MIMO.

Massive MIMO provides additional capabilities in maneuvering the combined radio link such as narrowing or widening the shape of combined radio link and steering in horizontal and/or vertical directions. These software-driven maneuvering capabilities are referred to as 3D Beamforming. 3D Beamforming is achieved by precisely controlling the radio link from each of individual antenna elements, with the sophisticated software. This is analogous to lighting up a theater stage, wherein without beamforming the entire stage is nearly uniformly lit up all the time. And with beamforming, appropriate sections of the stage are lit up with variable intensity spotlights as and when required.

3D Beamforming provides multiple benefits in mining and industrial environments where the radio frequency environment changes constantly and the mission critical nature of connectivity demands stringent performance requirements. These benefits include consistently providing optimized coverage aligned with the changing radio

Massive Multiple input multiple output (MIMO) systems multiply radio link capacity using multiple transmission and receiver atennas via multipath propagation.

environment and intelligently delivering radio energy where needed, when needed and at the right power level. It also lowers the system level interference, thereby increasing the overall system capacity.

Blue Danube Systems, a provider of mobile wireless access solutions, and Redline Communications, a company that offers industrial wireless broadband network connectivity solutions for mission-critical applications, collaborated to deploy 3D Beamforming solutions in private LTE/5G networks, integrating each companies' platforms and technologies. The companies also announced plans for further research and development to advance integrated solutions to transform experiences in industrial deployments.

Blue Danube's Coherent Massive MIMO solution has shown to exceed commercial wireless network improvement objectives and has demonstrated beamforming flexibility with mobile operators worldwide. The commercial evaluation with Redline is expected to demonstrate that the combined solution of Redline's baseband product and Blue Danube's massive MIMO radio can characterize and flexibly adapt to the unique radio characteristics and ever-changing footprint of industrial locations, while still meeting the latency and throughput requirements of deployed applications.

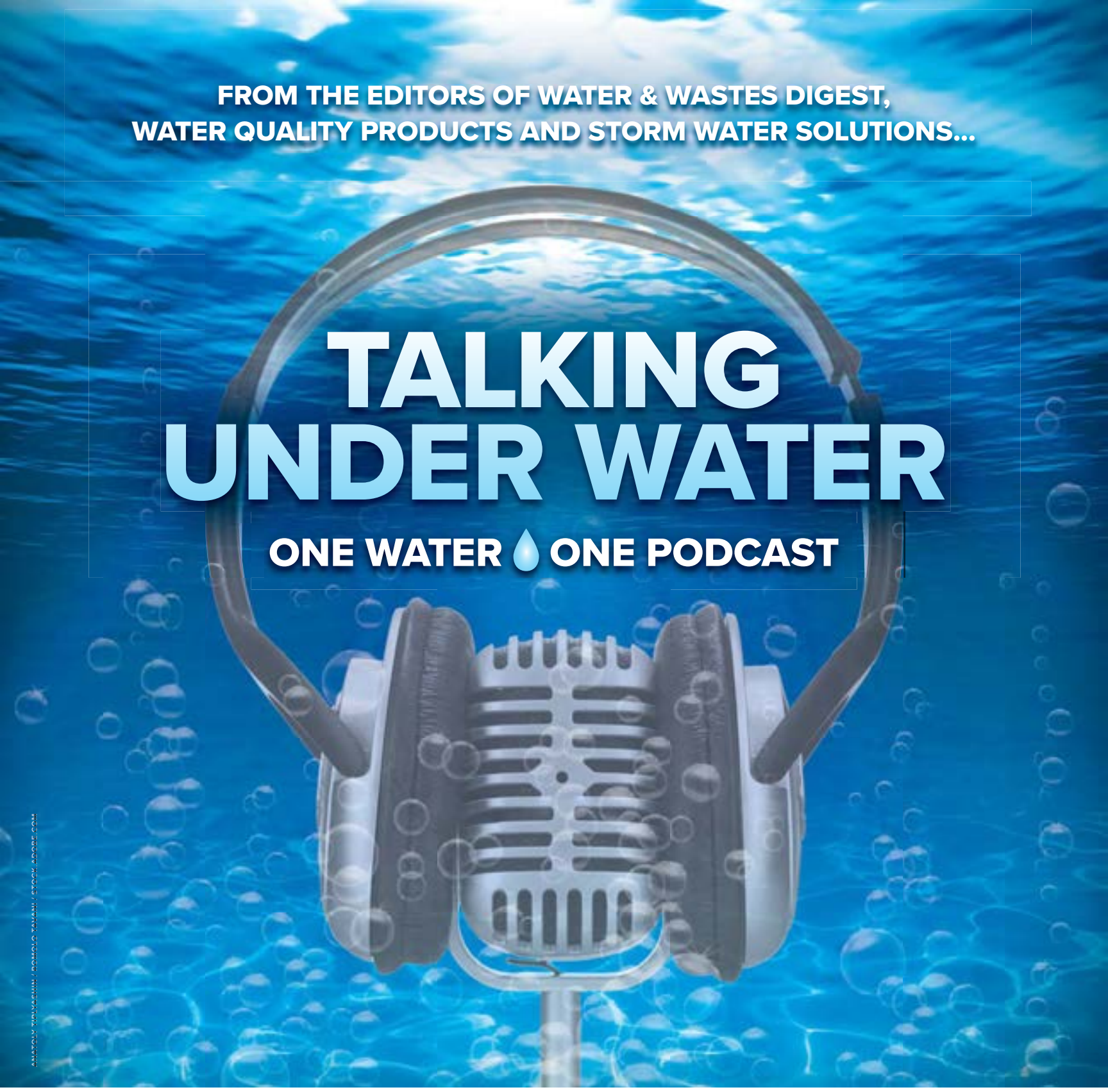
There's no question that IoT systems can dramatically improve the productivity of mining operations and the safety of personnel working at both surface and underground excavation sites. With access to real-time data and analytics, geologists, mine planners and pit controllers, as well as drilling and blasting teams can utilize visualization tools that provide 3D displays of a mine.

Industrial IoT can also automate maintenance and operations of machines and allow users to automatically transfer and receive data over a network without requiring human intervention. Remote monitoring of operations can ensure maximum efficiency and better identification of performance issues. Providing analytics to predict failures before they occur, M2M sensors can detect the real-time status of heavy equipment and vehicles. Considering the cost of an excavator going down at a mining operation can be as much as $5 million per day and losing a haul truck can mean a loss of $1.8 million per day, equipment performance has significant repercussions.

Of course, all these industrial IoT applications demand a bedrock of secure wireless networks with high-availability and seamless mobility. When high throughput and low latency are non-negotiable requirements, only a private LTE network can answer these demands.

Innovators are just at the very beginning of realizing what is possible when deploying dynamic 3D beamforming and massive MIMO radio solutions in private LTE/5G networks for industrial applications. However, when human safety and prosperity are concerned, we cannot bring about these deployments soon enough. The future of mining is digital, and it is connected. Hence, mining operations and the networks that support them need to become more agile and better prepared for the new technologies that will continue to transform this sector. WWD

Reno Moccia is executive vice president of sales and marketing for Redline Communications. Moccia can be reached at rmoccia@rdlcom.com. Ray Sojka is director of sales and strategic channel development for Blue Danube. Sojka can be reached at Ray.Sojka@bluedanube.com.



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Edward C. Little Water Recycling Facility

By Bob Crossen

California coastal facility treats recycled water for specified purposes

Location: El Segundo, California
Size: 40 mgd
Equipment: Ozonation, microfiltration, ultrafiltration, reverse osmosis, chlorination, peroxide, ultraviolet disinfection, SCADA

The Edward C. Little Water Recycling Facility was among the first plants to design its facility around treamtent for specified industrial and agricultural water uses.

When it comes to enumerating water's value, the Edward C. Little Water Recycling Facility has been developing the tools to educate, entertain and engage Los Angeles residents about water for more than 20 years, while also producing a drought-proof source for local communities.

Patrick Shields is the general manager of West Basin Municipal Water, which operates the plant, and he said the Edward C. Little facility, located in El Segundo, California, was commissioned in 1995. Initially it recycled 20 million gallons of water per day (mgd) with 15 mgd dedicated to paying users—namely industry and agriculture. The remaining 5 mgd are dedicated to the West Coast Basin Seawater Barrier and the Dominguez Gap Barrier.

These seawater barriers amount to a 9-mile stretch along the coast of Los Angeles and include 153 wells, all aimed at preventing seawater intrusion into potable groundwater aquifers. The water that El Segundo Water Recycling Facility produces for these barriers—along with other similar facilities in Los Angeles—has to meet strict, specified standards. For years, it had been imported drinking water, but now the facility treats recycled water for this purpose and still meets the drinking water standards for it.

"We're always looking to replace applications where drinking water was formerly used, and now we use highly treated recycled water," Shields said. "In the case of the barrier water, we use ultrafiltration, ozonation, microfiltration, then reverse osmosis, then peroxide dosing then ultraviolet radiation. And then some water conditioning and chlorination. It's essentially drinking water standards."

But that water is only one of five types produced at the Edward C. Little facility, as it produces disinfected tertiary water, nitrified water, low pressure boiler water and high pressure boiler water in addition to the barrier water.

Designing Water by Application

The facility uses advanced treatment equipment to handle the incoming water it receives from the Hyperion Water Reclamation Plant in Los Angelesn to produce its five types of water. Initially, treatment used was simple. The facility ran the influent through a lime clarifier to create barrier water in the 90s. That, however, has seen considerable updates in the past 25 years.

It started with microfiltration as a pretreatment for reverse osmosis (RO). Then in 2006, when the facility added 5 mgd to its barrier water production, it introduced ozone as a pretreatment to microfiltration, which in turn is pretreatment for RO.

"The water we get from Hyperion is not really the best quality—it meets standards for ocean discharge in a 5-mile outfall—but when you're introducing it to membranes, it needs considerable conditioning," Shields said. "Its organics, ammonia and TSS is really high and at times TOC can be very high, so that can foul membranes very, very quickly."

Ozone, he said, was the facility's means of addressing those quality issues. Shields said the process is energy intensive and noted operators are careful to use this treatment option properly so as not to break down compounds in TOC to the point it can then pass through the microfilters.

Following the ozonation update, Shields said the Edward C. Little Water Recycling Facility added polyvinylidene difluoride membranes and produced another 5 mgd for the seawater intrusion barrier in addition to what it had already committed. This facility, he said, is among the first of its kind and has been a model for others like it.

"We're considered, kind of pioneers, because we came and blazed the trail," Shields said. "Some folks were doing one type of recycled water or one purpose as an

Recent rennovations to the Edward C. Little Water Recycling Facility Water Education Center included updates to educational information and interactive exhibits. Since it was built in 1995, the Water Education Center has been visited by more than 100,000 school children and college students.

offshoot of the permit requirement. We went in full tilt looking at all applications and then designed parts of the treatment process around those needs."

With its capabilities to provide this variety of water, Shields noted it can adjust some of the water produced depending on the contractual obligation. For example, he said, industrial users look for ammonia-free water while agricultural users prefer to include ammonia.

Public Outreach

Naturally, the Edward C. Little Water Recycling Facility is a critical piece in providing a drought-proof water resource for El Segundo and Los Angeles, which are prone to dry spells and lack of rain.

"Now with climate change, we are subject to increasingly more severe droughts, longer droughts," Shields said. "Recycled water is a reliable source for suitable applications."

While the water it produces is not for direct potable use, Shields noted that providing recycled water opportunities means the community is not spending its potable water for irrigation or industrial applications.

Beyond providing this resource, the facility also developed outreach programs to teach the community about what it does and how it impacts the daily lives of people in the community.

When commissioned in 1995, the facility built a Water Education Center (WEC), which Shields said has been wildly popular. It has since undergone renovations with a grand re-opening in October 2019.

The updated facility now features up-to-date education information and interactive exhibits for visitors of all ages. More than 100,000 school children and college students have visited the center since its opening in the 90s.

"People are wanting to do conferences, colleges want to bring their kids over, [and] we have school programs. We have more than 3,000 kids signed up for next year already," Shields said. "From the board, it's been a policy decision to educate the public in terms about water conservation. Now we're talking about climate change and the role of recycled water."

Regardless of the topics, he said people will continue to visit, and he is happy to play a role in demonstrating water's value. WWD

Bob Crossen is senior managing editor for WWD. Crossen can be reached at bcrossen@sgcmail.com.

FIVE TYPES OF DESIGNER WATER AT EDWARD C. LITTLE WATER RECYCLING FACILITY

1. **Disinfected Tertiary Water must meet California Title 22 requirements for Indirect Potable Reuse: Groundwater Replenishment - Surface Application and may not exceed 2 NTU turbidity.**
2. **Seawater Intrusion Barrier Water must remain below 0.5 mg/L Total Nitrogen and 0.5 mg/L Total Organic Carbon.**
3. **Nitrified Water is the same as disinfected tertiary water, but uses biological treatment to remove ammonia to prevent corrosion in cooling towers.**
4. **Low Pressure Boiler Water uses an extra step of microfiltration and RO to reduce total dissolved solids (TDS) below 35 mg/L.**
5. **High Pressure Boiler Water is the same as the lowe pressure boiler water but makes another pass through RO to reduce TDS below 3 mg/L.**

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ARC S1HB is a high-build, single-coat, edge retentive barrier coating for metal structures, such as oil and chemical storage tanks. Its high-build, edge-retentive properties ensure maximum coating coverage over hard 90° edges and corners with minimal thinning at the sharp edge. It was designed with fluorescent pigmentation, enabling applicators to perform immediate quality control inspection using a UV light source while the application is in progress, speeding up the check and assuring high quality applications.

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Bulk Bag Discharger

The BULK-OUT Model BFF bulk bag discharger features a steel safety cage to prevent contact with moving parts during operation and automated unloading of bulk bags. The enclosure features externally-mounted controls and full height doors with an intrinsically safe relay that halts operation when the door is open. It has top-mounted receiving cups and a removable bag-lifting frame for forklift loading of bulk bags.

Flexicon

www.flexicon.com | 888.353.9426

Fume Hoods

The UniFlow Polypro Trace Metal fume hoods are designed for applications where it is imperative that the fume hood be constructed of non-metallic materials. These fume hoods are ideal for water treatment, marine and soil sciences, environmental toxic analysis, and toxicology. The fume chamber and integral work surface are one welded seamless piece of white polypropylene. The hood is equipped with front horizontal sliding sashes that are either tempered glass or polycarbonate with four sash panels on two tracks, vapor proof lighting, switches and an exhaust collar.

Hemco

www.polyprofumehoods.com | 816.796.2900.

I/O System Controller

The 750-8215 is industrial IoT-ready, comes with two Ethernet ports, two PROFINET ports and is programmable with e!Cockpit software (CODESYS 3.5). The PROFINET ports are switched for use as a line configuration enabling the controller to function as an I/O device connected to a PROFIBUS master. The two Ethernet ports can be used in a switched configuration or separated,and support other protocols, such as EtherCat and Sparkplug (with additional licenses).

Wago

www.wago.com | 800.3467245

Temperature Transmitter

The iTEMP TMT71 and TMT72 are single-channel transmitters with user-friendly operation concept, wireless communication via Bluetooth in conjunction with accurate and reliable measurements. The technology offers improvements in process efficiency, plant availability and cost. The configurable transmitters are compatible with signals from resistance sensors, thermocouples, resistance and voltage transmitters and provide an output via the 4 to 20 mA signal or the HART 7 communication (TMT72).

Endress + Hauser

www.endress.com | 888.363.7377

Metering Pump

The Proseries-M MD-3 dual diaphragm metering/dosing pump delivers precision chemical feed for municipal water and wastewater treatment. Its near continuous flow mimics peristaltic pumps, particularly at low feeds. There is no gas build-up or loss of prime. It is chemical resistant and has a 2000:1 turndown. It can output up to 52.6 gph and support pressures to 145 psi. It is NSF 61-listed.

Blue-White Ind. | www.blue-white.com | 714.893.8529

Water Intelligence Platform

Sentryx obtains data from any access point along the pipe, including sensors, meters and valves, to display important information about pressure, flow, leakage, chlorine and pH. Its machine learning technology transforms data to provide utilities with insight into the health of their distribution systems to make informed operational and maintenance decisions.

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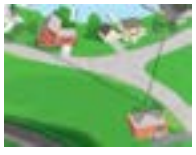

Monitoring

Key components of the Strategic Monitoring for Advanced Remote Transfer System include a logic controller with a touch-screen operator interface placed in the station and multiple remote-control boxes at selected valve pits within the system. The remote-control boxes use solar-powered radios to communicate with the logic controller, which then communicates with station controls.

Airvac, a brand of Aqseptence Group

www.aqseptence.com/airvac | 574.223.3980

Oil & Water Separator

The OilDawg is an easy-to-install, simple-to-operate, coalescing-type oil and water separator. Its features include coalescing media baskets that are removable for cleaning and a rotating pipe skimmer for removing accumulated oil. The separator effectively removes free oil droplets down to the 10-µ range.

Park USA

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Blower Series

Performance³ is a product portfolio with the Delta blower, the Delta Hybrid rotary lobe compressor and the Aerzen Turbo blower.

Aerzen USA | www.aerzen.com/en-us | 610.380.0244

Screen Filter

The Model ORZ self-cleaning screen filter requires approximately one-third as much water as conventional filters. Models are available with 2- to 24-inch connections and increased screen areas. Screen elements come in either single layer woven or multi-layer 316 LSS construction, and filtration degrees range from 5 to 3,000 µ.

Orival | www.orival.com | 201.568.3311

Sewer System

The FPS PowerSewer System is a flexible, service friendly and efficient system for residential and commercial applications. The basin's internal C-channel assembly releases from the top of the unit, simplifying accessibility to and maintenance of its components.

Franklin Electric

www.franklinengineered.com | 866.271.2859

Sludge Blanket Monitors

EchoSmart sludge blanket monitors take the guesswork out of blanket measurements in clarifiers, thickeners and anywhere an underwater interface measurement is needed. Smart-sensor technology provides for wireless networks of up to 16 sensors, reducing the per-tank price. In addition, the ability to remotely monitor these systems via cellular modems ensures support for challenging processes.

Analytical Technology Inc.

www.analyticaltechnology.com | 800.959.0299

Remote Terminal Unit Series

The MyDro series of remote terminal units augments legacy unit functionality with the addition of enhanced electronics and an onboard, interactive display screen. The RTUs simultaneously support 16 digital inputs, six analog inputs, four pulse inputs and two analog outputs.

Mission Communications

www.123mc.com | 877.993.1911

Pressure Transmitter

The Valueline pressure transmitter is one of several instruments carrying NSF Standard 61 approval for use in drinking water applications. It offers total error band accuracy, custom ranges up to 15,000 psi, custom cable lengths or connectors, your choice of industry-standard analog outputs and guaranteed lightning protection on 4-20mA models.

Keller America | www.kelleramerica.com | 877.253.5537

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