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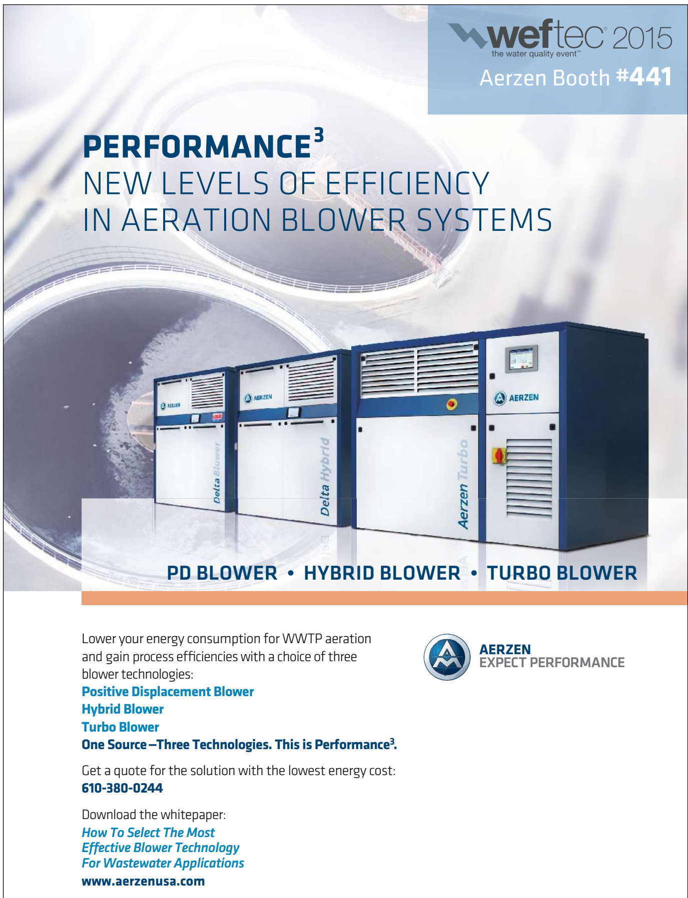

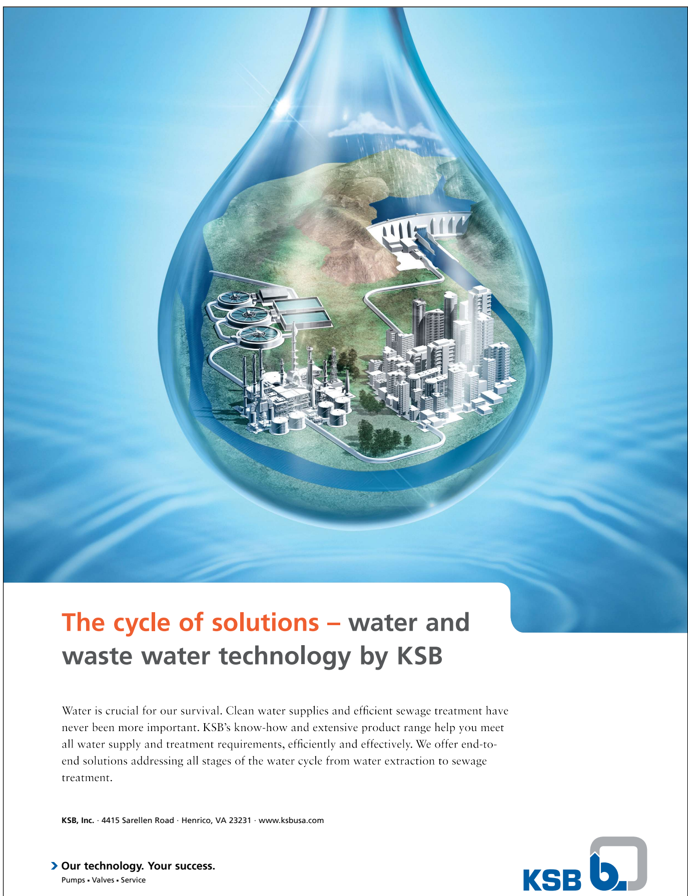


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Utilities In Search Of Direction, Look No Further

The Water Environment Federation (WEF) is harnessing both natural resources and human drive to lead an energy surge in the water sector. WEF President Ed McCormick discusses where the industry is headed and how utilities can stay ahead of the curve.

By Kevin Westerling
Chief Editor, editor@wateronline.com

The water industry's trajectory is like "a tidal wave taking off," according to Ed McCormick, WEF's 2014-2015 President of the Board of Trustees (passing the gavel in October). While tidal waves can elicit thoughts of dreaded storm surges, this proverbial tidal wave is a decidedly good thing. On the wastewater side in particular, it seems the industry is ready to embrace innovative, efficient, and sustainable solutions, in large part due to WEF's guidance.

In advance of the 2015 WEFTEC conference and as a victory lap for WEF's accomplishments during his tenure, I asked McCormick about the key issues facing the industry going forward. After all, the WEFTEC program is designed to address such challenges, and the job of WEF president is to develop leadership strategies for the future.

His response was all over the map … and yet clear as can be.

Points Of Direction

Like the points on a compass, McCormick explained that the direction of the water/wastewater industry can be designated by the letters N, E, S, and W. But instead of North, East, South, and West, our areas of concern are Nutrients, Energy, Stormwater, and Water reuse.

And for each area of concern, WEF has mapped out a plan.

Nutrients: This year WEF is launching its Nutrient Roadmap to help utilities not only remove nitrogen and phosphorus from waste streams — thus protecting vulnerable waterways and reservoirs — but also capture and recycle them as fertilizer. Phosphorus, in particular, is an issue because it forms pipe-clogging struvite yet is an irreplaceable and finite resource for agriculture. "By removing that phosphorus, we solve an internal plant problem while making revenues at the other end, by selling the phosphorus," said McCormick. "I would envision more and more of that happening."

Energy: The forerunner to the Nutrient Roadmap was the Energy Roadmap, which didn't come first by accident; at this juncture, using less energy is perhaps the most essential and accessible ingredient to successful treatment plant operations. The first step is energy management. "It's easier to save a watt than to produce an additional watt," McCormick noted.

Meanwhile, great strides are being made in energy recovery. "About 80 percent of the energy that comes to us in wastewater is thermal energy, versus about 20 percent [that is] chemical," said McCormick, citing a recent study by WEF and the Water Environment Research Foundation (WERF). "Historically, our industry has gone after that 20 percent. There's a lot of fertile ground for us to recover the heat from the wastewater. Depending on the time of year, our collection systems can be a heatsink in the summertime for cooling buildings and in the wintertime for heating buildings and anaerobic digestion."

Stormwater: "Stormwater is big, and it's becoming bigger," said McCormick. Evidence of this fact can be seen in utility and regulatory focus on combined sewer and sanitary sewer overflows (CSOs and SSOs); massive, citywide green infrastructure plans (à la Philadelphia); and the annual Stormwater Congress, a tailored program within WEFTEC that gets larger each year. And, of course, because of storms.

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"What used to be our 100-year storm seems to be happening all too frequently. When you have two or three '100-year' storms in five years, what you're realizing is that the data we're using is not updated," McCormick stated. "Whether it's much less or much more precipitation, we're experiencing more intense weather patterns."

Water Reuse: If you speak with anyone from WEF, you won't hear the term "wastewater treatment plant," but you will hear "water resource recovery facility." The shift in wording is a conscious effort to create cultural change — to expunge preconceived notions about the old WWTP and reset the way utilities, policymakers, and the public perceive these facilities, as WRRFs. It's about creating energy from wastewater, saving and repurposing nutrients, and recycling water to bolster dwindling supply. The trend toward municipal water reuse is well underway but is nascent relative to its potential. To help advance adoption, WEF's next "roadmap" will cover water reuse, according to McCormick.

> *"I don't think we've had a renaissance like this one, a true sea-change in the industry, since the early '70s — since the EPA was formed and the Clean Water Act was created."*
>
> **Ed McCormick**, president, Water Environment Federation (WEF)

No utility gets there alone, however. There are stepping stones to reach these points of sustainability.

Collaboration And Innovation

McCormick called collaboration a core value for WEF, asserting that "Competition doesn't work effectively in the water sector. … What our members want is for the various water associations to come together in a unified way, not overlapping in their activities but each working to its strengths."

While 98 percent of WEF members are located in North America, McCormick stressed the need to look overseas for collaboration and innovation.

Speaking on WEF's newfound (or at least newly formalized) global policy, he stated the need to "bring the best the world has to offer — the most innovative, cutting-edge, cost-effective ideas — back to our members."

But the U.S. has systemic roadblocks in place. McCormick cited the conservatism ingrained in the North American water sector, acknowledging that "Oftentimes it's in our specifications."

"As a requirement to bid on a job, you have to have at least x — three or five operating facilities — that have been in operation in North America for the past y years," he related. "That's a problem. When Europe has three operating facilities and there's only one in North America, that should not be precluding you from becoming an innovation leader."

Nothing a collective tidal wave of energy can't overcome. Optimism still rules this day.

"I don't think we've had a renaissance like this one, a true sea-change in the industry, since the early '70s — since the EPA was formed and the Clean Water Act was created. If you talk to your average water sector professional, they're aware that things are changing in a big way," said McCormick.

In this new era, he reminds us: "There really is no waste. There are only wasted resources." ■

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Let's Solve Water

'Project Clean Lake' Breaks New Ground In Pollution Control

The Northeast Ohio Regional Sewer District's $3 billion pollution-control plan includes massive and lengthy tunnels but goes the extra mile by adding advanced wastewater treatment.

By Michael Uva

In 1972, the Clean Water Act was created to address the nation's water-quality issues, among them the foul spectacle of raw sewage discharging into the environment. In Cleveland, the Northeast Ohio Regional Sewer District's construction projects during the following decades would reduce these discharges significantly — from an estimated 9 billion gallons a year down to 4.5 billion in 2013.

However, in 1994, the U.S. EPA adopted a Combined Sewer Overflow (CSO) Control Policy, which required wastewater agencies to develop long-term CSO-control plans to further reduce overflow. Cleveland and hundreds of cities around the country have negotiated long-term plans with the EPA to address sewage overflows.

Fighting Overflow

Why do overflows occur? The combined sewers prevalent in older cities carry both sewage and stormwater. When heavy rains overload the combined sewers, relief points within the sewers (known as regulators) allow the untreated stormwater and sewage to overflow into area waterways to avoid backups and home and street flooding. This CSO contains bacteria from human waste, industrial waste, and other pollutants swept from the ground's surface. Following rain events, Cleveland's beach-goers are often advised not to go swimming in Lake Erie due to elevated bacteria levels that accompany CSOs.

Project Clean Lake is the sewer district's $3 billion, 25-year program to reduce the total volume of CSOs in Cleveland from an estimated 4.5 billion gallons annually to less than 500 million gallons. By 2035, the number of overflows will be reduced to four or fewer per year, resulting in an estimated 98 percent capture and treatment of all wet-weather flows in Cleveland's combined sewer system.

At the heart of Project Clean Lake is the construction of seven large-scale storage tunnels, ranging from two to five miles in length, up to 300 feet underground, and up to 24 feet in diameter — large enough to fit a semi-trailer truck. This technology is widely used in CSO-control plans across the country. The tunnels can hold tens of millions of gallons of CSO, rather than allowing it to discharge into Lake Erie and the Cuyahoga River. After the rain stops, massive hydraulic pumps convey the flow back to the surface and to one of the district's three wastewater treatment facilities.

In April 2011, the sewer district broke ground on its Euclid Creek Tunnel project, which includes an 18,000-foot-long, 24-foot-wide storage tunnel 200 feet underground. Just over two years later, in August, 2013, "Mackenzie," the district's 1,500-ton tunnel boring machine, completed its three-mile-long excavation. The finished tunnel will have the capacity to capture about 65 million gallons of combined wastewater and stormwater and will directly impact water quality in Lake Erie and local streams.

Project Clean Lake also includes a minimum of $42 million in green infrastructure projects, which the federal government had never before included in its CSO-control consent decrees. These stormwater-control measures, which include such technologies as bioswales and detention basins, can store, infiltrate, and evapotranspirate rainfall before it even makes its way into the combined sewer system. In the last five years, the sewer district has committed more than $31 million to green infrastructure projects.

Plant Power

Enhancements to the sewer district's three wastewater treatment plants, which together treat over 90 billion gallons each year, are crucial components of Project Clean Lake. At the district's Easterly and Southerly treatment plants, the amount of wastewater that can receive treatment will increase. This is necessary to accommodate the greater volumes of combined flow that will no longer be allowed to discharge straight into the environment. In particular, the Easterly plant is undergoing major construction through 2016 to expand its secondary treatment capacity, including the installation of six additional final settling tanks.

Despite the ongoing construction, Easterly was recognized in 2014 with the highest performance honor from the National Association of Clean Water Agencies: the Platinum "Peak Performance" Award, for five consecutive years of meeting National Pollutant Discharge Elimination System (NPDES) permits. The Westerly and Southerly plants also received Gold Awards for continued excellence in meeting their NPDES permits.

In addition, all three district plants are implementing advanced methods for dealing with wet-weather flows from overwhelming rain events. "Even with the new storage tunnels, you still can have

Construction at the Easterly Wastewater Treatment Plant (March 2015) to expand secondary treatment capacity as part of the Project Clean Lake consent decree with U.S. EPA.

overflow," explained Douglas Dietzel, a process specialist at the Westerly plant. "So, as part of our agreement with the EPA, we're increasing our ability to treat wastewater during high-flow events."

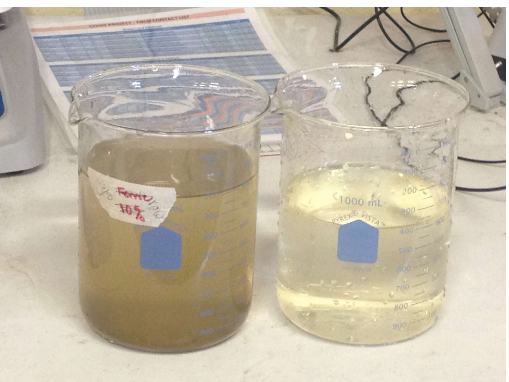
The Westerly plant, which sits on the shore of Lake Erie, is Cleveland's oldest wastewater treatment site (constructed in 1922) and serves approximately 103,000 residents. The plant processes an average flow of 26 million gallons per day (MGD) of wastewater, and its Combined Sewer Overflow Treatment Facility (CSOTF) provides storage for six million gallons and preliminary treatment for up to 300 MGD during wet-weather flows. In the CSOTF, the heavier organic material is allowed to settle out of the wastewater, but the flow can still contain pathogens when it is returned to Lake Erie, since it does not pass through secondary treatment or disinfection.

Chemically Enhanced Treatment

A new project, called Chemically Enhanced High Rate Treatment (CEHRT), will expand the overall size and scope of the treatment process with the inclusion of chemical storage and feed facilities, providing treatment and disinfection capabilities absent from the current system.

CEHRT is actually two acronyms combined: Chemically Enhanced Primary Treatment (CEPT) and High Rate Disinfection (HRD). CEHRT is an advanced way of treating wastewater overflow by speeding up the natural, gravity-based settling process used in the normal treatment process (through the addition of chemicals) and providing disinfection.

"Coming into the plant is all this negatively-charged organic material," explained Dietzel. "We neutralize that charge with ferric chloride, which has a positive charge. Then we use an anionic polymer, a long chain of hydrocarbons, to stick to all of those suspended particles." The polymer creates a "floc," meaning that the suspended organic particles clump together and settle out of the water. The flow then goes to the HRD tank, where sodium hypochlorite, a strong bleach, is added to kill off any remaining pathogens. "Instead of having just settled wastewater, you have treated flow safely going back out into the lake," said Dietzel.



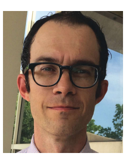
The beaker at left shows influent before the CEHRT process; at right, effluent after CEHRT.

The EPA gave the district an opportunity to demonstrate the effectiveness of lower-cost treatment options like CEHRT through pilot demonstration projects. If successful, the district would be able to avoid implementation of the more costly ballasted flocculation treatment technology. "The EPA initially wanted us to use a much more expensive sand-injection process," said Dietzel. "They gave us three years to test out CEHRT at all three of our plants, and if it worked we could use it."

At the Westerly plant, a polymer blend unit makes a polymer solution for the CEHRT process.

The plants have utilized a bench test to determine the optimum amounts of ferric chloride and polymer to get the process to work. "Based on our testing, we see that CEHRT works very well," said Dietzel, noting the contrast between the brown, muddy wastewater and the clear, post-CEHRT effluent. If given the go-ahead by the EPA, the CEHRT systems could be fully operational at all three district plants as early as December 2021.

Project Clean Lake means a cleaner Lake Erie. But, with a $3 billion price tag, it also means that rates will increase. As the district's main source of revenue, customers' sewer-bill payments will fund these construction projects and plant enhancements, and rate increases will be significant. The success of the CEHRT pilot program, and opportunities to optimize projects through advanced planning and value engineering, will help the district minimize Project Clean Lake's financial impact on its ratepayers. "The CEHRT system is relatively new, and very few wastewater agencies in the U.S. use it," said Dietzel. "We are the first large sewer authority to do something like CEHRT. It will save our ratepayers money, and that's our goal." ■



About The Author

Michael Uva is the senior communications specialist at the Northeast Ohio Regional Sewer District.

A Future Without Waste

What the road to full resource recovery looks like and how to get on it.

By Art Umble

"There is no waste in our future!" That was the declaration of Water Environment Federation President Ed McCormick at this year's "Energy Positive Water Resource Recovery" symposium, co-sponsored by the National Science Foundation, the U.S. EPA, and the U.S. Department of Energy (DOE). Though a terrific challenge to us all, it's not out of reach if we start today and take responsibility for leading the charge. The question is where do we start? Much of the answer lies in changing behavior away from "business as usual" and toward a radical embrace of full recovery of energy, water, and nutrients resources — primarily in that order.

Clearly, climate change is advancing due to our reliance on fossil fuel energy sources, and this has taken us down a dangerous path. In fact, the Japanese Meteorological Agency recently published that 2014 was the hottest year on record. In the U.S., the National Oceanic and Atmospheric Administration recently announced that the carbon dioxide (CO_2) concentration in our atmosphere has now exceeded 400 ppm, and it's climbing at a rate historically unprecedented. A concentration of 450 ppm has been identified by the Intercontinental Panel on Climate Change as the threshold for our planet warming to a level of 2° C over baseline, at which the predicted consequences are not just dire but irreversible. Some are already underway. For example, the oceans are sinks to one-quarter of the atmospheric CO_2. The acidification resulting from absorbing more and more CO_2 is having detrimental impacts on shellfish — unable to form their shells — and a growing imbalance in global ecology is already emerging.

Energy-Water Nexus

To change our ways, socio-political and technical approaches abound. In the socio-political arena, some are making the bold call for global divestment from companies that promote fossil fuel development, claiming these companies essentially "own climate change" and should be accountable. On the technical side, accelerating development of renewable energy sources is the challenge. In the wastewater treatment industry, for example, this takes the form of recovering energy from raw organic matter in wastewater, in which about 10 times the energy required to operate today's conventional treatment plants is embedded. Can this be captured and recovered?

Yes, numerous plants around the globe are recovering this energy. In fact, some are now producing more energy (in the form of electricity) than they need to operate, returning "surpluses" back to the power grid. As an example, today the East Bay Municipal Utility District (MUD) in Oakland, CA is at 130 percent energy-positive. The Strass, Austria, wastewater treatment plant is now at 170 percent energy-positive. Ithaca, New York's plant is at 100 percent (neutral). How are they doing this? In East Bay's case, they are taking in large quantities of high organic strength wastes (fats, oils, greases, and other food wastes) and "co-digesting" (anaerobically) these with sludges generated from within the plant from treatment of the wastewater. In the case of the Strass plant, they are applying aggressive, cutting-edge treatment approaches including carbon diversion/sequestration and mainstream deammonification technologies. Other plants are experimenting with algae production from wastewater and co-digesting the harvested algae to increase biogas production for energy. All of these activities are contributing to shifting our energy balance away from the primary climate change driver, fossil fuels.

Though our energy imbalance is causing climate change, the effect is significant changes to the global water-balanced budget. Climatic patterns alter rainfall distributions and intensities, which are already having a negative impact on water quantity and quality. This is placing higher demands on the limits of treatment technology. Many are promoting the acceleration of wastewater reuse, particularly in water-scarce regions, to offset depleting supplies. Others believe that desalination (including seawater, brackish groundwater, and wastewater) must be of highest priority since recent generations of membrane technology have dramatically reduced the energy inputs required. (Desalination of seawater requires about 3.5 kWh/m^3 treated; desalination of wastewater about 1.7 kWh/m^3.)

If we are to turn the tide against our "business as usual" inertia, most agree that reducing demand for both energy and water is paramount, followed by an intensification of innovative technology focused on all facets of resource recovery from all waste streams. This "intensification" refers to technology that is disruptive and transformative. In today's world, technology is truly disruptive only if it reduces TOTEX (total expenditure from "cradle-to-grave" of the system) by a minimum of 30 percent over the course of its useful life, and physically fits into spaces smaller than conventional technologies. In wastewater treatment, examples include granulation technology, biocatalyst technology, high-rate ballasted flocculation technology, deammonification technology, and sludge-reduction technology. Though disruptive indeed, few have gained a mature foothold in the marketplace. This means that both fundamental and applied research must increase in importance and be appropriately funded through both public and private sources.

Innovation At Work

But encouraging signs have recently been seen to address this, coming from the U.S. DOE. For example, Stanford University, in collaboration with the Colorado School of Mines, received a multi-million DOE grant to implement the "ReNUWIt" (Reinventing the Nation's Urban Water Infrastructure) research center, focusing on engineering energy-efficient wastewater reuse. Interestingly, this "engineering" includes both technical and social aspects of systems integration for sustainable outcomes. The ReNUWIt center illustrates a methodology for moving innovative ideas forward: 1) research drives development; 2) development drives demonstration; 3) demonstration drives deployment. This is known as "R3D" in the vernacular.

In essence, the ReNUWIt research center represents a "live" example of what is known as a "test bed" for technology adoption. Right now a movement is afoot within federal agencies (EPA, DOE, Department of Defense, Department of Agriculture, U.S. Geological Survey, and others) to partner with academia and private business to construct a series of three to five regional water and wastewater "technology test bed" sites throughout the U.S. and Canada. These test beds would serve as "plug & play" facilities for anyone wishing to prove their technology within an open, transparent, standardized test protocol platform that immediately publishes critical performance results data to any who desire it. This is believed to be critical in streamlining the advancement of a new technology into the marketplace.

Because regulatory drivers have traditionally stifled innovation, the EPA is recognizing that it too must follow the innovation curve. The EPA's participation in the "test bed" conversation has been applauded within our industry because it shows the EPA is rethinking its position on regulatory control: Early adopters may receive "relaxed" standards, such as "performance-based" standards and incentives; as the technology matures, more prescriptive limits can be imposed.

So what does this all mean for us right now? Historically, we humans tend to change our behaviors when our standards for living are threatened by some outside force, and furthermore, only when that force becomes a crisis. We tend to be comfortable with "business as usual" until the crisis hits and our backs are against the wall. Only then do we engage and respond, and to date, our innovative nature has always "saved the day" from catastrophe. Unfortunately, such luxury does not exist with climate change. We must act now. First, we must reduce our demand for energy and water and continue shifting our necessary consumptions to renewable resources. Then, we must intensify our efforts to recover all resources from all waste streams. To accomplish this, we must engage every opportunity to test every innovative idea efficiently and thoroughly. Public and private entities must partner to fund and drive the R3D process. We must adopt flexible regulatory frameworks that promote, not hinder, innovation. Not surprisingly, this is really more about leadership than it is about instituting mechanisms to advance innovative technology. Do we have the commitment within ourselves to lead to a sustainable future, one with no waste? ■

About The Author

Dr. Umble is the wastewater practice leader for MWH and provides technical analysis and support to design teams for new and rehabilitated municipal wastewater treatment facilities. Umble is a leader in initiatives promoting environmental stewardship, serving as a technical advisor/reviewer for Water Environment Research Foundation, International Water Association, and the WateReuse Foundation collaborative research projects.

The Journey To Predictive Maintenance

With the digital age fully upon us, it's time for treatment plants to evolve beyond preventative maintenance and embrace predictive maintenance.

By Paul Brake

Effective and efficient maintenance is at the heart of any treatment plant. It doesn't matter how well a process was designed, how expertly it was installed and commissioned, or how expensive the components are; if maintenance fails, the whole system fails. There is an old saying, "Stay out in front, but stay behind the plow."

The Costs Of Standing By

Traditionally, maintenance was based on failure. We fired up our systems, and when something broke, we rushed in and fixed it. This has proven to be costly — very costly. The first big cost is for parts. Either we have to warehouse a spare for every critical piece of equipment, or we have to expedite delivery from a vendor. Both are cost-prohibitive.

The second major cost comes with the process downtime. If you lose a pump, everything downstream of that pump goes out of commission. Don't make the mistake of thinking this applies only to major feed pumps. If a chemical injection pump fails, the entire line then can go out of compliance, and you have to shut it down for repair.

The growth and developments in the computer industry have spawned an entire product line that allows the next generation of maintenance methodology.

There is a fourth cost to the "run to failure" mode that most do not stop to consider. If you wait until a bearing fails completely in a pump, think about how much collateral damage that can cause. What if it allows your impellers to contact the housing? What if it allows a significant leak? What if it takes the drive motor out with it? The cost of "run to failure" is so high that almost nobody does it anymore.

The Preventative Paradigm

Today, and for quite some time, a paradigm of "preventative maintenance" has prevailed in most facilities. This is definitely a step forward. Historically, it has reduced maintenance costs by about one-third. Preventative maintenance relies on equipment history and statistical techniques to determine a theoretical mean time to failure. Using this calculated result, a company will order replacement parts, schedule turnarounds and area shutdowns, and prepare staff or hire outside contractors for scheduled maintenance.

This sounds like a good plan, and before modern computers and sensors were in play, it certainly was. We do that with the cars we drive. A manufacturer will tell you, for example, to change your oil every 3,000 miles and your transmission oil every 50,000 miles. But these numbers ignore operating conditions. One car may be doing highway driving in dry, cool air, while the next will be city driving in highly polluted, wet, hot air. One car may be driving on flat prairies near sea level, and the other could be in the mountains. Therefore, any experienced operator or tradesman will tell you that the maintenance requirements must be different. There is no way that the oil in these cars will be in the exact same condition at 3,000 miles of travel; yet, they all change out at that distance. In fact, there may be some driving conditions that would allow change out at 6,000 miles and others that require service at only 2,000 miles.

This is the critical flaw of preventative maintenance. We base our maintenance on statistical time intervals and ignore the specific operating conditions of the equipment. The two typical results are that we either perform unnecessary maintenance, or we don't get to the equipment in time, and we have a full failure.

In the first situation, we create unnecessary shutdowns that cost us process and production losses. We employ maintenance staff that could be otherwise better employed. We bring in outside contractors that we really don't need to hire and pay. We throw out bearings that are perfectly serviceable. And our maintenance budgets are bulging at the seams.

In the second case, we are actually operating in a run-to-failure mode and do not realize it. We then face all the problems and costs of that methodology; yet, we are completely unprepared for it, and thus it costs us even more.

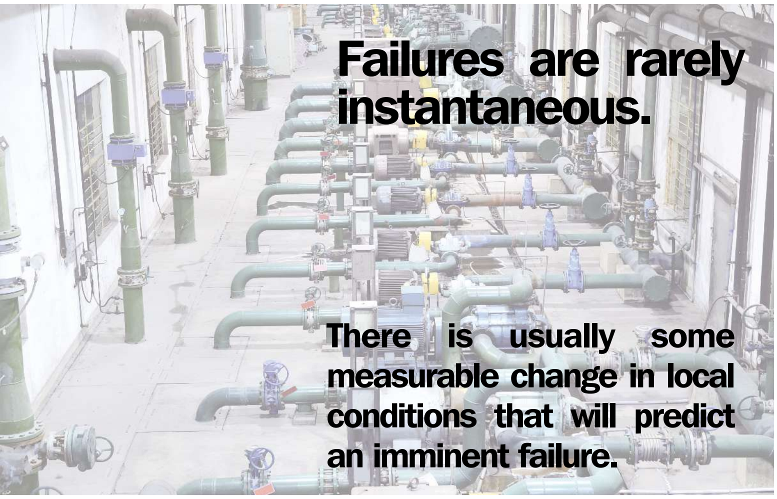
If our processes are subject to changes, then no preventative maintenance system is appropriate. Our inflow in summer could be 10 or 20 degrees higher than in winter, as could be our operating conditions of motors and pumps. That alone will render a preventative maintenance schedule ineffective.

A New Era

We are in a new era of maintenance. It has snuck up on us slowly as a happy byproduct of a completely different technology advancement. The growth and developments in the computer industry have spawned an entire product line that allows the next generation of maintenance methodology. These computer advances have created smart sensors, information pathways, and computational equipment and software that allow for modern predictive maintenance techniques.

One side of the road was run to failure, the other side was preventative maintenance. Think of predictive maintenance as a happy, middle-of-the-road approach that takes advantage of the benefits of both, while eliminating the liabilities.

In the water and wastewater industries, like many others, we have moved progressively into automating our processes and equipment. Automation involves condition-monitoring of specific process measurements as well as equipment setpoints. And automation



also includes data transmission and central computerization. This process automation is what allows us to move relatively seamlessly into a predictive maintenance system.

Predictive maintenance relies on monitoring the actual operational condition of critical equipment and uses the data, and trends in the data, to detect upcoming failures. Failures are rarely instantaneous. There is usually some measurable change in local conditions that will predict an imminent failure. We can thus run equipment to its natural life cycle and provide maintenance and repair when it is actually needed. It allows planning of the repairs and procurement of parts and services, and it prevents catastrophic failures and collateral damage. This will also reduce process and production losses and eliminate the environmental non-compliances we face when our processes get knocked out mid-stream.

This is an opportunity to stay out in front, while the existing developments and technological advancements keep us "behind the plow." Predictive maintenance, driven by the pharmaceutical and petroleum industries, is becoming mainstream in other sectors. There are numerous companies that can assist in transforming a plant from its current paradigm into a predictive maintenance system. Condition-based monitoring and computerized control systems are already on the market. Many of the sensors currently being used can be easily integrated as condition monitors into a predictive maintenance system. For example, measuring flow from a pump will allow you to determine if the pump is operating properly. If you have to continually bump your variable-frequency drive (VFD) to maintain flow, or if the current draw starts to increase to maintain flow, or if flow or pressure start to drop, that information will be fed directly into the predictive maintenance software. The user interfaces can act as portals for maintenance staff to access the information they need.

Predictive maintenance has a side effect — a good one. It will allow you to improve processes, both in quality and efficiency, through better equipment operations, less downtime, and a more complete monitoring of your process conditions.

Feeding The System

The more information you feed into your predictive maintenance system the better, to an extent. There is always the risk of information overload, and some information simply does not tell you anything about the condition of equipment in your plant. The same holds true with process automation. Occasionally someone sets up an oxidation-reduction potential (ORP) or a level switch that really does not give you information that is indicative of your process. An example is monitoring pH at one end of a tank and adding pH control at the other. Without proper and complete mixing, your control system will not be able to properly maintain a consistent pH. The same is true for condition monitoring in predictive maintenance. All data must be real time, accurate, and pertinent.

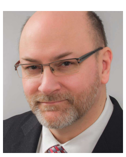
There are a few items that you will want to include that are not normally a part of process automation. Accelerometers (vibration sensors), for instance, can detect an upcoming bearing failure. Thermal scans will identify hot spots. Each plant is different. Every process is different.

With modern wireless communication systems, incorporating more and different condition-monitoring equipment becomes far less onerous and more economical. There are numerous protocols and systems available, and there are volumes of information available on each.

Some condition monitoring can also be farmed out to vendors. Thermal imaging, ultrasonic thickness measurements, and oil analysis are examples of tests that are better handled by people who are properly equipped and do them for a living. Bringing in that level of technology and expertise on a full-time basis would be cost-prohibitive. Bringing in an inspector every month, or three months, or year to walk your plant and take the measurements for you is an economical and highly effective solution.

In the water and wastewater industries, most of the tools necessary to implement an effective and efficient predictive maintenance system have been slowly introduced for process automation. We have most of what we need already on site. It's time for a paradigm change. Every time a new technology comes into use, it is the attitudes of the people involved that must be changed first.

The easiest way to drive the change to predictive maintenance is to go slowly, one piece of equipment at a time. Start with the largest, costliest items and work your way through your process from there. Predictive maintenance is not just the future of maintenance; it is the present. We've had most of what we need for years. Now it is time to completely implement predictive maintenance into the water and wastewater industries. ■



About The Author

Paul Brake is a mechanical engineer with nearly three decades of industrial and engineering experience. Brake specializes in the design and maintenance of water/wastewater and process equipment and is currently part of the strategic maintenance team at the North Atlantic Oil Refinery.

Saving Silicon Valley:

How A Reuse Project Became Its Own Tech Breakthrough

The Silicon Valley Advanced Water Purification Center project provides expanded reuse opportunities, increased sustainability, and promise for the future.

Photo Credit: Santa Clara Valley Water District

By Sanjay Reddy, Jim Fiedler, Hossein Ashktorab, and Jim Clark

Long before Governor Jerry Brown declared a drought state of emergency in January, water managers throughout California had gone to impressive lengths to stretch existing supplies and prepare for continued water shortages. Last year, the WateReuse Association recognized the inspirational Silicon Valley Advanced Water Purification Center (SVAWPC) project with its (Large) Project of the Year Award, and this year the project became Global Water Awards' 2015 Wastewater Reuse Project of the Year. The SVAWPC has produced highly purified water for a drought-proof recycled supply for over a year.

A collaborative effort between the Santa Clara Valley Water District (SCVWD), which owns and operates the facility, and the city of San Jose, which operates South Bay Water Recycling (SBWR), the SVAWPC is the largest project of its kind in Northern California and the first in the San Francisco Bay Area. It transforms treated wastewater that would otherwise be discharged into San Francisco Bay into 8 MGD of sustainable supply, which meets California's primary drinking water standards for applications including industrial processes, cooling water, landscaping, irrigation, and recreation. The facility uses a trio of tertiary treatment technologies to add a local, safe, reliable resource to Silicon Valley's supply portfolio.

Transforming Water

Water reuse requires not only motivation and technology but also a market that values the product. An earlier study revealed that salinity was a concern in the existing recycled supply for a region where consistent quality was crucial in industrial user operations. A feasibility study confirmed that development of an advanced recycled water treatment facility with a high-quality water product that could be blended with existing recycled water would provide more consistent recycled water quality. Evaluation of options ensued, and approximately $5.5 million in state grants from the California Department of Water Resources and $8.25 million in federal funding through the American Recovery and Reinvestment Act helped fund the resulting $72 million project.

The state-of-the art SVAWPC purifies nitrified secondary effluent from the neighboring San Jose-Santa Clara Regional Wastewater Facility using an integrated membrane system consisting of 38 million liters/day (ML/d, or 10 MGD) microfiltration (MF) and 30.3 ML/d (8 MGD) reverse osmosis (RO) followed by a 38 ML/d (10 MGD) UV disinfection process. The purified water is then blended with existing recycled water produced at the regional facility to enhance quality and expand reuse.

The backwash from the MF units and neutralized products from the MF and RO chemical cleaning are returned to the regional facility for treatment. The brine from the RO system is returned to the regional facility's chlorine contract basin for blending with the plant's effluent prior to the discharge into San Francisco Bay. Using advanced treatment processes to further remove pollutants and other potentially harmful constituents, such as salt, from the recycled water opens up additional potential uses for the recycled water. The higher-quality recycled water could be used in the future to improve groundwater quality, which would further reduce the demand on potable water supplies.

The new water supply is distributed via the regional purple-pipe recycled water system. More than 700 SBWR customers now use the enhanced recycled water. With total dissolved solids levels of approximately 500 mg/L, the blended water reduces chemical use and maintenance costs for industrial users and is easier to use in some irrigation and agricultural applications because of reduced salt buildup.

Demonstrated Success

A 30-day performance acceptance test demonstrated that equipment could operate continuously for 24 hours a day under design conditions with no major interruptions and still meet permitted water quality requirements. The test also demonstrated successful integration of the product water into the existing recycled water system under various operating modes.

Black & Veatch served as the prime consultant for the project, providing design, membrane procurement, and construction and operations support. JR Filanc served as the general construction contractor. The SVAWPC began operations in March 2014, followed by a grand opening ceremony in July.

In addition to increasing recycled water treatment capacity and quality for the region and allowing more versatile uses, the expandable SVAWPC is helping raise awareness and support for advanced processes that render water of such high quality capable of more versatile uses. Today, recycled water meets about 5 percent of the county's total water demand; by 2025, the SCVWD plans to double that number. The

RO treatment provides the final filtration step at the Silicon Valley Advanced Water Purification Center.

Photo Credit: Black & Veatch

district is using the facility to evaluate the possibility of using highly purified water for potable reuse.

Value Beyond Dollars

The value of the SVAWPC exceeds the price retailers and end users pay for the purified water. It helps facilitate a shift away from imported water supplies. It decreases the region's dependence on the Sacramento-San Joaquin Delta, improving the resiliency of the region's water system. And it helps motivate water users to switch their industrial, landscaping, and agricultural demands from potable to recycled water. The expandable facility also lessens discharges of treated effluent into San Francisco Bay, which helps preserve the tidal habitat.

In its first year of operation, the facility has consistently met and exceeded the design goals for finished water quality. Changes in the influent water quality required adoption of additional operational strategies to minimize impacts to the treatment process and finished water-quality goals. The discharge of the brine from the RO system to the regional facility's chlorine-contact basin has been optimized for improved performance of the treatment process. The SVAWPC provides broad reuse opportunities that add resiliency to a system impacted by severe drought. ■

UV disinfection represents the final stage of treatment before storage and blending with existing supplies.
Photo Credit: Black & Veatch

About The Authors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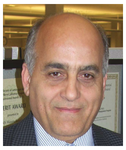
Fiedler


Ashktorab


Clark

Sanjay Reddy is a project director in the Walnut Creek, CA, office of Black & Veatch. Jim Fiedler is chief operating officer, and Hossein Ashktorab is recycled water unit manager for the Santa Clara Valley Water District in San Jose, CA. Jim Clark is a senior vice president for Black & Veatch based in Los Angeles. All authors have extensive experience with water management, especially water resource recovery and reuse.

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Let's Solve Water

Attacking Sanitary Sewer Overflows

California municipalities write the book on solving sanitary sewer overflows by sharing best practices and technology tips.

By Billy Wright

A Tale Of Two Cities

Two California cities dramatically reduced the occurrence of sanitary sewer overflows (SSOs) through enhanced technology and business process improvement. The effort included evaluating operations to establish a performance baseline, implementing multiple best business practices/strategies, and using technology to manage the data.

A host of best business practices was used that ranged from streamlining workflows to utilizing advanced technology. For example, a complete computerized maintenance management system (CMMS) with geographical information system (GIS) connectivity and closed circuit television (CCTV) data was used to enhance routine schedules, track work, and improve operations.

This transformation led to improvements in the efficiency and effectiveness of operations, with increased quality as a direct result of routine cleaning, improved work reporting practices, application of good business tools, and integration and automation of work processes. These efforts and related implementations produced the desired effects of SSO reductions in both agencies.

The risk of not meeting these requirements not only endangers the public and the environment but also results in large fiscal impacts as a consequence of fines or fees.

Behind SSO

SSO is a condition in which untreated sewage is discharged into the environment prior to reaching sewage treatment facilities. It can be the result of a wastewater sewer system either having an overflow, spill, release, discharge, or diversion of untreated or partially treated wastewater. Some of the factors that can create these issues include infiltration or inflow of excessive stormwater into sewer lines during heavy rainfall, rupture or blockage of sewerage lines, malfunction of pumping station lifts or electrical power failure, and human operator error at treatment plant facilities.

The U.S. EPA estimates the magnitude of the problem to be about 40,000 SSO events occurring in the U.S. each year[1]. The volume of untreated sewage discharged to the environment is less than 0.01 percent of all treated sewage in the U.S.; the total volume amounts to several billion gallons per annum and accounts for thousands of cases of gastrointestinal illness each year[2].

Numerous municipalities and special districts that manage wastewater systems must face the seemingly insurmountable challenge of adhering to court-mandated consent decree orders or agreements made by environmental groups and regulatory agencies against responsible entities who manage wastewater systems. These efforts include operational performance, environmental stewardship, and regulatory reporting requirements, or else they incur hefty penalties for this pollution and non-compliance. Shrinking budgets may be unavoidable, and other methods must be used in lieu of increased staffing in order to optimize resources and accomplish organizational goals while still meeting all regulatory requirements. The risk of not meeting these requirements not only endangers the public and the environment but also results in large fiscal impacts as a consequence of fines or fees.

Improved By Necessity

The sewer networks for each city range in size from 87 to 105 miles of gravity sewer and have approximately 13,000 and 11,000 service connections respectively. Each agency operates and maintains six lift stations and produces an average of 3.5 million to 4 million gallons of wastewater per day. Evaluation of sewer network performance is often summarized by a single

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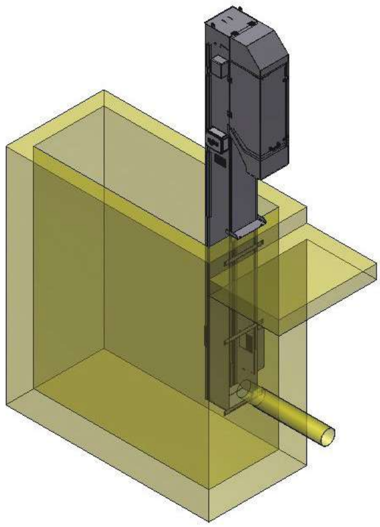

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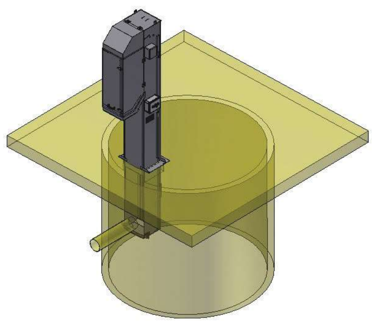

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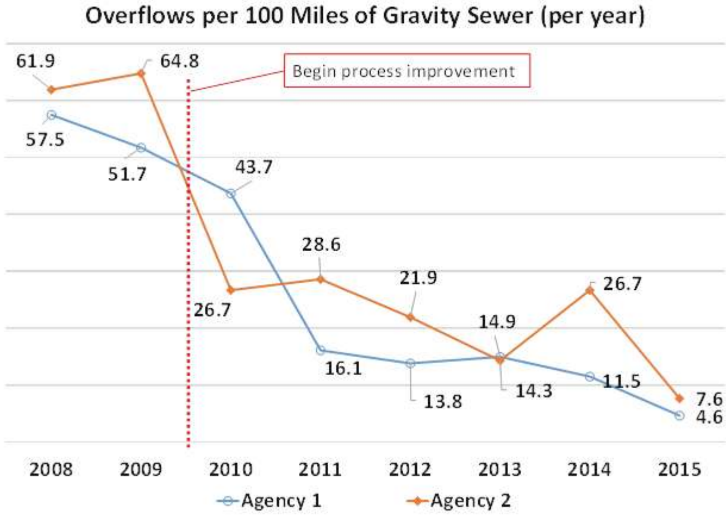
value, which is calculated as the total number of SSO occurrences per 100 miles of gravity sewer. This value is reported to the state water board and used as a benchmark by state regulators, environmental groups, and wastewater agency management.

Prior to the implementation of improved business processes and related management tools, both agencies were consistently experiencing 50 or more SSOs per 100 sewer miles, while the state average is fewer than seven. This resulted in legal actions filed by various environmental groups and two separate court-mandated consent decree orders that established specific limits for SSO events, requirements for performance reporting, and substantial increases in maintenance responsibility and system monitoring. Failure to adhere to this sudden increase in workload would result in overwhelming fines and penalties for small cities with already limited financial resources.

Figure 1



Approach

Each agency implemented a complete computerized maintenance management system as part of the improvement process. Business processes were established that provided management data and tools to best direct the available resources. These included establishing a performance-based work plan and budget that related accounted resources with actual work accomplishment. Performance metrics were also identified that established benchmarks for productivity and unit costs that could be monitored through the use of standard outputs and reports.

After determining the annual performance plan and budget for each maintenance activity, a monthly work calendar was developed to identify potential peaks in the workload and identify any need for additional contractor support. Short-term scheduling procedures aided by GIS outputs were established and utilized a combination of the performance plan, work calendar, and consent decree requirements as inputs when assigning crews to specific efforts.

The CMMS was configured in each agency to support the established business processes and monitor critical parameters defined by management. Output reports were also developed that compared the planned values to actual work reporting in order to periodically monitor operational performance and affirm adherence to management goals.

Results

Each agency now has complete and transparent awareness of wastewater conditions and employee work effort, and has specific information available for all users of the system within two weeks of work completion. They have developed activity-based work plans that outline the annual work load distribution and unit cost estimates for all defined tasks. Guidelines include resource requirements, work method, and quality of results that relate all work to cost. These changes have resulted in a data-driven, focused approach based on business practices with direct accountability established.

With these tools in place, each agency has experienced an approximately 90 percent decrease in SSO events per 100 sewer miles since implementation. The annual value for each agency is shown in Figure 1 starting at 61.9 SSOs per 100 miles for one and 57.5 for the other and ending with 7.6 and 4.6 SSO per 100 miles. Both agencies have shown consistent and dramatic improvement in performance with no additional resources assigned to wastewater collection maintenance groups in either case.

These two agencies demonstrate that such an SSO problem can be addressed by establishing performance-based planning linked to assets and their conditions. This, along with real-time monitoring of work against specific goals and applying best management practices by dedicated employees, can help improve the environment with measurable results. ■

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About The Author

Billy Wright (bwright@laconsulting.com) is a senior consultant with LA Consulting. The company, established in 1993, provides a wide variety of planning, systems, and technology services applied to public agencies and municipalities with an emphasis on systems implementation and technical support for public works operations and maintenance. The firm's corporate headquarters is in Manhattan Beach, CA, about 20 miles west of Los Angeles.

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Evolution In Wastewater Goes With The Flow

While options for clean water flow measurement abound, there is room for improvement on the wastewater side – but new technologies are closing the gap.

By Andy Godley

Flow measurement underpins almost every aspect of the water and wastewater industries. In the clean water part of the cycle, flows are monitored and measured at all stages from source to delivery, driven by factors such as environmental protection (abstraction), reduced leakage, and revenue generation. On the wastewater side, however, there is generally less flow measurement in place as, historically, the drivers for wastewater flow metering have not been as strong.

Playing Catch-Up

There are significant technical difficulties when metering wastewater that make it much more challenging to measure than clean water and may also partly explain why there is less metering of wastewater flows.

Firstly, once abstracted, most clean water travels through pipes that are pressurized by pumping or gravity and run full. Wastewater, on the other hand, is often running through partially-filled pipes, sewers, and channels with a free surface flow. Closed-pipe flow is, on the whole, much easier to meter than open-channel flow, where the level of fluid and its velocity can vary independently. Thus, a given volumetric flow in a specific channel may be a shallow, fast-moving flow or a deep, slow-moving flow. Unless a control structure such as a weir or flume is in place, two measurements — velocity and liquid level — are often required to calculate volume.

Clean water flows also tend to be contained in round pipes. In wastewater, we find all kinds of interestingly-shaped sewers and channels. When no structure is in place, the shape needs to be characterized with respect to depth to calculate the wetted area (volumetric flow being wetted area multiplied by mean velocity).

Then, of course, clean water is, by definition, clean; wastewater isn't. Wastewater can be highly variable in content, carrying heavily-fouling substances such as fats, oils, and greases (FOG), as well as light solids and heavy solids, such as grit and other debris.

Pressing For Measurement

In the U.K., regulations stemming from the Urban Wastewater Treatment Directive and the Water Framework Directive have changed the emphasis on wastewater flow measurement. It is set to change even further with the new pressures on water companies caused by the Outcome Delivery Incentives (ODIs) put in place as part of the latest industry price review. These include, for example, incentives to reduce the incidence of sewer flooding. The consequences of pollution spills from malfunctioning combined sewer overflows (CSOs) are now more severe, with higher fines being levied by the Environment Agency for such incidents. This is leading, in the words of David Tyler, Environment Strategy Manager at Southern Water, "towards a more resilient and adaptive sewer network, one which is inexorably underpinned by in-sewer flow monitoring."

Finally, there is also the opening of the retail market for water and wastewater services in 2017 in England that will allow non-household customers to buy their wastewater services from any provider, not just their local water company. This should stimulate new ideas for service provision with better understanding of wastewater discharges, underpinned by flow measurement.

The majority of wastewater, whether from residential premises, industrial, or commercial sites, is discharged to the sewer network. A large industrial user will have a trade effluent meter (TEM) monitoring its discharges so that charges can be levied based on the Mogden formula, which combines flow, solids, and biochemical oxygen demand (BOD) to assess loading on the treatment process. The opening of the retail market for non-household water services in 2017 is stimulating new interest in this area. Those offering services based on more accurate flow measurement, and hence more accurate charges, are likely to develop additional services that can be provided using this data.

Applying Solutions

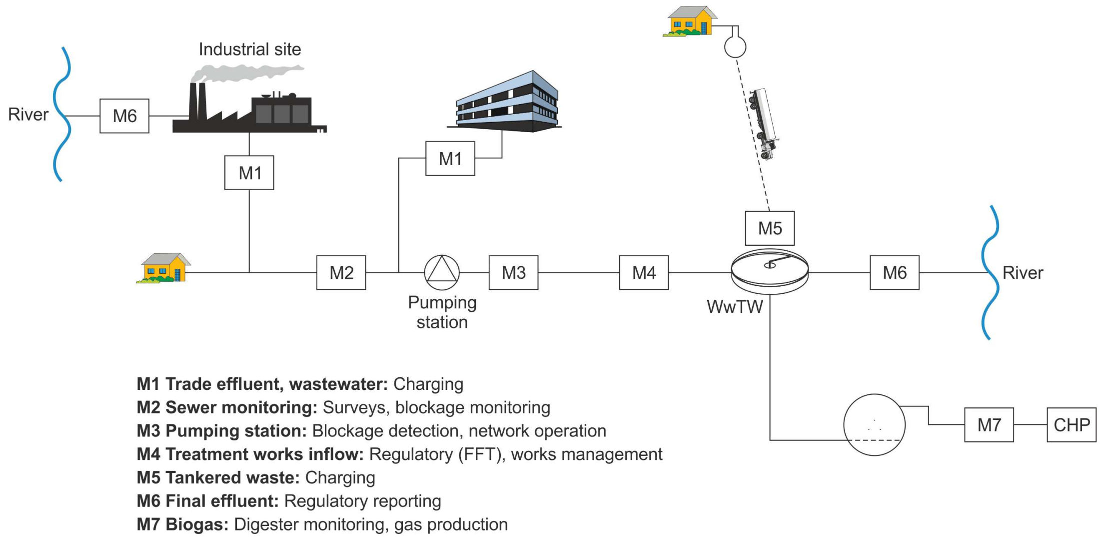
This may be an area where insertable sensors, such as the Nivus correlation pipe sensor, can be used to good effect. Such sensors can be installed in a live pipe without disruption, but more importantly, can be removed for cleaning, thus providing ongoing accuracy. Some are already in use for monitoring trade discharges to the environment from on-site treatment plants.

At sites without trade effluent meters, charges are based on the metered potable water supplied. Where waste flows to a combined sewer that also receives surface runoff, adjustments are made in the charging mechanism. An interesting development for sites without a specific TEM, therefore, is the wastewater meter offered by Dynamic Flow Technologies.

This uses microwave technology to measure the actual discharged waste flow. Models have currently been developed for typical drain flows in 4-inch (100 mm) and 6-inch (150 mm) pipes and will allow charging based directly on the quantity of foul discharge, rather than some assumed relationship with the water in and unmeasured adjustments for runoff. This technology is currently on trial with Wessex Water in the U.K. and could lead to new charging mechanisms for sites where clean water usage is relatively low but where there are large surface areas for rainwater runoff (for example, an out-of-town superstore where relatively little clean water is used in toilets and canteen facilities, but there are large roofs and parking areas).

In-sewer flow measurement is perhaps one of the most challenging flow applications in the water industry, due to the highly fouling nature of the fluid. However, it is also one of the most necessary for the reasons cited above. Non-contact sensors that are less

Measurement Points In The Wastewater Network



prone to fouling are clearly desirable.

While sewage levels are monitored quite widely using non-contact methods, non-contact velocity measurement is also now available using products such as the Raven-Eye and the LaserFlow. Both user Doppler methods — the former based on radar and the latter on lasers. These afford the opportunity to better understand what is going on in a sewer and distinguish, for example, level increases due to blockages and genuine high-flow storm events, both of which might lead to flooding but require different responses.

The Future In-Sewer

In-sewer flow measurement can also help manage loads going into treatment processes. WRc, an independent public limited company that provides water/wastewater research and consultancy, has recently been investigating the opportunity for smarter auto-desludging of primary settlement tanks. Desludging may be initiated by in-sewer meters warning of an incoming high load, thus creating headroom to deal with the first foul flush from a storm event and avoiding excess solids being carried through into second-stage treatment.

The Manning Formula (or derivatives) has long been used to estimate flow-rate based solely on a single level reading, though some of its assumptions and limitations mean that it is usually only an estimate at best. However, at the International Flow Measurement Conference held this July at Warwick University in Coventry, England, Laurent Solliec of Nivus presented an improved method using two-level sensors. This new approach can overcome some of the difficulties with traditional slope-area methods, such as coping with backwater. Tests in a sewer in Germany have been promising. Two-level sensors could provide a relatively easy-to-install and low-cost method for sewer flow monitoring.

The non-contact area-velocity meters are causing considerable interest for use on treatment works inflows and outflows, particularly now that independent testing by WRc under the Environment Agency's Monitoring Certification Scheme (MCERTS) has shown such approaches as being capable of producing data of the quality required by the regulator. LaserFlow and Raven-Eye are opening up the market for such devices, but, like all innovations, their work raises new questions.

One key aspect that is being debated is the in situ calibration and verification of these devices. Under MCERTS, users are required to have ongoing confidence in the operation of their effluent flow meters, including measurement validation. Systems are also subjected to an external inspection and in situ verification every five years by an MCERTS inspector. There are a number of methods for doing this at the moment, but recent papers have identified new and potentially more convenient methods. Tamari, et al.[1] report promising results from handheld radar, and Lüthi, et al.[2] have developed an app for a mobile phone that captures the movement of the liquid surface using the device's camera and analyses to give a measurement of flow.

Emerging, there are a large number of innovations for wastewater flow measurement driven by the need for better management of wastewater flows for environmental protection and the opportunities to develop new charging methods. It is often difficult to get new technologies accepted by a conservative water industry. There are encouraging signs that the U.K. water companies are becoming much more interested in implementing innovative solutions. Independent test schemes such as MCERTS and the European Environmental Technology Verification pilot project play a significant role in establishing the capabilities of new developments, though there is still work needed to develop methods for field verification. ■

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Andy Godley is a senior consultant for Flow Measurement and Metering at WRc plc. Godley has been involved with flow for more than 25 years, working across both the clean and wastewater sides of the industry for users, suppliers, and regulators. He sits on a number of British, European, and international standards committees on flow topics.

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Measuring Innovation: Water Quality Analytics Startups To Watch

In an industry with more than its share of startup tech companies, Lux Research identifies innovators in water quality analytics that are poised to make a splash.

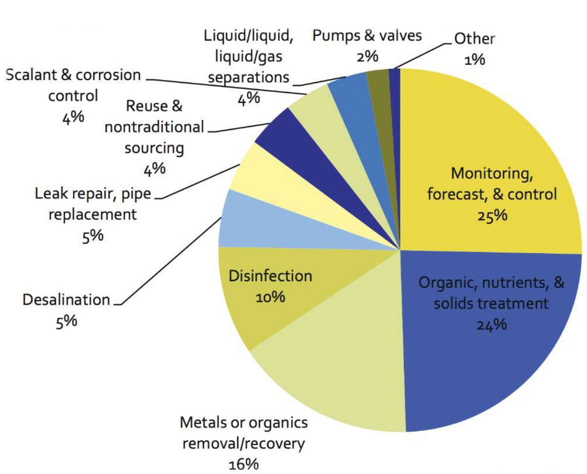
By Abhirabh Basu

The water industry is flooded with technology companies competing to remain afloat. Every year, Lux Research, a strategic advisory company, interviews executives of more than 120 startups in the water space. According to Lux's analysis (Figure 1), a striking concentration of startups focuses on analytics technologies, with many using advanced sensors to measure water quality. These companies represent a full quarter of the startup activity in the industry. Such a large crop of analytics companies indicates a long overdue change in process control.

A Work In Process

In contrast to other sectors, the water industry lags behind in process control by decades. For instance, while factory production has long been closely monitored and automated by computers, the same cannot be said for most water systems. The chemical complexity of these systems, as well as the geographic scale in the case of municipalities, have proven to be significant barriers to process control. Traditional lab testing and spot sampling continue to create delays in operators' ability to detect crucial process and water quality issues.

Figure 1: Startup Activity In The Water Industry



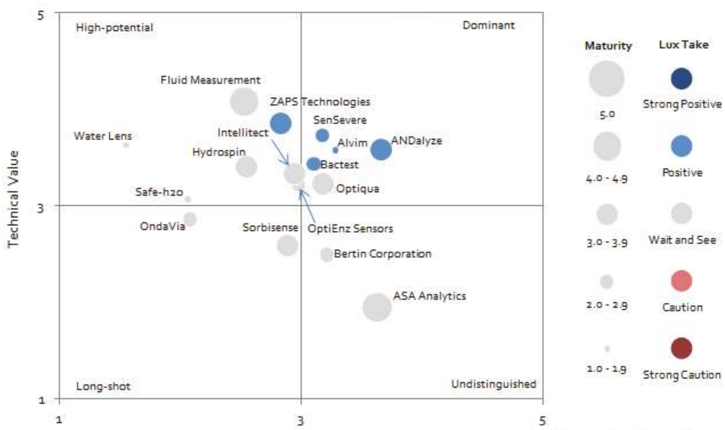
Source: Lux Research, Inc. www.luxresearchinc.com

Today, the water analytics market is valued at $2 billion and is growing at five percent per year. Established companies such as Hach, Mettler Toledo, Agilent, and Veolia dominate the space and provide robust techniques to measure a range of traditional parameters. However, new and innovative startups are challenging the status quo, creating technologies that offer better real-time data acquisition and more analyte-specific and sensitive analytics.

Mapping Innovation

In order to compare emerging startups, the Lux Innovation Grid (Figure 2) maps innovation in a particular market segment or technology area, ranking companies on both their general business execution and their technological value.

Figure 2: The Lux Innovation Grid On Water Quality Analytics Companies



Source: Lux Research, Inc. www.luxresearchinc.com

Companies in the upper right corner of the Lux Innovation Grid, so-called "dominant" startups, have relatively strong business execution and technical value and make great partners or investment targets. These companies are often first to the market with revolutionary or disruptive technologies and face little competition.

SenSevere has introduced real-time bromide and hydrogen sensors that function in highly corrosive and challenging environments. Bromide in water treatment plants and distribution systems can interact with organic matter during regular chlorine disinfection to form trihalomethanes (THMs), which are carcinogenic in humans. Currently, water treatment plants infrequently test bromide levels by sending water samples to laboratories. SenSevere's chemical sensors detect bromide at

Tightening discharge restrictions from regulators worldwide has increased the need to closely monitor waste streams, allowing next-generation sensor technologies to break out of the lab.

levels as low as 10 ppb, allowing operators to immediately address contamination in their system.

Italian startup Alvim provides sensors to directly monitor biofouling. Compared to traditional methods of measuring biocide loss and general fouling, Alvim's sensors offer valuable process control for applications in cooling water systems, industrial water treatment, desalination, food processing, and paper mills. In one example, Alvim deployed five sensor units in a pulp and paper process line to monitor biofilm buildup, allowing operators to adjust their processes to use fewer chemicals or alter chemical use to address key problems. The company is currently developing an explosion-proof version of its sensor for oil and gas applications. Alvim has several established customers including GDF Suez (now known as ENGIE) and Danone.

Illinois-based ANDalyze, which is currently seeking a buyer, provides a sensitive DNA-based fluorescence test for free metals that can expand to detecting trace levels of organics and bacteria. Its handheld device currently measures trace metals in the low ppb range and can display results in less than 30 seconds. The tests are robust, easy to use, and exceed the sensitivity of other handheld devices. The company has secured more than 20 distributors worldwide, including the analytics giant Hach. ANDalyze is currently developing an online instrument with the U.S. Army's Construction Engineering Research Laboratory (CERL) to monitor metals and possibly other compounds in a continuous process.

On The Horizon

"High-potential" companies, which appear in the upper left quadrant of the grid, represent those that have attractive technologies but struggle to gain market share. However, these companies make good licensing targets or investment targets for those who can tolerate a higher degree of risk. Water analytics companies that have previously appeared in the high-potential quadrant include Neosens and Capilix, which were both promptly acquired by Aqualabo Group and Metrohm, respectively.

Among current high-potential companies, Zaps Technology has improved its standing since Lux's previous interview with the company. The company's real-time monitoring system uses three optical techniques simultaneously — absorbance, reflectance, and fluorescence. This allows it to rapidly detect more than 100 water quality parameters, from simple chemicals, like chlorine and ammonia, to complex analytes such as organic compounds, E. coli, chlorophyll, and algae, with a high degree of sensitivity. Zaps is attempting to go head-to-head against traditional biochemical oxygen demand (BOD) testing with its alternative BOD measurement that provides results in seconds, compared to the painstaking standard five-day tests. The company is currently awaiting method approval from the U.S. Environmental Protection Agency (EPA), but if approved, its technology can potentially revolutionize wastewater monitoring by allowing plant operators to prevent surface discharge of contaminated waters in real time.

Lux recently spoke with OptiEnz Sensors, which is field-testing its fluorescence technology with new sensor probes for real-time and continuous monitoring of organic compounds in water. In addition to its benzene, toluene, ethylbenzene, and xylene (BTEX) sensors, OptiEnz has developed carbohydrate sensors for the food and dairy industry. Its tricholoroethylene (TCE) sensor can instantaneously detect TCE in the single-digit ppb range, an application useful for groundwater monitoring near industrial facilities. OptiEnz's value proposition lies in providing robust sensor probes to compete against tedious laboratory testing procedures. It has started generating revenue through tests with Fortune 100 companies in the food and beverage, pharmaceutical, biofuels, and frack water treatment industries.

Tightening discharge restrictions from regulators worldwide has increased the need to closely monitor waste streams, allowing next-generation sensor technologies to break out of the lab. Water quality analytics have moved away from time-consuming laboratory tests to continuous and real-time monitoring and rapid analysis techniques, such as lab-on-chip analysis, that require minimal operator expertise. The water industry is long overdue for automation in process control, but new technology is finally achieving this goal. Industry leaders who are scouting for innovative technologies to improve their processes should engage the leading startups in the space. ■

About The Author

Abhirabh Basu is a research associate at Lux Research (www.luxresearchinc.com) on the Water Intelligence team, where he conducts research focused on water treatment technologies. Basu has a B.S. in Chemical Engineering from Panjab University in India and an M.S. in Environmental Engineering from New York University Polytechnic School of Engineering.

7 Ways Smart Meters Save Water

In an era of drought and conservation, smart meters can be utilities' best allies in the fight to preserve water supplies.

By Lon W. House

Smart meters have been prominent in the energy utility world and are beginning to make substantial inroads in the water utility world. Smart meters are probably more useful for the water sector than for the energy sector, and the old days of billing total water consumption during the last month or two is being phased out with the introduction of time-of-use water consumption information.

Smart meter installations have reported numerous benefits, both operational and on the customer side (see Table 1). Aside from the obvious savings from reduced need for onsite meter reading, the ability to identify not just the volume of water consumption but also the timing of that consumption has significant benefits, particularly to customers, and may be a linchpin for enhanced water conservation efforts. This is particularly an issue for California, where urban water customers are under mandatory 25 percent reductions in water usage due to the lack of available snowpack contributing to the current drought.

Smart Conservation Efforts

Reduced customer leak losses: All smart meter programs provide automatic customer leak detection. According to the algorithm they follow, at some point in a 24-hour period for a duration specified by the water utility, customer's water consumption should drop to zero. If customer usage never drops to zero, that account is flagged for utility operators' notice. There are corrective algorithms that account for customer usage of evaporative/swamp coolers if that is a concern in the utility area.

> *Smart meters collect water consumption data with a timestamp and transfer that information to the utility. This can either be a one-way communication to the utility (AMR – automated meter reading) or a two-way communication between the utility and the individual smart meter (AMI – advanced metering infrastructure).*

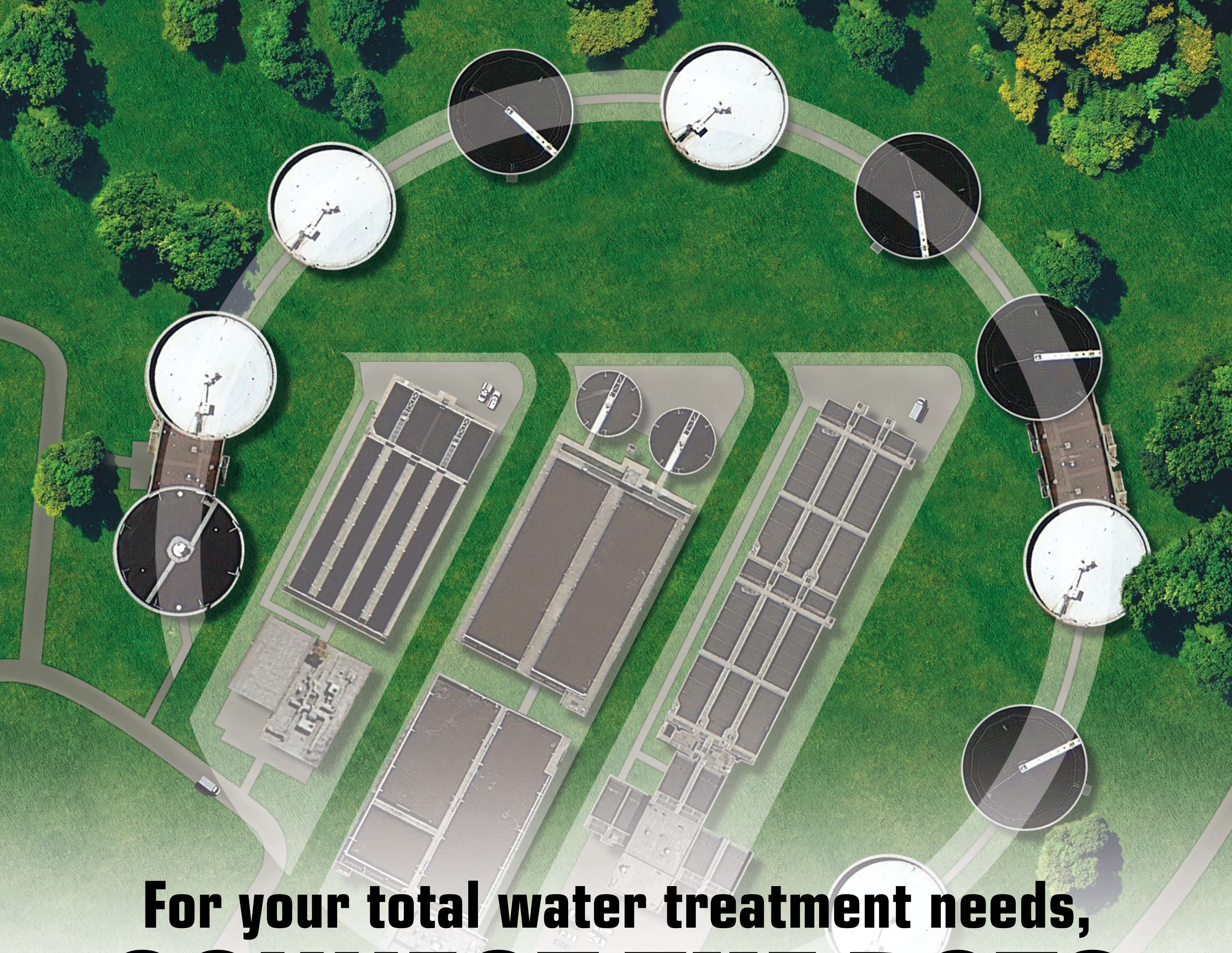
Outdoor watering day limitations: Another typical water conservation effort is to limit outdoor watering to pre-specified days, such as even-numbered days, only on Tuesday or Thursday, etc. Enforcement of this measure without smart meters requires considerable personnel expense, as someone has to physically inspect the site. With smart meter data, customers watering on the wrong days become immediately obvious.

Time-of-use watering restrictions: One water conservation program that is popular is to limit outdoor watering in the daylight or afternoon hours. The enforcement of this type of program has the same issues as the outdoor watering day programs, but interval water consumption data quickly identifies customers who are not participating.

Table 1

Smart Meter Benefits	Comments
Reduced meter reading costs	*No need for onsite reads. Saves both regular cycle reads and special reads.*
Reduction in security and safety issues	*No need for onsite reads at dangerous or inaccessible locations.*
Increased customer service	*Resolve billing disputes. Use for identifying and explaining customer use patterns and volumes.*
Reduced unaccounted-for water	*Detect theft of service.*
Improved billing and cash flow	*Automated billing and meter reads.*
Improved outage information and response	*Identifies system outages and location.*
More efficient asset management	*Tracks and predicts changes in trends and demands.*
Leak detection	*Quickly identifies customer leaks.*
Allows creative rate design	*Can support alternative rate designs, such as water budgets instead of volumetric rates.*
Conservation programs	*Identify timing of water use (e.g., outdoor watering only on certain days). Can be used to identify indoor water uses and efficiency (e.g., toilet, shower, clothes washer, dishwasher use). Determine volumes of water consumption by time period (e.g., daily water use limits).*

Source: *Smart Meters and California Water Agencies: Overview and Status*, California Energy Commission, CEC-500-2010-008, March 2010.



In this new era of water supply limitations, enabling customers to understand how they are using water as well as how much they are using is paramount to program success and customer satisfaction.

Creative rate design: Traditional volumetric water rates are being replaced by creative water tariffs in response to policy directives and water conservation efforts. Water budgets have been successfully implemented in California (e.g., by Coachella Valley Water District and Irvine Ranch Water District) as an alternative to volumetric rates. Water budgets specify water consumption volumes based upon individual customer characteristics like lot size, number of bathrooms or bedrooms, and landscaping. Smart meter water data is critical to the success of water budget implementation. It provides customers with detailed information on how much water they are using and when they are using it, and alerts them when they are in danger of exceeding a specific water tier limit and going into a higher-priced bracket.

Identification of customer inefficiencies: Water technologies have identifiable water use patterns. For example, toilets are a quick couple gallons of water usage, whereas dishwashers and clothes washers spread water usage over a much longer timeframe. By knowing the timing and volume of customer water usage, a utility can analyze the various water end uses and, theoretically, identify customer-specific inefficiencies like high-water-use toilets. This application has obvious customer privacy issues but can provide a very useful tool for assisting customers in identifying where they are using water and ways to reduce that water usage.

Verification of water conservation investments: Access to time-varying customer water usage data can provide immediate feedback on the effectiveness of water conservation investments. For example, comparing an hour's water consumption pre- and post-change of water sprinklers is a graphic illustration of the amount of water saved via the sprinkler conversion.

Timely notification of water conservation efforts: It is very difficult to get timely customer response to conservation programs using traditional monthly or bimonthly water billing. What these traditional bills tell customers is how much water they used more than a month ago. They do not allow a customer to track water usage and adjust water consumption to meet pre-specified conservation efforts, as smart meter data does.

Making The Change

In this new era of water supply limitations, enabling customers to understand how they are using water as well as how much they are using is paramount to program success and customer satisfaction. While smart meter water data can be used in a punitive way, its greatest use is educational; informing customers when they are not participating in the program correctly, notifying them when they are approaching water consumption limits, identifying leaks on their side of the meter, showing them where they are using water, and suggesting behavior options to reduce their water consumption.

While interval water meter data is fundamental to modern water conservation programs, there are issues and concerns about the transition to smart meters. Issues concerning the cost of the new smart meters, their compatibility with existing infrastructure, integration of interval water consumption information into current billing systems, customer access to the water consumption data, and protection of customers' privacy are legitimate concerns that need to be addressed. But there are creative ways to address them.

An anecdotal illustration of a creative approach to addressing the water interval consumption need can be found in Long Beach, California's, smart water meter pilot. Rather than changing out the old meters to new smart meters, the city has deployed add-ons to existing water meters. The "Innov8 register" can be added to most common meters to provide data-logging in intervals down to one minute and flow down to 0.2 gallons. The meters then communicate wirelessly over a cellular data network and provide web-based analytics for customers and the utility to see their water usage.

The ready availability of interval water consumption information from smart meters significantly enhances the options for water conservation programs and can greatly improve customer participation and satisfaction in conservation programs. They are a foundational tool for water utilities going into the 21st century. ■

About The Author

Dr. Lon W. House is the owner of Water and Energy Consulting, with offices in California and Arizona. House is a consultant to the Association of California Water Agencies and the California Rural Water Association, as well as a water-energy consultant for the California Energy Commission and California Public Utilities Commission. He is also the energy and efficiency trainer for the National Rural Water Association.

Decentralized Wastewater Treatment Shines As Aquifer Recharge Solution

Decentralized wastewater treatment systems have come a long way. Learn how new advancements have broadened their potential and may provide relief to fast-depleting groundwater resources.

By Jessica L. Kautz

Potable water sources are being exploited worldwide; water tables are dropping at drastic rates, causing wells to run dry, saltwater to intrude inland and leaving an increasing number of people without reliable sources of life-sustaining water. As populations continue to grow and shift, it is imperative for all aspects of the water cycle to be optimized for sustainability.

Wastewater treatment creates a large impact on the water cycle, as large volumes of water are processed on a daily basis. The foremost goal of wastewater treatment has always been and continues to be the protection of public health. However, as the industry grows and the complexities of the challenges expand, it is important to consider that the method and level of treatment greatly impact environmental health and sustainability, as well as our potable water supplies. It is our responsibility as engineers, designers, and citizens to protect both public and environmental health.

Models Of Wastewater Treatment

Two general models are used in wastewater treatment — centralized and decentralized wastewater treatment. Centralized wastewater treatment involves the collection of wastewater from a large area to one centralized location, where it is most commonly treated and released into local surface waters. Conversely, decentralized wastewater treatment provides treatment and disposal either directly on site or at a nearby location. Both methods can be designed to provide equivalent levels of treatment and protection of public health.

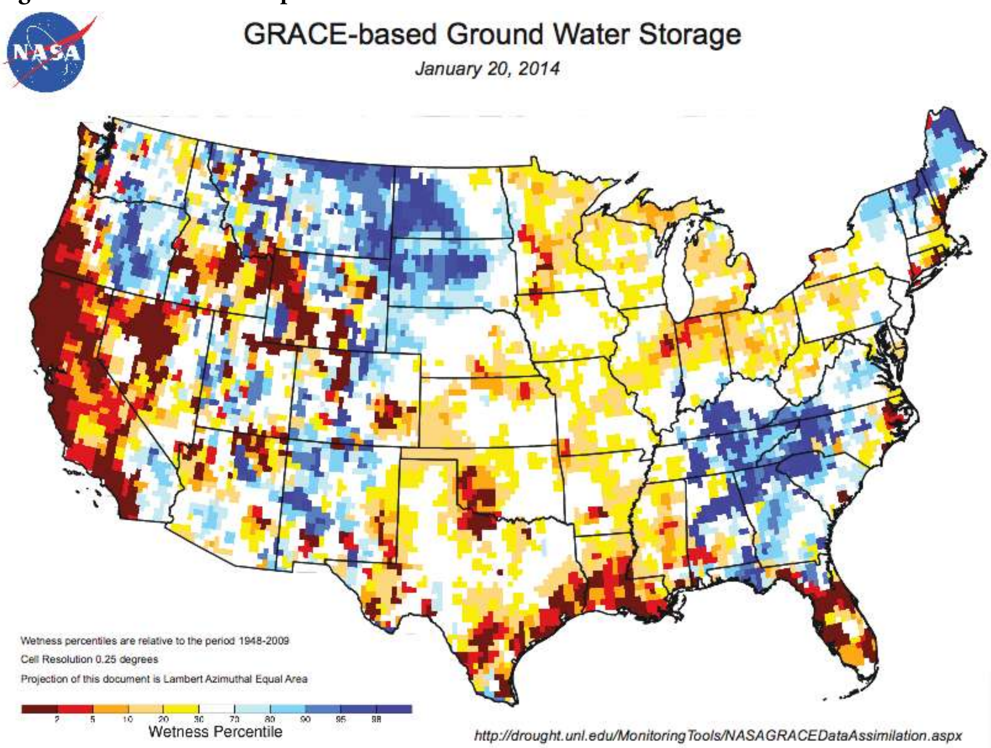
However, centralized and decentralized wastewater treatment systems vary greatly in regard to their impacts on environmental health and potable water supplies. Centralized treated effluent is usually released into flowing waterbodies (such as rivers or oceans); malfunctions in system performance therefore pose a significant risk to public health as they can flood surface waters with contaminants or hazardous chemicals. In addition, the clean water discharged from the facility is largely carried away from its original location before it filtrates into the soil, evaporates, or is removed for a downstream potable water supply. Discharge thus provides limited groundwater recharge of the billions of gallons of treated effluent released daily. Centralized wastewater infrastructure also adds to groundwater depletion, as leaking pipes can cause groundwater to infiltrate into the pipes and be carried to the centralized facility.

Decentralized systems, on the other hand, treat and filter effluent through the soil directly into the local aquifers. Once filtered through the natural soil into the aquifers, the clean water travels to surface waters or wells or estuaries, where it can be utilized by humans and natural ecosystems. In this way, decentralized wastewater treatment systems provide the most passive and environmentally sound form of aquifer recharge and wastewater recycling.

Aquifer Recharge Using Decentralized Wastewater Treatment

Aquifer recharge is a growing method of water table stabilization and water supply in the U.S. The U.S. EPA defines aquifer recharge as, "the enhancement of natural groundwater supplies using man-made conveyances such as infiltration basins or injection wells." As currently defined by the EPA, aquifer recharge systems are typically used in areas with limited ground or surface water availability.

Figure 1. Groundwater depletion in the continental U.S.



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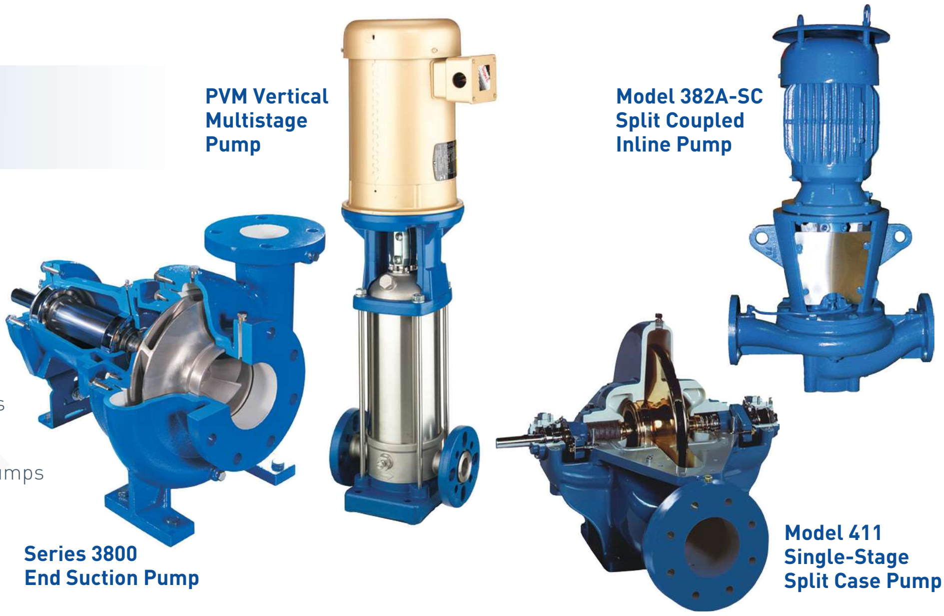

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200	Up to 180	Up to 41	Up to 575	Up to 175	Up to 210	Up to 99
300	Up to 4,500	Up to 1,022	Up to 790	Up to 241	Up to 300	Up to 149
3800	Up to 4,200	Up to 954	Up to 520	Up to 158	Up to 300	Up to 149
400	Up to 15,000	Up to 3,406	Up to 1,000	Up to 305	Up to 300	Up to 149
500	Up to 1,200	Up to 273	Up to 180	Up to 55	Up to 180	Up to 82
700	Up to 10,000	Up to 2,271	Up to 500	Up to 152	Up to 275	Up to 135
PVM	Up to 800	Up to 182	Up to 960	Up to 293	Up to 248	Up to 120

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However, when adequately designed and installed, a decentralized wastewater system can process large amounts of wastewater through the underlying soils, making it one of the most passive, sustainable forms of aquifer recharge.
Rather than partially to fully treating wastewater effluent, then discharging it to a surface pond or injection well before recharging the aquifer, decentralized systems provide both wastewater treatment and groundwater recharge in one step.

Figures 1 and 2 show the groundwater deficits in the United States and the decentralized utilization rates for each state, respectively. In general, areas in dark red on the groundwater storage map correlate with areas of light decentralized utilization, as well as the opposite; a general correlation can therefore be made between low septic utilization rates and groundwater depletion. While other factors greatly impact groundwater depletion (e.g., precipitation, urbanization, and agricultural practices), the figures can be interpreted to show that decentralized wastewater treatment has an impact on groundwater storage.

Applicability Of Decentralized Wastewater Treatment

As technology continues to advance, an increasing number of sites have become viable candidates for decentralized systems. For example, designing a small-scale, advanced treatment train prior to dispersal of the effluent into the native soil can decrease both the absorption area and depth to limiting layers that are required for adequate treatment. This has allowed decentralized systems to be placed in areas previously inaccessible, in turn increasing the volume of groundwater recharge associated with decentralized systems.

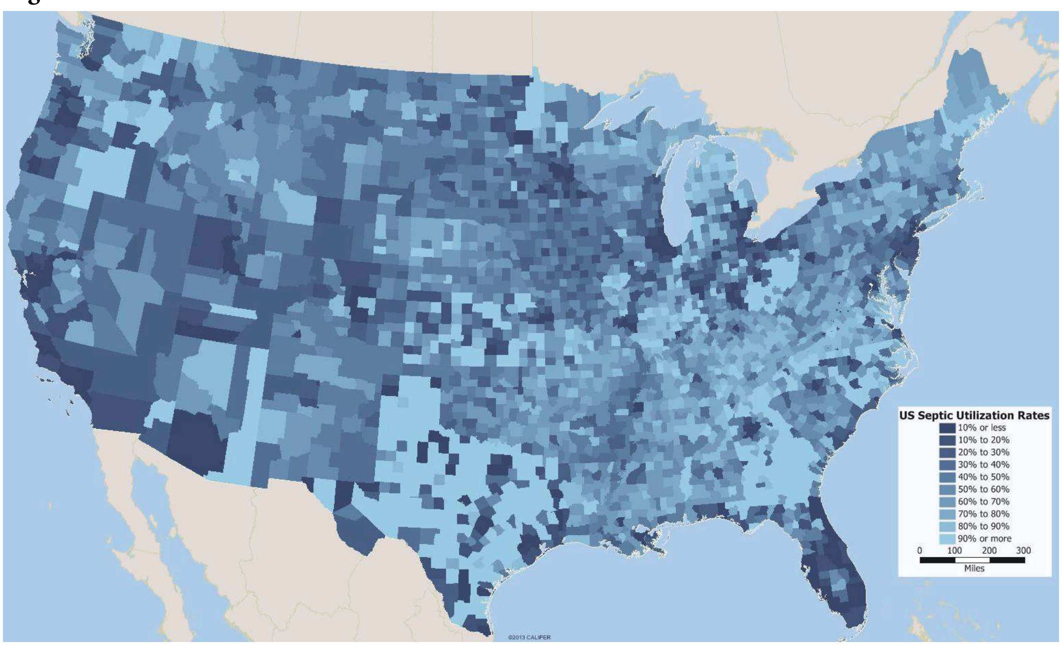
While traditionally thought of as a low-flow wastewater treatment solution, decentralized systems can be designed to treat any volume of wastewater. Community decentralized systems are being designed and used increasingly where lot sizes or site conditions limit the use of individual on-site wastewater treatment systems. Large systems can also be developed for large flow commercial and industrial sites, decreasing the hydraulic and nutrient stress placed on centralized wastewater treatment plants.

Decentralized systems are conventionally managed by individual homeowners, who can be undereducated or unable to adequately maintain their systems; this is a main reason why the decentralized model is often immediately dismissed. This is also changing. Centrally managed decentralized wastewater treatment systems, such as publicly and privately owned community systems, are being staffed with trained and educated personnel in the same manner as centralized systems.

Case Study: Loudoun County, Virginia

Loudoun County, VA has adopted a combined approach to wastewater treatment, utilizing both centralized and community decentralized treatment facilities. Community decentralized treatment facilities are publicly owned and maintained by Loudoun Water in the same manner as the county's centralized treatment plant. As the county continues to grow, developers integrate new community decentralized facilities then transfer ownership and operation to Loudoun Water. All homes connected to the community systems pay taxes and fees matching those paid by homes connected to the centralized system, which allows sustainable operation and maintenance. One of the subdivisions serviced by decentralized wastewater treatment is Elysian Heights. This wastewater treatment system was designed to serve a 324-home subdivision and 5 acres of commercial land. For more information on the Loudoun Water decentralized systems, visit www.loudounwater.org.

Figure 2. Decentralized wastewater treatment utilization in the continental U.S.



Conclusion

Decentralized wastewater treatment can provide equal or better protection of public health while outshining centralized wastewater treatment in environmental protection. Where individual lots are not suitable for decentralized treatment on site, community decentralized systems can provide sustainable and responsible wastewater treatment. Decentralized systems provide a low-cost, environmentally friendly, passive form of both wastewater treatment and aquifer recharge, combatting the declining groundwater table and protecting public health. ■

About The Author

Jessica L. Kautz, EIT (jkautz@infiltratorwater.com) recently joined Infiltrator Water Technologies as a project engineer after graduating with her M.S. in Civil and Environmental Engineering from the Colorado School of Mines and her B.S. in Civil Engineering with an Environmental Concentration from the University of Hartford. Kautz has spent her time at Infiltrator working closely with both the Research & Development and Science & Government Affairs departments to research, develop, and gain approval for new products.

Industrial Case Study: Lessons From Nestlé's Zero Water Facility

Under pressure to avoid using Southern California's endangered groundwater supply, Nestlé has announced plans to convert a Modesto milk factory into a "zero water" facility capable of extracting water from the materials it manufactures and reusing it for industrial processes.

By Peter Chawaga

The climbing costs and increased environmental pressures stemming from dwindling freshwater resources have industrial companies across the board looking for the key to reuse. There is no shortage of academic literature, new products, and corner-cutting methods that promise to stretch every drop. But sometimes it's best to just follow the leader.

A Call To Action

Nestlé announced in May that it would transform a milk factory in Modesto, CA into a "zero water" facility, one that draws nothing from groundwater sources and extracts from the raw materials it manufactures all of the water it needs to function.

The announcement of the forthcoming change in Modesto came as part of sweeping California conservation efforts from the Swiss multinational food and beverage company. All five of the water bottling plants and four food and pet care production facilities that it operates in the state will undergo water-reducing equipment and procedure upgrades. These will include process optimization, a focus on water reuse, and the deployment of new technologies.

"We are focused on how to adapt our bottling and our manufacturing operations, and our supply chain, to make them more resilient and more resistant to drought conditions," José Lopez, Nestlé's Head of Operations, said in the official statement announcing the changes.

The efforts to transform the Nestlé bottling plants in California are estimated by the company to save over 55 MG per year.

The effort likely comes in response to scrutiny leveled at the company for its practice of bottling California's groundwater for sale under its Arrowhead and Pure Life brands. The California-based "Courage Campaign" is petitioning the state's Water Resources Control Board to put an end to all of Nestlé's bottling operations there. The online petition has garnered over 139,000 digital signatures.

"While California is facing record drought conditions, it is unconscionable that Nestlé would continue to bottle the state's precious water, export it, and sell it for profit," the campaign pledge reads.

Having heard the concerns over his company's practices during a drought that shows no signs of subsiding, Lopez acknowledged that it's time for his multi-billion dollar company to do more to conserve water, whatever the upgrade costs.

"It doesn't make economic sense to do this, obviously," he told *Bloomberg* in May. "The drought this year is teaching us you have to think of ways to adapt. What seems today not fully advisable from an economic standpoint will become a necessity."

Nestlé is approaching these extensive conservation efforts in dramatic fashion. The company anticipates that implementing its zero water plan at the Modesto facility will cost $7 million. This will save nearly 63 MG per year, 71 percent of its absolute withdrawals in 2014. It expects to have fully executed the changes by the end of 2016.

Realizing Change

The zero water technology is already in place and living up to its name at a Nestlé milk factory in Jalisco, Mexico.[1] The achievement there serves as a starting point for the changes being made in Modesto.

"Technology we have already deployed successfully elsewhere in the world to help address the challenges of water scarcity will improve our water use efficiency, relieving pressure on California's water resources," Lopez said in the company's statement.

The next step was to carefully scrutinize how things used to run in Modesto and identify room for improvement.

"We began by updating our factory water map, which includes all water users for the facility," Nestlé told *Water Innovations*. "We then conducted a mini Kaizen event[2] involving our factory team and various subject matter experts to identify the top water users. Following this event, we prioritized projects aimed at finding solutions to reduce, reuse, and recycle water use in our operations."

The Nestlé team found that reuse offered the best chance to achieve zero water.

"The critical first step is to set the minimum baseline," the company said. "From there, water reuse becomes the focal point to further the transformation [to a zero water facility]. The approach we took was to first focus on water reductions to set the baseline for minimum consumption required for our process."

Nestlé installed evaporation technologies in Modesto which allow the plant to reuse the waste left over from making Carnation condensed milk.

"We looked at opportunities to optimize reuse water where possible, such as reusing or recycling milk water from the evaporator process that ultimately reduces overall water consumption," Nestlé said.

Evaporator technologies are typically favored in produced water treatment, as the process isn't particularly sensitive to traces of oil. But they are also becoming popular in industrial plants looking to increase reuse. Water recovered from evaporator systems will meet virtually all discharge specifications and is ideal for reapplication in cooling processes.

Most evaporator systems on the market consist of a falling film evaporator, followed by a crystallizer and filter press or rotary spray dryer, which separate liquids that can be reused.

In addition to evaporation upgrades, the Nestlé plant introduced a new filtration system.

"I worked with Nestlé at their Arrowhead bottled water plant in Cabazon, CA to install a filtration system on their cooling tower in order to reduce the amount of blowdown water they would send to the sewer," said Jim Lauria, president and founder of Team Chemistry, LLC and an executive in the water technology field.[3]

A large air conditioner tower can discharge 70,000 gallons and evaporate 200,000 gallons of water per day, according to "Recycled Water Use In Cooling Tower Systems," a presentation from water and wastewater consultant Paul R. Puckorius given to a WateReuse Association workshop. The practice of utilizing reused water in a cooling tower has been popular for decades because of this high consumption coupled with the fact that cooling tower water does not need to be of comparatively high quality.

When asked about other innovations that a facility eyeing water reuse might consider, Lauria pointed to a problematic industry fixture.

"One of the largest depositories of water associated with any industrial facilities is their wastewater lagoons," he said. "These hold large volumes of water, over a large area, for long periods of time. If not properly managed, they can contaminate ground and surface water, produce greenhouse gases and noxious odors, and provide breeding grounds for mosquitos. If properly managed, on the flip side, they can be a viable source of recycled water, energy, bio-solids, and nutrients like phosphorous and nitrogen."

Where There's A Will

Beyond the significant and vital conservation achievements these innovations will bring to Southern California, Nestlé's zero water design serves as a template for industrial plants everywhere. If Nestlé can reduce its water use so significantly, then why can't the next corporation? After all, the company is quick to point out that while it has been demonized for bottling California's groundwater, its nine plants there use less than 1 billion gallons a year while the state consumes 13 trillion gallons.

"All industrial sectors have the opportunity to recover water used throughout the plants," said Lauria. "The company must have the will to budget for treating the process water to a level that can be used for a downgraded purpose, like for cleaning, cooling, or irrigation."

Nestlé echoes Lauria's opinion that achieving zero water is a simple matter of wanting it badly enough.

"The largest obstacle is will," the company said. "This is not an easy journey, and it involves a commitment from all involved. In addition, the journey involves a degree of technical knowledge. Companies need to know their process well and have the will and tenacity to proceed."

For The Future

All told, the efforts to transform the Nestlé bottling plants in California are estimated by the company to save over 55 MG per year and reduce the absolute yearly withdrawals by 8 percent compared to 2014.

The company says it is likely it will identify and implement additional reduction methods in the near future.

"We are always looking for ways to improve our water efficiency," Nestlé said. "In line with our 2013 'Commitment on Water Stewardship,' Nestlé actively seeks new opportunities to reduce, reuse, and recycle water in our operations."

Nestlé has teamed with the World Resource Institute to identify and alleviate the water risks inherent with its food and bottled water manufacturing operations. It claims to have 376 water-saving projects currently underway, poised to save 1.84 million cubic meters of water this year.

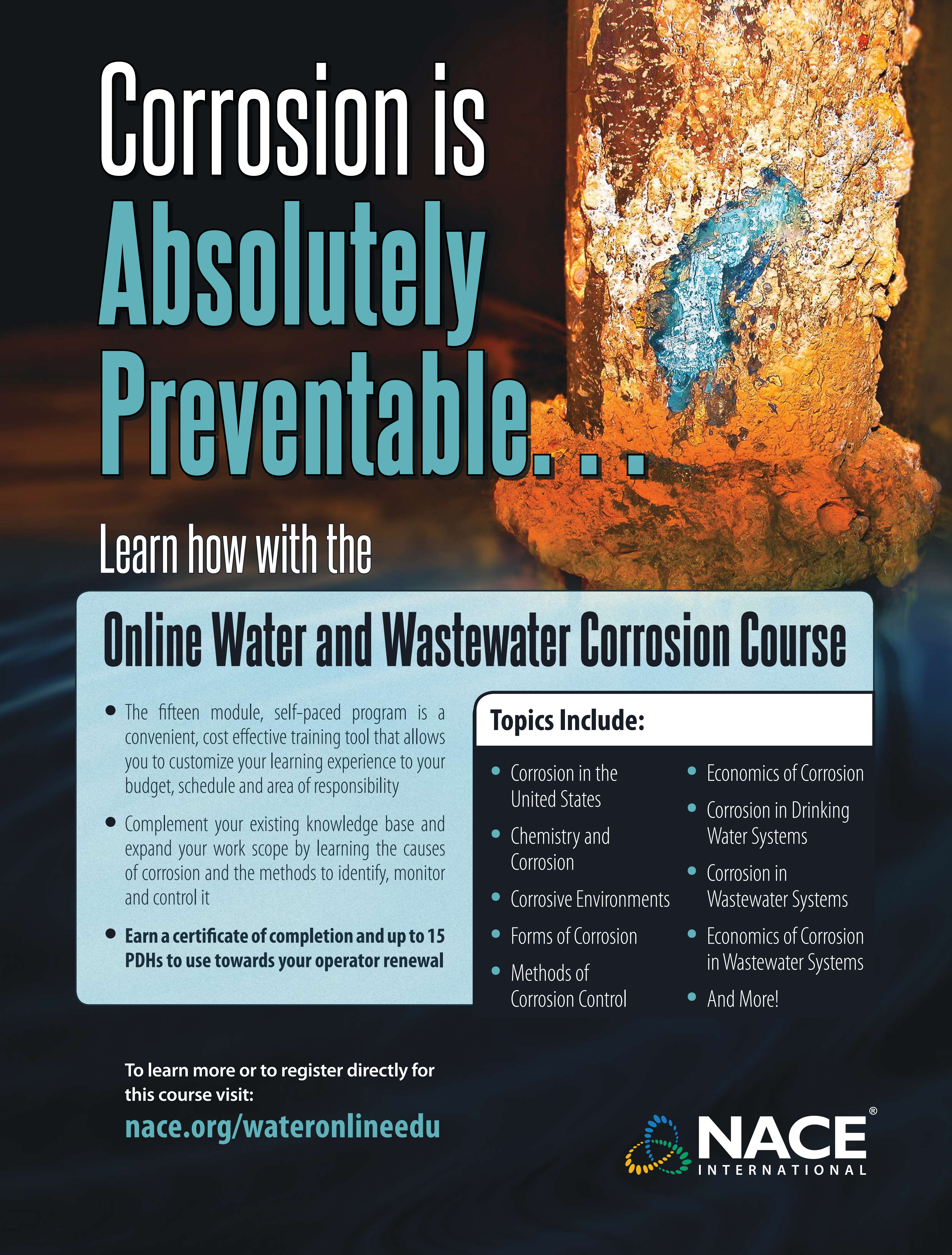
Whether it's inspired by a real dedication to endangered water resources or to produce goodwill in the face of protests, the bottom line remains those gallons being saved. Few companies operate on the scale that Nestlé does, but any player in any industry can look toward the zero water facility as a guide. Starting with a commitment to change, then finding the technological solutions that are right for it, every factory can join Nestlé and milk its water for all it's worth. ■

Footnotes

1. Nestlé announced the zero water changes there in 2014. The company estimates that this "Cero Agua" facility saves 1.6 million liters of groundwater a day.
2. A Kaizen event brings operators and managers together to review an existing process and identify areas for improvement, utilizing input from all those involved in the action. It stems from a Japanese business philosophy developed after World War II that translates to "continuous improvement."
3. Lauria is also an author. In his introduction to ***Damned If We Don't***, published by Water Anthology Press, he writes: "Optimizing the water that flows into and out of industrial ecosystems challenges us to innovate. Clearly, the technology in each of those systems can be as sophisticated as possible – certainly the more sophistication we build into the system, the more efficient we can become in making every drop count."

About The Author

Peter Chawaga is the associate editor for ***Water Online***. He creates and manages engaging and relevant content on a variety of water and wastewater industry topics. Chawaga has worked as a reporter and editor in newsrooms throughout the country and holds a bachelor's degree in English and a minor in Journalism. He can be reached at pchawaga@wateronline.com.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