JULY 2021

Water Innovations

Hydroinformatics 101: Intro To Water Optimization And Efficiency

PLUS: Lessons on Granular Activated Carbon, Cybersecurity, and More.

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By Kevin Westerling
Chief Editor, editor@wateronline.com

The Shape Of Water, Starring AWWA's Tracy Mehan

If water-industry superstars were celebrated like entertainers, an introduction to G. Tracy Mehan III wouldn't be necessary. But water, as industry veterans know, doesn't quite get the attention it deserves … until services are threatened. At that point, as all along, we turn to our water leaders for answers, which is why I contacted Mehan for this Q&A.

For those with a career in water, or a passion for protecting it, a full introduction to Mehan may not be necessary. And, in truth, we don't have enough space here to cover all of his achievements. A still-long, but much-deserved, overview [deep breath]:

Currently, Mehan is executive director of government affairs for the American Water Works Association (AWWA), an adjunct professor at the George Mason University School of Law, and a member of the Environmental Law Institute (ELI).

Formerly, he was assistant administrator for water at the U.S. EPA from 2001 to 2003, and he served on EPA's Environmental Financial Advisory Board from 2014 to 2018.

Additionally, he was principal of The Cadmus Group (2004-2014), environmental stewardship counselor to the 2004 G-8 Summit Planning Organization (2004), director of the Michigan office of the Great Lakes (1993-2001), interim president for the U.S. Water Alliance (2015), and source water protection coordinator for the U.S. Endowment for Forestry and Communities (2013-2015).

And lastly, though first to be achieved, he earned degrees from Saint Louis University and its School of Law (we'll spare him the graduation dates).

With that, we turn to our celebrated, if not celebrity, Q&A guest for direction in this critical time of change and challenge in the water and wastewater industry.

As AWWA's executive director of government affairs, how are you focusing your energy with this presidential administration and EPA? Are there new windows of opportunity with this new leadership?

We at AWWA are lending our voices to the conversation on the Hill to ensure that water infrastructure and lead are not overlooked in the legislative scrum. We also support greater financial support for removal of PFAS compounds. The ultimate cost of PFAS regulation will likely dwarf the costs of lead service line removal. Last year, my staff did a preliminary analysis for the Congressional Budget Office of national costs associated with implementing drinking water treatment to remove PFOA and PFOS, two legacy compounds likely to be regulated first by EPA. There are hundreds in commerce, but these two are known quantities and allowed us to make some calculations. The costs quickly exceed $3 billion if the standard were to be based on EPA's current health advisory, which has been largely ignored by states regulating at even lower limits. If EPA were to move closer to the standard used by states like New Jersey, capital costs quickly exceed $38 billion. These figures do *not* include operating costs and waste management, which would likely exceed $1 billion *annually*, again, depending on the regulatory standard and waste-management requirements currently under consideration by Congress and EPA. PFOA, PFOS, and other contaminants are designated as hazardous wastes or substances under the Resource Conservation and Recovery Act (RCRA), and Superfund costs respectively skyrocket.

Water issues have received increasing attention — mostly negative — from both the U.S. press and citizens in recent years, yet the track record for utilities is astoundingly good. How can we as an industry change the current narrative?

Flint has cast a dark cloud over the water sector, very unfairly, to my mind. It was a governance failure at the local, state, and federal levels, in that order, a failure to comply or enforce the existing Lead and Copper Rule (LCR). It has put a premium on utilities strengthening trust with their public and customers, not taking them for granted, communicating proactively and frequently, and listening to their concerns. Social media has to be part of every utility's strategic communication planning. We also need to affirmatively communicate our success in managing very complicated, highly engineered, capital-intensive systems that support vast distribution networks. For example, how many people know that, according to EPA, the median blood-lead levels in kids 1 to 5 years of age have dropped 95 percent over the past 40-plus years? And the number of the nation's large drinking water systems with a 90th percentile sample value exceeding the LCR action level of 15 parts per billion has decreased by over 90 percent since its initial implementation? There is more to be done, but success has been real. We commissioned the national polling firm, Morning Consult, last year and found that four in five Americans served by a water utility (77 percent) say the quality of their tap water is excellent or good. But not wanting to rest on our laurels, AWWA has long encouraged its utility members to begin creating an inventory of all lead service lines, on public and private property. This is a crucial first step toward systematically replacing them over time. The old adage, "If you can't measure it, you can't manage it," still applies.

In broad terms, what are the biggest challenges facing the U.S. in terms of water security, and what are the means to overcome them?

Key challenges to water security include aging infrastructure, financing, climate variability and droughts, aging workforce, cybersecurity, and affordability for the poorest of our customers. Technology will play a part in the solution to these challenges; but a sustainable, robust, equitable rate structure will be key to creating the technical, managerial, and financial bases for innovation and infrastructure renewal, not to mention assisting households with low incomes. The hard truth is that ratepayers — utility customers, if you will — will still be the primary source of financing under any realistic scenario of increased federal support for water infrastructure. Hence, prudence in the promulgation of future regulations, with an eye to efficacy, benefit-cost ratios, and net social benefit, is important. That said, 90 percent of the 51,000 community water systems — many of which are serving hundreds, not thousands, of customers — are achieving all published Safe Drinking Water Act standards (90 parameters), according to EPA.

Drinking water utilities have been slower to participate in the Water Infrastructure Finance and Innovation Act (WIFIA) program than utilities managing wastewater, stormwater, and water-reuse projects. Why is that, and how do we encourage more participation from the drinking water sector?

EPA has done a fantastic job supporting WIFIA — a new federal credit program, conceived and enacted into law due to the efforts of AWWA — under the leadership of Andrew Sawyer. But water utilities have been too conservative in not considering WIFIA as an innovative financing tool. They need to learn how they can use WIFIA to their advantage for pressing challenges like replacement of distribution and lead service lines, as well as traditional treatment and reuse. You could even protect a headwaters forest or implement agricultural management practices as source-water protection at scale. AWWA has been working hard with our partners at EPA to educate our members on the benefits of WIFIA, including low, fixed rates, locked in at closing, almost 40-year payback schedules, and the ability to "sculpt" or time payments to fit income flow (e.g., the retirement of other debt). I think things are changing for the better for our sector as drinking water managers learn more about the program.

Do you or AWWA have a particular position on the PFAS threat and how it should be handled?

AWWA and its members will follow the science. By that, I mean the science-based, data-driven, risk-focused processes set out in the '96 amendments to the Safe Drinking Water Act. We understand that Congress is anxious to see action, but legislative micromanagement of very complex scientific and economic issues is problematic. Issues such as these require expert attention by EPA based on the best available science. The federal agencies — EPA and OMB — are equipped to do legitimate benefit-cost analyses, a practice most state governments are not able to do effectively. I know, as I served in two state regulatory agencies. Affordability is a pressing concern these days, and thoughtful regulation must balance benefits, costs, and equity. Congress does not have the tools or the time to do the work of federal environmental agencies.

What were the lessons of the COVID-19 pandemic through the lens of water? Is there a silver lining to carry into the future?

Resilience in the utility sector is essential, not just for climate, but also for unforeseen disasters of all kinds — most notably, COVID-19. I have been impressed with how our utility members and other partners responded to the crisis despite threats to the health of staff and the financial pressure caused by the shutdown of the economy and the imperative to suspend shutoffs. It proved that water people view this work as a vocation, not just a job. The word "vocation" comes from the Latin *vocare*, to call. The provision of safe, affordable drinking water is the highest of callings. ■

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Cybersecurity Hygiene Is Effective Preventive Maintenance

Organizations can enhance cybersecurity and minimize cyberattacks by improving basic cybersecurity hygiene.

By Jacques Brados and Laurie Kusmaul

Cyberattacks are escalating in the real world. Recent events raise concerns about loss of fuel, interruption of electricity, alteration of chemicals in drinking water, and impairment of other critical infrastructure. These concerns are not new to industrial control system (ICS) defenders, responders to incidents, and system assessors. Numerous thwarted and successful incidents occur, but don't always make the news.

Cyberattacks repeatedly occur using weak entry points with malevolent software (malware). In some cases, the malware has been around for a year or more. Unfortunately, the attacks continue to result in ransom demands, loss of critical data, and increased concern or fear. Improving basic cybersecurity hygiene can help utility owners and operators enhance security and minimize cyberattacks.

Help Is Available

The Department of Homeland Security has an agency dedicated to critical infrastructure, called the Cybersecurity and Infrastructure Security Agency (CISA at cisa.gov). CISA can help federal, state, local, tribal, and territorial governments, as well as public and private sector critical infrastructure organizations. CISA services are generally free, and the agency offers a no-cost vulnerability scanning (pen testing) service and other no-cost assessments for critical infrastructure organizations. More information can be found at https://www.cisa.gov/cyber-resource-hub.

CISA has a dedicated ICS group called the Industrial Control System – Cyber Emergency Response Team (ICS-CERT) that offers free training, onsite assessments of the ICS, vulnerabilities of ICS vendors, ICS incident response, and several other services at https://us-cert.cisa.gov/.

A list of basic activities to reduce the probability of a ransomware incident is available from CISA.[1] Following are some key takeaways from that list, which follows National Institute of Standards and Technology (NIST) guidelines, along with author recommendations based on many years of experience.

Make Backups — And Restore From Those Backups

This may seem like a mammoth task for already-stressed and often-overworked information technology (IT) and ICS teams. But restoring from backup is the most important thing an organization can do to recover from various threats, including ransomware attacks, without feeling forced to pay the ransom. It's also important to know that backups are good and restoration will work. Examples of backup issues include unreliable tape media, inclusion of a Structured Query Language database that is not captured in the backup set because the file was open, and the existence of malware prior to backup.

Backups may be stored online or offline. Operational backups are kept online and used to restore an accidentally deleted file more quickly than offline backups. While convenient and accessible, these backups will get encrypted during a ransomware attack. Security backups are kept offline and used to restore data after a significant incident.

Various scenarios exist for restoring data from security backups, and any restoration exercise should include documenting success and potential issues.

- A full restore from backup involves pulling hardware from inventory, restoring from offline backup to a machine on a disconnected test bench environment, and scanning for viruses. Some data likely will need to be entered manually to fill the gap in time from when the offline backup occurred.
- Restoration from golden images entails the use of computers or virtual environments that are normally powered down. They are regularly updated, data is synchronized, and then they are powered back down. This provides a standard baseline environment to quickly use in production when an incident occurs.
- A full restore from installation media and data, which is typically a last resort, is a factory reset on the compromised hardware. Reinstallation of firmware (the software stored on a computer to make it run), the operating system, and applications must occur before data can be restored. Consider documenting the location of the installation media in the incident response plan.
- For an ICS, it may be necessary to restore programmable logic controllers (PLCs) and industrial network switches along with the servers and computers. Pulling the parts together from inventory to build a PLC on a test bench, reloading the program, and checking for faults can increase cybersecurity and peace of mind.

Look For IT Vulnerabilities

It's important to look for weakness in the defense systems and commit to a scheduled exercise. IT and ICS owners should examine all hardware and software configurations. Have some fun thinking like a cyberattacker: How could someone with your knowledge threaten or harm your organization even without your username, password, and keys?

Consider hiring an "ethical hacker" to help detect such threats. White box, nondestructive penetration testing has proven beneficial for many owners. Someone from the client organization provides advance approval of the planned tests and looks over the shoulder of the tester. Often, the tester gets access to the point of typing the command "delete all," but does not enter the command. In this way, the client can see how a cyberattacker would be successful. From an IT perspective, penetration or pen testing remotely may be just as successful for internet-facing devices.

Look For ICS Vulnerabilities

The ICS requires passive and respectful testing because it is more sensitive to scanning, and resulting problems can be more severe and complex to recover from. Active penetration test scans performed by IT professionals not trained in the operation of the ICS have stopped water pumps and tripped electrical generators, causing outages.

Regularly Patch And Update Software And Operating Systems To The Latest Available Version

There are armies looking for vulnerabilities in software to exploit. Microsoft and other software companies have dedicated teams looking for vulnerabilities and patching their codes. These vulnerabilities are broadcast widely along with the fix, but it is each organization's responsibility to apply patches rapidly.

On the IT side, this means updating to the most recent version of finance, billing, inventory, customer service, marketing, work order, and other software packages. Owners should upgrade to the most recent version of the operating system and patch frequently. Currently, most organizations use Microsoft Windows as their operating systems. Every six months, Microsoft provides a significant update to supported operating systems. Each client software package needs to be tested on the new operating system to identify potential problems. A planned list of tests might include such functions as timesheets, payroll, and year-end payroll. Testers might create a fictitious asset and a work order, make entries, and close the work order. They should also try to enter erroneous data such as trying to work 25 hours in a day, incorrectly typing a password, and entering negative water consumption.

Microsoft releases smaller security patches and bug fixes on the second Tuesday of every month. These come with rankings of Critical, Important, Moderate, and Low to help administrators determine which patches/fixes to apply. Consider releasing the critical ones without testing. If a server or application fails, it can be restored from backup.

On the ICS side, applying updates can prove more complicated. There are well-documented occurrences where Microsoft updates did not work with ICS software. Facility operators' screens showing process parameters such as water quality have turned blue and displayed error text (referred to as the "blue screen of death"). In such cases, plants may not continue to operate in automatic mode, and operators may need to switch to manual control until the ICS support team can respond.

Industrial control systems are the most critical and have the highest impact if downtime occurs. When ICS support team members are asked why they don't take the time to test patches offline, the general response is that ICS and IT systems are typically not connected. This frequently proves to be a fallacy; the ICS is often found to be connected and possessing outbound access to the internet in most author-conducted evaluations. It's crucial to take the time to test and install operating system and ICS software patches.

Know Where The ICS And IT Systems Are Connected

One of the recommendations from the Colonial Pipeline response team was to verify that the ICS can function without the IT system. Consider asking your IT/ICS managers these questions:

- Where are the points of connection between the ICS and the IT system?
- Are these IT/ICS link cables clearly labeled?
- Is there clear guidance for when to disconnect the IT/ICS link cables?
- What happens to the ICS when all IT/ICS link cables are disconnected?
- Has disconnecting the IT/ICS link cables been tested in the past 12 months?
- Where are the results documented, and when is the next test scheduled?

Change Default Passwords, For The Love Of Bits And Bytes!

The most popular way for a cyberattacker to gain unauthorized access is to send a bad link or infected file via email. An employee or external contractor who unknowingly clicks on a link or attachment delivered this way releases some form of malware. Intruders who gain access to the network this way typically use default or easily guessable passwords to create problems. Establishing multifactor authentication and changing default passwords to strong passwords or passphrases are strong deterrents.

No-Computer Wednesdays

For a few hours every Wednesday, a water utility turns off the ICS computer monitors at a treatment plant. The computers are still on in case an unexpected event occurs. The operators run the plant and distribution system in manual mode because the utility director wants to be sure plant employees know how to work systems beyond watching computer monitors. This practice, which is part of the emergency preparedness and disaster recovery plan, ensures that the instrumentation and PLC programs function as expected without operator intervention.

There are other great ways to test the ICS midweek:

- Periodically recover an ICS server from a backup.
- Disconnect the ICS and IT system for a few hours to confirm network segregation.
- Change passwords to devices that only support local passwords.
- Coordinate with the local emergency manager to simulate a fire in the data center or a chemical building. Frequent exercises with operators, ICS support, IT support, managers, fire, and police are good cyberattack defenses.

No-Change Fridays

In the ICS world, patches and changes are done in the middle of the week, with everyone watching for adverse effects. Changes are never done on Fridays or over the weekend. The last day of the work week is for:

- Documenting what occurred during the week by updating and closing work orders.
- Policy and procedure review and updating.
- Reviewing vulnerabilities published in the IT world at Multi State – Information Sharing and Analysis Center (MS-ISAC), the NIST National Vulnerability Database (https://nvd.nist.gov/), or other locations.
- Reviewing vulnerabilities published in the ICS world at https://us-cert.cisa.gov/ics/advisories.
- Reaching out to a neighboring utility to discuss what others are seeing and doing.
- Planning the evolution for the following Wednesday.

Fresh Perspective

A new set of eyes can be helpful for assessing any system, whether they belong to an internal auditor or a trusted consultant. Someone who knows your industry, but does not know your organization or specific unit, can provide the right perspective and ask hard questions to help you. Better to have friends rather than enemies find vulnerabilities.

It Comes Down To Healthy Practices

Consider personal hygiene and preventive maintenance. Brushing your teeth, bathing, eating right, exercising, paying attention to potential threats around you, and visiting a doctor and dentist require time and money. But healthy practices decrease your chances of an emergency trip to the hospital. Investing now in cyber hygiene can yield cyber benefits when you least expect it. ■

References:

1. https://www.cisa.gov/sites/default/files/publications/CISA_MS-ISAC_Ransomware%20Guide_S508C.pdf

About The Authors

Jacques Brados, CISSP, is the water cybersecurity national practice lead for Black & Veatch. He has secured industrial control systems and IT systems for 21 years as a consultant and as a municipal manager. He has also supported American Water Works Association cybersecurity risk-assessment tool development.

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IMPLEMENTING GRANULAR ACTIVATED CARBON SYSTEMS:

IMPORTANT DESIGN AND START-UP CONSIDERATIONS

As granular activated carbon (GAC) is increasingly employed to treat PFAS, new practitioners can improve their results by knowing what to expect — thanks to data and experience acquired from prior installations.

By Scott A. Grieco

The impact of per- and polyfluoroalkyl substances (PFAS) and other emerging contaminants (ECs) to drinking source water has caused many water utilities to implement additional treatment technologies. One of the most widely used treatments being used for removal of certain PFAS is granular activated carbon (GAC). However, many drinking water utilities — especially those using groundwater resources — often only employ disinfection and are therefore unfamiliar with the use of treatment technologies such as GAC.

There are five aspects of implementing a GAC system that are not well understood by those who do not regularly design or operate GAC systems:

- Soaking requirements
- Backwash requirements
- pH adjustment period
- Arsenic content
- Disinfection

Often, the start-up of GAC systems exhibits unacceptable increases in the effluent pH, which can result in effluent pH exceeding allowable values.

Soaking Requirements

When new GAC is added to the system, it is dry, and the external void space and internal pore spaces are filled with air. The GAC material only occupies 20% of the bed volume; the remainder is air. The internal GAC pores are approximately 40% of the GAC bed volume. Soaking allows the water to diffuse into the pores and displace the entrained air. Because GAC surfaces are hydrophobic, it takes a reasonably long time to wet the carbon pores and displace the air. The amount of time required is a function of temperature and carbon mesh size. Higher temperatures allow for faster diffusion; conversely, larger particles have longer pores and require more time for diffusion.

At ambient temperatures (50–60°F or 10–15.6°C), soaking requires 48 to 72 hours. The vessel should be filled in upflow mode at no more than 5 gpm/ft². During the soaking period, the vessel should be isolated from the treatment process and the water held static within the vessel. An example of wetting as a function of time and carbon particle size is provided in Figure 1.

After water soaking, the carbon bed needs to be backwashed or drained and refilled upflow at no more than 2 gpm/ft² to displace all the entrapped air (from the carbon pores). Air will not be displaced in the normal downflow operation.

If the carbon is not properly wetted/de-aerated, operational and performance problems can result. These include an increase in pressure drop as the air is displaced from the carbon pores and trapped within the bed, and poor or very little adsorption (migration/diffusion of the contaminants to the adsorption sites inside the carbon particles can only occur if there is water in the pores).

Backwashing of newly installed GAC is required to remove carbon fines and stratify the bed.

Backwash Requirements

Backwashing of newly installed GAC is required to remove carbon fines and stratify the bed. Stratification allows the larger carbon particles to settle to the bottom of the vessel and provide vertical particle size distribution. Recommended backwash procedures may vary from vendor to vendor, but there are three important aspects that should be followed:

- The specific backwash flow rate required is dependent on water temperature and specific GAC product installed.
- Incorporating a ramp-up period gently separates the carbon and removes entrained air.
- Incorporating a ramp-down period will allow stratification of the GAC.

Table 1 provides general requirements that should be planned into design and operation of the system. Backwash water should be clean and free of solids. Specific requirements will be dependent on carbon product, pH and buffering capacity of the water, and target pH values. The effluent of the backwash needs to be sewer-discharged or collected for discharge/disposal depending on the configuration.

A bed expansion of 25% to 30% should be targeted for backwashing. The following are general guidelines for backwashing:

- Ramp-up period of 5 min. at 0% to 15% expansion
- Backwash period of 20 to 25 min.
- Ramp-down period of 5 min. at 15% to 0% expansion

Reverse flow rates for fluidizing the bed in terms of gpm/ft² are available for the specific media used at the water temperature of the system. These should be used to quantify the amount of backwash water required. Because water is denser at colder temperatures, it requires less volumetric flow rate to fluidize the bed. It is important to be mindful of the water temperature. If the flow rate utilized is higher than recommended for the given temperature, it is very possible that media can be washed out of the vessel.

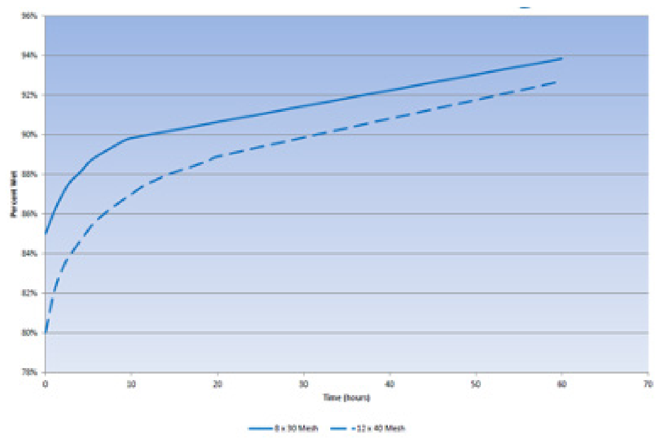

Figure 1. Example wetting curves for 8x30 and 12x40 mesh bituminous GAC. (Source: Calgon Carbon Corporation)

It should be emphasized that the primary reason for conducting a backwash on new carbon is to remove fines. As such, the backwash water often contains elevated concentrations (>50 mg/L) of total suspended solids (TSS). It is also typical that the largest concentration will be released within the first 5 minutes of backwashing, with decreasing TSS concentrations as a function of backwash time.

pH Adjustment Period

Often, the start-up of GAC systems exhibits unacceptable increases in the effluent pH, which can result in effluent pH exceeding allowable values. It is not uncommon to observe values greater than 9.5 or 10 Standard Unit (S.U.). The extent of the pH excursion depends upon the water quality (mainly initial pH and buffering capacity).

The pH increase has also been shown to be largely independent of base GAC material and whether or not the carbon has been acid-washed by the manufacturer (Farmer, 1996). The cause of the high pH is due to surface functional groups from the GAC activation process, which drive protonation (attraction of H+) and thus raise water pH values.

Notice that pH decreases as a function of runtime. This is because following protonation, the surface is charge-neutralized with the anions (chloride, sulfate, etc.) present in the water (Farmer, 1996). The pH of the effluent can be elevated for 200 to 500 bed volumes. Additionally, this elevated pH can result in the leaching of aluminum, manganese, and other transition metals from reactivated carbon (Desotec, 2020).

Recirculation can limit the amount of bed volumes required to obtain a neutral pH, but forward-flushing with influent water is the best course of action. Under most scenarios, the required flushing may require two to three days of continuous operation to

Activated Carbon Type	Initial Contact pH	Flushing Required (Bed Volumes)
Sub-bituminous	10.4	350
Bituminous	10.4	350 - 400
Reactivated Bituminous	10.6	400
Bituminous Acid-Washed	9.8	200 – 250
Coconut	10.3	200 - 250

Table 1. Activated carbon type, initial pH, and required rinse volumes for pH stabilization (Adapted from Farmer et. al., 1996)

waste. Thus, planning for sewer connection in the design is always best. However, if a sewer connection is not available, temporary collection for discharge/disposal will be required. The above general table from Farmer et al. provides a general idea of base materials.

As can be seen by Table 1, acid-washing may reduce the rinse volume needed to reduce the effluent pH to an acceptable level. However, acid-washing alone is often not sufficient to eliminate initially high effluent pH values. There are also pH-stabilized products available. These can significantly reduce or eliminate the amount of rinse time. The carbon should have an added specification of a maximum "modified contact pH" to show it is a pH-stabilized product.

Results of pH neutralization of a Jacobs-designed system are provided in Figure 2.

As can be seen in these examples, the initial pH of the GAC effluent ranged between 8.8 and 9.2 S.U. Site A (shown in red)

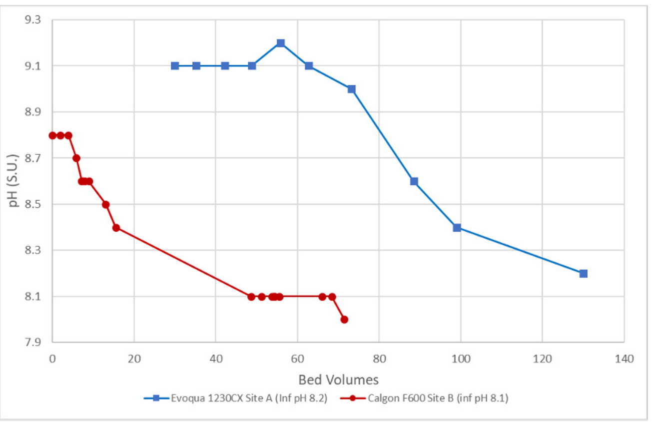

Figure 2. pH vs. bed volumes (data from single-pass rinsing [not recirculated]) (Source: Jacobs)

is a coconut-based product, whereas Site B (shown in blue) is a bituminous-based product. The source water also appears more buffered at Site A, which required a larger flush volume (~70 bed volumes [BVs]) until the pH started to decrease. This resulted in a total required flush volume of 130 BVs. Site B source water is less buffered and started to decrease within 5 BVs and required about 50 BVs to stabilize the pH at the influent value of 8.1 S.U.

These examples show that the information originally provided by Calgon Carbon in the table may be conservatively high but useful for worst-case planning. The actual volume required will be a function of actual GAC material type, product lot received, and buffering strength of the influent water.

Arsenic Content

All coal contains some arsenic, which is present primarily within the mineral pyrite interspersed in the coal (USGS, 2005). This means that widely used bituminous and sub-bituminous products often contain arsenic. It is often thought that coconut-based GAC is less likely to contain arsenic. However, as coconut shells used to produce GAC are often harvested from locations with arsenic-rich soil, the coconut tree will take up the arsenic and concentrate it in the coconut shell.

In a study reported in *Water Conditioning & Purification*, 16 of 20 bituminous and 11 of 19 coconut GACs resulted in detectable levels of arsenic subsequent to leaching tests. As such, when GAC is placed on-line, regardless of the base material source, there is a high likelihood that leachable arsenic present on the activated carbon surface can be transferred to the liquid and end up in the drinking water. Thus, a flush of GAC to drain is often required.

Figure 3 shows the results from a recent start-up using a bituminous-based product.

The various data sets represent different vessels within the overall system. Each vessel received the same bituminous-based product but from various supplier lots. As can be seen, the initial arsenic concentration ranged from 8 to 20 µg/L. For each vessel, the effluent arsenic concentration was reduced to less than 5 µg/L

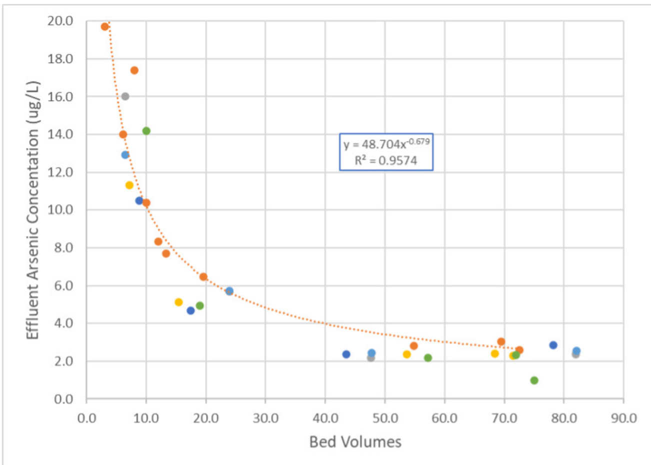

Figure 3. Arsenic concentration vs. bed volume from bituminous GAC start-ups (Source: Jacobs)

Although activation of GAC occurs at high temperatures (800–1000°C) and destroys all the bacteriological contamination on the raw material, it is possible for GAC to become contaminated during transport.

in less than 30 BVs. This supports that arsenic flushing can be accomplished within the same process as required for pH.

Manufacturer-supplied, acid-washed GAC can reduce or eliminate the need for flushing but is more expensive. And since pH flushing is most often required (as discussed above), spending extra money on acid-rinsed carbon for arsenic reduction may not always be warranted.

Disinfection

Disinfection of empty adsorption vessels, piping, and other equipment should be achieved through chlorination via standardized AWWA procedures (ANSI/AWWA C653-97).

Although activation of GAC occurs at high temperatures (800–1000°C) and destroys all the bacteriological contamination on the raw material, it is possible for GAC to become contaminated during transport. Thus, before being put into service, the GAC must be evaluated to verify that it is free of bacteriological contamination. After the GAC is installed, soaked, backwashed, and flushed as described above, the system needs to be checked for presence of bacteria via a rinsing procedure.

Rinsing should be performed at the design flow rate that corresponds to an empty bed contact time (EBCT) of 10 minutes. Two samples for bacterial analysis (coliform and/or heterotrophic plate count [HPC]) shall be collected from the GAC effluent at 10 minutes and 60 minutes of rinsing (or an alternate interval no less than 30 minutes apart). HPC levels less than 500 colony-forming units per milliliter (cfu/ml) are considered acceptable, but state-specific regulations should be considered.

If the system requires disinfection, it can be accomplished by adding a 5% sodium hypochlorite solution to the GAC vessel. However, carbon quickly decomposes the hypochlorite ion, which may compete with bacterial disinfection process. Alternatively, the GAC vessel pH can be elevated to >12 using sodium hydroxide (NaOH). The amount of caustic required is dependent on the water pH, buffering capacity, and vessel size. It is recommended to recirculate the solution for 2 to 3 hours followed by a soak for at least 8 hours. During this process, the pH should be maintained at a value of >12. The solution should be neutralized with hydrochloric acid, circulated, soaked, and discharged to drain.

Summary

As more utilities are considering GAC for PFAS treatment, there are aspects of GAC system start-up that are not widely publicized, and the designer and operator should be aware of these critical items.

Consideration for soaking, backwashing, pH neutralization, arsenic rinsing, and disinfection should be considered as part of a GAC system design. Connection to a sewer for the new GAC system is recommended. However, for systems in remote locations, temporary water collection and transport/disposal at a nearby wastewater treatment plant may be necessary. ■

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About The Author

Dr. Grieco is the global technology leader for emerging contaminants and groundwater treatment within Jacobs Drinking Water & Reuse group. His area of expertise is physical/chemical treatment of emerging contaminants and persistent environmental compounds, with a specific emphasis on adsorption processes and technologies. He has over 29 years of experience in the evaluation, design, and optimization of water and wastewater treatment systems across the public utility, remediation, and industrial sectors. Grieco holds a BS in chemical engineering, MS in environmental engineering, and Ph.D. in bioprocess engineering and is a registered professional engineer in New York.

SHORING UP WARM-CLIMATE WATER SYSTEMS TO WEATHER DEEP FREEZES

The 2021 Texas freeze was a hard lesson learned for the state's water utilities, but others can be more prepared as a result.

By Stephanie Bache and Joe Aillet

Frozen pipes from Winter Storm Uri, which ravaged Texas in February 2021.

For decades, the aging of water and wastewater infrastructure has been the industry's greatest concern, stoking stakeholders' worries about the reliability and resilience of such assets against the ravages of a dramatic weather event.

One week last February in Texas brought it all into sharp focus. A historic, deadly deep freeze pummeled much of the Lone Star State, spawning widespread power outages that disrupted water and treatment systems, froze and burst pipes, and left millions without clean drinking water.

That cascading fallout shined a spotlight on the readiness — or lack thereof — of water suppliers and wastewater-treating sites in warm U.S. climates, begging the question at a time when concerns about climate change and the severe weather episodes they produce are rising: When it comes to weatherizing or hardening water infrastructure, what can, and should, decision-makers do to defend those assets against such calamities almost certain to recur?

The short answer is "plenty," understanding that emergency preparedness always must be part of the tool kit used against the disruptive events increasing in frequency and costs. According to the National Oceanic and Atmospheric Administration, events estimated to result in at least $1 billion in damages have soared, from roughly three per year in the 1980s to about a dozen each year in the 2010s, creating a significant burden on infrastructure.

Attacking the issue takes thoughtful introspection about the potential threats and the cost-benefit of implementing the suite of hardening options. Are there enough redundancies and levels of preparedness in the right places? What assets are critical to the mission of a water utility, and what would happen if it lost power for not only hours or days but weeks? Does it need to add generators or even an independent power source? What rate increase will customers tolerate to protect against future outages?

Based on their customers' expectations, it's up to each water utility to determine its target level of resilience and to develop a plan to get there. Sorting it all out doesn't have to be daunting, given the available practical options that set the foundation for heading off potential trouble.

SCADA

Ensuring the safe, efficient operation of water infrastructure begins with supervisory control and data acquisition (SCADA) systems. Several key factors that involve SCADA include field instrumentation and components, communication systems, and operator interfaces. The ability to monitor and control remote devices is critical to the system's commercial operation and the understanding of how and where water and wastewater effectively get to their intended destinations.

Many utilities have either aging or insufficient SCADA systems that may prove to be unreliable during critical weather events, rendering operators blind as to how their system is performing. Having an updated SCADA system is critical to understanding a system's reliability. Using historical SCADA data collected during a weather event in conjunction with hydraulic distribution models can accurately replicate how well a system performed and identify the critical infrastructure upgrades needed to maintain adequate system pressures during power outages.

Think of SCADA as four crucial "Rs" — reliability, resistance, and response and recovery.

Reliability speaks for itself, ideally rooted in a good organizational game plan and an acceptance that remote operations are entrusted to be a utility's eyes on the ground. With SCADA, reliable data about the workings of assets such as instrumentation, control valves, and pumps are essential; and outages during extreme weather events can cause those instruments or devices to fail. In such situations, having emergency backup power sources may be the key.

Resistance can begin with a proactive, preventative maintenance plan that includes annual calibration of all instrumentation and a thorough examination of whether devices are properly connected and functioning. Such proactive planning can be vital during weather emergencies, giving technicians confidence that they have accurate information at their fingertips if troubleshooting is required. Practicing emergency scenarios is recommended, offering insight into how SCADA systems are handling and how operators address the issues that crop up.

Response and recovery are like coaches and players reviewing game films, critiquing what played well and, most importantly, what failed. Data and hydraulic models are analyzed in what should be a quest to build a hardened system, folding them into the utility's reliability plan.

All of this should be a continuous and constantly updated cycle.

Hydraulic Modeling And Digital Twins

Beyond exploiting the benefits of advanced data, utilities with aging or frail water systems can augment their winterization efforts by digitally replicating their physical assets to get historical, current, or predictive analyses in near real time.

Welcome to the world of digital twins, the utility sector's equivalent of a flight simulator. As a potentially huge addition to utility intelligence, integrated digital twins can support effective decision-making and failure-prevention efforts. By combining information technology (IT) and operations technology (OT), utilities can simulate a range of weather and other scenarios to help guide operators' decisions and optimize performance of existing assets.

Sensor deployments, metering, increasingly smart data modeling, digital twins, and analytics provide new levels of expansive insights that can complement institutional knowledge — before veteran workers retire — to create a permanent record of critical system functions that can be studied, refined, and improved.

The big picture: Detailed, data-driven asset planning not only helps utilities prepare their assets in advance of weather events but also helps utility personnel effectively handle these situations as they occur. If a water or treatment plant's operators are complaining about whether pumps are working properly — or if there's trouble maintaining tank levels — modeling can test those performances under expected conditions, help pinpoint the problems, and bring about thoughtful solutions before actual disaster strikes.

Other planning should address questions about power and the critical utility systems that need to remain functioning: What would happen during an outage lasting one day, three days, or a week? What needs to be done to maintain emergency water for customers? What facilities are absolutely critical to serve during an emergency? Should generators be added?

In short, models are invaluable in proactively helping evaluate existing and future emergencies, identifying everything from potentially overloaded pipes and bottlenecks to pressure surges and/or tank issues.

Hardening Your System

Once utilities take a step back and determine their vulnerabilities, the next goal would be to ascertain single points of failure and what improvements can be implemented to reduce the utility's overall risk.

Steps should include scrutinizing the efficacy of the utility's heat tracing and exposed small-diameter piping, which might be best buried or enclosed as a hedge against freezing weather. Critical instrumentation that is outdoors could be evaluated for alternative devices or migrated into cabinet enclosures with small heaters as safeguards against icy events.

And in cases of pipelines and pump systems that were especially susceptible to wintry events because they were stagnant, can drains be installed in such systems to prevent potential damage of freezing water? For extreme wet weather events, the utility can explore raising sensitive equipment or building physical barriers such as berms around the site.

> **By combining information technology (IT) and operations technology (OT), utilities can simulate a range of weather and other scenarios to help guide operators' decisions and optimize performance of existing assets.**

Microgrids, Battery Storage As Onsite Power Options

For many water and wastewater utilities striving to winterize and protect against other extreme weather events, loss of power is the elephant in the room. Enhancing resiliency starts with identifying ways to mitigate exposure to outages and addressing two key questions: "What is needed, and how can redundant, standby power be incorporated into the system?"

A proven solution can be a microgrid — a source of green, cheap power when it's needed the most.

Such technologies are any distributed energy resource that can be rapidly dispatched — everything from a battery to a natural-gas-powered generation setup — when conditions demand it. Microgrids can be supplemented by solar and fuel cells, along with other technologies, that are intermittent and therefore less reliable.

Generators also are an option, with diesel-powered backup energy sources often being converted to ones using natural gas that emits less carbon.

Given the cost of both building and operating a microgrid, ownership structures of such a resource must be sorted out. Does the utility want to pay for it and own it, or would it be advantageous to simply leave that outlay and operation to someone else who ultimately will provide the cheaper, greener backup power? There are many options available on the market for providing redundant power that can be tailor-fit to the owner's needs; these can be procured through a competitive selection process.

Administrative Resilience

Far beyond questions about the resilience and readiness of their physical infrastructures against the backdrop of ascending concerns about climate change, water and wastewater utilities would be well-served by being introspective about something crucial but often overlooked.

Call it administrative readiness.

Falling far outside the scope of the reliability of visible physical assets, utilities can bolster their management and institutional preparedness.

Physical addresses of mission-critical customers — entities such as hospitals, food services, power suppliers, and military sites — should be updated and readily retrievable, giving utility operators and decision-makers a quick, ready reference point of where critical infrastructure resides within their service area when a catastrophic event develops.

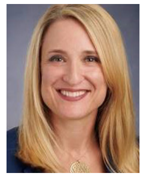
Given that customers increasingly are young and digitally connected, social media policies and platforms should be updated, knowing that sites such as Facebook and Twitter serve as valuable and popular ways to engage the community in real time about storm events. Utilities would be wise to begin promoting their social media sites now in billing fliers and other correspondence, making customers aware that they are the go-to places for crucial details during catastrophic events.

Cross-training crews also gives utilities both flexibility in their capacity to address extreme events at any given moment and the peace of mind of knowing that they have sufficient numbers of employees to handle a breadth of necessary work.

Another area of administration resilience includes vendor contracts. Incorporating "first right of refusal" in matters of fuel, chemical, and equipment such as valves, fittings, and small-diameter piping should be considered.

Considering these steps — and taking action to implement them — will help prepare your utility for the next emergency event. ■

About The Authors



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HYDROINFORMATICS 101:

Intro To Water Optimization And Efficiency

Hydroinformatics offers a fresh perspective that is enabling communities around the world to tackle age-old problems in new ways and with a bigger toolset.

By Bryant McDonnell

The water sector is in the throes of a bold transformation, driven by technology and smart water infrastructure. While advanced digital solutions have been leading the charge, there is a powerful, lesser-known force driving this disruption — hydroinformatics. Evolving from the early discipline of computational hydraulics, hydroinformatics is the application of information and decision support systems to address the equitable and efficient management of water.

Hydroinformatics engineers thrive from multidisciplinary perspectives, folding in expertise from traditional civil and environmental engineering, signal processing, machine learning, and control theory. Similar to computational hydraulics, hydroinformatics relies on the digital simulation of water flows and related processes but focuses on its application rather than the technology alone.

The Holistic Approach Of Hydroinformatics

Combining smart technologies with real-time data analytics and both physics- and non-physics-based models, hydroinformatics engineers work with clients to develop the next generation of sustainable, efficient, and autonomous water systems. As the industry continues to embrace digital solutions, water networks are becoming more and more instrumented. Therefore, the accurate and granular sensing of data is of fundamental importance to the application of digital systems in order to deliver high-quality results that inform better decision-making.

In a collaborative practice, hydroinformatics teams often work in conjunction with software developers to design solutions that optimize water and wastewater networks. Hydroinformatics engineers begin by analyzing a particular client's challenges to come up with a highly configured algorithmic solution, such as a control strategy using existing assets, which can then be optimized with a genetic algorithm to work under an array of hydraulic conditions.

Optimization objectives can include (but are not limited to) adverse hydraulic conditions (such as flooding, overflows, high pressures), energy usage, and capital costs. Possible solutions are implemented, tested, and further refined with each iteration by hydroinformatics engineers to become solidified, before collaborating with software developers to bring a real-time decision support system into production.

The data collected, combined with the expertise to evaluate how these data correlate with a utility's day-to-day operations, result in solutions that promote greater system visibility for early intervention. Such solutions are both sustainable and cost-effective, supporting long-term resiliency and capital planning.

Hydroinformatics In Action

Take smart network optimization systems, for example. Sewer overflows are a growing problem for many utilities in the U.S. and around the world, and with instances of severe weather on the rise due to climate change, utilities are challenged with managing them effectively in an affordable way. Xylem's end-to-end wastewater optimization solution integrates directly into existing wastewater networks, using a combination of sensors and weather data, digital twin technology, and optimization algorithms to drastically reduce sewer overflows, minimize flooding events, and optimize functionality while maintaining regulatory compliance.

Serving a population of more than 850,000 people over 290 square miles, the Metropolitan Sewer District of Greater Cincinnati (MSD) operates combined and sanitary sewer systems, some of which were built more than a century ago. The systems were built to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. Whether by design or due to infiltration and inflow of stormwater they have a tendency to overflow, discharging an average of 14.4 billion gallons of combined sewage every year into the Ohio River and its tributary streams within Cincinnati's urban watershed.

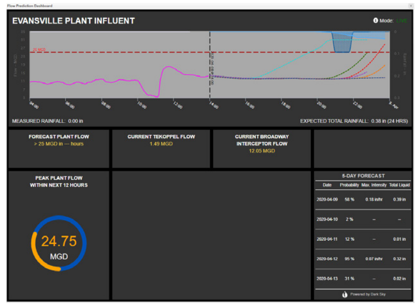
In 2002, the U.S. EPA entered into a federal consent decree with MSD, mandating the elimination of sanitary sewer overflows and significant mitigation of combined sewer overflows into receiving waterways. Engineers estimated the cost to mitigate the sewer overflows through capital investments at $3.1 billion, an unacceptable capital expense to pass along to MSD's customers.

To overcome these challenges MSD partnered with Xylem to optimize the performance of their existing assets through advanced digital optimization solutions. Xylem worked with MSD to implement Xylem's Wastewater Network Optimization solution that utilizes a combination of sensors and weather data to create a real-time decision support system (RT-DSS) that delivers automated, optimized control of existing assets to reduce sewage overflows while maximizing storage and treatment plant operations during wet weather.

After MSD implemented a coordinated real-time control (RTC) program, overflow volumes were reduced by 247 million gallons annually, representing a 45 percent reduction in overflow compared to the original design. Additionally, operational enhancements from the project increased treatment facility utilization by more than 100 percent, the result of more efficient use of existing assets.

Taking a similar approach, the City of Evansville in Indiana reduced its sewer overflows by more than 100 million gallons a year. Leveraging the same wastewater network optimization technology, the city effectively provided a software upgrade to its existing sewer system — allowing water managers to collect and analyze valuable data insights and convert the city's existing network into infrastructure that is more resilient and affordable.

With real-time situational awareness of critical data points throughout the system, the city now has the visibility needed to allocate resources accordingly during instances of severe weather events.



Flow prediction dashboard from the City of Evansville

A New Future For Water Management

With challenges surrounding water availability, water quality, and water-related natural disasters set to increase in the near future, the time has come for utility managers to think smarter about water. This unique and relatively untapped discipline can transform utility operations by prescribing cost-effective and adaptive solutions that level the playing field and solve the world's most complex water challenges.

With robust and high-resolution data and decision support forecasts coming online, the future of water network management will become capable of running a self-discovery of problems accompanied by recommendations to operators on the best mitigation strategies and respective outcomes. This will ultimately enhance resiliency in the face of unforeseen threats, decrease capital costs on infrastructure upgrades, and protect the environment to promote a sustainable and efficient approach to urban water management. ■

About The Author

Bryant E. McDonnell serves his team as the Senior Manager of Hydroinformatics and Process Control for Xylem. He is a Professional Engineer (OH, KY, NE, MO) and has degrees in civil and environmental engineering from Southern Illinois University Carbondale and the University of Cincinnati. He is an autodidactic analytical software programmer and has been working in the hydroinformatics space for over 10 years. He was the original author behind OpenWaterAnalytics-PySWMM (Python Programming Interface to Stormwater Management Model) open-source software library. He is passionate about solving old problems in new ways to save money for public utilities and their ratepayers.

SOUNDING THE ALARM: How To Enable Efficient Infrastructure Surveillance And Response

With SCADA and an upgraded remote alarm notification system, North Port Utilities in Florida can keep 'eyes' on operations even when workers are off — out of sight but never out of touch.

By Greg Jackson

Located on the Gulf of Mexico between Tampa and Sarasota, North Port, FL, has 80 miles of freshwater canals and is the only city in Florida with an entire 8,000-acre state forest inside its city limits. The city's residents, visitors, and many businesses depend on the Water and Wastewater Utilities Department.

Responsible for the city's water and wastewater infrastructure, North Port Utilities manages 115 lift stations, 30 miles of sewer gravity lines, 70 miles of sewer lines, 3,000 manholes, 1,632 fire hydrants, 307 miles of water transmission lines, and 3,000 valves, as well as booster stations and storage tanks at two wastewater plants and one water plant. Visualization software, including SCADA, helps the city's utilities monitor lift stations and both water and wastewater plants, which drastically reduces the frequency of visits to remote sites.

For approximately 13 years, the city has relied on SCADA and remote alarm notification software to push critical alarm and event details to remote workers in any abnormal operating conditions. Three years ago, Robert Davies, North Port Utilities instrumentation and controls supervisor, joined the team. He oversees all electronics, electrical maintenance, and SCADA for the city's water and wastewater plants and sewer lift stations. After thoroughly reviewing the existing setup, including hardware and software, and bringing the city's new wastewater plant online, he updated the water and wastewater plants' servers and upgraded to the latest versions of the AVEVA System Platform and an updated alarm notification system, which ensured that the visualization and notification software that manages the utilities' sites was running on the most robust products.

In his supervisory role, Davies is intimately involved with servicing and maintaining their SCADA applications. Davies is also responsible for the configuration of the alarm notification software, which includes setting up alarm escalation. For example, the water plant is set up on a six-hour, day-and-night schedule because when the plant is staffed during the day the system does not send notifications. However, when the plant is offline, the alarm notification becomes active and sends alarms, if necessary, such as during a power failure. The water and wastewater sites run 24 hours but are staffed for 16.

"This remote alarm notification software is our 'eyes' on during the eight hours when the plants are not staffed," Davies said.

Upgrading Technology

The utilities' staff uses this alarm software to receive alerts via SMS, voice, and email. Davies is currently in the process of implementing the software's mobile app to streamline decision-making through push notifications. This will allow the team to quickly see what is wrong, send an acknowledgment, and monitor alarm condition changes in real time, right from a smartphone. The mobile app also promotes team problem solving through a chat feature that will help Davies' team converse, brainstorm, and share solutions on the fly, from wherever they are — whether in the plant, at home, or on the road. Another benefit of the mobile app is how efficiency will be improved through the team visibility feature that shows who has seen an alarm as well as who has acknowledged it, reducing guesswork and redundant responses.

"I really appreciate the escalation alarm feature. First it notifies the plant's main phone line, then the operator's cell phone, then the chief operator, and superintendent, and finally it will call me if no one else has responded to the notification," commented Davies. "However, I'm looking forward to exploring the robust features on the new mobile app," Davies said.

Overview of the city's wastewater equipment connected to remote alarm notification software. When an alarm occurs on specific equipment, the City of North Port can visualize the alarms through its SCADA system.

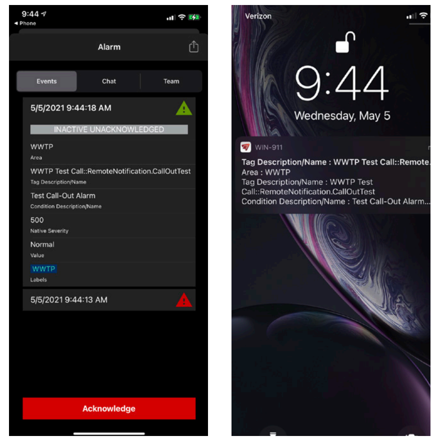
Making A Difference

The alarm notification software has been extremely helpful during unexpected communication failures at some of the utilities' booster station cellular sites in notifying team members when the cellular modems were down. Typically, the alarm callouts are for power failures, analytical instrument out-of-ranges, pump-start fails, excessively high water levels, and compliance issues that require quick reaction from the team.

Utilities are always concerned with saving money and avoiding noncompliance fines. This remote alarm notification software provides Davies and his team with the confidence to keep things running smoothly. This regularly occurs with a wastewater treatment plant that must maintain a specific compliance residual in the pouring contact chamber because water is put out for irrigation reuse purposes. At night, when no one is at the plant, if residual is lost, the system goes into a reject mode. The water that continues to come in must go somewhere, which leads to the possibility of retention pond flooding. Continuing this domino effect, if the retention ponds overflow, this water could go into local estuaries and cause a lot of problems. However, because of the alarm notification, these issues are avoided.

"Getting notifications about compliance issues saves us a substantial amount of money by preventing any fines from the Department of Environmental Protection [for being out of compliance]," said Davies.

Davies also cited how advanced notification from the alarm software prevents problems with the lift and sewer and pumping stations. He is planning to integrate a Data Flow Systems database to an OPC Data Access server to be able to connect to the software system for alarm callout for this application.



Actual images of test alarms on North Port Utilities' instrumentation and controls supervisor Robert Davies' phone.

"The remote alarm notification software that we're using is a good, solid product that saves me a lot of time and works exactly as it is supposed to. The tech support team is always timely in helping resolve any issues," added Davies. ■

About The Author

Greg Jackson is CEO of Austin, TX-based WIN-911 and may be reached at greg.jackson@win911.com or (512)326-1011. Prior to becoming CEO five years ago, Jackson held leadership positions in international sales, business development, operations, and product/solution development. The company helps protect over 18,000 facilities in 80 countries by delivering critical machine alarms via smartphone or tablet app, voice (VoIP and analog), text, email, and announcer-reducing operator response times, system downtime, and maintenance costs. For more information, visit https://www.win911.com/.

Community Wastewater Treatment Options Expand With Decentralized Treatment Approaches

Sometimes conventional wastewater treatment solutions won't work for a given application, and sometimes a nonconventional approach is simply the better choice for high-quality, cost-effective performance.

By Dennis F. Hallahan

For wastewater treatment engineers, designers, and community decision-makers, selecting the most effective technology and design to meet treatment needs, existing and impending regulations, capacity for future expansion, and cost effectiveness can be challenging. The wide variety of new technologies and innovative system designs has increased performance and reduced maintenance. These innovations can also utilize or repurpose existing infrastructure and lower overall construction and operating costs.

For municipalities, capital expenditures for upgrades to publicly owned treatment works are highly scrutinized. This level of oversight and the limited resources available to cities and towns for infrastructure upgrades may create an atmosphere that limits consideration of the available cost-effective, high-performance options. The good news for communities interested in sustainable development is that new codes are catalyzing the development of an expanding number of approaches for upgrading residential onsite systems or expanding an existing centralized treatment facility.

A broad search for the best available wastewater treatment option can net a solution that better matches the unique conditions of the individual project and the community and create a climate for desirable development. While opting for traditional wastewater treatment solutions might be the comfort zone, alternative and advanced technologies frequently offer better performance and greater versatility in challenging environments or when under financial constraints. Most alternative wastewater treatment systems have long, successful performance records and provide third-party treatment testing and certifications that consistently show superior and reliable treatment capabilities.

Large Commercial And Industrial Systems

In some cases, towns and municipalities have centralized wastewater treatment plants (WWTP) that are overburdened and cannot support community growth. In such cases, large decentralized systems can be designed to handle new, large-flow commercial and industrial development, thereby decreasing the hydraulic and nutrient stress placed on centralized WWTPs and augmenting the capacity to sustain community growth. In the case of community wastewater treatment facilities that are reaching or over capacity, adding an exfiltration bed utilizing subsurface infiltration, such as an engineered chamber drainfield system, can extend the life and community investment in the WWTP and have the added benefit of reducing phosphorus and eliminating outfall discharges to bodies of water.

The Best Solution May Be A Combination Of Approaches

In many instances, utilizing a combination of approaches is the best solution for large commercial systems or communities. These system designs often provide decentralized collection that moves to a centralized treatment facility, then to a large disposal field. Most publicly and privately owned community systems are, similar to centralized systems, centrally managed by professional operators.

Top-Line Considerations

Anticipated flows, available land, financial considerations, and special community characteristics that need to be retained are top-line considerations requiring analysis by wastewater design engineers and the communities or projects they represent. The timeline for municipal treatment upgrades is also important to consider in relation to the viability of desirable new development. It's key to review all of the available technology and design options, including traditional approaches and alternative, advanced solutions based on anticipated wastewater flows, existing systems, and regulatory environment challenges.

Wastewater Design Strategies For Sustainable Development

There are many approaches to sustainable wastewater design. The following are a few options that provide excellent treatment and versatility to address challenging wastewater treatment needs.

STEP Systems

Communities without public sewer systems or adequate onsite septic systems to employ decentralized strategies can tie into an existing neighboring centralized WWTP with the installation of septic tank effluent pump (STEP) systems to upgrade individual onsite treatment systems. A STEP system incorporates individual tanks to collect wastewater that is then sent to a centralized treatment plant.

Cluster Systems

Where centralized wastewater treatment facilities are overburdened and the addition of new sewer lines is prohibited, or where individual septic systems are frowned upon, cluster systems are being recommended to developers by local health departments and planning agencies. Cluster systems collect the wastewater from individual or groups of dwellings or businesses and transfer that wastewater to a centralized drainfield for treatment.

Advanced Onsite Wastewater Treatment Systems (AOWTS)

AOWTS provide high-level treatment strategies and system designs that address nitrogen reduction, watershed protection, and sensitive environments. Wastewater engineers find these pre-engineered systems easily adaptable to a variety of site conditions and particularly beneficial in coastal or watershed communities where dispersal to surface waters is no longer an option or polluting discharges endanger watersheds. AOWTS provide long-term treatment solutions that can be designed in multiple small-scale or single large system applications.

Membrane Bioreactors (MBRs)

MBRs employ suspended growth for treatment and clarification via semipermeable membrane material. The membranes have pores created during the manufacturing process that are very small and uniform in size. The membrane module or cassette is submerged directly in the suspended aeration process. The effluent moves from outside the membranes to inside under a minimal vacuum that pulls the permeate into the void area inside the membrane and out of the system for discharge.

Professional Management

Recognizing the need to advocate advanced wastewater treatment systems on a scale that will support positive development, wastewater and municipal engineers also recognize and often require these systems to be professionally managed. Professional management provides more control on the quality of the waste treatment process. Some utilities are favoring this approach as the most cost-effective, long-term solution.

Applications In Action

Innovative Upgrade Of New Hampshire Community's Municipal Wastewater Treatment Plant Incorporates Recirculation For Denitrification

Originally designed in 1959 as a seasonal wastewater treatment facility (WWTF) for a lakeside community in Newbury, NH, the 50,000-GPD Blodgett Landing WWTF was not equipped to meet the treatment requirements of the 21st century. As the population grew and residences were converted to year-round use, effluent testing and groundwater monitoring confirmed nitrate concentrations were a growing problem.

Following a successful pilot study to explore collecting a portion of the treated effluent to recirculate through the sludge layer of the existing 34,000-gallon Imhoff tank to facilitate denitrification, plans were made to incorporate denitrification into the planned

Pipe bundles in the double-stacked configuration are properly spaced.

Parameter	Average		% Change	Parameter	Average		% Change
TSS - Influent	122	mg/L	-95.78%	Total Nitrogen - Effluent	7.8	mg/L	-72.40%
TSS - Effluent	5	mg/L		Total Phosph. - Influent	4.7	mg/L	-61.0%
Nitrite - Influent	0.50	mg/L	-1.51%	Total Phosph. - Effluent	1.8	mg/L	
Nitrite - Effluent	0.49	mg/L		BOD - Influent	115	mg/L	-94.5%
Nitrate- Influent	0.93	mg/L	573%	BOD - Effluent	6	mg/L	
Nitrate - Effluent	6.29	mg/L		pH - Influent	6.8		2.69%
Ammonia - Influent	19.8	mg/L	-96.98%	pH - Effluent	7.0		
Ammonia - Effluent	0.6	mg/L		Total Coliform - Influent	263,071,948	CFU/100 mL	-99.9972%
TKN - Influent	27.4	mg/L		Total Coliform - Effluent	7,251	CFU/100 mL	
TKN - Effluent	1.7	mg/L	-93.70%	Fecal Coliform - Influent	10,724,907	CFU/100 mL	-99.9823%
Total Nitrogen - Influent	28.3	mg/L		Fecal Coliform - Effluent	1,903	CFU/100 mL	

Ongoing Average Performance of the Blodgett Landing Municipal Wastewater Treatment Facility from January 2012 to November 2020

upgrade to the treatment plant. Project engineers at Presby Environmental, Inc. (PEI) recommended incorporating the Enviro-Septic technology into the existing sand filter configuration to enhance aerobic nitrification and allow increased denitrification in the recirculation process. The passive treatment performance of the technology utilizes the naturally occurring bacterial process, eliminating the need for added chemicals, biological additives, or electrical energy. Its subsurface configuration and low maintenance requirements are desirable for any community. For Newbury, this innovative approach allowed the rehabilitation and continued use of the existing Imhoff tank and sand filter/rapid infiltration basins (RIBs), resulting in construction cost savings.

The upgraded Blodgett Landing WWTF has been operating for over eight years with very consistent results. The Blodgett Landing Facility has experienced significant reductions in certain wastewater contaminants, including fecal coliform, total nitrogen (TN), five-day biochemical oxygen demand (BOD5), and total suspended solids (TSS).

New Package Sewage Treatment Plant Replaces One In Service For More Than 35 Years At Louisiana Community Park

Pelican Park in Mandeville, LA, is a 550-acre community park with 32 athletic fields, two gyms, and a 46,000-square-foot multipurpose community center. The community park also includes an 18-hole disc golf course and parking for more than 1,700 vehicles. Nearly 35 years ago, the community installed a 3,000-GPD package sewage treatment plant to serve the park's operations at that time. With the tank nearing the end of its expected lifecycle due to rust resulting from outdated prep and coating methods, the park's staff knew they needed a new replacement system.

Because the park was happy with the existing system and its longevity, they contracted Delta to fabricate a new extended aeration package plant replacement system that would be easy for the team to use due to familiarity with the previous model. Package sewage treatment plants are custom designed to the particular sewage treatment needs of each location and are suitable for permanent or temporary use in areas beyond the reach of municipal wastewater systems. The package treatment plant is shipped to the project site as a self-contained unit that requires minimal assembly.

The new system at Pelican Park effectively handles the more than 12,000 park visitors each Saturday and 1 million visitors per year. The early 2021 installation and start-up went smoothly.

Conclusion

Municipalities, states, and the federal government have tough decisions to make in addressing wastewater treatment needs and the funds required for infrastructure improvements. New approaches and products provide increasingly better performing, cost-effective alternatives to traditional centralized sewering and old onsite septic system technologies. In many cases, where centralized wastewater infrastructure is not in place or where it is over capacity and no funds are available to undertake new infrastructure projects, taking alternative and/or advanced treatment approaches into consideration is necessary to sustain development and to protect waterways, groundwater supplies, public health, and the environment. ■

About The Author

Dennis F. Hallahan, PE, has more than 30 years of experience with onsite wastewater treatment systems design and construction. Currently Technical Director at Infiltrator Water Technologies, he is responsible for technology transfer between Infiltrator and the regulatory and design communities and consults on product research and testing for universities and private consultants. Hallahan received his MS in civil engineering from the University of Connecticut and his BS in civil engineering from the University of Vermont. He is a registered professional engineer in Connecticut and holds several patents for onsite wastewater products.