



# Focusing on Resilience in the Face of Emerging Contaminants

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# Resilience is a strong emerging theme within the water sector.

There are over 150,000 public drinking water systems in the United States and more than 80 percent of the population receives their potable drinking water from these systems. And today - according to the EPA, our water systems are faced with a growing list of challenges.

In particular, the water utility industry is facing challenges with respect to emerging contaminants, including issues of public confidence, monitoring, treatment and affordability, as regulators move to issue new water quality requirements at both the federal and state levels. This can lead to a lack of clarity both for water industry professionals, but also the public at large. These information gaps can lead to misinformation, skepticism, and even paranoia. Clear, concise, scientific driven data and directives that are effectively communicated can provide the water industry and the public with the knowledge of what the challenges are, where they exist and how to build resilience against them. We aim to achieve that for you, the reader, in the following pages.

In March 2020, America's Water Infrastructure Act (AWIA) began requiring community drinking water systems to develop or update Risk and Resilience Assessments (RRAs) and Emergency Response Plans (ERPs) if the systems serve more than 3,300 people.

In response, water technology providers are on the frontlines of helping utilities reduce their risk and improve their overall resilience through monitoring, management and treatment solutions to eliminate contaminants of emerging concern and rebuild trust with customers.

## The evolving nature of emerging contaminants

With advances in testing and health research, experts are learning of new potential dangers in our drinking water. Sometimes chemicals that had not previously been detected (or were previously found in far lesser concentrations) are discovered in the water supply. These chemicals are known as "contaminants of emerging concern" or simply "emerging contaminants."

The United States Environmental Protection Agency (USEPA) leads the federal charge to ensure our citizens' public health is protected via the Safe Drinking Water Act (SDWA). As part of SDWA, the USEPA will add emerging contaminants to their Unregulated Contaminant Monitoring Rule (UCMR) to understand the prevalence of the contaminants. If during the sampling period, the USEPA determines the emerging contaminants on the UCMR are a threat to public health, they will add the contaminants to the Contaminant Candidate List (CCL) with the intent of providing a federal regulation.

Emerging contaminants can now be detected at trace levels but even at these very small amounts can pose a chronic health risk. For the most part, they are not yet federally regulated as they move through the USEPA

evaluation and rule-making process. The list includes pharmaceuticals, personal care products, pesticides, herbicides and endocrine-disrupting compounds.

Prior to the emergence of these contaminants, municipal source waters were relatively clean and, for the most part, required minimal levels of treatment followed by disinfection. Stringent new drinking water standards to address these potent compounds demand more innovative treatment approaches.

Increasing levels of micropollutants pose a significant challenge for drinking water treatment plants drawing from source waters, and often need to be removed to protect both human health and aquatic species. But many of these manmade chemicals are not found naturally in the environment and do not go away or break down, earning them the nickname - forever chemicals. We will explore two emerging contaminants that have sparked state regulations and budding interest at the federal level - 1,4-dioxane and PFAS.



systems mentioned in advance of a full-scale design. The next step is to custom-design the AOP process to complement the existing process and ultimately ensure maximum reliability with the highest possible efficiency. Leading water technology providers offer a comprehensive suite of AOP treatment solutions and are key partners in implementing a system – taking the project from lab testing through onsite piloting and into full-scale implementation, including process guarantees.



The key to selecting the best AOP solution is to find the right combination of these processes to most efficiently generate hydroxyl radicals that reduce the target contaminants. The best AOP for a facility's water treatment needs depends on many factors including:

- The concentration of 1,4-dioxane in the water
- Treatment target concentrations, including regulatory requirements
- The water matrix, including parameters such as pH, TOC, DOC, COD, alkalinity and more
- Upstream and downstream unit operations in the overall treatment train
- Site-specific energy and chemical costs
- Available footprint for new technologies

**The Importance of Treatability Testing** - Nothing is more important than proving selected AOP treatment processes will work as required. But water quality matrices are site-specific and using historical experience alone often isn't enough to provide that level of certainty. That's why laboratory, bench scale and pilot testing of processes are key tools in the design process.

In addition to providing the certainty that the chosen process will work, bench scale and pilot plant testing provide extremely valuable data regarding sizing, energy requirements, reliability, flexibility, and even ease of operation.



### Bench Scale Testing

Laboratory testing and bench scale work can provide valuable data on treatability, chemical usage, UV dose, ozone dosage and selection of the right advanced oxidation process and operating parameters.

A broad array of laboratory resources and bench scale testing is available for a number of different processes to assist with process selection and design. Laboratory and bench scale applications include advanced oxidation (ozone / UV and peroxide) dose testing, biological treatability studies, UV dosage response curves, ozone treatability testing and dose response curve, and filtration studies.

### Pilot Scale Testing

On-site pilot plant testing can further demonstrate the effectiveness of treatment at a facility. In particular, pilot plant testing can help ensure that a system is properly sized, preventing over-designing and wasting capital, or under-designing and risking non-compliance.

In many cases, full pilot plants can be set up on site for advanced study of a customer's particular problem. These compact units come containerized for easy transport and set up. Examples of available pilot plant testing units include UV disinfection, ozone oxidation and advanced oxidation processes, biological filtration, sand filtration, and, of course, combinations of these processes.

These pilot plants enable the engineers to confirm treatment feasibility, as well as test operating scenarios, gather data for proper sizing and fine tune the capital investment costs and operating requirements. The customer gains a better understanding of expected treatment outcomes, as well as capital and operating costs.



**Expertise at work** - Teaming with application experts at established water technology providers like Xylem not only offers access to treatability testing resources, but also an abundance of historical project experience to expedite the course of 1,4-dioxane remediation projects. Generally speaking, when discussing 1,4-dioxane remediation, the focus is on three areas: the ultraviolet transmittance of the water stream, the scavenging potential of the water quality matrix and the dose response of 1,4-dioxane to the AOP process applied.

### Ultraviolet Transmittance (UVT)

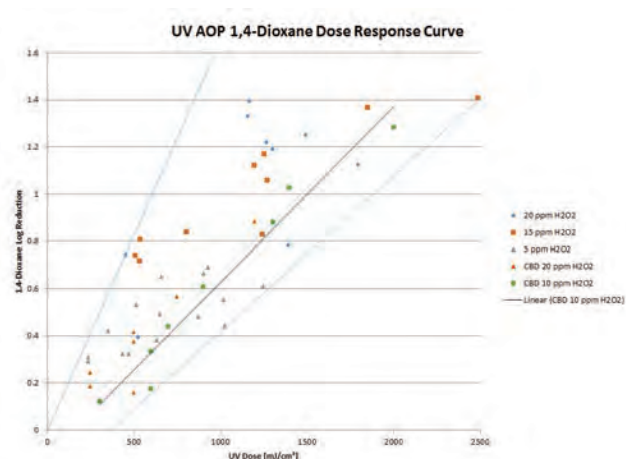
UVT is a measure of the effective penetration of UV light through the water stream. The value is represented by a percentage that indicates how much light would effectively pass through a 1 cm vial of water. By and large, the higher the clarity of the water, the greater the UVT. Water streams with very high UVTs (i.e. typically >90% and definitely >95%) are a better fit for UV AOP because of the more effective nature of UV light hydroxyl radical formation. However, in water streams with lower UVTs (i.e. <90%), it is valuable to consider both UV AOP and Ozone AOP as ozone's efficacy can be greater than that of UV in these conditions.

### Scavenging Potential

The term "scavengers" is defined as "a constituent that consumes or renders inactive the chemicals in a mixture." When utilizing AOP for 1,4-dioxane remediation, scavengers do just that. They consume and compete for the attention of the hydroxyl radicals generated from the AOP process, reducing the efficiency of eliminating 1,4-dioxane. Some critical scavengers in a water stream that can require greater doses of UV AOP or Ozone AOP to remove 1,4-dioxane are dissolved organic carbon (DOC) and alkalinity. It is important to be aware if the presence of these items exist in the water stream (and if there is uncertainty, lab and pilot tests can be performed to determine the concentration of these scavengers) to best understand where on the dose response curve a project exists.

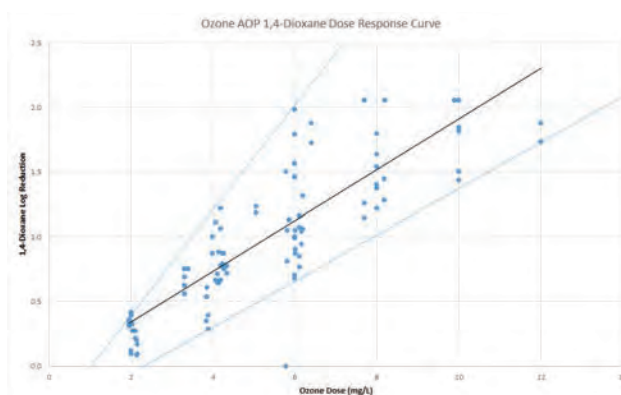
### 1,4-Dioxane Dose Response Curve

As mentioned above, every water stream is different and lab and/or pilot testing is suggested to best understand site-specific UVT, scavenging potential, and UV AOP and Ozone AOP dose response curves. However, with an abundance of 1,4-dioxane projects completed, Xylem has been able to compile a general dose response curve for both UV AOP and Ozone AOP. An example of a UV AOP dose response for 1,4-dioxane is shown to the right.



*UV AOP dose response curve showing linear regression in the black line and band of typical dose responses in blue lines.*

Again, water streams with higher UVTs and lower scavenging potential will be on the lower end of this band and systems with lower UVTs and higher scavenging potentials will be on the higher end of this band. A general guideline for Ozone AOP dose response for 1,4-dioxane is shown below.



*Ozone AOP dose response curve showing linear regression in black line and band of typical dose responses in blue lines.*

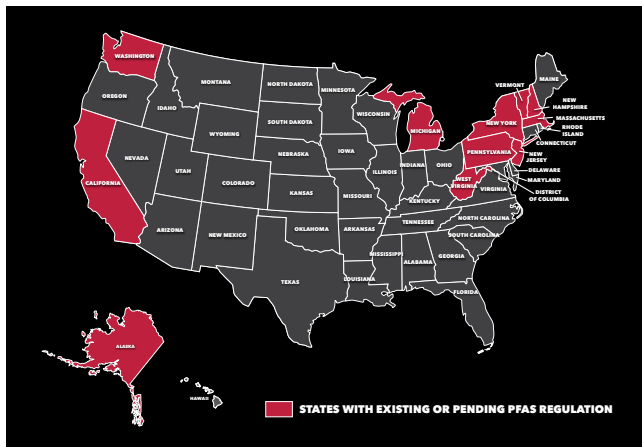
The ratio of ozone to peroxide will allow the ability to shift up or down this band, but keep in mind that peroxide is also a consumable so just adding more peroxide may not always be the most cost effective option. This is why it's important to not only review the performance of different candidate AOPs, but also the economics of any of the candidate AOPs that demonstrate ideal performance.



## PFAS

Due to their growing presence, persistence and adverse health effects, per- and polyfluoroalkyl substances (PFAS) are another family of emerging contaminants that have become major concerns for drinking water supplies nationwide.

PFAS are present in a wide range of consumer products and were once thought beneficial because of their ability to repel fire, water, oil and stains. They have been used in stain and water-resistant fabrics, non-stick products, polishes, pizza boxes, waxes, paints, cleaning products and fire-fighting foams. But many scientific studies have now linked these chemicals to various cancers, cholesterol diseases, pregnancy-induced hypertension and preeclampsia and thyroid disorders. These chronic health effects and the fact that PFAS are “forever chemicals” made it even more concerning that over 600 sites in the US identified PFAS family compounds during UCMR 3.



**Regulations** - The USEPA has set a guidance level of 70 ng/L (parts per trillion) for two particularly harmful PFAS chemicals - PFOA and PFOS. Furthermore, as of February 20, 2020, USEPA announced preliminary regulatory determinations for both PFOA and PFOS as part of CCL 4, which is a critical step as they plan to include regulations for these contaminants. In 2019, the USEPA released a PFAS Action Plan (EPA, 2019), thus increasing demand for the development of more efficient and cost-effective removal technologies. Additionally, many states have

established guidelines and enforceable maximum contaminant levels for specific PFAS that are of concern in their area.

**The Future of PFAS and Considerations to Make in Resiliency Planning** - The widespread nature of these contaminants has made a strong need for identifying appropriate and resilient water treatment technologies that can be incorporated in existing drinking water facilities.

Low volatility and high water solubility makes it harder to effectively and efficiently remove these PFAS using many conventional treatment technologies. Once these chemicals have been spilled and are in the source water, they are there to stay.

Current options for drinking water treatment technologies to remove PFAS include granular activated carbon (GAC) adsorption, ion exchange (IX) and reverse osmosis (RO). Of these, GAC adsorption is the most common, with many water treatment facilities and industries already using it to remove other contaminants. Reverse osmosis and ion exchange are effective technologies, but they also are more expensive and intensive to implement. GAC as an adsorption technology is comparatively less expensive, but the media does need to be replaced once the adsorption sites are all occupied and reactivated or incinerated to fully remove/destroy the PFAS compounds.

As Xylem is a leader in both filtration technologies and water treatment application expertise, we are providing GAC adsorption solutions for water utilities now. The challenge can be that media specificity and type are very particular for the specific PFAS family compound you are trying to remove and in the event that concentrations of that compound are high, the media replacement frequency can be quite high. That is why beyond just supporting water utility customers today, Xylem is on the edge of innovation - seeking new technologies to improve the life cycle costs of PFAS removal for our utility partners for decades to come.



## Ensuring drinking water resilience

As the municipal water sector becomes increasingly focused on a secure and resilient water supply, there is a growing emphasis on water quality and eradicating emerging contaminants.

Being resilient not only adds value to the public the utility serves, it also benefits the environment, gives utility owners peace of mind and has long-term economic benefits.

Xylem has the expertise and solutions to help utilities improve their resilience across the water cycle. Through implementation of innovative treatment solutions, utilities have the capacity to tackle the challenges emerging contaminants pose head-on, protecting our drinking water supplies and safeguarding the environment while lowering operating costs.

# Xylem ['zīləm]

- 1) The tissue in plants that brings water upward from the roots;
- 2) a leading global water technology company.

We're a global team unified in a common purpose: creating advanced technology solutions to the world's water challenges. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. Our products and services move, treat, analyze, monitor and return water to the environment, in public utility, industrial, residential and commercial building services settings. Xylem also provides a leading portfolio of smart metering, network technologies and advanced analytics solutions for water, electric and gas utilities. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise with a strong focus on developing comprehensive, sustainable solutions.

**For more information on how Xylem can help you, go to [www.xylem.com](http://www.xylem.com)**