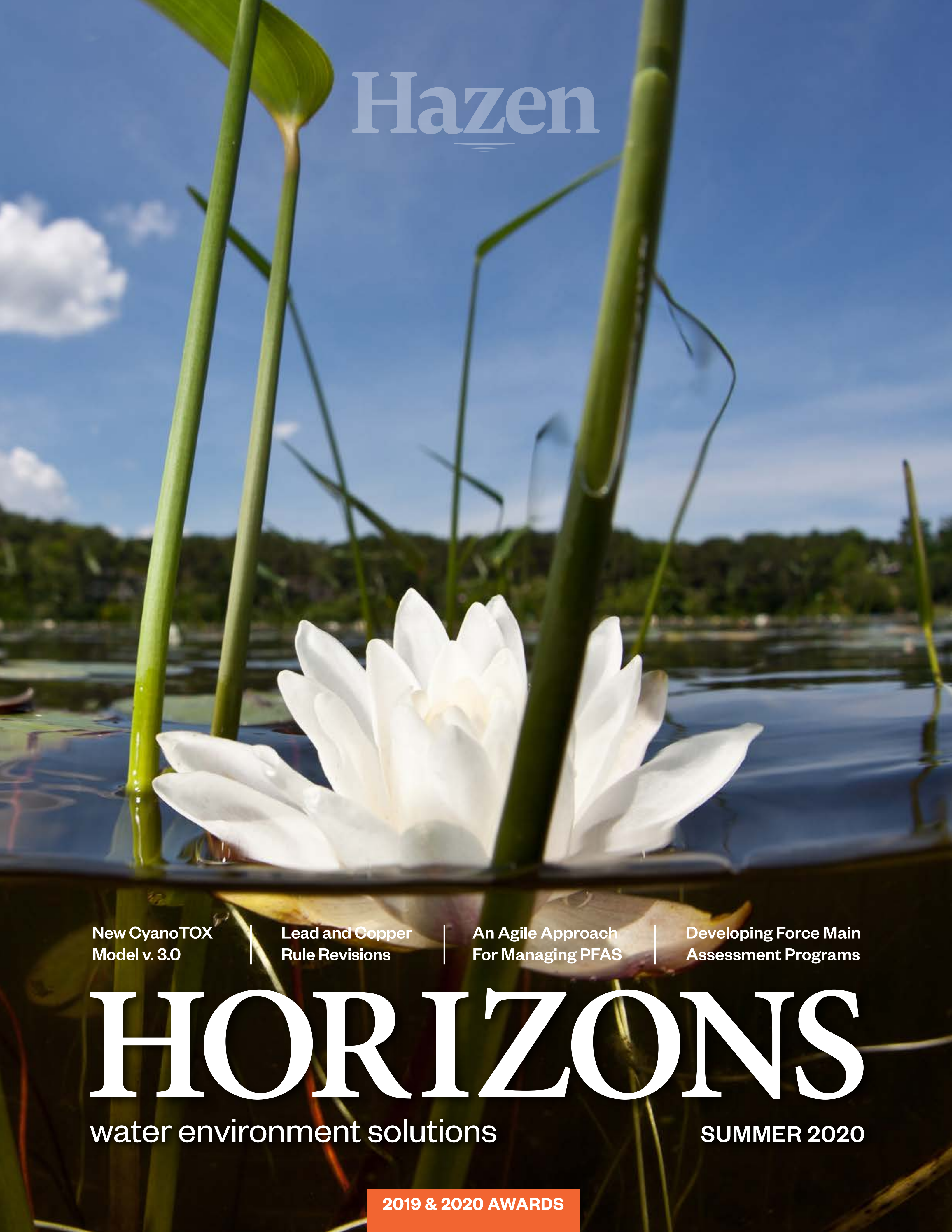


Hazen

New CyanoTOX Model v. 3.0

Lead and Copper Rule Revisions

An Agile Approach For Managing PFAS

Developing Force Main Assessment Programs

HORIZONS

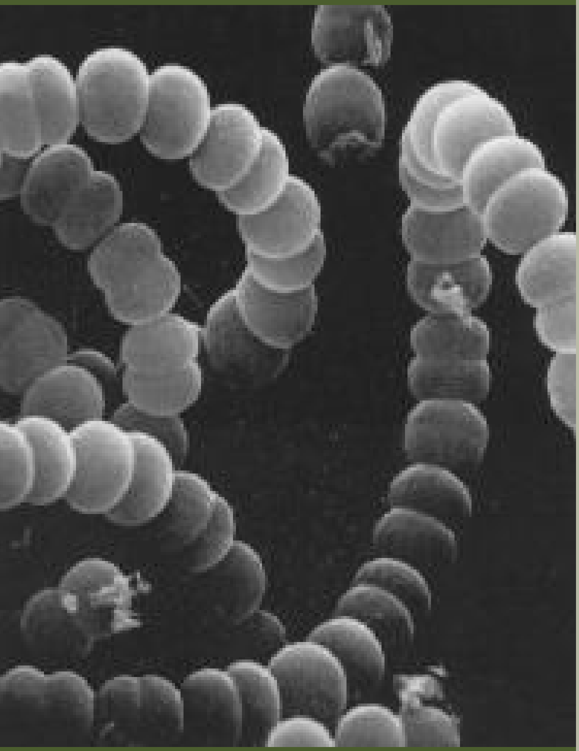
water environment solutions

SUMMER 2020

2019 & 2020 AWARDS

New CyanoTOX Model v.3.0

A Digital Twin Model for Cyanotoxin Removal at Drinking Water Plants



In 2015, the USEPA issued health advisories for the cyanotoxins cylindrospermopsin and microcystin, compounds that are produced by naturally occurring cyanobacteria (blue-green algae) and have negative health impacts on humans and animals. That same year, the Hazen-Adams CyanoTOX Tool was developed and published by AWWA and the Water Research Foundation to help utilities evaluate how various oxidants could be used to manage extracellular cyanotoxins.

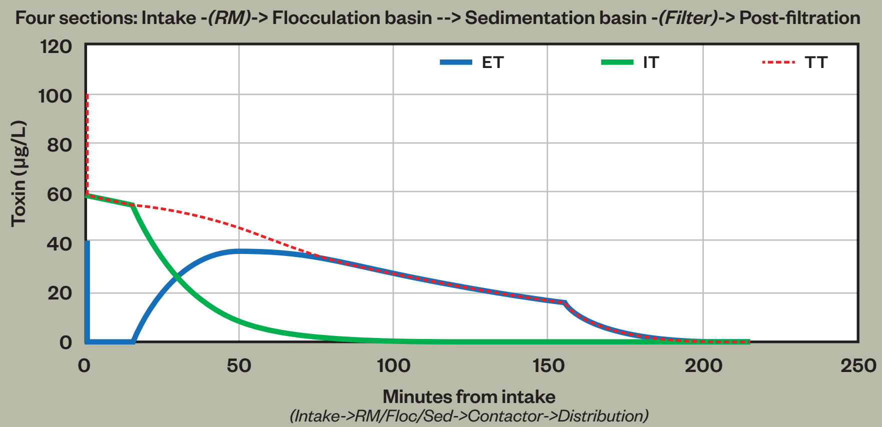
The original model and its follow up (v.2.0) could not account for cell lysing (when the cell bursts open, releasing all its intracellular contents) and cell leaking (when the cell slowly leaks its intracellular contents). CyanoTOX v3.0, released this year, has been expanded to include oxidation, cell damage, leaking, and lysing with the ability to model the entire drinking water treatment plant as a "digital twin." The tool provides water utilities with a means to assess how changes in their existing treatment scheme—from hydraulics, to disinfection, to activated carbon—and standard filtration will influence the degradation and removal of specific cyanotoxins or groups of cyanotoxins.

The CyanoTOX v3.0 model provides utilities with a unique tool that can guide future planning and help inform how future treatment changes could impact flexibility and responses to cyanotoxin events. As a digital twin, utilities can now examine the coordinated impact of various treatment decisions on the removal of cyanobacteria cells and cyanotoxins in both the intracellular and extracellular forms.

The model can be used during a bloom event; however, the extraordinary power of this tool is to use it as a digital twin ahead of time as a way to model scenarios, set trigger levels, and develop action plans before a bloom event ever occurs.

Stand-Alone Lysing Module

CyanoTOX 3.0 contains a separate module that models intracellular, extracelluar, and total toxins (ET, IT, and TT) throughout the water treatment plant.



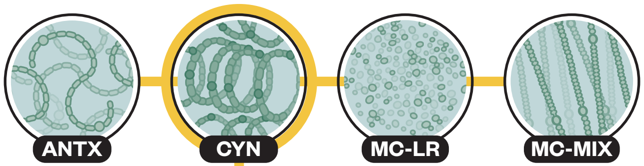
The model is not intended to be a simultaneous compliance tool to manage cyanotoxins along with other compliance targets (i.e., DBPs, lead and copper, disinfection). However, it will allow a utility to conduct exercises on various scenarios of cyanobacteria bloom events and see how the plant performs with respect to health advisory targets or other targets set by the utility.

How Model Works

The model evaluates individual unit process operations, not the entire plant's oxidation processes.

Inputs | Outputs

1 Pick Cyanotoxin

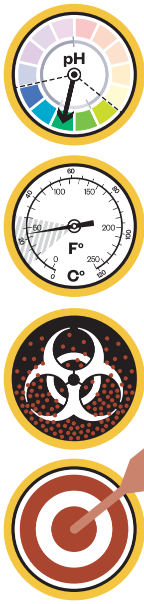


Choose from 1 of 4 options: Anatoxin A, Cylindrospermopsin, Microcystin-LR, or Microcystin-Mix.

2 Input Variables

Process Unit pH
Model is valid for pH levels 6-10 SU

Process Unit Temperature
Model works for 10-30 C°

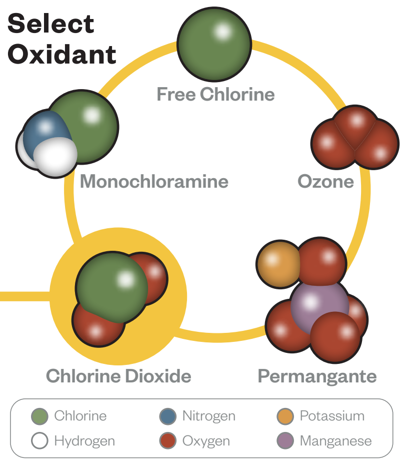


3 Extracellular Cyanotoxin Concentration (µg/L)

4 Target Value Cyanotoxin Concentration (µg/L)

A Health Advisory Levels
B Cyanotoxin Concentration Goal

5 Select Oxidant



6 Choose Calculator Version

CT Value | Dose-Decay

7 Input Final Parameters

Baffling Condition Factor

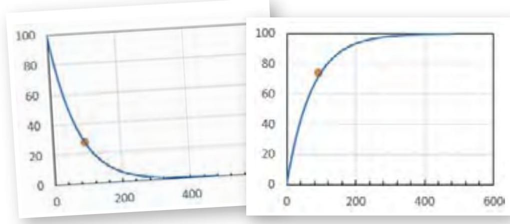
KEY OUTPUTS

- X% — **Cyanotoxin Removal**
- Y% — **Cyanotoxin Remaining**
- 000 (µg/L) — **Final Cyanotoxin Concentration**
- 000 (mg-min/L) — **Estimated CT** (If CT not entered)
- 000 (mg-min/L) — **CT Needed To Achieve Target****
- 000 (µg/L) — **Max Influent Cyanotoxin Concentration To Achieve Target****

** If Target entered

Charts

Based on input data, the model produces several graphs illustrating cyanotoxin removal and concentration over time.



CyanoTox v3.0

Was created with the help of Craig Adams, PhD, of St. Louis University and is ***free and downloadable*** from AWWA and the Water Research Foundation.

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More Algae & Cyanotoxins Resources

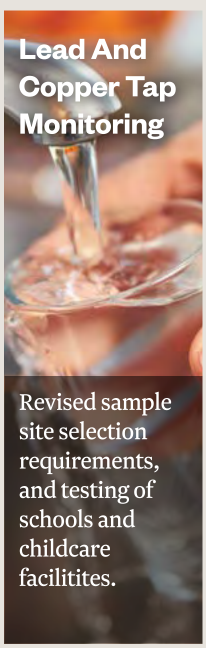
Lead & Copper Rule REVISIONS

The Lead and Copper Rule (LCR), established in 1991, requires utilities to monitor and control lead and copper levels in drinking water. The LCR Revisions released in 2019 propose sweeping changes to many aspects of the Rule, constituting the first major update to the National Primary Drinking Water Regulations in more than a decade and impacting every U.S. water system.

The Revisions will significantly alter how utilities implement corrosion control treatment, conduct compliance sampling, manage lead service lines, and communicate with customers. Understanding the implications of these Revisions will allow utilities to plan for continued compliance, and Hazen has developed an online interactive tool to help utilities proactively prepare.

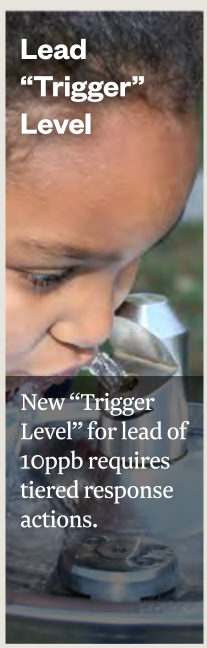
Key Revisions Impacting Utilities

We have described five key areas that will affect utilities. More details are available at our Lead and Copper Rule Revisions online interactive.



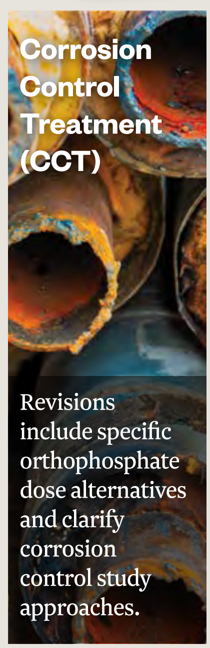
Lead And Copper Tap Monitoring

Revised sample site selection requirements, and testing of schools and childcare facilitites.



Lead "Trigger" Level

New "Trigger Level" for lead of 10ppb requires tiered response actions.

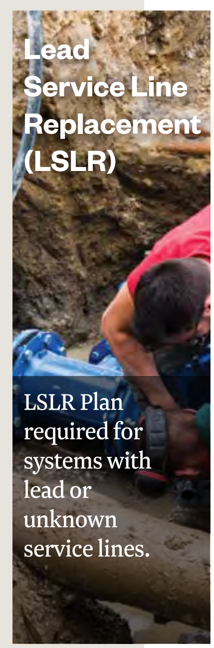


Corrosion Control Treatment (CCT)

Revisions include specific orthophosphate dose alternatives and clarify corrosion control study approaches.

Service Line Inventory

Public and private inventory required for systems with lead or unknown service lines.



Lead Service Line Replacement (LSLR)

LSLR Plan required for systems with lead or unknown service lines.

https://www.hazenandsawyer.com/infographics/lead-copper-rule-revisions/

TAP SAMPLING

Lead and Copper Tap Sampling Prioritizes LSLs

The proposed LCR revisions redefine compliance site selection criteria and place a priority on sampling from sites with the highest potential for lead release—those containing lead service lines.

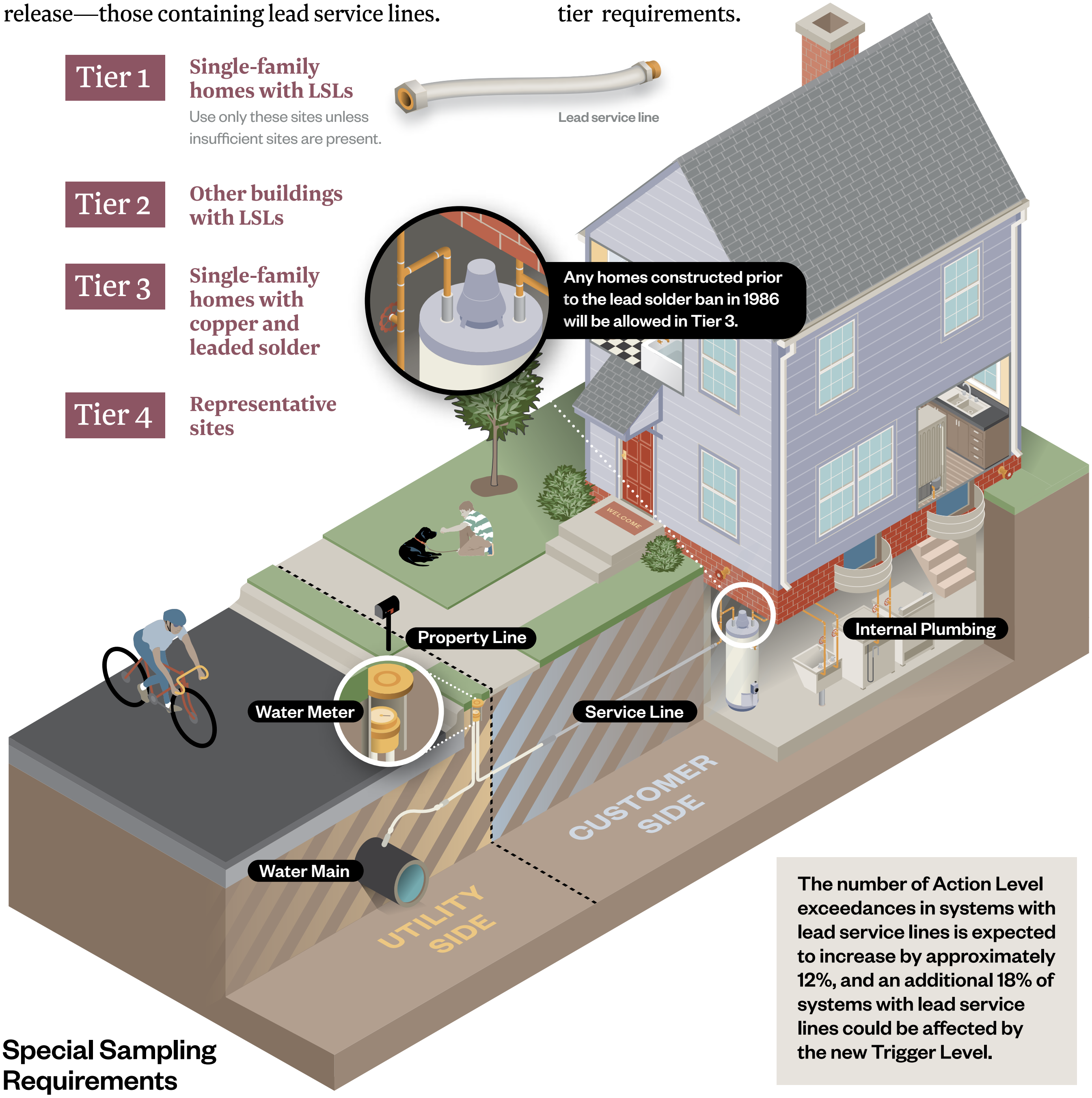
Water systems will need to reevaluate their LCR sample site selection to determine if compliance monitoring locations comply with the proposed tier requirements.

Tier 1 — **Single-family homes with LSLs**
Use only these sites unless insufficient sites are present.

Tier 2 — **Other buildings with LSLs**

Tier 3 — **Single-family homes with copper and leaded solder**

Tier 4 — **Representative sites**



The number of Action Level exceedances in systems with lead service lines is expected to increase by approximately 12%, and an additional 18% of systems with lead service lines could be affected by the new Trigger Level.

Special Sampling Requirements

The LCR revisions also introduce additional sampling requirements. This proposed regulatory change will require utilities to adopt new protocols for evaluating and mitigating lead release on a site-specific basis, increasing utility coordination and communication with customers. Utilities will also be required to sample from schools and childcare facilities, where high-risk populations, including children, are present. To meet this requirement, utilities will need to develop a sampling plan for these high-risk locations and develop procedures to communicate both the sampling results and potential actions the location can take to reduce lead in drinking water.

"TRIGGER" LEVEL

Changes Further Protect Public Health Efforts

In addition to the current Maximum Contaminant Level Goal (MCLG) of zero and Action Level (AL) of 15 ppb for lead, the revised LCR aims to strengthen corrosion control treatment and further protect public health by establishing a new trigger level (TL) of 10 ppb. Revisions to the LCR define a tiered response of required actions based upon the level of exceedance (trigger level and action level). Approximately 10% of systems surveyed in Hazen's 2019 Corrosion Control Treatment Survey reported historical 90th percentile Pb levels between 10 and 15 ppb and would be affected by the proposed Trigger Level.

https://www.hazenandsawyer.com/publications/evolving-utility-practices-and-experiences-with-corrosion-control-results-f/

90th Percentile	Required Actions
15+ ppb	**Tap Sampling:** Standard monitoring every 6 months **CCT:** Implement or re-optimize treatment **LSLR:** Full replacement at 3% per year
	ACTION LEVEL 15 ppb
>10-15 ppb	**Tap Sampling:** Standard monitoring every year **CCT:** Conduct new CCT study or re-optimize treatment **LSLR:** Full replacement at defined goal rate
	TRIGGER LEVEL >10 ppb
0-10 ppb	**Tap Sampling:** Reduced monitoring every 3 years* **CCT:** Maintain treatment and WQPs **LSLR:** Voluntary

To prepare for these upcoming regulatory changes, utilities can evaluate potential compliance impacts of the Trigger Level by analyzing historical LCR data. Utilities should determine the frequency with which 90th percentile lead levels have historically exceeded 10 ppb. A spatial analysis for compliance sampling sites can also be completed to help identify and address portions of the system with elevated lead levels.

** Upon finalization of the rule, LSL systems must revert to annual sampling for 3 years, after which they can return to reduced monitoring if the 90th percentile is under 10ppb.*

CORROSION CONTROL

Corrosion Control Treatment Becomes High Priority

According to the proposed Revisions, utilities will be required to conduct a corrosion control study if either the lead trigger level or action level is exceeded. Utilities may also be required to conduct a corrosion control study prior to a source water or treatment change, or if the USEPA or state regulatory agency deems the utility's current corrosion control treatment not optimal.

Based on the new requirements of the proposed LCR revisions, the number of systems needing to evaluate corrosion control treatment is expected to increase substantially. Nearly 20% of systems that currently meet the action level could exceed the trigger level and require a corrosion control study.

When corrosion control testing is required, the proposed LCR revisions require the use of pipe loops for evaluating various corrosion control techniques (coupon testing is no longer an acceptable test method). This form of testing is more labor and time intensive and utilities will need to plan accordingly. Systems will also be required to evaluate specific orthophosphate doses (1 mg/L and 3 mg/L as PO4), which is expected to push systems to use higher orthophosphate doses than historical norms.

CASE STUDY: Corrosion Control Treatment

Cobb County-Marietta Water Authority (CCMWA) is a regional public utility that provides wholesale potable water to 13 retail, industrial, and institutional water suppliers and is the second largest supplier of safe drinking water in Georgia. CCMWA, along with its wholesale customers, has historically reported lead and copper levels that are well below the EPA action levels. However, in recent years, there have been a growing number of reported pinhole leaks in copper plumbing throughout systems served by CCMWA. As a result, CCMWA chose to take a proactive approach towards corrosion control to evaluate pinhole leaks and prepare for upcoming regulatory changes to the LCR.

The study included a detailed desktop corrosion control evaluation, transmission and distribution system sampling, bacterial analysis, and a comprehensive scale analysis of harvested copper pipes. While historical LCR data showed lead and copper levels well below action levels, a historical water quality analysis revealed the propensity for soft water pitting. Further analysis revealed the absence of a protective carbonate scale within the existing pipe scales and the presence of copper sulfate hydroxides in pitting caps, all characteristic of soft water pitting. Recommendations for optimizing corrosion control within the CCMWA system included the stabilization of finished water pH along with either increasing finished water alkalinity or the addition of orthophosphate.

A pilot-scale pipe loop study is currently being conducted to evaluate the effectiveness of various corrosion control techniques in controlling copper pitting as well as the leaching of lead and copper into drinking water. Corrosion control techniques being evaluated include orthophosphate and zinc orthophosphate along with pH adjustment.

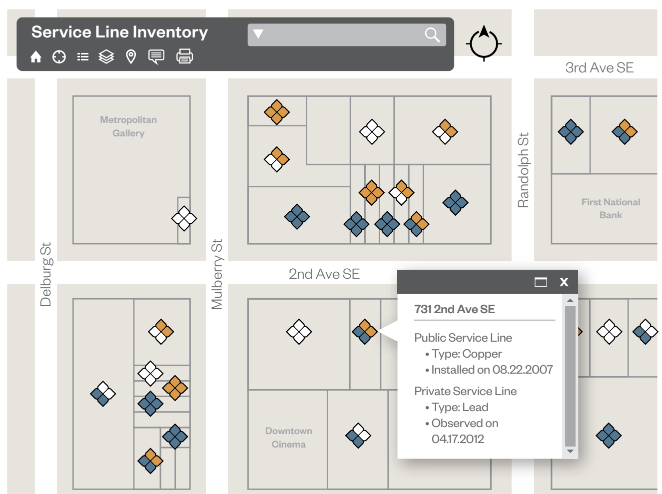
INVENTORY

Developing Service Line Inventories

Where present, lead service lines are the primary source of lead in drinking water. The first step in understanding and addressing lead service line risks is to determine their locations in the system. The proposed LCR Revisions require all water systems to develop a publicly available inventory of all publicly and privately-owned service lines in the distribution system, which must be submitted within 3 years. For large systems, the service line inventory must be posted to a publicly available website in electronic format (interactive maps are recommended due to ease of use for customers).

Systems will be required to submit annual notification letters to all customers with lead service lines or service lines of unknown material. While many systems have unknown service line materials (often historically assumed to be non-lead), the LCR Revisions will require unknown service line materials to be presumptive lead. By improving the accuracy of the inventory to reduce unknown materials, the burden of regulatory requirements associated with LSL notifications and required LSL replacement can be alleviated.

To prepare for inventory development, systems can review historical records about local LSL use and analyze property data to identify portions of the system more likely to contain LSLs. Utilities with



Using standard ESRI GIS products, the service line inventory map can be integrated with custom data collection applications on mobile devices for use in the field to record service line materials. The platform provides efficient data management for utilities and easy public access, which is required in the Revisions.

paper records of service line installation date or material should review or digitize service line records. While the LCR Revisions do not explicitly require service line identification, utilities may also benefit from developing procedures for service line identification in the field. As unknown service lines will be presumed to be lead service lines for compliance purposes, utilities will need strategies to systematically identify service lines to reduce the number of unknowns in the system over time.

REPLACEMENT

Expansion of Lead Service Line Replacement

The proposed LCR Revisions aim to accelerate the removal of sources of lead in drinking water by expanding full lead service line replacement (LSLR) requirements and mitigating the potential for lead exposure during the replacement process.

Systems with unknown or lead service lines will be required to develop a Lead Service Line Replacement Plan establishing how a utility intends to perform LSLRs within the system for voluntary replacements or mandatory replacements in response to a Trigger Level or Action Level exceedance. The LCR Revisions require utilities to establish a goal rate for LSLR and identify methods that they will use to fund the replacements as part of the LSLR Plan.

Systems exceeding the Trigger Level or Action Level at the 90th percentile will be required to replace full LSLs, including privately-owned portions, at a specified rate. In this scenario, partial LSL replacements do not count towards replacement rate requirements, and customer coordination is critical to encourage customer acceptance of private LSLR. Annual notifications to customers with LSLs may also increase the number of private LSLRs. When notified of a private LSLR, the water system has 45 days to replace the public LSL.

CASE STUDY: Lead Service Lines

The City of Chesapeake (VA) retained Hazen to develop a LSLR Plan to proactively prepare to identify and replace LSLs and protect public health. Like many water utilities, the City had observed LSLs during water utility projects but had minimal available records to indicate existing LSL locations and did not have an established approach for identifying and replacing LSLs.

A preliminary assessment of LSL quantity and likely locations in the City was performed using historical records research of local plumbing codes, utility construction standards, published industry research, and City staff knowledge. The City's Real Estate Assessors' database was used to analyze building construction dates as an indicator of potential service line installation dates and materials. Water distribution main installation date and material records were also analyzed to identify potential areas with LSLs. Based on the records research and data analysis, it was estimated that anywhere from 1,400 to 7,000 LSLs may be present within the City. Geographic areas with the greatest likelihood to contain LSLs were delineated and service line identification efforts within these areas were prioritized.

An action plan for LSL identification and replacement was developed. This included a protocol for full LSLR, including customer outreach, funding, and protocols to mitigate lead exposure. The City reviewed legal barriers to private LSLR and developed approaches to encourage customers to agree to private LSLR. As the City is not legally able to pay for private service line work, the City applied for grant funding through the Virginia Department of Health LSLR grant program to secure funding for private LSLR. The City also began development of a geospatial service line inventory and mobile field data collection tool to facilitate service line data collection during routine utility repairs and replacement.

Forward-Thinking Utilities Can Proactively Prepare

The Revisions will significantly expand utility responsibilities associated with privately-owned infrastructure issues, through the proposed "Find-and-Fix" provisions, private service line inventory, and full LSLR requirements. They will also further expand public outreach and education needs through more frequent customer contact and annual service line notification letters.

The Revisions will drive a major change in the ways that utilities communicate and coordinate with customers about lead in drinking water. Utilities can proactively prepare for continued compliance by assessing trigger level impacts, evaluating corrosion control treatment, and developing a framework for service line tracking, identification, and replacement.

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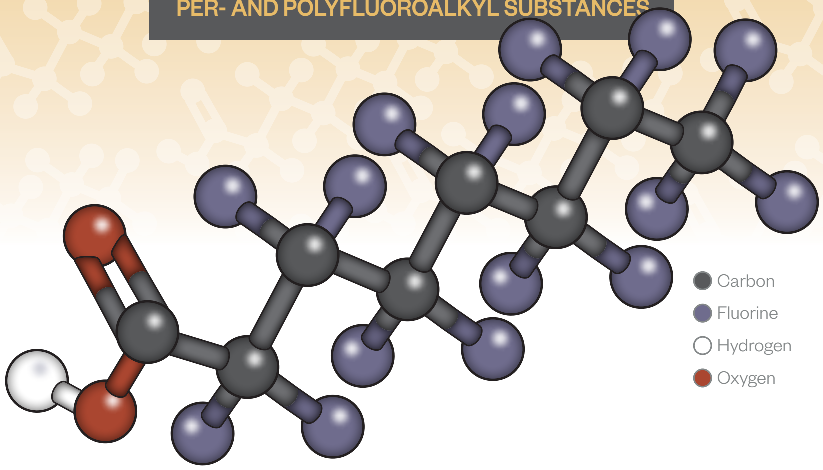
More on Proactive Approach to Corrosion Control

PFAS

PER- AND POLYFLUOROALKYL SUBSTANCES

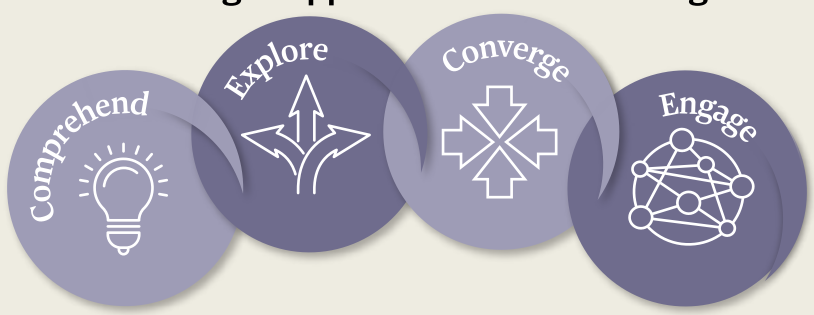


Per- and Polyfluoroalkylated substances (PFAS) are a class of more than 4,900 persistent and bioaccumulative chemicals that are impacting all aspects of the water sector.

Public awareness regarding PFAS and their potential health impacts is also high due to recent media attention. As water industry professionals, we face a rapidly changing regulatory landscape that is evolving to include not only maximum contaminant levels (MCLs) but drinking water health advisories and state-specific standards, potential limitations on wastewater discharge, and possible restrictions on land application of biosolids.

Addressing the uncertainties associated with PFAS requires a measured approach that balances short-term, cost-effective actions geared towards addressing today's PFAS regulations with proactive planning to meet long-term PFAS challenges.

Hazen's Agile Approach to PFAS Challenges



We've had success supporting clients from every part of the water cycle using an agile approach focusing on best value solutions unique to each situation.

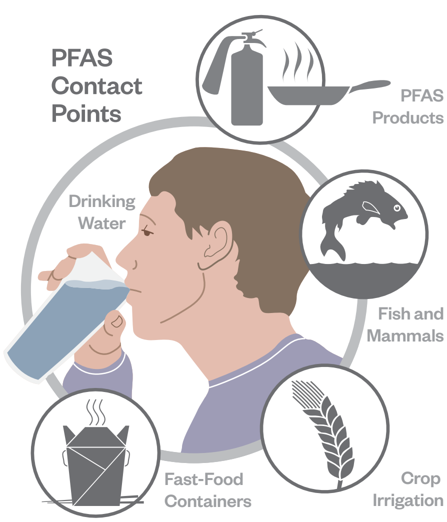
The methodical and intuitive approach addresses PFAS challenges in a manner that facilitates cooperation with regulators and communication with customers – a key aspect of this particular challenge.

Why Are PFAS Important?

Because of their unique water, oil, and flame resistant properties, PFAS are commonly used within consumer products and industrial processes.

PFAS are of environmental and human health concern because they remain in the environment for a long time, are exceptionally mobile, and have a propensity to bioaccumulate. Some PFAS compounds have also been linked to human health impacts, including endocrine impacts, and are potential human carcinogens.

The US EPA has issued a drinking water health advisory level for PFOA and PFOS, two compounds within the PFAS family.

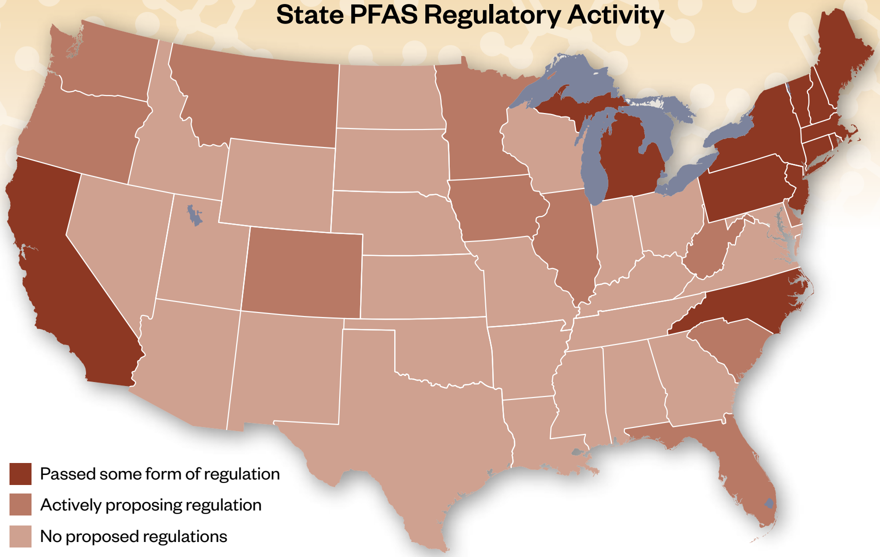


PFAS

Comprehending the Challenges and Drivers

Nearly every aspect of the water industry is affected by the proliferation of PFAS contamination. Already, we're seeing impacts on drinking water, wastewater, reuse, and biosolids operations. More than 20 states have developed or are developing drinking water guidelines or standards and it is expected that federal MCLs will be enacted in the future. Limitations to land application of biosolids and the development of categorical pollutant standards for PFAS are also likely to come from both states and the Federal government.

State PFAS Regulatory Activity



Comprehending your PFAS situation requires understanding existing and expected regulatory requirements, public expectations, and testing to determine the types and concentrations of PFAS in water, wastewater, or biosolids. Testing ahead of regulatory mandates can allow for early identification of issues and position a utility to proactively engage with industries or technology providers as needed. Source tracking and identification of PFAS in the local watershed or sewershed is also key to identifying sources of PFAS, types and concentrations of PFAS (now and expected in the future), and opportunities for wastewater treatment. This stage should result in a baseline of information regarding the utility's PFAS levels or lack thereof, defined objectives, and defined drivers.

INSIGHT: Evaluate water quality parameters to identify any that may limit options for PFAS reduction methods. For example, natural water quality constituents in groundwater can impact the selection of granular activated carbon (GAC) versus ion exchange (IX).

CASE STUDY

REGULATIONS/DRINKING WATER

In January 2020, California decreased the Notification Levels (NLs) from 14 ppt PFOA and 13 ppt PFOS to 5.1 ppt PFOA and 6.5 ppt PFOS—to date the most stringent regulatory requirements in the U.S. for PFOA and PFOS. State regulators also decreased the Response Level (RLs) from a combined 70 ppt to 10 ppt PFOA and 40 ppt PFOS. The RLs reflect levels at which a water system must stop using the water source, treat the water to remove the PFOA/PFOS, or provide public notification. Water systems have up to one year from the receipt of monitoring orders to comply using a running-annual average concentration calculation. Shifting PFOA and PFOS regulatory standards in California have resulted in many more water systems being impacted than were previously, and this may continue as regulations evolve.

PFAS

Exploring Options for PFAS Management

Use the wide knowledge base gathered during the previous stage to explore a world of options, brainstorming all available technical and business solutions and then screening them to identify and discard any options with potential fatal flaws.

Exploration of options for PFAS control plans should include both short-term and long-term elements. An integrated water perspective should be adopted to ensure that any actions taken will consider the entire system as a whole. Short-term plans will aim to meet existing requirements for treatment and public disclosure, and long-term plans will likely include elements such as identifying and controlling sources, cost-effective treatment options, and possible public communications campaigns.

PFAS Control Options to Explore:

- Source Control
- Treatment at facility:
  - Liquids – GAC, IX, MF/RO
  - Solids – Volume reduction, thermal treatment, diversification of land application
- Bench/Pilot/Full-scale testing

INSIGHT: With the regulatory focus on long-chain PFAS compounds like PFOA and PFOS, manufacturers have switched to short-chain PFAS like PFBS or PFHxS and fluorinated alternatives, such as GenX—compounds for which the impacts of treatment in drinking water are not yet well understood.

To address this knowledge gap, a Water Research Foundation project (4913) is being conducted by Hazen with university and industry partners to develop a guidance manual for selecting cost-effective and sustainable treatment options for short-chain PFAS removal. This industry-leading guidance aims to simplify design decisions for future PFAS of concern by accounting for background water quality treatment impacts and overcoming limitations in the applicability of scaling from bench to full-scale design.

For more information go to https://www.waterrf.org/research/projects/investigation-treatment-alternatives-short-chain-pfass

CASE STUDY

WASTEWATER/BIOSOLIDS

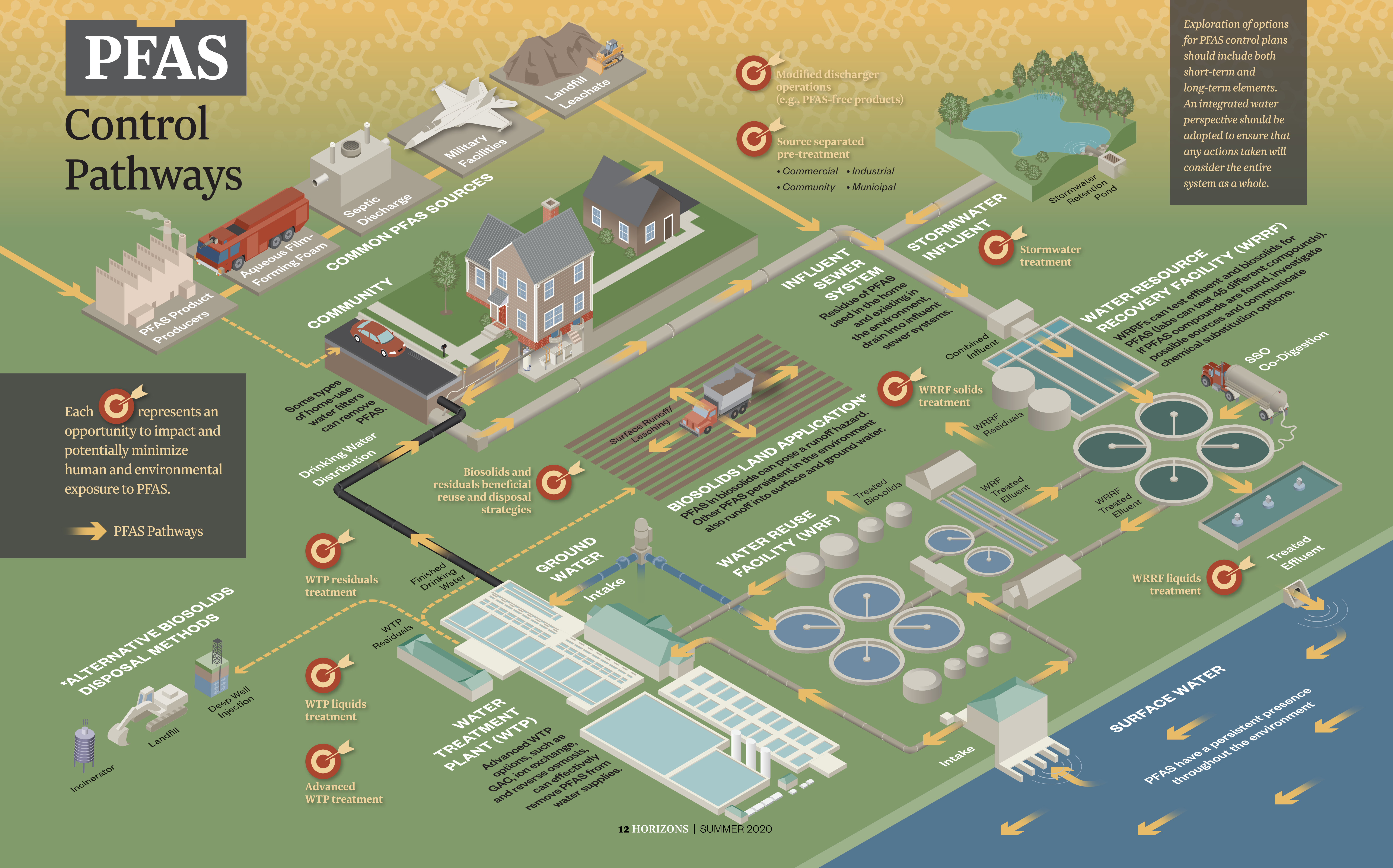
With PFAS-related regulations rapidly evolving in the state, a utility in the Northeast commissioned an evaluation of near- and long-term options for addressing possible biosolids management challenges. A high-level evaluation by Hazen identified industries with the highest risk of discharging PFAS to WRRFs. The evaluation also determined that the cost of biosolids disposal will increase in the near term and utilizing technologies that reduce the mass of solids in conjunction with thermal treatment technologies that can destroy PFAS would provide the greatest value. Promising thermal treatment technologies include pyrolysis, gasification, supercritical water oxidation, and hydrothermal liquefaction. Source control strategies were also identified as a possible beneficial part of a holistic PFAS control plan.

PFAS Control Pathways

Exploration of options for PFAS control plans should include both short-term and long-term elements. An integrated water perspective should be adopted to ensure that any actions taken will consider the entire system as a whole.

Each [target icon] represents an opportunity to impact and potentially minimize human and environmental exposure to PFAS.

→ PFAS Pathways



PFAS

Converging on Sustainable Solutions

Comprehending the situation and exploring the wide range of possible outcomes should result in a collection of viable options to address PFAS within a specific context.

These options are then refined, weighted, and ranked based on feasibility, cost, and other factors specific to the utility to create short-, medium- and long-term plans for controlling and eliminating PFAS.

Lifecycle costs, which include consideration of both capital and O&M for an extended period of time are critical when exploring options viable for a utility. There are a range of options with lower capital costs and higher operations costs (and vice versa) and the “best fit” based on water quality and treatment targets.

A key component of the short-term solutions is their flexibility, allowing them to be built into longer-term sustainable solutions.

INSIGHT: Although water supply permits identify specific treated water quality goals (limits and compounds), consumers may demand PFAS-free water. The HazenGAC model can perform comparative cost evaluation of different treatment goals, enabling strategic planning decisions as analytical methods improve and regulatory body testing requests evolve.

CASE STUDY

A utility in the Northeast recently experienced a significant water main break, requiring complete shutdown until repairs could be completed. To maintain necessary flow rates in the system and meet customer water demands during repairs, the utility developed a short-term plan to augment its supply with one of two groundwater wells that serve as supplemental sources to the surface water supply—wells that had previously been discovered to contain low levels of PFAS compounds. Using strategic lab sampling and testing, the utility was able to demonstrate compliance with regulations and that PFAS levels were far below both EPA health advisory levels and stricter state MCLs. As a key part of their short-term plan, Hazen helped the utility communicate quickly and clearly to customers and the state’s environmental protection department, gaining approval for the use of the well and maintaining the trust of the customers.

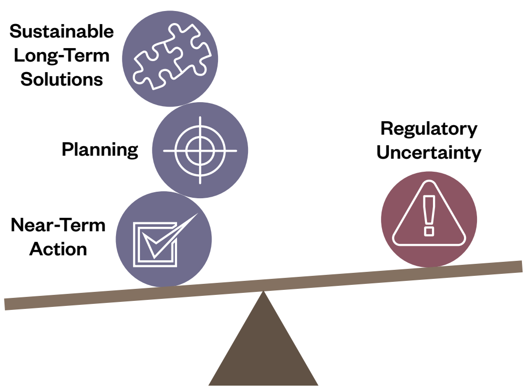
CASE STUDY

A utility in the Southwest is bracing for significant impacts to their future water supply from groundwater contamination from a firefighting foam called AFFF (aqueous film forming foam) at a nearby Air Force base, while simultaneously addressing low-level PFAS in their current water supply from other sources. With the utility’s treatment goal of “non-detect” for total PFAS, Hazen developed a series of potential solutions for the water system. This included evaluating cost and feasibility implications of GAC or IX treatment designed as “complete” treatment, located on site at the well collection and distribution system entry point versus a wellhead treatment system for between one and four of their highest PFAS wells. The utility developed a long-term plan that included implementation of a single wellhead system to start, designed to handle flow from two near-proximity wells. This solution was selected because the treatment approach reduces capital and O&M costs, provides near-term reductions in system PFAS levels to below detection, and offers an opportunity to evaluate effectiveness of the technology in anticipation of a future, system-wide application.

PFAS

Engaging the Most Appropriate Strategies

Once the utility has explored the benefits and drawbacks of all options, and assessed and weighed each, the best approach can be implemented. A measured approach includes short-term action to meet immediate needs, and planning and future action for a sustainable solution in a world of uncertainty.



CASE STUDY

A California water utility was ready to start up their new groundwater treatment facility last year but regulatory requirements with lower PFAS limits caused the facility commissioning to be paused. A treatment assessment was conducted and a cost-effective path forward identified, resulting in the addition of lag GAC vessels to provide the necessary contact time for effective PFAS removal. A key component to the project was the permitting process, necessitating effective communications with the regulatory agency in the planning and design stages.

CASE STUDY

At one utility in the South, a cross-border biosolids site that is contaminated with PFAS is heavily impacting surface waters, causing PFAS levels in their source water to rise near the EPA Health Advisory limit. The facility had recently invested in MIEX technology to achieve Stage 2 DBP compliance, but the technology has proven incapable of reducing PFAS levels at the plant. To further complicate the situation, the local regulatory body indicated they will likely regulate PFAS in some fashion at a future date. A phased approach used HazenGAC to key in on an appropriate partial-treatment solution, installing 8-mgd GAC to treat 40% of plant capacity paired with blending to achieve PFOA and PFOS reduction. This solution was responsive, quick to install, and cost-effective by leveraging existing assets (an on-site mothballed pump station). It also allows for ongoing research at the facility to study treatability of PFOA and PFAS, and short-chain PFAS compounds. Development is underway for testing an innovative combined GAC/IX approach.

Proactive Approach Avoids Pitfalls

A proactive approach can help utilities best plan for the future. Developing a thorough understanding of pending regulations, treatment, and source control options can facilitate development of a tiered plan to address PFAS.

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HOW TO DEVELOP AND IMPLEMENT

An Effective Force Main Condition Assessment Program

Successful Programs Utilize An Asset Management Approach

Utilities across the country are facing the reality that many of their collection system assets are near (or beyond) their useful life. The 2017 ASCE Infrastructure Report Card gave Wastewater Infrastructure in the U.S. a score of D+ and there is a $105 billion annual investment gap in water and wastewater infrastructure renewal and replacement.

An increase in force main failures across the country has driven more attention—both industry and public—to these types of failures. Maintaining operations during a force main failure is more challenging than a gravity sewer failure because of the difficult access for installation of temporary pumping or piping and the long distance to the next point of discharge.

Given equal size and flow, failure of a force main asset is generally more critical than a gravity sewer failure from a Consequence of Failure (CoF) point of view—forcing many utilities to answer difficult questions about the condition of their force mains, possible risks, what technologies to use, and budgeting to repair or replace force mains.

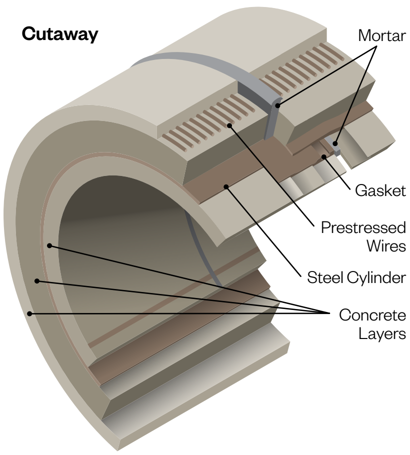
Hazen has successfully utilized a phased, risk-based approach to cost-effectively develop and implement a force main condition assessment program to better inform and justify CIP funding.

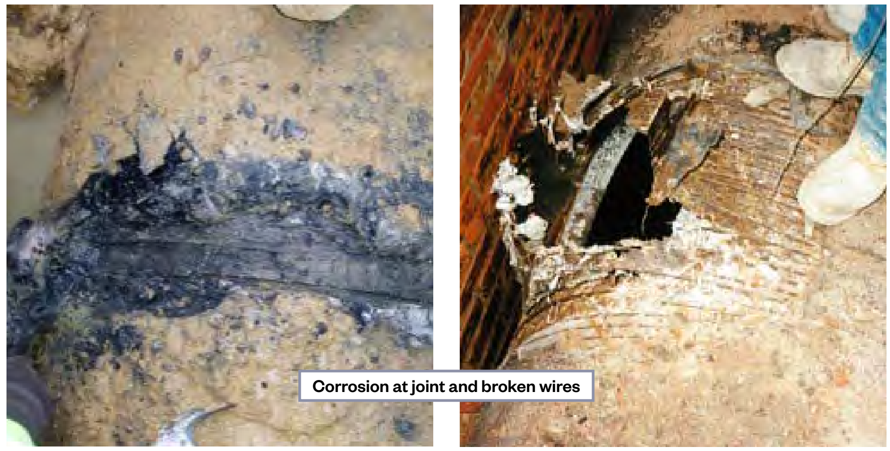
Rather than focusing on particular inspection technologies, leveraging existing data and knowledge of why force mains fail are key to developing a cost-effective, risk-based field program.

Understanding Why Pipes Fail

Prestressed Concrete Cylinder Pipe

PCCP pipe is a common material used for force mains due to its ability to handle large pressures at a wide range of diameters. In sewer force mains, the primary causes of failure include corrosion at joints, internal pipe corrosion, and wire breaks. Intrusion of chlorides, sulfates, or CO_2 through concrete and into reinforcement or prestressing wires is also a major risk for PCCP.




Corrosion at joint and broken wires

PVC Pipe

PVC pipe is a common material used for force mains due to its low cost, ease of installation, and ability to resist corrosion. However, this material can fail due to bell failure, over-homing, excessive deflection, cyclic fatigue, or point load failure. PVC pipe failure is also often due to poor installation.

Broken PVC pipe

Metallic Pipe

The most common metallic pipe used on force mains includes cast iron, ductile iron, and steel. Cast iron pipe was essentially replaced with ductile iron pipe during the 1960s and 1970s. External corrosion is the primary risk for metallic pipe but it can also fail due to internal corrosion, joint failure, or in the case of cast iron, graphitization. Erosion corrosion can also be found in locations where gritty materials wear the invert and subject the direct metal to sulfide.


Corrosion in metal pipe wall

Asbestos Cement Pipe

While asbestos cement pipe is not currently used in new pipes, it has been used in the past for force main construction. This type of pipe can fail from carbonation (when dissolved CO_2 forms calcium carbonate, which further devolves and leaves the cement matrix), direct corrosion, or poor bedding.

Apply The Right Technology At The Right Time

Robust Data Gathering and a Phased Approach Promotes Flexibility

We can interpret assessment results in such a way as to develop a cost-effective force main rehabilitation and repair plan. A key feature of the program is to take a phased approach.

The phased approach considers:

"When" *condition assessment should occur.*

"Where" *it should occur.*

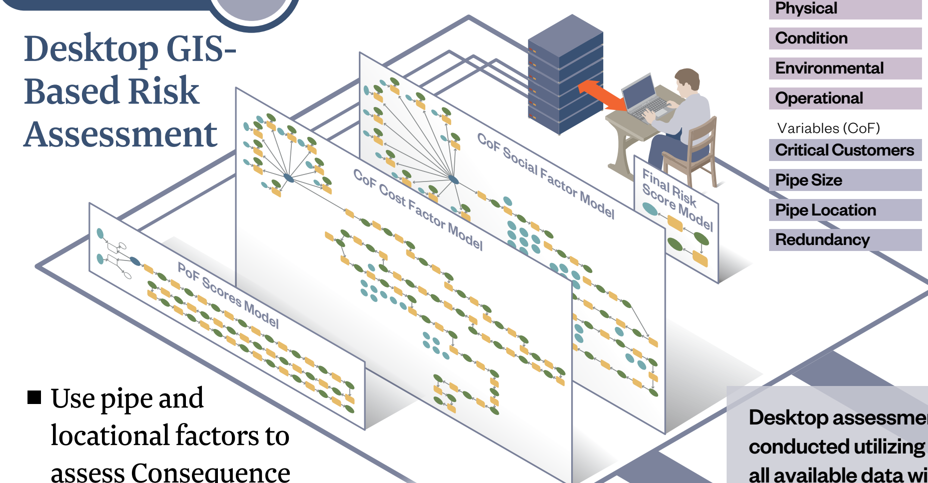
"What" *methods should be used.*

Gravity sewer assessments, by comparison, are always CCTV and/or multi-sensor inspection.

More on Proactive Approach to Corrosion Control

PHASE 1

Desktop GIS-Based Risk Assessment

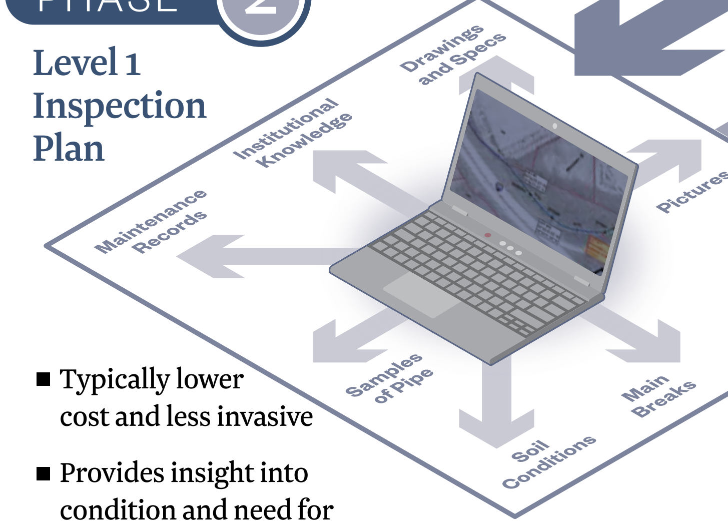


- Use pipe and locational factors to assess Consequence (CoF) and Likelihood of Failure (LoF)
- Use historical data
- Consider pipe vintage instead of just age
- Profile analysis critical

Desktop assessment conducted utilizing all available data will point to either a Level 1 or Level 2 Inspection Plan depending on many factors, such as criticality, access, and cost, as well as level of confidence in Phase 1.

PHASE 2

Level 1 Inspection Plan



- Typically lower cost and less invasive
- Provides insight into condition and need for more direct assessment

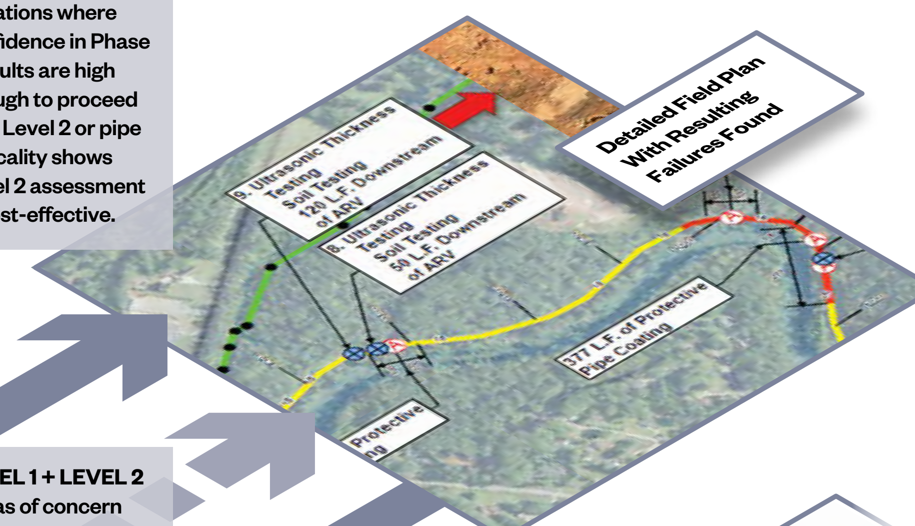
LEVEL 1 ONLY
Screening shows no likely significant defects to warrant additional scrutiny or provides sufficient data to inform extent of replacement.

LEVEL 1 - Indirect and/or screening level condition assessment techniques such as soil testing, pipe to soil potential, leak/gas pocket detection, acoustic/pressure wave.

LEVEL 2 - Direct thickness testing using ultrasonic thickness, eddy current, magnetic flux leakage, or coupon.

LEVEL 2 ONLY
Locations where confidence in Phase 1 results are high enough to proceed with Level 2 or pipe criticality shows Level 2 assessment is cost-effective.

LEVEL 1 + LEVEL 2
Areas of concern from Level 1 suggest performing a Level 2 assessment can cost-effectively locate extent of problems and refine asset renewal decisions.



PHASE 2

Level 2 Inspection Plan

- Higher cost
- More invasive
- Direct measurement with moderate to high resolution

INVESTMENT STRATEGIES

Determine Remaining Useful Life | Optimize Capital Investment

PHASE 3

Replacement

- Replace critical pipes
- Forecast long-term funding needs
- Refine risk model

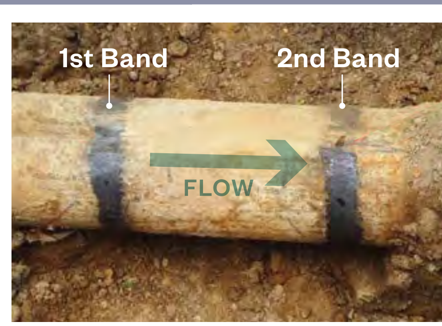
LONG-TERM FUNDING STRATEGY

Determine Funding Strategy | Build Asset Management Plan

WHY HAZEN? EXAMPLE

Bullitsville Force Main

Testing the 12-inch Bullitsville Force Main **cost less than $40,000** for condition assessment, including Pure Sahara followed by Ultrasonic Thickness testing.

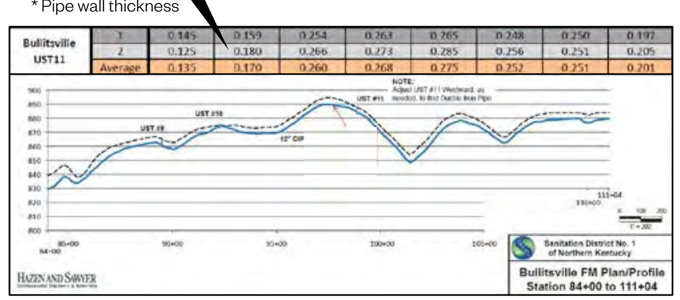


The condition assessment showed that overall the Force Main was in excellent condition and poor sections were replaced.

More Than 50% Loss*

The assessment findings resulted in **construction savings of more than $400,000.**

* Pipe wall thickness



A cost-effective Force Main condition assessment program begins by leveraging existing data and understanding local factors that impact pipeline condition. Appropriate technologies can then be applied to refine pipeline condition to better target limited asset renewal funding.

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AWARDS

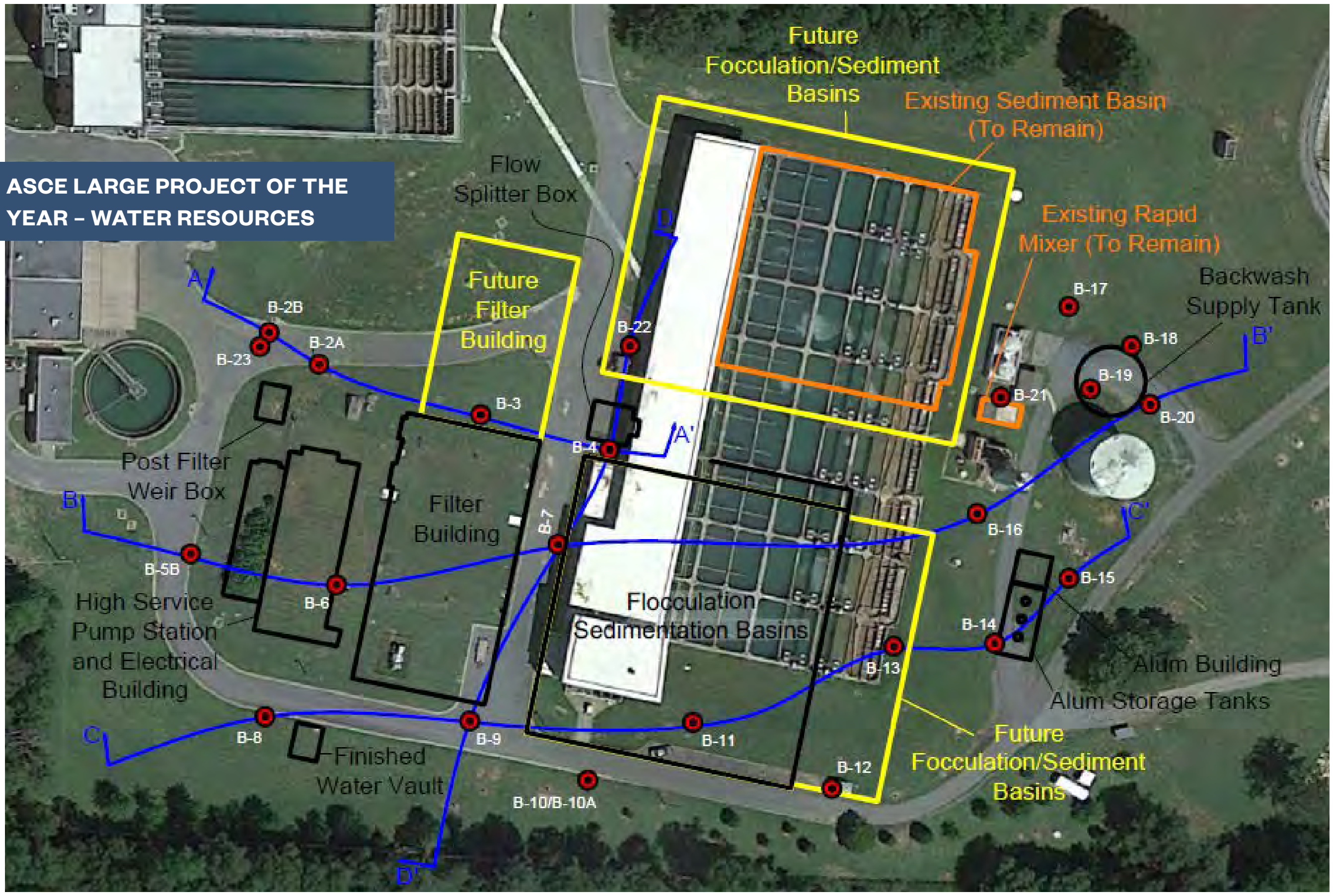
2019

NYC PUBLIC DESIGN COMMISSION SPECIAL RECOGNITION

The Bluebelt Program

The NYC Department of Environmental Protection pioneered the Bluebelt system over 20 years ago to manage stormwater runoff through natural drainage corridors including wetlands, ponds, and streams. These natural features are enhanced to better convey, store, and filter stormwater before it is discharged into the local waterway. This project pioneered the use of effective sediment and erosion control techniques in the NY metro area. A variety of stormwater BMPs were implemented, including extended detention ponds to attenuate storm flows and improve water quality, shallow marsh wetlands to filter out sediment and nutrients from stormwater, and outlet stilling basins to reduce water velocity prior to discharge into existing streams and drainage corridors.

ASCE LARGE PROJECT OF THE YEAR – WATER RESOURCES



James E. Quarles Water Treatment Plant 1 Replacement

This $71.8M project in Georgia to replace the original Plant No. 1 (constructed in 1952) is being constructed in the footprint of part of the original plant while maintaining adequate treatment capacity and water supply to customers. Hazen designed the new Quarles Plant No. 1, which includes innovative processes and structures that improve redundancy, reliability, and flexibility while considering those that will help meet current water quality goals and future anticipated regulatory requirements. It also addresses existing hydraulic limitations; replaces aging infrastructure and eliminates current vulnerabilities; and serves as a foundation for reliable capacity well into the future.

NYC PUBLIC DESIGN COMMISSION SPECIAL RECOGNITION

Gowanus Combined Sewer Overflow Facility and Open Space

Continuing the City's work to limit combined sewer overflows into the Gowanus Canal, this proposed 8-million-gallon underground tank and associated headhouse will intercept and store combined sewage during wet weather events. The 1.6-acre open space offers multipurpose passive recreation and a waterfront esplanade while allowing for maintenance access to the tanks below. To complement these subtle glimpses of the wastewater infrastructure, the headhouse affords visitors the opportunity to learn through digital graphics about the inner workings of the facility and the history of Gowanus.

2020

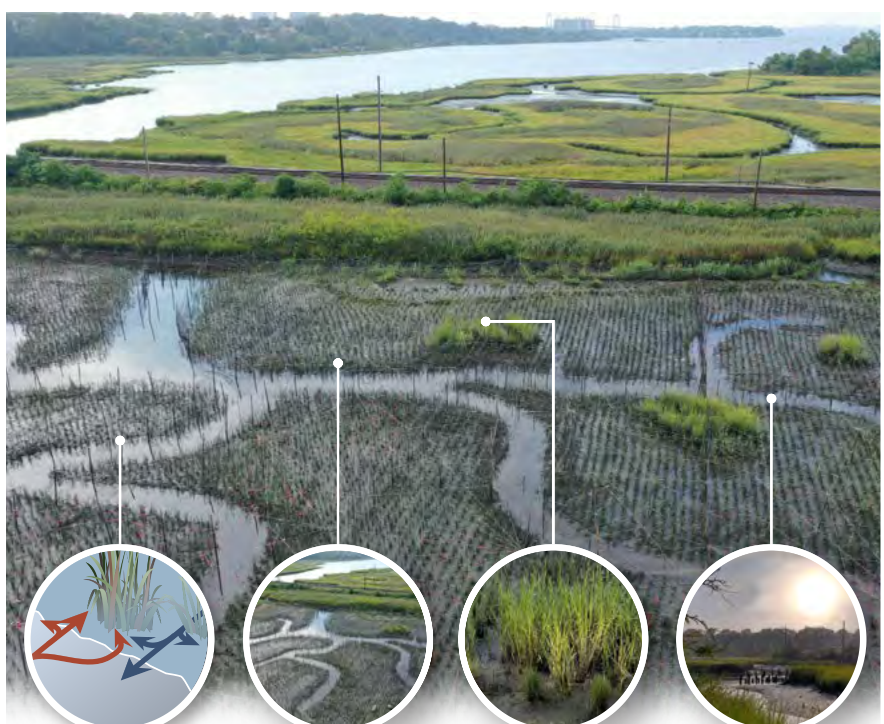
ACEC NY DIAMOND AWARD

The East Side Coastal Resiliency Project (ESCR) is the largest post-Sandy resiliency project in New York, and the first to be implemented within Manhattan. This $1.45 billion project involves construction of an integrated flood protection system for a 2.4-mile section of Manhattan. The Environmental Impact Statement and permitting team is leading a coordinated effort that balances a tiered environmental review (NEPA, SEQRA, CEQR) with regulatory and design implications under an aggressive schedule. There is no precedent for a project of this size and scope in New York City. Once completed, ESCR will serve as a model for the integration of coastal protection into livable spaces.

ACEC NY PLATINUM AWARD

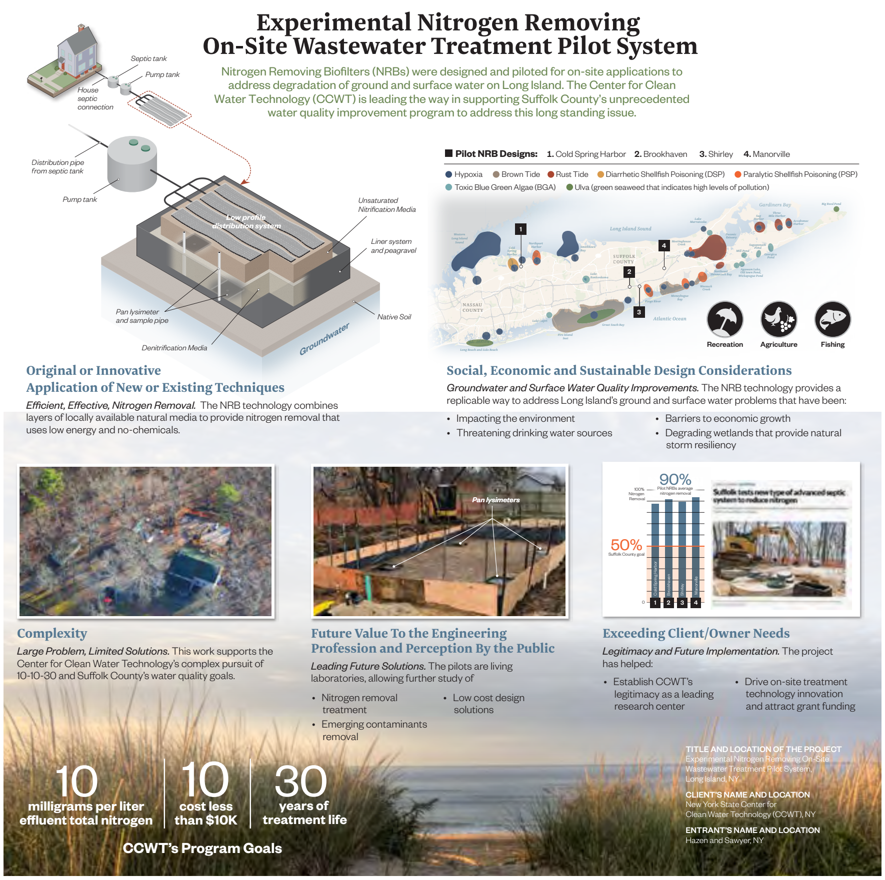
Alley Creek Tidal Wetland Restoration

The eastern shore of Alley Creek, a tributary of Little Neck Bay in Queens (NY), is the site of a first-of-its-kind wetland reconstruction providing year-round water quality improvements and mitigating the effects of a nearby combined sewer overflow (CSO) outfall. This pilot project uses progressively smaller sinuous tributaries to maximize contact time between incoming water and native wetland plant species, improving water quality by removing fecal coliform bacteria and increasing dissolved oxygen levels.



Tidal flows bring water into the system | Sinuous channels enhance contact | Bacteria attach to vegetation | UV light eliminates bacterial pollutants

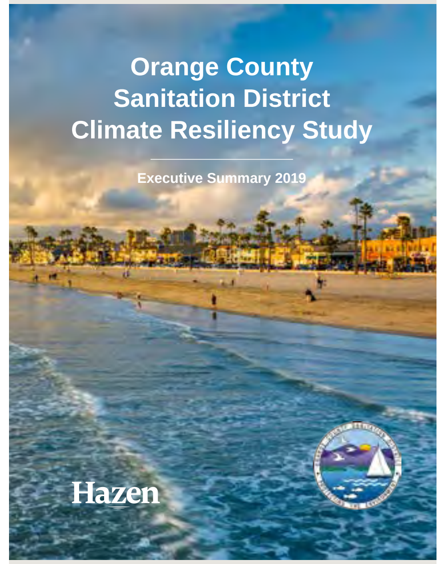
ACEC NY GOLD AWARD



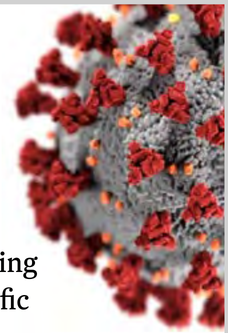
Experimental Nitrogen Removing On-site Wastewater Treatment Pilot System

Water quality in Suffolk County (NY) has plummeted over the last 40 years due to increasing nitrogen levels—causing issues in local lakes and coastal marine waters, threatening public safety, and restricting growth. This nitrogen increase is attributed to wastewater discharged from individual on-site wastewater treatment systems like the antiquated cesspools and septic systems found in 70% of Suffolk County homes. Hazen was selected to evaluate and pilot available on-site wastewater treatment technologies, resulting in five Nitrogen Removing Biofilters (NRBs) being designed and installed throughout the County as "living laboratories." The NRBs are low-energy, zero-chemical, low-cost, use local materials, and demonstrated an average of 90% nitrogen removal.

AAEES EXCELLENCE IN ENVIRONMENTAL ENGINEERING AND SCIENCE AWARD



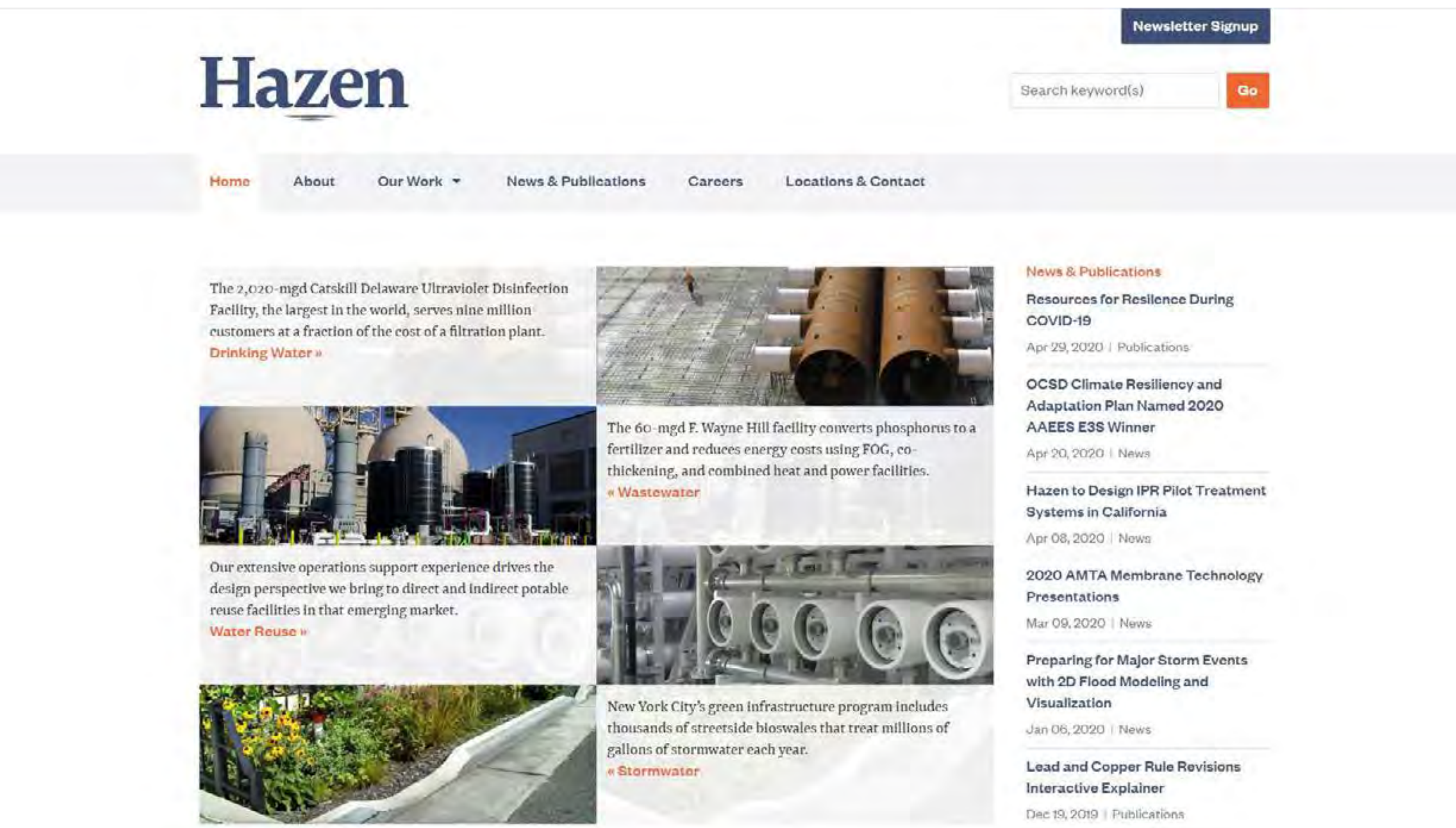
The OCSD Climate Resiliency and Adaptation Plan is one of the first projects in California, and Orange County specifically, to integrate the implications of climate change into improved design standards, emergency preparedness, and facility operations for the future. To develop the plan, Hazen worked with a multidisciplinary team at OCSD to develop innovative solutions while referencing the latest developments in climate science and emergency preparedness. OCSD conducted a study to assess and develop adaptations to mitigate the risks posed by climate change to facilities and operations. The study identified adaptations that would protect the highest value of assets while providing a high level of reliability at a reasonable cost, have minimal deployment requirements, and have the fewest impacts on operability.



The current public health crisis is something that we are all grappling with—as a company, as a country, and around the world. We realize that in this time of pandemic, there is tremendous uncertainty – uncertainty about the best way to maintain day-to-day facility operations, uncertainty about short- and medium-term utility operations, and uncertainty about long-term impacts on financial and strategic planning. This uncertainty coupled with the rapidly changing circumstances surrounding COVID-19 informed our decision not to feature any specific pandemic related pieces in this edition of Horizons.

Instead, we have collected our most up-to-date resources for facility staff, utility managers, and local governments on our website – essential information for essential employees. Please visit **hazenandsawyer.com/publications/resources-for-resilence-during-covid-19** for information about scenario planning, financial considerations, virtual site mapping and other tools, and lessons learned from our work over the past few months.

Stay well and stay safe.



HORIZONS
water environment solutions

On the Cover:
New England lake in summer.
–Photo by Ethan Daniels

Hazen