Intelligent Water Systems

THE CHALLENGE

As with other industries, newly developed technologies drive water utilities to adapt their day-to-day operations. Water networks have been a special focus, with new instrumentation options for water production, transmission, distribution, wastewater collection, and consumer end-points coming to market. Implementing these technologies can improve the efficiency and reliability of water networks, but with myriad options, utilities need guidance on which technologies are most worthwhile and how they should be implemented.

THE RESEARCH

The Water Research Foundation (WRF) advances science and innovation for the use and management of sensors, networks, and data to improve decision making and utility efficiency. Focuses include big data, the internet of things (IoT), analytics, and workforce skills needed to meet the demands of a digital future. Research improves the reliability of underlying physical water networks through better collection and analysis of, and action on, data from network events. Research strategies may include the use of real-time monitoring and automation, operational readiness, and network planning. WRF's Innovation Program also facilitates identification, testing, integration, deployment, and optimization of smart technologies.

In 2015, WRF recognized the emerging trend of intelligent water systems, and launched a research focus area on this topic, Defining Attributes and Demonstrating Benefits of Intelligent Distribution Systems. Projects funded in this area identify, evaluate, and communicate best practices for the application of advanced sensing technologies and networks to improve compliance strategies and efficiency of operations and watershed management. This research area builds on recent and current work by others and evaluates effectiveness of available and future technology and networks through demonstrations. This effort helps develop and maximize the capacity to use the vast amount of data generated to support water facilities as they transition to utilities of the future—improving the quality and services of drinking water and wastewater as well as ecosystem health.

Sensors and Meters

In the last few decades, online sensors have evolved into sophisticated units that can be integrated into computerized control systems and remotely monitored. As regulatory requirements increase and the potential for water system disruptions takes on greater importance, more utilities are relying on technologies like sensors and meters to optimize their treatment processes and prepare for and offset potential system risks. WRF research is advancing the science of technologies to monitor, collect, and transfer measurements in real-time—helping utilities proactively solve critical water problems.

Many utilities operating sanitary sewer and combined storm sewer systems are faced with water quality and quantity challenges related to collection system management.

These challenges are primarily related to the control of industrial/commercial wastewater inflows and wet weather flows that affect the viability of treatment and water reuse operations and the frequency/pollutant loading into the environment from system overflows. With the recent emergence of low-cost, reliable water quality and quantity sensors and the exponential increases in computing power, the promise of real-time monitoring and operation of collection systems to address these challenges is being realized. *Designing Sensor Networks and Locations on an Urban Sewershed Scale* (SENG6R16) identifies sensor technologies (both available and in use) through a survey, workshop, and interviews to develop use cases and IoT strategies for improving operations and management of urban sewersheds as background and preparation for demonstrations.

> **"As the North American water market transitions toward intelligent water systems, we are very excited to partner with WRF. Their outstanding research expertise will bring invaluable knowledge to our membership as we continue to promote critical discussions and cutting-edge research tools needed to advance the water sector."**
>
> **AMIR CAHN, EXECUTIVE DIRECTOR, THE SMART WATER NETWORKS FORUM**

Potable reuse of reclaimed water is typically achieved through multi-barrier treatment trains, consisting of technologies such as microfiltration, reverse osmosis, advanced oxidation, and/or granular activated carbon. To ensure efficacy of treatment, water quality must be evaluated in real-time to verify that these barriers are operating as designed, and to reassure communities that there are no adverse public health effects from using reclaimed water for potable purposes. *Monitoring for Reliability and Process Control of Potable Reuse Applications* (Reuse-11-01) develops an operations support tool that integrates sensors and data generated within the treatment process for immediate feedback and alerts. The tool integrates existing sensors as an early warning system for the treatment process to support real-time decision making.

A growing number of drinking water utilities are implementing advanced meter reading (AMR) and advanced metering infrastructure (AMI) to capture detailed, high-volume information from customer meters. With this expanded water usage information, utilities can better respond to customer billing questions, enforce policies for water usage and conservation, and better quantify and ultimately reduce the level of non-revenue water in their distribution systems. To realize these potential benefits, utilities need to clearly understand the improvement opportunities enabled by AMI data, and understand the need for new data processing and analysis tools. The ongoing WRF study, *AMI-Meter Data Analytics* (4741), is investigating how AMI data can maximize utility benefit by identifying strategies for AMI data analyses. Results will include a performance index to optimize meter maintenance and replacement strategies based on actual meter performance.

The American Water Works Association's 2017 *State of the Industry Report* cited deteriorating infrastructure as the top concern among utilities, and pressure has contributed to pipe failure in several studies. In several case studies, pressure reductions apparently correlated with reduced pipe breaks, and many times major pressure surges in a distribution system could be followed by a series of pipe breaks. Lowering pressure, consistent with water quality protection, may provide significant reductions in pipe breaks, leakage, and energy costs—and certain smart water technologies are applicable for measuring and managing pressure with the direct result of reduced water loss and less stress on pipes. A current WRF project is helping the water sector take advantage of these benefits—providing best practices for implementing smart water technology to manage pressure and flows in water distribution networks. *Utilizing Smart Water Networks to Manage Pressure and Flow for Reduction of Water Loss and Pipe Breaks* (4917) will lay out a step-by-step approach for planning, design, technology selection, and operations and maintenance to extend pipe life and reduce water loss.

Data and Security

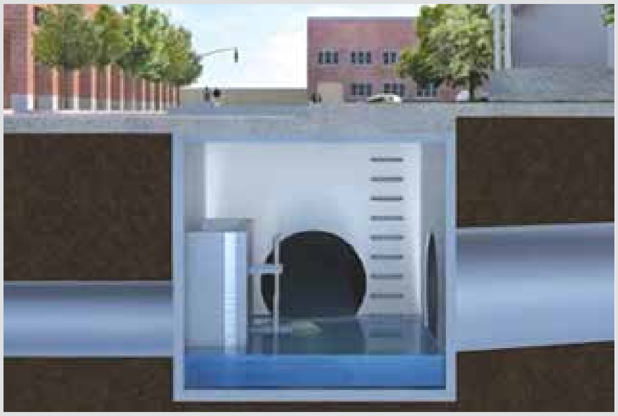
IoT technology and the need to process great amounts of data from multiple and often disparate sources are becoming very important in all industries, including the water and wastewater industry. Findings indicate that the water sector has not embraced big data analytics and IoT as rapidly as other industries. While utilities are collecting significant amounts of data, data quality is an issue that hampers data utilization. Generally, the technology solutions available address only single water industry uses. This leaves the onus on utilities to provide the integration capabilities when multiple applications are implemented. *Leveraging Other Industries—Big Data Management* (SENG7R16) captures the state of knowledge on IoT and big data processing in the water sector and key non-water sectors. This knowledge will help to improve operations efficiency, asset investment decisions, and regulatory compliance, while reducing environmental impact.

Today's water utilities utilize a wide range of information sources, including supervisory control and data acquisition (SCADA) systems, AMI/AMR systems, water quality monitoring systems, and security monitoring systems. Each of these information sources, along with the technologies used to transmit the associated data, has evolved largely

SOLUTIONS IN THE FIELD: Opti

In recent decades, more green solutions have made their way into traditional stormwater systems, but managing these decentralized approaches hasn't always been easy. Additionally, most of these systems are operated in a passive manner, which doesn't optimize their performance. In 2011, WRF launched an effort with EPA that would help change that. The program, Innovation and Research for Water Infrastructure for the 21st Century, provided resources to advance water technologies, opening the door for Geosyntec and University of Massachusetts researchers to evaluate new stormwater solutions that incorporated recent advances in computer hardware and software. Up until that point, few truly "smart" stormwater systems that involved active, real-time control had been attempted.

The research examined highly distributed real-time control (DRTC) technologies for green infrastructure, such as advanced rainwater harvesting systems, dynamically controlled green roofs, and controlled under-drained bioretention systems. By and large, testing was successful, showing that technologies could be robust, low cost, and flexible. Now, stormwater flows could be monitored remotely on internet-connected devices and controlled in real time—a dramatic step forward. Next, Geosyntec wanted to demonstrate that the DRTC technologies they developed could play a key role in managing urban infrastructure. Results from this research, published in the 2014 report, *Transforming Our*



***Cities: High-Performance Green Infrastructure* (INFR1R11), showed that technologies significantly lowered contributions to CSOs, reduced stormwater runoff, and retained stormwater for onsite use—helping to push the technology into full commercialization the same year.**

This led to the formation of the independent company, Opti, which focuses on delivering continuous monitoring and adaptive control solutions for stormwater applications. A second phase of research, through a partnership with LIFT (Leaders Innovation Forum for Technology, a joint WEF/WRF initiative), helped further accelerated this technology, demonstrating its use at scale. To date, the technology, a cloud-based platform for real-time monitoring and control of green stormwater infrastructure has more than 130 installations, combining sensors with internet-based weather forecasts to make decisions that could help prevent flooding or combined sewer overflows—like whether to release stored water prior to rain events.

independently. Utilities must deal with numerous communication platforms along with multiple communication protocols and cybersecurity measures. *Defining Optimum Security and Communication Methodologies for Intelligent Water Networks* (4670) inventories the different types of information sources currently being used by water utilities along with the associated communication media and protocols. The security risks associated with each information source and its communication approach were assessed, and it was determined whether the current cyber-security measures in use provide acceptable protection. In cases where the current measures appear inadequate, alternate approaches were recommended to improve security. An Intelligent Water Systems Matrix was developed to present general and security considerations for communication methodologies used by the most common information systems.

Workforce

The transition to an intelligent water system has obvious impacts on the utility labor force, eliminating functions like meter or other remote instrumentation reading, but adding other functions such as data interpretation. Utilities must prepare to meet employee training needs and attract workers to fill more skilled positions.

In addition to retraining the current water workforce, there is an urgent need to attract additional employees to this sector. Many of our infrastructure assets are in urgent need of repair or restoration, and the workers needed to carry out these efforts are in short supply. These challenges offer an enormous economic opportunity: the water sector is well positioned to offer more durable careers to a wide variety of workers.

In 2018, WRF partnered with the Metropolitan Policy Program at The Brookings Institution, who published *Renewing the Water Workforce: Improving Water Infrastructure and Creating a Pipeline to Opportunity* (4751). This research provides insight on the nation's 1.7M water workers, including data on wages, skills, and demographics. The report also presents actionable strategies—a new water workforce playbook—that all types of leaders can use in future hiring, training, and retention efforts.

An ongoing project, *Building Workforce Skills for Intelligent Water Operations* (4663) will help prepare utilities for anticipated workforce changes as they implement increased

automation and smart water technologies. The research team will examine changing job requirements and means of attracting and training new and existing workers to fill more skilled positions.

INNOVATION

Whether it's sensors, SCADA, asset management decision support tools, or geo-intelligence, LIFT's Intelligent Water Systems Challenge offers an exciting opportunity for students, professionals, and technology aficionados to showcase their talents and innovations, with a focus on leveraging data using the best available tools to help utilities better understand the dynamics of complex systems for making better decisions.

The LIFT Intelligent Water Systems Challenge asks participants to demonstrate the value of intelligent water systems to utilities, thereby fostering the adoption of smart water technologies. Winners of the 2019 Challenge City of Boulder, Colorado School of Mines, Baylor University, and Carollo Engineers.

WHAT'S NEXT?

As the water sector becomes more dependent on intelligent water systems and increasingly data driven, the need to manage and interpret this data will be critical. Big data, the IoT, machine learning, artificial intelligence, etc. are all associated with intelligent water systems. However, there is no coherent model, framework, or set of management practices and principles on what a data-driven or digital utility is. In 2019, WRF funded *Definition of Data-Driven Utility: How to be a Digital Utility and the Framework for an Intelligent Water System* (5039) to fill this gap.