In Focus:

Water Systems & The Digital Evolution

- Investment
- Digital Twin
- 5 Important Considerations
- Projects Advancing Infrastructure

Produced by WATER FINANCE & MANAGEMENT | Bentley Advancing Infrastructure

Table of Contents

Focus on Funding:
How Might Historic Federal Investment Affect the Water Industry's Tech Integration Push?

By Andrew Farr

Incorporating new technology into water and wastewater utility operations is nothing new. Like any other industry, it's an endless progression. More recently, however, digital monitoring systems and software have slowly increased in adoption. Experts often note that the slow pace of water utilities to adopt new processes and systems is common given the risk involved and a water utility's responsibility to public health and the environment.

Often coupled with this theme of digital technology implementation is the concept of holistic water management. That is, taking a system-wide approach to your water management strategy, implementing asset management plans that result in more effective asset performance, looking for opportunities for cost savings and being proactive about future capital planning. Utility systems are seeing the value in it and digital technology has a significant role to play.

For example, the Pojoaque Basin Regional Water System in Santa Fe County, New Mexico, collects water from the Rio Grande, pumps raw water to a treatment plant, and then distributes potable water to end users within five pueblos and other portions of the county. The Bureau of Reclamation was tasked with final design for Phase II of the project that included 88 miles of pipeline network with diameters ranging from 8 to 18 in.

With the use of Bentley Systems' WaterGEMS and HAMMER, two pipeline systems were designed within a single model and provided total design cost savings of approximately $1.2 million (USD) on the project. The cost savings were possible by saving time in developing pump station steady state including pump criteria and pipe sizing, optimizing losses and allowing gravity flow, analyzing fire flow for 594 demand nodes, sizing air chambers for each pump station, and developing 22 extended period scenarios for modeling.

Hydraulic modeling and analysis and in particular the use of digital twin is one innovation we'll explore in more detail throughout this eBook, but advancements have been made in a number of areas both in water/wastewater pipeline network management, as well as treatment plants.

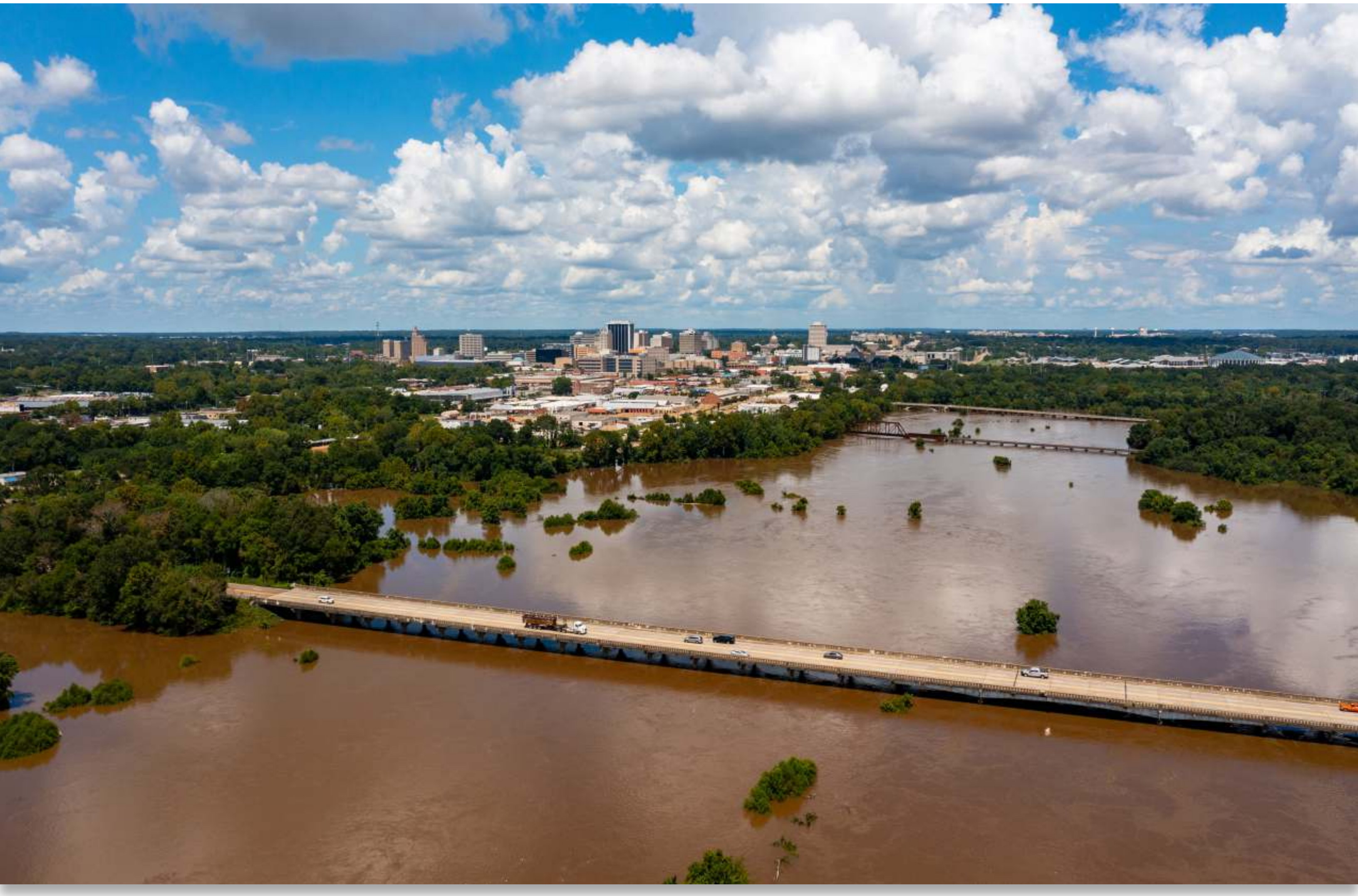
Metering, pipeline and flow monitoring, pressure monitoring, water quality and temperature monitoring, supervisory control and data acquisition (SCADA) systems for treatment plant monitoring and alerts, geographic information systems (GIS), and computerized maintenance management systems (CMMS) are just a handful of tools that utilities use that are becoming more "digitalized" and can help significantly with operational decision making.

According to water industry executives, the digital transformation in the water sector is accelerating. Utilities now are going beyond a single technology and looking for more comprehensive, integrated solutions such as AMI systems that connect smart meters and communications networks for remote meter reading, adding more applications over time to enable better operational and maintenance planning decisions and minimize risk.

It all happens at an interesting time for the water industry, especially in the United States where the utility sector is enjoying a boost from the federal government that it doesn't ordinarily get.

The Impact of Federal Investment

The Infrastructure Investment and Jobs Act (IIJA, or sometimes called Bipartisan Infrastructure Law), signed by President Joe Biden in November 2021, is providing roughly $55 billion in new spending for drinking and wastewater infrastructure. In addition, about $14 billion has already been appropriated for water projects from the American Rescue Plan Act, also passed in 2021.



The flooded Pearl River in Jackson, Mississippi, shown here in August 2022.

The majority of IIJA funds are being distributed through the U.S. EPA's Drinking Water and Clean Water State Revolving Fund loan program

According to EPA, the drinking water program gets about $30.7 billion (including $15 billion for replacing lead pipes) and the clean water program, which includes money for stormwater projects, gets about $12.7 billion. The remaining billions are distributed through programs that target specific problems or communities.

As explained in a recent overview by PolitiFact, allocation of IIJA funds has hit a few snags, including staffing shortages and lack of technical assistance at the state agencies distributing the funds.

In addition, the Drinking and Clean Water SRFs typically issue funding in the form of loans that local water systems have to pay back to the state. But under the IIJA, 49 percent of the new money must be awarded to disadvantaged communities as grants, not loans. The definition of disadvantaged community, along with many of the other rules and requirements, differ by state.

For example, in Mississippi, the City of Jackson would need special approval from the state for any water project loan exceeding $5 million.

Jackson, Mississippi, of course, is the epicenter of the latest high-profile water emergency when in late August, the flooding of the Pearl River caused low pressure at a major treatment plant and systemwide, resulting in no potable water for at least 150,000 residents for several days. Jackson was under a boil water advisory for two months and the city's mayor estimated it would cost more than $1 billion to fix problems with its distribution system.

Opportunities Exist Now

The water utility sector may still be at the beginning of its overall digital transformation. A 2021 report from Dodge Data & Analytics and Bentley Systems, *The Digital Capabilities of US Water Utilities SmartMarket Brief*, analyzed the readiness of the water market for digital transformation via a survey. Among the findings, 87 percent of water utility respondents said that they gather data digitally, and 90 percent said a challenge is that data is either isolated in disconnected IT systems, spreadsheets or paper records, which prevents effective operations and maintenance at their organization on occasion.

So, how does the continuing evolution of digital technology in the water industry tie in with increased federal funding? After all, if you work in industry, then you have likely heard all the commonly cited financial projections and know that money from the IIJA and other federal sources is a drop in the bucket compared to what is actually needed (the American Society of Civil Engineers estimates the funding gap for water and wastewater infrastructure could reach $434 billion by 2029). Do solutions providers and their utility customers stand to benefit from the new money coming into sector?

"Anytime you're talking about numbers that are in the billions, that gets a lot of attention," says Gregg Herrin, vice president of water infrastructure at Bentley Systems. "That does provide opportunities for utilities to take advantage of funding and apply it to projects that maybe they wouldn't otherwise have the money for.

"But the reality is, there are also thousands of smaller, individual events that happen every day that provide an opportunity for utilities ask, 'How could we have prevented this? How could we do this better? What would have made us more aware of this problem and how do we prioritize them?'"

As Herrin explains, regardless of how funding flows any given year, there are a number of issues and potential events that drive the needs of water and sewer utilities and their decisions on a much more localized basis than just big funding available at high levels.

This is where the digital aspect comes into play, he says.

"If you can use your digital tools and technologies in a way that helps you make all of those decisions better and helps you avoid risks, that's going to pay off in the long run regardless of whether funding is coming from a federal grant or your everyday ratepayer."

Andrew Farr is the managing editor of *Water Finance & Management*.

DC Water's Digital Twin Journey

Improving Operational and Financial Resilience Through Implementation of a Water Infrastructure Digital Twin

By Alireza Parhami, Paul West & Akshaya Niraula

DC Water distributes drinking water and collects and treats wastewater for more than 670,000 residents and 17.8 million annual visitors in the District of Columbia, and is committed to leveraging technology innovation to deliver high-quality services in an affordable, resilient, and environmentally friendly to its customers,

In July 2021, DC Water approved a new five-year strategic plan, Blueprint 2.0, to enhance its readiness and resilience. The plan will drive performance by leveraging technology to improve reliability, increase efficiency, reduce cost, drive innovation, and enhance the customer experience. As part of its strategic plan, DC Water sought to implement a real-time, cloud-managed water infrastructure "digital twin."

When it comes to the water distribution systems, there are too many moving parts. Pumps, tanks, system and boundary valves, coupled with unpredictable main breaks and power outages, have cascading effects on the delivery of reliable drinking water in a safe and resilient fashion The decision to pilot a digital twin, or a replica for the water distribution system, was because of the sheer size of DC Water's water network, the dynamic nature in terms of operational unknowns, and, at times, the physical unknowns, and to test the benefits that we could gain out of the implementation.

What is a Digital Twin?

A digital twin is a realistic and *dynamic* virtual representation of a physical asset, process, or system. Creating a digital twin for a water system involves integrating existing models and data. This could include engineering models (hydraulic models of the water network and 3D models of the water treatment plant and pumping stations), new virtual reality models (if 3D models are inadequate, outdated, or non-existent), and GIS, asset management and customer data. Additionally, digital twins are continuously updated with operational data from SCADA systems, sensors, meters, and other measured sources—creating a real-time model that can be used in operations and maintenance.

Seeking a Digital Twin

As cities and populations grow and systems face aging infrastructure, climate change, and ever-shifting challenges, utilities are turning to data and digitally integrated systems to help them better design, operate, and maintain these complex systems. They are measuring, capturing, and storing more data than ever before; however, data are typically locked into the system that created them and the departments that use them, resulting in siloed data repositories that are vastly underutilized.

For its pilot, DC Water selected Bentley's OpenFlows WaterSight to implement a digital twin that would help address these challenges by bringing together information technologies like GIS, asset data, operational technologies such as Maximo work order management, SCADA, and engineering applications like hydraulic simulation tools. The goal was to better mitigate service disruptions, reduce non-revenue water losses, leverage data to reduce operational and capital expenditures, and improve the overall level of customer service.

With an implemented digital twin, DC Water could more easily replicate the data from its enterprise systems in a managed cloud application database, where they could organize and scrub the data in near real-time and then configure operational applications—such as use cases—to address key operational challenges for water utilities. For example, a digital twin can help utilities understand pump and tank operational performance, automate non-revenue water audits by month or by pressure zone, or analyze and mitigate operational events—such as pump shutdowns or pipe breaks—using a browser-based SCADA integrated hydraulic model.

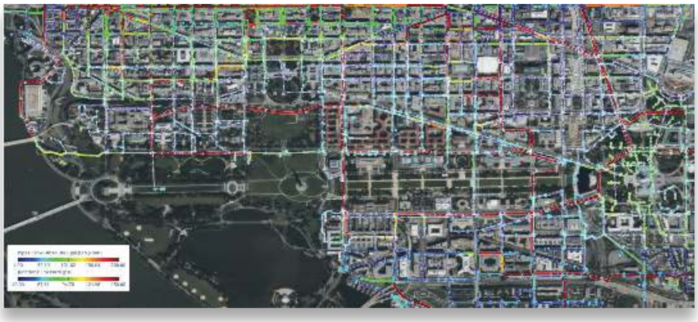
Deploying Digitalization Across the District

DC Water's digital twin journey started in mid-2020 with their distribution system and went "live" at the beginning of 2021 with Phase 1, or pre-enterprise-wide deployment phase, of the implementation process. The team identified four goals for this phase. The first was SCADA, which included sensor "health" monitoring and anomaly alert notification. The second was pumps with hydraulic performance visualization. The third was hydraulic model/SCADA integration to improve calibration and support other operational use cases. The fourth was pipe break response and mitigation, which included using an integrated browser-based hydraulic simulator.

DC Water began by looking at how the sensors are sending the data and looking for anomalies. They also observed the pump combination, especially when multiple pumps were running together. The team was interested in a hydraulic model conducted at a regular interval by feeding the SCADA data near real-time data, seeing how the system behaves or produces the result when both of those are combined. They also wanted to know how the application would help them be better prepared in an emergency.

With the goals defined and data collected, the implementation team worked to make the data available for cloud applications so they could do live simulations and other SCADA data-related activities. One of the key benefits of the water infrastructure digital twin is that the data output can be viewed in a browser-based application, making it accessible on any device by any authorized user.

With an implemented digital twin, DC Water can more easily replicate the data from its enterprise systems in a managed cloud application database.



The digital twin can also help utilities like DC Water better understand parameters like flow and pressure, shown here, and automate non-revenue water audits by month or by pressure zone.

Lessons Learned

DC Water is in the first phase of the implementation process. However, all functionalities of the water infrastructure digital twin that the team tested have been validated. By using a water digital twin, DC Water learned the importance of setting both immediate and long-term objectives. Their immediate goals included integrating and establishing the connectivity amongst all data sources and functions like monitoring pump efficiency. The web-based accessibility of the hydraulic model will allow staff in operations to observe system performance in real time, which is key as they typically do not have access to the actual hydraulic modeling tool. The water digital twin will allow them to view readily generated results or even simulate some "what if" scenarios to make informed decisions. Long-term objectivities include tracking water consumption, or comparing production versus consumption, which involves the integration of all AMR sources, AMR data, and complete access to all the pump productions and production sources.

The benefits of a water infrastructure digital twin are numerous for DC Water. The team will now be able to leverage all the data across all the enterprise applications and a common environment, where the data and analytics of the operational applications are more visible across the enterprise. They have the potential to reduce both operational and capital expenditures and non-revenue water losses. Perhaps most importantly, however, a digital twin can help them leverage and optimize investments in their enterprise software and tools to improve the customer's overall level of service, whether that is improving water quality, operating pressures, or just improving operational response.

As a forward-looking utility that considers implementing a digital twin as an essential business priority, DC Water knows that while data is crucial to the implementation, collaboration amongst stakeholders is key to success.

Alireza Parhami, P.E., is Sr. Hydraulic Modeling Lead, DC Water.

Paul West, P.E., is Senior Success Manager, Water, Bentley Systems.

Akshaya Niraula, P.E., is Principal Application Officer, Water, Bentley Systems.

5 Important Considerations

That Can Help Advance Your Water Utility's Digital Transformation

Water utilities have no shortage of data. In fact, they have many complicated enterprise systems and an increasing amount of operational IIoT data to manage. They face constant pressure to deal with their data effectively. However, some business challenges require in-depth insights that can only come from integrated data. As a result, there is an increasing need for water utilities to adapt new digital solutions to manage day-to-day operations and capital planning decisions.

So, what is the most effective way for utilities to leverage digital solutions to drive intelligent water asset management and capital planning decisions? Here are five important considerations that can help advance your water system's digital transformation.

1. **A digital journey can start at any point of an asset's lifecycle.** From planning to design to construction, including the operation and maintenance phase, there are many ways to leverage digital solutions. For example, by implementing water distribution system data integration and operational analytics, utilities can bring various critical data sources into a single environment. This provides a holistic view and insights of present, historic, and forecast performance for every asset within the system without the need to use different software or tools, which don't communicate with each other.

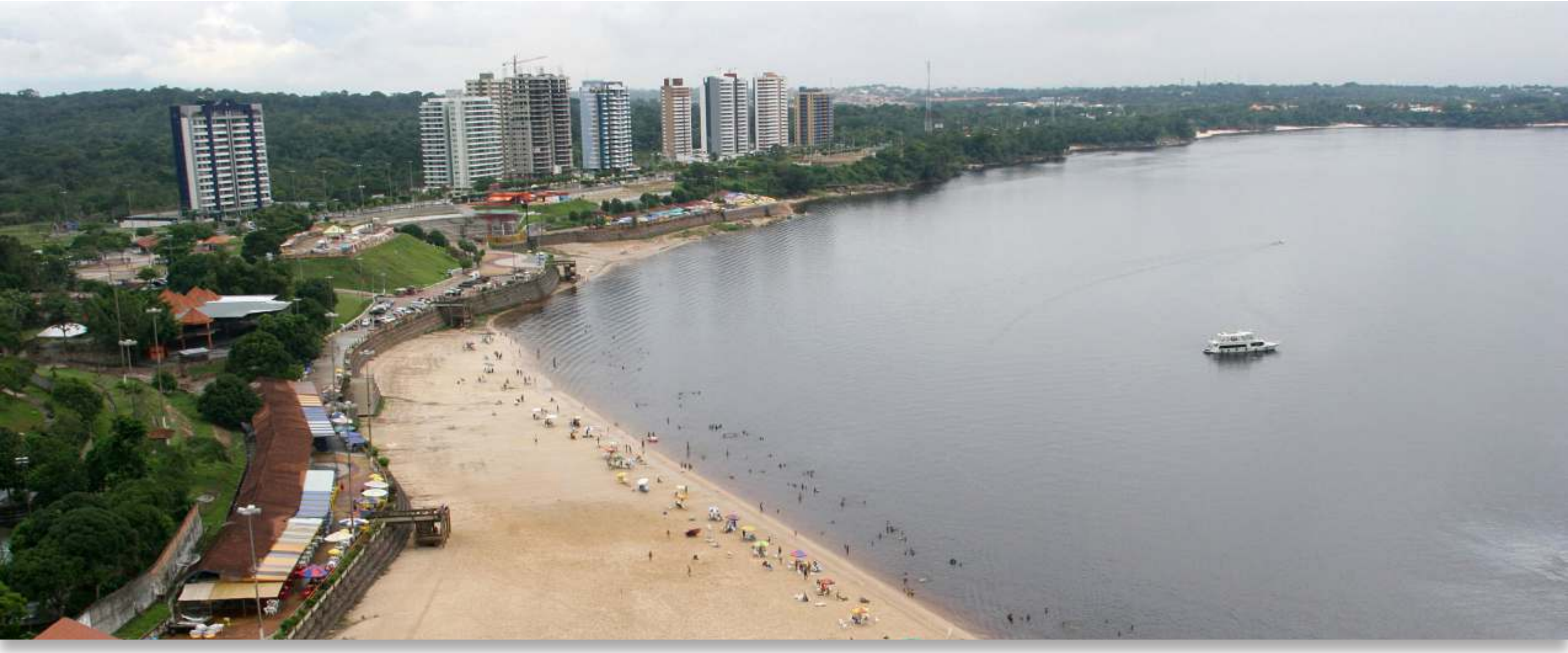
2. **Having a strategic vision. It is key to define the applications, the people, the processes, and data analytics that can create efficiencies, solve day-to-day problems, help your team, and improve the level of customer service.** There can be multiple enterprise software systems and databases that are integrated to provide operational digital solutions with analytics and key performance indicators. These may include anomaly detection, alert notification, pump, tank and water quality performance information, non-revenue water audit, real-time operational event model simulation capabilities, etc. A common mistake is to integrate certain enterprise data before first identifying and prioritizing the desired near-term and long-term business applications. Having a strategic vision will dramatically save your team time by integrating only the key datasets that align with the strategic plan.

3. **Understanding internal resources to implement and manage digital software solutions. It is important to know if you have the right resources to develop, deploy, and manage software solutions in-house.** Or, if you should maintain and improve your enterprise system data that is managed externally and provided as a Software as a Service (SaaS). One of the pros of in-house development is that the utility would have in-depth knowledge of its own infrastructure and systems, and this creates a lot of efficiencies. In most cases, however, the pros for utilizing an external vendor/SaaS far outweigh the pros of in-house options especially because many utilities lack the resources to manage a unified digital platform, and thus require external support and expertise.

4. **A digital solution must be flexible. The software should provide not only operational analytics and key performance indicators in the form of dashboards, but also allow the user to create custom dashboards and additional indicators and data visualization reports.** This will give the user flexibility. For example, you can run a hydraulic, real-time model, see the results, but you can also export that data to be used in offline modeling for further investigations and additional scenario analysis.

5. **A digital solution must be scalable.** Many water utilities already have a lot of digital components that operate their water infrastructure, including GIS, hydraulic model, SCADA, IIoT, or work order management systems. What is often not understood is how to integrate all data into a unified digital solution that can help solve everyday utility problems. A digital solution should be scalable without limitations in size or number of sensors. Utilities should be able to start small by testing a pilot area and then continue to build a complete system.

Every water utility has its own digital journey. The scalability of an effective digital solution allows you to make decisions and define priorities aligned with the organization's core values, but also in accordance with where it stands in its digital process.



Brazil's AEGEA Implements Digital Twin at Manaus' São Jorge District

Utility Works to Improve Leak Detection and Optimize Operational Workflows

AEGEA, one of Brazil's largest private water and sanitation companies, serves more than 21 million people in 153 cities across the country. Founded in 2010, the utility manages water infrastructure assets through full or partial common concessions, sub-concessions, and public-private partnerships (PPPs). The utility manages public concessions in the entire water cycle, including supply, collection, and sewage treatment, according to the profile and needs of each town.

"We play a fundamental role in supplying vital resources for the quality of life of millions of Brazilians," said Lais Regis Salvino, digital infrastructure engineer at AEGEA. "Our operations are guided by respect for society, the environment, and ethical principles. We are a transforming agent in the lives of people and the cities where we operate."

In 2021, AEGEA turned its attention to improving the quality of water services and asset management decisions in Manaus, the capital and largest city in the state of Amazonas. The utility initiated a pilot project in the district metered area of São Jorge, which serves 10,000 customers, to optimize operational activities and prevent pipe bursts. The pilot project included a 61.4 kilometer network with the goal of monitoring operations of the Manaus water supply system.

Searching for a Solution to Meet their Needs

Situated in the Amazon Rainforest and isolated from other main cities, Manaus' position and geography created a unique challenge for water providers. As a result, AEGEA needed to find a solution capable of remotely monitoring and analyzing Manaus' water systems. Such a system would also prevent them from having to conduct multiple site visits that lead to increased fuel and labor costs. Moreover, it would enable them to focus on predictive maintenance, which extends the operating life of the infrastructure and, in turn, reduces the resources required to keep it running safely and reliably.

"We can check the level of the tanks, the efficient point of our pumps, and determine if we have any leaks in our network before they turn into a problem."

—Lais Regis Salvino, Digital Infrastructure Engineer, AEGEA

Innovative Technology Establishes a Connected Data Environment

Using the application they created and curated a digital twin that brought SCADA, GIS, hydraulic modeling, and customer information into a connected data environment. With a digital twin, they could deliver cost-effective operations and maintenance strategies in real time. Because digital twins can be used at different scales OpenFlows WaterSight utilizes real-time data to create a model that continuously monitors all infrastructure assets, including pipes, pumps, valves, and tanks. The scalable environment provides utilities access to critical system and individual asset performance information to enhance operations, maintenance, and decision-making.

"Powered by a single water infrastructure digital twin, the application provides visibility of nonperforming assets or anomalous network conditions, as well as efficient analysis of present, historic, and forecasted performance for all assets," said Regis Salvino. "OpenFlows WaterSight also helps us uncover areas of improvement."

Leverage Hydraulic Models to Simulate Network Events

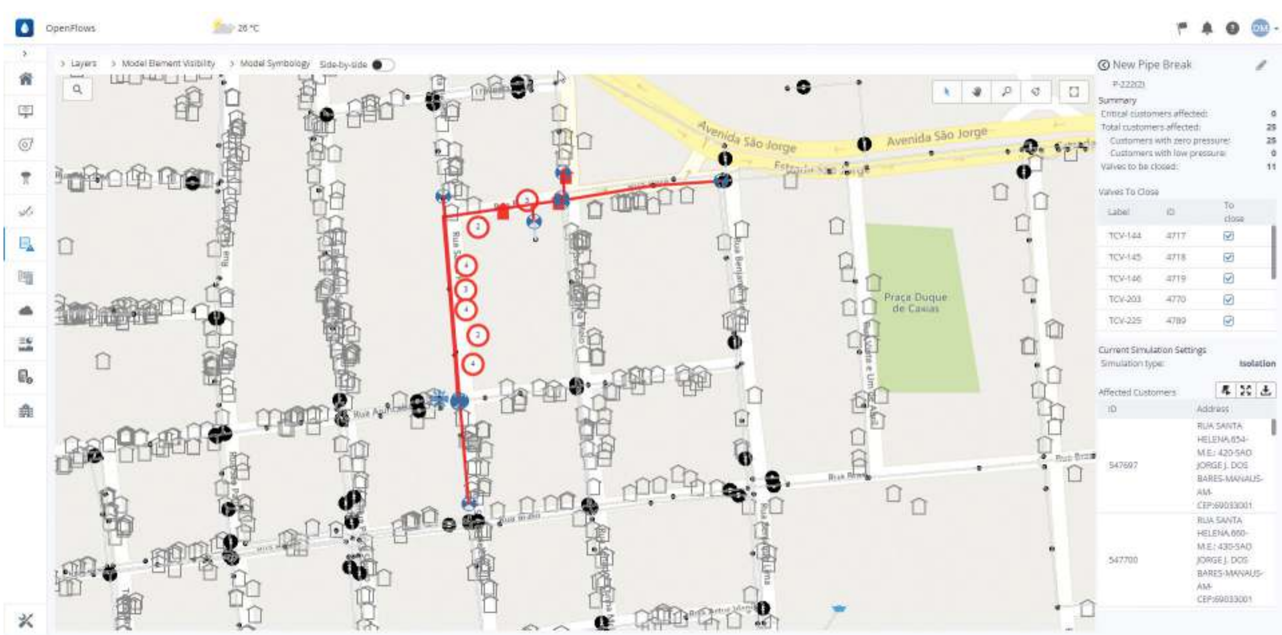
During system deployment, the Bentley support team assisted AEGEA during the first eight weeks after gaining access to the system's sensors, billing, and hydraulic modeling information. Two separate sensor databases were connected—one in Oracle and the other in SQL Server—pushing historical and live data with 15 minutes registration frequency, as well as enabling the pattern curve calculation for each. Some of the sensors provided important data that was used as boundary conditions for the hydraulic model, including the valve operational status, tank level, and input flow for each district metered area.

Hydraulic models were mainly used by the engineering department; however, AEGEA learned that by using OpenFlows WaterSight, they could easily and successfully leverage the engineering hydraulic models for daily operations and maintenance. The advantage here is that AEGEA can leverage the usage of an existing hydraulic model in WaterGEMS, import it to WaterSight's cloud, and use the data to run real-time simulation of network events such as pipe breaks, pump shutdowns, valves operations, and fires to better understand and anticipate the impacts on service levels. With these capabilities, operators can have a real-time hydraulic analysis of the entire network, covering the gaps between sensors data.

Analyzing Behavior for the Best Results

Using OpenFlows WaterSight enabled AEGEA to improve the system's efficiency by analyzing the system's behavior to determine the best way to operate it. Additionally, AEGEA set up alarms based on pattern curves to detect anomalies in the system to track active leakage events.

Furthermore, the deployment of the water infrastructure digital twin at Manaus' São Jorge district effectively integrated all data stored in the different systems into one single platform, providing the utility additional insights, including water balances, tank performance, forecasts, among other insights. As a result, AEGEA could see the behavior of their systems with real data, as well as improve operational workflows to determine how to best manage their operations. In addition, AEGEA reduced awareness and response times to



AEGEA can leverage its existing hydraulic model in WaterGEMS, import it to WaterSight's cloud and use the data to run real-time simulations of network events such as pipe breaks, pump shutdowns, valve operations and fires to better understand and anticipate the impacts on service.

> *The digital twin also integrates all data stored in the different systems into one single platform.*

network events with the support of real-time simulation and automatic events generation capabilities.

"Bentley OpenFlows digital twin solutions allow us to improve our system. With digital twins, we can analyze the behavior of our systems with real data and determine the best way to operate them. We can check the level of the tanks, and determine if we have any leaks in our network before they become a problem," Regis Salvino said. "Bentley's support was critical to the success of this project and to AEGEA's commitment to transform the lives of people and the cities where we operate."

For more information about Bentley OpenFlows WaterSight, visit Predictive Operational Intelligence for Water & Wastewater Networks | Bentley

Project Summary

Organization: AEGEA

Solution: Water

Location: Manaus, Brazil

Project Objective:

- To integrate all data stored across different systems into one single platform.
- To improve leak detection, asset management decisions and optimize operational workflows.

Fast Facts:

- AEGEA is one of Brazil's largest private water and sanitation companies, serving over 21 million people in 153 cities.
- AEGEA wanted to improve the quality of water services and asset management in Manaus, the capital and largest city in Amazonas.
- The utility initiated a pilot project in São Jorge to optimize operational activities and prevent pipe bursts.

ROI:

- The deployment of the infrastructure digital twin at São Jorge integrated all data stored in the different systems into one single platform.
- OpenFlows WaterSight reduced awareness and response times to network events with real-time simulation and automatic events generation capabilities.

Products Used: OpenFlows WaterSight