



# Transforming *global water* challenges using *innovative solutions*



Aligned with the 2023 World Water Week's theme *Seeds of Change: Innovative Solutions for a Water-Wise World*, we all are encouraged to rethink how we manage water as individuals and as a society. With climate change posing the potential for more frequent and costly weather events, innovative adaptation measures are critical for minimizing their impacts on communities and improving the preservation of this precious resource.

Digital technologies such as virtual and digital twins, are advancing the development of sustainable water systems, relying on effective data management systems that guide decision-making from planning up to construction and operations. This results in not only reducing water waste but also making water supply go further. On the flood resilience front, cutting-edge digital tools are enabling communities to see substantial impacts flood mitigation solutions can provide. Harnessing the power of AI will also help take one step further in shaping more resilient water infrastructure.

We are pleased to offer WSP water insights on how to leverage technological innovations to help communities be more resilient and water utilities be more proactive in their operations.

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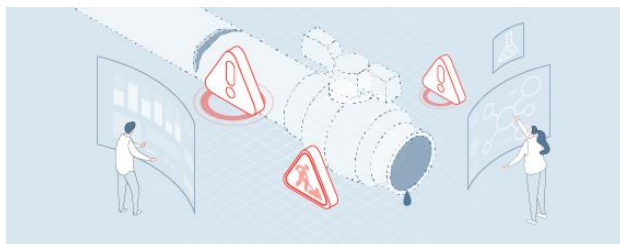


# DIGITAL TWIN: YOUR ESSENTIAL PARTNER IN WATER MANAGEMENT

Virtual replicas equip utilities to proactively manage and improve water systems.

Today, digital technologies are advancing the development of sustainable water systems. Data-driven solutions facilitate efficient management of operations, prevention of problems and quick response to issues. These capabilities are especially important at this point in time, as the world's water supply is under great pressure from overexploitation of groundwater, rising demand from industries and growing populations, polluted sources, and climate change. Government policy, investment in less water-intensive industrial processes, and reduced domestic water use are among the key factors that can help safeguard water resources. Water management is another.

To help manage their water-supply operations and improve system performance, water utilities are making use of digital twins. These virtual replicas of physical assets build on effective data management, utilizing real-time data to create a shared holistic perspective of assets and enable optimization of processes through informed and timely decision making.



In the following Q&A and related case studies, WSP hydraulic modelling experts provide insight into how digital twin technologies help water-system professionals make the best decisions—to run water systems efficiently, minimizing waste and maximizing supply of water for communities.

Jean-Luc Daviau explores a “faster” digital twin for the water supply system from Toronto to York Region in Canada, and Thomas Johansson discusses real-time modelling in the Linköping water supply network in Sweden.

## What is a digital twin?

A digital twin is a virtual replica of an asset that incorporates associated real-time data during operation of that asset. It provides an immersive and integrated visualization of previously siloed information and enables use of modern digital analysis techniques, such as condition-based monitoring and predictive analysis, to plan for the continued functioning of infrastructure.

## What value do digital twins bring to water system planning and operations?

**Thomas Johansson:** Real-time understanding gained through a digital twin makes for the right decisions in a timely way. Having an accurate and a completely detailed digital twin of a water network, linked to SCADA [Supervisory Control And Data Acquisition], enables operators and engineers to consider the entire water supply system when they plan upgrades, assess the best way to repair or improve the system, and respond to unusual situations.

Using a digital twin over a water supply network also offers the opportunity to train people to work with the system in the most effective way, testing measures and solutions in the model before committing them to reality. Because the digital

twin can display real-world measurements with corresponding simulation results, utility staff can develop a high degree of confidence in the tool. A digital twin can help optimize pump schedules and material and energy use related to pipe repair or upgrades. In turn, these enhanced choices reduce costs as well as the utility's carbon footprint.

Digital twins help water utility operators:

- Test new equipment or control sequences virtually, without risk to real-world operations.
- Quickly determine possible solutions before going to the site physically: a safer response.
- Collaborate across engineering, planning and operations for better and faster decisions (leveraged by outside consulting, contracting and test services).
- Train to work with the system in the most effective and safe way possible: compile and display the valuable data they collect for optimal system performance; and visualize and animate time-dependent operations, such as reservoir cycling or transient pressure travel.
- Predict the future using data analytics and computer model simulations for planning (what-if scenarios), to respond intelligently to pipe breaks and to handle crises (resilience).

### ***How would you compare the digital twins for the Swedish and Canadian water systems?***

**Jean-Luc Daviau:** Digital twins are all about supporting utilities and their operators. The

digital twin achieved in Linköping, Sweden provides real-time, detailed decision support to engineers and operators as they tackle real-world water supply challenges. It's inspiring to know it was done and is now in use. For the Toronto and York Region systems in Canada, we aspire to predict long-term, cumulative wear-and-tear using the systems' digital twins. Both day-to-day operations and emergency management have a role to play in water management.

**Thomas Johansson:** The digital twins for the Swedish and Canadian systems use different sensors and solution algorithms. The Linköping model can self-generate and solves flows and pressures every 10 minutes to predict gradual changes in the water network; the data in the Toronto and York Region models change monthly or yearly, but the "faster" digital twin can predict changes in the network from gradual to nearly instantaneous. For example, valve closure simulations support an operator's most frequent emergency response, which is to isolate an area with a break. Right now, in the Linköping model, we can gauge how pressures and storage levels respond to valve closures but without the transient pressure waves.

### ***How then can a "faster" digital twin change the way water utilities carry out their operations?***

**Jean-Luc Daviau:** While many emergency scenarios such as power failures can be predicted ahead of time, the same is not true of the best way to respond to a pipe break or fire that can occur anywhere.

Networks are a heterogeneous fabric of pipes that have "folds" due to topography, "cuts" due to rail or highway corridors, and "strings" that link distant parts via tunnels or transmission mains. Disturbing any point of this surface affects the entire system in ways that are hard to predict.

A digital twin allows operators to isolate the area by closing water valves, and the model can also generate a list of the impacted customers. This can be done today using a geographic information system [GIS] framework and reasonably detailed hydraulic models. A “faster” digital twin can do the same while also indicating the fastest safe speeds or sequence to close these valves or fire hydrants, to avoid causing wear-and-tear—or another break elsewhere. Gaining such insight requires consideration of every pipe and the dynamic equipment parameters that represent a system’s response to fast events, both of which are available through a hydraulic transient (“faster”) model.

Digital twins require GIS and SCADA links but benefit most from large-scale IoT sensors and cloud-based data to store, process and serve-up, hundreds of times, the pressure and flow measurement data. Of course, faster pressure sensors are also needed for a “faster” twin. The faster computers and high-speed sensors we have today enable us to use a “faster” digital twin to tackle transient event simulation with a high level of detail, just like we do for everyday events across entire water systems.

There are two key concepts to get across to engineers and system operators as they look toward the future: Number one, a system’s response time increases with size, making it more vulnerable to changes in flow or pressure; the same pump stop can be tolerable one year and problematic 10 years later. Number two, transient mishaps can wreak havoc within systems. Picture a dam break; it’s fast and destructive, but it is visible. Liberating that kind of energy underground would present immense challenges in terms of response, containment and resolution. With the right tools, utilities and their operators can prevent major issues and more effectively manage problems when they arise.

## Case Studies

### **Linköping Water Supply Network, Real-time Modelling – Sweden**

#### **Client: Tekniska Verken AB**

Tekniska Verken AB is the municipality-owned company in the municipality of Linköping, Sweden that serves the Linköping area: 1,568 km<sup>2</sup> with a population of 163, 000.

Tekniska Verken contacted WSP some years ago and asked for help to update an old hydraulic model over the water supply network. The aim was also to start the work toward establishing an online model for the network, continually fed with data from the SCADA system (Supervisory Control And Data Acquisition) system. WSP’s part in the project was to build the model and connect it to the SCADA system, help Tekniska Verken to carry out capacity studies, and train those working in the system so that they now run the system themselves.

Tekniska Verken had a growing need for an updated hydraulic model due to extensive growth in the municipality with a lot of new housing and industry areas. A growing population calls for the ability to carry out accurate capacity studies and to optimize all assets as well as system performance in an aging water supply network. Optimization includes identifying problems—such as those related to pressure, leaking pipes and water quality—and underperforming areas.

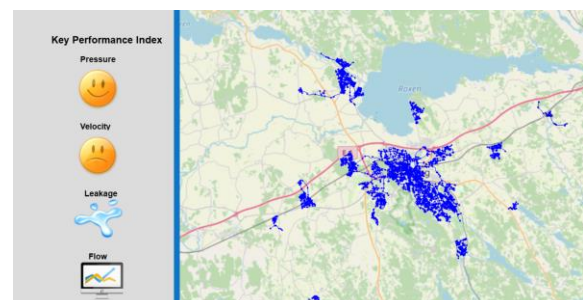


Figure 1 – Simplified overview of the real-time model of the Linköping area

The digital twin model has been instrumental in managing and operating the layers of water-related infrastructure—including booster stations and associated pipe networks, storage tanks and treatment facilities—thereby providing ongoing support for the proper functioning of the network. In addition to capacity studies, the digital twin has facilitated general studies of the network, hydraulic design of new areas, identification of operational issues, and support when redimensioning/relining the existing network.

The model is built directly from the geographic information system and the customer consumption system. When the data regarding flow, pipe pressure and reservoir levels is collected from the SCADA system, via the database, a simulation of the entire network is performed automatically. In that way, Tekniska Verken gets a new overview with actual data every 10 minutes 24/7.<sup>1</sup> The data provides a base to identify, examine and correct current problems before they become major issues. All the used SCADA data is stored, so it can also be applied to perform historical simulations; studying occurrences in the past supports proactive maintenance in the water supply system, to prevent reoccurrence.

The water supply systems of today are very complex with multiple points of operation and interconnectivity; the original systems were not designed for subsequent additions. Having a digital twin model over the water supply network is a natural step for Tekniska Verken in their task to run the system efficiently and continue to support community water needs.

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<sup>1</sup> The time interval is influenced by the complexity of the model.

<sup>2</sup> Digital twins use sensors and 3D models to mirror system performance in real-time (or nearly so). A “faster” digital twin does the same for transient events that occur up to 1000 times faster and risk damaging systems. Hydraulic transient states typically occur upon power failure, resulting in pumps

## ***A “Faster” Digital Twin for the Water Supply from the City of Toronto to York Region - Canada***

**Clients: Toronto Water and the Regional Municipality of York (York Region)**

Toronto Water is a division of the City of Toronto that operates a water supply system from Lake Ontario northward to supply York Region in Ontario, Canada. The dozens of pump stations and large transmission networks in both systems serve 4 million residents across 2,400 km<sup>2</sup>.

Toronto and York Region both recognized that utilities must pay close attention to hydraulic transients<sup>2</sup> due to the higher frequency of leaks and breaks in aging infrastructure. At scale, “water hammer,” a type of hydraulic shock, either causes catastrophic failures or continuous and significant deterioration of infrastructure, reducing its life expectancy and driving-up staff and repair costs.

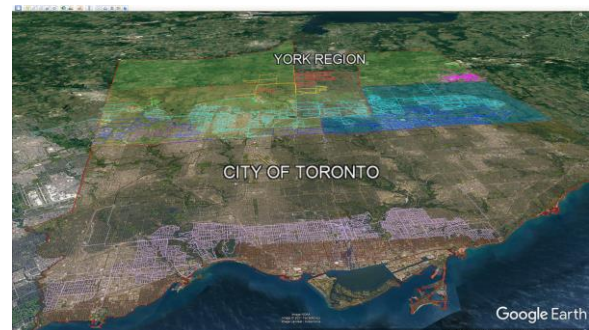


Figure 2 - South Toronto and South York Region Hydraulic Transient Models

To manage water supply risks, the WSP team<sup>3</sup> updated these water systems’ hydraulic models and related pressure measurements to match

kicking-off and eventually re-starting, ultimately to return the system to its “normal” operation. Transient model software simulates such events and is able to account for the compressibility of water, special valves and surge control equipment.

<sup>3</sup> WSP was the lead consultant, with HydraTek as sub-consultant.

24/7 performance. The tests used existing SCADA (Supervisory Control And Data Acquisition) system sensors, supplemented with transient pressure sensors that recorded data at 1/100s intervals to collect real-world dynamic responses to power failures. These IoT (internet of things) sensors and web interfaces help calibrate the models in an operational sense—with the goal of supporting preventative maintenance and reducing the frequency of pipe breaks and the extent of emergency road closures for repairs.

When WSP created the original technology inside HAMMER software 20 years ago, the software's core code allowed for massive increases in computer power that would eventually enable simulations of systems with hundreds of pipes. The Toronto and York Region system models have tens of thousands of pipes that are solved for transient flow and pressure equations using 3/1000s time increments; however, it takes several hours or days to simulate a transient event that lasts just minutes in the real world. These simulations are useful now to manage risks and control pumps. As computing and sensors evolve, there will come a day when even such large systems can be simulated in real time for transient events—a capability currently available only for simpler pipelines or high-risk nuclear systems.

The “faster” digital twin (transient) models and sensors now enable risks to be managed effectively across large, complex networks because the interactions caused by pressure waves travelling at the speed of sound can be accurately measured, simulated and therefore controlled. For the Toronto and York Region systems, over 300 transient scenarios were simulated to quantify and reduce risks arising from emergency conditions, such as power failures, control valve mishaps, or hydrant flow starts/stops during fires. The resulting extremely high and low transient pressures simulated across the system were correlated to pipe-break

data and mapped to highlight areas with the highest risk.

Without such tools, simpler and conservative predictions drive up capital and operating costs because engineers cannot quantify the extent to which the network is its own protection, as loops can split and dissipate transient energy.

The updated and improved models are now information assets that will be maintained by the in-house hydraulic engineers at Toronto Water and York Region and used to answer operational questions such as how to respond to pipe breaks, special events or changes in demand (such as during COVID-19) and how to grow the system. Over the next few years, the models will also “grow” and connect, forming a single model, so that the large-scale system can be truly represented at the highest accuracy to pinpoint problem areas.

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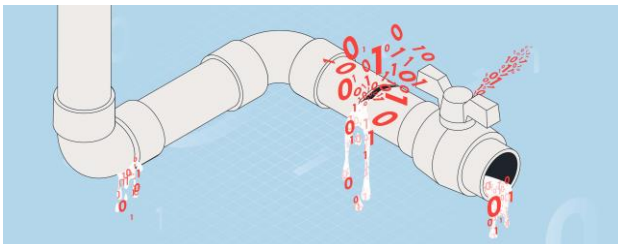
# FOCUSING DATA ON SUSTAINABLE WATER DELIVERY

Accomplishing more with less to meet essential human needs and preserve water resources worldwide

Well-run water-system infrastructure is critical to supplying water to communities. However, sustainable provision of water is increasingly jeopardized by aging pipelines as well as excessive consumption, the effects of climate change and a growing and shifting global population.

Circa 70 percent of the Earth is covered in water, but only about 3 percent is freshwater, and less than 1 percent of that amount is available for human use.<sup>1</sup> Uneven distribution and polluted sources where supply is severely limited further strain the ability to meet the needs of humanity.

According to the United Nations, water scarcity can mean scarcity in availability due to physical shortage, or scarcity in access due to the failure of institutions to ensure a regular supply, or scarcity due to a lack of adequate infrastructure.<sup>2</sup> Water scarcity is a pressing and complex issue that water utility operators can help address through data management. Effective data management optimizes operational decision making in the treatment of water, and wastewater, and the distribution of water for diverse purposes, including drinking, bathing, and use by industries and in agriculture.



In the following Q&A, WSP experts discuss how data, digitization and intelligent software jointly provide promising opportunities for utility operators to make supply go further.

WSP experts: Matthew Gallagher, Director of Technology, Digital, Australia; David Rawlinson, Lead Data Scientist, Australia; Anna Dahlman Petri, Senior Water Advisor, Sweden; and Morten Engedal Sørensen, Business Development Manager, Informatics, Denmark.

## ***What are the key points to understand about effective data management?***

**David Rawlinson:** Data management encompasses many different aspects of data, including how it is collected, stored, shared and used. Different technologies suit different situations, and for data management to be effective, the right tools must be used for each job.

Increasingly, cloud infrastructure enables multiple databases to be part of a single “picture,” drawing from many sources. Using accurate and timely data as the basis for a wide range of decisions is a key quality of a digitally mature organization. This is harder than it sounds, because the various data sources were until recently not easily available to decision-makers. Digitization and database projects aim to fix this issue by bringing all the data together to create a “single source of truth”—a coherent picture for all users.

<sup>1</sup> [NGWA, The Groundwater Association](#)

<sup>2</sup> [United Nations, Water Scarcity](#)

Creating a single, coherent view of data is one of the first prerequisites for projects involving artificial intelligence [AI] and machine learning [ML], as these technologies often draw on data throughout an organization. Frequently, this view creates an immediate and valuable return on investment even before any smart algorithms have been written, simply because of the increased agility for sharing and integrating timely data from various sources.

Typically, a water network operator will use a variety of technologies to complete their digitization strategy. A collection of databases and other sources is known as a data “warehouse”; the term conveys the heterogenous nature of the contents. Although relational databases manage data integrity internally, data integrity is usually an application-layer concern in a data warehouse. Often, databases in a warehouse are replicas of standalone legacy databases that have been brought into the warehouse to provide a single point of access.

A data “lake” differs from a warehouse in that it tends to capture large quantities of less structured raw data, such as timeseries measurements or documents. These might be stored in newer “No-SQL”<sup>3</sup> databases that offer higher performance but fewer guarantees, such as referential integrity and consistency.

Creating and maintaining a clear understanding of the relations between data in different databases is a crucial ongoing task of data management.

**Anna Dahlman Petri:** Whatever the technologies used, an effective database must be in equal measure updated, accurate and

accessible. These three elements can turn a database from a static list into a tool that can be relied on, even in pressured, time-critical situations. Accurate and detailed data is also, of course, the starting point for a digital twin.<sup>4</sup> By supplying modelling software with live data regarding pressure, flow and demand at key points throughout the water network, the operator can simulate in real-time the impact of changes in conditions throughout the water system. This aids in making the best decisions in daily operations and allows utilities to identify and even predict and prevent unwanted events, such as a supply shortage, a pipe break or contamination event.

**Morten Engedal Sørensen:** To effectively manage and use data for optimizing water systems, the fundamental design of the data model infrastructure is important. The data model used is usually developed in computer aided design systems (CAD). Securing a strong data model is the starting point for effective asset management; a strong data model sets the fundamental rules and logic related to the system water flow.

A digital twin then enables utilities to efficiently manage data concerning the water flow. Data from SCADA, IOT and other surrounding applications can be stored in a structured form as a homogeneous data set and applied to the digital twin. This process ultimately brings about transparency by collecting and displaying the same data to all stakeholders involved in operating the system; it also enhances the usage of artificial intelligence and machine learning.

For a utility company to be able to address current and future challenges, access to high-

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<sup>3</sup> SQL: Structured Query Language

<sup>4</sup> A digital twin is a virtual replica of an asset that incorporates associated real-time data during operation of that asset. It provides an immersive and integrated

visualization of previously siloed information and enables use of modern digital analysis techniques, such as condition-based monitoring and predictive analysis, to plan for the continued functioning of infrastructure. See “[Digital Twins Contribute to Infrastructure Resilience](#),” [wsp.com](#)

quality data is crucial. A digital twin equips utilities with the accurate and timely information needed to make decisions and take actions that address urgent issues and prevent future ones from arising.

On the way to the customer's tap, many water utilities are losing an estimated 20% to 35% of the fresh, treated drinking water they produce.

Source: Nickel Institute <sup>5</sup>

***Can you further explore how data management and high-quality data help water utilities address system challenges such as waste?***

**David Rawlinson:** When demand increases but supply is constrained, attention naturally turns to being more careful about waste, such as transmission losses. This means that we need to measure more carefully and pay better attention to anomalies and trends to find and prevent losses. Accurate and detailed data can reduce waste and improve efficiency.

**Anna Dahlman Petri:** In order to reduce waste, it is necessary to see where waste is occurring or where it is likely to happen in the system. This need points to one of the greatest challenges facing all water utility owners—almost all the water distribution system is underground, making it much more difficult to spot and fix any issues, often requiring costly digging operations and road closures.

In view of this reality, the best operational method is not to work on the physical network first but to create a model, such as a digital twin, of the water distribution network. A high-quality database vastly reduces the cost of creating a

model while increasing the usefulness of the model in forecasting anything from probable weak pipes to network performance during predicted peak loads.

Once it is finished, a model is a great tool for developing reliable scenarios for decision making. These scenarios help us to understand possible impacts to the surroundings and what customers might experience in the case of a breakdown in aging infrastructure. Scenario development enables us to be prepared and take measures at the right time and place to mitigate potential damages. The consequences of a network failure might be anything from physical damages due to erosion from underground leakage, to the societal costs of leaving people without access to clean water.

Data management is therefore itself an effective tool to avoid time-consuming investigations and the need to rehabilitate damages. And no tool is better than its input data.

**Matthew Gallagher:** The preventative role of data management is significant; more effective management of aging infrastructure can provide high value and reduce risks for asset owners. In fact, the data demands of aging infrastructure may be greater than those of modern infrastructure.

First, aging infrastructure suffers a comparative lack of sensing and measurement devices designed into the system—sensors have become much cheaper and more readily networked, meaning that we can automatically have a continual stream of relevant measurements. In older systems, retrofitted sensors, or ad-hoc measurement procedures, typically make data more indirectly or sparsely acquired. This situation creates a more heterogeneous and complex dataset.

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<sup>5</sup> Nickel Institute, Lose the Leaks, January 30, 2020

Second, with infrastructure that has aged, there is greater uncertainty about the condition of the infrastructure due to material degradation and damage caused by external environmental factors over time. We generally know less about material quality and processes of older constructions, and quality control was less consistent. This means we need to generate new, additional data to measure these things in-situ or try to infer endpoints directly without having a precise model of the infrastructure.

Both these factors tend to require more complex and bespoke inference to gain a clear and accurate picture of the infrastructure. In a modern system, data streams neatly into a well-designed database with little technical debt. However, in older systems, a patchwork of different technologies provide data to various legacy systems; as discussed earlier, harmonizing data can be a significant challenge. Often, the first task is to provide digital infrastructure—such as databases—that capture all key data sources and present a coherent, unified view. We also need to keep the data up-to-date as new measurements arrive, performing curation and quality control. Frequently, the data remains fragmented, or is only periodically re-integrated with other sources. That is why digital maturity indices emphasize continual demonstration of data provenance, versioning, backup, and disaster recovery. None of these things are possible without good data management.

**Morten Engedal Sørensen:** Aging infrastructure certainly brings greater complexity. The expected conditions of the infrastructure must be validated from insights based on relevant data collected from different sources.

By correlating data that conveys the age of the pipes with data about soil composition, groundwater level, vegetation, and measured flow, it is possible for data scientists to provide a

valid understanding of the condition of the infrastructure. In addition, retrieving data from the surrounding SCADA and IoT systems and applying the logic and rules from the data model paves the way for the application of artificial intelligence and machine learning; this process leads to valuable predictions about the current state of the assets underground and provides vital information for supporting maintenance decisions or replacement activities.

### ***What role does data have in helping utility operators control costs and manage demand?***

**Matthew Gallagher:** Not all demands are equally important, and demand overall is elastic. Generally speaking, demand emerges from a population of users who have different needs and requirements. Data is critical to understanding these users, when and where their demand varies and how responsive the population is to various price levels at different times. Input costs such as electrical power also vary over time, meaning that optimum management is a juggling act of forecasting demand to adjust pricing. For many reasons, an element of uncertainty is unavoidable, which means that a variety of outcomes must be considered and “priced in” at all times.

**Anna Dahlman Petri:** A key challenge that water utilities face is they must be able to deliver on peak days when the demand can be twice the average. If that peak could be predicted and managed, the risk of failure would be mitigated, and the size and complexity of the water system could be optimized.

Accurate, real-time data could be used to create price models benefitting all parties—of course, with regulations in place and relevant data available; for example, a forecast can lead to a reduced price during windy or sunny days when

sustainable electricity is more abundant, allowing industry to optimize their usage, and thereby helping the overall network.

A good understanding of the demand base and the actual supply can also allow for more accurate tariff rates on a more granular basis. This is especially useful when considering areas with the most-water-intensive industries, which tend to be more responsive to water price adjustments.

**Morten Engedal Sørensen:** Within the network, the key indicators concerning flows and pressures in all parts of the network are known to the utility operators by collecting data from the many infrastructural components in many different locations. By using the data, it is possible to make corrections to the parameters in the network and thereby take different actions to adjust the water supply to flow to particular areas or sites.

To be cost-effective, it is necessary to predict how much water will be consumed. Data can be used for that prediction; and aligned pressure potentially translates into lower electricity cost for utilities. By using data, and artificial intelligence, operators can optimize pump use and use of other components in the system to deliver water in the most efficient way.

All of the above is only possible when the water supply is sufficient. In case of breakage or leaks, recent events show how local disasters can cause huge losses of water and lead to extreme scarcity of water in regions that normally have a steady supply of water. In such cases, a digital twin can compute an area isolation plan to ensure that the part of the main with the leak or breakage could be isolated to prevent loss of water, while areas that are not affected can remain supplied.



### ***How can artificial intelligence and machine learning contribute to informed decision making?***

**David Rawlinson:** Artificial intelligence, in particular machine learning, has matured enormously in the past 10 years, especially when applied to sensing and perception. This technology contributes to decision making by allowing detailed and comprehensive audits of physical infrastructure, enabling 3D reconstruction, automatic defect detection and other capabilities.

But measurement itself is rarely the end goal. Instead, the objective is to construct a more detailed and accurate picture of current operating conditions to allow optimization of other processes as such maintenance, network operations and risk management. Optimization might involve finding ideal parameters for a policy, calibrating a simulation, or predicting the outcomes of various network configurations or scenarios.

Machine learning can help elsewhere too. It can improve situational awareness by filtering and consolidating alarms and providing tools—such as chatbots—to communicate with users and manage their accounts or recommend services. Hopefully, the picture that's emerging is that artificial intelligence and machine learning is not a separate entity, but a type of technology that can be integrated into many business areas.

Our experience is that the most effective role of artificial intelligence and machine learning is

“decision support” for skilled operators and managers, rather than attempting total automation. Real-world systems—particularly featuring complex and geographically distributed infrastructure—tend to experience far too many strange and unanticipated events that cannot be incorporated into more narrowly defined software functions, even with advanced AI. Human subject matter experts are still the best generalists. In an ideal world, artificial intelligence and machine learning removes boring, repetitive and well-defined tasks while providing contextualized, insightful data views that enable experts to perform a “detective” role, exploring and understanding unusual events.

United Nations Sustainable Development Goal 6: Clean Water and Sanitation—Ensure availability and sustainable management of water and sanitation for all

### ***In what ways can data management facilitate wise use of the world's water resources?***

**Anna Dahlman Petri:** The water cycle is the continuous movement of water within the Earth and atmosphere. It is a complex system. Water never really disappears but occurs in different qualities and quantities in different places on earth. How we use it and what for—you could say we borrow it within the cycle—has a great impact on sustainability. Good data management creates the ability to understand future needs and helps all of us “borrow wisely” today, to conserve water and preserve our natural resources.

**Morten Engedal Sørensen:** When it comes to wise use of water, data can play an important new role.

The demand for water keeps growing along with the growth in world population. Increasing demand combined with pollution and climate change impacts put pressure on nature's process of replenishment within the water cycle. There is plenty of water in the world, but these and other factors are draining the usable freshwater that is accessible to humans.<sup>6</sup>

Besides legislative initiatives to encourage behavioral changes among consumers to avoid overuse, wise use also calls for actions in the utility sector to minimize loss of water within the network. It is imperative to make available water go further and to create and maintain an equilibrium with nature.

From a future-ready perspective, data from a large variety of data sources contribute to disclosing the important processes of the water cycle<sup>7</sup> and thereby the various actions needed to make sure that consumption is in balance with this vital but scarce natural resource.

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<sup>6</sup> GreenFacts, Facts on Health and the Environment, Water Resources 4.3

<sup>7</sup> “Quantifying renewable groundwater stress with GRACE,” June 16, 2015, AGU – Advancing Earth and Space Science, [Water Resources Research](#)

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# HOW WSP'S DIGITAL FLOOD MANAGEMENT TOOL IS SAFEGUARDING COMMUNITIES

## Bringing Flood Risk to Life Through Augmented Reality: WSP's FloodVue™ digital tool

With climate change posing the potential for more frequent and costly weather events, adaptation measures are critical for reducing future economic losses. Cutting-edge digital tools are enabling communities to see substantial impacts flood mitigation solutions can provide.

WSP developed FloodVue, an augmented reality tool, to help communities and landowners visualize flood scenarios and create an immersive picture of severe weather impacts before they occur. FloodVue is changing flood risk communication and highlighting the benefits of adaptation.



“With many factors and trade-offs at play, we are empowering clients with the data they need to make smarter, more resilient decisions,” said Andy Clevenger, global water sector lead for WSP. “This advanced digital model is successfully bridging the gap between the need for critical flood mitigation and the justification to procure essential funding for sustainable infrastructure investment.”

One of the most visible aspects of a changing climate is the increase in extreme weather events, including heavier downpours, higher storm surges and more intense tropical storms. As record-breaking flooding events become

more frequent, adapting the built environment to withstand a more volatile climate is fundamental to building greater levels of sustainability and resilience in the cities and communities where we live and work.

According to the World Resources Institute, the number of people impacted by flooding will more than double within the next decade, and it is anticipated that the current economic loss due to riverine flooding will triple by 2030 to roughly \$500 billion annually.

Prediction models show that every dollar spent to make infrastructure disaster-resilient preemptively saves \$4 in reconstruction costs later.



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*FloodVue help visualize flood scenarios by creating an immersive picture of severe weather impacts before they occur, and also how mitigation can reduce that impact.*

## **Bringing Flood Risk to Life**

If a picture is worth a thousand words, then the ability to visualize multiple data sources and flood flow details using a four-dimensional (4D) model — which incorporates velocity and intensity, multiple storm event elevations, historical storm elevations, flood mitigation scenarios and high-water mark locations — is proving to be worth a thousand pictures.

“Communicating flood risk through traditional two-dimensional (2D) maps fails to resonate with stakeholders as deeply as photos depicting severe flood damage in the aftermath of a storm event,” Clevenger said. “This can make community buy-in to procure necessary funding and select the most impactful flood mitigation projects challenging.”

In the flood-prone Midwestern U.S., FloodVue is being used to create conceptual mitigation alternatives for multiple communities. The 4D visualizations make impacts personal to stakeholders.

“At WSP, our application development team is ecstatic to be working on such a cutting-edge tool that will bring a new way of communicating flood risk to our communities,” said Dan Gwartney, GIS manager and lead geospatial scientist at WSP. “Engaging with people and showing them how FloodVue works continuously builds on our excitement. It’s amazing to see how engaged they become with this type of flood representation.”



*In the flood-prone Midwestern U.S., FloodVue is being used to create conceptual mitigation alternatives for multiple communities. (Pictured: Davenport, Iowa).*

## **Stronger Investment Support**

Not only has the use of FloodVue increased engagement, it has also resulted in stronger support for community investment to construct critical flood control, including natural and nature-based systems like wetlands restoration, as well as infrastructure that includes dams, levees, coastal flood works, pump stations and other floodplain conveyance improvements.

Through the immersive visuals of FloodVue, stakeholders are put directly in the flooding scenario with and without proposed mitigation.

Typical flood mapping provides only a 2D view of predicted flooding and flood mitigation options. In a predictive modelling map, a blue line indicates where flooding will occur and a green line indicates how designing a new detention pond will preserve critical infrastructure upstream.

However, this view is not as impactful as the augmented reality visualizations developed in FloodVue that put the viewer directly within the path of the flood waters.



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*FloodVue improves a community's ability to withstand a changing climate by interpreting data to create a visual representation and address flood impacts before damage occurs.*

## **The Power of Flood Management**

WSP is helping safeguard communities against flood-related impacts and become FutureReady® now. Digital solutions, like FloodVue, advance a community's ability to withstand a changing climate by interpreting large sums of data to generate a comprehensive visual representation and address potential flood impacts before the damage occurs.

"We're using FloodVue and the rest of WSP's digital sustainability toolkit for improving local engagement, empowering communities and inspiring action," Clevenger said.



©WSP USA

*The floodplain without mitigation is on top, and with mitigation is below. The map on the left shows in blue where flooding will occur and in green the impact of a detention pond.*

*Watch the webinar recording on FloodVue™:  
Bringing Flood Risk to Life Through Augmented  
Reality*

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# FIVE WAYS ARTIFICIAL INTELLIGENCE IS GOING TO SHAPE THE FUTURE OF WATER AND RESILIENT INFRASTRUCTURE

AI technology is revolutionizing how we view climate change and its damaging impact on water infrastructure, laying the groundwork to find more sustainable solutions.

For quite some time we've been aware of artificial intelligence, commonly known as AI. But for most of us, AI was limited to fantastic science fiction tales in the movies or large-scale experiments conducted by scientists and engineers.

Certainly, who thought it would be something of significance that would directly touch our daily lives. Right?



Recently there has been a shift in that perception, with a surge in popularity among individuals and organizations discovering ways to utilize AI in one form or another to benefit daily life.

While AI and machine learning (ML) were well-established within the technology industry, those enterprise tools were perceived as premium products only. Publicly available AI tools have been on the rise in recent years, gaining immense popularity across various industries.

From infrastructure to finance, and marketing to logistics, AI is revolutionizing the way businesses operate and interact with customers. And as we observe World Water Day on March 22, we see the tremendous need for education

and a cohesive vision to ensure water security for all.

The release of powerful and publicly available tools like ChatGPT, DALL-E and Midjourney have showcased emerging possibilities for AI. It's no longer limited to classic pattern recognition — AI

can break barriers and expand its “creativity” by producing texts or generating images using simple text as input similar to human-like conversation — although fact-checking is a must.



©DALL-E/RIFAT ALAM

*This “retro synthwave neon-soaked” image was generated using a simple text prompt in the AI program DALL-E without any reference image or edits.*

## **Leveraging AI for Water and Resilient Infrastructure**

The exponential growth of data plays a critical role for AI's success. In today's world, data is being generated at an unprecedented rate — a trend that is going to continue across the globe.

Another significant driver of the recent rise in AI is the growing availability of cloud computing. Cloud-based platforms allow a flexible and cost-effective way to access the computational power required to run large AI algorithms.

The current status of infrastructure in the U.S. has been the focus of discussions in recent years. The \$1 trillion Bipartisan Infrastructure Law (previously known as the Infrastructure Investment and Jobs Act) puts special focus on water related infrastructure.

The need to invest in infrastructure is becoming increasingly pressing, particularly in the face of climate change. Extreme weather events including flooding and sea level rise are putting our infrastructure at risk, and without significant investment, many communities will be left vulnerable to the impacts of climate change. This includes not only the risk of damage to infrastructure during extreme weather events, but also the increased costs of maintaining and operating infrastructure in a changing climate.

AI and emerging technologies will play a key role in these efforts. Beyond just using typical pattern recognition or finding trends from historical data, AI has a lot to offer that will redefine the future of water infrastructure planning and management.

Here are five ways AI is going to change the future of water and infrastructure in the U.S. and around the globe:

### **1. Predictive Maintenance for Water Supply**

AI can help predict equipment failures and maintenance needs, leading to improved uptime and reduced downtime. A number of local municipalities and agencies across the U.S. have implemented AI systems that detect potential equipment failures in real time, allowing maintenance teams to address issues before they cause a problem.

### **2. Future Flood Risk Prediction**

Mother Nature can be extremely complex when it comes to flooding. The classical practice of future flood risk determination was based upon “past performance” or historical data.

AI has added new dimension to future flood risk detection for complex predictive modeling. Numerous pilot studies are being conducted nationwide where the AI can “learn” using previously completed modeling instead of just historical data and “predict” the flood risk for more complex areas with multiple risk factors. This allows the authority in charge to take preemptive measures to protect its infrastructure and citizens by helping mitigate flooding impact.

### **3. Water Quality**

AI can analyze future water quality patterns using similar results and data from sensors to identify changes in water quality, which can be indicative of contamination or other issues. This enables the local agency to have preplanned action plans ready to respond to issues such as harmful algae blooms or other contaminants.

### **4. Sustainability and Energy Optimization**

AI can optimize energy usage in water treatment and distribution, reducing costs and carbon emissions.

Water treatment and distribution require significant amounts of energy, making them an ideal candidate for optimization through the use of AI. AI can be utilized for predicting future demand in treatment and distribution network by analyzing historical water usage patterns. AI can also be used to optimize the distribution network itself.

By analyzing flow rates, pressure, and other data, AI can identify areas of the network that are over- or underutilized. This can serve as a

decision support system to adjust the network and ensure that water is distributed efficiently, reducing energy consumption and carbon emissions.

## 5. Asset and Water Resource Management

AI can help manage and prioritize infrastructure assets, ensuring their proper maintenance and replacement. It can also help conserve water by optimizing irrigation and reducing wastage.



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*Beyond just using pattern recognition or finding trends from historical data, AI has a lot to offer that will re-define the future of water infrastructure planning and management.*

## Time to Harness the Power of AI

The lack of data in many areas/sectors, and initial cost/benefit and adaptation for these AI technologies will be a major challenge. However, despite these challenges, now is the time to harness the power of AI with an open mind.

There is no doubt that AI is going to transform the water and infrastructure industry in a multitude of ways, from improving water resource management to addressing issues of climate and flood resiliency, AI has the potential to address many of the industry's most pressing challenges.

As technology continues to advance, we can expect to see even more innovative solutions emerge to help ensure a sustainable and efficient future for our water and infrastructure

systems. WSP is currently involved in several innovative pilot projects for future flood risk assessment, the findings of which will be used in the future to train AI/ML based algorithms.



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*AI will transform the water and infrastructure industry in many ways, from improving water resource management to addressing issues of climate and flood resiliency.*

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As one of the world's leading professional services firms, WSP exists to future-proof our cities and environment. We provide strategic advisory, engineering, and design services to clients in the transportation, infrastructure, environment, building, energy, water, and mining sectors. Our 66,000 trusted professionals are united by the common purpose of creating positive, long-lasting impacts on the communities we serve through a culture of innovation, integrity, and inclusion. Sustainability and science permeate our work. In 2022, WSP derived more than half of its \$11.9 B (CAD) revenues from services that support the UN Sustainable Development Goals. The Corporation's shares are listed on the Toronto Stock Exchange (TSX:WSP).