SAND TECHNOLOGIES

The AI Revolution in Water Utilities

How water engineers are deploying AI for smarter water management

The Impact of Aging Infrastructure

Human ingenuity has transformed how urban planners approach their water infrastructure for millennia. From ancient Roman aqueducts to modern desalination plants, technology has always been at the heart of the water-management revolution. As the water infrastructure ages, technology plays an additional role in maintenance, a facet that has become even more pronounced with recent advancements in artificial intelligence (AI).

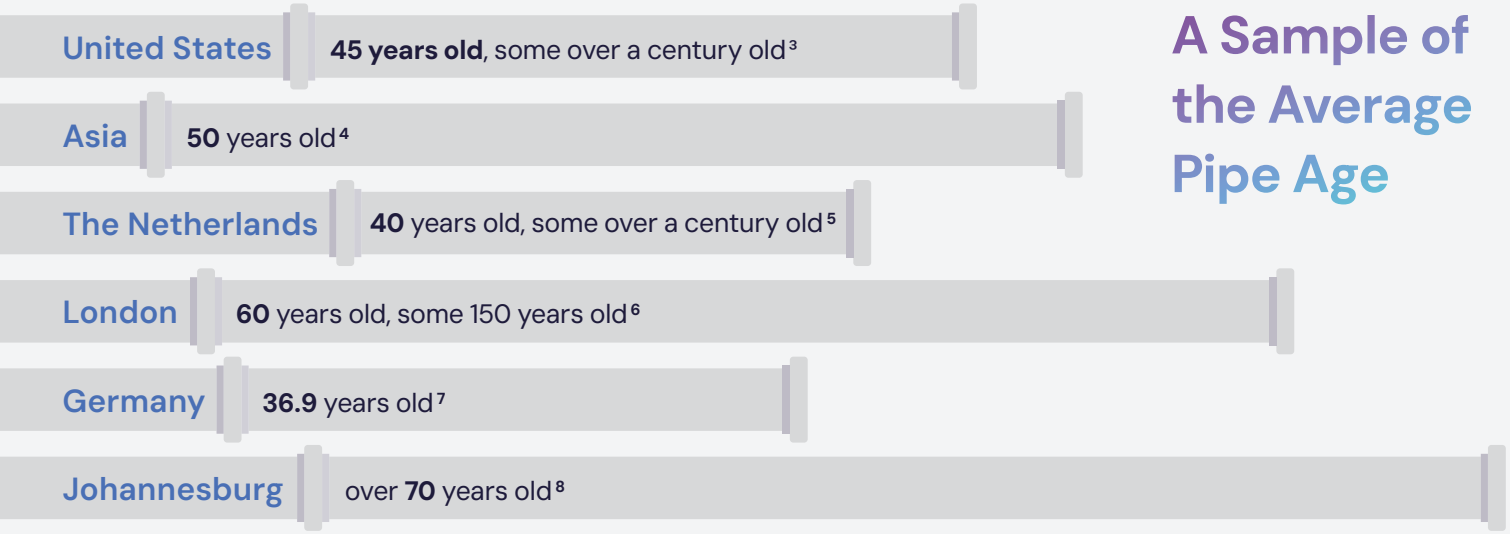
In many countries, particularly those with booming city populations, existing water pipes and treatment facilities are ill-equipped to handle modern water demands. Aging water infrastructure silently erodes the city's ability to meet citizens' needs.

As pipes reach their end of life, the repercussions extend beyond waste. Aging infrastructure and environmental factors increase contamination risks, posing severe health threats to communities, causing disruptions to daily life and increasing costs to the city.

Such threats are already playing out in cities worldwide. In April 2014, residents in Flint, Michigan, learned that their water supply was contaminated, leaving thousands exposed to lead poisoning.[1] More recently, massive leaks in Atlanta, Georgia, caused widespread flooding and disrupted residents' lives for days.[2]

These real-life examples underscore the urgent need for robust water management systems to safeguard our most vital resource — clean water. Urban planners and policymakers must embrace innovative AI and smart solutions to modernize water management.

A Sample of the Average Pipe Age



The Role of AI in Modernizing Water Management Systems

AI water management stands apart from conventional water management systems in four significant aspects. First, it gathers a more extensive array of data across the entire water network. It can analyze unstructured data, such as text, images and video. And AI systems continuously learn and improve performance over time, making it a perfect solution for monitoring water infrastructure.

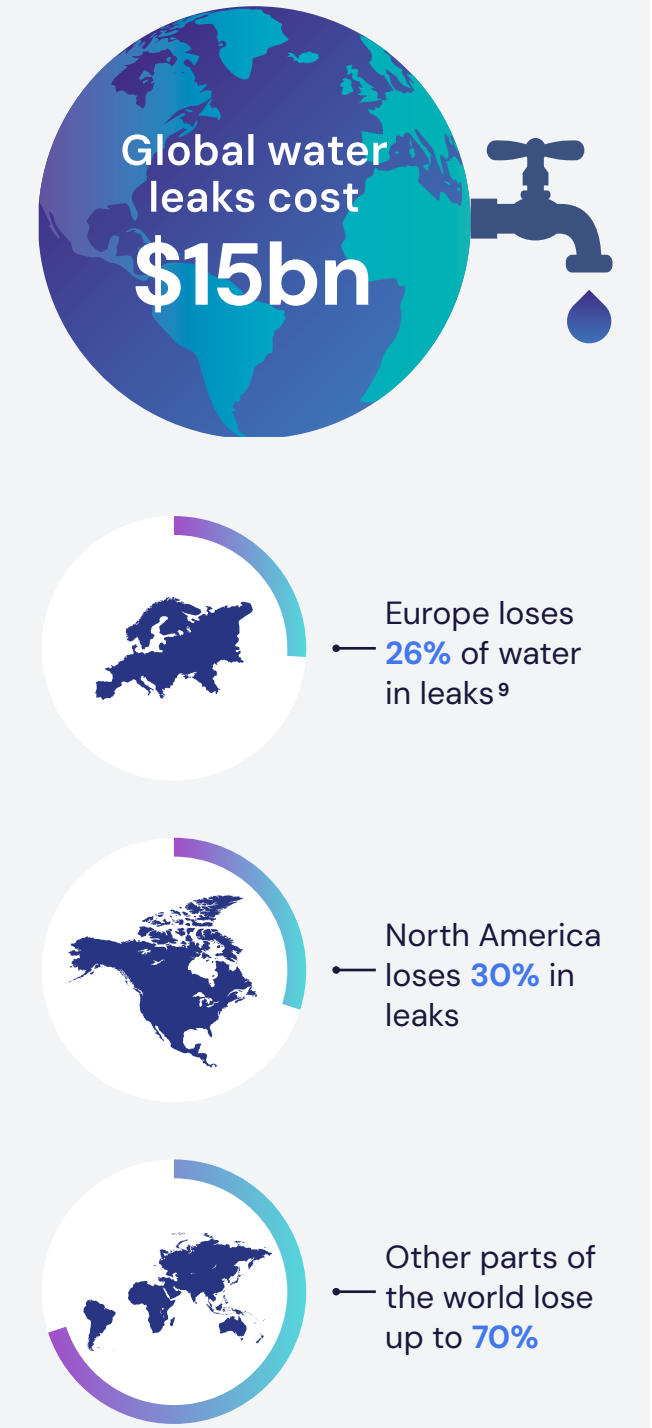
Second, AI water management integrates data silos from existing systems. In traditional water management, data collection relies on multiple systems like SCADA, CMMS, and LIMS. AI does not replace these; it significantly upgrades the data insights. It aggregates all data from these systems with new data collection from IoT devices, cameras and video into a single source of truth. By analyzing historical data, AI water management systems find patterns, making it possible to predict future issues with very high accuracy.

Third, IoT data is collected almost instantaneously, enabling water management teams to avert issues sooner. The deployment of 5G technology has made this possible, allowing sensors to operate in areas that were once too challenging to reach, now gathering more detailed data. The near real-time transmission of this data enhances the responsiveness of water management teams.

The fourth differential is predictive analytics. This capability adds a deeper layer of benefits by allowing water utilities to forecast demand, identify potential issues *before* they escalate and allow for proactive maintenance and efficient resource allocation. Data modeling integrates these insights to create comprehensive simulations, empowering stakeholders with powerful data-driven decision-making that balances environmental impact with operational efficiency. Together, these AI capabilities offer a powerful toolkit for addressing the complex challenges of modern water management.

> AI does not replace traditional water data systems; it significantly upgrades the data insights.

Four AI Applications in Water Management



AI is revolutionizing various industries, and water infrastructure is no exception. At its core, AI can manage intelligent processes like constant monitoring, pattern recognition and process automation. When applied to water infrastructure, AI detects and prevents leaks, improves water quality and leverages predictive analytics for predictive maintenance and accurate demand forecasting. Integrating advanced AI technologies into existing water management systems makes water infrastructure more resilient, efficient and sustainable.

LEAK DETECTION AND PREVENTION

Early detection is crucial to reduce repair costs and conserve one of our most precious resources. Sensors placed strategically throughout the infrastructure collect data continuously. Advanced AI algorithms and machine learning use this data to monitor water assets and infrastructure around the clock and identify leaks before they become significant problems.

In recent years, AI-driven leak detection systems have revolutionized how industries manage and prevent costly water and gas leaks. UK water utilities have implemented AI to monitor thousands of miles of pipes, enabling early leak detection and significantly reducing water loss.[10]

WATER QUALITY MONITORING

Ensuring clean and safe water is paramount, and AI technology is revolutionizing this process. By deploying advanced AI algorithms and IoT sensors, utilities can monitor water quality in real time, detecting contaminants and anomalies the moment they occur. Utilities can even automate water quality balance. This proactive approach helps maintain regulatory compliance and safeguards public health by preventing waterborne diseases.

An example of AI water quality automation is in Newark, New Jersey. The city sought to create a best-in-class water product.[10] The AI system predicts and automates quality adjustments to prevent issues, ensuring compliance with federal and state regulatory requirements.

In addition, water quality monitoring should include river health, which is critical for city, agricultural and industrial leaders. AI can provide a holistic view of river health with predictive and actionable insights about river water quality. Armed with this data, stakeholders can collaborate to improve their water ecosystem.

PREDICTIVE MAINTENANCE

One of the most used cases for AI and advanced analytics in water utilities is predictive maintenance. AI offers a proactive approach to infrastructure management that can significantly extend the life of essential assets. The technology anticipates equipment failures before they occur, allowing for timely interventions that prevent costly breakdowns and service disruptions.

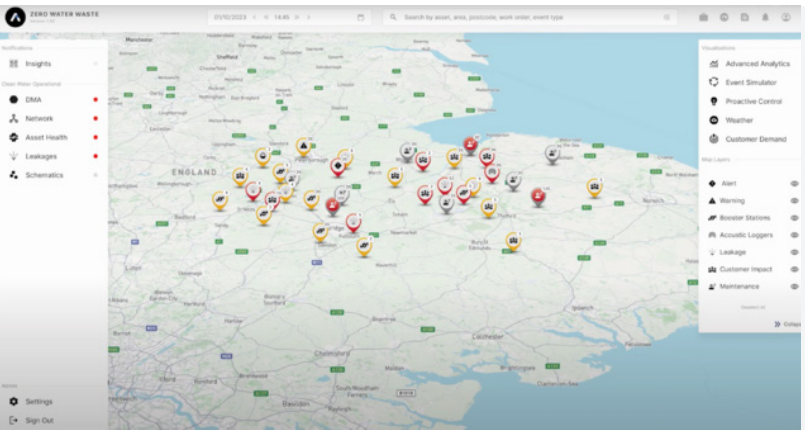
Predictive maintenance transforms how water utilities operate, moving from a reactive stance to a proactive strategic model that safeguards resources and the environment. The initial investment in predictive maintenance technology may seem high, but the expense of reactive maintenance is more significant. In North America alone, the estimated annual cost of water main breaks is approximately $2.6 billion.[11]

DEMAND FORECASTING

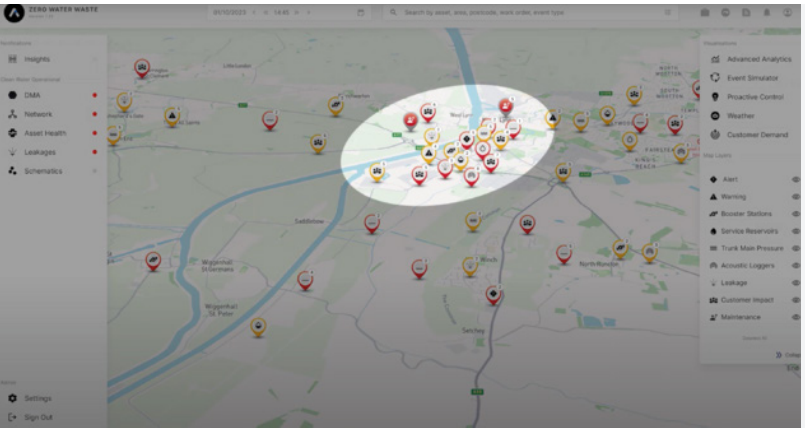
AI is revolutionizing how water utilities manage their resources, offering a powerful tool for forecasting demand as well as optimizing resource allocation and planning. Beyond simply predicting when and where water is needed most, AI can identify patterns, anticipate potential shortages and recommend efficient distribution strategies. The power of predictive analytics can enhance operational efficiency and contribute to the broader goal of environmental stewardship, ensuring wise use of every drop.

Zero Water Waste Digital Twin Model

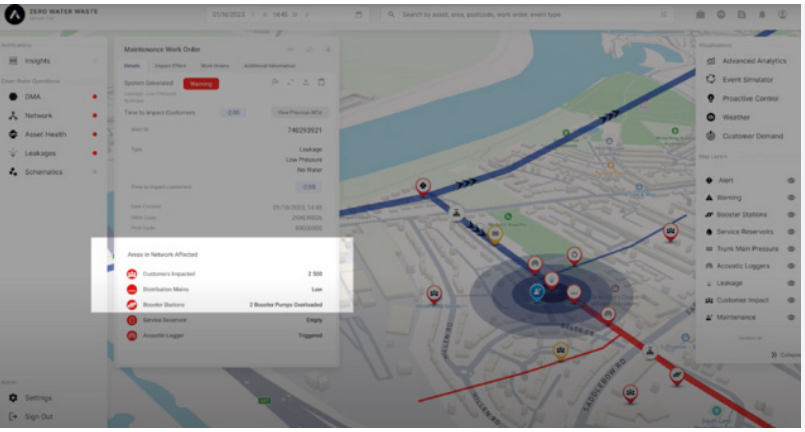
Our Zero Water Waste Digital Twin is helping large water utilities upgrade to AI water management. This sustainable water management system integrates with network digitalization and provides data-driven insights. The model flags potential risks, automates work orders and sends potential leak event information to field engineers via a companion field app. It tracks demand and supply, service interruptions and pinpoints targeted leaks.



In the first image, the model provides situational awareness or insights into the water network. An overview of a geographic area displays icons indicating the status of the network. Colors represent any inherent risk to assets or customers. The icon graphics provide the kind of risk, such as a risk to water supply.

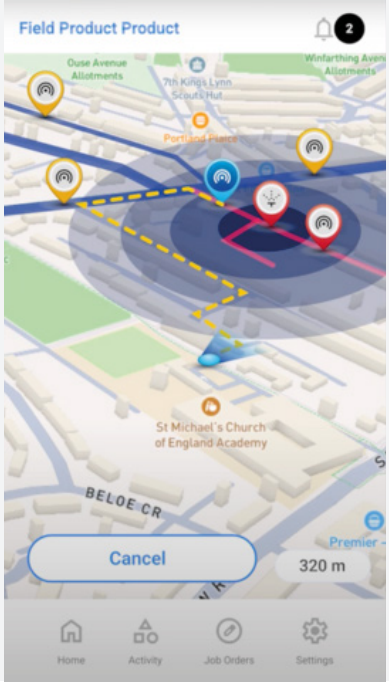


Zooming in, an operator can see a cluster of alert and warning icons in a concentrated area, indicating a potential leak event.



Clicking on an alert, the model zooms in further to show details of the area surrounding the alert. A pop-up window displays details of the alert, including the effect on the surrounding infrastructure and an estimate of customers affected.

Once the problem is detected and the remediation plan established, the model auto-populates the required permit-to-work forms for field crews to begin repairing the leak. The model can display an entire incident timeline for future audits. The timeline shows all sequenced events related to the burst until closure, including estimated time to customer impact, when teams deploy, etc.



Field engineers receive leak information on a companion app, showing the areas to investigate. The app provides a geospatial view with the potential leak area coded by color and icon. These areas are determined using factors like age, material and soil conditions. The colors, icons and detailed location data help the field engineer to find and resolve the leak quickly.

Overcoming Barriers to AI Adoption

Unparalleled opportunities are possible when adopting AI water utility management. Yet, despite its promising potential, the sector grapples with significant barriers that hinder widespread AI integration. These obstacles range from technical challenges to hardware and software scalability, cultural barriers and more.

To be fair, these same obstacles exist in any industry that seeks to adopt artificial intelligence. Overcoming these challenges requires a concerted effort in several technical areas and, perhaps more importantly, a shift in organizational culture.

DATA QUALITY

Data quality is a significant technical challenge. Poor data quality leads to inaccurate predictions and unreliable outputs, undermining the very purpose of deploying AI. To avoid this problem, companies must establish standardized data formats, rigorous data cleaning, and validation and normalization processes to ensure accurate and relevant data for all AI models. Keep humans in the loop to review data cleaning and outputs. Data quality requires human oversight.

> Overcoming the challenges to AI adoption requires a concerted effort in several technical areas and, perhaps more importantly, a shift in organizational culture.

REENGINEERING FOR EXISTING SYSTEMS

Implementing an AI solution is more complex than simply integrating new technology into existing systems. Incorporating AI with legacy systems often requires substantial reengineering efforts, as older systems may need help to handle the high volumes of data or the real-time processing demands of modern AI algorithms. These challenges necessitate a thorough understanding of the data landscape and technological infrastructure.

HARDWARE AND SOFTWARE SCALABILITY

Adding more sensors and IoT devices means a constant flow of data, making scalability and flexibility a top issue to address. A robust infrastructure that can handle vast amounts of data and complex computations in real time is required to support these devices. Advanced hardware and sophisticated software capable of dynamic scaling for increased workloads are also necessary.

REGULATORY AND COMPLIANCE ISSUES

With any AI solution, navigating regulatory and compliance issues is crucial to ensure legal adherence and ethical standards. Compliance isn't just about avoiding fines — it's about building trust with your customers, employees and stakeholders by demonstrating a commitment to transparency, fairness and accountability.

Understanding the complexities of data privacy laws, industry-specific regulations, or ethical considerations in AI deployment can safeguard your organization from potential risks. Prioritizing regulatory and compliance issues establishes a strong foundation for responsible AI. Additionally, prioritizing robust security protocols and stringent privacy measures is a must for organizations to protect their valuable data assets and uphold the trust of their customers.

CULTURAL AND ORGANIZATIONAL BARRIERS

Implementing an AI solution isn't just a technological shift — it's a cultural transformation that requires careful navigation of organizational dynamics. Companies must anticipate and address the inevitable resistance to change that such a profound innovation brings.

Leaders should foster an environment with clear communication, continuous training and inclusive involvement in any AI implementation process. Success hinges on a collective mindset that embraces change, values ongoing learning and fosters an environment that supports iterative progress. These principles ensure that AI initiatives meet immediate goals and that businesses adapt and evolve to drive long-term success.

Case Studies

Aging water assets and infrastructure leave the water utility sector at high risk of failures where valuable water is lost. As a result, proactive maintenance is now critical. Some water utilities are already using AI and achieving impressive proactive maintenance results.

For a major UK water utility, our team used AI to manage infrastructure, perform predictive maintenance, prevent pollution and manage climate commitments, resulting in the following impacts:

Outcomes

- **50%** reduction in leakage
- **75%** reduction in high-priority site combined sewer overflows
- Defined pathway for **75%** reduction in carbon emissions by 2035
- **Optimized TOTEX** decisions across assets and operations

Our team developed a Hydro-Risk Visualiser for a water utility client as a real-time water management control room.

Outcomes

- **50%** improved incident response time
- **10–15%** reduction in network leakage
- **90%** reduction in the time required to locate leaks
- **20%** reduction in supply interruptions
- **$26M savings** over a 5-year regulatory period

References

1. Flint Water Crisis, CDC Casper, 2024
2. Everything we know about Atlanta's water main breaks, Atlanta News First, 2024
3. US water infrastructure: Making funding count, McKinsey & Company, 2021
4. Providing Safe and Dependable Water to Future Generations, Kubota, 2023
5. General data on drinking water network in the Netherlands, TU Delft OpenCourseWare
6. London water supply infrastructure Wikipedia, 2024
7. Invisible but Vital Water Pipes, Tracto Insider
8. South Africa water crisis is a problem for business but also an opportunity, NTU, 2024
9. Free flows: New Jersey turns to AI to safeguard water quality, Graeme Neill, 2021
10. Finding Leaks with Artificial Intelligence, Thames Water
11. US and Canada face 260,000 water main breaks annually, study says, ESE Magazine, 2024

The AI-Enabled Future of Water Utilities

The water utility industry faces challenges threatening its efficiency and sustainability. Smart city planners and environmental engineers must harness the power of AI to build a sustainable water infrastructure. However, smooth integration requires careful planning and strategy.

Water utilities should thoroughly audit their current systems to identify areas where AI can add the most value: optimize water distribution, enhance predictive maintenance, leak detection, demand forecasting, improve customer service, etc., and start with one objective.

Evaluate various AI tools based on scalability, ease of integration with existing systems and quality of data analytics capabilities. Choose a solution that meets immediate needs and provides long-term value and adaptability as the technology and your business evolve.

Collaborating with AI experts can smooth out this entire process. Consider the vendor's expertise in the water sector, their track record of success with data and AI implementations and the level of collaboration and customer support they offer.

Integrating an AI toolkit into water management will enhance the efficiency and resilience of water systems and ensure equitable access to this vital resource for generations to come.

The future of water utilities is here, powered by intelligent technology.

Sand Technologies' industry experts enable our water utility clients worldwide to protect and monitor their infrastructure, manage wastewater and ensure water quality.

Contact us today to see how your business can capitalize on AI and data intelligence.

water@sandtech.com

sandtech.com/water