ARCADIS

DEMYSTIFYING

Intelligent Water

Creating a human-centric future with artificial intelligence and predictive analytics

A research collaboration with

bluefield RESEARCH

Improving quality of life

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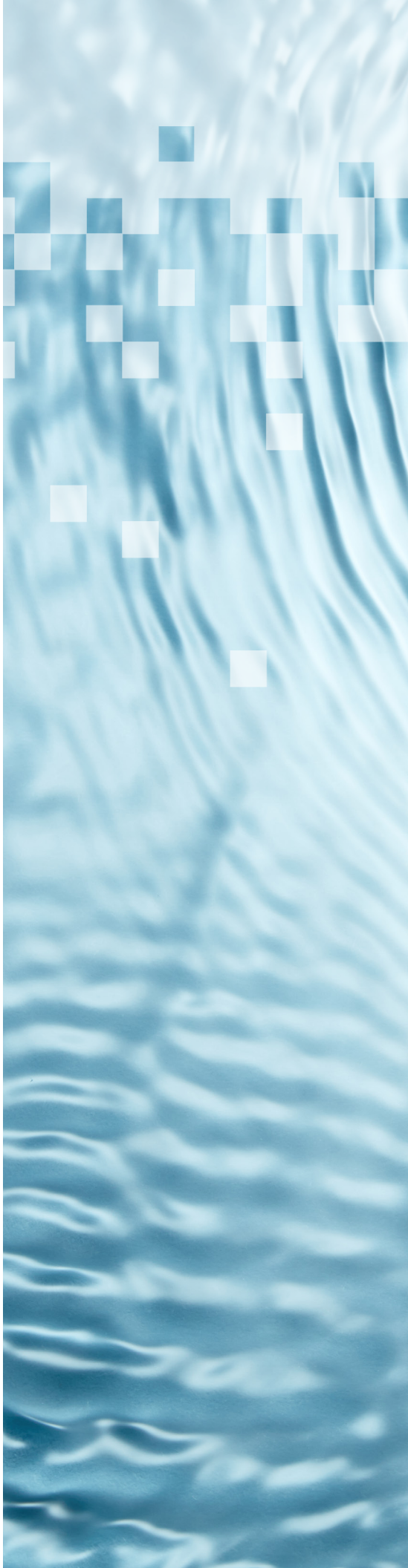


Foreword

Industries evolve over time, and instilling fundamental changes can be a challenge. In some cases, it takes bold steps – even if they're incremental – to push a paradigm past a plateau.

Look at the automotive industry. In the early 1900s, it was plagued by uncompetitive wages, nearly 400 percent employee turnover, and mediocre production rates of about one vehicle every 12 hours. Henry Ford, guided by research on how to reverse these trends, introduced the first moving assembly line. The move revolutionized how cars were made. Assembly time shrank to a breezy 90 minutes while cutting production costs in half. Worker salaries doubled, improving retention and recruiting efforts, and the cheaper assemblies made vehicles affordable for the masses.[1]

Today, utilities (water, wastewater and stormwater) sit in a similar position: They're achieving the best results they can using the limited resources at their disposal. But competing pressures of customer expectations, a retiring workforce, regulatory challenges, disrupting technologies, and spending needs continue to build. A fundamental change is needed, but what will it look like?

The answer is Intelligent Water. Application of artificial intelligence (AI), machine learning and predictive analytics are within reach today. However, I believe Intelligent Water is less about technology replacing our people and more about technology empowering our people in new ways. It provides skilled workers with tools to make the best decisions possible in real time. The collective intelligence (CI) of people and computers together is far greater than either is alone. This new way of thinking, with a human-centric focus on Intelligent Water, presents a far greater opportunity to positively impact the water sector.

These are the ideas Arcadis and Bluefield Research explore. We hoped to get a better idea of the what, why and how of Intelligent Water by examining its potential for addressing two of the biggest human-centric challenges facing the industry: Affordability and resilience. From what we found, its ability to meaningfully impact these areas is clear through the CI lens.

As you unpack our findings, the need for change becomes apparent. Utility spend continues to increase. Water and sewer rates continue to increase while water consumption continues to decrease.

The water sector tends to be risk-averse, and it can be tough to consider a strategy change while competing with the immediate pressures of each day. I get that. But we also must acknowledge that today's troubling trends result from decades of maintaining the status quo. The opportunity to change is ours, the time to do it is now, and I believe that by working together, all things are possible.

Intelligent Water is critical to Smart Cities – where vast interconnected networks communicate and collaborate to benefit entire regions. Utilities can leverage it to address current problems as well. Venture capital investment in digital technologies for water is exploding, providing a venerable buffet of potential solutions to help utilities employ optimized, human-centric operating models.

I hope that this research provides insights you can use to help revolutionize the ways water impacts communities. Try to imagine the automotive industry without assembly lines – it's impossible. I expect very soon we'll say the same about the water sector, with Intelligent Water serving as the means for a remarkable change. Embracing the evolution can create meaningful impact today while building the foundation for sustainable, smarter cities and regions.

Jim Cooper,
Intelligent Water Lead

Executive summary

The water sector is, and always will be, about people. It incorporates consumers and working teams alike. If you work in the water sector and are empowered by technology, **you are Intelligent Water.**

Intelligent Water can – now and in the future – enable experts across the water sector to make optimal decisions at opportune times.

Intelligent Water allows utilities to consistently check the pulse on communities' relationships with their water, giving insights into the micro- and macro-level effects of changing economic, environmental, social and political conditions. But to realize human-centric outcomes from Intelligent Water, we need to be open to different solutions. "The way we've always done it" will not suffice, and utilities must meet current fears and skepticism regarding technology and change with curiosity and optimism.

The purpose of this research study is to prove that Intelligent Water can address two of the most complex and critical human-centric challenges facing the water sector today: Affordability and resilience. This report explains why we focused research on these challenges and demonstrates how people in the water sector can address them in intelligent and sustainable ways.

Intelligent Water 101: **Key terms**

Intelligent Water

The process of water systems embracing digital technologies and ecosystems in front-line operations and utility management with the purpose of improving financial stability, customer experience, and O&M key performance indicators, fueled by a cultural shift toward innovation.

Key research findings and recommendations

Utilities need to innovate around resilience and affordability

U.S. municipal utilities manage a total of $1.25 trillion worth of water, wastewater and stormwater assets, and five of the top 10 issues ranked by water utilities in the American Water Works Association 2018 State of the Industry report relate to resilience needs. The remaining five relate to funding sources, the public's understanding of water's value and their willingness to pay. Clearly utilities are at a difficult crossroads – realizing more must be done, but unsure where the funds will come from or if they will come at all.

Recommendation: Asset lifecycles could be extended with more robust insights into asset conditions. Using advanced asset management solutions that incorporate AI and predictive analytics, U.S. water utilities could save $17.6 billion through 2027.

Affordability is wavering, with rate increases outpacing income growth substantially since 2012. At current trends, projections see 36 percent of households potentially unable to afford water in the next five years. Maintenance spending reached an all-time high of $50.2 billion above capital in 2017, indicating a more reactive and unsustainable service model. Only 21 percent of utilities feel they are currently able to fully cover costs of service.

Recommendation: Intelligent Water can make water more affordable for all. The first step toward affordability is to save money, and Intelligent Water can optimize spending plans and unleash new operational efficiencies that allow utilities to meet increasing spending needs and moderate rate changes. Utilities can use advanced tools to monitor asset health and right-size their maintenance with less costly predictive and preventive techniques, thereby freeing up precious dollars to invest in needed capital improvements.

Intelligent Water is at the tipping point – the time to act is now

As of 2018, approximately 17 percent of utilities report having adopted advanced data-mining and analytics. This group represents the innovators and early adopters while the majority continue to consider the proposition. One thing is for certain: Market investment continues to grow. Over 350 companies currently offer digital solutions in the water sector with over 65 new launches since 2015. Intelligent Water now touches all aspects of a utility, including the boardroom, daily operations and customer engagement.

While utilities will exceedingly face management decisions in this rapidly evolving digital water ecosystem, the majority recognize Intelligent Water will be a long-term evolution – not an overnight revolution.

Recommendation: Utilities must assess their self-awareness and identify their positions and maturities on the Intelligent Water journey to inform their plans and build toward a true Intelligent Water network.

The evolution begins by building a fit-for-future utility, one that is better prepared for an accelerating pace of change by using today's asset (human, digital, physical, etc.) investments to create sustainable long-term resilience plans.

Recommendation: Embrace the three guiding tenets of fit-for-future utilities:

1. Empowering innovation to incorporate new opportunities as they arise.
2. Being driven by customer needs and not technology.
3. Focusing on collective intelligence (CI), where skilled workers make optimal decisions supported by data-driven analytics and a widening application of AI.

Intelligent Water and Smart Cities are related

There is no escaping the interconnected world. According to Cisco, there will be more than 500 billion connected mobile devices across the globe by 2030, and North America is projected to have the fastest growth rate for new devices at 16 percent annually. Smart Cities and Intelligent Water are expected to evolve in-step with each other and capitalize on the advantages of interconnectedness together.

Recommendation: The water sector must evaluate how it can leverage the Internet of Things to enhance not only operations but livability and affordability for entire communities. By fostering cultures of innovation where staff are encouraged to explore new ideas, utilities might uncover value-added solutions that would not have been considered under the current paradigm. When strategically aligned, Intelligent Water can be the catalyst to a Smart City implementation.

The proposition for Intelligent Water

Affordability: Reframing challenges as opportunities

The water affordability crisis looms large. If rate trends of the past several years continue, **thirty-six percent of households won't be able to afford water within the next five years**.[2] Consumers aren't the only ones concerned; only 21 percent of utilities feel they are currently able to fully cover costs and services (Figure 1).[1]

Are utilities equipped to cover costs?

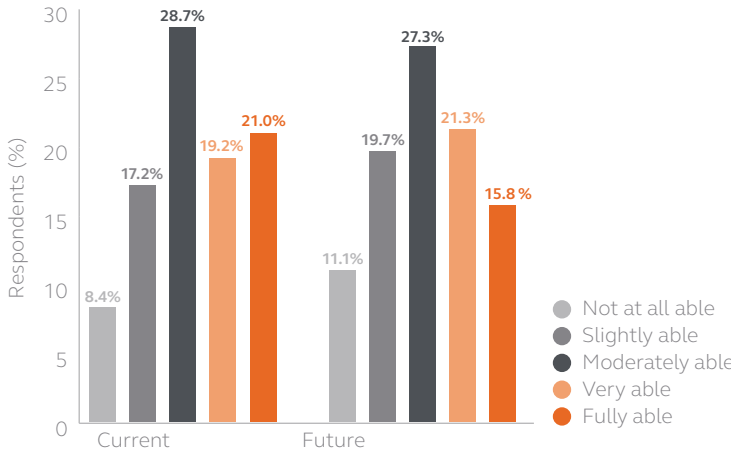


Figure 1 – Assessment of a utility's ability to cover the full cost of providing service currently and in the future. Source: American Water Works Association..

Consumer rates' year-to-year climb

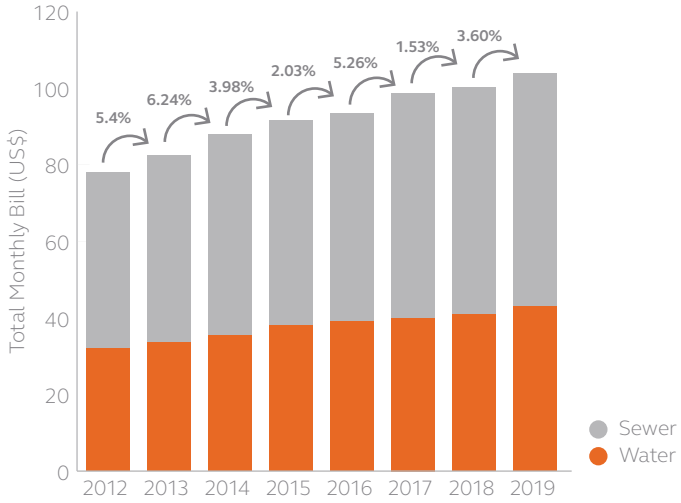


Figure 2 – Water and Wastewater Monthly Bills for Largest U.S. Cities by Population Served, 2012-2019. Source: Bluefield Research.

To meet scaling financial obligations, many organizations have turned to rate increases. Rates rose nearly 30 percent from 2012 to 2018, more than triple what the real median household income grew since 2013.[3, 4]

Putting certain cities under a microscope reveals how affordability impacts people's day-to-day lives. Economically vulnerable residents in the Detroit metropolitan area, for example, spend an average of 10 percent of household income on water and sewer bills, with 84 percent cutting back on other expenses in order to afford water and sewer service.[5] In Philadelphia, unpaid water bills exceed $170 million, coupled with 40 percent of customers falling behind on payments at any given time.[3]

Volume-based revenue model falling short

U.S. population continues to climb, growing from 150 million in 1950 to 325 million in 2015 with a projected 100 million additional people by 2050.[4] Meanwhile, conservation and efficiency measures are driving publicly supplied water volumes into negative growth territory, undermining traditional, volume-based utility revenue models. The U.S. Geological Survey has reported total U.S. volumetric declines of 12 percent since 2005, while population has increased 8 percent during the same period (Figure 3).

When you couple the ongoing reduction in demand with increased spend, rates would need to be substantially higher than what they are today. Clearly, rate increases aren't the answer for most utilities. The key will be leveraging innovation to do more with less. Insight-driven solutions can help utilities optimize spending plans and create new operational efficiencies while moderating rate changes.

Figure 3 – U.S. Population vs. Water Usage, 1950-2015.
Source: Bluefield Research using U.S. Geological Survey and U.S. Census Bureau data..

Reality check: **Cashflow**

95%
Amount of public infrastructure spending generated from local and state governments.

$50.2 billion
Divergence in Capital and O&M spending in 2017, a historical high.

$67 billion
Shortfall between EPA requests and awards for funding water and wastewater infrastructure projects, signaling upcoming financial challenges for system owners.[6]

50%
Utilities that feel "less than very able to fully cover costs of providing continued service."[1]

4%
The average annual increase of water and sewer rates, which outpaces inflation.[3]

Spending and rate figures make it clear: Utilities must rethink their approaches to address affordability.

Resilience: Considering shocks and stressors equally

The danger of maintaining status quo only grows when you consider resilience. Resilience is the ability to adapt to and bounce from acute shocks (e.g., climate events) and chronic stresses (e.g., workforce attrition, aging assets) that consistently put the $1.25 trillion worth of U.S. utility assets at risk.[3] Acute shocks like climate events typically garner the most attention. The U.S. experienced 241 weather and climate disasters exceeding $1 billion since 1980, at a total cost of more than $1.6 trillion (Figure 4).[7]

The costs of acute shocks

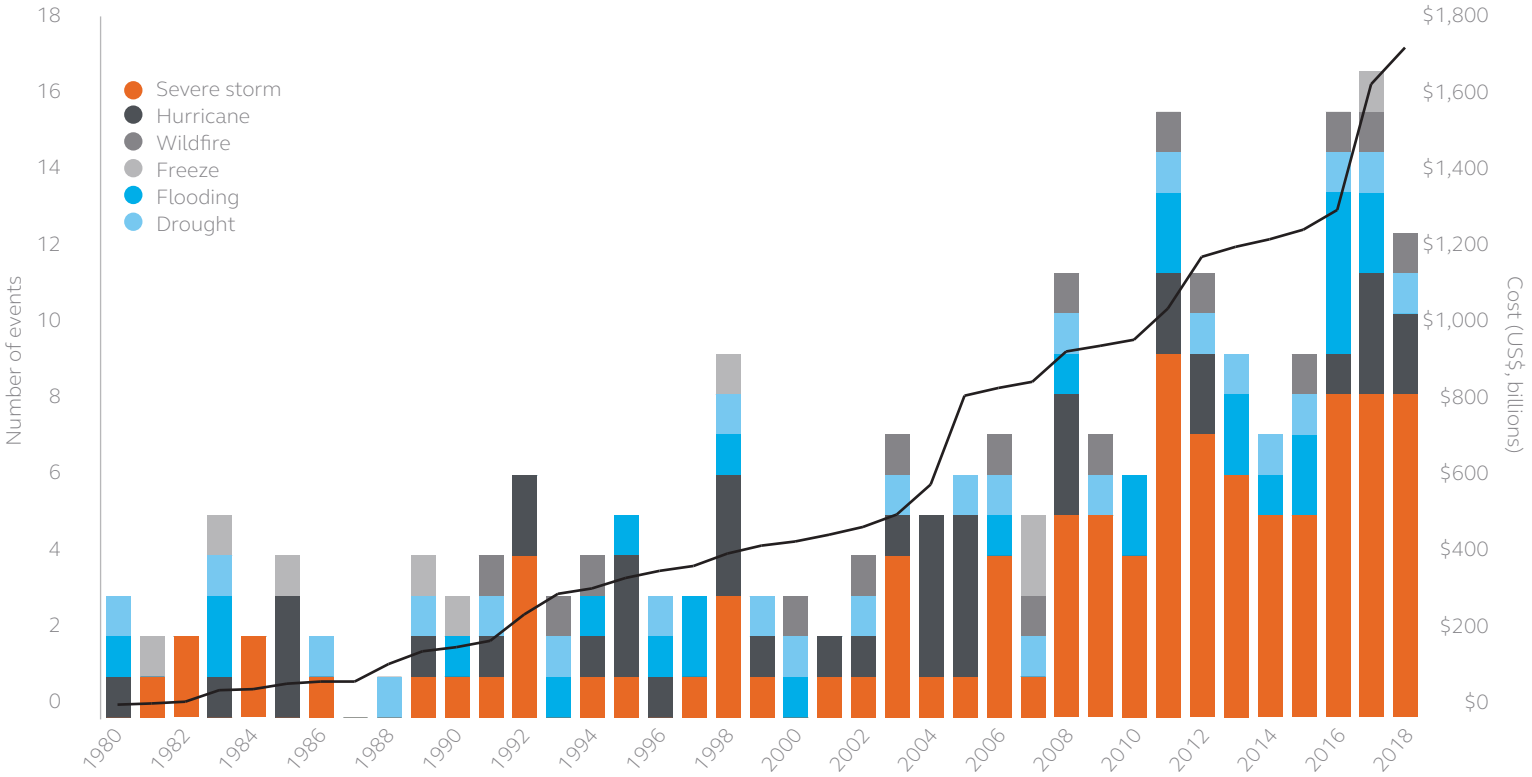
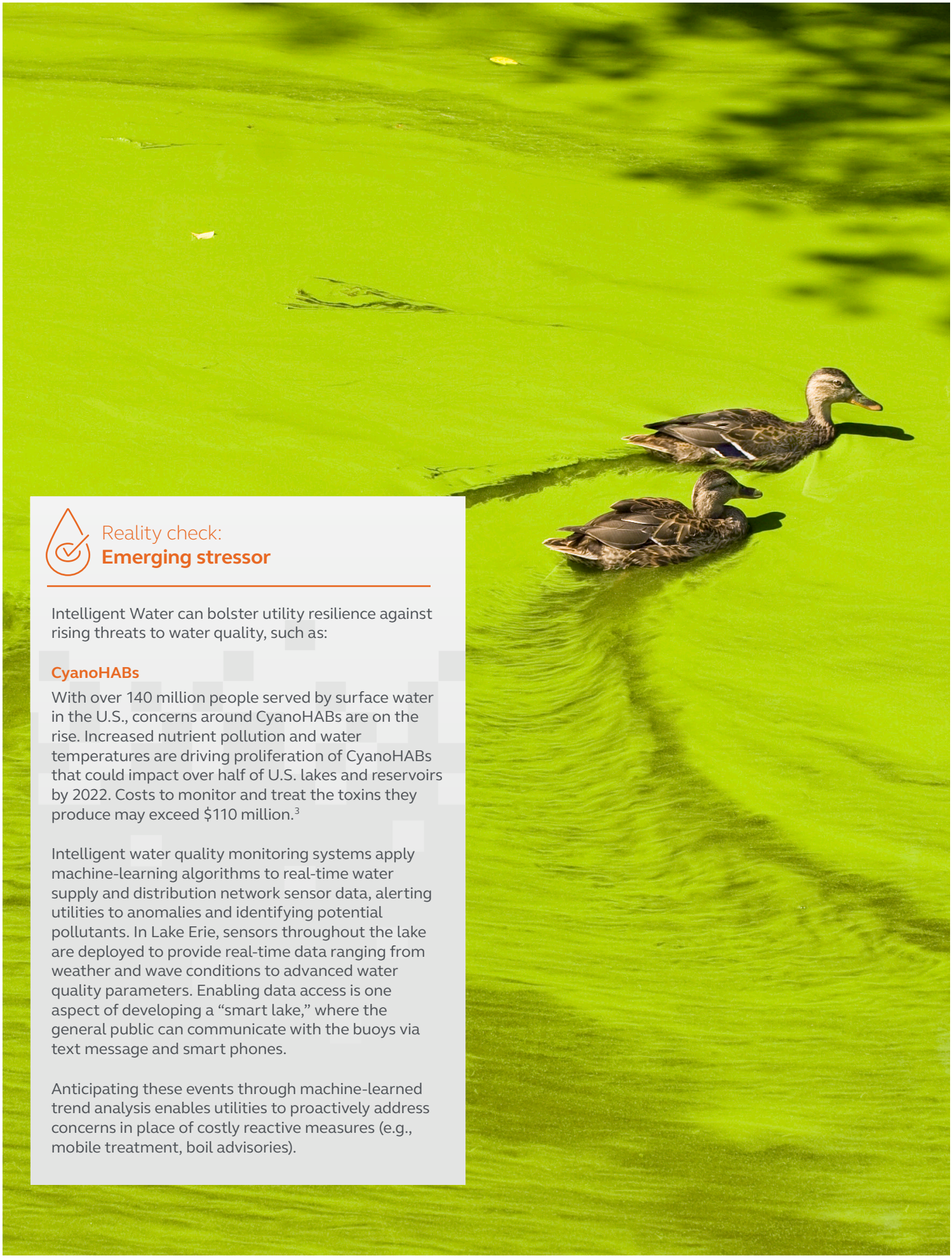


Figure 4 – Billion-Dollar Disasters: Number and Cost of U.S. Weather-Related Disasters, 1980-2018.
Source: National Centers for Environmental Information.

Utilities have much to worry about beyond storms. Chronic stressors can lead to headline-drawing incidents or worsen the impacts of incidents like climate events. Equally weighting them in resilience plans strengthens a utility's ability to adapt and rebound from threats of all types.

Workforce attrition is a growing stressor, with around 30 percent of 1.7 million water utility workers expected to retire in the next decade.[8] Leaders are anxious about the amount of institutional knowledge and experience that will walk out the door. At the same time, they must reconsider the education and skills needed to run the utilities of today and tomorrow, while reimagining recruitment and retention approaches to align with changing workforce expectations.

Cybersecurity made the most dramatic shift in concerns for utilities, jumping from 26th in 2017 to 13th in the American Water Works Association (AWWA) 2018 State of the Water Industry report. Aging networks are being exploited in ransomware attacks and leaks of private information. Intelligent Water could provide more security, and the newly enacted America's Water Infrastructure Act requires utilities to prepare. This is another indicator of how important and holistic resilience has become to the industry, because it mandates a comprehensive assessment to all water utilities, across multiple asset classes and threats.



Reality check:
Emerging stressor

Intelligent Water can bolster utility resilience against rising threats to water quality, such as:

CyanoHABs

With over 140 million people served by surface water in the U.S., concerns around CyanoHABs are on the rise. Increased nutrient pollution and water temperatures are driving proliferation of CyanoHABs that could impact over half of U.S. lakes and reservoirs by 2022. Costs to monitor and treat the toxins they produce may exceed $110 million.[3]

Intelligent water quality monitoring systems apply machine-learning algorithms to real-time water supply and distribution network sensor data, alerting utilities to anomalies and identifying potential pollutants. In Lake Erie, sensors throughout the lake are deployed to provide real-time data ranging from weather and wave conditions to advanced water quality parameters. Enabling data access is one aspect of developing a “smart lake,” where the general public can communicate with the buoys via text message and smart phones.

Anticipating these events through machine-learned trend analysis enables utilities to proactively address concerns in place of costly reactive measures (e.g., mobile treatment, boil advisories).

Top concerns center on resilience

According to the AWWA 2018 State of the Water Industry report, five of the top 10 issues currently facing the water industry relate to resilience.

1. **Renewal and replacement of aging water and wastewater infrastructure.**
2. Financing for capital improvements.
3. Public understanding of the value of water systems and services.
4. **Long-term water supply availability.**
5. Public understanding of the value of water.
6. **Watershed/source water protection.**
7. **Aging workforce/anticipated retirements.**
8. Public acceptance of future water and wastewater rate increases.
9. **Emergency preparedness.**
10. (tied) Governing board acceptance of future water and wastewater rate increases.
10. (tied) Cost recovery (pricing water to accurately reflect its true cost)

Intelligent Water investments are booming

Since 2009, more than $150 million in venture capital has been allocated to digital water solution providers (Figure 5).[3] The burgeoning demand for asset management, data acquisition and advanced analytics will continue to drive venture funding and investment, supported by projected (if not existing) needs.

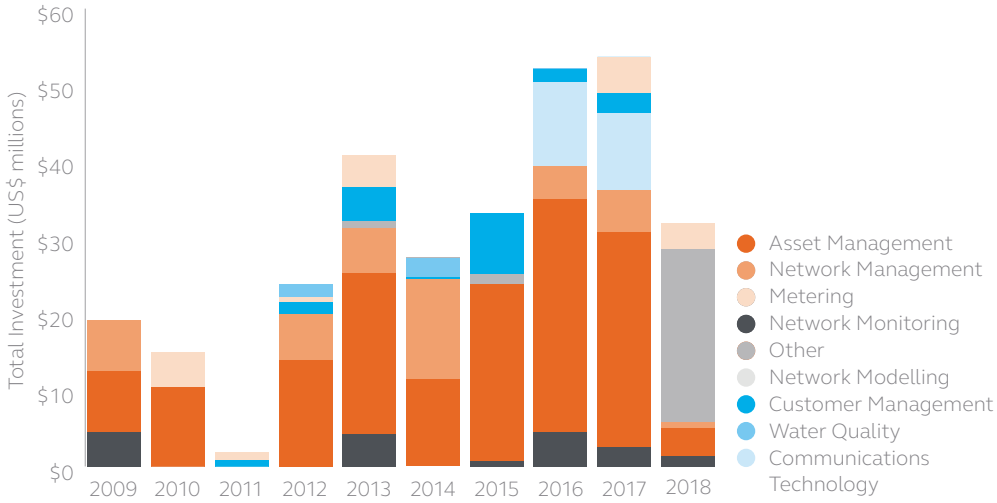


Figure 5 – Digital Solutions Attract Venture Capital Interest. Source: Bluefield Research.

The water sector's supply chain and service provider landscape is experiencing its own transformation. Of more than 350 companies offering digital solutions, 64 percent have been founded since 2000. In 2015 alone, there were 28 digitally focused company launches targeting the water sector (Figure 6). This boils down to the reality that all utilities will exceedingly be faced with management decisions in a rapidly evolving digital ecosystem.[3]

Figure 6 – Digital Water Companies by Year of Founding. Source: Bluefield Research

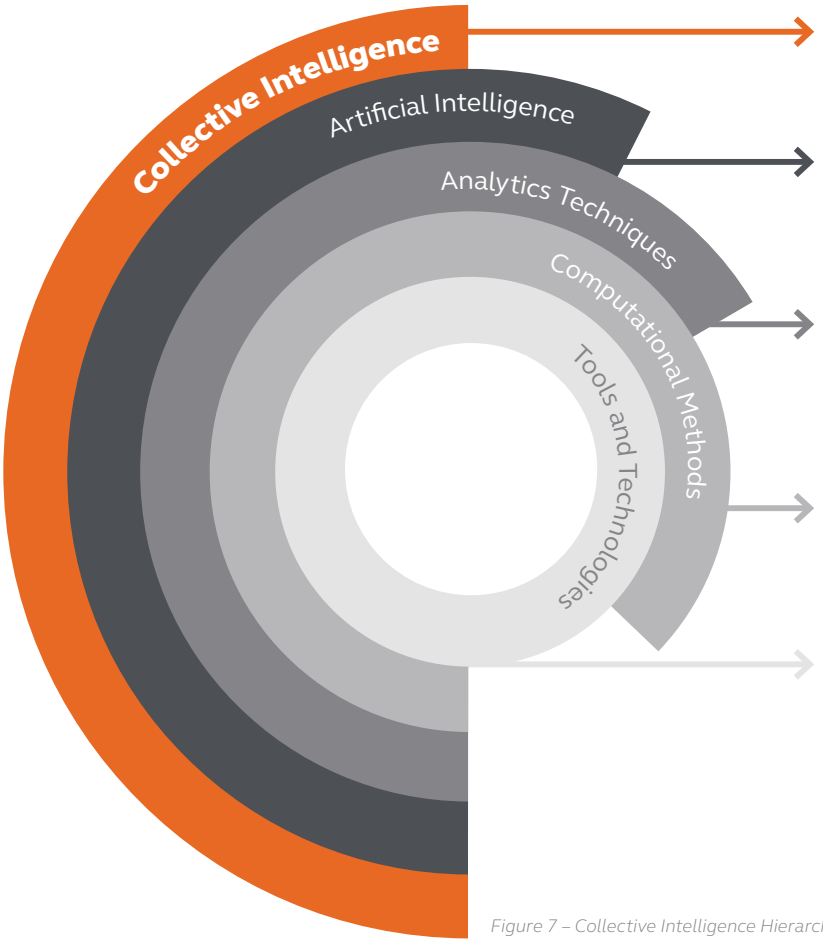
Demystifying Intelligent Water

Complex challenges such as affordability and resilience will endure, but Intelligent Water can transform utilities' abilities to address them.

AI technology such as machine learning, predictive analytics and the Internet of Things (IoT) is expected to revolutionize business the same way the Internet did.
What does it all mean?

Some might assume that technology will make all segments of the workforce obsolete, putting their jobs at risk. This couldn't be further from the truth. The goal is establishing collective intelligence (CI), where humans leverage digital solutions to improve resilience and affordability. It's about working smarter, not harder. Intelligent systems will enhance staff capabilities and automate tedious, time-consuming or dangerous tasks.

Collective intelligence hierarchy: Evolving with a human-centric approach



Abilities	Examples
Human intelligence capabilities	**Resolve bias, connecting broad spectrum of expertise**
Sense, reason, engage and learn	Machine learning, computer vision, natural language processing, robotics
Learn and solve specific problems	Supervised learning, unsupervised learning, reinforcement learning
Reason and pattern recognition	Neural networks, support vector machines, regression, decision trees
Physical enablement and measurement	Platforms, UX, APIs, sensors, meters

Figure 7 – Collective Intelligence Hierarchy. Source: Arcadis.

A group of subject matter experts brainstorming together can accomplish great things. So too can powerful computers working together in the cloud. With CI, the two groups combine to unlock significant value that would be inaccessible to either group on its own. This allows a utility to deploy human-centric improvements and data-driven solutions around business decisions, customer relationships, operational efficiency and asset planning.

Intelligent Water will be a long-term evolution, but there are ways to leverage CI like this today. It all begins with the familiar tools and technologies (such as sensors and meters) used to monitor and control, except now they're all connected in the IoT. Computational methods and analysis techniques that have been part of the data-intensive utility management programs incorporate more real-time data and use algorithms to learn, improve and predict. AI, via machine learning, brings all these analyses together to create actionable insights for staff at the controls (Figure 7).

The water sector can use these tools to empower staff throughout their organizations and establish a foundation for a truly intelligent, human-centric future in the water sector.

Intelligent Water 101: **Key terms**

Collective intelligence (CI)
Ability of humans and machines to collectively present far greater intelligence than either element could on its own.

Artificial intelligence (AI)
Ability of machines to sense, reason, engage and learn in a manner that seems intelligent.

Machine learning
Ability to improve processing results from experience for a specific need.

Predictive analytics
Application of advanced data processing techniques to predict future conditions.

In the boardroom: Optimizing business intelligence

Executive decision-makers must meet customer expectations for reliable, affordable and resilient service using limited physical, financial and human capital. Strategies must identify cost-effective solutions for assessing asset conditions, targeting high-impact capital improvement and replacement projects, and maximizing the service lives of remaining assets.

Asset management

Advanced asset management tools, including those powered by AI and predictive analytics, have the potential to save U.S. water utilities a total of $17.6 billion in capital expenditure between 2018 and 2027, according to Bluefield Research forecasts (Figure 8).[3]

The truth is that while many assets are at or near the ends of their expected lives on paper, most utilities lack insight on the health and performance of their assets in practice. Utilities can optimize their approaches by moving away from relying on industry standard data to algorithms using utility-specific data, which doesn't need to be perfect, to continuously learn and improve asset decisions.

Algorithms trained on large historical asset failure datasets and data on individual assets (e.g., age, performance, condition, geospatial context) can calculate both the likelihood and the cost of failure. Other algorithms trained on historical maintenance and real-time operational data then inform the best decisions for overall maintenance approach, rehabilitation or replacement interventions.

This technology can also support long-term capital planning by identifying the highest-impact projects that fit specified parameters such as budgetary limits, performance targets, future planning scenarios or high-priority geographic areas.

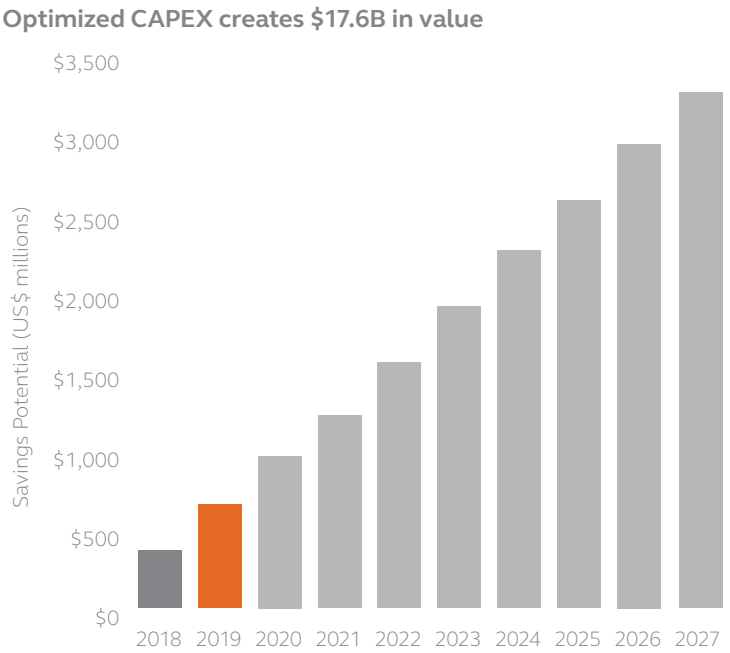
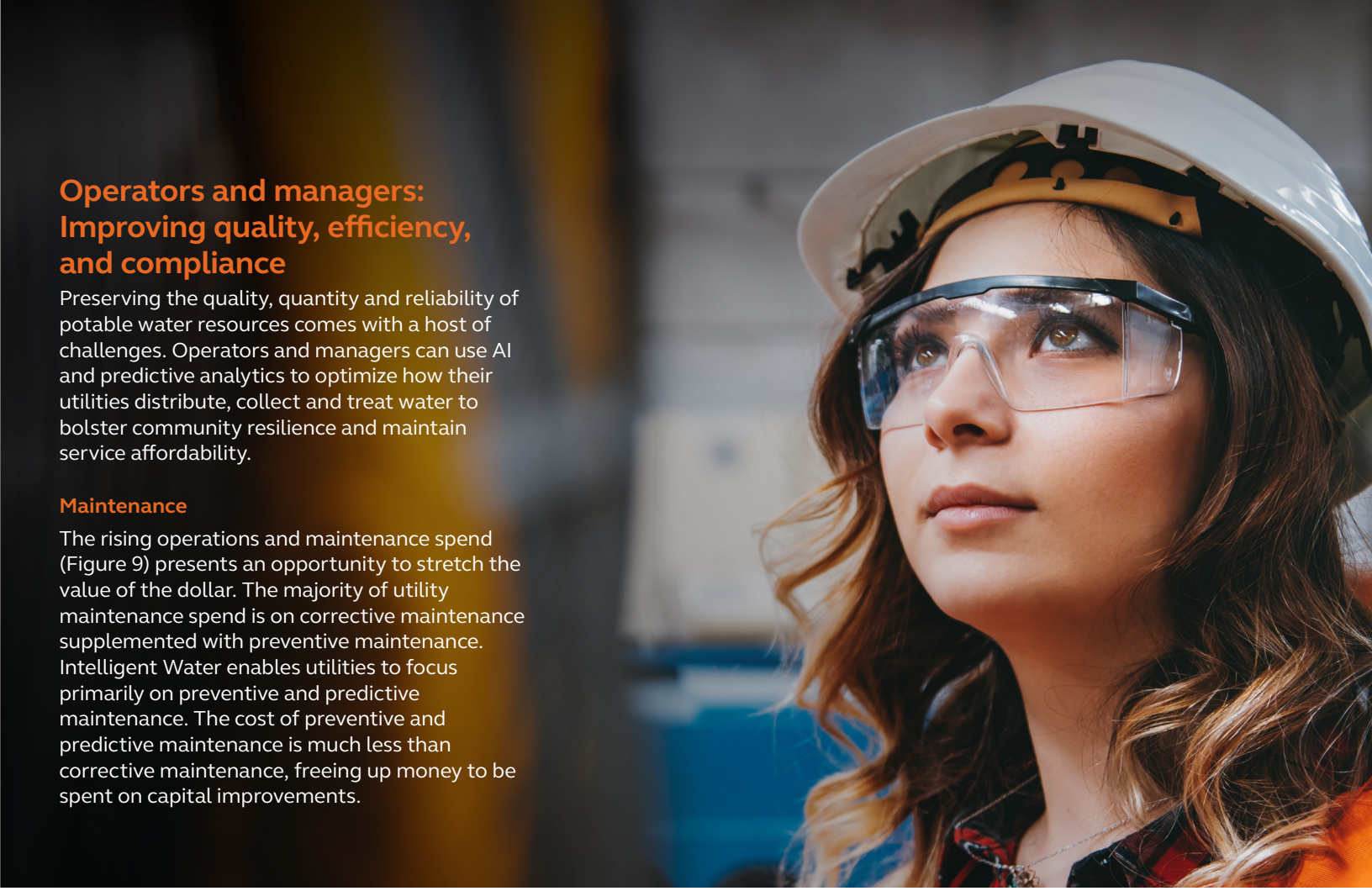


Figure 8 – Potential U.S. CAPEX Savings from Advanced Asset Management, 2018-2027. Source: Bluefield Research.



Operators and managers: Improving quality, efficiency, and compliance

Preserving the quality, quantity and reliability of potable water resources comes with a host of challenges. Operators and managers can use AI and predictive analytics to optimize how their utilities distribute, collect and treat water to bolster community resilience and maintain service affordability.

Maintenance

The rising operations and maintenance spend (Figure 9) presents an opportunity to stretch the value of the dollar. The majority of utility maintenance spend is on corrective maintenance supplemented with preventive maintenance. Intelligent Water enables utilities to focus primarily on preventive and predictive maintenance. The cost of preventive and predictive maintenance is much less than corrective maintenance, freeing up money to be spent on capital improvements.

Get ahead of rising maintenance costs

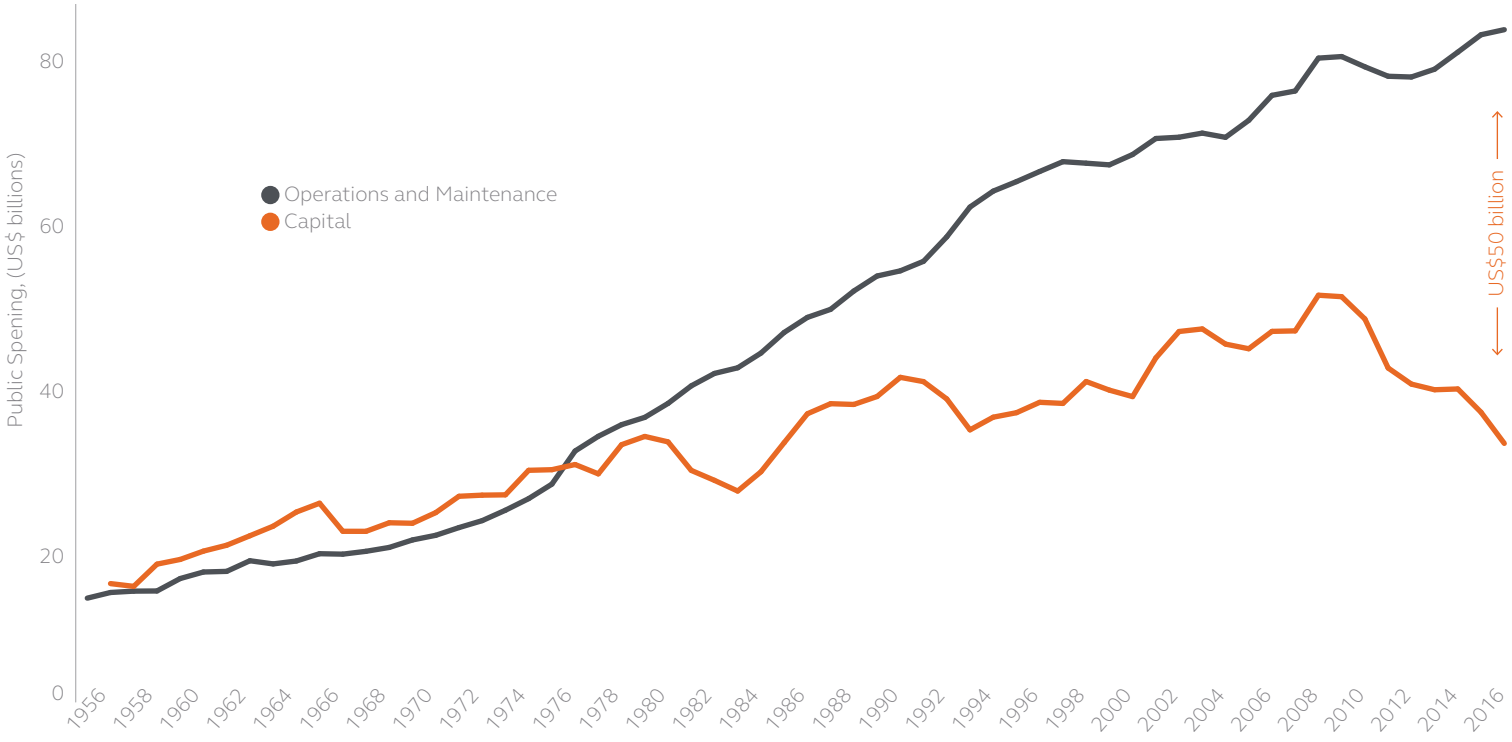


Figure 9 – Public spending on Capital and O&M Investments, 1956-2016.
Source: Bluefield Research using U.S. Congressional Budget Office data.

Regulatory compliance

Heightened regulatory pressure might call for costly transformations – but the investments in digital upgrades could be less than the cost of waiting. For example, consider wet weather. The EPA issued 91 consent decrees between 1998 and 2018 for violations of the Clean Water Act, with total civil penalties of $48.2 million and total estimated compliance costs of $51.6 billion (Figure 10).[10]

The value of avoiding consent decrees

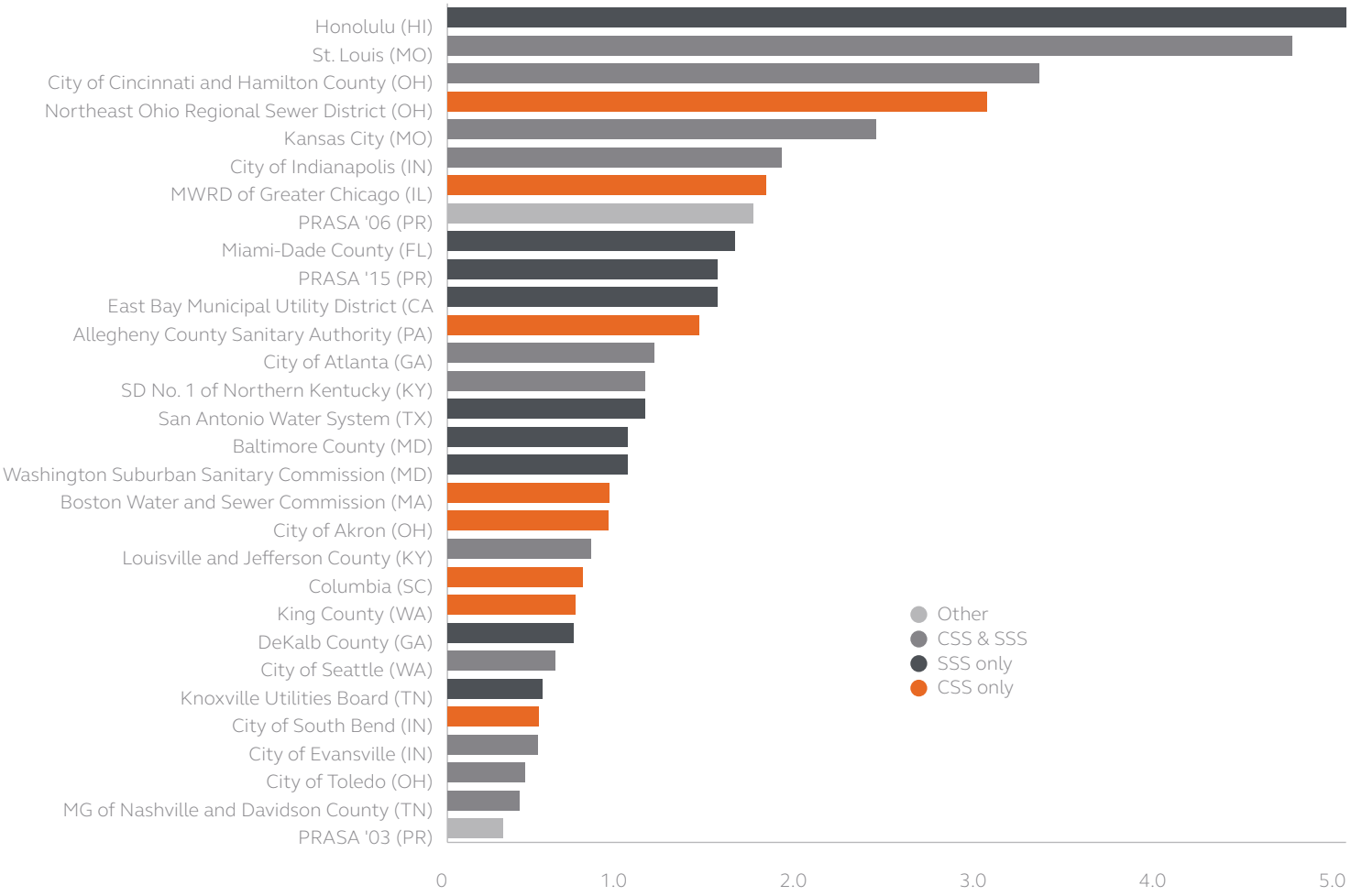


Figure 10 – Outstanding Costs for Top 30 Consent Decrees. Note: Combined Stormwater System (CSS); Sanitary Sewer System (SSS). Sources: EPA, Bluefield Research.

Wet weather optimization

Intelligent wet weather management systems combine meteorological forecast data with real-time information on levels, flow, and storage capacity across stormwater and combined sewer collection networks, helping optimize capacity during wet weather events to reduce flooding and overflows.

That optimization comes with real savings. For example, in Cincinnati, the estimated cost was $1.00 per gallon to treat stormwater and $0.40 per gallon to store stormwater using traditional methods. But in reality, it only cost $0.01 per gallon to meet a regulatory consent decree using intelligent network optimization solutions.[10]

The potential savings multiply when you factor in how these systems help organizations avoid regulatory fines associated with wet weather incidents. A data-centric focus toward stormwater has proven valuable for cities such as Pittsburgh, Columbus and Los Angeles.

Distribution network intelligence

U.S. utilities lose nearly two trillion gallons of water – or 15 percent of the total drinking water treated nationwide – to leaks each year (Figure 11). Non-revenue water (NRW) rates climb as high as 43 percent in major U.S. cities and exceeds 85 percent in some smaller rural communities. In addition, the nation sees roughly 240,000 water main bursts per year (more than 650 per day), exacerbating the stress on limited utility budgets and scarce community water supplies.[3]

Across the nation, NRW is rising

Figure 11 – Non-Revenue Water (NRW) Rates in Select U.S. Cities.
Source: Bluefield Research using American Water Works Association data.

AI-enabled event management platforms aggregate and analyze real-time distribution network data from across a variety of departmental silos – remote monitoring instruments, control room SCADA systems, customer service call centers, etc. – to help utility managers proactively address leaks, bursts, pressure events and other network incidents.

Point-of-use: Engaging customers and building relationships

The proliferation of smartphones, IoT technology and social media has transformed the relationship between utilities and their customers, enabling an unprecedented degree of two-way communication.

Staff can inform homeowners of anomalies or engage them via social media with water conservation tips. Customers can act as utilities' eyes and ears on the ground, alerting staff to leaks, pressure changes or water quality issues that may indicate bigger problems in the network.

Smart home/facility water management

Water damage accounted for more than 31 percent of total annual losses incurred by insured homeowners, on average, between 2013 and 2017 (Figure 12).[11] And the average commercial facility leak goes undetected for 45 days, with an average volume of five gallons lost per minute.

AI-enabled leakage detection systems detect anomalies that are consistent with leaks and automatically shut off a water supply in order to prevent further water loss and property damage.

Water leads in homeowner insurance losses

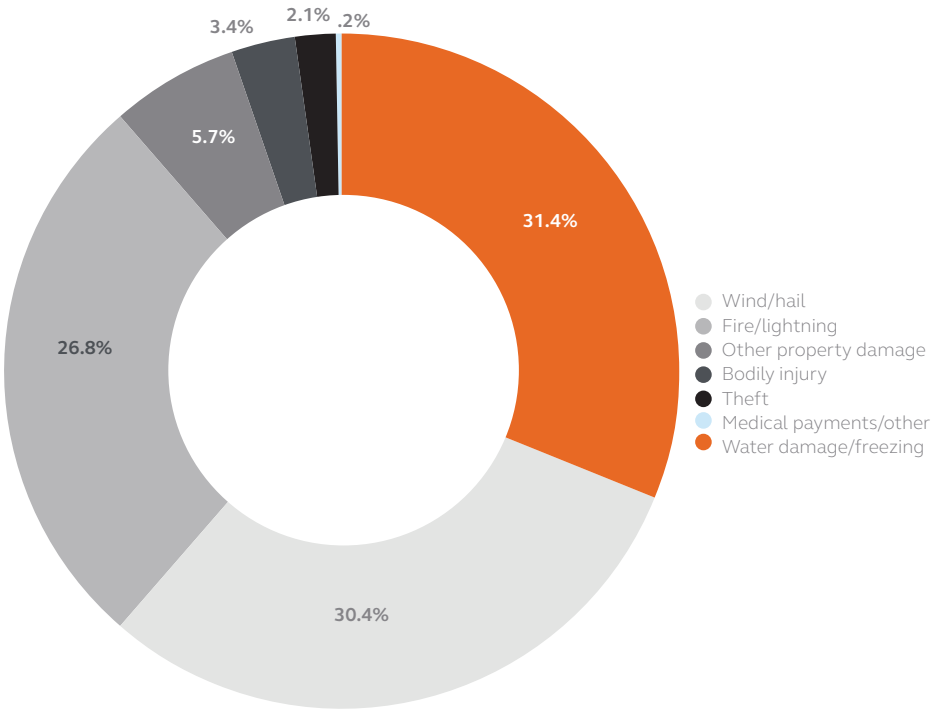


Figure 12 – Homeowners Insurance Losses by Cause, 2013-2017 (Average Annual %).
Sources: Insurance Information Institute, Bluefield Research.

Customer management

Natural language processing helps utilities to identify patterns in the written feedback that their customers provide to them, giving a clearer view into how customers feel about their service providers, as well as the topics (conservation, billing, utility policies, etc.) they care about most.

AI platforms also help customers make sense of their real-time smart meter consumption data and can suggest targeted water conservation measures based on individual household usage patterns. Alongside improved customer satisfaction, this engagement can reduce the number of service calls that can cost around $200 per call.[3]

Reality check:
Customer expectations

Real-time data access

A primary tenet of Intelligent Water is improving the customer experience. Consumers are asking for more transparency regarding water; they want to know about its quality, their consumption, and the role they play in improving both.

Companies outside of the water sector are providing in-home water quality and quantity monitors customers can attach to their service connection outside of the purview of the utility. Utilities must be the ones informing customers about their water. Intelligent Water can provide the same access with the added benefit of providing actionable insights beyond monitoring data.

Armed with real-time access to data on individual account usage, potential leaks, and other concerns, customers and their utilities can spot anomalies before they become costly. Instead of calling to express discontent over a high water bill after the fact, customers become part of the preventative action and receive a better experience overall.

Industry perspectives

Owning and enhancing water's role in a community

An interview with Nicole Pasch
Acting Assistant Environmental Services Manager
City of Grand Rapids

Woven throughout intelligent water's dashboards, sensors and analytics programs is a desire to test creative solutions. "You have to roll your wins into tries," explains Acting Assistant Environmental Services Manager Nicole Pasch, describing how organizations can leverage momentum from an Intelligent Water achievement into the next great idea.

For Grand Rapids, a 30-year combined sewer overflow (CSO) project eliminating 12.6 billion gallons of raw sewage from flowing into the Grand River in 1969 to zero in 2014 sparked additional improvements and community engagement using intelligent tools.

People-driven affordability

"Looking into affordability accelerated our Intelligent Water journey," Pasch says. When the global financial crisis hit in the late 2000s, diverging household incomes and a surging poverty rate inspired the City of Grand Rapids to reconsider investment equity. Instead of the traditional household median income lens, they used poverty-level income to measure the effects of capital investments and operational costs on users.

> "Our goal became doing the right work, at the right time, under the right conditions and for the right reasons."

Intelligent sensors and predictive analytics helped the utility maintain affordability while taking advantage of low municipal bond rates to complete the CSO project. Fringe economic and quality of life impacts, such as beautification associated with work (e.g., repaved roads, urban landscape design), entered the conversation for the first time.

By isolating the most impactful areas of work, a potential $1 billion investment in a hydraulic model system was whittled to a more affordable $30 million plan.

Success breeds success

The CSO project opened citizens' eyes to improved water quality, paving the way for a future river revitalization project. Even the media saw the utility in a new light, addressing a recent mechanical issue that caused the release of partially treated waste from the system with better technical understanding than the doom-and-gloom headlines of days past.

The strengthened community presence also enhanced collaboration with the community. "Breaking down barriers and allowing everyone a little input creates great results," Pasch says. A local brewery, for example, teamed with the utility to manage its pollutant discharge, which allowed for a $4 million investment in a pipe for high pollutants rather than a $130 million expansion of secondary treatment capacity.

Looking ahead, the organization is exploring how predictive analytics might expand pollutant capacity, as well as ways to share real-time and predictive water quality data with citizens. Pasch predicts the path ahead will lead to more notable wins and, by extension, more creative tries.

Creating value as demand drops

An interview with: Thomas Ginn
Planning and Technical Services Manager
Cobb County-Marietta Water Authority

The decreased demand for water is forcing many utilities to pivot their plans. In Georgia, The Cobb County-Marietta Water Authority (CCMWA) expanded its network for decades to brace for an increase in demand that has not come yet. Now, with the prospects of further reduction in demands, CCMWA is dealing with infrastructure with capacities greater than current demands, according to Planning and Technical Services Manager Thomas Ginn.

Ginn hopes Intelligent Water can create value to offset the projected revenue that was lost when demand dipped.

"Because of demand decrease, we're looking to leverage smart networks to utilize new technology to operate our additional infrastructure as cost-efficiently as possible," Ginn says. For example, enhanced leak detection using transient monitoring allows the utility to detect large leaks over its expansive network more quickly and optimize field crew time.

Ginn believes intelligent water can leverage the excess infrastructure to meet its goal of 100 percent up-time and optimized energy use. "Our operators have saved us a tremendous amount of money [over the years] by being able to minimize pumping in peak hours. What we would like to do is use technology to stretch the system even further," Ginn says.

Intelligent resilience planning

Still, some stressors remain. Over the past 25 years, $250 million in infrastructure investments improved the system by replacing older infrastructure assets, but "as these newer assets age, they're all going to require much more attention than the assets of a generation ago," Ginn notes. He sees potential for intelligent tools to provide better insights into potential problems and cost-effective solutions.

Like most of the industry, workforce attrition is a concern as the utility's experienced operator team nears retirement age. According to Ginn, the workforce of the future will demand intelligent water solutions as the norm.

> "They're going to ask: 'Why can't I just run the system from my phone? Why can't I run what if scenarios?' I think over the next 10 years our industry must adopt the tools available to attract and keep the interests of the best and brightest."

Self-awareness required: The Intelligent Water journey

Assessing organizational maturity, especially capacity for innovation and change, is an important first step along the journey to Intelligent Water.

Advanced solutions play critical roles in three key decision-making phases: Core, tactical and strategic. Advanced analytical insights such as predictive analytics can only be achieved once a utility has effectively integrated disparate data sets together, clearing the hurdle of utility mistrust of previously collected data.

Consider a cross-industry representation of the diffusion of innovation (Figure 13). It's the innovators and early adopters that are already receiving the benefits of Intelligent Water. Evaluating where a utility sits along the adoption curve can inform preparations for change.

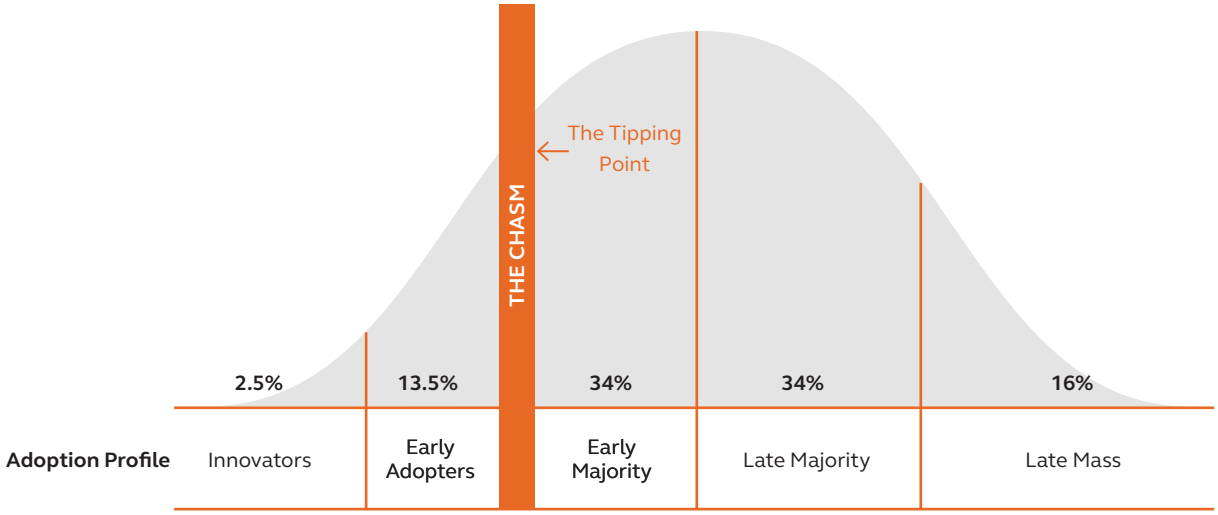


Figure 13 – The Theory of Diffusion of Innovation. Sources: Rogers, Everett and Gladwell, Malcom.

While assessing technology adoption is a key component of self-awareness, assessing maturity as an organization is critical to self-awareness as well (Figure 14). A utility can assess its maturity by mapping intelligence across each strategy. Take asset management: Most plans begin by establishing a core asset management layer, marking the representation of assets within geo-spatial models and a first step towards situational awareness. Tactical solutions follow, generating asset-centric operations and maintenance data to better understand performance in real-time and inform reliability-centered maintenance practices. The tactical solutions work together to form an overall intelligent strategy that maximizes an organization's strengths.

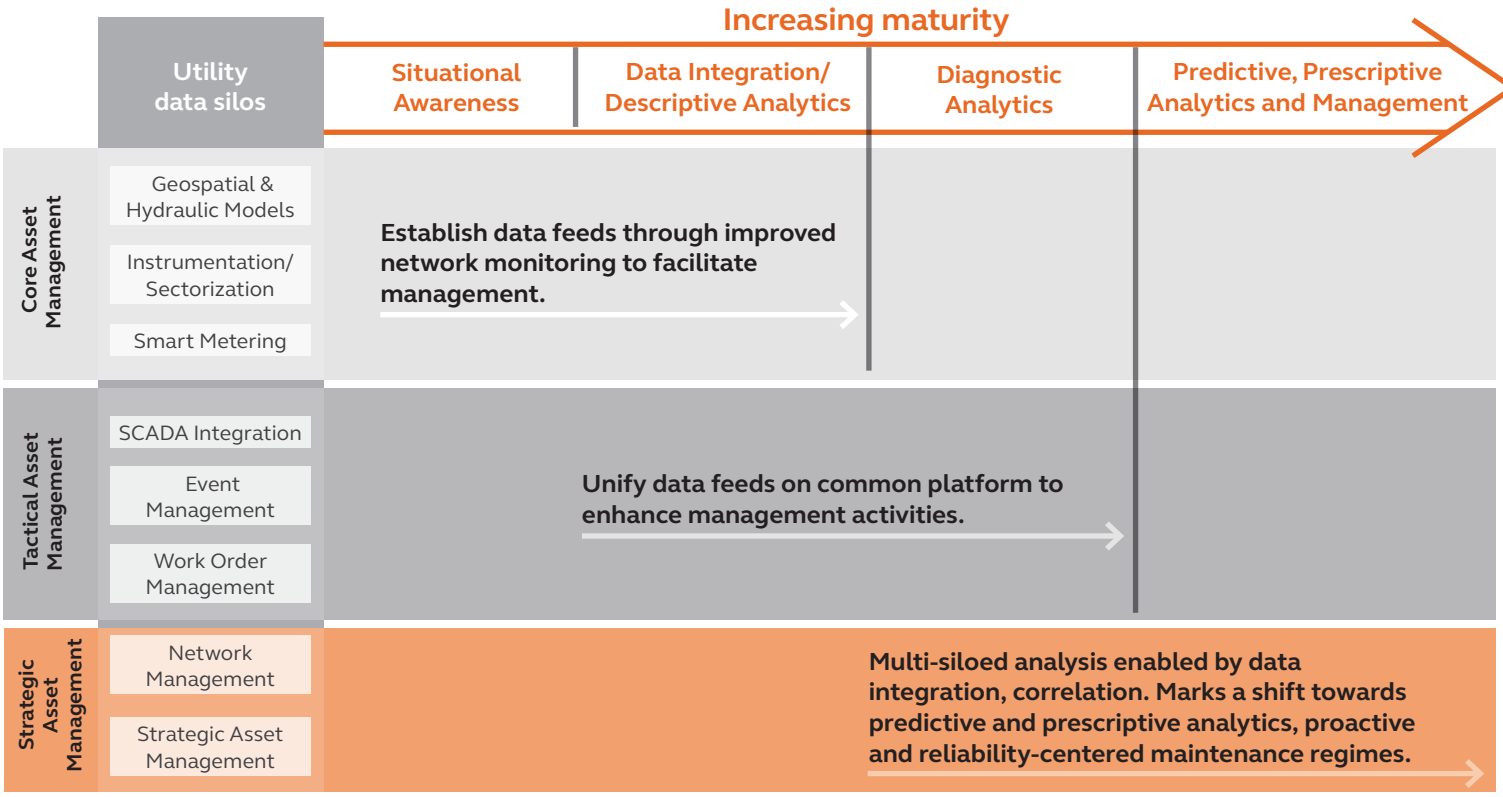


Figure 14 – Example application of Situational Awareness applied to asset management. Source: Bluefield Research.

Five questions to frame CI implementation

You might discover that your organization is ready to implement intelligent solutions that leverage CI. Each potential application poses a different set of requirements. Keep these five questions in mind when mapping and implementing any CI technology:

1. Does the technology provide a better result, outcome or business impact than your current process?
2. Where is your organizational maturity relative to innovation and change?
3. Is the tool less complex to implement than other tools with a similar output?
4. Can the technology (and the data it collects) be made transparent across the organization?
5. Can the new tool be easily adopted by the workforce?

Navigating current AI challenges

Even if an organization is ready to adopt AI, using it won't always be obstacle-free. Uses for AI are still evolving, and introducing it to your organization means addressing these common challenges:

- Data is required, but perfect data is not. Utilities that wait for a complete and perfect dataset to adopt advanced technologies will miss untapped value today. However, incorrect conclusions can be reached by machines with insufficient data, so a healthy data input is necessary.
- Today's AI is task-specific whereas future AI will be enterprise-wide. At this stage, AI is limited to narrowly focused, project-specific tasks that operate at levels less than human intelligence. Through a combination of experiential learning, refinement of solutions, and technology proliferation, the future of AI is expected to transition toward greater machine reasoning and ultimately artificial super intelligence exceeding human intelligence levels.
- Positive outcomes from AI and predictive analytics are not always guaranteed. We are early in the intelligence revolution. One of the larger benefits of AI is to reduce resource demands and errors in data collection and curation, but these new tools must be managed by experienced professionals capable of identifying anomalies within the specific environments.
- The social impacts of AI are evolving. Today, many large technology firms are still operating in uncertain environments tested by a lack of visibility into ethics concerns surrounding AI. Deep learning presents a unique challenge, as machines could potentially develop bias that impacts their predictions.

Becoming a fit-for-future utility

Some organizations might be further along the Intelligent Water journey than others, but most organizations are in the nascent stages of evolution.

Digital transformation remains a significant challenge for utilities, even amidst the overwhelming evidence in support for change:

27% of utilities have neither adopted, nor begun to implement, maintenance management tools

36% have neither adopted, nor begun to implement, customer information systems

40% have neither adopted, nor begun to implement, cyber intrusion safeguards

Only **20%** of utilities leverage big data tools and techniques to glean insights about their water and wastewater systems

17% use big data to better understand customers and system O&M[1]

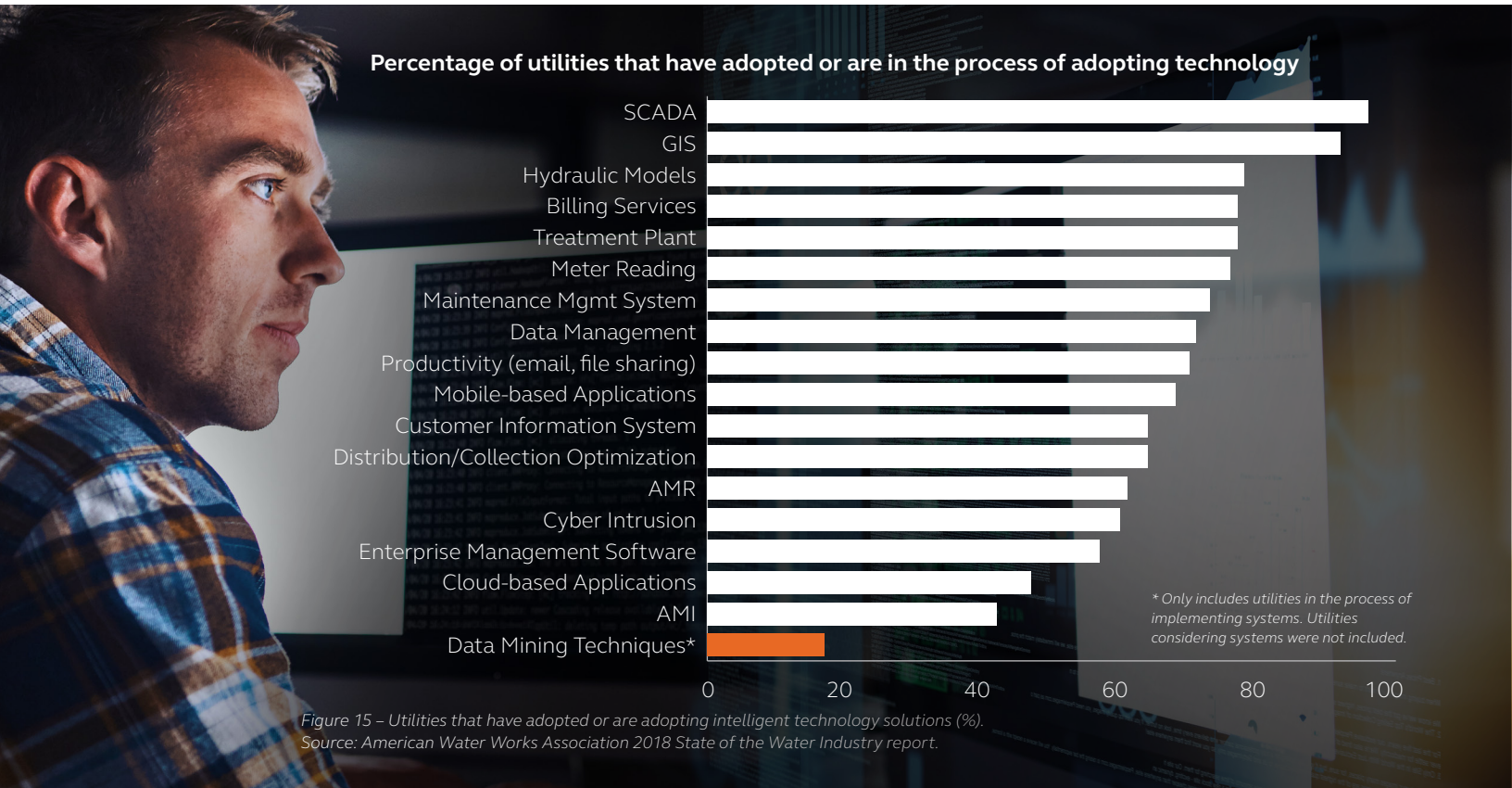


Figure 15 – Utilities that have adopted or are adopting intelligent technology solutions (%).
Source: American Water Works Association 2018 State of the Water Industry report.

Utility leaders must begin to adopt more innovative management approaches embracing and leveraging Intelligent Water's potential. Doing so will result in a more empowered utility workforce capable of optimizing performance, controlling cost and delivering improved services to customers.

Three guiding tenets to help establish a fit-for-future organization:

1. Empower digital innovation:

Set a vision with a perspective towards resilience. Conditions are constantly in flux, whether they be large storm events inundating stormwater systems or asset failures resulting in overflows. But water system management from supply to disposal has historically remained the same. Transitioning to a more sustainable operating model requires embracing innovation and digital technology to address resilience and affordability. Every utility is driven by different priorities and the availability of data is equally variable. But recognizing the potential for data management, real-time analytics and planning tools can propel an organization toward adopting more intelligent tools.

2. Target CI

Technology doesn't solve problems; technology helps humans solve problems. The adoption of AI technologies aims to strengthen, not replace, an organization's human assets. By merging human institutional knowledge with available Intelligent Water technology, utility leaders can arrive at informed, data-driven decisions.

Central to any transition is workforce buy-in. Fueled by futuristic movies and sci-fi literature, the threat of robots and machines taking over is overstated. AI does not operate in a vacuum and requires management to efficiently identify risks, incidents, and opportunities for improvement across a network. A systematic focus on applying data analytics will reduce the risks of workforce volatility. Collectively, the new workforce and application of AI technology will provide greater value for utility leaders and stakeholders.

3. Focus on the customer experience

Customer needs should drive the prioritization of areas to be addressed by Intelligent Water. **The water sector is people-driven, enabled by data**. Let customer needs drive the conversation, not the technology itself. Connecting customers to their infrastructure environment will create value over time. Customers (domestic, commercial, and industrial) are rarely presented with insights into their water and wastewater supply. The interaction typically stops at paying the monthly bill. For them water is out of sight, out of mind.

But as demonstrated in the power and telecommunication industries, customers can appreciate the value of more enhanced utility offerings delivered though transparent mechanisms. Utilities can no longer operate in a bubble, and proactive customer engagement is paramount to making this change.

Utilities can become more customer-focused by delivering personalized presentations of water consumption, peer comparisons and network disruptions impacting water availability and quality.

The pace of change will accelerate as more organizations realize the value of adoption. Fit-for-future organizations are better prepared to handle changes and incorporate new opportunities as they arise, giving them the chance to drive the market rather than be driven by it.

Reality check: **Interconnectedness**

Utilities cannot escape the reality of an increasingly connected world.

500 billion
Mobile devices that will be connected by 2030.

16%
Compound annual growth rate for mobile devices in North America from 2017 to 2022, the highest rate among global regions.

200%
Year-to-year growth rate for the IoT.[12]

Looking ahead: Intelligent Water and Smart Cities

Intelligent Water will serve as a foundational building block for Smart Cities. They'll provide an opportunity to leverage the vast sensor and communication networks of water systems to benefit the cities, even in areas that don't typically incorporate water or utilities.

The truth is, a Smart City lacking Intelligent Water won't be very smart at all.

The sector already represents one of the strongest business cases for Smart City communication and data deployments. At the same time, demand-side factors, including affordability, urbanization and a convergence of infrastructure management will play a role.

Demographic forces will shape the infrastructure landscape

The U.S. population is expected to grow by more than 100 million people from 2010 to 2050, a majority of which will reside in metropolitan areas.[4] The surge in demand on critical infrastructure , including and beyond water, will compel utility leaders to better capture and leverage insights across all assets.

Telecom heavyweights want a role in Smart Cities

Telecom companies' continued expansion within the water IoT market is expected to put pressure on more specialized metering providers and potentially alter which communication networks and protocols are best suited for water, gas, and electric Advanced Metering Infrastructure (AMI) customers.

These larger, well capitalized firms are already aiming to displace established, specialized water sector players by leveraging expansive communications network infrastructure (including 5G networks), brand recognition, and the interoperability of their low-power wide-area network offerings across a range of municipal IoT devices and applications. This will be a key consideration for municipalities looking to use AMI investments as anchor points for Smart City platforms.

Intelligent Water 101: **Key terms**

Smart Cities

Smart Cities are urban environments focused on using the IoT to optimize utility, mobility and living. Building intelligence into a city's One Water approach is critical to any Smart City initiative.

Eyes in the sky on the horizon

The role of satellite-based leak detection could prove critical in more quickly assessing underground assets across the U.S. Satellites are poised to more readily and efficiently identify sources of NRW, reducing errors and the need for field personnel.

Closer to ground, visual inspection of network assets and reservoirs will increasingly be performed by drones. This will bolster workforce safety, particularly in more dangerous environments.

Converging infrastructure and benefits to water utilities

To date, the water and power sector verticals have mostly coexisted as customers of one another, rather than as partners in managing energy and water flows within city networks. That's changing, and water utilities can help lead the paradigm shift rather than leaving it all to the power sector.

The U.S. is transforming how it's powered, with wind, solar and natural gas on the rise while coal use declines. The change will put stress on electricity grids, and potentially create value for water and wastewater systems via improved onsite power management and power purchase agreements with electric utilities.

One Water principles take root in the utility sector

A parallel convergence is also taking place within the U.S. water industry, as utility leaders look to harmonize management practices across the water cycle, from source water extraction and distribution, to wastewater and stormwater collection, disposal, and reuse.

Intelligent Water platforms can help utilities to collect, process, and share data and insights across departmental silos, thereby enabling a more holistic, collaborative approach to water resource management.

Beginning the human-centric evolution

AI and interconnected systems can help utilities and communities improve water affordability and resilience.

The changes will be disruptive, but the reverberations will strengthen your organization's capabilities.

Intelligent Water represents a long-term evolution for most utilities, but there are ways to install a solid foundation today that your organization can build its intelligent network upon. Understanding your maturity and capacity for innovation and change can inform your strategy so that AI is a true game-changer.

Maintaining the status quo will be insufficient. Many utilities need to innovate to effectively address known challenges regarding climate, workforce, and aging infrastructure. What about the unknown that lies ahead? Equipping your organization to take a proactive stance toward disruptions using AI and predictive analytics is a surefire way to put up your best defense against whatever comes next.

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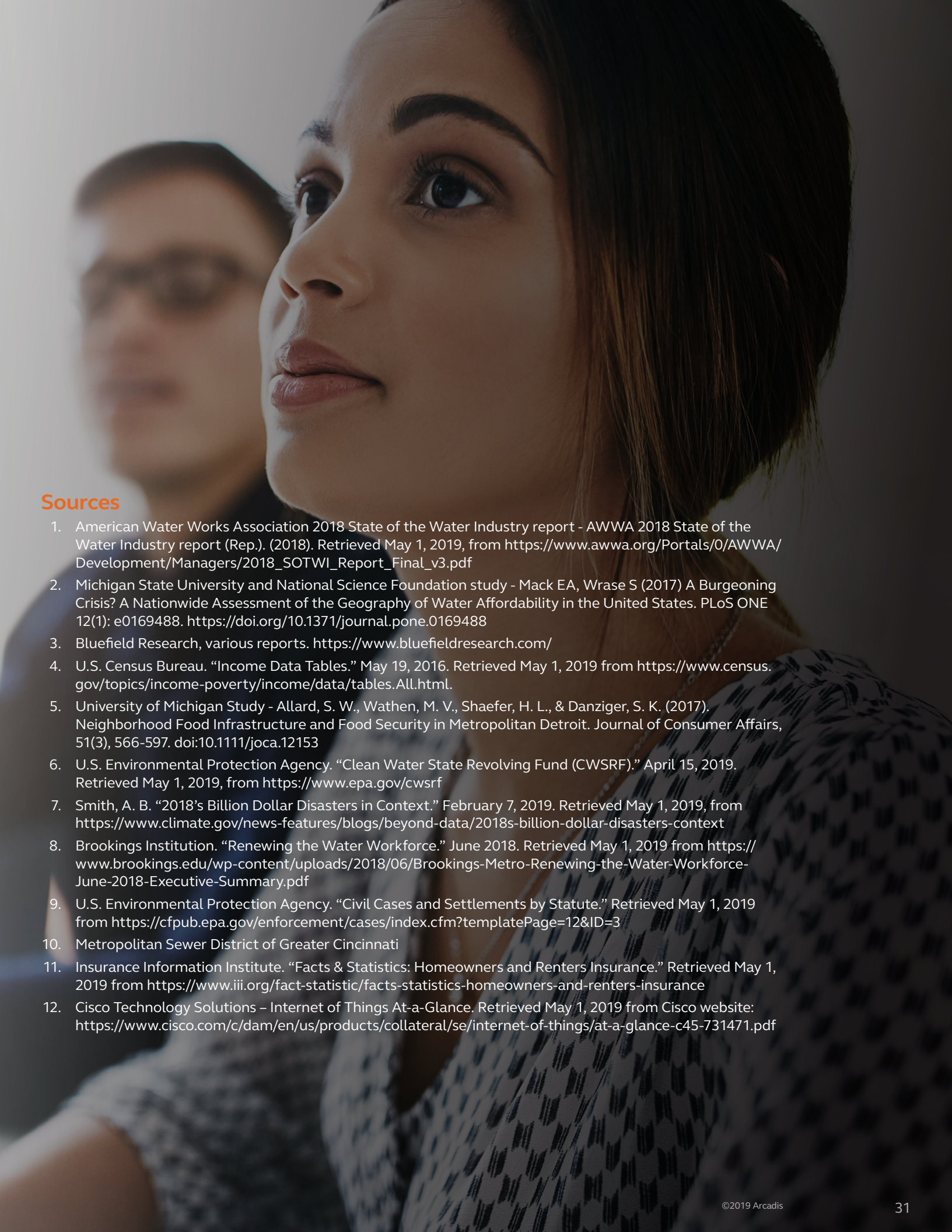
Figure 11 – Non-Revenue Water (NRW) Rates in Select U.S. Cities, Source: Bluefield Research using American Water Works Association data

Figure 12 – Homeowners Insurance Losses by Cause, 2013-2017 (Average Annual %). Sources: Insurance Information Institute, Bluefield Research

Figure 13 – The Theory of Diffusion of Innovation. Sources: Rogers, Everett and Gladwell, Malcom

Figure 14 – Example application of Situational Awareness applied to asset management. Source: Bluefield Research

Figure 15 – Utilities that have adopted or are adopting intelligent technology solutions (%). Source: American Water Works Association 2018 State of the Water Industry report



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