A less-than-flattering portrait of the water sector was revealed in AWWA's 2015 *State of the Water Industry Report*. The report showed that the health of the sector declined slightly when compared with 2014 results. Additionally, the soundness of the sector is expected to decline for the next five years. Why the downward slope? The 2015 report details major concerns, most of which can be traced back to key business practices.

Advancements in asset management focus on improvement. By implementing asset management business practices described in this article, utilities can successfully address the concerns cited in the 2015 *State of the Water Industry Report*, as well as uncover cost-effective ways to address asset renewals and replacements, better manage resources (physical, financial, and human), and improve the public’s understanding of the value of their water system. Utilities can take a unique approach and focus on improving different practices to maintain the health and soundness of their operation—there is no single solution or a one-size-fits-all approach that applies to all situations.

**THE CURRENT STATE OF ASSET MANAGEMENT PRACTICES**

A summary of asset management practices was presented in one report that described existing practices and future plans of US and Canadian water utilities with respect to those practices covering utility operations. The report...
showed that the main drivers for improved asset management practices were the need to upgrade, repair, and replace aging infrastructure, as well as the ability to better determine capital investments, effective maintenance strategies, and budgets (Bernstein 2013).

The core mission of utilities is to provide quality levels of service acceptable to their customers.

Members of the AWWA Asset Management Committee were asked to rate the most important business practices utilities could adopt. They selected the following: identifying levels of service; consideration and management of asset risks; condition assessment for evaluating an asset’s remaining useful life; development of strategic asset management plans; investment decision-making or business cases that consider environmental, social, and financial costs and benefits; and asset replacement planning. The following sections describe examples of the progress made in each of these areas.

**IDENTIFYING SERVICE LEVELS**

The core mission of utilities is to provide quality levels of service acceptable to their customers. Utilities new to advanced asset management are not often unsure about how to establish service-level goals, but rather are unsure about which goals should be set and measured. Service levels typically include technical service levels, such as main-break rates, the amount and duration of unplanned interruptions, and customer service levels that include call-hold times and the number of complaints received. Service-level goals for health and safety (e.g., number of accidents) and the environment (e.g., greenhouse gas emissions) are also included for a more balanced approach.

According to research (NWC 2014, Ofwat 2010), utilities in England and Australia have been required to monitor their performance using multiple service levels for many years. An annual report in Canada also captured information on the performance of utilities on a variety of measures (AECOM 2013). In the United States, the QualServe benchmarking report compiled utility performance data on many of the same measures (AWWA 2014). The Albuquerque (N.M.) Water Authority’s performance plan provides a good example of how performance data were used as a guide to operational performance improvement (the cover of the plan is pictured on this page). Although there are other utilities that have similar approaches, the current state of setting and measuring service-level standards in the North American water utility sector remains almost entirely voluntary.

A report establishing key performance goals for distribution systems showed that the most important goals of the project included the following: maintaining chlorine residual for water quality integrity, maintaining pressure for hydraulic integrity, and limiting the number of main leaks and breaks for infrastructure integrity (Friedman et al. 2011). Another report noted 13 performance indicators for drinking water assets “that should be considered as the bare minimum in developing an asset management program” (Oxenford et al. 2012).

The creation and use of service standards has improved performance and driven a better understanding and support for utility operations within their respective communities. Since 2011, Toho Water Authority (2014) in Kissimmee, Fla., has reported quarterly service levels for water, wastewater, and reclaimed water services to its board of supervisors in six key categories: infrastructure reliability, organizational responsiveness, regulatory compliance, customer service, financial performance, and workforce initiatives. Each category has six to eight key performance indicators with an overall roll-up indicator for the service-level category. Simple green, yellow, and red graphics indicate areas in which improvements are needed. Another comprehensive approach to planning and monitoring performance was created by San Francisco Public Utilities Commission (Calif.) (SFPUC 2011). Its *Strategic Sustainability Performance on Goals and Objectives, Fiscal Year 2010–2011* report tracked hundreds of key performance indicators and covered six categories: customers, community, environment and natural resources, governance and management, infrastructure, and workplace.

**THE ROLE OF RISK MANAGEMENT**

According to the Water Research Foundation’s Asset Management Knowledge Portal, “risk management is the most important concept related to the management of water
utility assets.” The AWWA Asset Management Committee ranked “assessing the risk of asset failure” as one of the most important asset management topics.

The risk of failure as it relates to infrastructure assets is an integral part of asset management for high-performing utilities. Asset-based risks are typically defined in terms of likelihood or probability of failure (related to the condition of the asset) and the consequence of a failure. Annual risk costs can be quantified for budgetary and life-cycle costing purposes by multiplying monetized consequence of failure estimates by the estimated annual probability that the failure will occur. A framework for risk management was described in the Australian/New Zealand Standard for Risk Management, Standard AS/NZS 4360, which focused on the following: identifying risks, evaluating those risks, and considering risk mitigation or treatment options (SAA 1999). In order to justify mitigation, it becomes helpful to quantify risk costs that can then lead to business case evaluations on the effectiveness of risk reductions.

Many utilities focus their risk management efforts on water pipe, which is the largest proportion of net asset value to the utility. The most cost-effective maintenance strategy for most distribution pipes is reactionary. Repair costs and social impacts associated with leaks and breaks are generally dwarfed by costly proactive approaches of physical condition assessment and pipeline replacement. This is not the case for frequently breaking or higher-consequence pipes, such as larger-diameter distribution or transmission mains or pipes manufactured using materials that are more prone to catastrophic failures. One report compiled and analyzed costs associated with 30 large-diameter pipes across North America. After monetizing the various consequences, the report indicated the average failure costs were close to $2 million with half of those being societal costs (Gaewski & Blaha 2007).

In Oregon, Portland Water Bureau’s approach to risk management of pipes focuses on high-consequence crossings of major highways, railroad lines, and pipes on bridges; the photograph on this page is an example of how an above-ground road-crossing pipe that was out of alignment was caught during an inspection. The estimated average consequence of two previous failures, one under a major highway and the other on a bridge over a railroad line, was $2.5 million (Leighton 2014). As a result, condition assessment, valve exercising, and valve installation on those pipes became a priority for the Portland Water Bureau.

The Metropolitan Sewer District (MSD) of Greater Cincinnati (Ohio) was another utility that applied risk management across the organization. The intent of its effort was to capture high risks in three categories: corporate, operational, and physical assets (IWA & WSAA 2012). MSD developed a risk register to track risks and risk mitigation efforts. Additionally, MSD prioritized capital projects and changed the frequency of maintenance activities partly because of the risk to the utility and its community.

USING CONDITION ASSESSMENT TO IMPROVE DECISION-MAKING

Assets fail in many ways. Armed with condition assessment knowledge, utilities can make better decisions about asset renewals or replacements, which in turn can save valuable financial resources that can then be allocated to address more critical needs. The approach by which condition assessment is used should be thought of as reducing the range of uncertainty in risk assessments, and helping identify factors affecting asset condition applied across a wider suite of like assets. Utilities should consider ways to incorporate existing data (e.g., leak detection programs) into their decision-making processes for long-term replacement planning.

Assessing the condition of water pipes can be challenging and potentially expensive. Many utilities acknowledge that replacing pipes in good condition as part of a routine replacement program (on the basis of age alone) is not sustainable or practical. Some utilities prefer an “assess and address” approach that deploys appropriate condition-assessment inspection tools to determine the likelihood of failure. This information is then used to estimate the remaining useful life. Once the assessment is
completed, appropriate renewal options, such as repairs, rehabilitation, replacement, re-inspection, or no action, can be considered as part of an asset management plan.

Some inspection tools are relatively new to the market. But there is no silver-bullet inspection tool that provides all the data needed to establish the remaining useful life of a pipe (Faber 2014). However, there are several tools that can target various pipe-material failure modes (i.e., leaks, gas pockets, cracks, broken reinforcing components, wall loss) and can aid in managing the pipeline and help make defensible decisions.

The key to using condition assessment for risk-based decision-making is confidence in the data based on the resolution required. False positives and false negatives are a concern when using new technologies. Appropriate pilot testing is vital and should be performed with data validation and a prior understanding of the scientific principles employed when evaluating various technologies for condition assessment. Ultimately the desired outcome of a pipeline condition assessment project is to cost-effectively mitigate risks associated with potential failures and to understand when and where repairs and replacements of weak links in the system should occur.

ASSET MANAGEMENT PLANS

The AWWA Asset Management Committee ranked the development of asset management plans (AMPs) as one of the most important asset management topics because of its perceived value in helping utilities capture knowledge and plan future efforts. Authors in one report described the business practice of the Portland Water Bureau in creating tactical AMPs and noted, “[AMPs] are best efforts to create strategies, recommend actions, and quantify resources for future planning efforts (bringing all the departments together)” (Leighton & Letteney 2014). As a result, hundreds of recommended strategies were developed for preventive and reactive maintenance, repair, and replacement practices. As part of the initiative to develop AMPs, asset management staff provided guidance, tools, and training to AMP developers. A working group of AMP leaders met monthly to share information and facilitate the education process.

The Washington Suburban Sanitary Commission (Laurel, Md.) also identified and added asset management strategies and investment needs to its annual budgeting process. Its AMP included levels of service performance, business risks, and failure modes analysis (Vitagliano 2014). In Edmonton, Alta., Canada, EPCOR Utilities’ approach to AMPs was to create them at the enterprise level, the system/asset level, and the sub-asset level. EPCOR’s distribution-mains AMP included information on asset inventory, management of data, approach for 5 to 10% of capital replacement (Hunt et al. 2014, Pure Technologies 2013). Additionally, several utilities have been able to use capital, as opposed to operational, budgets for pipeline-condition assessment and repair (Coghill et al. 2014). Using this approach, projects are regarded as extending the useful life of assets, which previously may have had zero book value on the basis of their age.
BUSINESS CASE ANALYSIS

Making better capital investment decisions through business case evaluations is becoming a key component for advanced asset management programs, particularly when the value of water infrastructure is under-appreciated; the photograph on this page is an example of how risk analysis helps in determining asset replacement. Within the water sector, best practices emphasize the need for business cases. Guidelines for optimized decision-making, which considered the life-cycle cost of the assets, as well as the benefits and costs of both qualitative and quantitative alternatives, were created by the International Infrastructure Management Manual 2001 Edition (NAMS 2001) and updated by subsequent iterations of the manual. Qualitative and quantitative factors introduce the concept of evaluating more than just the economic considerations of what can be considered a triple-bottom-line approach of evaluating the economic, environmental, and social project impacts.

Multi-criteria scoring and a monetized risk-based approach are two approaches that have been used for business-case evaluations within the sector. The Columbus Department of Public Utilities (Ohio) (Campanella 2015) and the Portland Water Bureau (Leighton 2015) are examples of utilities with rigorous monetized risk-based approaches. Meanwhile, the New York City Department of Environmental Protection (N.Y.) and the City of Virginia Beach (Va.) have both adopted sophisticated, multi-criteria scoring approaches (Hyer 2015).

The monetized risk-based approach includes assigning costs for financial as well as environmental and social consequences, and multiplying the consequences by the probability of those failures to determine a risk cost. Risk costs for project alternatives or risk costs between unlike projects are then compared to select the appropriate project to complete. A good source for understanding the specifics of the methodology is the Portland Water Bureau Business Case Development Guidebook (Brainich 2010).

While guidance exists on the approach, there are no set values to use for social and environmental costs, leaving utilities responsible for developing and defending their calculations. The process of assigning monetary values can be challenging, mainly because the values may vary from community to community. Nevertheless, the science behind monetizing triple-bottom-line factors is growing within the water industry and in most industries as a whole. As the practice grows, utilities are publishing their work for others to reference, increasing the ability for utilities to compare the costs and benefits of potential projects and to gain a better understanding of what investments will bring greater value.

The multi-criteria approach includes identifying key project criteria and defining a range for each criterion (e.g., one to five). The primary advantage of a multi-criteria approach lies in its simplicity, allowing for relative comparisons between project alternatives based on a number of factors. Care must be taken when applying a multi-criteria approach methodology. If there are too many triple-bottom-line criteria
EVALUATING AN ASSET’S USEFUL LIFE

Another key practice of asset management is determining the timing of replacing assets, which requires estimating an asset’s effective useful life (EUL). EULs can vary greatly because of many factors. One pipe may have an EUL of 50 years, while another can last as long as 200 years. Often assumed, EULs can be quite uncertain, which is reflected on the national level by the wide range of public water system infrastructure needs predictions: AWWA claims $1 trillion for the next 25 years (AWWA 2014), and the US Environmental Protection Agency predicts $384.2 billion between 2011 and 2030 (USEPA 2013). Uncertainty about EULs also affects the reliability of long-term financial planning.

Various approaches are available to assess the physical condition of a pipe and can help estimate a pipe’s EUL. Condition assessment costs are decreasing but are still not commonplace for many utilities. However, the absence of physical condition data is not an obstacle for water main replacement planning. Main-break data can be used as an indicator of condition. Therefore, trends and estimates of EULs can be made that allow utility managers to create long-term financial plans (Figure 1).

Physical condition assessment and statistical analyses are not competing approaches but rather complementary. Numerous technical sessions and various presenters outlined methods that combine physical condition assessment with statistical techniques to estimate or validate EULs. The presenters described replacement planning models that can function with little to no reliance on data and advanced methods of deploying descriptive and predictive statistical techniques on utility specific data (Vanrenterghem Raven & Vause 2014, Helgeson & Vanrenterghem Raven 2013, Miller 2013).

Improving the ability to determine EULs using condition or performance data will advance utilities closer to the ideal vision of health and soundness. Replacement decisions based solely on assumed EULs can lead to higher life-cycle costs as a result of premature replacement or excessive pipe failures before their planned replacement. Ideally, investment decisions should be made using statistical analysis, which may drive new efficiencies and wiser spending as well as offer ways to improve replacement and renewal planning.

CONCLUSION

There is no one way to advance in asset management. However, utilities can make improvements using some of the key practices described in this article, especially when addressing immediate needs, working within a budget, and responding appropriately to the concerns expressed in the AWWA 2015 State of the Water Industry Report.

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REFERENCES


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