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Challenges in the Water Industry: Infrastructure and its Role in Water Supply

Every day, millions of U.S. residents rely on water for basic needs such as drinking, showering, cleaning, cooking and fire protection. Yet beyond simply turning on the faucet, very few people today think about what it takes to fill a glass of water.

From the times when massive aqueducts were built by the Romans to when American settlers started digging wells, up until the 19th century obtaining a glass of water required a trip outside with a bucket. A hot bath necessitated the additional task of splitting wood and building a fire. Developments such as cast iron and steam and electric power enabled both large pipes to be constructed and for water to increase in flow and quantity.[1] By the late 1800s, pipes were being laid underground in the U.S. and the first water infrastructure system was established.

Today, this massive water supply system, serving 300 million Americans, is in serious need of replacement, upgrading and maintenance if it is to continue to support a growing U.S. population. A 2005 "Report Card for America's Infrastructure," by the American Society of Civil Engineers gave the water infrastructure across the U.S. an alarming grade of D-minus.[2] In addition, the substantial investment required to update this system will increase the cost of water. Indeed, estimates on how much it will cost to repair this infrastructure range from $276 billion[3] to $1 trillion[4] over the next 20 years.

In order for people to better understand the need for these increasing costs, it is essential to develop an appreciation for the value of water. Understanding how the infrastructure system works, its current challenges and how best to address these challenges, will help to develop this appreciation.

HOW DOES IT WORK?

[1] "Aqueduct." Encyclopædia Britannica. 2007. Encyclopædia Britannica Online. Retrieved 13 Mar. 2007 http://search.eb.com/eb/article-9008127
[2] Yardley, William. "Gaping Reminders of Aging and Crumbling Pipes." 08 Feb. 2007 *The New York Times*
3 Environmental Protection Agency. Online. Retrieved 09 Jan. 2007. http://www.epa.gov/safewater/needssurvey/index.html
4 The American Society of Civil Engineers. Online. Retrieved 09 Jan. 2007. http://www.asce.org/reportcard/index.cfm?reaction=factsheet&page=6

The water infrastructure system is relatively straightforward. From source to tap, water travels through three main channels: the pumping station, the treatment facility and the distribution system.[5]

Pumping Station

The pumping station serves two primary purposes. The first is to extract raw (untreated) water from a source, such as an aquifer or river, using large pumps, pipes and a power source to drive the pumps. Its second purpose is to transport the water from the treatment facility to distribution system (discussed below). The pumping station, usually situated above ground, requires regular maintenance and upgrades, as well as sophisticated equipment, in order to perform its function.

Treatment Facility

After raw water is pumped from its source, it is sent to a treatment facility. This is where water is treated to meet the levels of purity and quality set forth by the U.S. Environmental Protection Agency (EPA). Increasingly stringent EPA regulations require treatment processes to be continually updated and tested, advancing the levels of technology, skill and chemical solutions used. Treatment facilities are designed by engineers to meet the specific consumption and quality needs of the communities they serve. As those needs increase, treatment resources must be provided so that the facilities can remain in compliance with established standards.

Distribution System

Once the water has been treated it is then ready to enter the distribution system.[6] The distribution system is the network of pipes that span fields, mountains and highways so that it can reach homes, businesses, fire hydrants and a multitude of other destinations. The U.S. water pipe network stretches across 700,000 miles and is more than four times the length of the National Highway System.[7]

In order to ensure that adequate supply is delivered to different recipients, engineers run computer simulations of the hydraulic activity of the water in order to determine proper pressure, pipe sizing and other factors. A fire-hydrant, for example, will require high levels of pressure and larger piping. Generally, pipe sizes can range from forty-eight to six inches in diameter. Booster pumps are often attached to the pipes to help further regulate water pressure.

CHALLENGES

While appearing deceptively simple, much planning and investing goes into supporting this infrastructure system. And much more needs to be done if this system is to continue meeting the demands of the U.S. population. As the population increases, so does the demand for water, placing further stress on an already strained system. The main challenges facing water infrastructure are outlined below.

An Aging System

The vast majority of the nation's pipes were laid in three phases: in the late 1800s, the 1920s and just after World War II.[8] Many of these pipes were made to last 50-75 years. Their constant use and age compounded by their low rate of replacement means that most of the pipes in the U.S. are in critical need of repair.

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[5] For the purposes of this paper, the discussion on infrastructure will center on supply water and not other water services such as wastewater management or stormwater runoff systems, both of which are worthy of their own discussion on how to best manage and upgrade.
[6] In some cases, water will first enter a storage facility or reservoir so that it can be supplied when demand exceeds pumping capabilities.
[7] The American Water Works Association. Online. Retrieved 13 Mar. 2007. http://www.drinktap.org/consumerdnn/Default.aspx?tabid=198
[8] The American Water Works Association. Online. Retrieved 13 Mar. 2007. http://www.drinktap.org/consumerdnn/Default.aspx?tabid=198

Among the different problems plaguing the pipes, corrosion ranks amongst the most perilous. This is caused by a natural reaction between water and metal. Likewise, soil properties can corrode pipes from the outside. This leads to leaks and creates two subsequent issues. First, it allows contaminants to enter the pipe and thus, the water supply. Second, it allows treated water to seep (and sometimes steadily flow) out of the system and be wasted. And while even the best-run water systems seep water between the treatment plant and the tap,[9] more can be done to avoid unnecessary loss of this precious resource.

Once a severe leak is discovered, the pipes are unearthed and then repaired or replaced. In many instances, this requires digging up city streets or highways to access the pipe. Such a procedure can temporarily shut down a community's water system and disrupt service. Additional costs accompany this process as well. Roads must be repaved at the expense of the responsible water authority, traffic must be redirected, the public must be notified of potential water boil advisories, and so on.

In extreme cases, eroding pipes cause the ground above them to collapse, creating sinkholes. In Denver in 2008, a ruptured 30-year-old pipe caused a sinkhole that shut down three lanes of a major Interstate for almost two weeks. In New York City, where some infrastructure dates back to the 1800's, an 84-year-old pipe caused an eruption of a midtown street, causing mass evacuations and resulting in injured bystanders.[10]

Financing the Upgrades

Financing the upgrade of these aging pipes is another challenge. In fact, municipal expenditures for water and wastewater infrastructure are one of the highest expenditure categories, second only to education.[11] The distribution system is generally thought to be the area that needs the most attention and investment, directing much of the financing towards the pipes underground.[12]

The problem, however, is that the cost of water infrastructure replacement far exceeds the financial capabilities of many local water utilities.[13] Many municipalities, for example, believe that the federal and/or state governments will make available grants and other low-cost funding as a means of dealing with this infrastructure challenge.[14] It is estimated that utilities spend approximately $10.4 billion annually on infrastructure improvements.[15] Despite spending billions each year, there is an annual shortfall of at least $11 billion to replace aging facilities near the end of their useful life and to comply with existing and future federal water regulations. The shortfall does not account for any growth in the demand for drinking water over the next 20 years.[16] Furthermore, money that has been earmarked towards building new infrastructure often gets diverted to other projects, aggravating the challenge.[17] Why does this happen? Because these events generate little interest and are considered to be low visibility activities.

"You can't easily go to a ribbon-cutting or have your picture taken in front of a new sewer line," noted Dean Marriott, director of the Portland Bureau of Environmental Services.[18] Many water industry experts agree that getting people to care about something they cannot see is a challenge. Even when a tremendous amount of capital has just been invested in a system, "people are not going to notice that their service is any better than it was,"[19] notes Gary Naumick, Director of Capital Program Management of American Water.

Another issue centers on the costs of operating infrastructure. The cost of water itself is minimal, but there are a host of other expense drivers associated with the planning, design, construction, operation and maintenance of a pipeline. The electricity used to pump the water from its source and across terrain, for

[9] LeChevallier, Mark W. Ph.D. Director, Innovation & Environmental Stewardship, American Water. Interview. 21 Nov. 2006.
[10] Long, Colleen. "Water pipelines across US breaking; repair costs at nearly $300B." 08 April 2008 Associated Press
[11] Anderson, Richard, Ph.D. "Major Capital Investment in Water and Wastewater Infrastructure." 25 Jun. 2006 *US Conference of Mayors. Mayors Water Council.*
[12] Naumick, Gary. Director of Capital Program Management/Asset Planning & Strategy, American Water. Interview. 09 Mar. 2007
[13] The American Water Works Association. Online. Retrieved 13 Mar. 2007. http://www.drinktap.org/consumerdnn/Default.aspx?tabid=198
[14] Long, Colleen. "Water pipelines across US breaking; repair costs at nearly $300B." 08 April 2008 Associated Press
[15] Long, Colleen. "Water pipelines across US breaking; repair costs at nearly $300B." 08 April 2008 Associated Press
[16] American Society of Civil Engineers 2005 Report Card on Infrastructure. Online. Retrieved 14 Mar. 2007 http://www.asce.org/reportcard/2005/page.cfm?id=24
[17] Turkopp, Richard C. "Evaluating lifetime pumping costs: how to perform life-cycle analyses for a forced system." 22 Mar. 2006 *Public Works*
[18] Yardley, William. "Gaping Reminders of Aging and Crumbling Pipes." 08 Feb. 2007 *The New York Times*
[19] Naumick, Gary. Director of Capital Program Management/Asset Planning & Strategy, American Water. Interview. 09 Mar. 2007

example, is one of the largest recurring costs.[20] Another significant driver is the purchase and installation of pipes.[21] And additional costs continuing to increase include that of building, replacing or improving treatment plants; protecting water from pollution or terrorist attacks; accessing new water sources, just to name a few.[22]

ADDRESSING THE CHALLENGES

While the challenges outlined above are daunting, they are not insurmountable. Some of the ways in which industry experts propose to meet these challenges are outlined below.

Rehabilitation and Replacement

One of the more basic ways to address the infrastructure challenge is to focus on the pipes. The developments and improvements that have been made can be broken down into two categories: rehabilitation and replacement.

Rehabilitation is often the preferred method of fixing a broken pipe. One such rehabilitation solution is called cleaning and lining, whereby a cleaning device is sent inside corroded pipes to scour off the accumulated mineral build up. Once a pipe has been scoured, it can then be lined with several types of inert material. The lining can serve two functions. First, it protects the pipe from further internal corrosion caused by water reacting with a metal pipe. Second, it may strengthen the pipe, which is particularly useful as the scouring sometimes weakens its structure.

To support the rehabilitation process, acoustic monitoring technologies can help detect if and where a pipe is leaking. These devices use computer analysis to listen to a pipe during quiet hours (i.e., before dawn) and pinpoint exactly where a leak is occurring. The pipe can then be uncovered, examined and repaired accordingly.

If a pipe can not be rehabilitated, it must be replaced. Examples of such cases are pipes that have multiple leaks or are structurally very weak. Replacement is usually a last resort, as this process is more costly and labor intensive, particularly since it requires installing brand new pipes.

Other steps have also been taken to increase the general longevity of current and future pipes. For example, most pipes today are lined with cement so that the water does not react directly with the metal and produce corrosion. Water can also be treated so that it is less reactive with metal. In addition, metal pipes can be wrapped with plastic to prevent external corrosion from aggressive soils. But while there are technologies and methods to repair these pipes, it is still a vast and expensive undertaking.

Finding the Funds

Funding this undertaking has become one of the most critical factors in addressing the infrastructure challenge. With 85 percent of the nation's water serviced by the public sector, the burden to finance the upgrades rests mainly on municipalities, local communities, and ultimately, state and local governments. But as noted before, the billions of dollars needed to upgrade infrastructure make the cost burden more than local political structures can sustain.

To assist, the government has set up funds to help finance the upgrades, such as the State Revolving Fund (SRF), which was established in 1987. SRF enables state and local governments to get low interest loans in order to fix aging water infrastructure. States are required to match the funds they use by at least 20 percent. Since the inception of SRF, the federal government has distributed more than $20 billion. States

[20] Turkopp, Richard C. "Evaluating lifetime pumping costs: how to perform life-cycle analyses for a forced system." 22 Mar. 2006 *Public Works*
[21] Turkopp, Richard C. "Evaluating lifetime pumping costs: how to perform life-cycle analyses for a forced system." 22 Mar. 2006 *Public Works*
[22] "Infrastructure." Water Encyclopedia. Online. Retrieved 13 Mar. 2007. http://www.waterencyclopedia.com/Hy-La/Infrastructure-Water-Supply.html

have been able to leverage that money into $47 billion for improvements and pollution control projects. Ultimately, rate increases help finance some of the infrastructure upgrades.

Additional measures have been proposed, such as The Water Quality Financing Act of 2007 (H.R. 720), which would commit $14 billion to communities for fixing their antiquated infrastructure. Finally, cities also have the option to apply for municipal bonds in order to finance their work. The problem however, is that these funds are still not enough to finance upgrades, with their estimated price tag of up to $1 trillion over the next twenty years.

Other solutions point to the private-sector, which is currently serving 15 percent of the U.S.'s water services. A recent survey from Standard & Poor's noted that approximately $100 billion was raised in 2006 alone for infrastructure funds. The problem is there are barriers impeding the private-sector's investment in the U.S. water infrastructure, such as caps placed on private activity bonds in 1986 that have never been updated. Meaning, there is a limit to how much private sector money can be made available to municipalities. Some argue that a rise in the cap would enable municipalities to tap into much needed private sector capital and address this obstacle.[23] [24]

Public-Private Partnerships have also been touted as solutions, whereby private-sector water companies assist in the design, rebuilding and operation of publicly-owned water systems. Public-Private-Partnerships offer one of the most viable ways in which cities, towns and communities can access the capital and industry expertise of the private-sector. It is believed that such partnerships will play an increasingly critical role in helping the U.S. overcome its water infrastructure challenges.[25]

CONCLUSION

A glass of clean and safe water is the product of thousands of miles of pipes, enormous amounts of planning, countless hours of labor, the latest in technology and water testing and significant capital investment. But if the U.S. is to prepare its water infrastructure for the 21st century, a significant amount of work, planning, coordination and funding is required. And doing so requires a strong commitment from not only utilities, but rate-payers and government as well.[26] It is essential that these players see how all these pieces fit together. This means appreciating the value of water and understanding what is at stake, but also, more critically, acknowledging that the key players must work together in generating viable solutions. The U.S. cannot afford to have this water system fail.

[23] Coy, Debra. Testimony. 19 Jan. 2007 Taken from the political transcript "Rep. Eddie Bernice Johnson holds a hearing on clean water infrastructure- Committee Hearing."
[24] Anderson, Richard, Ph.D. "Major Capital Investment in Water and Wastewater Infrastructure." 25 Jun. 2006 *US Conference of Mayors. Mayors Water Council.*
[25] For more information on Public-Private Partnerships, please refer to another American Water authored white paper: "Challenges in the Water Industry: Public-Private Partnerships as a Solution." http://www.amwater.com/awpr1/web_resources/aww/pdf/011807.WhitePaper.PPP.Final.pdf
[26] The American Water Works Association. Online. Retrieved 13 Mar. 2007. http://www.drinktap.org/consumerdnn/Default.aspx?tabid=198