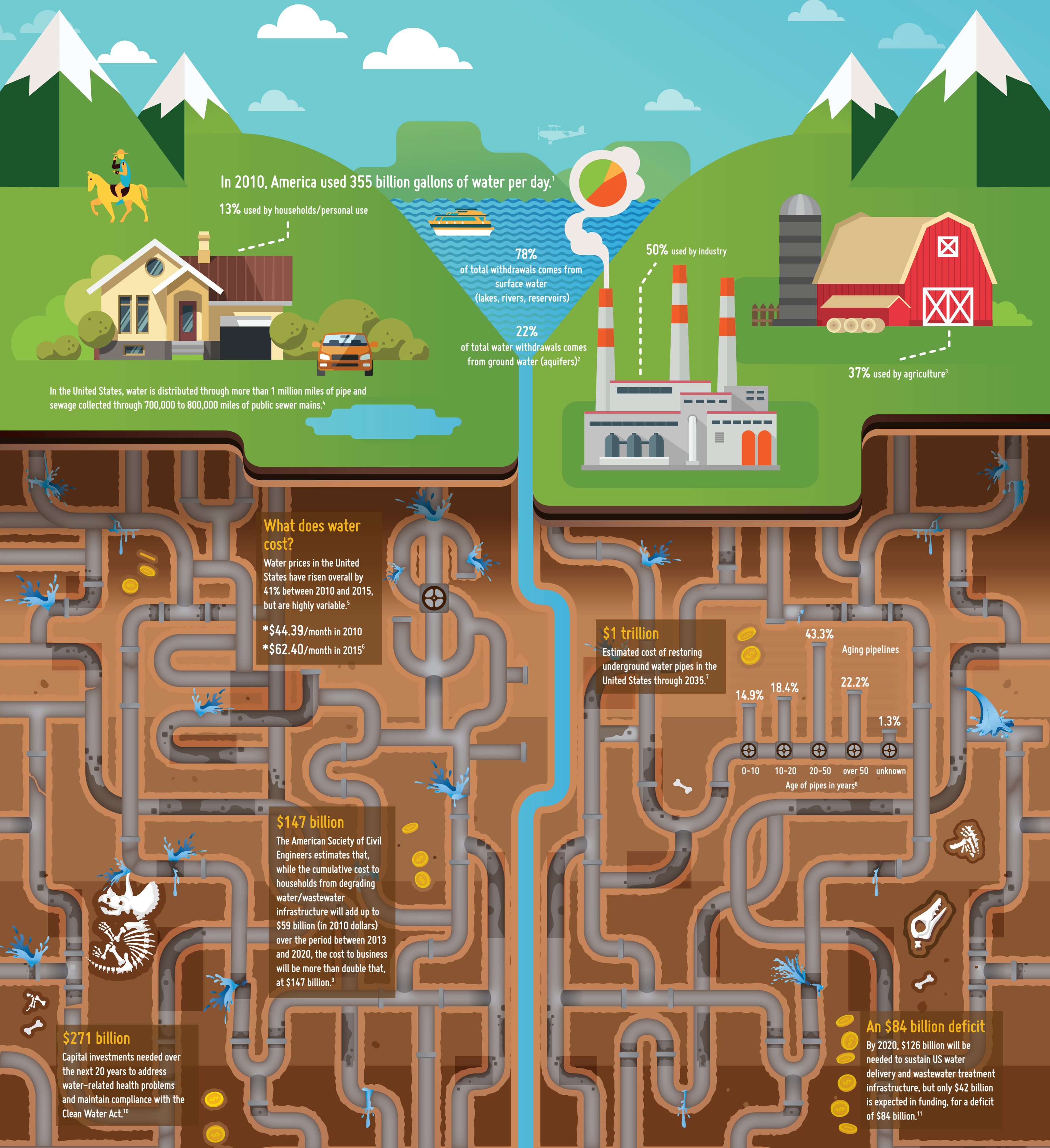
Issues by the Numbers

The aging water infrastructure: Out of sight, out of mind?

March 2016



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The aging water infrastructure: Out of sight, out of mind?

The sad shape of many of our highways, bridges, and transit systems is very evident as we dodge potholes and hope that our train will eventually arrive. However, one of the most critical aspects of the United States' aging infrastructure is literally buried underground, out of sight and, usually, out of mind. It is often only when failures occur that we are reminded of how much we take for granted our access to safe drinking water.

WHEN economist Robert Gordon categorized the three phases of industrial revolution, he designated the first phase as the period between 1750 and 1830, when the steam engine, mechanized cotton spinning, and railroads were invented. He defined the second phase as the period from 1879 to 1900, which saw the invention of running water with indoor plumbing along with electricity and the internal combustion engine. Clearly, both of these phases ignited periods of strong productivity growth—and the third phase, the computer and Internet revolution, has sparked productivity increases as well (although Gordon himself has been less than impressed with the third phase's productivity potential).[1]

Many of the critical inventions of these successive periods of productivity growth are assets that are constantly renewed as old or outdated equipment is replaced by newer and better models. However, inventions that required substantial infrastructure to build, such as railway lines and water pipes, have typically been put into place and then largely ignored. The emphasis has generally been on expansion, not replacement and upgrade. Yet the tendency to leave older infrastructure alone may be a luxury we can no longer afford when it comes to one of the United States' most important resources: water.

To supply the nation's homes and businesses with water, the United States depends on a country-wide network of aging underground pipes, many of which are reaching, or have exceeded, the end of their useful life. The number of water main breaks across the country, from Syracuse to Los Angeles, is staggering: 240,000 per year, according to one estimate.[2] The direct cost of these leaks is pegged at $2.6 billion per year.[3] And the total cost to the economy is not limited to the cost of the lost water. Beyond households, most economic activities, from hospitals and schools to factories and farms, depend on reliable access to safe water. The American Society of Civil Engineers estimates that, while the cumulative cost to households from degrading water/wastewater infrastructure will add up to $59 billion (in 2010 dollars) over the period between 2013 and 2020, the cost to business will be more than double that, at $147 billion.[4]

It is clear that the country's water infrastructure needs an overhaul and that the dollar cost of doing so is climbing rapidly. What is unclear, however, is where the money will come from. The need for infrastructure investment could mean a continued increase in water prices—which would more closely align the price of water with its value. Innovations in technology, public policy, and funding are the need of the hour.

Evolution of the system

> It is clear that the country's water infrastructure **needs an overhaul** and that the dollar cost of doing so is climbing rapidly.

The total population of the United States grew by approximately eight-fold between 1790 and 1860— roughly the period of the historic Industrial Revolution—with much of the increase concentrated in cities.[5] This rapid, concentrated growth made the provision of safe drinking water and better wastewater management critical public health issues whose importance became especially evident during the cholera outbreak of 1832. In his book *The Cholera Years*, Charles E. Rosenberg writes, "Cholera was the classic epidemic disease of the nineteenth century, as plague had been of the fourteenth."[6]

In addition to the cholera epidemic, frequent fires in cities catalyzed the development of water supply services that sourced water from large water bodies such as rivers and lakes as opposed to inland wells. The Great Fire of New York in 1835, for instance, led to the development of the Old Croton Aqueduct (built in 1842) from the Croton River. Around the same time, the city of Chicago built its first water management system, which sourced water from Lake Michigan. Boston and Washington, DC also set up water systems during the same period.

By 1850, an estimated 83 systems were in existence to provide water to communities, with more than half of these privately owned.[7] Before the turn of the 20th century, that number had risen to over 3,000, more or less evenly split between being privately and publicly owned.[8] Additionally, new methods of water purification were introduced in the late 19th century; these included slow sand filtration and a quicker filtration process using chemical coagulation.

The United States' sanitation system also developed in the middle to late 1800s. Initially, sewer systems were combined systems for both sanitary wastewater and storm water, with the first planned combined sewer systems constructed in Chicago and in Brooklyn in the late 1850s.[9] These systems emptied combined sanitary wastewater and storm water into nearby water bodies. The drainage they provided constituted an important prerequisite and a ready convenience for the process of industrialization through the 19th century.

By 1909, cities with populations above 30,000 had approximately 24,972 miles of sewers, while cities with populations above 100,000 had 17,068 miles of sewers. Most of these were combined sewers rather than separate systems for wastewater and storm water.[10] In fact, up until the end of the 19th century, the choice of the type of centralized sewer system (combined or separate) depended on several factors, including topography and population density; a well-defined system for choosing between the two systems did not

THE PROBLEM WITH LEAD

Lead and copper can leach into drinking water if pipelines made of lead or copper are corroded. Prolonged exposure to lead and copper can result in brain damage, kidney failure, and gastrointestinal sickness, as well as hinder the production of red blood cells. Because of this, lead and copper in drinking water pose a potent risk to public health.

Upcoming long-term revisions to the USEPA's Lead and Copper Rule (LCR), along with other decisions impacting water supply, put the question of lead in drinking water in the spotlight. Of significance is the skepticism expressed regarding the sampling techniques used under the LCR thus far, including claims that lead concentration is often underestimated.

The LCR, introduced in 1991, applies to water utilities and defines the maximum contaminant levels (MCL) for lead and copper in drinking water. The LCR stipulates that lead concentrations should not exceed 15 parts per billion and copper concentrations should not exceed 1.3 parts per million in more than 10 percent of water samples collected from customers. Furthermore, the rule requires utilities to exercise corrosion control measures to prevent percolation of heavy metals into drinking water.[18]

The LCR has undergone several changes since 1991. In 2013, the National Drinking Water Advisory Council (NDWAC) Lead and Copper Rule Working Group (LCRWG) was formed to discuss long-term revisions to the rule. Some of the working group's key recommendations, delivered in August 2015, include:

- The LCR should enforce the replacement of lead service lines, following the principle that there is no safe level of lead.
- States should include the cost of replacing lead service lines in the criteria for allocating Drinking Water State Revolving Funds.
- The USEPA should release a guidance manual so that public water systems and their primary agencies can make use of the latest technology in corrosion control treatment.
- The USEPA should allow for consumer-requested testing of tap samples for lead.
- The USEPA, CDC (Centers for Disease Control and Prevention), HHS (US Department of Health and Human Services), and HUD (US Department of Housing and Urban Development) should conduct training on lead poisoning for local health agencies, medical professionals, and local and state lead poisoning prevention agencies.
- The LCR should separate the requirements for copper from those for lead.[19]

exist. Toward the end of the century, the argument for separate sewer systems had gained momentum. Population growth, change in the characteristics of wastewater, and an increase in the quantity of wastewater—as well as the growing need for wastewater treatment—made separate sewer systems a more desirable technology in the early 20th century.

Safeguarding the water supply

As the nation's community water systems were being established, protecting drinking water sourced from large water bodies became a growing concern, as the quantity of wastewater being disposed into water bodies was on the rise. In 1914, the US Public Health Service adopted and enforced drinking water standards for the first time.[11] The objective was to protect interstate travelers and to contain the spread of disease. By 1915, the use of chlorine to treat water was common across the United States, resulting in a significant drop in waterborne diseases.

Protecting drinking water took precedence over wastewater treatment. For instance, in 1924, more than 88 percent of the population in cities with more than 100,000 residents continued to pipe untreated wastewater into water bodies.[12] It was not until the passage of the Water Pollution Control Act in 1948 that the federal government first entered a sector historically controlled by state and local governments. Since then, federal influence over water quality has grown, with the establishment of the United States Environmental Protection Agency (USEPA) in 1970 marking a major milestone.

The Clean Water Act, passed in 1972, and the Safe Drinking Water Act, passed in 1974, are the two primary federal statutes addressing water quality in the United States. Both are administered by the Office of Water at the USEPA.[13] The Clean Water Act (CWA) is a pollution control program that makes it illegal to discharge any pollutant from sources such as pipes or ditches into waterways without a permit. Individual homes do not need permits if they are connected to a municipal system, use a septic system, or do not have a surface discharge. However, the facilities that process wastewater from those homes are required to have a permit if they discharge into surface water. The CWA also gives the USEPA the authority to set water quality standards for all contaminants in surface waters.[14]

The Safe Drinking Water Act was enacted in response to growing concerns over the use of organic chemicals to treat drinking water in the years after World War II. This act gives the USEPA the authority to set legally enforceable standards for public water systems. These standards prescribe acceptable levels for more than 90 contaminants that may occur in water that can adversely impact public health, including disinfectants (such as chlorine), disinfection byproducts (such as bromate), inorganic chemicals (such as lead), microorganisms (such as those that cause Legionnaire's Disease), organic chemicals (such as polychlorinated biphenyls [PCBs]), and radionuclides (such as uranium).[15]

While the rules are set at the national level, monitoring generally takes place at a lower level. For the CWA, all but four states are authorized to implement compliance monitoring.[16] For drinking water, the USEPA and the states depend primarily on the analysis of water samples collected by public water systems themselves.[17]

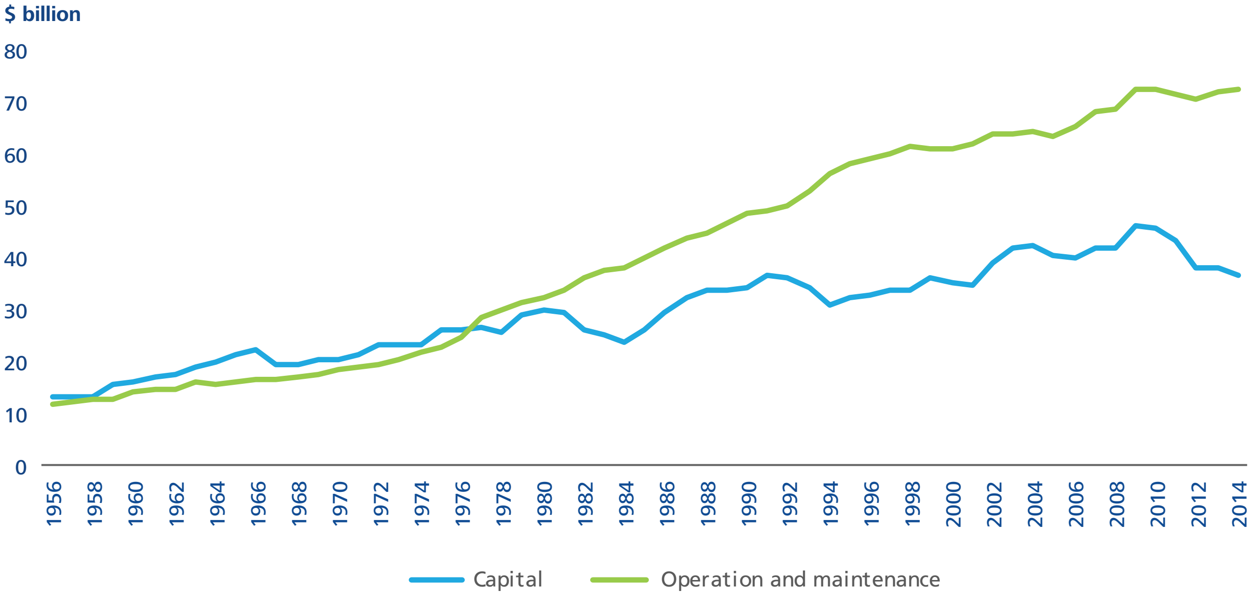
The issues: Aging, funding, pricing

Today, most Americans and American businesses get their water from one of approximately 51,000 community water systems. Many of these community systems are small, with about 55 percent serving populations of 500 or fewer people. Less than 1 percent of community systems serve communities of more than 10,000—but these very large community water systems, which are predominantly located in the country's 100 largest metropolitan areas, serve fully 82 percent of the population.[20]

As shown in figure 1, funds expended on plant operation and maintenance of water utilities have risen over time as systems have expanded, while real spending (and even nominal spending) on capital infrastructure has been on the decline. Almost all of the spending on operations and maintenance comes from state and local governments, with the federal contribution generally running less than 1 percent. The federal contribution to capital spending has been highly variable over time, peaking at almost 40 percent of total capital spending in 1977 as the Clean Water Act of 1972 was being implemented; there was another, smaller rise in 2010 as the provisions from the American Recovery and Reinvestment Act of 2009 were implemented following the 2007–2009 recession (figure 2).

However, the pace of investment in water utilities—which include supply systems for distributing drinking water as well as wastewater and sewage treatment systems—has not been keeping up with the need. The American Water Works Association's (AWWA's) State of the Water Industry (SOTWI) report for 2015 lists renewal and replacement of water and wastewater infrastructure at the top of the stack of the five most important issues faced by the US water industry.[21] Indeed, most of the underground water pipelines in the United States are either nearing or have already surpassed their useful life. In a 2001 report titled *Dawn of the replacement era*, the AWWA points out that cast-iron pipes that were laid in the late 1800s have an average lifespan of 120 years;[22] pipes laid in the 1920s, constructed using different

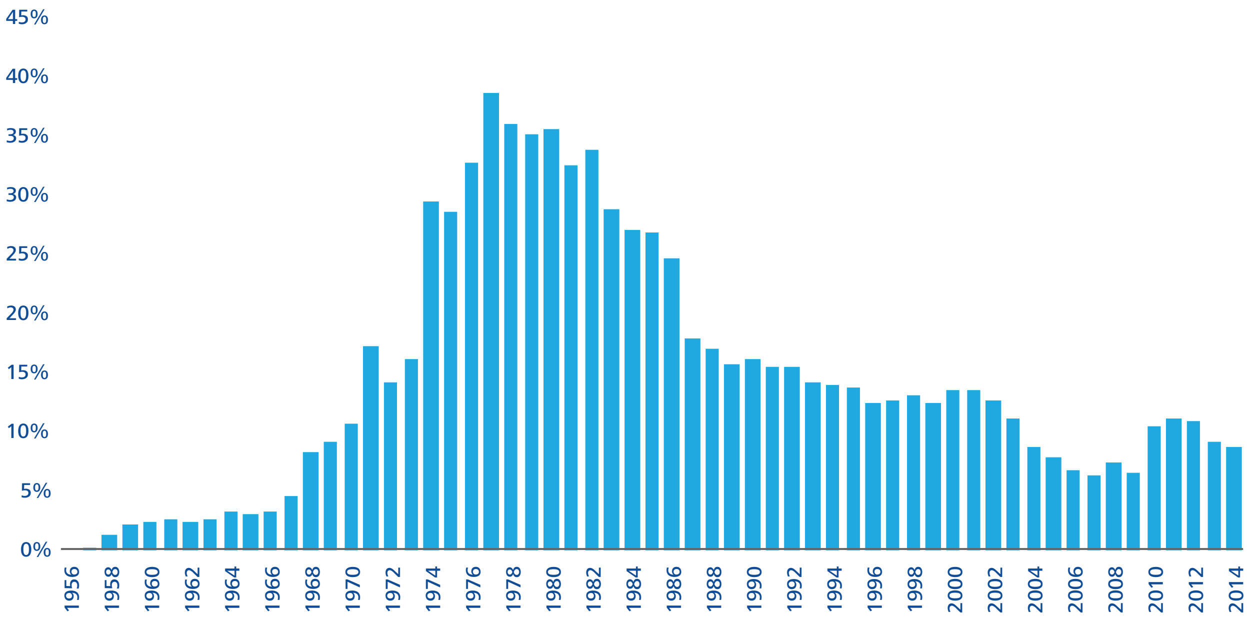
Figure 1. Public spending on water utilities (in 2014 dollars)



Source: Congressional Budget Office, "Public spending on transportation and water infrastructure, 1956 to 2014," table W-7, https://www.cbo.gov/publication/49910.

Graphic: Deloitte University Press | DUPress.com

Figure 2. Federal share of water utility capital spending



Source: Congressional Budget Office, "Public spending on transportation and water infrastructure, 1956 to 2014," table W-2, https://www.cbo.gov/publication/49910.

Graphic: Deloitte University Press | DUPress.com

manufacturing techniques, have a lifespan of a 100 years,[23] and pipes laid during the post-World War II economic boom are expected to have a useful lifespan of about 75 years.[24] This means that much of the underground pipeline network will be due for replacement in the next two decades.

The AWWA estimates that the cost of restoring underground pipes will total at least $1 trillion over the next 25 years, without including the cost of constructing new infrastructure or repairing treatment plants.[25] Separately, the USEPA's 2011 Drinking Water Infrastructure Needs Survey and Assessment (DWINSA) estimated that the United States will require $384 billion in capital investment over the next 20 years to ensure that drinking water standards are in compliance with the Safe Drinking Water Act.[26] (This estimate includes only those infrastructure needs that are eligible for funding by the Drinking Water State Revolving Fund [DWSRF], meant as a supplement to state and local funding. Infrastructure needs mainly related to population growth and maintenance costs do not qualify for DWSRF funding.) In addition, the

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USEPA's 2012 Clean Watersheds Needs Survey estimates that $271 billion in capital investment will be needed over the next 20 years to address water-related health problems and ensure that watersheds are compliant with the Clean Water Act.[27]

This brings us to the burning question of funding. The SOTWI report for 2015 lists renewal and financing capital improvements as the No. 2 issue facing the US water industry.[28] Water usage fees and local taxes support the needed capital and operational costs of providing safe drinking water using the infrastructure already in place. However, the primary concern is that current fee rates do not fully cover water utilities' renewal and replacement costs for that infrastructure. In fact, only a little more than one-third of water utilities earn enough revenue to cover all their costs.[29]

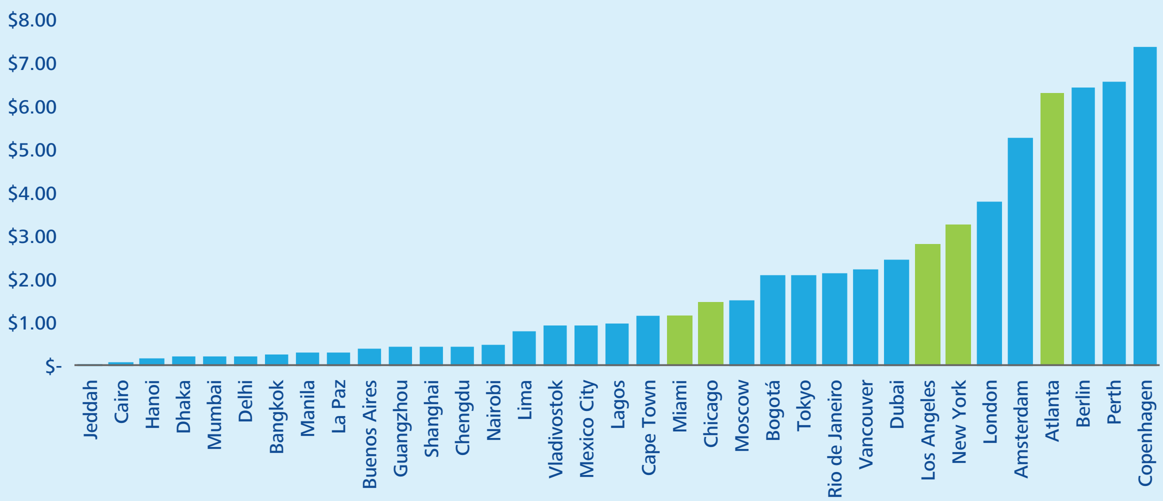
The persistently low price of water contributes to the difficulty that water utilities face in funding renewal and replacement efforts. In 2012, most Americans paid less than $3.75 per 1,000 gallons of safe water.[30] It is true that water prices are trending upward: In 2015, the average monthly cost of water across 30 major US cities rose by 6 percent, outstripping the consumer price index by more than 4 percent.[31] But even though US water prices increased by 41 percent between 2010 and 2015,[32] the average US household spent just $530 on water in 2014—only about 20 percent of the average amount spent on gasoline ($2,468).[33]

Moreover, water utilities are selling less water than before due to both a fall in usage since 2000[34]—prompted in part by tiered pricing (the more water used, the higher the cost

WATER PRICES WORLDWIDE

The United States, on average, uses far more water than Europe and at a lower price. The per-capita water footprint in the United States is slightly more than one-and-a-half times that in France and double the footprint per capita in Germany.[36] The larger American water footprint is closely linked to the fact that water in the United States generally costs less than in Europe (figure 3). In drought-stricken California, for example, water costs approximately $40 to $70 a month—less than the cost of cell phone services or cable television (both of which are comparatively cheaper in Europe).[37]

Figure 3. Water prices around the world (US dollars per cubic meter)



Source: Brian Dumaine, "What is water worth?," *Fortune*, May 1, 2014, http://fortune.com/2014/05/01/what-is-water-worth/.

Graphic: Deloitte University Press | DUPress.com per gallon) in some markets—and the slower addition of new customers and new residential construction in the wake of the Great Recession. Coupled with rising maintenance costs, this decrease in the volume of water sold, under the usage-based fee structures most common in the United States, has put pressure on water utilities' revenues. This makes it very likely that the price of water will climb even higher as utilities strive to make ends meet. At a time when real wage growth has been sluggish, higher water prices could mean even lower usage. This might be good news from a conservation viewpoint, but it could spell trouble for utilities with usage-based pricing structures in place as their prices reach the limit of what the market can bear.

This pressure on utilities may be lessened if fee structures are revised and the price of water climbs high enough to cover costs. One of the most commonly proposed solutions for recovering costs is by shifting a greater degree of cost recovery to fixed fees from usage-based fees.[35] This and other innovations in water pricing will likely need to occur to finance needed investments in infrastructure renewal and replacement. Options range from China's policy of differential pricing for rich urban users to Australia's approach of trading water as an economic commodity.

The government can play a part in encouraging alternative funding mechanisms through legislation. In December 2015, for instance, the US Congress passed a five-year, $305 billion transportation bill that, among other things, lifted a ban on the issuance of tax-exempt bonds with loans for projects under the Water Infrastructure Finance and Innovation Act (WIFIA).[38] The WIFIA, which was enacted in 2014, funds up to 49 percent of the cost of water, wastewater, storm water, or water reuse projects through low-interest federal loans. Prior to the 2015 bill's passage, funding the remaining 51 percent of such projects through tax-exempt bonds was banned by law.[39] Lifting this ban allows utilities the leeway of raising money from the public while providing tax incentives. That said, the need to repay debt is another factor that could drive utilities to raise water prices in the future.

The path forward

How do we address the need for 21st-century water infrastructure? To do so, the country will likely need to move past 20th-century solutions to a 21st-century way of thinking to help ensure resilient and sustainable *access to safe drinking water for everyone*. However, this will probably be a challenge, not only because of our increasing population and the resulting competition for water, but because of the need to maintain and expand the infrastructure that makes safe drinking water possible.

The bottom line is that there is no simple solution. We will need to scale innovative funding solutions and technologies, as well as adopt public policies that promote innovation in the water sector. With regard to innovative funding, we have seen the emergence of green bonds, such as the 100-year bonds used by DC Water,[40] and public-private partnerships, such as that in Bayonne, New Jersey.[41] Technologies such as predictive analytics (to identify potential asset failures and accelerate repairs) and in situ underground pipe repair are also being adopted. Finally, customer engagement efforts to increase conservation are likely to be part of the solution.

The bottom line is that there is **no simple solution**.

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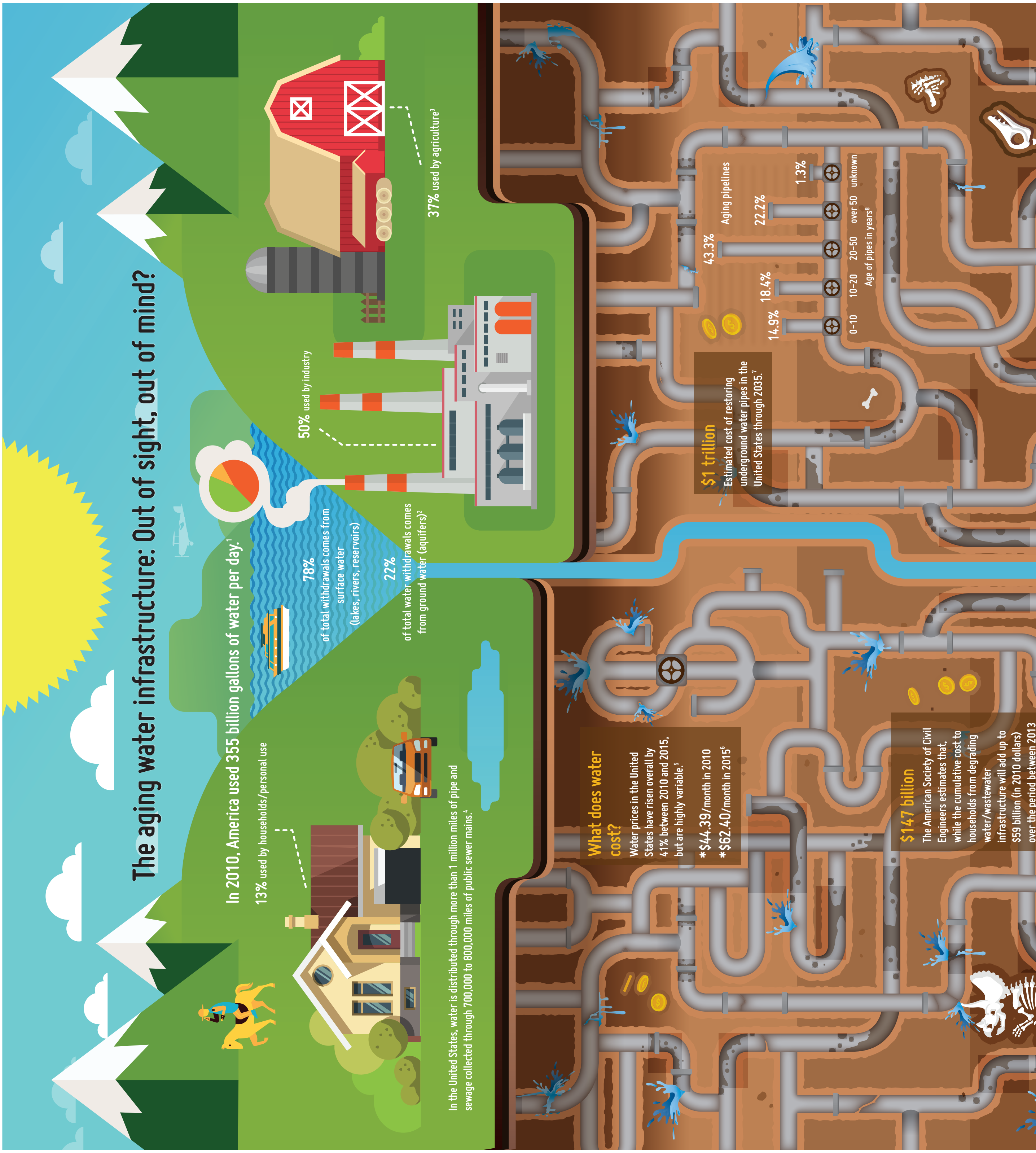
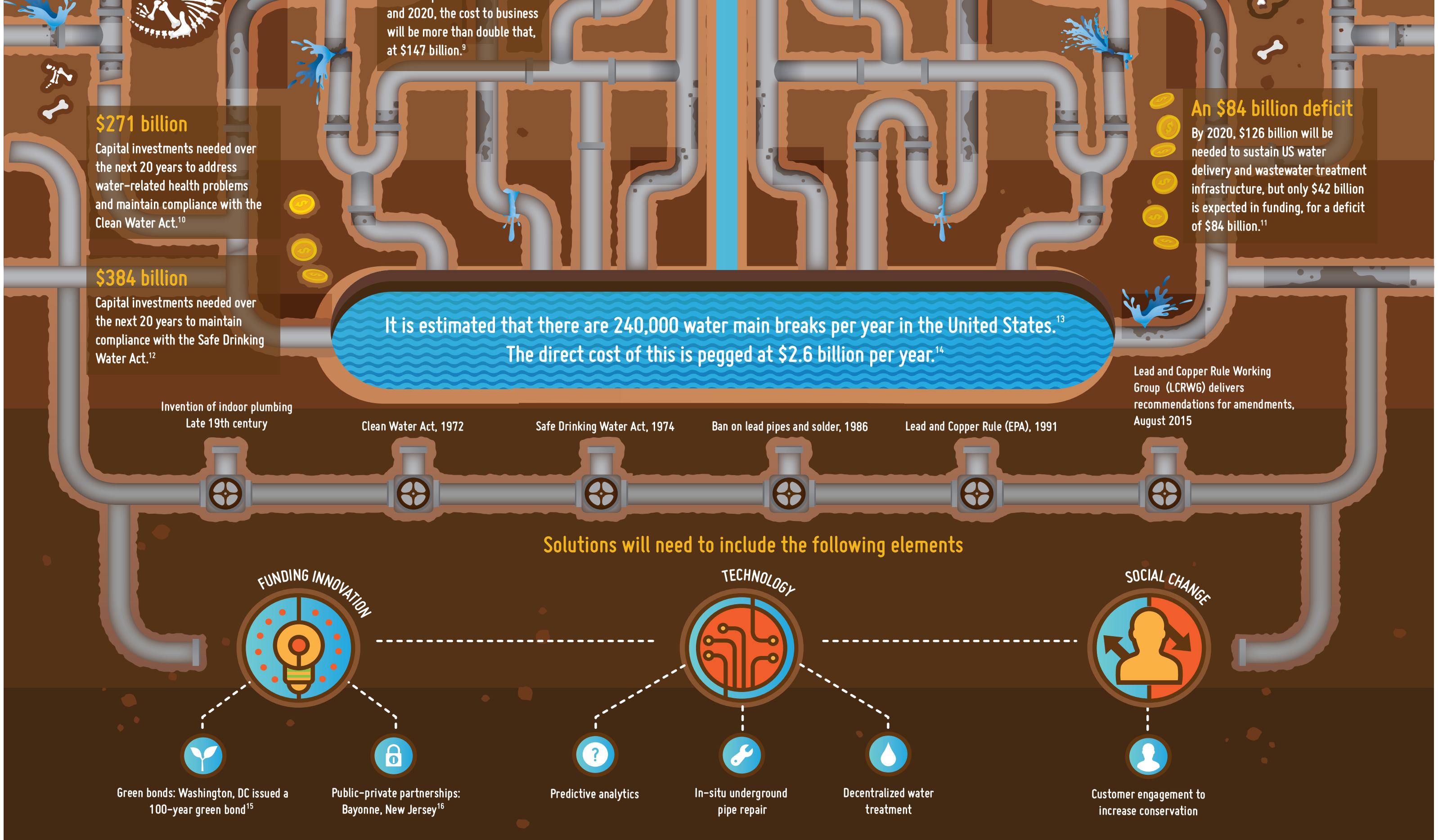
Appendix

The aging water infrastructure: Out of sight, out of mind? (infographic)

View the infographic online at: www.dupress.com/articles/us-aging-water-infrastructure-investment-opportunities-infographic





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