Wastewater

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Photo by Ivan Bandura

EXECUTIVE SUMMARY

The nation's more than 16,000 wastewater treatment plants are functioning, on average, at 81% of their design capacities, while 15% have reached or exceeded it. Growing urban environments signal a trend that these facilities will increasingly accommodate a larger portion of the nation's wastewater demand. Though large-scale capital improvements have been made to systems experiencing sanitary sewer overflows, efforts have slowed in recent years. As many treatment plants and collection networks approach the end of their lifespans, the financial responsibilities for operation and maintenance will become more costly. Estimates indicate that utilities spent over $3 billion in 2019, or more than $18 per wastewater customer to replace almost 4,700 miles of pipeline nationwide. Recently, the more prevalent use of asset management plans enables 62% of surveyed utilities to proactively manage wastewater infrastructure maintenance rather than reactively respond to pipeline and equipment failures. In 2019, though the annual water infrastructure capital investment gap is $81 billion, the sector has made strides to address current and future needs through resilience-related planning and innovations that produce profitable byproducts or cost savings from wastewater treatment.

INTRODUCTION

A critical component that influences the well-being of any community is its system for removing and treating wastewater for the protection of human and environmental health. Wastewater infrastructure includes a network of sewer pipes that collect and carry household, business, and industrial effluents to wastewater treatment systems — onsite or centralized facilities. Within these treatment systems, wastewater undergoes processes to remove harmful constituents and reduce pollution to the Environmental Protection Agency (EPA) and/or state-regulated levels prior to being discharged into nearby waterbodies or, in some cases, recovered for water, energy, and nutrient reuse.

Photo: rdonar

AXIAL HYDRODYNAMIC FLOW PUMP IN WASTEWATER PLANT.

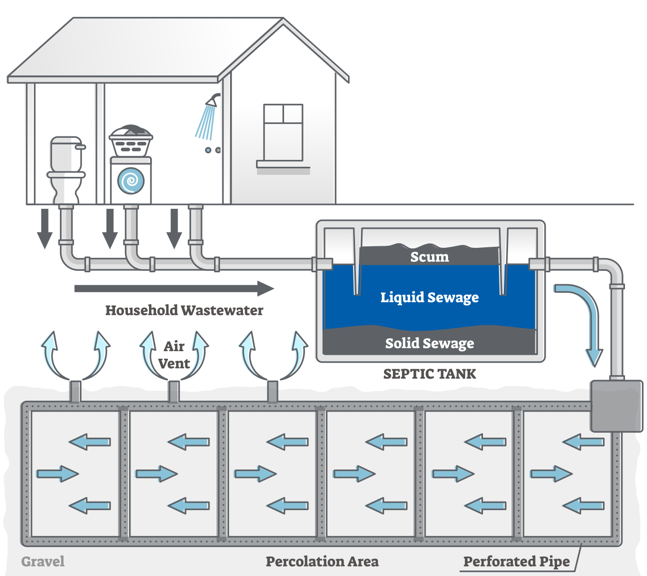
CAPACITY

There are more than 16,000 publicly owned wastewater treatment systems of various sizes serving the majority of wastewater needs in the United States.[1] The remainder of the population — approximately 20% of Americans — rely on onsite wastewater systems such as septic tanks.[2] Although the nation's population growth projections are modest,[3] a 2018 Pew Research Center study expects 86% of this growth to occur in urban and suburban areas.[4] Growing urban environments signal a trend that centralized wastewater treatment plants (WWTP) will increasingly accommodate a larger portion of the nation's wastewater demand. Currently, 62.5 billion gallons of wastewater per day is being treated by centralized WWTPs. Across all sizes of WWTPs, systems are operating at an average of 81% of their design capacity, while 15% of systems are at or have exceeded that threshold.[5]

In addition to WWTPs, the nation's wastewater footprint also includes a network of over 800,000 miles of public sewers and an additional 500,000 miles of private lateral sewers that connect homes and businesses to public sewer lines.[6]

CONDITION

The majority of the nation's WWTPs are designed with an average lifespan of 40 to 50 years, so the systems that were constructed in the 1970s, around the passing of the Clean Water Act in 1972, are reaching the end of their service lives.[7] However, smaller onsite systems, such as septic tanks, have a shorter average lifespan of 20 to 30 years.[8] Most states do not collect condition data for these smaller systems, so an accurate assessment of the remaining lifespan or current condition is nearly impossible to determine. In 2015, the National Association of Home Builders estimated that the median age of owner-occupied housing across the U.S. was 37 years old, an indication that, without proactive homeowner maintenance, there may be significant needs for upgrading and/or replacing onsite wastewater infrastructure.[9]



Nationwide, the drinking water and wastewater pipes in the ground are on average 45 years old,[10 11] while some systems have components more than a century old.[12] The typical lifespan expected for wastewater pipes is 50 to 100 years.[13] As collection systems age and decline in condition, groundwater and stormwater enters the networks through cracks, joints, or illicit connections as inflow and infiltration. When collection systems are overtaxed, sanitary sewer overflows (SSOs) can occur. Between 2012 and 2016, the EPA reports that improvements were made to more than 180 of the nation's large sanitary sewer systems, which typically accommodate over 10 million gallons of wastewater per day, and are prone to episodic SSOs.[14] In recent years, the progress has slowed.[15] Aside from SSOs, conveyance systems are also susceptible to other failures like blockages caused by consumer products such as wipes and paper towels.

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OPERATION & MAINTENANCE

Wastewater infrastructure may be owned by a public, private, or cooperative entity, and the operation and maintenance (O&M) may be conducted by the same party or subcontracted elsewhere. As utilities face the challenges of meeting increasingly stringent water quality regulations, funding significant infrastructure replacements, and affordably providing services amid growing public and environmental health risks, the option of merging (utility consolidation) may unlock financial, technical, and managerial resources to meet current needs and adapt to future demands.[16]

According to the U.S. Conference of Mayors, trends among municipal WWTPs show that nationwide O&M expenditures have increased by approximately 4% annually from 1993 to 2017, an increase partially due to deferred capital expenditures.[17] Depending on the type of WWTP and the collection system, O&M spending varies. In rural areas where decentralized systems are common, the responsibility to coordinate and finance O&M activities ranging from $250 to $500 every three to five years falls on homeowners.[18] However, with little to no instruction or oversight from state regulatory agencies, if O&M goes unaddressed, systems may fail, costing homeowners between $3,000 and $7,000.[19]

Thousands of miles of the nation's aging pipes are buried beneath increasingly urbanized cities and will require more and more inter-agency collaboration and data sharing, particularly as maintenance needs grow.[20] In a 2019 American Water Works Association report, as much as 62% of wastewater pipeline maintenance performed by combined utilities occurs through the proactive execution of asset management plans; the remaining 38% is completed as a reactive response to failures.[21] The report goes on to mention, since 2017, replacement rates for wastewater collection pipes have essentially stagnated. Nevertheless, in 2020, Bluefield Research estimated that utilities throughout the country will spend more than $3 billion on wastewater pipe repairs and replacements, addressing 4,692 miles of wastewater pipeline. This value translates into more than $18 per wastewater customer, a cost that is projected to grow by an average of 5% annually.[22]

FUNDING

Wastewater infrastructure may be funded by local user fees and taxes, state-specific grants or discretionary set-asides, and federal grants or financing mechanisms. Funding and financing differ through the simple fact that infrastructure financing, like any loan or bond, requires repayment over a 30- to 50-year period.[23] According to the Congressional Research Service, the federal government's share of capital investment has fallen from 63% in 1977 to less than 9% in 2017.[24] State and local entities shoulder the majority of capital projects and O&M expenses, which were approximately $20 billion in 1993 and increased to $55 billion by 2017.[25 26]

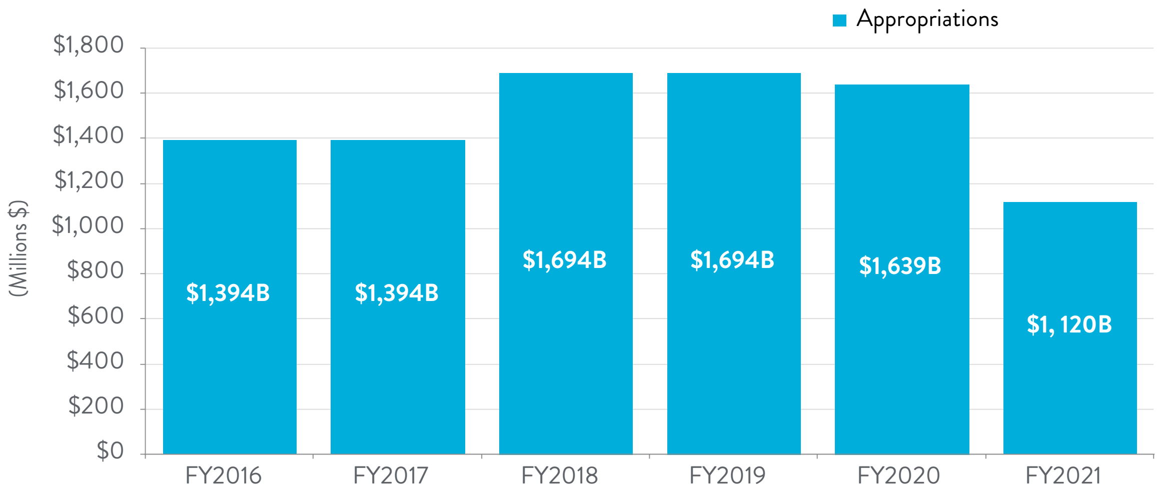
Though utilities are seeking to address affordability challenges in vulnerable communities, decreasing usage due to water conservation appliances, persistent leaks from aging infrastructure, and increasing inflation have all contributed to the 24% increase in rates reported from 2008 to 2016.

Nationally, a single-family residence pays an average rate of $504 annually for wastewater collection and treatment.[27 28] Since 2008, user rates have trended upward to reflect the true cost of service and also due to dwindling revenues for many wastewater utilities.[29] Though utilities are seeking to address affordability challenges in vulnerable communities, decreasing usage due to water conservation appliances, persistent leaks from aging infrastructure, and increasing inflation have all contributed to the 24% increase in rates reported from 2008 to 2016.[30]

Some WWTPs are recouping savings and generating profits by implementing innovative technologies that reuse water, recover energy, and recycle nutrients.[31] Furthermore, state leaders have turned to levying local taxes, initiating restoration fees, and creating legislative set-asides as a means to invest in wastewater infrastructure and to close the funding gap.

While wastewater utilities are responsible for covering the majority of their expenses, many also look to federal financing mechanisms, particularly for large capital projects.

EPA Clean Water State Revolving Fund Appropriations



Wastewater Funding and Financing Mechanisms

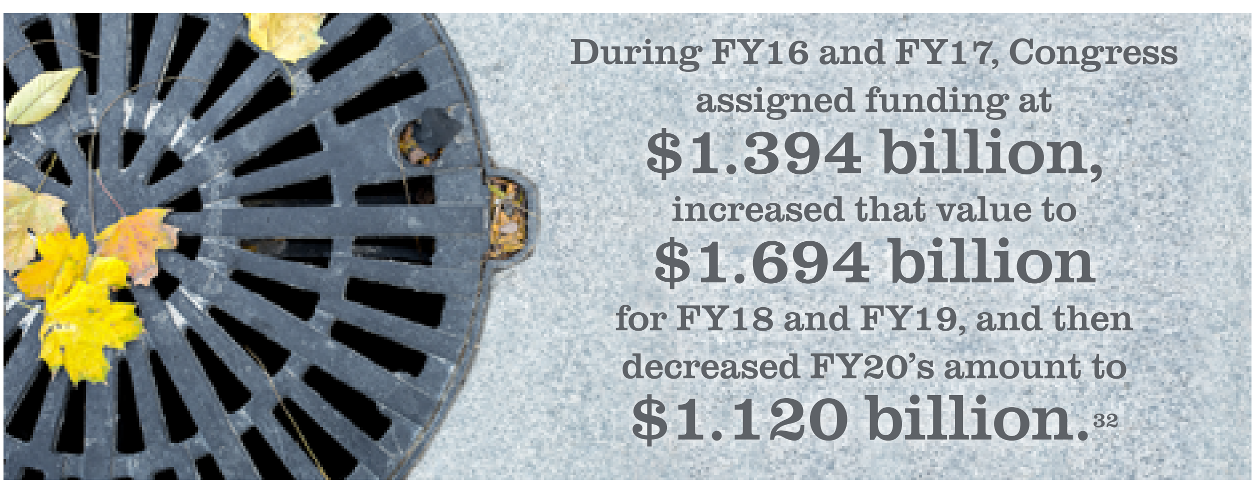
Federal Agency	Program	Details
U.S. Department of Agriculture	Rural Utilities Service: Water and Waste Disposal Programs	The purpose of this program is to provide basic human amenities, alleviate health hazards, and promote the orderly growth of the nation's rural areas (communities with populations of 10,000 or less) by meeting the need for new and upgraded drinking water, wastewater, stormwater, and solid waste infrastructure.
U.S. Department of Housing and Urban Development	Community Development Block Grants (CDBG)	The program's primary objective is to develop viable communities by providing decent housing and a suitable living environment, and by expanding economic opportunities, principally for persons of low and moderate income. Accordingly, CDBG resources are not limited to drinking water, wastewater, and/or stormwater infrastrucure, but these projects must compete with other eligible activities including historical preservation, energy conservation, lead-based paint abatement, and more. The block nature of the CDBG distribution enables local government's to exercise discretion and on-the-ground knowledge when selecting appropriate projects that achieve program objectives.
U.S. Environmental Protection Agency	Water Infrastructure Finance and Innovation Act Program (WIFIA)	Established in 2014, the WIFIA program provides credit assistance through long-term, low-cost supplemental loans for regionally and nationally significant infrastructure projects. WIFIA authorizes EPA to provide credit assistance directly to an eligible recipient for a broad range of drinking water and wastewater projects that generally cost $20 million or more.
U.S. Environmental Protection Agency	Clean Water State Revolving Fund Loan Program (CWSRF)	Established in 1987 by amending the Clean Water Act, federal funds are directed to CWSRF programs in all 50 states and Puerto Rico to capitalize state infrastrucutre loans. CWSRF resources must be matched by 20% state-backed funds. Various projects from CWSRF include new construction and upgrades of wastewater treatment plants, stormwater infrastructure, nonpoint source pollution management plans, and more.

Photo courtesy of WSP USA

THE BALTIMORE BACK RIVER WASTEWATER TREATMENT PLANT

For instance, the EPA's Clean Water State Revolving Fund (CWSRF) provides resources to state agencies enabling them to act as "infrastructure banks" that grant funds and oversee low-interest loans. CWSRF grants require local entities to put forth a 20% match to the funds requested. During FY16 and FY17, Congress assigned funding at $1.394 billion, increased that value to $1.694 billion for FY18 and FY19, and then decreased FY20's amount to $1.120 billion.[32] In 2019, Bluefield Research reports that state agency requests for CWSRF funding exceeded $55.9 billion, indicating that the total, nationwide need significantly outpaces available funding.

Working in conjunction with EPA's CWSRF program, the Water Infrastructure and Finance Innovation Act (WIFIA) is an additional long-term, low-cost funding mechanism for regionally and nationally significant, large-dollar-value projects. From FY17 to FY19, Congress has increased WIFIA's lending capacity from $2.5 to $6 billion with more than $21 billion being requested for over 150 applicants



nationwide. In FY19, the federal government invited more than a dozen wastewater and water reuse projects to apply for over $2.3 billion in loans.

The U.S. Department of Housing and Urban Development manages the Community Development Block Grants program under which urban, economically disadvantaged areas may apply to receive grant funding. However, rural communities, those that cannot financially bear the responsibilities of long-term loans, may look to the U.S. Department of Agriculture's (USDA) Rural Utilities Service — Water and Environmental Program — for grant and financing options tailored particularly for their needs.


Photo: Louisville MSD

THE SOUTHWESTERN PARKWAY COMBINED SEWER OVERFLOW BASIN PROJECT

FUTURE NEED

In 2019, the total capital spending on water infrastructure at all levels was approximately $48 billion, while capital investment needs were $129 billion, creating an $81 billion gap. This underscores a chronic trend of underinvestment in critical water-related infrastructure —drinking water and wastewater systems. With this gap, only 37% of the nation's total water infrastructure capital needs were met. Assuming the water and wastewater sectors continue along the same path, the total gap will grow to more than $434 billion by 2029.

Also influencing the wastewater sector's future needs are the growing O&M costs that are outpacing available funding. As system components near or exceed their expected lifespans, O&M for water infrastructure become costlier. In 2019, 90% of the nation's $104 billion O&M funding need was met, leaving an annual gap of $10.5 billion. If trends continue, the country will face a single-year O&M shortfall of $18 billion in 2039.

The implications of unaddressed capital and O&M future needs are particularly pervasive within the nation's water-reliant businesses and healthcare industry. Economic projections indicate that by 2029, chronic service disruptions would cost water-reliant businesses $111 billion and American households a cumulative $378 million in healthcare costs.[33]

PUBLIC SAFETY

In some communities where legacy infrastructure exists, wastewater and stormwater systems are integrated into a combined sewer network. When these areas experience heavy rainfall or rapid snowmelt, the capacity of the combined system is overtaxed and results in combined sewer overflows where large volumes of partially treated or untreated wastewater bypass the treatment process and enter local waterbodies. According to the EPA, there are approximately 860 combined sewer systems throughout the country.[34] Over the last two decades, more than 200 of the nation's largest combined sewer systems (those serving > 50,000 people) have been identified and had actions taken to reduce overflow discharges that degrade water quality.[35]

Additionally, utilities grapple with treating and disposing of byproducts containing contaminants of emerging concern such as per- and polyfluoroalkyl substances (PFAS, forever chemicals) or novel biological components (antibiotic-resistant genes).[36 37] EPA studies state that the PFAS family of chemicals is persistent in both the environment and human bodies, which means they are likely to accumulate over time. Furthermore, evidence shows that exposure to PFAS can lead to adverse human health effects. As these threats increase, so too does the need for costly improvements in wastewater treatment systems.[38 39]

RESILIENCE

Utility managers, WWTP operators, engineers, and elected officials are increasingly incorporating aspects of resilience — a system's ability to withstand and adapt to the impacts of natural and/or man-made disasters — into the design, siting, and planning phases of their wastewater infrastructure. However, the suite of wastewater infrastructure vulnerabilities varies by geographic location, type of treatment system, age, and ownership status, so there is not a "one size fits all" solution.

For instance, some wastewater systems are in low-lying areas that are especially prone to the impacts of flooding, while others may be in drought-prone regions or areas with increasingly frequent wildfires.[40] Rather than continuing to operate under a "business as usual" framework, some critical infrastructure decision-makers are shifting their efforts from singularly addressing short-term metrics like population growth, capacity demands, and affordability, and are incorporating long-term, resilience-related factors into planning such as sea level rise, frequency, intensity, and likelihood of natural disasters, cybersecurity threats, and post-interruption recovery time.[41] For instance, the drinking water sector recently set a resilience precedent that may be instructive for many wastewater stakeholders. In 2018, resilience planning was streamlined within drinking water utilities with the signing of America's Water Infrastructure Act (AWIA) which requires drinking water systems to routinely develop and update Risk and Resilience Assessments and Emergency Response Plans.[42]

Across all sizes of wastewater treatment systems, technological and scientific innovations have made significant contributions to addressing the sector's challenges.

INNOVATION

Across all sizes of wastewater treatment systems, technological and scientific innovations have made significant contributions to addressing the sector's challenges. For example, water conservation appliances have reduced the volume of wastewater entering the system, treatment process innovations have more efficiently utilized existing capacity and limited resources, and real-time conveyance network monitoring can pinpoint and prioritize areas suffering from inflow and infiltration or in need of O&M.

Sensors and monitoring innovations are being installed to collect real-time data on the wastewater conveyance network's condition to inform and prioritize the system's O&M schedule. After a wastewater utility in San Antonio, Texas, implemented in-pipe sensors, data was collected to optimize the network's cleaning schedule, saving thousands of dollars in each location a sensor was installed.[43]

Additionally, in recent decades, resource recovery has increasingly shifted the traditional wastewater treatment mindset away from generating a product solely for disposal but reconceptualizing this "waste" as a "resource." Innovations such as anaerobic digestors, indirect potable reuse, and biosolids reuse systems can recover water, energy, and nutrients from treated wastewater and may contribute to the resilience of treatment facilities, communities, and entire watersheds.[44 45]

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RECOMMENDATIONS TO RAISE THE GRADE

- Infrastructure owners should engage in asset management practices across infrastructure sectors to extend the lifespan of assets and prioritize limited funding. Asset management must include continuous assessment of the condition of assets and prioritize investment decisions based upon a comprehensive suite of data.
- More collaborations between researchers, technologists, wastewater utilities and operators, and federal decision-makers will be needed to develop and quickly deploy effective regulations, systems, public safety education, and policies that address 21st century concerns such as per- and polyfluoroalkyl substances (PFAS, forever chemicals) or novel biological components.
- Expand EPA's CWSRF program and the Water Infrastructure and Finance Innovation Act (WIFIA) with additional long-term, low-cost funding mechanisms for regionally and nationally significant, large-dollar-value projects.
- Identify new grant programs and funding mechanisms whose goal is to eliminate and/or decouple the nation's remaining combined sewer systems.
- Develop a federal grant pilot program for publicly owned wastewater treatment plants whose purpose is to create or improve waste-to-energy systems that increase wastewater treatment efficiency.
- Incorporate geographically specific projected impacts of climate change into wastewater infrastructure planning and long-term funding decisions.
- Utilities should ensure their rates cover the full cost of service including operation, maintenance, and capital needs; clearly communicate rate increases to the public; and balance local issues of affordability.
- As all wastewater systems face multiple and increasing natural threats, a rule similar to America's Water Infrastructure Act of 2020 should be implemented to direct utilities to develop, update, and implement vulnerability (risk and resilience assessments) and emergency response plans.

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