Stormwater

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EXECUTIVE SUMMARY

Stormwater systems range from large concrete storm sewers, roadside ditches, and flood control reservoirs, to rain gardens and natural riverine systems. While stormwater utilities are on the rise, with more than 40 states having at least one, the impervious surfaces in cities and suburbs are also expanding, exacerbating urban flooding, which results in $9 billion in damages annually.[1] Stormwater also affects water quality as polluted runoff from pavement enters water bodies. Nearly 600,000 miles of rivers and streams and more than 13 million acres of lakes, reservoirs, and ponds are considered impaired.[2] Federal funding, though up in recent years, averages about $250 million annually, which leaves a growing annual funding gap of $8 billion just to comply with current regulations. With few dedicated funding sources, complicated governance and ownership structures, expansive networks of aging assets, increasingly stringent water quality regulations, and concerning climate change projections, the expected performance of stormwater systems is declining. Many of the country's legacy stormwater systems are struggling with the high cost of retrofits needed to address urban flooding and climate change. Upgrading large networks of aging systems underneath densely populated areas carries significant costs and engineering challenges.

INTRODUCTION

Stormwater runoff is defined as rain or snow melt that travels over impervious surfaces such as roadways, buildings, or parking lots, and landscaped or agricultural areas and is then collected and conveyed into streams, rivers, lakes, bays, or oceans.[3] As impervious surfaces in increasingly developed cities and suburbs expand, so do the impacts of increased runoff from larger rainfall events which can lead to urban flooding.[4]

Nationally, stormwater infrastructure can take many forms, including piped systems, detention basins, ditches, canals, channels, and roadway conveyance systems.[5] In recent years, green stormwater infrastructure has been introduced in new developments and coupled with traditional "gray infrastructure" to maximize the benefits from natural hydrologic cycles using vegetation, soils, site grading, and natural filtration processes. Green infrastructure provides benefits by reducing runoff, minimizing erosion, and contributing to water quality improvements; examples include rain gardens, constructed wetlands, vegetative roadway bioswales, and permeable pavements.[6]

The United States Environmental Protection Agency (EPA) classifies stormwater systems as those that are publicly owned, discharge into waters of the U.S., and are not part of a sewage treatment plant such as Municipal Separate Storm Sewer Systems (MS4s). MS4s are regulated by the EPA under the National Pollution and Discharge Elimination System (NPDES) program.[7] Apart from EPA regulations, states, counties, and local governments may also require stormwater management practices through local ordinances, building codes, and development plans.

CAPACITY

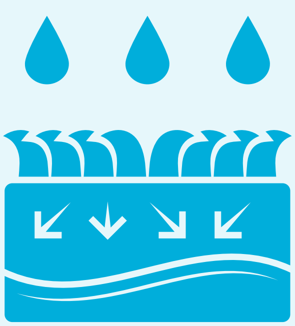
While there is not yet a comprehensive national database of assets, estimates suggest there are 3.5 million miles of storm sewers, 270 million storm drains, and 2.5 million stormwater treatment assets across the U.S.[8,9,10,11,12,13,14] Under the NPDES MS4 program, municipalities are required to map their stormwater systems and, as of 2018, nearly 40% of stormwater utilities have taken this step.[15]

Stormwater infrastructure capacity is principally derived from the design standards used for construction. Terms like "10-year" and "100-year storms" (meaning those with a 10% and 1% annual probability of occurrence, respectively) are currently used to describe a system's capacity. However, such design standards have only been used in recent decades, and the standards differ within and between states.

While design standards govern a stormwater system's *theoretical* capacity, routine operation and maintenance (O&M), age, and the changing frequency and intensity of storm events, are the main drivers affecting a stormwater system's *actual* capacity. Given the recent increase in rainfall trends and urbanization, the actual capacity of a stormwater system is often less than the design standard.[16] Many of the country's legacy stormwater systems, such as those in Chicago and Philadelphia, for example, are now struggling with the high cost of retrofits that are needed to accommodate these changes. Upgrading large networks of aging systems that are now underneath densely populated areas carries significant costs and engineering challenges.

Photo by Anna Denecke

STORMWATER MANAGEMENT INFRASTRUCTURE IN WASHINGTON, D.C.



Given the recent increase in rainfall trends and urbanization, the actual capacity of a stormwater system is oftentimes less than the design standard.[16]

CONDITION

The condition of stormwater infrastructure is indicated, in part, by the system's age. Without better stormwater asset records, the average age of the system cannot be directly determined, so the lifespan of the primary construction material is used as a proxy. Stormwater conveyance systems may be constructed of corrugated metal, reinforced concrete, or plastic, and their lifespan is projected to be 50 to 100 years. Storage and treatment systems such as detention and retention ponds have an average lifespan between 20 to 30 years.[17 18] Based on this, systems constructed in the 1970s or prior have exceeded or are nearing the end of their useful lives and are likely undersized given current stormwater management practices and climate change impacts.

Another key indicator of stormwater infrastructure condition is the system's ability to reduce negative impacts to local waterbodies. Under the NPDES program, stormwater systems are required to meet the overarching goal of reducing the discharge of pollutants from runoff.[19 20] While water quality is a priority across the nation, from 2010 to 2018, the length of impaired rivers and streams increased from about 424,000 miles to more than 588,000 miles.[21]

FLOODING IN MADISON, WISCONSIN

OPERATIONS & MAINTENANCE

Stormwater infrastructure may be owned and managed by various public or private entities such as state or local governments, individual or corporate property owners, or homeowners' associations. All stormwater systems require some level of routine maintenance, but the ongoing management of stormwater systems can be complex and expensive. Storm sewers require jetting and cleaning, and stormwater detention basins, bio-retention facilities, permeable pavement, and bioswales all require unique maintenance tasks with specialized knowledge. This can be a challenge for all levels of government, private property owners such as shopping centers, or homeowners' associations.

The MS4 NPDES permitting process has been an effective regulatory lever influencing O&M practices and frequency due to the expectation of routine inspections. Under the NPDES program, all MS4s are required to have maintenance plans. However, private entities, cooperatives, and individual homeowners responsible for O&M are often not routinely monitored and left to manage critical and sometimes expensive components of the stormwater system on their own. Deferred maintenance increases the likelihood of urban flooding and increases threats to water quality protection.[22 23]

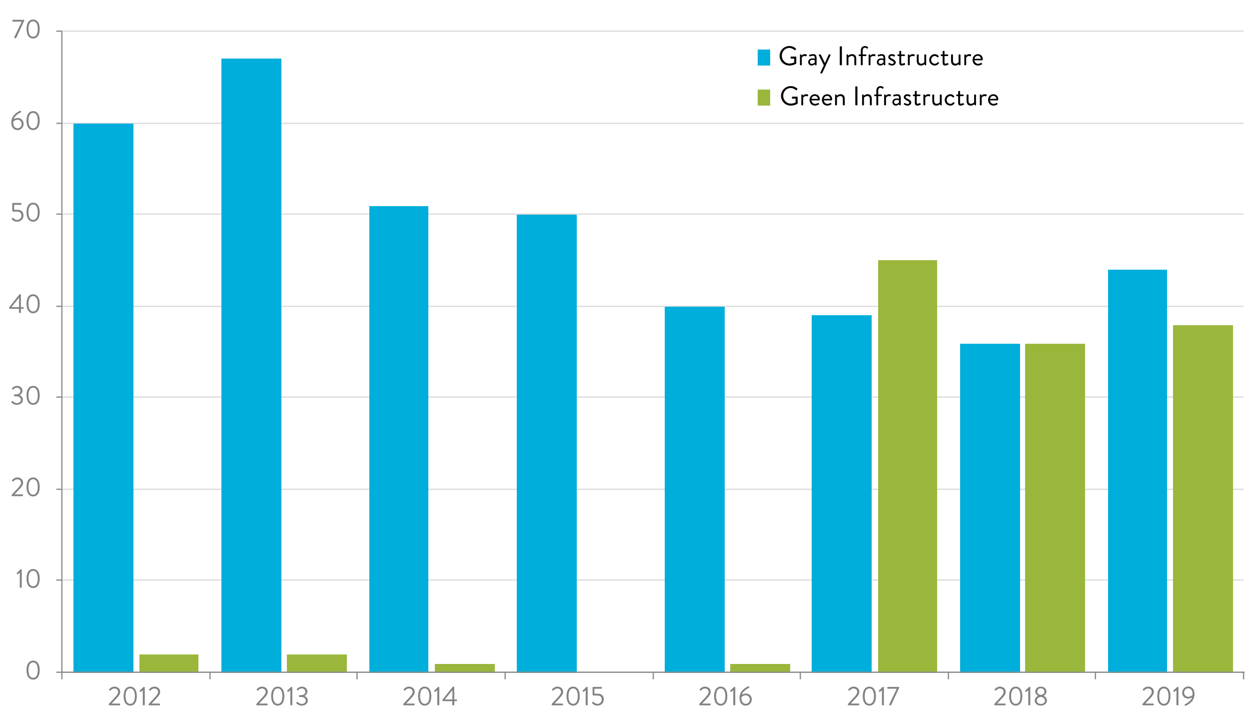
FUNDING

Funding for stormwater infrastructure across the country is limited and comes from multiple sources — local revenue, state and/or federal grants and financing, and non-traditional funding streams. Because the financial responsibility for managing stormwater systems can sometimes be unclear and draw from entities' general funds, hundreds of public entities in at least 40 states have taken the initiative to create stormwater utilities to collect fees based on property size, impervious area, and other site-specific characteristics. Out of communities with municipal MS4s, the percentage with stormwater utilities or fees has grown from approximately 19% in 2013 to upward of 26% in 2018.[24 25] For a single family home, the average monthly stormwater fee in 2018 was $5.34.[26]

For large capital improvements, state entities or municipalities may use general obligation bonds. They may also seek federal resources like those from the EPA's Clean Water State Revolving Fund (CWSRF) which has provided nearly $2.2 billion for more than 1,100 stormwater projects since its inception.[27] More recently, the CWSRF's program funding for stormwater projects has trended upward from more than $58 million in 2012 to more than $387 million in 2019 with the portion of funding for green infrastructure also increasing.[28] Though trends are improving, only 3% of all CWSRF funds have gone toward stormwater and similar types of projects.[29] Additionally, the EPA's Water Infrastructure and Finance Innovation Act (WIFIA) is another federal funding mechanism. In 2019, at least three stormwater infrastructure projects applied for $673 million in WIFIA loans out of the program's $7.7 billion in overall support.[30]

While there are limited and highly competitive grant programs at the local, state, and federal levels that cover a very small portion of the overall need, non-traditional mechanisms for funding stormwater infrastructure have also emerged and include public-private partnerships; leveraged synergies among solid waste, transportation, and/or wastewater sectors; and market-based solutions that monetize permit requirements like nutrient and/or stormwater volume trading.[31 32]

Projects Awarded Clean Water SRF Funds Over Time



Source: Clean Water SRF Program Information National Summary (2019) https://www.epa.gov/sites/production/files/2020-02/documents/us19.pdf

FUTURE NEED

As water quality measures for MS4 permitting become more stringent, local governments and stormwater utilities having to update or expand their systems, stretching their limited economic resources. In 2020, the Water Environment Federation's National MS4 Needs Assessment estimated that the sector's annual funding gap is $8 billion among MS4 permittees.[33 34] Separately, an economic analysis by ASCE shows a water-related infrastructure investment gap of $434 billion over 10 years for drinking water, wastewater, and stormwater combined.

The trajectory of urban flooding impacts will likely continue the upward trend as our older stormwater assets cannot accommodate the changing rainfall patterns and intensity.[35]

Many utilities are behind in accounting for the condition of their assets, planning, and funding for short- and long-term maintenance, and strategizing necessary capital improvements. A clear picture of the existing assets and their condition is needed to provide flood projection models with data to identify areas of significant risk where limited, available resources may be targeted for improvements.

Photo by ASCE

PERMEABLE PAVEMENT AND STORMWATER DETENTION IS BUILT INTO A PARKING LOT IN RESTON, VIRGINIA.

PUBLIC SAFETY

Flooding is one of the nation's greatest natural hazards, carrying catastrophic public safety and economic tolls. Annually, from 2004 to 2014, urban flooding alone cost communities an average of $9 billion in direct damages and 71 deaths.[36]

When stormwater systems become overwhelmed, there are acute and long-term public safety implications that create ripple effects to other infrastructure systems. Effects throughout the community may include sinkholes, flash floods, collapsed roadways, extensive property damage, inflow into sanitary systems which inundates wastewater treatment plants and pollutes waterways, and loss of life. Over the last two decades, to buttress the impact of these losses, the National Flood Insurance Program has more than doubled its enacted policies while the number of private insurance companies entering the market between 2016 to 2019 has also more than doubled.[37]

STORMWATER TREATMENT CHANNEL IN SOUTH FLORIDA

RESILIENCE & INNOVATION

Impacts from climate change will have variable effects on the form and frequency of extreme events across the nation. To withstand these effects, stormwater infrastructure is increasingly implemented with a context-sensitive approach, that leverages a localized understanding of flood risk, land use practices and regulatory expectations. This approach informs the types, designs, locations, and long-term sustainability of stormwater systems. Resilience for stormwater infrastructure is reflected by a mix of optimized green, gray, and natural infrastructure, land planning and urban growth, updated asset management and, in water-scarce areas, the productive reuse of stormwater.

Current innovations employed by utilities include the use of real-time control systems, complex modeling, cloud computing, data storage, and predictive analysis.[38] Large datasets can be used to optimize the capacity of stormwater conveyance, storage and treatment systems, investments in O&M activities, and other costs. The affordability of sensors has also improved, expanding the potential for system implementation of real time data and control.

Finally, some areas employ a regional approach to stormwater management through volume and nutrient trading within watersheds. This can economically incentivize stormwater innovation.

HURRICANE HARVEY SUMMER FLOODING IN TEXAS

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RECOMMENDATIONS TO RAISE THE GRADE

- Fully fund and disseminate information from the EPA's Clean Watersheds Needs Survey on a routine basis (every four years) and elicit more stormwater-related detail, including information about maintenance, repair, pollution prevention, and urban flooding.
- Develop a stormwater-specific funding and financing program based upon the best practices from the existing Clean Water State Revolving Fund.
- Stormwater infrastructure and design regulations are critical for protecting communities from costly urban flooding and protecting water quality in our waterways. Stormwater systems should be a combination of gray, green, and natural infrastructure and should be mainstreamed in planning and development processes nationwide.
- Develop state-based peer-to-peer partnerships to build local government capacity to create and manage stormwater utilities that sustainably fund, operate, maintain, assess, and, when necessary, expand stormwater infrastructure.
- Establish a grant program for 21st century technical career training for "green collar jobs" in the stormwater sector that recruit the next generation's talent and mainstream tools for data-driven decision-making, such as asset management software, life-cycle cost analysis, and affordable rate structuring.
- Expand the inclusion of current and forecasted climate variability in codes and standards for the design, operation, maintenance, and expansion of stormwater infrastructure and routinely provide funding to NOAA to update the climate data.
- Ensure stormwater infrastructure is fully eligible and aggressively pursued via federal funding and financing mechanisms that are supporting the nation's drinking water and wastewater systems.
- Develop a comprehensive education campaign on the true costs, savings, risks, and avoided hazards associated with stormwater infrastructure investments, and disseminate these details through broadly accessible platforms.
- Educate communities on best practices for creating stormwater utilities that institute rates that reflect the true cost of treating and handling stormwater runoff.
- Point source and nonpoint source pollution should be addressed through a watershed approach that encourages regional coordination to improve impacts from stormwater-induced flooding.

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