Innovation in Action: 21st Century Water Infrastructure Solutions

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Innovation in Action:
21st Century Water Infrastructure Solutions
Executive Summary

Introduction

Infrastructure is back. After years of being ignored, devalued, overlooked, and neglected, water infrastructure is in the news. Everyone, it seems, wants to be an infrastructure hero. But even in the digital age, much of the infrastructure discussion at the federal and state levels is centered on the conventional approaches of the past century.

Missing from the conversation is the reality that many public water resource agencies are investing in local water infrastructure and finding a new set of strategies – localized and distributed across communities – to be viable, sustainable, affordable and equitable solutions to water management challenges.

WaterNow Alliance's new white paper examines site-level strategies that can address the range of drinking water, wastewater, and stormwater issues facing the nation. **Through 13 case studies of public utility successes, the report demonstrates the new water infrastructure is decentralized, onsite, and local.** These strategies entail their own set of implementation challenges, and this paper doesn't address all of them (and some are explored in WaterNow's Tap into Resilience Toolkit that will also be regularly updated based on new research), but points the way to solutions that are already demonstrating meaningful success and can be replicated and scaled nationwide.

As the climate changes and communities move toward a One Water strategy, these localized solutions will support communities in building a resilient water future. The issue is scale. Communities will only realize the full potential of the benefits that distributed solutions can provide if they can invest in and adopt these strategies widely across their businesses, neighborhoods, residences, streets, and parks. The paper includes a 10-part decision making framework that supports local water leaders in bringing this approach to scale.

Major Findings:

(1) Distributed strategies can effectively serve as water infrastructure across the "One Water" spectrum of water resource management challenges.

(2) Tangible evidence demonstrates that localized strategies can be affordable, sustainable, scalable, and provide multiple co-benefits.

(3) Cities and utilities nationwide can readily build on current successes and adopt decentralized sustainable practices most suited their communities.

What is Distributed Infrastructure?

Installations, appliances, and technologies located at or near the point of use and distributed across many properties, and generally employed in coordination with a utility's conventional infrastructure. WaterNow has identified 5 categories capturing these strategies listed below:

- Water Use Efficiency
  - Indoor high efficiency appliance and fixtures
  - Turf replacement
  - Smart irrigation controllers
  - Customer-side leak detection devices
- Stormwater and Flood Management
  - Green roofs and blue roofs
  - Urban forests
  - Bioswales and rain gardens
  - Green streets and permeable pavements
  - Coastal restoration
  - Low impact development
  - Aquifer storage and recovery (ASR)
- Reuse and Other Alternative Non-Potable Water Sources
  - Onsite non-potable water systems
  - Graywater systems
  - Rainwater harvesting
- Source Watershed Protection
  - Headwaters preservation and restoration
  - Conservation easements
  - Revegetation
  - Riparian buffers
  - Wetland restoration and creation
- Replacement of Private Service Lines
  - Lead service line replacement
  - Private sewer lateral replacement

Public Utilities Are Leading the Way

WaterNow's research found noteworthy gains in deployment of decentralized strategies from green stormwater infrastructure (GSI), to conservation and efficiency to lead line replacements in communities nationwide. The white paper focuses on public agencies – cities, towns, counties, water districts, sanitary and stormwater agencies, and other special districts – because these entities serve the vast majority of the U.S. population, and will shoulder much of the burden for addressing the impacts of climate change. As stewards of public resources, as well as public dollars, they can pass along significant benefits to their communities in the form of access to low interest, tax-free financing; accountability and transparency to local ratepayers; greater responsiveness to equity and affordability concerns, among others.

Localized Water Infrastructure Case Studies

The strategies profiled in this white paper address a range of water management challenges:

- **extending or generating new water supply**
- **improving water quality**
- **capturing urban runoff**
- **reducing wastewater overflows**

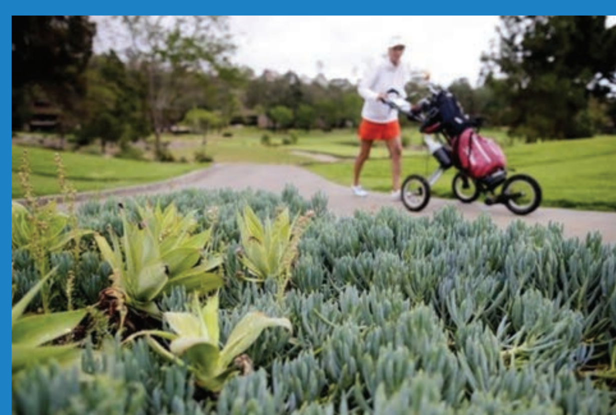
They often serve more than one of these purposes simultaneously. We have focused on examples where communities have made investments in solutions that are effective, affordable, sustainable, and scalable. Together, these case studies show that cities and utilities nationwide can build on current successes and adopt sustainable practices in their communities.

The most commonly cited drivers for turning to localized infrastructure include:

- concerns about climate change
- drought or long-term water supply limitations
- more affordable ways of addressing combined sewer overflows (CSOs) and urban stormwater management challenges
- increasing local resilience
- and compliance with various regulatory mandates
- higher cost of more conventional alternatives

In addition, the case study communities almost uniformly made the decision to "go greener" based on perceptions that these distributed strategies could provide a range of community and equity co-benefits including but not limited to:

- urban revitalization and green space
- energy savings
- increased local economic development
- improvements in public health



Water Supply Case Studies

• Santa Fe Water Division: Efficiency As A Way of Life

- Combination of mandates and financial incentives have resulted in broad adoption of distributed water efficiency measures leading to major reductions in per capita water.

• Moulton Niguel Water District: Not Using Less, Wasting Less

- Consumer rebates for onsite outdoor and indoor efficiency measures based on data analysis showing greatest potential for water savings.

• San Antonio Water System: Conservation As Supply

- Early leader in treating decentralized conservation measures as a source of water supply, implemented primarily through financial incentives for consumers.

• Tucson Water: Efficiency Means Avoided Costs

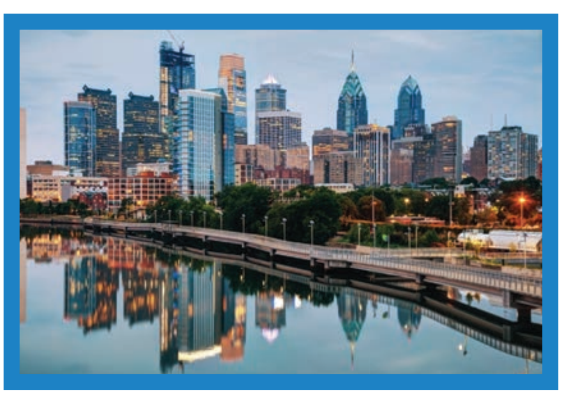
- Long-term investment in consumer incentives for efficiency has kept total water use flat since 1985 notwithstanding significant population growth.

• Austin Water: Water Resource Planning For The Next Century

- 100-year One Water plan focused on local resilience and mitigating climate change impacts largely through expanded investments in efficiency and reuse.

• Seattle Public Utilities [Part 1]: Putting Capital Behind Efficiency

- Debt financing efficiency rebates for private property installations.



Wastewater and Stormwater Case Studies

- **Philadelphia Water Department: Green City, Clean Waters**

  - Billion dollar investment in distributed green stormwater infrastructure across the community over the next 25 years to address combined sewer overflows.

- **Milwaukee Metropolitan Sewerage District: Going Big On Green**

  - Goal to use distributed green infrastructure to capture 740 million gallons of stormwater (per storm) by 2035—more stormwater than is captured than MMSD's Deep Tunnels.

- **City of Eugene: Leveraging Development Standards To Deploy Decentralized GSI**

  - Local ordinance requiring onsite stormwater management for new development, and city-wide green infrastructure to address urban runoff.

- **Seattle Public Utilities [Part 2]: Incentivizing Citywide Private Property GSI**

  - Debt financing green infrastructure for private property installations.

- **One Water LA: One Water Planning In Action**

  - Comprehensive One Water Plan integrates centralized facilities and distributed green infrastructure program to manage stormwater.

- **DC Water: Clean Rivers Project**

  - Green stormwater infrastructure for public and private property owners to address combined sewer overflows.

Lead Service Line Replacement Case Studies

- **Madison Water Utility: A Lead Leader**

  - City-wide program to replace private lead service lines paid for in part with public funds.

Innovations in Finance

For most utilities, significantly scaling adoption of distributed water strategies will require access to investment capital in the same way that they raise capital to fund conventional water infrastructure. The white paper reviews a number of opportunities available to utilities including State Revolving Fund and other low interest federal loan programs and Environmental Impact Bonds and similar types of performance-based vehicles.

In a particularly interesting development, the General Accounting Standards Board (GASB) has clarified that consumer incentives issued by public entities to pay for decentralized water systems can be capitalized, opening the door for utilities to deploy tax-free municipal bonds to finance rebate programs. This would allow utilities to put their investments in distributed and conventional infrastructure on par, amortizing costs for both of these long-term expenditures over time, avoiding rate-shock and more equitably sharing the cost burden with future ratepayers.

The GASB guidance is a game changer. If even a tiny percent of the billions in annual capital spending for local water infrastructure nationwide is redeployed to distributed onsite solutions, it would represent vast new investment capacity and a major expansion in the adoption of these technologies and programs.

Decision-Making Framework

WaterNow has distilled lessons from the case studies into a high-level decision-making framework for deploying these strategies at larger scale as best fit a community's particular needs:

1. **Identify whether and how DI strategies can address local drivers.**
2. **Identify appropriate models and data to assess potential performance.**
3. **Evaluate costs and benefits holistically – include financing options and multiple benefits.**
4. **Incorporate distributed onsite systems into capital planning alongside conventional infrastructure.**
5. **Think broadly and creatively about financing options.**
6. **Incorporate stakeholder outreach and engagement in planning & implementation.**
7. **Plan for project- and place-specific implementation challenges.**
8. **Identify internal capacity, gaps and available support resources.**
9. **Have a plan for ongoing maintenance.**
10. **Establish performance metrics and evaluation methods.**

Conclusion

Water is the delivery vehicle for climate disruption in the United States. Water resource utilities – particularly the public entities serving the vast majority of the U.S. population – are on the front lines to ensure that their communities are safe, healthy, and resilient when it comes to water resources, and that these services are available and affordable for all. We have only just begun to realize how the new distributed water infrastructure can serve these functions while providing significant co-benefits, particularly to more vulnerable communities, in the form of increased local resilience, affordability, green space, economic development, community engagement, and more.

Hundreds of communities nationwide have been experimenting with distributed systems on a relatively small scale, and those profiled here are thinking bigger. We have the technology, the data, and the tools to take advantage of the opportunities that localized strategies present now.

What is needed is primarily a shift in our collective thinking about what constitutes "water infrastructure," and the leadership to invest and move forward accordingly.

About Waternow Alliance

Local decision makers hold the keys to our water future. 95% of water infrastructure spending occurs at the community level, and 87% of people nationwide are served by public water utilities. While Federal and State agencies have a vital role, the policies, strategies and priorities established by local leaders have the power to fundamentally shift how we think about and use water. WaterNow Alliance is a network of over 400 public water utility leaders in more than 30 states supporting sustainable, affordable, and climate resilient water strategies in their communities. WaterNow engages its members and connects them to ideas, resources, and one another; advocates for policies that create pathways for sustainable and affordable solutions; demonstrates success by providing technical project assistance to communities implementing projects on the ground. WaterNow Alliance is a division of Multiplier (formerly the Trust for Conservation), a 501(c)(3) organization.

About The Authors

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Cynthia Koehler, co-founder and Executive Director of WaterNow Alliance, is an attorney and water policy expert with 25 years of experience in federal and state water law and policy. Her work has focused on building networks of utilities, conservation groups, federal and state agencies, and academics engaged in sustainable water solutions. She was previously the Legislative Director for California water issues for the Environmental Defense Fund, and Legal Director for Save San Francisco Bay Association. Cynthia has also served for the last 14 years as an elected board member of the Marin Municipal Water District, a public water provider. She was an appointed member of US EPA's Local Government Advisory Commission (2016-18), and Governor Brown's Urban Advisory Group (2017-18). Cynthia is the recipient of The Bay Institute's Hero of the Bay Award, and other honors. She holds a B.A. from Pomona College, and a J.D. and Environmental Law Certificate from the University of Oregon School of Law.

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Carline Koch leads WaterNow Alliance's work in identifying and addressing policy and legal barriers to implementation of sustainable water management practices through toolkit development, legislative and administrative advocacy, and policy white papers. She was previously a partner at Lawyers for Clean Water, Inc. representing environmental non-profit organizational clients in federal citizen suit actions and impact litigation advocating for the protection of California's water and public trust resources. Caroline serves on the Board of the San Francisco League of Conservation Voters. She graduated with BA in English and Public Policy from Duke University and a JD with honors from Golden Gate University School of Law with a Certificate in Environmental Law.

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Public Water Utilities Deploy 21st Century Water Infrastructure To Build A Resilient Future

Introduction

Infrastructure is back. After years of being ignored, devalued, overlooked, and neglected in the public discourse, water infrastructure is enjoying something of a renaissance. It's suddenly sexy, in the news, and everyone, it seems, wants to be an infrastructure hero. In a rare bipartisan effort Congress passed a water infrastructure bill—dubbed "America's Water Infrastructure Act"—in 2018 that includes a 3-year reauthorization of $4.424 billion for the Drinking Water State Revolving Fund and a reauthorization of EPA's Water Infrastructure Finance and Innovation Act (WIFIA) for 2 years and $100 million.[1]

For all that, however, our water resource utilities—for drinking water, wastewater and stormwater—are facing major challenges and the federal investment, if it comes to pass, is the proverbial drop in the bucket. The country's aging water infrastructure and the massive level of investment needed to upgrade, expand, maintain, and repair our systems has been well documented. In addition, municipalities are struggling with myriad 21st century problems of an entirely new magnitude including but not limited to; emerging contaminants of concern (e.g., PFAS),[2] harmful algal blooms (or HABs), lead service lines, as well as rate affordability, access and equity issues, all of which are exacerbated by the effects of a changing climate. Flint, drought, and other water-related crises have captured the public's attention and concern, making it possible – and indeed essential – for utilities to invest not only in infrastructure, but in a fundamental cultural shift to come into the open and engage with their communities, ratepayers and local leaders.

It is clear that now is the time for water utilities to be making a generational investment in water infrastructure, and the question is what shape and direction that will take. The opportunity for local decision makers is to expand conventional perceptions about water infrastructure to include a combination of smarter approaches to support, supplement and extend our built systems, including specifically onsite systems and technology. These localized strategies are being referred to as "distributed infrastructure" because they are characterized primarily by the fact that they are distributed across a community. Big data and other innovations are part of this set of smart approaches as well, but for purposes of this paper, we focus on distributed strategies and how scaling up their adoption at the local level can provide critical benefits to communities nationwide.

Many onsite and localized water strategies have been pioneered and tested; a number of these are described in the case studies highlighted at the end of this paper. WaterNow has also compiled additional examples as part of our Tap into Resilience initiative and helped implement these programs through our Project Accelerator,[3] and our colleagues at The Nature Conservancy, American Rivers, Earth Economics, among many others, are in the field working on these projects to provide even more examples and success. From bioswales, green roofs, and "stormwater trees" capturing excess rainwater to turf-changeouts, onsite water reuse systems and smart irrigation controllers generating "new" water supply, to protecting public health with lead service line replacements, the potential for distributed solutions to supplement our built water systems has been proven but nevertheless remains largely untapped.

The challenge and the opportunity is to scale up these strategies, bringing them from the margins of small bore, community outreach programs with important but limited impact, and into long-term planning and investment alongside conventional centralized water infrastructure projects. This report brings together information, analysis and case studies indicating that we can substantially expand our vision of "water infrastructure" to include the vast set of onsite and localized strategies that can perform many of the same functions as conventional centralized approaches and supplement the services provided by these systems.

This paper explores two theses: (1) that scaling up investment in distributed, onsite and localized water solutions represents a critical opportunity for addressing our collective water challenges; and (2) public water utilities and their leaders are positioned to lead in this new direction.

Indeed, many public utilities are redefining "infrastructure" through their investments and are accessing a more diverse investment portfolio than in the past by expanding sustainable options to supplement their conventional infrastructure and integrated planning to build community resilience.[5] The question we explore in this paper then is **to what extent our conventional water infrastructure can be supplemented by increased investment in 21st century decentralized solutions, strategies, and technologies.** Many public utilities in all regions of the U.S. are experimenting with these options in response to local conditions and provide robust examples for how others can begin to do the same. To fill this gap in the ongoing discourse on the nation's water future, this report:

- **Provides an overview of how local utilities are shouldering investments in drinking water, wastewater, and stormwater infrastructure;**
- **Identifies how localized infrastructure options can support sustainable water management, defining available strategies and technologies, funding options, water resource management and co-benefits, and implementation mechanisms; and**
- **Includes 13 success stories of public utilities already investing in distributed water infrastructure**

These tools and real-world successes demonstrate how cities and public utilities can expand their water infrastructure planning and investments to include decentralized options. The paper concludes with a set recommendations including:

- **A conceptual decision-making framework for implementing decentralized water strategies as infrastructure at scale; and**
- **Areas of further analysis needed to advance large-scale deployment of localized water infrastructure solutions.**

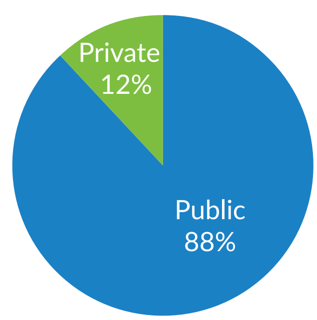
Local Utilities Lead Investments in Drinking Water, Wastewater, and Stormwater Infrastructure

Providing clean drinking water and effective wastewater and stormwater management is an inherently local challenge; publicly owned local water resource entities—cities, towns, counties, special districts—provide drinking water, wastewater, and stormwater management services to the vast majority of people in the United States. They also account for almost all of the country's investments in water infrastructure. Federal and state governments, by contrast, "play the role of regulator, financier and provider of occasional financial assistance."[6]

Drinking Water

The majority—88%—of the population in the U.S. is served by a public water provider, either a city, county or special district of some kind.[7] Much has been written about the fact that there are 52,000 drinking water utilities in the U.S.,[8] and the major challenges associated with such a large number of systems.[9] However, this figure obscures the situation somewhat; **fully 92% of the nation's total population is served by fewer than 8,700 utilities.**[10]

Percent of National Population Served by Private vs. Public Community Water Systems



Andrea Kopaskie, "Public vs Private: A National Overview of Water Systems", The Environmental Finance Blog, UNC School of Government

The issues facing the other 8% of the population, primarily living in rural and often economically disadvantaged communities, are serious and severe and must be addressed if we are to ensure that all Americans have reliable access to clean, safe and healthy water supplies. Fragmentation, limited financial resources, equitable access to safe sources of supply are enormous challenges for tens of thousands of these smaller systems and their communities, but are beyond the scope of this paper which focuses on public water providers serving populations of 5,000 and more.[11]

Wastewater and Stormwater

According to the most recent numbers in the EPA database, about 19,000[12] facilities nationwide provide wastewater and/or stormwater management services more than 75% of the US population.[13] These facilities include publicly owned treatment plants, wastewater collection systems, municipal separate storm sewer systems, and combined sewer stormwater systems.

U.S. Environmental Protection Agency, Washington, D.C.

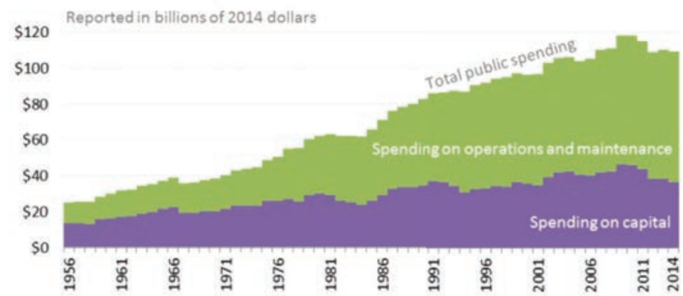
The State of Water Infrastructure & Investments: The Spending Is Local

Media reports commonly use the Infrastructure Report Card as a touchstone to describe the state of the nation's water infrastructure. The "report card" concept for this purpose was first introduced in 1988.[14] The original report, "Fragile Foundations: A Report on America's Public Works," by the National Council on Public Works Improvement convened by Congress, evaluated the country's transportation, water, and wastewater systems.[15] Though this report called for "dramatically enhance[ing] the capacity and performance of the nation's public works," it nevertheless determined that water supply and water resources were "in relatively good shape."[16] In particular, in 1988, drinking water infrastructure received a "B-", and wastewater a "C."[17] (Stormwater infrastructure was not separately evaluated.)

When the American Society of Civil Engineers (ASCE) picked up this role in 1998,[18] the grades for drinking water and wastewater infrastructure dropped precipitously to "D" and "D+," respectively.[19] Whether ASCE grades on a harder curve than the National Council on Public Works Improvement, or whether the status of the nation's water infrastructure deteriorated sharply over this period is hard to evaluate. But since 1998, water infrastructure grades have consistently hovered between D+ and D-, with ASCE's most recent report published in 2017.[20]

The prevailing media narrative suggests an egregious failure of public attention to the nation's water infrastructure, and without question massive public investment will continue to be required to secure the health, safety, reliability and equity of our water future. However, analyses from RAND and the National League of Cities (NLC) tell a more nuanced story. While there is a clear consensus that we are not as a society investing at the levels necessary to ensure the level of water resource management required, responsibility for paying for water infrastructure has shifted dramatically from federal and state governments to local utilities.

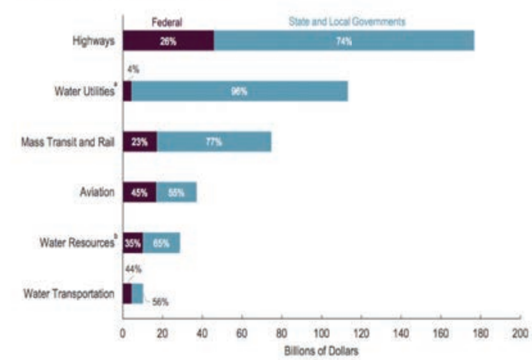
RAND's 2017 report, Everything Is Not Broken concludes that while federal and state spending on water infrastructure has declined substantially since the 1970s-1980s, the **"evidence on public spending does not support a broad claim of national divestment"**– largely because local governments have picked up much of the slack, keeping public spending on water infrastructure steady since the 1950s as a share of Gross Domestic Product.[21] Indeed, RAND estimates that local governments are now covering approximately 95% of spending on drinking water and wastewater infrastructure.[22] Similarly, NLC's report, Paying for Local Infrastructure in a New Era of Federalism, cites a significant decline in federal investment and less predictable state funding with local governments assuming even greater fiscal responsibility for critical water infrastructure.[23]



Graphed by the Environmental Finance Center at the University of North Carolina, Chapel Hill.
Source: Congressional Budget Office supplemental data for the *Pubic Spending on Transportation and Water Infrastructure, 1956 to 2014* report (March 2015). Displays public spending on supply systems for distributing potable water as well as wastewater and sewage treatment systems and plants. Real spending is shown after adjusting nominal spending to their 2014 dollar equivalent using infrastructure-specific price indexes.

Congressional Budget Office (CBO) also provides insight on local utility water investments. CBO's most recent report (for 2017) indicates that annual public spending on drinking water and wastewater infrastructure combined totaled $113 billion.[24] Of this amount, state and local governments spent $109 billion—or 96%.[25] (This figure reflects primarily local spending since states play a minor role in direct spending for water utilities.[26]) Federal funds totaling the remaining $4 billion were provided mainly in the form of grants but also as loans.[27]

The Federal Government's and State and Local Governments' Spending on Transportation and Water Infrastructure, by Type of Infrastructure, 2017



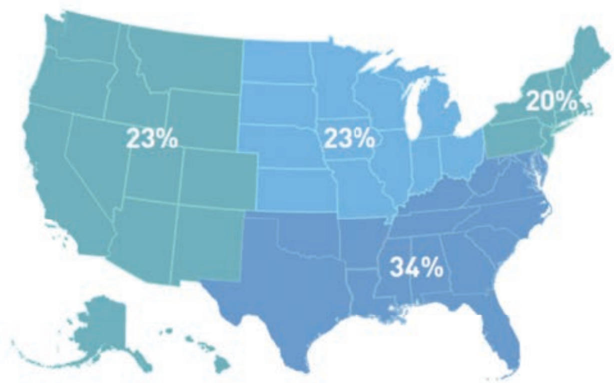
Source: Congressional Budget Office, using data from the Office of Management and Budget and the Census Bureau.
a. Includes water supply and wastewater treatment facilities.
b. Includes water containment systems (dams, levees, reservoirs, and watersheds) and sources of freshwater (lakes and rivers).

Even this broader story, however, begs the question about whether are we spending enough, and even more centrally, can we be spending smarter?

What Should We Be Spending on Water Infrastructure? Opinions Vary

Estimates of water infrastructure investment needs diverge widely. This appears to be because they are looking at different types of water needs and may also based on widely differing assumptions.[28] ASCE has suggested that we should be investing $55 billion per year in capital spending for drinking water and wastewater infrastructure, while the US Water

The Economic Benefits of Investing in Water Infrastructure, US Water Alliance



Alliance puts the annual figure for water, wastewater, and stormwater utilities at $123 billion annually.[29] The American Water Works Association (AWWA) indicates the number correct figure is $40 billion/year to maintain current levels of service for drinking water systems.[30]

As RAND points out, the concept of "need" is subjective and tricky. Is something "necessary" if it pushes up against a community's ability/willingness to pay?[31] Are the costs associated with solutions and approaches of the last century the best way to measure the investments that "need" to be made in the 21st?

What we can conclude with some confidence is the following:

- **Local governments—cities, towns, counties or special districts—will continue to be primarily responsible for providing drinking water, wastewater, and stormwater management services nationwide.**
- **Local ratepayers will continue to bear the burden for almost all of these costs (although there may be some resurgence of state support in some regions).[32]**
- **Some of the best minds in the country estimate that we "should" be spending tens of billions more on water infrastructure every year than we are currently.**

As demonstrated by the case studies below, many local governments across the county are in fact stepping up and making significant investments in not only their gray infrastructure, but increasingly in localized water strategies and solutions as well. In the aggregate, the cities and utilities profiled in this paper have invested tens of millions of dollars in onsite localized water infrastructure of various kinds. Together, these publicly owned local utilities are working to bring the United States' water infrastructure into the 21st century. Many are doing so by investing in decentralized strategies.

Sustainable Water Management With Distributed, Localized Infrastructure

In visualizing the water infrastructure we need, the central questions are: what are the services we want to provide and what are the best, most cost-effective ways to provide those services? In urban settings, water infrastructure needs to perform 3 basic functions:

(1) Provide clean, safe, reliable drinking water supplies for people, businesses, institutions and industry while protecting source water supplies;

(2) Move wastewater away from these homes, businesses, institutions, and industry, treat it to meet all applicable water quality requirements, and discharge it safely and without contaminating our rivers, lakes, streams, groundwater, oceans, and estuaries; and

(3) Manage stormwater to limit flooding and related damage and, again, ensure that its discharge does not harm water bodies and ecosystems.

Centralized water infrastructure can perform all of these functions well in many cases and we have built a lot of it.[33] At the same time, centralized systems are costly to build (especially in already developed landscapes), expensive to maintain, and can often involve adverse environmental impacts.

The question we explore in this paper is how our conventional water infrastructure can be supplemented by scaling up investment in decentralized solutions, strategies, and technologies. More water managers are finding that, in the aggregate, these localized systems perform the same water resource functions—sometimes even more effectively—than their centralized counterparts depending on the circumstances. They can often, if not always, do so at less cost while providing multiple community benefits and in concert with local environmental sustainability objectives. Deploying distributed, localized water infrastructure is also a central strategy for advancing the "One Water" concept of managing drinking water, wastewater, and stormwater in a fully integrated way, a vital approach for building water resilience in the face of climate change. Below we describe the types of localized water infrastructure available to combat drinking water, wastewater, and stormwater challenges, as well as the benefits of these approaches, funding and key implementation strategies.

Categories of Localized Water Infrastructure Strategies

Decentralized, distributed, localized, or onsite infrastructure are all terms for a "conceptual category" rather than a specific technology or legal term. In the context of urban water infrastructure, these words are used to refer to "dispersed facilities that extend beyond the central infrastructure and are located at or near the point of use."[35] This concept includes improvements,

What is localized water infrastructure?

Distributed systems that extend beyond the central infrastructure and are located at or near the point of use. These include improvements, devices, and technologies installed onsite that enhance a utility system by reducing the need for expanding the utility system or the scale of expansion needed.

devices, and technologies installed at diffused properties that enhance a utility system by reducing the need for expanding the utility system or the scale of expansion needed,[36] such as the "many improvements, practices, and devices that conserve water and retain stormwater onsite."[37] Localized water infrastructure is generally not owned or directly controlled by local utilities, because these systems reside on either private property or property that is owned by other public entities.[38]

These distributed, site-level solutions can address a myriad of sustainable water management challenges, including those related to drinking water supply, water quality, managing urban runoff, and wastewater overflows. They can also often serve more than one of these purposes simultaneously.[39] Based on our review of dozens of reports and studies, WaterNow has organized decentralized strategies into five broad categories:

- **Distributed Water Use Efficiency Systems**
- **Distributed Stormwater and Flood Management Infrastructure**
- **Distributed Reuse and Other Alternative Non-Potable Water Sources**
- **Decentralized Source Watershed Protection Strategies**
- **Decentralized Strategies to Replace Privately Owned Service Lines**

These categories are described briefly below.

Distributed Water Use Efficiency Systems

While there are dozens of water use efficiency options, we have sorted them into 4 groups:

- **Indoor high efficiency appliance and fixtures (residential, commercial, institutional, and industrial)**
- **Turf replacement and xeriscape**
- **Smart irrigation controllers**
- **Customer-side leak detection devices**

Some of these strategies are well-known and proven to be highly effective at addressing urban water supply challenges, including for example, turf replacement programs and high efficiency appliances and fixtures.[40] Tucson Water has deployed high efficiency toilets and high efficiency clothes washers for over two decade saving a total of 2.1 billion gallons (6,446 acre-feet). Moulton Niguel Water District (MNWD) in Southern California implements an aggressive turf replacement program that has replaced 5 million square feet of turf and saved 500 million gallons since 2011. Significant additional water savings from these proven distributed water use efficiency systems are possible; Tucson Water's program reached only about 8% of customers in its service area, and MNWD's program, while impressive, converted about 1% of the eligible square miles of MNWD's service area.[41]

Newer, data-based, and innovative water use efficiency technologies, including but not limited to smart irrigation controllers, customer-side leak detection devices, and energy recapture technologies, hold additional significant promise. Smart irrigation controllers provide the ability to wirelessly and remotely operate outdoor irrigation systems based on customizable zones tailored to specific vegetation types and sun exposure and hyperlocal weather monitoring to prevent over watering, among other features.[42] These smart irrigation systems may also provide local utilities the ability to remotely regulate outdoor water use during times of peak demand similar to peak electric demand management.[43] Customer-side leak detection devices alert home and business owners about leaks on their properties in real time, a major advantage over learning about leeks only on receiving large water bills, often a month or more after the fact. These devices generally fall into two categories: (1) whole home devices or (2) distributed moisture sensors (which are placed strategically around a home and send an alert when moisture is detected).[44] As of 2019, there are several ongoing pilot studies testing the water saving opportunities of these leak detection devices being conducted including in the Silicon Valley and the East Bay of California, Las Vegas, Nevada, and San Antonio, Texas.

Distributed Stormwater and Flood Management Infrastructure

Managing stormwater runoff to protect local water bodies is a major challenge nationwide and is expected to significantly ramp up due to increases in impervious surfaces and our changing climate resulting in more intense storm events. "Green" solutions distributed widely across properties within a community are gaining traction as a supplement, and in some cases alternative, to more expensive underground tunnels and other conventional infrastructure approaches to managing stormwater and related urban runoff issues.

"Green infrastructure" (GSI or GI) has by now become a well-known term, generally referring to systems that employ vegetation and other natural elements that help move water through communities in ways that restore or mimic the natural water cycle.[45] Green infrastructure can include for example, planted bioswale channels designed to concentrate and convey stormwater runoff while removing debris and pollution; permeable pavements that slow runoff and allow it to percolate underground; urban forests capturing runoff, reduce the amount of water reaching city surfaces, and increase soil water storage (see illustrations). Additional GSI strategies include:

- Green roofs
- Stormwater detention systems
- Stream and wetland restoration
- Coastal restoration
- Downspout disconnection[46]
- Low impact development

As detailed in the case study below, DC Water uses a variety of green infrastructure solutions such as permeable pavement, bioswales, and stormwater trees to manage stormwater on both public and private property.

Similarly, Eugene, Oregon's stormwater program has funded local commercial property owners to install stormwater retention ponds, as well as a local university's upgrades to brick planters to host native species and manage roof runoff from nearly 2,000 square-feet of impervious surface onsite. These types of projects are central elements of Eugene's urban stormwater management plan required to be implemented under the city's MS4 permit.

Distributed Reuse and Other Alternative Non-Potable Water Sources

At least 3 types of onsite systems can provide a community with alternative water sources for non-potable use:

- Onsite advanced reuse systems
- Graywater systems
- Rainwater harvesting

Onsite advanced reuse systems (pictured here) represent some of the most exciting water innovations and opportunities to stabilize water supply and make it more resilient at the community level. They are also the most technologically complex. These systems treat some or all gray and “black” wastewater[47] generated onsite for reuse for non-potable uses at the building or neighborhood level, such as toilet flushing and irrigation.[48] More sophisticated systems are able to also capture rainwater runoff, building foundation water or even air condensation for repurposing. These systems are best adapted for large buildings, developments, or campuses.

Graywater systems reuse “gray,” or soapy water from sinks, tubs, showers, and washing machines for outdoor residential irrigation, e.g., “laundry to landscape” systems.[49] Graywater reuse systems can be used by businesses, institutions or residences.

Rainwater harvesting can include rain barrels and cisterns that collect and store rainwater for later reuse for outdoor irrigation or rain gardens designed to retain rainwater.[50] While there can be a tendency to dismiss the value of rainwater capture as negligible, in the right venue these systems can have a critical impact.[51]

By accessing these alternative sources, communities can reduce their reliance on potable drinking water supplies and more appropriately match the resource with the particular need.

Decentralized Source Watershed Protection Strategies

"Healthy source watersheds are vital natural infrastructure for nearly all cities around the world."[52] Decentralized strategies to protect source watershed protection include but are not limited to:

- **Conservation easements**
- **Land preservation**
- **Revegetation**
- **Riparian buffers**
- **Wetlands restoration and creation[53]**

Conservation easements are a way for water utilities and landowners to voluntarily agree on certain permanent restrictions on the use of land in the utility's source watershed while the landowner retains ownership of the property.[54] Revegetation, riparian buffers, and wetlands restoration and creation each involve the restoration of the natural environment or habitat to rebuild nature's ability to "treat" polluted water before it even reaches a conventional water treatment plant.[55]

These decentralized source water protection strategies can work interactively to provide comprehensive water quality, flood, erosion control, and in some cases water supply benefits to a community reducing and in some cases eliminating the need for expensive higher level treatment options.

Decentralized Strategies to Replace Privately Owned Lateral Lines

Lead in urban drinking water supplies is a pernicious public health problem, particularly in connection with lateral service lines connecting residences to utilities' main lines, often disproportionately affecting disadvantaged communities. The Lead Service Line Replacement Collaborative has stated that, for homes with lead service lines (LSLs), "the service line typically contributes the greatest percentage of lead to the tap. With the reduction of lead in new plumbing material, the next large opportunity for reducing the risk of exposure to lead in drinking water is the removal of LSLs."[56]

Overflows of raw or partially treated sewage from combined and separate systems are also a recurring problem impacting public and environmental health to which private laterals contribute. In 2010, EPA estimated that there are 500,000 miles of private sewer laterals in the U.S.[57] The condition of these privately owned pipes can have a significant impact on the performance of the overall sewer system when they allow stormwater and groundwater to flow into the system causing it to exceed capacity or when they fail due to age or blockages.[58]

We consider these laterals to constitute distributed localized infrastructure because they are dispersed, extend beyond the central infrastructure,and are located at the point of use. For purposes of this paper, this category includes:

- **Lead service line replacement**
- **Private sewer lateral replacement**

As discussed in the Madison Water case study below, deploying LSL distributed water infrastructure can be a feasible method for meeting drinking water needs, but may also be cost-effective for the utility compared with other alternatives.

Benefits of Decentralized Water Infrastructure

Decentralized approaches to water infrastructure serve many of the same functions as conventional infrastructure, i.e. provide clean drinking water and manage wastewater and stormwater, often more quickly, more affordably and with additional co-benefits. The following sections provide an overview of these multiple benefits as well as some real-world examples drawn from the case studies below.

Decentralized Strategies Support Compliance with Regulatory Requirements

Drinking water and wastewater providers must meet numerous federal, state, and local regulatory requirements. Given the national scope of our analysis, the two statutory drivers we focus on here are the federal Safe Drinking Water Act and Clean Water Act.[59]

The Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) was originally adopted in 1974 to ensure the safety of the nation's public drinking water supplies.[60] Similar to other federal environmental laws adopted in the 1970s, the SDWA sets up a cooperative federalism regulatory approach. The US EPA is responsible for establishing performance standards specifying limits on contaminants among other mandates, while the states are tasked with administration, implementation, and enforcement.[61] The SDWA has been amended several times, including in 1986[62] when the "use of lead-free materials during installation or repair of [public water systems] or plumbing systems providing water for human consumption" was mandated.[63]

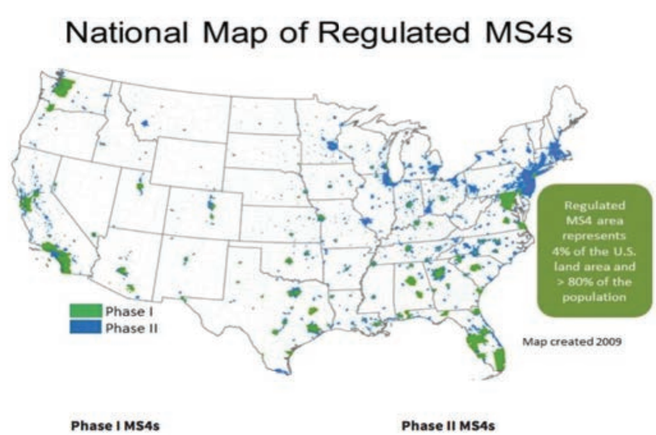
Madison, Wisconsin's lead service line replacement program brought it into compliance with the SDWA Lead and Copper Rule within about a decade and helped the city avoid millions in ongoing treatment costs.

Localized, onsite strategies can be effective in supporting communities' efforts to comply with SDWA requirements. As highlighted in the Madison, Wisconsin case study, site-level water infrastructure in the appropriate circumstances may enable utilities to meet these regulatory requirements more effectively than conventional centralized infrastructure. For example, as described in more detail below, by requiring the replacement of all lead service lines on private property rather than adding chemicals to its drinking water, Madison Water was able to comply with the SDWA in about 11-years completing their process in 2011. Had they taken the more conventional approach, Madison Water would still be paying for chemical treatments to meet this requirement today.[64]

The Clean Water Act

The federal Clean Water Act (CWA) was adopted in 1972 to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[65] As with the SDWA, the Clean Water Act sets up a cooperative federalism scheme. EPA establishes nationwide regulations and delegates implementation and enforcement authority to the states.

As with the SDWA, the Clean Water Act (CWA) establishes a complex statutory and regulatory scheme. In particular, the Clean Water Act regulates pollutants carried to the nation's navigable waters via direct discharges from industrial facilities, combined sewer systems, or wastewater treatment plants, among others.[66] The Act also regulates municipal separate storm sewer systems (MS4s) and industrial stormwater discharges to waters of the United States.[67] "Pollutants" include sewage, garbage, chemical wastes, heat, and industrial, municipal, and agricultural waste.[68] In January 2019, the Clean Water Act was amended to require U.S. EPA to "promote the use of green infrastructure in, and coordinate the integration of green infrastructure into, permitting and enforcement under this Act, planning efforts, research, technical assistance, and funding guidance of the Environmental Protection Agency."[69]



U.S. Environmental Protection Agency, Washington, D.C. [Public domain]

The Philadelphia Water Department (PWD), DC Water, and Eugene case studies included in this paper are all examples of how public utility investment in site-level water infrastructure can help cities come into compliance with CWA requirements – and how to do so on a shorter timeline than would be possible with conventional infrastructure alone. For example, PWD is planning to spend **$1 billion** in green infrastructure strategies to reduce its combined sewer system overflows.[70] The utility decided to make this major investment in decentralized green strategies because their analysis indicated that these would provide faster, more cost-effective improvements to water quality.[71]

"Our green infrastructure is already providing water quality benefits. Green City, Clean Waters improvements allow Philadelphia to enjoy better water quality and environmental and social benefits right now." – PWD Green City, Clean Waters Website

Decentralized Strategies Generate "New" Local Water Supply

In addition to serving important water quality functions, localized water infrastructure can help water providers boost local supplies, often in an accelerated timeframe compared with conventional built infrastructure. This approach treats water use efficiency, conservation, rainwater, and reclaimed water as supply. These local water supply benefits include:

- Groundwater recharge
- Reduced need for storage
- Reduced need for conveyance systems
- Climate change resilience
- Increased drought preparedness

For example, the San Antonio Water System (SAWS) employs a "conservation first" approach to water supply evaluation and treats conservation as a source of water.[72] Over the past 25 years, water conservation investments in San Antonio are estimated to have offset the need for 150,000 additional acre-feet of supply, or a cumulative savings of about 3.2 million acre-feet.[73] Seattle Public Utilities, Tucson, and Santa Fe also use a conservation first approach to water supply planning, as detailed in the case studies below.

Public utilities nationwide are increasingly viewing wastewater and stormwater runoff as a resource to be employed rather than waste to be disposed. The City of Los Angeles' "One Water Plan" identifies stormwater capture and groundwater recharge as essential local supplies that build reliability and resilience into the City's water system.[7 4]And Austin

Water's 100-year integrated water plan, aptly named "Water Forward," anticipates that community-scale onsite reuse water will eventually represent one third of all additional water supplies that the City will bring online. Austin will not only diversify its water supplies, but is looking to local sources matched to the specific identified need as an important component of its water planning.[75]

Decentralized Strategies Can Avoid or Reduce Utility Costs

Communities can often reduce (and sometimes avoid) the typically high cost of conventional infrastructure by incorporating localized strategies into their portfolios or management approaches. According to SAWS, its "conservation first" approach helped the utility avoid billions of dollars that would have been needed to build additional centralized water treatment to provide drinking water for San Antonio's rapidly growing population.[76] Their conservation programs were so successful that they also decommissioned one of their existing treatment plants saving the associated costs of operating that facility.[77]

Decentralized Strategies Can Provide Significant Co-Benefits

Decentralized water strategies provide particular opportunities to realize multiple benefits for local communities and the environment. These co-benefits range from permanent green jobs to open space to wildlife habitat to more affordable rates and more. Co-benefits of sustainable water management practices are the subject a number of studies, including an effort by our colleagues at the Pacific Institute to develop a "framework for evaluating the benefits and costs associated with water management strategies to help improve the careful consideration of multiple benefits in decision making."[78] We have referenced the Pacific Institute's multiple benefits analysis initiative into the distributed infrastructure implementation recommendations outlined below.

> **"Communities throughout the United States are advancing water management strategies that achieve multiple benefits, from complete street projects that create safe transportation options for all users and reduce pollutant runoff to water efficiency programs that reduce water and energy demand while increasing in-stream flows." – Moving Toward a Multi-Benefit Approach for Water Management, Pacific Institute**

Our review of the current research indicates that these co-benefits fall into at least 5 categories each with their own subset of advantages. The summary below is not exhaustive and additional co-benefits can manifest when applied in a particular setting.

Equity and Affordability Benefits

Investments in water efficiency and sustainable wastewater and stormwater management programs can be more affordable when compared to conventional built approaches.[79]

According to a report by American Rivers, in the Southeast water efficiency costs $0.46 to $250 per 1,000 gallons saved.[80] Similarly, Tucson Water's 2017 rate study found that prioritizing water conservation kept its customer's water and wastewater rates 11.7% lower than they would have otherwise been.[81] "Essentially, by conserving water each water and wastewater customer has avoided the costs of acquiring, delivering and treating additional water supplies that would have been necessary to provide a reliable water supply to a growing population."[82]

More fundamentally, in its recent report on evaluating multiple benefits of water management options Pacific Institute contends that equity—"the just distribution of costs and benefits among stakeholders"—is "an essential consideration that should be incorporated into all [multiple benefit] categories" because water management strategies are not inherently equitable or inequitable.[83] By way of example, the report cites Climate Interactive's Framework for Long-term, Whole system, Equity-based Reflection (FLOWER) as a way to examine the distribution of water management benefits as well as positive impacts on marginalized communities within a project or initiative.[84] As detailed below, equity and affordability considerations are part of a building a strong localized water infrastructure program.

Environmental Benefits

Decentralized water management strategies can improve the natural and built environments. The environmental benefits of localized water infrastructure have been recorded to include:

- **Increased wildlife habitat**
- **Improved water quality sooner**
- **Improved air quality**
- **Reduced pressure on rivers, streams and aquatic ecosystems**
- **Increased urban green space**

As detailed in the case study below, as explained in more detail in the case study below, SAWS uses native plants as part of its outdoor irrigation water efficiency and conservation programs. This practice not only saves water but also creates habitat for monarch butterflies and other pollinators—important species that have experienced significant declines in habitat in the U.S. over the past few decades.[85]

Economic Benefits

The local economic benefits of investing in water infrastructure, including decentralized strategies, have been well-documented.[86] These include:

- **Local, green jobs**
- **Increased local economic development**
- **Increased property values**

In a 2017 report, Alliance for Water Efficiency evaluated the near-term economic benefits of large-scale investments in water efficiency programs and found that “direct investment on the order of $10 billion in water efficiency programs [such as water system loss control, landscape irrigation upgrades, high efficiency toilets, industrial water upgrades, cooling tower upgrades, and restaurant equipment upgrades] has the potential to boost U.S. GDP by $13 to $15 billion and employment by 120,000 to 260,000 jobs.”[87] In one real-world example of these benefits, by investing in green infrastructure, Milwaukee Metropolitan Sewerage District produces 160 construction jobs per year, increases property values regionwide by an estimated $667 million, and will ultimately create 500 long-term green maintenance jobs.

Energy Benefits

The energy used to capture, treat, and transport water among other intersections, e.g., energy needed to operate household and business fixtures and appliances, between the nation’s water and energy systems create what is commonly referred to as the “water energy nexus.”[88] The water energy nexus often focuses on the West’s extensive water conveyance systems, but also operates at the local level. “Energy consumption by public drinking water and wastewater utilities … can represent 30%-40% of a municipality’s energy bill.”[89]

When water is used more sustainably there is a corresponding reduction in energy use and related greenhouse gases. A highly regarded 2017 study found that targeted outreach encouraging reduced household water use also reduces summertime electricity use by as much as 2.2% and that “water conservation instruments induce conservation beyond the water sector,” which “has direct implications for greenhouse gas and local pollutant reductions….”[90]

Social Benefits

Sustainable water management strategies can also provide significant societal benefits resulting from:

- Community engagement
- Education
- Aesthetics
- Open space
- Connection with nature & resources
- Improved public health

These social benefits help create a culture of water conservation, which in turn, makes localized strategies even more successful as is demonstrated by the SAWS case study and others detailed below.

Given this broad range of co-benefits, identifying and understanding the full scope of benefits for each particular project is important to evaluating the true value of onsite water strategies.[91] As detailed below, using a triple bottom line analysis and similar approaches can help account for these co-benefits.[92]

Funding Localized Water Infrastructure

If public utilities are finding that localized strategies can serve as effective, climate resilient, popular, and affordable solutions, they are not yet implementing them at large scale for the most part. WaterNow's annual surveys of our members identify a number of reasons for this, with financing challenges and perceptions of financing challenges, often at the top of the list.

Public water agencies, cities, towns, and special districts are, in general, adept with financing methods for major projects, designed with centralized utility-owned and operated assets in mind. Transitioning to a One Water management future that supplements these projects with larger investments in distributed, localized and onsite strategies, will require new financing tools as well as the capacity to repurpose conventional utility financing methods to pay for a broader range of infrastructure options. This section provides a high level overview of the opportunities available to public water resource entities to scale up their investments in the types of innovative, onsite, localized management strategies and solutions outlined above.

There are a number of ways to raise capital for localized water infrastructure available to public water service providers.[93] beyond rates, fees, and property or other types of local taxes:[94] (1) municipal bond proceeds, (2) state and federal loans, and (3) grants. How these categories of funding can be used to pay for decentralized solutions is detailed below.

Municipal Bond Proceeds

Public utilities that employ consumer-side-of-the-meter programs to deploy distributed and onsite water infrastructure in their communities are for the most part paying for these programs out of their operating revenue—cash. However, "[t]o upgrade their systems, utilities will have to pursue distributed infrastructure on a scale too large to be financed solely through cash."[95] Water efficiency and green infrastructure programs of the magnitude needed to account for the impacts of climate change such as more severe droughts and intense flooding will require public investments that in many if not most cases will require at least some capital financing, i.e., debt.[96] Several larger utilities—Seattle Public Utilities, the City of Los Angeles, Southern Nevada Water Authority and Milwaukee Metropolitan Sewerage District—are already moving in this direction using municipal bond revenues to pay for their water conservation and green infrastructure programs.

Municipal revenue bonds

Municipal revenue bonds have long been the debt-financing vehicle of choice for public water agencies. "Public water utilities, particularly larger ones, are expert in financing water infrastructure."[97] Most of these entities have the legal authority to issue debt, and the almost guaranteed returns and tax-free nature of municipal bonds makes them attractive for certain investors. Low interest rates and the ability to amortize costs over many years makes these instruments ideal for public entities requiring large amounts of capital to invest in infrastructure but anxious to avoid rate-shock for their consumers.

Our colleagues at Ceres published a paper in 2014 making the point, among others, that in order for utilities to invest in decentralized water strategies at scale, they'll need access to capital markets through municipal bonds.[98] A major impediment to this has been the widely held view that Governmental Accounting Standards Board (GASB) standards, which require public debt to be secured by an asset controlled by the public entity, preclude debt-financing for consumer incentives for distributed systems that would not be under the control of the utility.

However, GASB rules are sufficiently flexible to accommodate debt financing for these incentives. GASB Statement 62, adopted in 2010, establishes an alternative accounting mechanism for public investments in "business type activities" which do not result in tangible assets but are nevertheless also not properly accounted for as annual expenses because they represent longer-term investments. Under Statement 62, a public entity with rate-setting authority can establish a "regulatory asset," which can then be capitalized, by promising that future rates will be sufficient to cover the cost of the investment. Unlike conventional accounting, the "asset" under Statement 62 is not the object being purchased, but instead the promise of rates sufficient to repay the loan. Even though this Statement has been in place for over a decade, it nevertheless requires an almost metaphysical shift in thinking about utility financing and so, perhaps not surprisingly, has been employed only sparingly by public water utilities.

In response to an initiative undertaken by WaterNow in collaboration with Earth Economics and other partners, in May 2018, GASB issued new guidance connecting the dots from Statement 62 to public water utility investments in consumer rebates and other financial incentives.[99] The new GASB guidance, essentially making it clear that utilities can deploy municipal bond proceeds to finance localized water infrastructure, is a game changer. If even a tiny percent of the billions in annual capital spending for local water infrastructure nationwide is redeployed to distributed solutions, it would represent vast new investment capacity and a major expansion in the adoption of these technologies and programs. WaterNow's Tap into Resilience campaign—that includes numerous resources and a financing toolkit—has been developed to support public water utilities in not only learning about distributed water solutions but also how best to take advantage of this financing mechanism.[100] Cities and public utilities now also have the option of financing localized water infrastructure by pooling bond issuances with other cities, counties, towns, and districts.[101] This type of aggregation can be more cost-effective and bring needed capital to smaller communities with less capacity to issue their own municipal bonds.[102]

For example, Seattle Public Utilities uses municipal bond proceeds to fund its water conservation rebates programs.[103] The $2.2 million that Seattle spends on market-rate conservation rebates, as well as its low-income direct installation program, and its spending on outreach and marketing for those programs, are all part of the utility's capital budget.[104] Using bond proceeds has allowed Seattle Public Utilities to implement its market rate program on a regional scale, and its low-income program citywide.[105]

Green bonds

Green Bonds are municipal bonds where the proceeds will be used exclusively for projects and activities that serve environmental sustainability purposes.[106] Many traditional bond underwriters are increasingly developing green bond financing packages.[107] As explained in a Ceres report issued in 2014, there are at least four types:

- **Green use of proceeds bond**
- **Green use of revenue bond**
- **Green project bond**
- **Green structured bond**

The appropriate type for a particular project depends on available revenues and collateral to secure the bonds.[108]

The Water Consortium, a global group of climate finance and sustainability organizations such as Ceres, the World Resources Institute, and Climate Bonds Initiative, launched a new Water Infrastructure Criteria of the Climate Bonds Standards.[109] The criteria "defines and evaluates low carbon and climate resilient water infrastructure projects by encompassing two broad components: 1) climate mitigation and 2) climate adaptation and resilience."[110] Water infrastructure projects that meet the criteria can be included in green bond investment and receive Climate Bond Certification. In 2016, the San Francisco Public Utilities Commission was the first issuer of a green bond certified under the Water Climate Bonds Standard.[111] "Proceeds from the $240 million Wastewater Revenue Bond will support sustainable stormwater management and wastewater projects."[112]

Environmental impact bonds

Environmental impact bonds (EIB) are an innovative financing tool that leverages private investment to support high-impact environmental programs.[113] EIBs use a "Pay for Success" approach where private investors provide upfront capital for environmental projects and the beneficiary—either a public entity or a private institution that benefits from the project—repays the investors based on the achievement of the agreed-upon project outcomes.[114] "The bond structure is designed to meet the payor's needs—whether that's providing risk coverage in the case of underperformance, or a benefits share with investors and contractors to incentivize exceeding performance."[115] Because repayment of an EIB is benchmarked against specific performance outcomes EIBs create incentives to deploy innovative solutions.[116]

In 2016, DC Water became the first public utility to have employed an EIB. It turned to this innovative approach as a financing mechanism for its "DC Clean Rivers Project", as detailed it the case study below.[117] The first-of-its-kind EIB financed $25 million that was used to build the utility's first large scale green infrastructure project aimed at reducing combined sewer overflows.[118] In 2019, Atlanta, Georgia's Department of Watershed Management issued the first ever publicly issued EIB for $14 million, also to support distributed green infrastructure projects.[119]

State and Federal Loans

In addition to securing financing in the municipal bond market for distributed systems, local utilities also have access to various state and federal government loan programs for water infrastructure. Like municipal bonds, these programs have been typically accessed for conventional water projects, but they are often available to support decentralized alternatives as well.

State Revolving Funds

The Clean Water and Safe Drinking Water Acts both established state revolving loan funds (SRFs) to assist communities with upfront cash to build local water infrastructure.[120] EPA allocates SRF funding to each state that administers the SDWA and CWA. The states contribute an additional 20 percent to match federal SRF capitalization grants, and also administer the program according to state-specific eligibility criteria.[121] While states establish their own eligibility criteria, the American Recovery Act of 2009 required all CWSRF programs to use a portion of their federal grant for projects that address green infrastructure, water and energy efficiency, or other environmentally innovative activities.[122] This requirement is commonly referred to as the Green Project Reserve.[123] As of 2015, at least 23 states explicitly solicited projects to fund through their Green Project Reserve funds.[124]

State revolving loan funds can be used to:

- control nonpoint sources of pollution
- build decentralized wastewater treatment systems,
- create green infrastructure projects,
- protect estuaries among many other

States that conducted a seperate solicitation for GPR projects include:

Alabama	Alaska	Iowa	Kansas
Hawaii	Illinois	Maryland	Massachusetts
Lousiana	Maine	New Mexico	Oklahoma
Mississippi	Montana	Rhode Island	South Carolina
Oregon	New York	West Virginia	Wyoming
South Dakota	Utah	Georgia	

USEPA, ARRA Clean Water State Revolving Fund Green Project Reserve Report

Further, leading the way nationally, California, Vermont, Virginia, and Wisconsin recently updated their SRF criteria to allow utilities to use SRF loans and/or provided grant funds to pay for lead service line replacements on private property following clarification in 2016 that these types of programs are eligible for SRF funding.[125]

Most SRF dollars are allocated as low-interest loans, but states have some limited ability to provide grants under the SRF programs.[126] In particular, SRF programs implemented under the Clean Water Act requirements with annual appropriations of greater than $1 billion may issue grants to municipalities or inter-municipal, interstate, or state agencies to help address affordability issues or to implement a process, material, technique, or technology that addresses water or energy efficiency goals, mitigates stormwater runoff, or encourages sustainable project planning, design, and construction.[127]

Water Infrastructure Finance and Innovation Act

The Water Infrastructure Finance and Innovation Act (WIFIA) was enacted in 2014 specifically to accelerate investment in local water and wastewater infrastructure. It basically supplements the two SRF programs by providing long-term, low-cost supplemental credit assistance to local utilities for major projects.[128]

This program is separate from, but implemented in coordination with, the SRF programs to subsidize financing for large dollar-value projects.[129] Eligible borrowers under the program include local governmental entities that can use the funds to pay for projects that are eligible for state revolving fund loans, projects aimed at drought mitigation, aquifer recharge, water reuse, or alternative water sources.[130] Development phase activities, e.g., planning, and replacement activities are eligible development and implementation activities.[131]

Distributed green infrastructure, efficiency, conservation, onsite reuse, and other localized infrastructure projects generally meet the WIFIA eligibility criteria and could be funded under this program.[132] These distributed strategies meet the aims of the WIFIA program—rebuilding the nation's water infrastructure.

Federal Grants

Outright grants to support local infrastructure investments are highly prized by local agencies but are few and far between.

There are a few discrete pots of federal grant dollars that can support local investments in distributed water infrastructure with consumer side of the meter incentives: (1) the Bureau of Reclamation's WaterSMART program; (2) USDA's Water and Wastewater Disposal grants; (3) the Land and Water Conservation Fund administered by the Department of the Interior; and (4) US Department of Commerce Economic Development Assistance programs for distressed localities. These are summarized briefly below.

WaterSMART (Sustain and Manage America's Resources for Tomorrow)

The Bureau of Reclamation's WaterSMART program provides funding to water utilities, tribes and other public entities in the Western US in several categories, but under the general umbrella of projects to use water more efficiently, among other things.[133] There are 3 major WaterSMART grant programs: (1) Water and Energy Efficiency Grants (WEEG),[134] (2) Water Marketing Strategy Grants,[135] and (3) Small-Scale Water Efficiency Projects (SSWEP).[136] Congress's objective in establishing WaterSMART was to increase water supply reliability at the local level, support conservation and efficiency, and collaborate with local stakeholders to develop community-specific solutions.[137] Using federal dollars to leverage other sources of funding is a specific objective of the program as well.

Applying for a WaterSMART grant is not for the faint of heart; the process is complex and highly competitive. And while these are grants, they do not cover the full project cost. Applicants must generally provide a 50% cost-share. The amounts provided are not very large, ranging from $75,000 to $1.5 million,[138] but can make all the difference for a community. Overall federal funding for this program is relatively modest compared with other infrastructure initiatives. In 2018, 54 WaterSMART projects received a total of $26.5 million; $24 million was allocated for WaterSMART grants in 2019.[139]

USDA Water and Waste Disposal Grants

The Water and & Waste Disposal Loan & Grant Program is a rural assistance program administered by USDA to support drinking water systems, sanitary systems, and stormwater drainage systems serving households and businesses in rural areas and towns of 10,000 or less.[140] Local governmental and public agencies are eligible to apply for grant funding to pay for drinking water supplies and treatment, sewer collection and treatment, and stormwater collection and discharge.[141] Most of the program funding is available in the form of loans, but some grants are available. [142]

To the extent that onsite and localized strategies can address the water management challenges facing these rural communities, it appears that they would be eligible for grant funding under this program.

Land and Water Conservation Fund

The Land and Water Conservation Fund (LWCF), administered by the Department of the Interior, could also potentially be a source of federal grant support for local water entities to implement certain types of decentralized water management programs. The LWCF was originally enacted in 1964 to, among other purposes, "safeguard" the country's natural areas and water resources. The LWCF includes a "State and Local Assistance Program" which provides matching grants to local (and other) public entities governments to protect, build, or renovate parks, recreation areas, and open space.[143]

Given the open space and recreational co-benefits of many decentralized water management strategies, the right kind of green infrastructure projects may be eligible for funding under the LWCF State and Local Assistance Program. Distributed source watershed protection projects might also qualify for grants under this program, as these strategies often include open space protection and create opportunities for recreation.

Economic Development Assistance Programs

The US Department of Commerce administers an Economic Development Assistance grants program for the construction or rehabilitation of public infrastructure necessary to generate or retain local jobs and investments, among other local economic benefits.[144] These grants are specifically for local public entities in areas of "economic distress," meaning that they are struggling with economic stressors such as chronic unemployment, low-income, underemployment, population loss, or local industry closure.[145] While this program is not specifically geared toward water management, it has supported local water infrastructure projects in the past.[146] Public Works investments under this program generally range from $200,000 to $3 million.[147]

To the extent that community-scale distributed water programs can be framed as a meaningful opportunity to create local, green jobs, these strategies may qualify for funding under the Economic Development Assistance Programs.

Important Strategies for Successfully Implementing Decentralized Solutions

We have identified a robust set of decentralized, onsite, and localized water strategies capable of addressing the range of One Water challenges; and reviewed various methods available for financing them. The next challenge for most public entities is how to implement these strategies and deploy these technologies at large scale. While distributed systems serve the same functions as centralized infrastructure, their deployment is significantly different. Unlike building a treatment facility or laying pipe, decentralized solutions turn in large part on effective partnering with a utility's consumers.

This section discusses the appropriate supporting policies and programs necessary for deployment of these solutions. These include several interwoven policies and strategies: (1) financial incentives of various kinds for consumers of various types to advance adoption on private and non-utility public properties; (2) water pricing and rates; (3) local ordinances and/or codes that smooth the way for implementation; and (4) development of a cohort of community partners and professionals capable of supporting program build-out and continued operation and maintenance.[148]

Building a successful decentralized water infrastructure approach depends not only on deploying the appropriate technologies or strategies but also on using the holistic One Water concept by integrating water, wastewater, stormwater, and land use planning. These implementation strategies are detailed below.

Consumer Rebates and Other Financial Incentives

The central tool at the disposal of public utilities for deploying onsite, localized and other distributed sustainable water management strategies is consumer incentives. While there will always be a certain number of early innovation adopters, or people who "want to do the right thing," for the most part, significant, rapid and widespread deployment of onsite systems will require public utility investment. [149]

In the water supply and stormwater contexts, financial incentives include a broad range of rebates, reduced fees, or grants to encourage residential and non-residential customers to install:

- **Water efficient appliances and fixtures such as toilets, clothes washers, dishwashers, shower heads, and faucets**
- **Xeriscape**
- **Smart irrigation controllers**
- **Customer-side leak detection devices**
- **Graywater systems**
- **Rain gardens**
- **Rain barrels**
- **Green infrastructure such as permeable pavement or bioswales**
- **Onsite advanced reuse systems**
- **Green roofs**
- **Lead service line replacement**
- **Private sewer lateral replacement**

Many utilities, including nearly all of the case studies listed below, have financial incentive programs that provide rebates for one or more of these solutions. For example, incentives for turf replacement with xeriscape implemented by the MNWD ranging from $3.00 to $3.50 per square foot with a total program budget of $2.5 million annually have helped the District change out 5 million square feet of turf saving 500 million gallons of water since 2012.[150] SAWS' WaterSaver Landscape Coupon Program, has replaced over 2 million square feet of water-intensive grass with low water-use plants and permeable patios. Tucson Water has invested $10 million in customer rebates and incentives over the past 10 years installing approximately 58,000 high efficiency toilets and clothes washers, 2,000 rainwater harvesting and graywater systems conserving a total of 2.1 billion gallons (6,446 acre-feet) of water to date. Austin Water's program that offered rebates for all types of water efficient appliances and fixtures as well as a free efficient toilets that began in 1992 achieved 92% market saturation by 2010, and the utility intends to expand these rebates to include outdoor efficiency and conservation. Philadelphia implements a residential rebate and education program to incentivize homeowners to install green infrastructure on their property where homeowners can receive nearly 50% of the cost for installing downspout planters, rain gardens, or permeable pavers and for de-paving impervious surfaces as well as free rain; as of 2018, PWD has budgeted $25 million on incentives to residential customers for these private property retrofits and "greened" 980 acres of private property.

These "carrots" are proven implementation tools, and can be combined with conservation based rate structures and local ordinances or other legal mandates to further advance a local utility's sustainability and water management goals.

Conservation and Stormwater Management Rate and Fee Structures

Virtually all public water resource management entities, whether special districts, commissions, city or county governments, are legally empowered to establish rates for drinking and/or wastewater services. Stormwater is often in a distinct category; some local entities have the legal authority to establish rates or fees to manage stormwater but many do not and are therefore dependent on the public's willingness to enact stormwater fees. We review these issues below.

Drinking Water Rates

Drinking water utilities set rates, i.e., the amount the water provider charges its customers to cover the costs of treating and delivering drinking water.[151] These rates can be collected in a variety of ways, including as flat fees, uniform volumetric rates, or block or tiered rates.[152] Historically, volumetric rates were the most common.[153]

These rate structures can be set to promote conservation, i.e., "conservation pricing." While water—an essential resource—is "inelastic," conservation pricing can yield on average a 15% reduction in water consumption and up to a 22% reduction in per capita use.[154] There are several rate structure options cities and utilities have increasingly put into practice, including:

- **Repeal of volume discounts**
- **Increasing block or tiered rates**
- **Seasonal rates**
- **Drought pricing**
- **Flat fee combined with a variable, tiered rate**
- **Water budgets[155]**

Finding the right price and rate structure can be challenging as utilities rely on rate revenues to operate and decreased water consumption can mean reduced funds for delivery and treatment of water; certainly, this is not a novel issue. Responding to this reality has been the subject of many convenings and reports since the mid-1990s.[156] In 2010, Janice Beecher, a leading expert on this issue, said:

Water demand is recalibrating according to new economic realities and public policy directives. Ignoring declining demand does make it go away – or rather, come back. The intractable manager will remain cash-flow frustrated. The enlightened manager will be better positioned for cost recovery in accordance with fluid equilibrium.
Implementing one or a combination of the rate structures list above can help the "enlightened manager" find that equilibrium.[157]

Indeed, pricing policies making water more expensive, at least at higher tiers, inherently incentivizes business and residential consumers to use water more efficiently, either through technology or behavior changes. For example, SAWS uses a tiered rate structure to incentivize lower water consumption, together with other efficiency programs (as explained in the case study below). Over the past 25 years, SAWS customers have reduced their consumption by nearly half from 225 gallons per capita per day (GPCD) to 117 GPCD.[158] And communicating with ratepayers early and often about rate increases and conservation efforts is essential.[159]

Wastewater Rates

How wastewater utilities approach rates varies widely. Many utilities establish consumer rates;[160] others collect all or part or of their revenues via property taxes.[161] Another common practice is to impose a fee based on parcel-size or amount of water put into the wastewater system.[162] Approaches can also differ within a city or utility depending on whether a customer has metered or non-metered use or according to the type of property i.e., residential or commercial, being charged.[163] The University of North Carolina School of Government's Environmental Finance Center has created a "Rates Dashboard" designed to help utility managers and local officials compare and analyze water and wastewater rates against multiple characteristics, including utility finances, system characteristics, customer base socioeconomic conditions, geography, and history.[164]

The amount of wastewater flowing through the system is an important factor in the cost of collection, transport and treatment of wastewater discharges. Accordingly, in the context of sustainable water management, it is important to consider the question of how wastewater rates will be impacted by reduced water use or onsite reuse through advanced localized treatment. Depending on the governance and rate structure, this may mean that drinking water and wastewater utilities will need to coordinate rate planning because reduced water use leads to less wastewater.

Stormwater Fees

Cities and towns employ a variety of funding mechanisms to operate stormwater systems in their service areas, including general funds, bond proceeds, and stormwater fees—a user fee charged to property owners within the municipality's service area specifically to finance the cost of stormwater program implementation.[165] Stormwater fees can be structured in several ways, including:

- **Flat fees**
- **Assessed property value, i.e., property taxes**
- **Tied to potable water consumption**
- **Volume of stormwater runoff, i.e., "parcel-based" or "impervious area-based"**

Residential property owners generally support a "imperviousness-based fee models" taxes based on assessed property value according to some research.[166] Impervious area-based stormwater fees may be generally more preferable from a policy perspective because they link the use of the stormwater system with the cost of operating and maintaining it and can more readily be coupled with financial incentives designed to encourage reduced impervious areas in exchange for reduced fees.[167]

Some analysts maintain that "stormwater fees are the best option to fund stormwater-related improvements [because a] properly calibrated fee can provide a dedicated, long-term funding stream for stormwater management."[168] It also and "creates fewer accounting and planning hurdles than debt financing and provides steadier funding than a municipal general fund."[169] As of 2018 there are an estimated 1,400 to 2,000 cities across the country that have established a stormwater fee that is collected and administered either by a separate stormwater utility or as a stormwater department of an existing Public Works department. This funding mechanism is still emerging and 41 of 50 states authorize municipalities and counties to establish stormwater fees.[170] Stormwater utilities and fees appear to be gaining momentum, however.[171]

These are proven tools for implementing localized water strategies, as they motivate ratepayers to conserve water or create a dedicated revenue source that can be leveraged for deploying distributed infrastructure projects on both public and private property. As with rebates and other financial incentives, pricing mechanisms can also be combined with local ordinances or other legal mandates to further advance a local utility's sustainability goals.

Local Ordinances

Public utilities also have available different types of "sticks," i.e., local ordinances or other legal mandates, that can incentivize consumers to implement localized water infrastructure solutions. These include but are not limited to:

- **Seasonal outdoor irrigation restrictions**
- **Year-round outdoor irrigation restrictions**
- **Leak repair requirements**
- **Standards for plumbing fixtures, e.g. toilets, faucets, and shower heads**
- **Green building codes**
- **Onsite stormwater retention and/or management requirements**
- **Onsite reuse requirements**
- **Lead service line replacement requirements**

Updates to municipal codes to include one or more of these requirements can support full deployment of decentralized infrastructure programs. For example, plumbing codes requiring the use of water-efficient toilets have ensured the replacement of high water use toilets as they reach the end of their useful life.[172] And, as explained in the case studies below, the City of Santa Fe has adopted a comprehensive water conservation ordinance that applies to all water and all customers of the City water or wastewater services and the City of Eugene has adopted a stormwater ordinance that requires new or re-development to retain the first inch of stormwater onsite. These local ordinances have helped these cities achieve a wider range of localized infrastructure benefits.

Ratepayer Education and Outreach

Because localized infrastructure involves, in large part, installing systems or technologies on private property across a community, communication, education and outreach efforts, particularly in connection with financial incentives, are central components of an effective program. Further, innovative solutions such as smart irrigation controllers and consumer leak detection devices that produce near real-time information on water use offer ways to communicate with customers that have not previously been available:

Our twentieth-century water systems are not designed as data- rich enterprises. In many places water is unmeasured, and where it is, arbitrarily-assigned annual, semi- annual, quarterly or monthly reads are insufficient to allow a consumer to recognize the "water impact" of their decisions, let alone the financial impact.[173]

Site-level strategies represent a fundamental shift in how water and wastewater is managed; so, connecting the public with how these systems work and their importance to the community represents a related communications imperative. Ongoing implementation also depends on continued consumer and partner participation

The good news is that there are a large number of easily implementable tools available to utilities for community engagement, including but not limited to:

1. **Dedicated websites**
2. **Social media**
3. **Newsletters**
4. **Landscaping and other trainings**
5. **Local home owners' association workshops**
6. **Demonstration site educational tours**

7. Targeted mailings and/or calls

8. Bill inserts

9. School curriculum materials

10. Partner event sponsorship

11. Education and outreach by community organizations

Using a creative customized set of outreach tools helps to bring the community into the philosophy and mindset that they are connected to water resources and fosters a sustainability focused public going forward.[174]

Community Group and Professionals Partnerships

Successful implementation of localized water infrastructure often involves engaging a community network of nonprofits and professionals such as landscapers, contractors, and engineers. These community group and professional partnerships can help local utilities:

- Provide technical assistance to customers installing distributed infrastructure
- Build capacity for internal utility staff
- Foster relationships with utility customers
- Access additional grant opportunities
- Enjoy economies of scale

For example, utilities can hold Qualified Water Efficient Landscaper trainings to ensure area landscapers are familiar with native plants[175] and landscaping practices or nursery stock programs so that customers wishing to purchase native plants can, in fact, do so; Moulton Nigel, in Orange County California, is currently implementing this type of nursey stock program.[176] Or, as is the case with SAWS, agencies can partner with nonprofit groups that are already present in target neighborhoods, which helps government agencies build trust with its customers.[177]

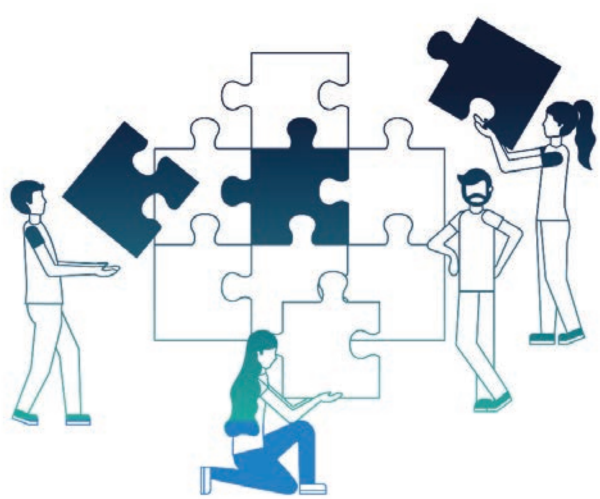
Integrated Water, Wastewater, Stormwater & Land Use Planning

It is widely recognized that local water, wastewater, stormwater, and land use planning systems, while often siloed from one another administratively, are innately inter-related functionally. Over the past decade, many local agencies have begun to take an integrated, One Water approach to holistically plan, invest, and operate their water and land use planning and systems.[178] "21st century infrastructure improvements are also about investing in long term solutions in an integrated way."[179] Decentralized systems are central tools for integrated water management, and their implementation can cross over intra-agency and/or jurisdictional boundaries.[180]

Integrated management takes several forms. At times implementing decentralized infrastructure necessitates coordination between departments in a single municipality, i.e., "intra-utility integration." In other instances, it requires cities and utilities to collaborate with separate utilities or cities in their region, i.e., "inter-utility integration." It could be the case that both types of integrated management are needed to carry out a truly holistic water strategy. For example, SAWS' successful water reuse program first required breaking down bureaucratic barriers to bring together 3 separate agencies.[181]

Municipalities and utilities scaling up localized water infrastructure will find it useful to examine interactions with existing or planned centralized systems.[182] A combination of green and gray infrastructure can often meet regulatory requirements in a cost-effective way. For example, DC Water is using green infrastructure projects in tandem with tunnels to address the City's persistent combined sewer overflows. But it was able to reduce the scope of the gray infrastructure piece by incorporating community-wide green infrastructure facilities.[183]

Integrated water management also means incorporating water planning into land use planning. The American Planning Association recommends, among other things, that land use planning practices employ an "integrated, systems-oriented, comprehensive approach to water management" by incorporating water into city's comprehensive plans, sustainability plans, and/or regional water plans.[184] To help land use managers and water utilities achieve this integration, our colleagues at Western Resource Advocates, in partnership with the Pace Law School Land Use Law Center, developed a comprehensive guidebook for local planners titled "Integrating Water Efficiency into Land Use Planning in the Interior West: A Guidebook for Local Planners."[185] "The goal of this Guidebook is to provide an informative compendium of land use techniques that can reduce water use in new and existing development and to target this information to local land use planners."[186] The Net Blue project as well as other initiatives are also working to link land use and water use efficiency retrofits.[187]



When implementing decentralized infrastructure strategies, it is important to consider:

1. **How these strategies can coordinate and supplement existing and planned systems;**
2. **How land use decisions may impact water supply planning and quality; and**
3. **Other agencies within and outside the implementing agency's jurisdiction that could add value to planning and implementation.**

With an integrated, One Water approach, decentralized systems can advance sustainable water management for entire communities and even regions.

Case Studies Overview

WaterNow has compiled 13 localized infrastructure case studies implemented by a diverse set of water resource entities nationwide. These case studies demonstrate that localized water infrastructure can help address the same water management challenges traditionally managed with centralized systems in a more environmentally sustainable and cost-effective way while also providing multiple co-benefits to local economies and community health. These examples were selected because they met at least 6 out of the 10 criteria listed in Appendix A as well as the research criteria set out in Appendix B.

Each case study attempts to address 4 questions:

1. **Why and how distributed infrastructure was selected over the more conventional infrastructure alternative?**
2. **How are these distributed systems performing relative to the identified water challenge?**
3. **How much has the utility invested in the distributed infrastructure solution and how it is funded?**
4. **What are the benefits of the distributed systems as implemented and how is the utility measuring these?**

While each community described in the case studies is working to address unique challenges, their stories spotlight common themes and "lessons learned" with potentially wide application.

Water Supply Case Studies

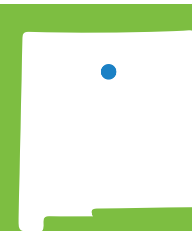
These 5 stories demonstrate how distributed infrastructure can effectively address water supply and water quality challenges, from protecting human health to population growth to prolonged drought to the impacts of climate change in cost-effective and resilient ways.

Santa Fe Water Division: Efficiency as a Way of Life

Utility: City of Santa Fe Water Division

Location: Santa Fe, New Mexico

Service area: Serving a population of 80,000 across 37 square miles



Challenge:

- Declining water availability and reliability
- Anticipated rapid population growth
- Climate change

Solution:

- A 3-part approach to making water use efficiency a Santa Fe way of life featuring decentralized strategies

Results and Benefits:

- Consumption has fallen 42% in 25 years even has population has grown
- Water use is ~90 GPCD as pf 2019

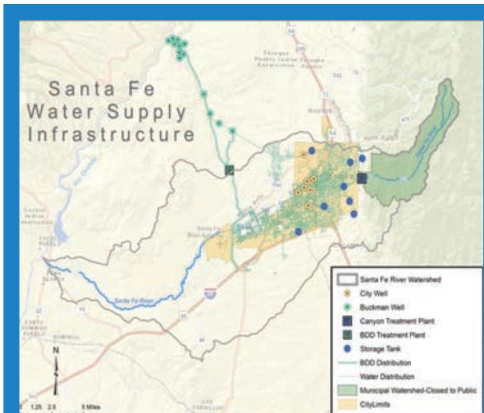
Costs and Funding Sources:

- Total conservation program budget: ~$700,000 (FY 18/19)
- Levee fund. A fee collected from utility customers each billing cycle dedicated to the Division's operating budget.
- Conservation Fund. An annual fee that can be used for any of the Division's water conservation programs. Unused funds from this annual fee roll over into the next year.

Location & Service Population

The City of Santa Fe, New Mexico—sitting even higher than Denver at about 7,000 feet above sea level—is located near the Rio Grande Valley at the Southern end of the Rocky Mountains. With 14 inches of rain and 300 days of sunshine per year, water supply is a perennial problem for this community of 80,000 residents.[188]

Santa Fe Water Division & Water Supply



The Santa Fe Water Division is part of the City's Public Utilities Department[189] and is responsible for providing drinking water, the City's water reuse and conservation programs, and municipal watershed management.[190] The City Council sits as the Division's governing body. Santa Fe gets its water from three sources: (1) the Santa Fe River, (2) the Rio Grande, and (3) groundwater from the Tesuque Formation aquifer.[191] The City's water supplies are interconnected with Santa Fe County's, making coordination between the two jurisdictions important.[192] Total present supply is 19,000 acre-feet per year (AFY)[193] **but the City anticipates a supply gap ranging from 6,300 AFY to about 10,000 AFY by 2055** based on projected population increases and projected reductions in available surface water supply due to climate change.[194]

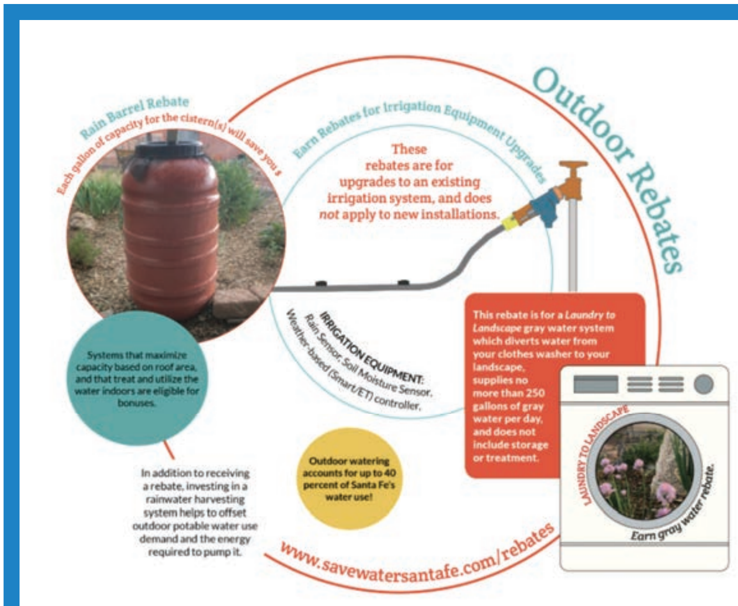
Water Conservation: Save Water Santa Fe

In 1997, Santa Fe adopted a "Comprehensive Water Conservation Requirements Ordinance" intended to reduce per capita water demand.[195] The ordinance applies to all water—potable or effluent—and all customers of city water or wastewater services, and sets out a number of water conservation strategies that fall into three categories: mandates, incentives, and behavioral.[196]

Mandatory conservation requirements include, among others, limits on outdoor irrigation during the hotter season and indoor plumbing standards.[197]

Recognizing that leak repairs can be prohibitively expensive for individual customers while the benefits of avoiding leaks accrue to the community as a whole, the Santa Fe provides residential customers one-time loans for the purpose of water leak repair on a first, come first served basis.

Santa Fe has gone beyond these more common requirements to require residential consumers to repair leaks when notified by the City.[198] Recognizing that leak repairs can be prohibitively expensive for individual customers while the benefits of avoiding leaks accrue to the community as a whole,[199] the City provides residential customers one-time loans for the purpose of water leak repair on a first, come first served basis.[200] This helps residents meet conservation requirements and avoid penalties for noncompliance.[201] The Division also has a high-water bill extended repayment program in the event the high usage was the result of a leak that is subsequently repaired.[202]



The City also has gone farther with its incentive programs than similarly situated communities. For example, Santa Fe covers the costs of meeting water conservation regulatory requirements for developers building low income housing.[203] While it has established fairly standard residential and commercial rebates to improve water use efficiency both indoors and outdoors,[204] the City also provides rebates for laundry to landscape graywater systems, smart irrigation controllers, and rain barrels.[205]

The City's behavioral programs are focused on intentionally fostering a long-term community culture of conservation with educational and outreach programs such as "Project WET" aimed at introducing and engaging elementary school children in water conservation projects, peer water conservation education programs for higher level students, and the "Eye on Water" mobile app designed to alert customers about their water use and potential leaks.[206]

Moving forward, Santa Fe is taking an even more deliberate approach toward a One Water future. In October 2018, the City Council adopted a new 25-Year Santa Fe Sustainability Plan. This Plan identifies water sustainability goals to deploy innovative technologies, long range planning, regional planning, and proactive approaches to ensure an integrated and resilient One Water strategy that optimizes water demand and supply.[207] The program goals include developing two neighborhood-scale water conservation projects and programs.[208]

Program Costs and Funding Sources

The City's Water Division has a total annual budget of about $34 million with a conservation fund of ~$3 million as of 2018.[209] In fiscal year 2018/2019, the Santa Fe city manager recommended an annual expenditure of ~$700,000 for water conservation programs.[210]

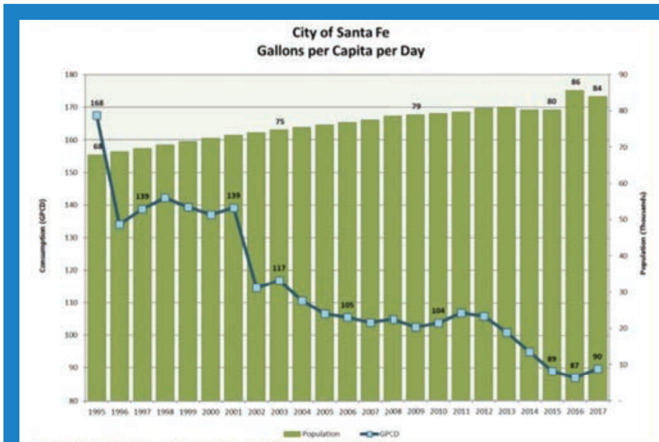


Figure 8: Gallons per capita per Day (GPCD) from 1995-2017

Santa Fe's water conservation programs are funded through two sources. The first is a fee that is folded into the utility rates collected from utility customers referred to as the "levee fund."[211] These funds become part of the Water Division's operating budget. The second is once-per-year fee of $4.00-$9.00 for single family homes, $8.00-$750 for multifamily residences, and $5.00-$350 for commercial buildings[212] earmarked for a "conservation fund" to be used on any type of conservation program. Any unused funds from this fee roll over into the next year.

Program Benefits and Performance Metrics

Santa Fe's long term investment in efficiency has paid remarkable dividends **reducing per capita utility customer demand by 42% since 1995**, **and has essentially decoupled water demand from population growth.**[213] As of 2017, average daily use had fallen to 90 gallons per capita per day (GPCD).[214] The City's water conservation efforts also benefit the community by providing opportunities for citizen engagement; in a recent survey, an astonishing 95% of citizens reported conserving water in the past 12 months,[215] demonstrating how a sustained effort can support a shared community understanding of the value of water and its role in their lives.

Another unique aspect of the Santa Fe program is that the City makes a point of emphasizing the multiple benefits that accrue to the community as a result of its water conservation programs, including but not limited to:

- **Increased water supply sustainability and reliability;**
- **Reduced short and long-term system costs;**
- **Enhanced local environment by minimizing transport of fertilizer, pesticide, and other contaminants from runoff to surface waters and deep percolation to ground waters; and**
- **Enhanced global environment by reducing energy consumption associated with water production, treatment, and distribution.**[216]

A unique aspect of the Santa Fe program is that the City makes a point of emphasizing the multiple benefits that accrue to the community as a result of its water conservation programs.

The City measures these benefits according to several performance metrics and widely shares the results with local consumers. The first is the "scorecard," which establishes several performance indicators such as number of conservation classes held, or percentage increases in customer participation in residential and commercial rebate programs, and ongoing staff training to ensure program implementation.[217] The City also quantifies the amount of water saved through its rebate programs and measures annual gallons per capita per day.[218] Everyone wants to be part of something successful and by engaging the community in measuring success, Santa Fe has been able to continue to foster local pride in its efficiency ethic.

Conclusion

Santa Fe's commitment to water conservation using a diverse set of decentralized infrastructure strategies has put the City on a path to sustainably manage its very limited water supplies. This solid foundation and the community's culture of saving water has also given Santa Fe a jumpstart on achieving its even more ambitious future sustainability goals as it looks ahead to the next 25 years in the face of a changing climate and continued population growth.

Moulton Niguel Water District: Not Using Less, Wasting Less

Utility: Moulton Niguel Water District

Location: South Orange County, California

Service area: Serving a population of 172,000 across 37 square miles

Challenges:

- Recurring drought
- Limited local supply
- More extreme weather

Solutions:

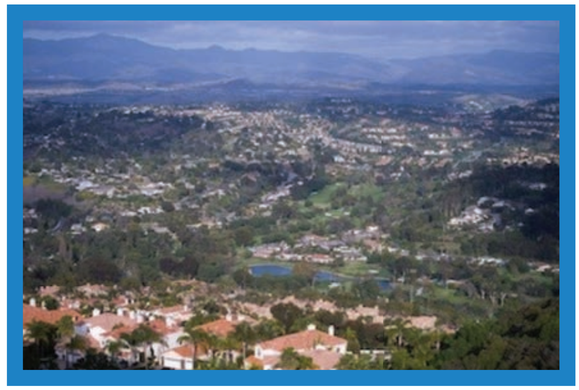
- Integrated water management
- Robust consumer efficiency rebates
- Increased non-potable reuse for outdoor irrigation
- Leveraging nuanced water demand data analysis in decision-making
- Multifaceted public education programs

Results and Benefits:

- Consumer Efficiency Rebates & Rates Structure
    - Average of 4,000 acre-feet of water savings annually
    - Total of 26,000 acre-feet of water saved since 2011
    - Removed 5 million square feet of turf since 2012
    - Saved 500 million gallons of water from turf removal since 2012

- Water Reuse
  - Meets 25% of demand with local supplies
  - Saves $6 million annually in imported water costs
  - Saved $20 million in avoided costs of infrastructure investments based on innovative demand forecasting tool

Location & Service Area



Moulton Niguel Water District (MNWD or Moulton) is a special district providing drinking water, recycled water, and wastewater treatment services to 172,000 people in South Orange County, California, roughly 45 miles southeast of Los Angeles.[219] It includes the City of Laguna Niguel and parts of Aliso Viejo, Laguna Hills, Mission Viejo, San Juan Capistrano, and Dana Point. It is governed by a seven member elected board. Annual precipitation averages approximately 14 inches, with most rainfall coming in the winter months and close to zero precipitation in the dry summer months.

Water Supply Sources

MNWD is almost entirely reliant on imported water from outside of its service area, which it purchases from the Municipal Water District of Orange County, the regional wholesaler of the Metropolitan Water District of Southern California.[220] Moulton has no access to either local groundwater or surface water supplies. In order to diversity its water portfolio and grow local resilience, Moulton has invested heavily in water use efficiency and water reuse.

Resilience Initiatives: Expanding Water Use Efficiency through Customer Rebates, Enhanced Data Analysis and Water Reuse

MNWD first established its rebate program in 2011, with refinements in 2016, to incentivize residential and commercial customers to install water efficient devices and replace turf.[221] Moulton's programs are somewhat more ambitious than typical water efficiency rebates; for example, MNWD's average residential turf rebate is more than $3,000. Moulton's initiatives also stand out for the creative and comprehensive consumer outreach and education strategies grounded in the belief that achieving efficient use of water often requires a

change in consumer interaction with and mindset about water.[222] Key to achieving this change is MNWD's shrewd ability to develop messaging that resonates locally. Moulton's consumer outreach stresses that "efficiency is not about using less; it's about wasting less." In addition to a sophisticated updated website, social media, email, fliers, and newsletters,[223] MNWD also hosts "My Water MNWD," an online portal providing customers with direct access to their historical water usage and various resources about water conservation programs, rebate opportunities, and more.[224] The District also holds workshops for homeowner associations and landscaper trainings that include first-of-their-kind bilingual workshops.[225]

MNWD's success is also predicated on its commitment to partnering with a range of regional agencies and nonprofits,[226] and a focused approach to changing consumer behavior. Recognizing that landscape change out programs can be daunting for residential customers, MNWD encourages them to begin with "easy" projects. A study with UC Riverside found that customers were more likely to take additional water efficient actions after taking one initial step. In response, the Moulton created a direct install program to help customers put in smart timers which it later built into a more comprehensive NatureScape direct install turf removal program.[227]

MNWD's robust consumer outreach program stresses that "efficiency is not about using less; it's about wasting less."

In keeping with its innovative approach to water management, Moulton was able to save ratepayers nearly $20 million by partnering with a number of tech firms to analyze its operations.[228] The District had been considering significant investments in new storage infrastructure to address peak demand challenges. However, an advanced demand forecasting tool indicated that the issue could be addressed more economically by working with some of the District's larger institutional customers to change the timing of their operations, eliminating entirely the need for the proposed reservoir.

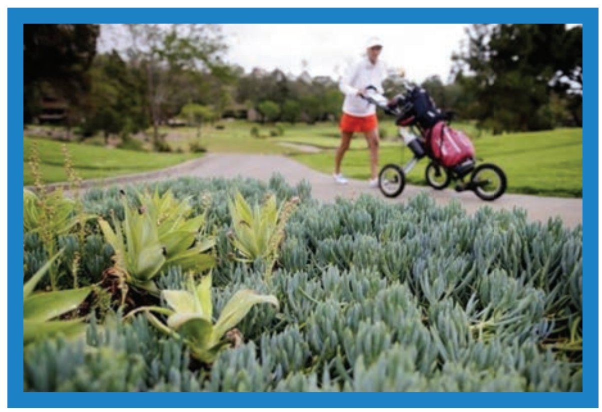
By partnering with a number of tech firms to analyze consumer demand MNWD saved its ratepayers nearly $20 million.

Moulton has also invested in recycled water "to reduce dependence on imported water and maximize the reuse of available resources."[229] For the past 50 years, MNWD has identified

recycled water as its highest priority alternative water supply,[230] with the recognition that "every drop of recycled water that is used is a drop of drinking water that doesn't have to be imported from hundreds of miles away."[231]

MNWD's recycling program currently serves almost over 1,400 customers with approximately 7,000 acre-feet of water annually to irrigate landscapes at parks, golf courses, recreational facilities, and street medians, among other various outdoor uses.[232] Its recycled water infrastructure consists of two advanced wastewater treatment facilities, 150 miles of recycled water pipeline, 13 recycled water pump stations, six steel storage tanks, and five pre-stressed concrete reservoirs,[233] and there are plans to expand this distribution system with MNWD's "recycled water optimization plan."[234] MNWD also uses an innovative water demand forecasting tool to more accurately predict additional demand for recycled water and better inform the level of infrastructure investment needed.

To further encourage reuse, MNWD offers recycled water retrofit rebates.[235] Customers that convert their existing irrigation systems to recycled water receive $1,250 per irrigated acre or up to 50% of the total project cost.[236] MNWD has also experimented with providing loans for non-profits and public agencies to finance the cost of onsite recycled water retrofits;[237] as of 2017, 53 loans had been issued totaling nearly $540,000.[238]



Program Budget and Funding Sources

Efficiency Programs

MNWD spends about 2% of its overall budget on its various rebate programs, about $2.5 million annually.[239] Of that, $1.5 million is dedicated to outreach and education. Funding for the program is secured by a dedicated stream within the District's operating budget from its water budget-based rate structure.

Water Reuse Programs

Moulton dedicates ~$10 million, or 7% of its overall budget, to the water reuse program.[240] Funding is a mix of annual operating revenue and capital improvement budget.

Program Benefits and Performance Metrics

MNWD maintains that its efficiency and water reuse programs have benefited the utility and its customers in many ways:

Water Use Efficiency Programs

- Water Savings. The combination of Moulton's budget-based rate structure, outreach and consumer rebate programs have resulted in an average savings of 4,000 acre-feet per year. The District can claim significant success particularly with its turf replacement program which has led to the removal of over 5 million square feet of turf.[241]

- Cost Savings. Since 2011, MNWD customers have cumulatively saved over $24 million from reduced water usage.[242] And the District maintains the lowest average bill in South Orange County.[243] These results demonstrate that efficiency can be an extremely economical approach to water supply reliability.[244]

- Energy Savings. MNWD's investment in consumer water use efficiency also helps to reduce energy use and greenhouse gas emissions. MNWD is in the process of quantifying these savings.

Water Reuse Programs

- Water Savings. Moulton's recycled water program currently provides about 7,500-acre feet annually,[245] or about 25% of overall water demand within its service area.[246]

- Cost savings. MNWD estimates that every acre-foot of recycled water results in a cost saving of over $1,000 per acre-foot (in avoided costs for imported water).[247]

- Energy Savings. MNWD estimates that non-potable recycled water saves considerable electricity, about 1,500 kWh per acre-foot less than imported potable water.

Conclusion

Moulton has focused on building local resilience in the face of very limited local water supply elevating those solutions most likely to conserve ratepayer dollars, which coincides with more emphasis on sustainable and decentralized strategies. Its success is predicated on building a strong community presence and a smart, sophisticated approach to investment decision making.

San Antonio Water System: Conservation as Supply

Utility: San Antonio Water System (SAWS)

Location: San Antonio, Texas

Service area: Serving a population of 1.86 million across 967 square miles

Challenges:

- Rapidly growing population and economy
- Prolonged drought
- Decreased water source permits
- Endangered Species Act compliance requirements

Solutions:

- A 3-pronged "Conservation First" approach that treats conservation as a source of water supply. This includes three primary strategies: (1) financial incentives to incentivize deployment of consumer-side-of-the-meter actions, (2) education and outreach, and (3) reasonable regulation.

Results and Benefits:

- Water consumption reduced by 50%
- Enhanced drought resilience
- Cost-effective water supply, affordable rates for all income levels
- Community engagement
- Increased wildlife habitat for monarch butterflies and other pollinators
- Greens urban spaces

Costs and Funding Sources:

- Annual Conservation Budget: ~$11 million (2019)
    - Incentive and education programs: $9.3 million (2019)
    - Conservation staff of 24 full-time people, 5 part-time enforcement officers, 4 seasonal PT staff, and periodic seasonal temporary staff: $1.5 million (2019)
- Funding source: Annual rate revenue

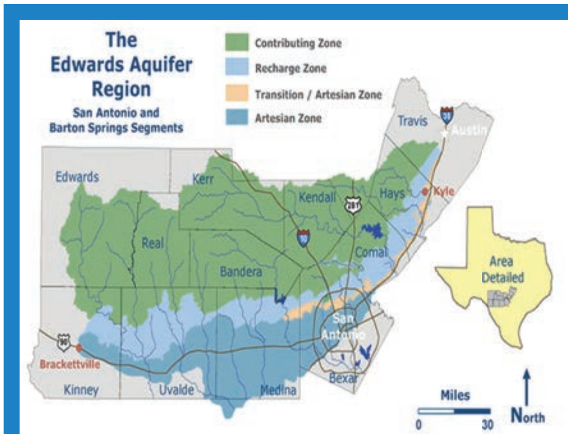
Location & Population

San Antonio, the 7th largest city in the U.S., is located in South Central Texas where its humid subtropical climate consists of long, hot and humid summers and cool to mild winters.[248] The City is one of the most flood-prone communities in North America but has nevertheless limited access to drinking water supplies.

The San Antonio Water System & Water Supply

SAWS was established in 1992 by the San Antonio City Council to consolidate three predecessor agencies and establish a single municipal utility responsible for water, wastewater, stormwater, and reuse.[249] SAWS is governed by a Board of Trustees consisting of the Mayor and 6 members appointed by the City Council.[250] In addition, SAWS board and staff receive input from 5 local citizen groups.[251] It serves a population of 1.8 million people in Bexar County (which includes the City), as well as parts of Medina, Atascosa, Kendall, and Comal counties.[252] SAWS' overall service population is expected to nearly double to 3.3 million by 2070.

San Antonio, overlying parts of four major aquifers, has historically relied almost entirely on groundwater for water supply. Chief amongst these is the Edwards Aquifer, a vast karst limestone artesian groundwater basin,[253] which is an indispensable natural resource for South Central Texas. The Edwards Aquifer covers 8,000 square miles and is able to recharge an average of 676,000 acre-feet annually.[254] Excessive pumping



and resultant conflicts have led to changes in groundwater use, and the Aquifer is now heavily regulated. As recently as 2000, the Edwards Aquifer provided 70% of SAWS' water supply; as of 2019 this reliance has dropped to 42% and is expected to continue to decline to about 31% by 2070, notwithstanding projected strong population growth over the same period.[255]

Conservation First

San Antonio's "Conservation First" policy has its genesis to some extent in the decades-long dispute over management of local groundwater. The massive Edwards Aquifer serves municipal, farming, and ranching interests well beyond San Antonio and may be the most intensively studied, and litigated, groundwater basin in North America. From the 1930s to 1980s withdrawals from the Aquifer quadrupled, and alarms were raised. Disputes that had been simmering for decades came to a head with litigation in the 1990s resulting in a seminal federal court decision requiring Texas to better regulate the Aquifer to ensure more sustainable management and environmental health.[256]

For SAWS, conservation is the cheapest source of water.

In response, in 1993 the Texas Legislature enacted SB 1477 establishing the Edwards Aquifer Authority charged with managing withdrawals from the Aquifer.[257] Although years of further litigation, negotiations, and planning ensued,[258] it was clear that San Antonio, as well as the many other entities historically reliant on the Edwards Aquifer, would be required to adjust to a water future in which withdrawals from this source plays a significantly reduced role.[259] SAWS is now a "permitted system" under the new regime with limits on its ability to pump.

Community leaders including former Mayor Bill Thornton recognized the need for a water plan prioritizing water use efficiency.[260] Mayor Thornton established a Citizens Committee on Water Policy to identify a long term water plan for the San Antonio area.[261] Building on that committee's recommendations, SAWS held 61 public meetings and worked with stakeholders to develop a 50-year water plan laying out conservation strategies that was approved by the San Antonio City Council in November 1998.[262] SAWS has issued several

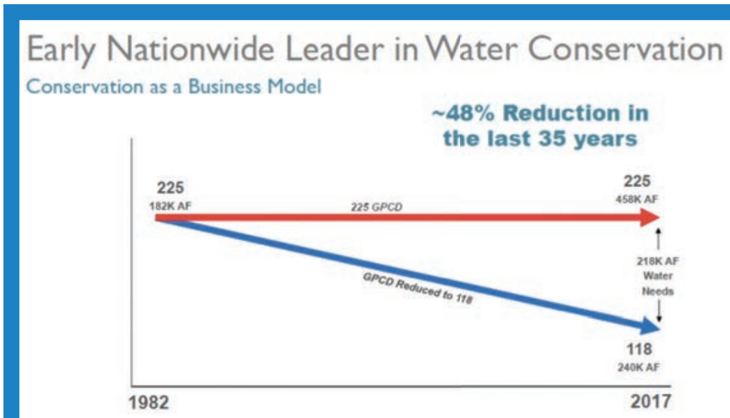
Vista Ridge Pipeline

In 2014, San Antonio determined that based on its long-term supply and demand assessments it needed to explore options for importing water from another section of the Carrizo-Wilcox Aquifer, which is 142 miles north of the city, via the Vista Ridge Pipeline that is expected to be completed in 2020. As part of the Vista Ridge Pipeline project, SAWS has a contract to purchase up to 50,000 acre-feet of water annually. Without the significant water savings achieved through SAWS' conservation first approach, the utility estimates that it would have needed to build an additional 4 Vista Ridge type projects, which would have amounted to ~$4 billion in additional costs.

updates to this plan, most recently in 2017.[263] The utility maintains on its website that "conservation is the cheapest source of water" noting that:

Water we save is water we don't have to buy. So it's important we do everything we can to decrease our water consumption. Plumbing fixture retrofits, watersaver landscapes and improved habits are all things that will help us make low water use a part of every person's everyday life.[264]

Summary of Program



SAWS' "Conservation First" approach, treating efficiency as a source of water supply,[265] has reduced the city's water usage by nearly half from 225 GPCD to 117 GPCD over a 25 year period.[266] SAWS' current goal is to further reduce residential consumption to 55 GPCD by 2070. It is also seeking to reduce total consumption (including commercial, industrial, and institutional (CII) uses and non-revenue water) to 88 GPCD by 2070.[267] SAWS assumes a total demand in 2070 that is approximately 74,000 acre-feet per year less than was estimated in its previous plan as a result of realized and anticipated water savings from conservation.[268]

Three primary strategies make up SAWS' conservation program: (1) consumer-facing financial incentives, (2) education and outreach, and (3) conservation regulations.[269]

Three primary strategies make up SAWS' conservation program:

(1) consumer-facing financial incentives

(2) education and outreach

(3) reasonable regulation

SAWS' premier offering is its WaterSaver Landscape Coupon Program, which has replaced over 2 million square feet of water-intensive grass with low water-use plants and permeable patios.[270] It also provides irrigation design rebates and free water efficient fixtures. SAWS conservation incentives are designed "to accelerate behavioral, process and equipment changes that lead to lower water use over time" in order to sustain a community-wide conservation ethic.[271] SAWS also employs a tiered rate structure to send a price signal to consumers.

SAWS invests heavily in education and outreach strategies including special newsletters and online offerings, as well as leak repair education and fixture retrofit assistance.[272] SAWS collaborates with numerous local educational and landscaping organizations[273] that lead tours and hands-on workshops and related initiatives.

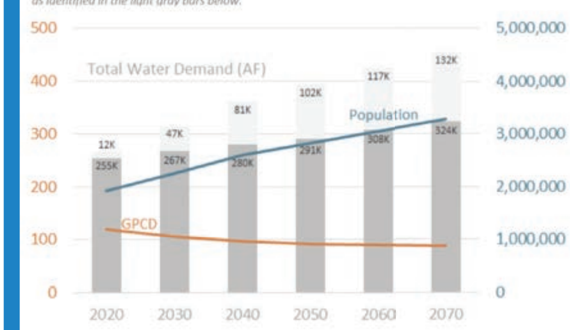
SAWS estimates that its education programs such as care guides for drought-tolerant plants and grass, and irrigation consultations have reduced household water usage by 84 million gallons every year.[274]

Finally, SAWS' has adopted conservation regulations designed to assist the community in reaching its water saving goals without significantly impacting local quality of life[275] Among other things, the ordinance establishes watering restrictions that can be triggered both by drought or by aquifer levels.[276]

SAWS estimates that its education programs such as care guides for drought-tolerant plants and grass, and irrigation consultations have reduced household water usage by 84 million gallons every year.

SAWS also works with the City to integrate its Conservation First water management strategies with the sustainability goals enumerated in San Antonio's Tomorrow Plan.[277] San Antonio has recognized that implementation of successful water use efficiency strategies hinge on smart and sustainable development, and therefore the need for an integrated approach with local land use agencies.[278] As SAWS strives to meet water demand targets despite rapid growth, San Antonio and SAWS cooperate to plan for sustainable growth for the City.[279] Critically, the San Antonio Tomorrow Plan proactively encourages use of water efficient technologies and green building design in construction and higher-density land use planning, which can use as little as 25% the amount of water per capita as suburban single-family development.[280]

Figure 1-3: SAWS aims to achieve a total GPCD of 88 by 2070 for a total demand of 324,000 AFY. If SAWS were to remain at 124 GPCD through 2070, SAWS demand would be an additional 132,000 AFY, as identified in the light gray bars below.



Program Costs and Funding Sources

SAWS' total annual conservation program budget is ~$11 million as of 2019, a little more than 4% of its operating budget.[281] Together, SAWS' incentive and outreach programs total about $9.3 million in 2019 with $1.5 for dedicated full and part-time conservation staff.[282] The program is paid for entirely out of annual rate revenue.

Program Benefits and Performance Metrics

SAWS' decades' long focus on comprehensive planning and efficiency has resulted in "big returns."[283]

- Water Savings. According to US EPA: "By 2007, SAWS had reduced per-capita water use by 49%, meeting their water use reduction goal seven years early. **Investments of $4.8 million/year realized $7.4 million in avoided water purchase and infrastructure costs."**[284] A Texas State University Report found that "[a]lthough [San Antonio's] population doubled between 1987 and 2007, total city water use remained relatively unchanged."[285] Since then, SAWS estimates that water use efficiency has yielded its largest water supply—3.2 million acre feet.[286] New water conservation investments are expected to replace the need for approximately 132,000 acre-feet per year of additional water supply, avoiding billions in costs that would be spent on additional Vista Ridge-type projects.[287]

- Cost Savings. As indicated above, SAWS estimates that its conservation programs have avoided millions in costs of procuring additional new supplies, additional water treatment facilities and **kept rates affordable** for all income levels. The cost of investment in conservation has remained between $3-$4 per capita.[288]

- Environmental & Social Benefits. By treating conservation as a source of water supply SAWS has also accrued various co-benefits including community engagement, resilience in the face of climate change, habitat for monarch butterflies and other pollinators, and greening of urban spaces.[289]

Conclusion

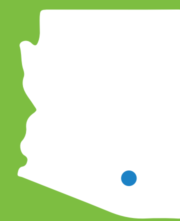
For the past 25 years SAWS has aggressively pursued water conservation as a source of water supply for its customers. As SAWS moves towards its goal to even further reduce water use to a total consumption of 88 GPCD by 2070, the utility will focus on community outreach and education efforts as vital companion strategies that go hand-in-hand with appliance and turf change outs.

Tucson Water: Efficiency Means Avoided Costs

Utility: Tucson Water

Location: Tucson, Arizona

Service area (within Tucson): Serving a population of 720,000 across 227 square miles



Challenges:

- Declining water supply availability and reliability
- Prolonged drought
- Climate change
- State-mandated conservation for groundwater

Solutions:

- Comprehensive water efficiency rebate programs to prioritize conservation as a source of supply.

Results and Benefits:

- Significantly lowered water consumption notwithstanding population growth
- Avoided costs of more than $155 million
- Urban greening, shading, and native landscaping benefits to Tucson
- Improved climate change resilience
- Improved drought resilience

Costs and Funding Sources:

- Annual program budget: $3.5 million
- Funding source: Dedicated fee on water use

Location & Population

Tucson is located in southern Arizona, about 100 miles southeast of Phoenix and 60 miles north of the Mexico border. The region is part of a global desert zone, one of the warmest locations in the U.S. with precipitation averaging 12 inches per year.

Tucson has a population of approximately 535,000 and is Arizona's second most populous city after Phoenix.[290] However, the larger Tucson-metropolitan area, which includes Oro Valley and Marana, is home to one million residents. Population growth is expected to be a modest 0.7% over the next few decades.[291]

Tucson Water & Water Supply

Tucson Water is a municipal water utility and a department of the City of Tucson. It provides drinking water and reclaimed water services to about 720,000 people in the metropolitan area.[292]

Historically, the Tucson metropolitan area developed by relying solely on groundwater, and, along with the rest of the state, was drawing from its aquifers at an unsustainable rate. In 1968, President Johnson approved a 336-mile canal to transport Colorado River water to the central and southern parts of the state. The Central Arizona Project (CAP), completed in 1993, is designed to carry a yearly average of 1.5 million acre-feet per year to central and southern Arizona. Tucson has rights to about 144,000 acre-feet annually, and recharges this allocation into an aquifer west of the City. The water remains underground until it is pumped and delivered for use in the service area. Tucson today is almost entirely dependent on Colorado River water transported by CAP and smaller amounts of local groundwater and recycled water.

State Mandate Driving Water Conservation and Efficiency

As a groundwater user within the Tucson "active management area" (AMA), established pursuant to the 1980 Groundwater Management Act, Tucson Water is required to participate in a mandatory conservation program.[293] Its requirement is currently set at 160 GPCD, but Tucson customers are well below this allocation at about 122 GPCD.[294]

Beginning in 1998, Tucson established its first water conservation program to meet the state-mandated conservation requirements set under the Groundwater Management Act.

Beginning in 1998, Tucson established its first water conservation program to meet the state-mandated conservation requirements.[295] Codified by city ordinances,[296] these policies included public education and rebates for various residential and commercial efficiency measures[297] including but not limited to:

- **High efficiency toilets ($75 each for up to two)**
- **Rainwater harvesting systems (up to $2,000)[298]**
- **High efficiency clothes washers ($200)**
- **Gray water systems (up to $1,000)**
- **Free water audit and customized incentive package for commercial customers[299]**

To address equity and affordability issues, Tucson Water provides limited-income individuals and families with free high-efficiency toilets[300] and grants (up to $400) and zero-interest loans (up to $2,000) for rainwater harvesting systems.[301] The utility has also invested in water conservation education; its programs have reached more than 450,000 people in the last decade.[302] It has also made a special effort to reach its Spanish speaking community with 1:1 interactions and Spanish-language materials for outreach and training.[303]

Currently the utility is planning neighborhood-scale green infrastructure aimed at making full beneficial use of rainwater and greening the urban landscape,[304] rounding out its integrated sustainable management approach.[305] Over the next two years, Tucson Water will participate in "One Water 2100," a utility-wide planning process to update and reframe the City's long-range water plan with a focus on how the city will utilize all available water resources and expand use of alternative resources, primarily rain and stormwater.[306]

> **Tucson Water is planning neighborhood-scale green infrastructure aimed at making full beneficial use of rainwater and greening the urban landscape, rounding out its integrated sustainable management approach.**

Budget and Funding

Tucson's total annual conservation program budget is $3.5 million:[307]

- Conservation rebates and incentives budget: $1.4 million
    - Rainwater harvesting rebate program budget: $400,000
    - Low-income grant and zero-interest loan program: $300,000
    - Other rebates and incentives(e.g., appliances and graywater systems): $700,000
- Education programs: $750,000
- Neighborhood-scale Stormwater Harvesting Program: $350,000
- Public relations and advertising: $30,000

The conservation budget is funded by a conservation fee assessed on potable water sales and allocated to a dedicated fund.[308] The utility's One Water efforts will also be funded by the conservation fee.[309] The fee is a relatively modest $0.10 per hundred cubic feet (ccf) (1 ccf = per 748 gallons) in fiscal year 2019.[310]

Benefits and Performance Metrics

Tucson Water and its customers have experienced several water and cost savings benefits as a result of the utility's investments in comprehensive conservation and efficiency programs.

- Water Savings. Now in its tenth year, Tucson's conservation program has **conserved more than 2.1 billion gallons** (6,446 acre-feet). The City is currently using water at the same level of use as in 1985, while population has increased by more than 226,000 people and service connections have increased by more than 75,000.[311] The program has resulted in the installation of 53,000 high-efficiency toilet and urinal installations, as well as 2,000 rainwater harvesting and gray water systems, amongmany other achievements.[312]

Population in Tucson has increased by more than 226,000 and service connections have increased by more than 75,000, but the City is currently using water at the same level of use as in 1985.

- Cost Savings. Tucson conducted a comprehensive avoided cost analysis in 2017 demonstrating that it saved ~$155 million by deferring and possibly avoiding the need to expand capacity of the water system and develop new, centralized recycled water supplies. It also found that **water rates were 15% lower than they otherwise would have been** as a direct result of the public's investments in conservation programs.[313]

Part of Tucson Water's success is that it has been committed to measuring conservation performance with a variety of evaluation tools including but not limited to:[314]

- **Water savings attributable to efficiency rebates[315]**
- **3-year efficiency pilot projects evaluated for water and cost savings**
- **Customer surveys and marketing studies to improve participation rates.[316]**

Conclusion

Tucson Water is constantly striving to save water and keep rates affordable and equitable, but it takes constant review and analysis of its programs to remain on the cutting edge of 21st century efficiency strategies. This is a challenge Tucson works to meet by deploying multiple localized water strategies.

Austin Water: Water Resource Planning for the Next Century

Utility: Austin Water

Location: Austin, Texas

Service area: Serving a population of 950,000 across 300 square miles

Challenges:

- Rapid population growth
- Drought and lack of reliable water supply
- Climate change

Solutions:

- The "Water Forward Plan," an integrated water resources strategy based on a 100-year planning horizon.

Planning Benefits:

- Allowed for consideration of options in a transformative way by imaging a world a century into the future to inspire creative solutions
- Accounts for anticipated impacts of climate change

Anticipated Implementation Benefits:

- Increased water supply reliability and resilience
- Water management will anticipate changes rather than be crisis-driven
- Water investments will be cost-effective, affordable, and environmentally sustainable

Location & Population

Austin, the state capital, is the rare Texas community surrounded by water. The (other) Colorado River, contained entirely within the state of Texas, flows through Austin feeding various nearby lakes.[317] The region has a temperate-to-hot, highly variable climate with an average of 300 days of sunshine a year;[318] annual rainfall is about 33 inches.[319]

Austin's population is the 4th largest city in Texas and the 11th largest in the U.S.[320] It is one of the fastest-growing cities in the country.[321]

Austin Water & Water Supply Source

Austin Water is a division of the City of Austin. It provides both drinking and wastewater services and has been a public utility for over 100 years.[322] All of Austin's drinking water is supplied from the Colorado River (Texas).[323] A series of dams along the river form the Highland Lakes, two of which—Lake Buchanan and Lake Travis—serve as the regions' reservoirs and flood control system.[324] Treated wastewater is discharged into the Colorado River (Texas) from two major treatment plants.[325]

Water Forward Plan

Like most of Texas, Austin was rocked by an historic eight-year drought that ended in 2016 during which the City faced near-record low reservoir levels and was required to evaluate emergency strategies.[326] Combined with a growing population expected to surge to nearly 2 million by 2040[327] and concerns about the changing climate, City leaders decided to be proactive and embarked on a unique planning initiative.[328]

To address these generational challenges, and climate change in particular, Austin Water selected a 100-year planning horizon and evaluated multiple future scenarios to build reliability into the Plan recommendations.[329] This long timeline allowed the planners to think about the available options in a transformative way by imaging a world a century into the future that is very different from today.[330] This structure introduced enough new complexity to inspire creative solutions without eliminating known management constraints.[331] The result is a Plan that is unique nationally for its holistic evaluation of potential solutions, and creative recommendations focused on achieving multiple community objectives.[332]

Plan Development Process

Based on the recommendation of a citizen advisory group, in May 2015, the City established the Austin Integrated Water Resources Planning Community Task Force to oversee the preparation of a long-term integrated water resources plan, in collaboration with Austin Water.[333] The Task Force included Council-appointed experts and ex officio members from various city departments including Water, Energy, Sustainability, and Watershed Protection.[334] This was an intensive 3.5 year effort with monthly Task Force meetings[335] and a massive public education and outreach campaign, eventually including 80 events to gather meaningful public input.[336] The public outreach effort underscored the importance of engaging with the community in venues where they were already convening and the need to frame the message in clear, accessible terms such as "water conservation" rather than more water industry jargon such as "long-range water supply planning."[337]

The best available climate science indicates that climatological changes will have profound impacts on Austin's flood and drought patterns in light of anticipated longer and deeper droughts accompanied by heavier rain events.

The Austin City Council unanimously adopted the Water Forward Plan on November 29, 2018. Implementation will be ongoing with immediate next steps, as of 2019, of exploration of innovative financing strategies, and incorporation of the identified strategies into city ordinances.

On the technical side, the initiative inspired Austin Water to develop new ways to evaluate water demand and account for the impacts of climate change. In particular, the utility used a "disaggregated demand forecasting model" to project demand by sector (e.g., single-family residential, multi-family, and commercial) and help planners understand where and how water was being used currently and how much current and future demand could be met by onsite non-potable sources.

This model enabled Austin Water to develop refined strategies around conservation, reuse, and reuse, and additional potable supplies or storage based on the types of water needed to meet particular demands. (Absent this disaggregated model, only rough estimates of water demand for non-potable uses would have been available.) The utility also invested in modeling to assess climate change impacts on basin hydrology based on drought conditions reflective of future climate change.[338] This led to the conclusion that **efficiency, aquifer storage, and reuse will be critically important to meeting the City's water resilience goals.**[339]

Summary of Plan & Recommendations

The Water Forward Plan is an extraordinary effort providing Austin with a blueprint for ensuring water resilience over the long-term by increasing its reliance on local water supplies through extensive onsite reuse and bold expansion of efficiency programs, among other elements.

Onsite Reuse. Austin anticipates that community-scale onsite water reuse will account for **1/3 of all new water supplies** that Austin will bring online. This will need to scale up quickly—Austin expects to produce, capture, and treat 20 times more water from buildings than any other city in the U.S by 2040. If achieved, this will amount to 10 million gallons per day of decentralized reuse. To meet this goal, Austin Water will foster reuse of all flows of water within the City including air condition condensate, rain water, stormwater, and black water (all forms of water that buildings create or intercept but were not previously treated as resources). Utility staff is developing "new ordinance concepts" that could require developments over 250,000 square feet to use "alternative and onsite waters to meet indoor and outdoor non-potable demands."[340]

As part of the Austin Forward Plan, Austin Water will foster reuse of all flows of water, including air conditioner condensate, rain water, stormwater, and black water. With this approach Austin anticipates that community-scale onsite reuse will account for 1/3 of all new water supplies.

Conservation and Efficiency. Austin has a 35-year legacy of investing in leading edge water use efficiency programs, to the point that it began phasing out certain programs because they had reached effective market saturation.[341] Nevertheless, the Water Forward Plan anticipates that next generation water use efficiency measures will play an important role in ensuring the community's long-term water resiliency.

Specific efficiency recommendations in the Plan include:

- **Efficiency requirements for cooling towers**
- **Water use benchmarking for larger buildings of a certain size**
- **Outdoor irrigation efficiency mandates and incentives[342]**
- **Expanding rebate programs for smart irrigation system controllers and water-efficient landscape**
- **Developing an ordinance to require water efficient landscapes for new single-family homes[343]**

All of these elements are distributed infrastructure of one kind or another.

To measure success, the City will track savings from efficiency measures and yield from wastewater reuse and aquifer storage and recovery through 2025 and 2040.[344]

Conclusion

While many American communities are awash in plans, Austin's Water Forward initiative stands out as an extraordinary effort. In embracing the realities of how the changing climate is reasonably likely to effect water management locally, and planning for a multi-generational horizon, Austin has unlocked a new level of creativity and possibility. Austin Water successfully overcame many initial challenges including data gaps and turned high level strategies into concrete solutions. The result is a unique integrated water management plan that solidifies Austin's commitment to sustainable water management into the next century that can be a national model.

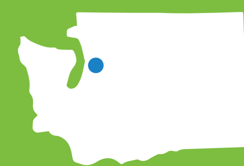
The Water Forward Plan anticipates that next generation water use efficiency measures—e.g., efficiency requirements for cooling towers, water use benchmarks for large buildings, outdoor irrigation efficiency mandates and incentives—will play an important role in ensuring the community's long-term water resiliency.

Seattle Public Utilities [PART 1]: Putting Capital Behind Efficiency

Utility: Seattle Public Utilities

Location: Seattle, Washington

Service Area: Serving a population of 1.4 million across ~ 84 square miles



Conservation Program Drivers:

- Ensuring sufficient drinking water supplies
- State efficiency mandates

Solutions:

- Aggressive consumer rebate programs to deploy decentralized low water use appliances and other efficiency solutions.

Benefits:

- 28% decline in consumption over time
- Active, long-term regional partnerships
- Community engagement

Costs and Funding Sources:

- Efficiency Rebates Budget: $5 million - $1.7 million annually since 1980s
- Funding Sources: Municipal bonds

Location & Population

Seattle is a seaport city of about 84 mostly hilly miles located on the isthmus between Puget Sound and Lake Washington. In the shadow of the Olympic and Cascade mountain ranges, Seattle is one of the wettest cities nationwide receiving at least an inch of precipitation 150 days a year.[345] Seattle is home to approximately 725,000 residents,[346] and is growing rapidly.[347]

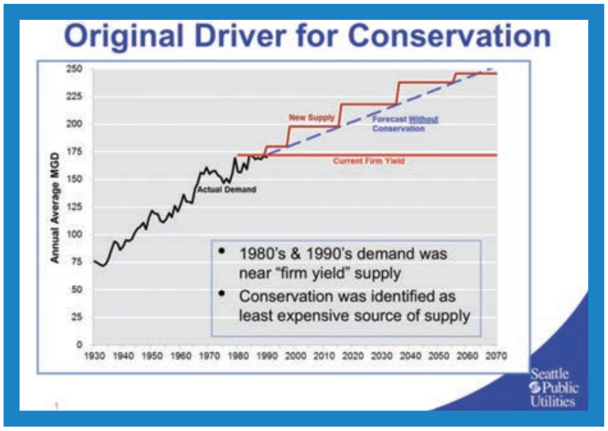
Seattle Public Utilities: Drinking Water Services

Seattle Public Utilities (SPU) is a department of the City of Seattle and operates two distinct utilities: (1) drinking water and (2) drainage and wastewater.[348] The water utility provides drinking water to a population of about 1.4 million customers in and around Seattle; approximately ½ of its water is sold to SPU retail customers and ½ is sold through wholesale contracts to 21 municipalities and special purpose districts to serve their own retail customers.[349] SPU's water supply system consists of surface reservoirs on local rivers.[350]

Water Conservation

Perhaps somewhat surprising given its reputation for unceasing rain, Seattle's water supply challenges have been the motivating force behind its multi-decade investment in water use efficiency.[351] In the early 1980s, SPU launched its initial efficiency program focusing on education and outreach, adding rebates for water efficient fixtures and appliances in 1985 as the utility began taking a hard look at the costs of procuring new water supplies. Analysis identified conservation as a viable, cost-effective alternative to developing new conventional sources of supply available to the City, such as purchasing additional water rights.[352] By 1993 it became SPU's official policy that conservation was the preferred source of supply.[353] The utility significantly upscaled its spending on consumer efficiency rebates by dipping into capital, as it would for other long-term infrastructure investments (see below).[354] Further spurring local action, the state legislature enacted a Municipal Water Law in 2003 (MWL), requiring, among other elements, that municipal water providers establish water savings goals for their customers, plan for, evaluate and report on specific measures capable of achieving these goals, install water meters on all customer connections by January 2017, and achieve a standard of water loss (system leaks) if no more than 10%.[355]

"...[A] new wave of conservation programs was begun [in] 2000 with the goal of reducing per person water consumption by 1% every year for 10 years. ... water consumption has shrunk by 44% from 151 to 85 gallons per day." -- SPU Water Trends 1990-2016



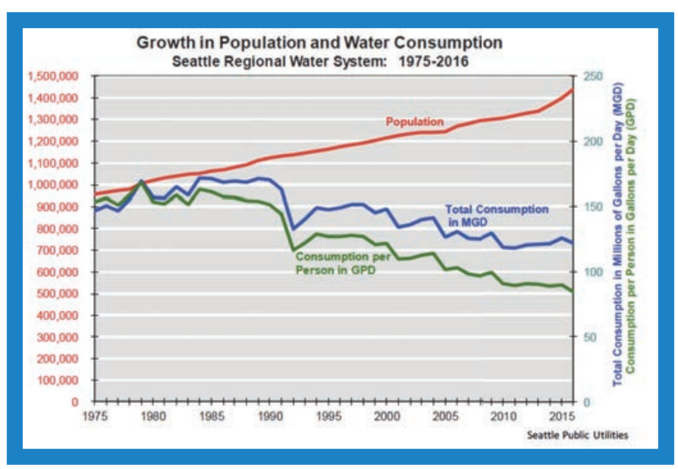
As described in the Saving Water Partnership's 2012 strategic plan, SPU and its utility partners set a combined conservation goal for reducing total per capita water demand (for homes, businesses, industry and institutions) holding total water use below a specified level notwithstanding population growth. "It includes water savings from utility funded, customer-based programs, price-induced conservation from customer response to water and sewer rate increases, and passive savings."[356]

Today, SPU is continuing to deploy—and invest in—distributed water use efficiency infrastructure across its service area, with consumer rebates (or direct installations) for key onsite efficiency measures including:

- **CII upgrades for kitchen and medical equipment, refrigeration, commercial laundries, as well as toilets, urinals, sprinkler systems and more**
- **Sprinkler system upgrades for large multi-family building landscapes**
- **Premium water efficient toilets (1.1 gal/per flush); and**
- **Free direct water efficient toilet installations for low-income residents within Seattle[357]**

SPU supports these infrastructure investments with comprehensive consumer education about efficient water use practices indoors and outdoors.[358] In addition, SPU administers the Saving Water Partnership for its wholesale water customers.[359]

Seattle began a new wave of conservation programs was 2000 with a goal of reducing per person consumption by 1% every year for 10 years. Since then, consumption declined "by 44% from 151 to 85 gallons per day." -- SPU Water Trends 1990-2016



Program Costs and Funding

Seattle stands out for treating its spending on efficiency as a long-term investment. For many years, SPU has capitalized its spending on consumer efficiency rebates, meaning it pays for these programs with long-term debt, out of its capital budget, that can be amortized over many years.[360] This has allowed it to significantly scale its spending on these programs to the tune of $1.7 million to $5 million annually at the program's peak in 2003.[361] More recently the utility has determined that water supplies are sufficient to meet demand for the time being and has therefore been cutting back on its consumer rebate programs while shifting emphasis to education and outreach.[362]

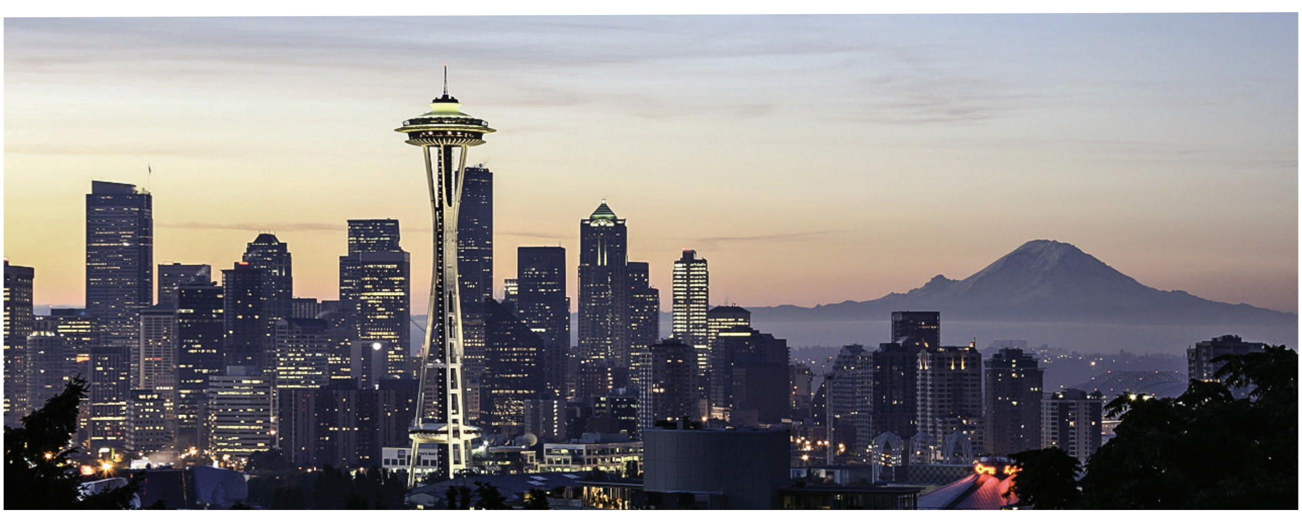
Program Benefits and Performance Metrics

"Between 1990 and 2016, consumption decreased by 28 percent while population increased by the same percentage." -- SPU 2019 Water System Plan

SPU's water use efficiency program is widely recognized as a major success. "On a per person basis, water consumption has shrunk by 44% from 151 to 85 gallons per day."[363] On average approximately 800 customers per year receive a rebate through the region-wide program; and SPU provides direct water efficient toilet installations for another 400 low-income residents or about 6,800 free toilets, since the program began in 2001.[364] SPU's water savings represent the combined effects of higher water and sewer rates, new federal and state plumbing codes, improved system operations, and the utility's conservation programs.[365] Together, these efforts have kept water consumption significantly below pre-1992 drought levels.[366]

Conclusion

SPU's has been a leader in using water efficiently. SPU has had capacity to invest millions of dollars in these innovative localized water strategies because, at least in part, it funds these programs from its capital budget. Using capital dollars is a financing mechanism available to, but not as of yet accessed, by most other public utilities in the country. While SPU may not have realized it was unique in this way, their example can help make capitalizing localized infrastructure the norm rather than the exception.



Wastewater and Stormwater Case Studies

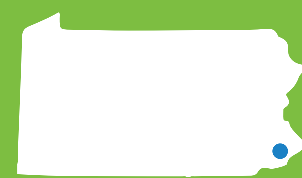
The 6 case studies below demonstrate that distributed green infrastructure strategies can cost-effectively address wastewater and stormwater management challenges while providing additional co-benefits to diverse communities nationwide.

Philadelphia Water Department: Green City, Clean Waters

Utility: Philadelphia Water Department

Location: Philadelphia, Pennsylvania

Service area: 1.6 million drinking water, 2.2 million wastewater customers across 140 square miles



Challenge:

- Combined sewer overflows (CSOs)
- Aging water infrastructure
- Climate change
- Urban revitalization
- Keeping rates affordable[367]

Solution:

- Ground-breaking 25-year planning and adaptive management framework to address CSOs with city-wide green stormwater infrastructure projects on private and public property in areas of the Philadelphia that are served by a combined system.

Benefits:

- Over 440 green infrastructure projects on public and private property
- 1200 "greened acres"
- Reduced CSOs by 7 million gallons
- $500,000 in local green jobs in one year alone
- Public engagement with over 5,000 customers

Costs and Funding Sources:

- Total green stormwater infrastructure budget: $1.67 billion over 25-years
- Planned Annual spending:
  - $25 million on distributed residential infrastructure rebates
  - $15 million on distributed commercial and institutional grants
  - $1 million on public property green stormwater infrastructure
- Funding sources:
  - Incentives and grant programs for distributed infrastructure: rate revenue
  - Public property green stormwater infrastructure: capital financing

Location & Population

Philadelphia is the 6th most populous city in the U.S, and largest in Pennsylvania, encompassing 142 square miles at the confluence of the Delaware and Schuylkill Rivers. Annual precipitation is 41.5 inches—well above the national average of 30.[368]

Philadelphia Water Department: Drinking Water, Stormwater, and Wastewater

Philadelphia was the first city in America to supply its citizens with drinking water (in 1801)—the current Philadelphia Water Department (PWD) dates its origins to that time.[369] Today the utility provides drinking water, stormwater, and wastewater services to the City of Philadelphia and 10 municipalities in surrounding Montgomery, Delaware, and Bucks Counties.[370] PWD serves 1.6 million drinking water customers and provides wastewater service to 2.2 million.[371] Local population growth has fluctuated both increasing and declining in recent years, creating complex challenges for PWD.[372] While thriving economically by many measures, household income in the area is below the national median.[373]

The Delaware and Schuylkill Rivers provide the city's drinking water with each river contributing half of the overall supply.[374] The wastewater system is made up of over 3,000 miles of sewer pipes and consists of two types of systems: combined (i.e., manages stormwater and wastewater) and separate (manages stormwater only); 60% of the system is combined and 40% is separate.[375]

Green City, Clean Waters

As is the case for many older communities with aging infrastructure, Philadelphia has confronted enormous sewer overflow challenges, which endanger public health as well as the integrity of local waterways. The federal Clean Water Act is the primary statute regulating these issues, mainly through (1) the Combined Sewer Overflow Control Policy (National CSO Policy) which sets out guidance for controlling overflows from combined sewers;[376] and (2) the "municipal separate storm sewer" (MS4) requirements which apply to separate stormwater systems.[377] Philadelphia has both combined and separate systems. The City recognized that it if was going to meet its 21st century challenges it would need modern, innovative solutions.[378]

> **"PWD developed our concept of regional watershed management planning after recognizing that, as the downstream most entity in each of the watersheds draining to the City of Philadelphia, the necessary long-term sustainable improvements to water quality and habitat within each waterway could not be achieved without watershed-wide stakeholder and agency support." -- City of Philadelphia's Program for Combined Sewer Overflow Control Program Summary (June 2011)**

In 2009, PWD had been evaluating how to address its sewer overflows, and violations of federal clean water requirements, for some time when it determined that "a green stormwater infrastructure-based approach would provide maximum return in environmental, economic, and social benefits within the most efficient timeframe, making it the best approach for the City of Philadelphia."[379] This resulted in the adoption of the City's landmark Green City, Clean Waters program to invest in community-wide, decentralized green stormwater infrastructure (GSI) over 25 years to help reduce the frequency and water quality impacts of overflows from the City's combined sewer system (CSOs).[380] PWD was the first utility in the country to receive EPA approval for an integrated planning and adaptive management framework for CSO management under its Long Term Control Plan required by the National CSO Policy.[381] A key element of the City's plan is to break down the silos that are often exist around disparate Clean Water Act regulatory programs.[382]

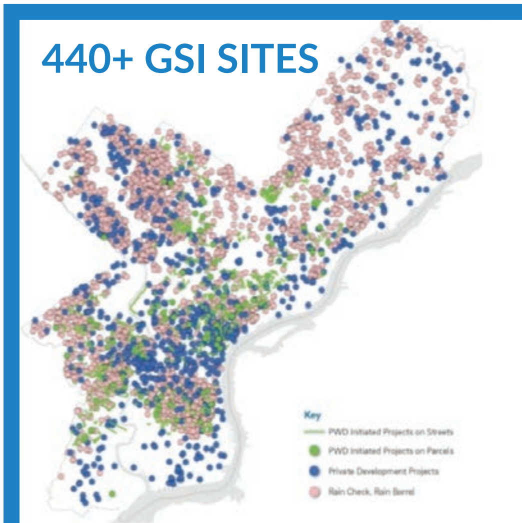
The objective of the Green City, Clean Waters program is **to convert more than one-third of the City's impervious surfaces in the areas** that are served by a combined sewer—about 65% of the City—to "greened acres," which are expected to capture 1 million gallons of rain per acre per year.[383] To qualify as a "greened acre," the area, either on public, commercial, institutional, or residential property, must manage the first inch of stormwater runoff.[384] The bulk of greened acre conversions are on public property such as city-owned streets and rights of way, which make up 45% of the impervious land in Philadelphia.[385]

The Plan also calls for GSI projects to be installed on private land, many in relatively low-income neighborhoods which are already providing additional "greening" benefits.[386] A report commissioned to review the first 5 years of the Green City, Clean Waters program found that private GSI projects were occurring "wherever development is happening... development is in fact occurring all throughout the city and therefore private GSI projects are similarly spread out."[387]

PWD has been making significant public investments in GSI on private property with financial incentives for businesses and homeowners in the community. Its "Rain Check" program offers cost assistance for residents installing stormwater improvements such as downspout planters, rain gardens, and permeable pavers; rain barrels are available for free.[388] The Rain Check program also has a robust customer engagement element that includes workshops, fliers, social media, mailings, classroom curriculum, and other outreach[389] through which PWD has reached 5,753 workshop attendees between 2015 and 2018.[390]

Since the Green City, Clean Water program began in 2011, PWD has invested $25 million annually on residential property retrofits, $15 million on CII property retrofits, and $1 million on public property GSI projects.

For its commercial, industrial, and institutional (CII) consumers, PWD offers a grant program to incentivize retrofits on non-residential property.[391] For example, PWD awarded a school coalition a $302,000 grant to install a GI project that resulted in 1.96 greened acres that now manages over nearly 2 million gallons of stormwater onsite per year.[392]



Program Budget and Funding

PWD has committed to investing $1.67 billion in GSI projects over a 25-year period.[393] Public property GSI projects are funded from PWD's capital budget; incentive programs for projects on private residential and CII properties are funded out of annual rate revenue.

As of 2018, on an annual basis PWD has invested $25 million on residential property retrofits; $15 million on CII property retrofits; and $1 million on public property GSI projects.[394] Cumulatively, PWD's annual GSI investments represent approximately 5% of its overall utility budget.

Program Benefits and Performance Metrics

Philadelphia's Green City, Clean Waters is one of the more acclaimed GSI programs nationally. Since the program began in 2011, PWD and the Philadelphia community has reaped many benefits.

- Water Resource Benefits. There have been 1200 greened acres with approximately 1,000 of those acres on private property. Further, **GSI projects have reduced CSOs by 7 million gallons.**[395]

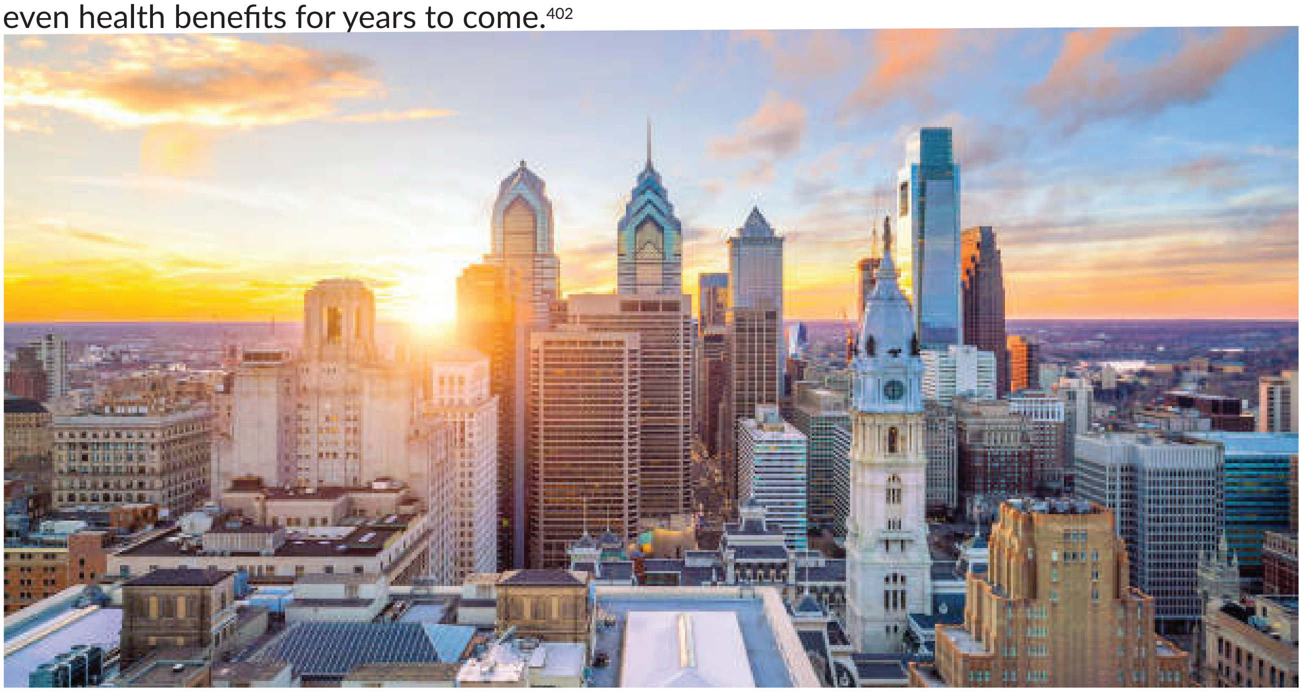
- Economic Benefits. PWD's GSI projects are significantly more cost effective than traditional gray infrastructure.[396] And they have already supported local, green jobs amounting to approximately $500,000 to local businesses in 2018. In addition, GSI investments of $1.67 billion over the twenty-five-year program are expected to support 1,000 jobs each year, **approximately $1.5 billion in total labor income, and $2 million per year in additional tax revenue**.[397] Local homeowners are also expected to see increased property values of approximately 10% resulting from GSI.[398] Studies show that GSI provides several advantages for commercial properties including "higher rents and property values, increased retail sales, energy savings, reduced maintenance costs, reduced utility bills, and improved safety, health, and job satisfaction for office employees."[399]

- Environmental Benefits. Environmental benefits include improved water and air quality, reduced soil erosion, wildlife habitat, and reduced greenhouse gases.[400] **Added green space through GSI has been estimated to have an overall environmental benefit of $10.5 million per year.**[401]

To measure these benefits, PWD used a triple bottom line analysis of the program's financial, environmental, and social impacts. Grounding the green stormwater infrastructure program in environmental and social impacts as well as financial and water management benefits helped PWD navigate the path towards moving the utility to holistic, sustainable water management that builds resilience for Philadelphia.

Conclusion

PWD has made a long-term commitment to growing distributed, onsite infrastructure on a scale that American cities have never experienced. It is betting that these localized stormwater management strategies will be effective, and the evidence so far appears to bear that out. The data also appear to offer strong initial indications that City leaders are correct that this approach is not only more affordable, thereby better protecting more vulnerable local ratepayers, but will provide significant local economic, aesthetic, environmental, and even health benefits for years to come.[402]



Milwaukee Metropolitan Sewerage District: Going Big on Green

Utility: Milwaukee Metropolitan Sewerage District (MMSD)

Location: Milwaukee metro area, Wisconsin

Service area: 1.1 million across 400+ square miles

Conservation Program Drivers:

- Combined sewer overflows (CSOs)/basement backups
- Stormwater runoff from municipal separate storm sewer system
- Community demand for more action

Solutions:

- Comprehensive onsite GI green infrastructure strategies distributed across the community on both public and private properties

Benefits:

- As of 2019, local GI projects capturing 40 million gallons of stormwater/yr
- Significant community engagement, pride

Costs and Funding Sources:

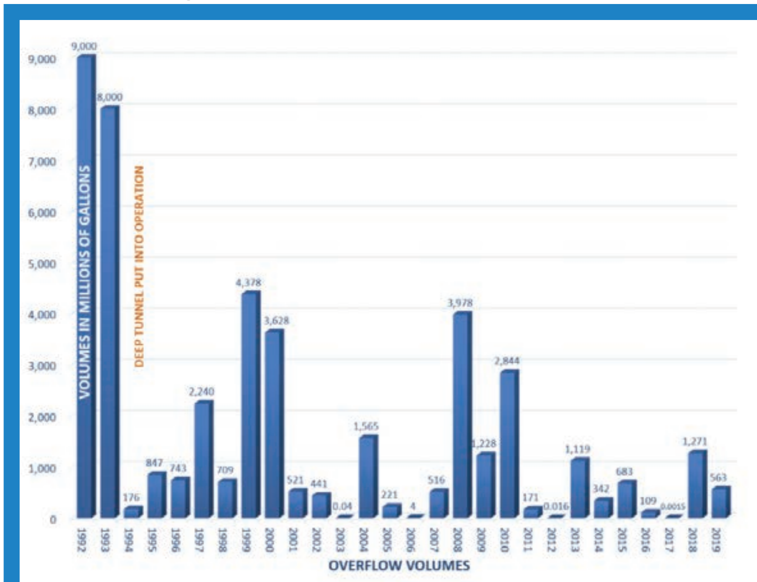
- Total annual project budget: $11 million
- Funding sources: Combination of rate revenue and MMSD-issued general obligation bonds (SRF funding may now be an additional option going forward)

Location & Population

Milwaukee, a city of about 600,000 people, was founded in the early 19th Century and sits on the shores of Lake Michigan at the confluence of three rivers. It averages 35 inches of rain a year; 1 inch of rain locally generates 7.1 billion gallons of water.

Milwaukee Metropolitan Sewerage District

MMSD is a regional agency responsible for wastewater treatment and flood management services for over 1 million people in 28 communities in the Greater Milwaukee Area.[403] Milwaukee can lay claim to being a water resource management pioneer; it established a Sewerage Commission more than a century ago and was first in the nation to build a secondary wastewater treatment facility.[404] Today's MMSD was created by state law in 1982, and is governed by 11-member Commission appointed by the City of Milwaukee and surrounding municipalities.[405]



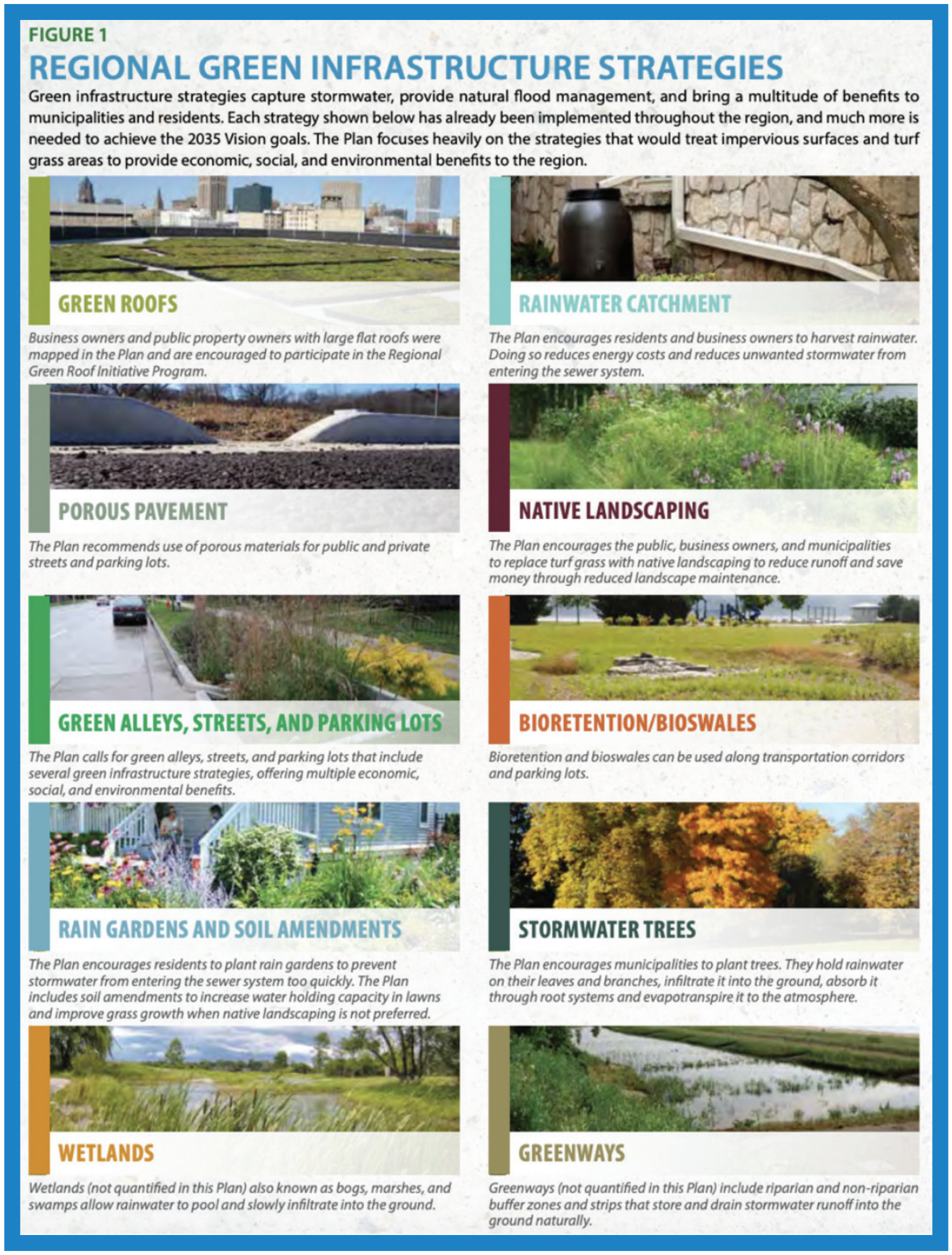
MMSD receives wastewater flows from the City of Milwaukee's combined sewer system, and also from a separate sewer system serving the suburban service area.[406] Sewer and stormwater system overflows were a constant for decades backing polluted water into basements and into local waters, and plans for a large tunnel to address the issue were developed throughout the 1970s-80s. Milwaukee's Deep Tunnel System, 19.4 miles long and 300 feet underground, was completed in 1993.[407] By that time, the community had spent about $3 billion on gray infrastructure.[408] Since 2002, MMSD has been weaving green infrastructure solutions into its strategy for addressing stormwater runoff, water quality and sewer overflow challenges since 2002, and its commitment to these distributed strategies has only grown over time,[409] even as it also invested another $1 billion two additions to the Deep Tunnel system.

MMSD Turning Green

Without question MMWD's Deep Tunnel system has been effective, slashing CSOs to historic lows (see graph above). However, the situation did not abate entirely and CSOs remained problematic for the region in wetter years. In addition, while conventional infrastructure was meeting all state and federal requirements, the community was demanding

that the agency take more action to abate overflows, motivating local leaders to explore innovative alternatives to conventional responses.[410] MMSD recognized a need and opportunity to involve the public in next generation solutions. Because green infrastructure is visible and accessible to the community, is less engineered, and can be installed on a homeowner's property MMSD determined that GI would be well-suited to meet its goals.[411]

In 2013, the MMSD Commission approved a regionwide strategic plan to implement green infrastructure on a large scale.[412] The strategic plan includes MMSD's "2035 Vision" to "achieve zero sewer overflows, zero basement backups, and improved water quality by the year 2035." The Plan is intended to achieve those goals by, in part, capturing the first 0.5 inch of rainfall from impervious surfaces with green infrastructure.[413]



The 10 strategies identified in the 2013 strategic plan, detailed in the box to the left, are all variations of decentralized infrastructure on public and private properties neither owned nor controlled by MMSD—from green roofs, to bioswales, wetlands, greenways, and stormwater tree plantings. The agency also gives away several hundred free rain barrels a year to lowerincome households.[414]

The strategic plan includes MMSD's "2035 Vision" to "achieve zero sewer overflows, zero basement backups, and improved water quality by the year 2035."

MMSD also has a dedicated "Greenseams Program," through which the utility purchases and preserves land particularly in flood-prone areas to prevent future flood damage.[415]

In the aggregate, **MMSD expects its investment in green infrastructure to capture and store 740 million gallons of stormwater.** For context, the Deep Tunnel holds **521 million gallons** of water.[416] To the best of our knowledge, Milwaukee may be the first wastewater agency nationwide to establish a specific goal for itself to capture more stormwater runoff with distributed green infrastructure than conventional gray infrastructure.

Moreover, this decision is in the best economic interest of ratepayers as well; MMWS' 2013 "triple bottom line" analysis found that an investment of $178 million for green infrastructure in the service area would result in stormwater capture equivalent to $222 million investment in gray infrastructure.[417]

MMSD implements green infrastructure in partnership with the 28 communities in its service area through its "Green Solutions" program[418] employing the 10 GI strategies identified in the strategic plan based on estimated number of gallons of stormwater to be captured. Public property projects are also selected when MMSD is able to coordinate implementation with other municipal projects such as street improvements.[419]

Program Budget and Funding Sources

MMSD funds its green infrastructure programs as part of its capital budget.[420] As of 2019, the utility budget for green infrastructure programs was as follows:

- **Greenseams, Six-Year Forecast Total - $7.2 million**
- **Projects to implement of 2035 Vision and/or MMSD's Regional Green Infrastructure Plan –**
  - **- January 2018-August 2021 - $2,616,703**
  - **- January 2018-December 2024 - $15,890,885**
- **Incentivizes for municipalities within the District to implement green infrastructure - Six-Year Forecast Total - $30 million.**[421]

MMWD supports its GI programs through a combination of rate revenue and debt-financing, the latter primarily via MMSD-issued general obligation bonds.[422]

MMWD supports its GI programs through a combination of rate revenue and debt-financing, the latter primarily via MMSD-issued general obligation bonds.

Program Benefits and Performance Metrics

MMSD's investments in green infrastructure have yielded a broad range of benefits for communities within its service area

- Economic Benefits. MMSD estimates that green infrastructure saves MMSD $44 million in infrastructure costs compared to building additional Deep Tunnel storage, a huge boon to ratepayers. The agency indicates that local GI will also develop 500 green maintenance jobs at full implementation and 160 construction jobs on average per year, and increase property values by an estimated $667 million throughout the MMSD planning area.[423]

- Social Benefits. MMSD's Investment in green infrastructure is expected to improve quality of life and aesthetics, lower crime rates, reduce stress by providing green spaces, and create recreational opportunities.[424]

- Environmental Benefits. By capturing stormwater, adding green space, and shading, green infrastructure provides multiple environmental benefits to the MMSD service area, including groundwater recharge, reduced carbon emissions, energy conservation, improved air quality, and water quality improvement.[425]

Conclusion

MMSD is one of the first wastewater agencies to go big on green by deploying distributed infrastructure at a large scale. It is succeeding in large part by actively engaging local businesses and residents and investing in adoption of a wide range of decentralized water capturing solutions. The agency is demonstrating real success in reducing CSOs, improving local water quality while also fostering community awareness about stormwater, and the role it plays in local health and environmental quality.

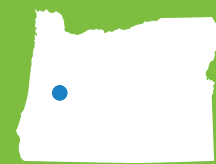
MMSD's green infrastructure program has helped the area communities realize the connection between storms and water. This, in turn, makes combating CSOs a community-wide effort while bringing multiple benefits to residents.

City of Eugene: Leveraging Development Standards to Deploy Decentralized GI

Utility: City of Eugene Public Works, Stormwater Program

Location: Eugene, Oregon

Service area: Serving a population of 168,000 across 41 square miles



Challanges:

- Managing urban stormwater to meet federal regulatory mandates
- Stormwater runoff from municipal separate storm sewer system
- Community support for protecting quality of local waterways

Solutions:

- Comprehensive stormwater management program including city-wide green infrastructure on public and private property

Benefits:

- 363 public Green Infrastructure facilities
- 1,000 private Green Infrastructure facilities
- Over 20,000 native trees and plants planted
- Reduced pollutant levels in local waterways
- Regulatory compliance with federal rules for water quality in city's urban streams
- Cost-effective implementation of stormwater management best practices (BMPs)
- Community engagement in helping to reduce stormwater pollution

Budget:

- Stormwater Utility Fund: ~$20 million

  - Capital Projects: ~$2.5 million

  - "Green Infrastructure Staffing" of one full-time employee: $100,000

  - Partnership with Long Tom Watershed Council to construct voluntary retrofits on private property, Stormwater Funds: $100,000 (total, between 2012 and 2018)

- Funding Sources:

  - Stormwater User Fees: $19 million

  - Stormwater System Development Charges (SDCs): $4.6 million

Location & Population

Eugene is in the center of western Oregon, about 100 miles south of Portland and halfway between the Pacific Ocean and the Cascade Mountains.[426] At an elevation of less than 400 feet, Eugene is surrounded by foothills, forests and the broad Willamette Valley consisting mostly of farmland. The Willamette and McKenzie Rivers and their tributary streams and creeks run through town. Eugene is the second largest city in Oregon and is expected to continue to experience significant population growth in the coming years.

Eugene Public Works, Stormwater Department

CITY OF EUGENE STORMWATER MANAGEMENT PROGRAM

The City Public Works Department provides wastewater and stormwater services for the community.[427] (Drinking water is provided by a separate public utility, the Eugene Water and Electric Board.) The public stormwater collection and conveyance system includes approximately 600 miles of enclosed pipes and other built-infrastructure as well as some GI.[428] Discharges from the system are regulated by Municipal Separate Storm Sewer System permit (MS4 Permit) pursuant to the federal Clean Water Act.[429]

City-wide Green Infrastructure

In response to new MS4 requirements and other factors, in 1993, Eugene's City Council adopted a Comprehensive Stormwater Management Plan (Stormwater Plan).[430] The City used the new mandate as an opportunity to think more holistically about how to manage local stormwater runoff and align that strategy with the its overall sustainability, open space, educational, and other community values.[431] This plan continues to inform Eugene's stormwater management practices;[432] for the last 25 years Eugene has looked to localized strategies to help the city achieve its stormwater management goals.

Eugene developed a number of Best Management Practices (BMPs) to implement this vision including specifically decentralized green infrastructure such as tree planting, onsite stormwater capture, and onsite treatment requirements for new development.[433] More recent changes to the city's stormwater development standards further prioritize decentralized strategies "that promote the use of natural and built systems for infiltration, evapotranspiration and reuse of rainwater and that use or mimic natural hydrologic processes while capturing and treating approximately 80% of the average annual rainfall."[434] These standards emphasize low impact development[435] and create a hierarchy of preferences with onsite capture, i.e., infiltration, first followed by filtration, i.e., treatment, then by off-site discharge via the MS4 which requires payment of a higher stormwater system development charge (SDC).[436] Before a developer can use filtration or off-site discharge it must demonstrate that an onsite strategy is not feasible according to specified criteria.[437] With stormwater management fully integrated into the City's overall sustainability planning, Eugene is now looking to include expanded GI as a strategy for mitigating and adapting to the impacts of climate change.[438]

There are two main aspects to Eugene's city-wide green infrastructure program: (1) projects on public property and (2) projects on private property. Projects on public property are constructed by the Public Works Department or as privately engineered public improvements and are typically located in the public rights of way or on other publicly-owned spaces such as parks or city operations and maintenance sites. Projects on private property are constructed by developers or Eugene residents and businesses on their own property.

Willamette River Basin Facts

- Ranks fifth among all the basins in total size (7,023 acres).
- Ranks second in the amount of area designated as 100-year floodplain (2,002 acres).
- Ranks sixth in total length of local open waterways (12 miles – does not include Willamette River) and last in proportion of waterways to basin size.
- Impervious surface area in the UGB is projected to increase from 40% to 44% at full buildout .
- Is home to Spring Chinook, listed as a threatened fish species.
- The Willamette River listed by the Oregon Department of Environmental Quality as water quality limited.

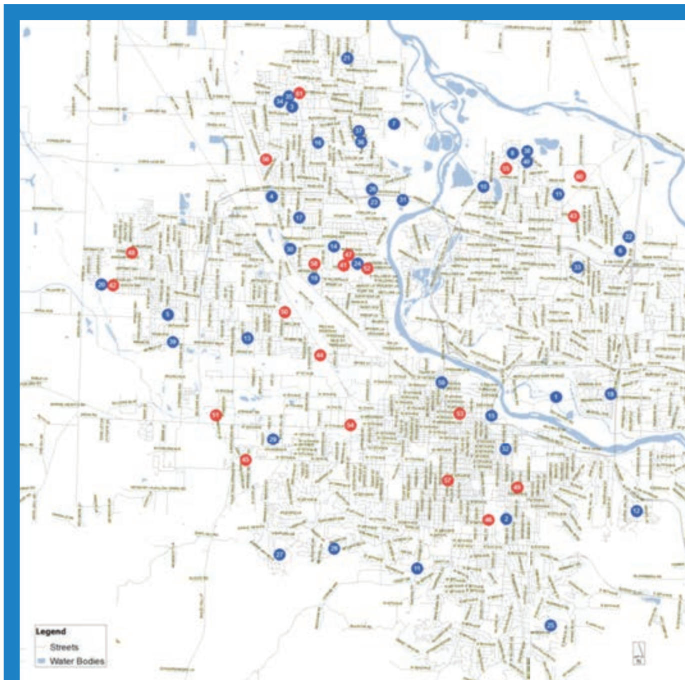
Public projects are identified in the city's Stormwater Basin Master Plans for Eugene's seven stormwater basins.[439] For example, the Willamette River Basin Master Plan's "Vision for Green Infrastructure" includes projects specifically for that area such as the Polk Street water quality facility which provides treatment for a developed 800-acre area, and provides a contextual framework for implementing certain strategies city-wide such as "[m]minimize[ing] future pollutants through onsite development

standards."[440] Stormwater capital improvement projects are often implemented together with other planned projects such as street improvement projects, and locations are selected according to where the greatest needs are, where the most efficiencies can be gained, and where the highest water quality benefits can be achieved.[441] New public green infrastructure installations must comply with the requirements of Eugene's development standards.[442]

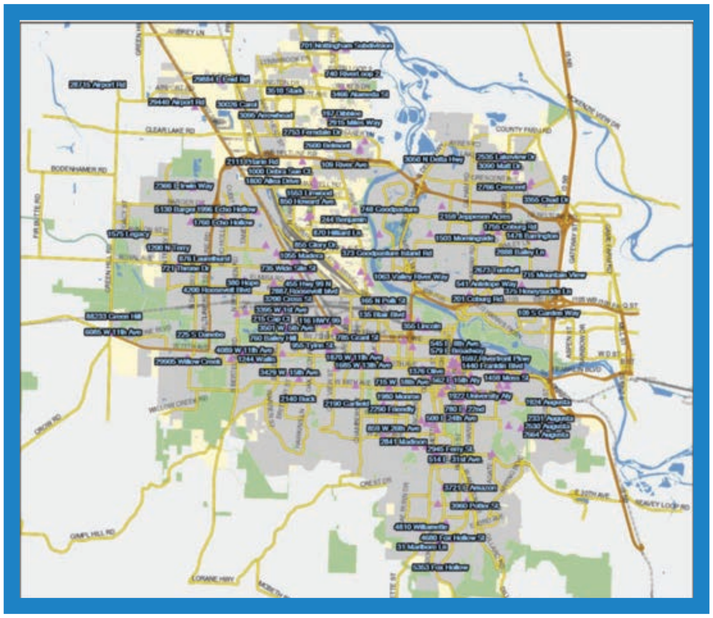
The City's stormwater standards that prioritize onsite stormwater infiltration govern new and re-developments of a certain size occurring after March 1, 2014.[443] In addition, the City's stormwater user fee and SDC (a one-time impact fee) is designed to incentivize onsite green infrastructure for existing private properties by giving home and business owners credits against these fees if the quantity of stormwater discharged to the MS4 is reduced or if onsite treatment exceeds the regulatory minimums.[444] For voluntary stormwater retrofits on existing private commercial properties, Eugene partners with the Long Tom Watershed Council to work with property owners who are interested in voluntarily incorporating green infrastructure stormwater installations as part of the watershed council's Urban Waters & Wildlife Program.[445]

Program Costs and Funding

Eugene has established an unusual dedicated funding stream to ensure sustained financial support for its stormwater management programs. These funds are collected from 2 sources: (1) a monthly stormwater fee on all residential, commercial, and industrial properties; and (2) a one-time SDC on all new development.[446]



Eugene's stormwater user fee rates vary based on type and size. Residential properties are categorized as small, medium or large based on their building footprint. Small and medium residential properties, defined as such by their building footprints, pay a flat monthly rate of $10.34 and $15.00, respectively



(as of July 2018). Rates for large residential and commercial/industrial properties depend on the amount of impervious surface area and pay $5.73 per 1,000 square-foot of impervious service.[447] SDC charges also differentiate between residential and commercial properties and vary based on size, amount of impervious area, and whether the development has met onsite stormwater development standards or must pay for off-site LID mitigation.

These two revenue streams are employed somewhat differently. The stormwater fees support operation and maintenance of the MS4, which includes the City's publicly owned green infrastructure such as planters, swales, wetlands, streams, rivers, and open channels, as well as the City's stormwater education and outreach to area students.[448] for capacity enhancements associated with new development.[449] Both funding streams support GI implementation. Out of a total stormwater program budget of about $20 million annually, Eugene dedicates ~$2.5 million,[450] or ~13%, to capital projects that includes its public green infrastructure installations such as **MS4 system rehabilitation projects that must use natural systems,** i.e., green infrastructure, wherever feasible, the City's program to **replace existing drywells** with connected piped systems combined **with rain gardens or pervious pavement**, and the City's **projects designed to improve water quality by installing vegetated planters, rain gardens** and structural water quality facilities with a total projected annual investment of ~$1.82 million per year over the next six years.[451] And the inventory of green infrastructure continues to grow, therefore the FY19 budget includes an increase of $100,000 per year for one full time employee to maintain

In total, since the early 1990s, Eugene has installed ~360 public and permitted 1,000 private green infrastructure facilities. The City expects the number of projects to continue to grow in the coming years.

Program Benefits and Performance Metrics

In total, since the early 1990s, Eugene has installed ~360 public GSI facilities and permitted another 1,000 private green infrastructure facilities.[453] This city-wide, decentralized green infrastructure has benefited Eugene in several ways.

- Water Resource Benefits. GSI installations are distributed throughout Eugene (see, e.g., maps of publicly and privately owned GSI to the left). Publicly owned GSI manages stormwater runoff for a total of ~9 acres, a 78% increase between 2006 and 2019.[454] While current projects represent a modest number of acres, continued building, operation, and maintenance of these GSI projects is part of the City's Stormwater Management Plan it is required to implement under its MS4 permit, and thus the number of GSI projects is likely to continue to grow.[455] And because decentralized stormwater management is codified in Eugene's municipal code, new GI will come online as new and re-development occurs. This GSI keeps urban stormwater runoff out of the MS4, or provides filtration using natural systems, which helps keep pollutants out of Eugene's many urban streams and rivers. The City's stormwater management strategy that prioritizes green infrastructure wherever possible has thus helped Eugene meet the requirements of its Clean Water Act permit; 20 years of water quality data indicate downward trends in pollutant levels for most of the City's contaminants of concern in local waterways including most critically total suspended solids, nutrients, and metals.[456]

- Economic Benefits. Eugene's investment in decentralized GSI has been cost effective. A City analysis of the cost of treating stormwater runoff with a centralized system versus requiring developed properties to manage their stormwater onsite demonstrated that distributed stormwater infrastructure would be more cost-effective than a centralized strategy.[457] This was due in part to the added economic benefits of a decentralized approach, and was a big part of the reason that Eugene chose to implement green infrastructure as part of its overall stormwater management program.[458]

- Social Benefits. The City believes that its stormwater management program has successfully engaged Eugene residents as partners and elevated community understanding about the importance of the water quality impacts of urban stormwater runoff and how they can be part of the solution.

Eugene is in the process of developing a new strategic plan for the long-term operation and maintenance of its GSI; the plan is to bring together the City's urban forestry and stormwater green infrastructure and include additional performance metrics for measuring the effectiveness of these strategies.

Conclusion

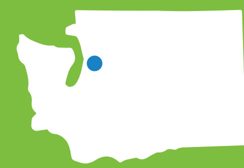
Eugene has been a quiet pioneer for the last two decades deploying onsite, decentralized and mostly green stormwater management strategies that have proven to be effective at addressing both water quality and flooding challenges. Critically, the City has found a way to finance these its investment in GSI that is affordable for both residents and businesses, garnering the critical political support necessary for success.

Seattle Public Utilities [PART 2]: Incentivizing Citywide GSI

Utility: Seattle Public Utilities

Location: Seattle, Washington

Service Area: Serving a population of 1.4 million across ~ 84 square miles



Green Infrastructure Program Drivers:

- Combined Sewer Overflows (CSOs)

Solutions:

- “Rainwise” – incentive program to incentivize citywide deployment of decentralized green stormwater infrastructure on private property

Benefits:

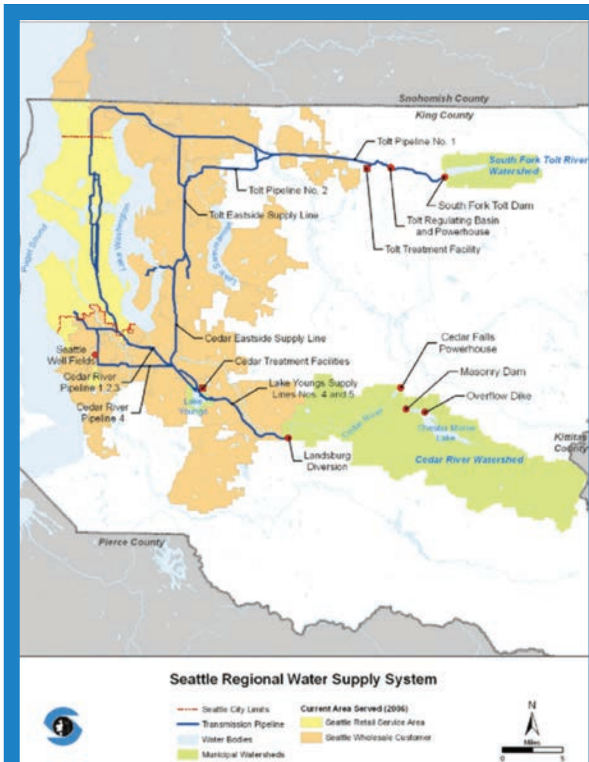
- 1600 RainWise projects installed
- 23 million gallons of stormwater controlled per year
- 2.17 million square feet (50 acres) of roof area captured by rain gardens or cisterns and removed from the sewer system
- Community engagement

Costs and Funding Sources:

- RainWise Budget: $1 million - $1.2 million per year since 2013
- Funding source: Municipal bonds

Seattle Public Utilities: Wastewater and Stormwater Services

As indicated above, SPU provides drainage and wastewater services for Seattle and outlying areas in addition to drinking water. It collects and discharges storm runoff and wastewater via a massive combined system of gray infrastructure designed to carry sewage and stormwater runoff from streets, rooftops, and parking lots: ~450 miles of separated sanitary sewers, ~970 miles of combined sewers, 477 miles of storm drains, 68 pump stations, 90 permitted combined sewer overflow outfalls, and almost 300 storm drain outfalls, and more.[459] In heavy rains, however, the system overflows contributing pollutants to surrounding water bodies severely impacting water quality.[460]



In July 2013, SPU entered into a Consent Decree with EPA that established a plan and schedule for the City to get to the next level of controlling CSOs. As described in a 2015 SPU report on its long-term plan to protect Seattle's waterways, the Consent Decree allowed the City to develop an "Integrated Plan" that, among other elements, encourages use of green infrastructure together with traditional engineered measures, **"as long as the City demonstrates its effectiveness and the combined measures provide substantially the same or greater levels of control than traditional engineered measures alone."**[461] "As a result, SPU is using green stormwater infrastructure (GI) to improve the quality of stormwater before it enters the drainage system in Seattle's three major salmon-bearing creeks: Thornton, Piper's, and Longfellow."[462]

RainWise Program

In addition to the Consent Decree,[463] in 2013 Seattle passed a resolution to control 700 million gallons of stormwater with green stormwater infrastructure by 2025.[464] SPU's RainWise rebate program, is part of this effort. Rainwise incentivizes decentralized GI solutions on private properties, specifically installations of rain gardens and/or cisterns and

In 2013, City Council Resolution 31459 established GSI as a key stormwater management strategy and challenged Seattle to rely on GSI whenever possible. It also set a community-wide implementation target -- to manage 700 million gallons of runoff annually with GSI by the year 2025. – Green Stormwater Infrastructure in Seattle, Implementation Strategy 2015-2020

disconnecting roof downspouts from the sewer system where appropriate.[465] The program grew out of a Seattle City Council request that the utility evaluate incentive programs for private property owners.[466] SPU conducted a "Programmatic Business Case" analysis to determine how to design an effective private property incentive program focused primarily on rooftops, which were determined to be a particularly key leverage opportunity.[467] The program began in spring of 2010 with a pilot basin of approximately 5,000 eligible properties.

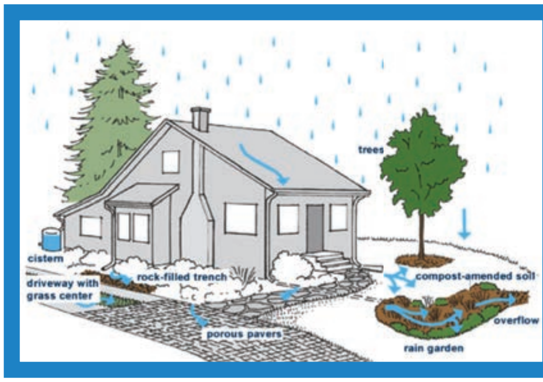
About 50,000 property owners within specific combined sewer basins are eligible to participate in the program, which is a partnership between Seattle and King County which has CSO basins under its jurisdiction with city boundaries.[468] If a property owner lives in a targeted basin, they first learn about appropriate green infrastructure strategies—either a rain garden, a cistern, or a combination of both—for their property via postcards, workshops, and contractor fairs that direct property owners to the RainWise website, which uses data maintained by SPU to accurately reflect the specifics of that parcel.[469] Next, the potential participant is given information about available financial support, as well as contractors qualified to evaluate and install the recommended technologies.[470] SPU and its partners train contractors at sponsored bi-annual trainings and hosts a roster on the website.[471]

SPU conducts both pre and post-inspections of the installed projects and then provides rebates for properly installed systems.[472] The rebates are significant -- up to $4.00 per square foot of rooftop runoff controlled by the rain garden and/or cistern. Reimbursements have averaged $4,800 per property covering 86% of the project.[473]

Reimbursements have averaged $4,800 per property covering 86% of the project. --SPU "700 million gallons" Rebate Program

RainWise participants are responsible for maintaining their project for five years, and enter into a maintenance agreement with SPU.[474] This helps provide SPU with certainty that the localized stormwater infrastructure will be in place as the utility works to address stormwater management.

In addition, SPU and its partner King County strive to make the RainWise equitable and inclusive.[475] For example, in 2017-2018, SPU created a user-friendly funding mechanism for working with community-based organizations and King County created the RainWise Outreach Grant Program that allows qualifying nonprofits and small businesses to apply for grants to become RainWise contractors.[476] RainWise also pays for outreach efforts to "multicultural residents that include providing additional customer service and coaching of clients that need extra help navigating the installation and rebate process of the program."[477] And through the RainWise Access Grant process, income-qualified participants can receive grant funding of up to $500 to make up the difference between the rebated amount and the final cost of the RainWise project.[478] Contractors may also receive low cost loans through the RainWise Pilot Access Loan to cover up front costs.[479]



For larger institutions — community centers, religious organizations, apartment buildings and businesses with large roofs — SPU offers "Large Roofs" rebates.[480] These properties typically receive rebates that correspond with smaller roofs and can offset property owners' annual drainage fee through SPU's Stormwater Facility Credit Program.[481]

SPU works closely with King County and other partners to implement the RainWise program.[482] These regional partners share certain overhead and outreach costs, have regular meetings, and prepare joint events, among other things.[483]

Program Costs and Funding

SPU's spending on the RainWise programs is primarily funded with municipal bond proceeds.[484] Historically, the program budget has been approximately $1 million. In 2018, to account for inflation, the budget was $1.2 million.[485]

"Stormwater runoff is a major cause of pollution in Puget Sound. It carries a soup of trash, bacteria, heavy metals, and other pollutants into local waterways." – SPU Green Stormwater Infrastructure 2017-2017 Overview and Accomplishment Report

Program Benefits and Performance Metrics

SPU uses several metrics to measure the success of the RainWise program, including:

- **number of projects installed**
- **number of gallons captured**
- **number and demographics of contractors trained**
- **number of roof acres captured.[486]**

By these measures, SPU has realized many stormwater management benefits from the program. To date:

- **2.17 million square feet (50 acres) of roof area has been captured by rain gardens or cisterns and removed from the sewer systems**
- **23 million gallons of stormwater has been controlled per year**
- **1700 RainWise projects have been installed**
- **41 "big roof" projects have been completed.[487]**

SPU has found that the RainWise program provides many co-benefits to the Seattle area in addition to managing stormwater runoff and limiting CSOs. These include:

- **Increased sewer capacity in a cost-effective way**
- **Improved air quality**
- **Increased number of trees and plants in neighborhoods**
- **Habitat for pollinators**
- **Added green space which promotes health and wellness**
- **Added resilience in planning for population growth and climate change[488]**

Further, this program actively engages the community in addressing stormwater management and encourages individuals to share their experience with their neighbors.[489] This has a multiplier effect prompting others to join the RainWise program.[490]

Conclusion

Seattle has committed itself to deploy green infrastructure to combat stormwater management challenges. SPU has invested millions of dollars in these innovative localized water strategies because, at least in part, it has capitalized these programs using municipal bond proceeds. Seattle's approach can be a model for scale on a national level.

One Water LA: One Water Planning in Action

**Utilities: LA Sanitation and Environment,
Los Angeles Department of Water & Power**

Los Angeles, California

Service area: Serving a population of ~4 million across 500 square miles

Challenges:

- CSOs
- Flooding
- Declining water supply reliability
- Climate change

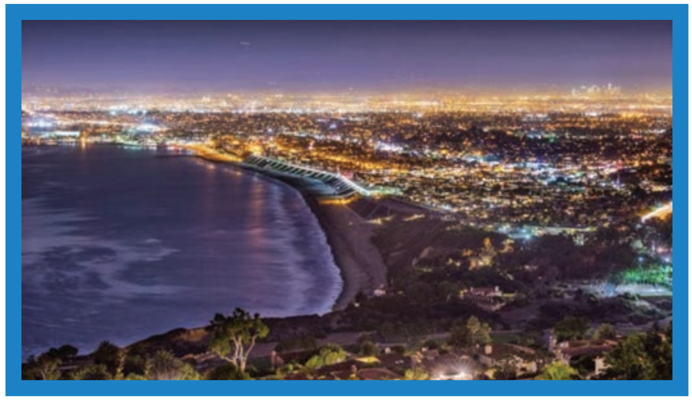
Solutions:

- One Water LA 2040 Plan, a roadmap coordinating effective and sustainable long-term water planning solutions, including a distributed green infrastructure element aimed at improving stormwater management by offering flood protection, water quality improvements, and local water supply.

Integrated One Water Planning Benefits:

- An integrated vision and implementation strategy to more sustainably and cost-effectively manage water resources.
- Greater local resilience and reduced reliance on imported water
- Reduced stormwater runoff
- Greater inter-agency cooperation and collaboration

Location & Population



The City of Los Angeles is home to about 4 million people covering an area of more than 500 square miles. Perpetually sunny, LA receives only about 15 inches of rain on average.[491] The Los Angeles River flows through LA to the Pacific Ocean and its primary drainage channel. The River has been lined with concrete for most of its reaches for flood control purposes.[492] The LA Department of Water and Power (LADWP), the largest municipal water and power utility in the nation, was established by city charter in 1925 and today provides water service to about 680,000 connections.[493] It is governed by a 5-member Board of Commissioners appointed by the Mayor and confirmed by the City Council. A severe drought, and concern over state-mandated water use restrictions, combined with growing local interest in ensuring environmental sustainability has led the utility to redouble its efforts to reduce per capital water use, limit purchases of imported water and increase its reliance on local supplies.[494] Los Angeles Sanitation & Environment's (LASAN), part of the City's Department of Public Works, is the lead environmental department for the City and is also responsible for (among other services) wastewater and watershed protection.[495]

One Water

Los Angeles embraced the One Water concept of integrating all of its water resource management early on. The City embarked on its first Integrated Resources Plan in 1999 which included LADWP and LA San as key partners. As described in the City's Urban Water Management Plan: "Utilization of an integrated watershed approach identified opportunities **that would not have been traditionally identified if water, wastewater, and stormwater were continued to be viewed independently**. In the past, the City utilized single-purpose planning efforts for each agency, such as one plan for wastewater and a separate plan for water supply."[496] The IRP enabled the City to develop a vision for meeting its long-term water needs "in a more cost-effective and sustainable way by addressing and integrating all its water resources." It also set a path for breaking through silos and enabling more functional working partnerships between City departments, other agencies, and non-governmental organizations.[497]

> **"One Water LA is a collaborative approach to develop an integrated framework for managing the City's water resources, watersheds, and water facilities in an environmentally, economically and socially beneficial manner." – One Water Progress Report June 2017**

20 years on these partnerships are now baked in to the City's DNA and LA's One Water Program has grown into a full-fledged phenomenon complete with its own website.[498] It seeks to fully integrate the City's wastewater, stormwater, watershed, and drinking water management by 2040 and achieve the following goals (among others):

- **Reducing its purchase of imported water by 50% by 2025**
- **Drawing 50% of its water supply from local sources by 2035**
- **Achieve 98 GPCD for a total potable use reduction of 25% (from 2012 levels) by 2035[499]**
- **Capture 150,000 acre-feet per year of stormwater[500]**

One Water LA 2040 Plan

Specific drivers for the One Water LA 2040 Plan include:

- **New stormwater quality regulations**
- **Threats of climate change**
- **Severe, recurring, prolonged drought**
- **Aging infrastructure**
- **Population growth**
- **Limited funding[501]**

Figure 1.1 One Water LA 2040 Plan Elements

In addition, Los Angeles Mayor Eric Garcetti established an aggressive sustainability agenda for water resource managers with his Sustainable pLAn 2019 that sets goals for reduced water imports by sourcing 70% of L.A.'s water locally, capturing 150,000 acre ft/yr of stormwater, and recycling 100% of all wastewater for beneficial reuse by 2035, and reducing potable water use per capita by 25% by 2035, among other objectives.[502] The water efficiency targets incorporated into LADWP's Urban Water Management Plan that are also based on the Mayor's sustainability plan.[503]

The LA 2040 Plan – What Is It?

The Plan represents the City's "continued and improved commitment to proactively manage all of its water resources and to implement innovative solutions."[504] Overall, the Plan embraces a One Water[505] approach to long-term water resources management for the City and its regional partners through 2040, and prioritizes programs, policies, and projects that will increase local water supplies, improve water quality, increase drought and climate resilience, and provide multi-benefits for all Angelenos. It sets two primary goals:

1) Develop a vision and implementation strategy to more sustainably and cost-effectively manage water.

2) Identify ways for City departments and regional agencies to integrate their water management strategies.[506]

The Plan includes a wide variety of deliverables to bring together LASAN, LADWP and their partners' strategic planning and analysis.[507] These elements are set out in 10 volumes and include, among each of those shown in the figure to the right, the Stormwater & Urban Runoff Facilities Plan.[508] For purposes of this case study, we focus on the City's distributed green infrastructure projects and goals.

The LA 2040 Plan & Distributed Green Infrastructure

The Plan's Stormwater & Urban Runoff Facilities Plan summarizes LA's stormwater infrastructure as a starting point for identifying management needs over the next 25 years.[509] It Plan identifies over 1,200 project opportunities to provide improved flood protection, water quality benefits, and/or water supply enhancements and help meet the Sustainability pLAn goals.[510] The majority of these projects are decentralized in nature distributed across the community including mainly green streets opportunities.[511]

"This focus on green streets moves away from the traditional prioritization of large-scale regional/centralized facilities, allowing a densely-urbanized city like Los Angeles to implement multi-benefit projects without the often impossible-to-find space that these types of projects typically require." -- One Water LA 2040 Plan

Specifically, the Plan identifies 445 Green Streets program opportunities and 176 additional distributed green infrastructure projects.[512] The distributed green infrastructure projects represent 52% of all identified stormwater projects in the Plan.[513] Among other benefits, the Plan claims it will produce:

- **nearly 7,000 new jobs**
- **savings of $1.97 for every $1 spent**
- **improved public health**
- **climate adaptation & resilience**
- **habitat restoration**
- **improved quality of life through new open space.**[514]

While the City has identified a significant funding gap to meet the estimated costs of implementing and operating and maintaining the green infrastructure and other stormwater projects, the Plan includes recommendations on additional funding sources including grants, cost-sharing with intra-city agencies, voter-approved initiatives, leveraging water supply benefits of stormwater capture, and special taxes.[515] Of these options, the Plan identified debt-financing as a key funding avenue because, in part, the City's "stormwater management program involves substantial investment in capital projects with a long useful life, generating benefits over long periods of time."[516]

Stakeholder Engagement for LA 2040 Plan Development

A hallmark of the LA 2040 Plan is the extensive stakeholder engagement LASAN and LADWP undertook to inform its development.[517] The engagement process was separated into two phases. The first focused on developing the Plan's Vision, Objectives, and Guiding Principles; while the second focused on gathering public input on planning tasks, studies, and recommendations. "By bringing together all parties in the planning stage, a collaborative process was developed that will continue through the Plan's implementation and beyond."[518]

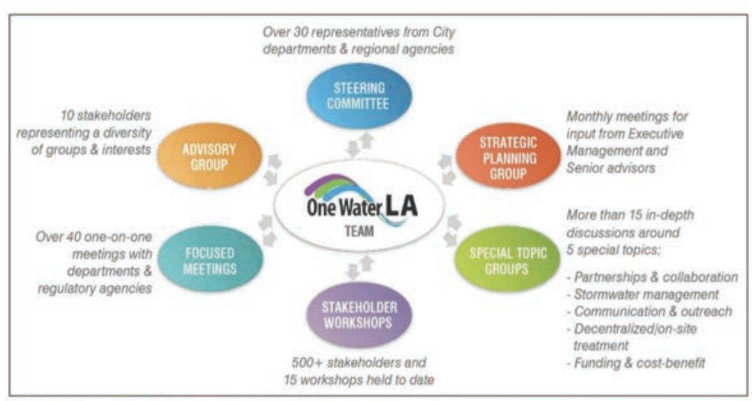


Figure 2.1 Multiple Levels of Stakeholder Engagement

In 2014, the "One Water Steering Committee" was formed to guide the Plan development. LASAN and LADWP were the lead agencies that together with 12 other City departments held 9 Steering Committee meetings over the course of the Plan development. Stakeholder involvement also included an Advisory Group, a Stakeholder Group, a Strategic Planning Group, Special Topic Groups, as well Stakeholder Workshops.[519] In total, the City engaged over 500 stakeholders, held 15 workshops, and conducted another 15 plus discussions around special topics including stormwater management and decentralized-site treatment.[520] The stormwater management special topic group was the most popular amongst stakeholders, and the group's recommendations included that the City offer incentives, rebates, and rewards such as stormwater fee discounts and subsidies for project development on private parcels, among other things.[521]

This level of engagement was crucial to breaking down institutional barriers within the City's internal departments and fostering integrated management, hearing and addressing public concerns and contributions on the need for increased resiliency, and building consensus about where the City should invest its resources including on the need for a stormwater fee, since then established by Measure W.[522]

Conclusion

Few cities have the water supply and stormwater management challenges facing Los Angeles, but perhaps even fewer could match the resources and capacity that Los Angeles has been able to bring to bear. Nevertheless, the One Water LA Plan represents an extraordinary effort that can serve as a model for other communities seeking to transition to a One Water Future. The key takeaways from LA's experience to date are the benefits of breaking down silos, investing in stakeholder engagement, focusing on the hard work of long-term planning, and the value of setting aggressive but achievable goals to guide action. Since the Plan's completion and with support resulting from the robust stakeholder engagement established through the process, the City has set an ambitious target to recycle 100% of its wastewater by 2035, and has partnered with LA County to achieve the passing of Measure W, a local ballot measure approved by voters in 2018 that sets a new parcel tax that will be used to fund stormwater capture and other system improvements.

DC Water: Clean Rivers Project

Utility: District of Columbia Water and Sewer Authority (DC Water)

Location: Washington, D.C.

Service area: 700,000 drinking water customers, 1.6 million wastewater customers over 725 square miles

Challenges:

- Combined sewer overflows (CSOs)
- Pollutant discharge in local waterways
- Compliance with Federal Consent Decree

Solutions:

- A dual gray-green infrastructure approach, with programs implementing localized stormwater solutions on public and private property.

Benefits:

- Reduced combined sewer overflows (CSOs)
- Reduced pollutant levels in local waterways
- Quicker timeline for pollutant reductions
- Green jobs, educational opportunities
- Supports Washington D.C.'s Sustainability Plan

Costs and Funding Sources:

- DC Clean Rivers Project budget: $2.7 billion
  - Green Infrastructure Budget: $158 million
  - Downspout Disconnection Program: $220,000 (2018), $170,000 (2017)
- Funding source: Municipal bonds (green bonds and EIBs), paid back by ratepayers through the DC Waters Clean Rivers Impervious Areas Charge ($25/month per ERU)

Location & Population

The Nation's Capital is home to approximately 700,000 residents and has over 20 million visitors a year.[523] Washington, DC (District or DC), encompasses just under 70 square miles and is bordered not only by Maryland and Virginia, but also a great deal of water.[524] Situated in the mid-Atlantic region, D.C. is known for its hot, humid summers, and has an average annual precipitation of 40 inches.[525]

DC Water

DC Water, created in 1996 as the "District of Columbia Water and Sewer Authority," is an independent authority within the District government. It provides drinking water and sewer service to 680,000 residents within the District and treats wastewater for approximately 1.6 million people in neighboring jurisdictions in Maryland and Virginia.[526] It is governed by an 11-member Board of Directors representing its service jurisdictions.[527]

The sewer system is made up of 1,900 miles of sanitary and combined sewers and includes the Blue Plains Advanced Wastewater Treatment Plant located at the southernmost tip of the District that treats an annual average of nearly 290 million gallons of wastewater per day.[528] As a separate department within DC Water, the Clean Rivers Project is comprised of a system of deep tunnels, sewers, and diversion facilities to capture combined sewer overflows (CSOs) and deliver them to the Blue Plains Advanced Wastewater Treatment Plant as well as green infrastructure aimed at reducing CSOs to the Potomac River and Rock Creek.[529]

Green Infrastructure & Clean Rivers Project

DC Water's green infrastructure approach was the brainchild of then-CEO and General Manager George Hawkins who joined DC Water in 2009.[530] Hawkins advanced the GI cause as an innovative solution to stormwater management to control CSOs that would bring multiple benefits to the community including environmental health, social improvements, and economic growth.[531]

Following this lead, DC Water has embraced green infrastructure, as the utility continues to work to comply with the federal Clean Water Act—another program driver—and actively engage District residents in the process.[532]

DC Water first began making green infrastructure a priority in 2011 with a series of projects and partnerships to build momentum and support for the concept.[533] One of these early projects included work on Irving Street in the Anacostia watershed, which often experienced flooding.[534] DC Water's initial plan was to install a deep tunnel to add capacity to the system; but area residents demanded a faster solution and so the utility turned to GI.[535] DC Water was able to complete a retrofit of the street and install bioretention consisting of planted filter beds of native vegetation, specialized soil and stone aggregate that is slightly depressed into the surrounding landscape at 14 sites in median islands and the roadside along the Irving Street corridor in under a year, helping to address overflows while a long-term solution is implemented by building a deep tunnel that is expected to be completed in 2023.[536]

Following extensive study, evaluation, and public comments[537] DC Water decided in 2015 to incorporate green infrastructure into its plan to control CSOs. DC Water together with the District, the Environmental Protection Agency, and the Department of Justice and others amended its Long Term Control Plan Consent Decree to allow for the use of green infrastructure to meet federal Clean Water Act requirements for the Potomac and Rock Creek areas.[538] Prior to the amendment, the Plan had called only for deep tunnels, or gray infrastructure. As stated in the amendment: "GI reduces the scope of gray infrastructure needed to control stormwater runoff that contributes to CSOs, and has the potential to provide many environmental, social, and economic benefits to the community."[539] As amended, the Plan sets out a hybrid approach where DC Water will implement both green and gray infrastructure to control CSOs—an approach meant to represent the best solutions in the best places.[540]

In particular, for overflows that discharge to Rock Creek, green infrastructure will be installed to control up to 1.2 inches of rain over 365 acres across 5 projects located on both public and private property.[541] DC Water recommended that these Rock Creek projects replace the previously planned gray infrastructure tunnel.[542]

For CSOs that discharge to the Potomac, a combination of green and gray infrastructure will be used with green infrastructure installed to control stormwater up to 1.2" inches of rain over 133 acres across 3 projects.[543] Design and construction of DC Water's Clean Rivers Project green infrastructure began in 2017 and will continue through 2030.[544]

As of April 2019, DC Water had completed the first of its major green infrastructure projects, e.g., bioretention on planter strips and curb extensions, permeable pavement on streets and alleys and downspout disconnection (including rain barrels),[545] for both the Potomac River and Rock Creek:

In Rock Creek's first GI Project, 77 green infrastructure facilities and two green infrastructure parks were constructed… Through the Potomac River's first GI project, 43 green infrastructure facilities were constructed in [other] neighborhoods.[546]

To foster implementation of its GI plan, DC Water plans to work with the District to:

- **Minimize regulatory and institutional barriers**
- **Identify opportunities to add GI to ongoing public projects**
- **Ensure consistency of design standards**
- **Encourage and facilitate green infrastructure on public and private property[547]**

The Green Alley Partnership is an example of collaboration between DC Water and the District. The program is being jointly implemented by DC's Department of Transportation and DC Water to install permeable pavement in one particular alley within the Potomac River sewershed and six other alleys within the Rock Creek sewershed.[548] The partnership between these two agencies has allowed them to share in the cost of the projects, making them more cost-effective, allowed DC Water to install these projects sooner than originally planned, and helped DC Water streamline the construction process by working with the District to standardize the construction specifications and obtain a single permit for all 8 and any future alley projects.[549] This approach significantly streamlines the permitting review and approval process for future alleys, saving cost and deploying green infrastructure faster.

Example of a typical alley receiving permeable pavement under the Green Alley Partnership:

Typical alley before construction — *Typical alley with permeable pavement after construction*

Budget and Funding

The green infrastructure elements of DC's overall $2.7 billion Clean Rivers Project are relatively small; $158 million or 6% of the total cost.[550] These costs are paid for out of DC Water's capital budget which is funded by the utility's revenue bonds.[551]

DC Water also issued the nation's first environmental impact bond to help pay for its green infrastructure projects.[552] The $25 million EIB will be used to pay for GI in the Rock Creek area.[553] Under the EIB "pay for success" model, DC Water is conducting a three-step program evaluation of the effectiveness of green infrastructure in managing stormwater runoff to: (1) measure existing amount of stormwater runoff before GI is installed for the particular site; (2) set anticipated stormwater runoff reduction amounts representing a range of performance levels verified by an independent, agreed-upon engineering firm; and (3) measure the actual stormwater runoff reduction after GI has been installed at the particular site.[554] If the GI outperforms and reduces stormwater runoff by more than 41.3% as compared with the pre-GI rate, DC Water will make an "Outcome Payment" to investors of $3.3 million.[555] If, however, the GI underperforms and only reduces stormwater runoff by less than 18.6%, investors will make a "Risk Share Payment" to DC water of $3.3 million.[556] In the event the GI performs as expected at levels between these two extremes neither DC Water nor the investors are obligated to make contingency payments, and DC Water repays the EIB over time.[557]

Program Benefits and Performance Metrics

DC Water used a triple bottom line approach to evaluate the benefits of its green infrastructure projects. The benefits identified include:

- **Quicker reduction of CSOs**
- **Increased property values**
- **Neighborhood beautification**
- **Reduced heat island effects**
- **Habitat creation**
- **Green jobs**
- **Enhanced community gathering spaces**
- **Supports the District's Sustainable DC Plan[558]**

Conclusion

Using a green-gray hybrid approach to addressing CSOs in D.C. will not only help DC Water meet the requirements of the Clean Water Act, but will also provide a host of other benefits. Green infrastructure installations bring local jobs, additional open space, and wildlife habitat, while realizing incremental water quality improvements sooner than the tunnels. Integrating localized infrastructure with conventional systems meets thus DC Water's water management challenges and brings multiple benefits that benefit the community and the environment.

Lead Service Line Replacement Case Study

The below case study provides the leading example of how replacement of private lead service lines can address elevated levels of lead in drinking water and help protect public health—an example pertinent now more than ever with cities across the country facing lead exposure challenges and recent changes to state and federal lead regulatory standards.

Madison Water Utility: A Lead Leader

Utility: Madison Water Utility

Location: City of Madison, Wisconsin

Service area: Serving a population of 250,000 across 100 square miles

Challenge:

- Elevated levels of lead in drinking water

Solution:

- A comprehensive, city-wide Lead Line Replacement Program

Benefits:

- Improved water quality, reduced lead levels in drinking water
- Protects public health and safety
- Met or exceeded regulatory minimums
- $2.5 million saved in avoided costs (as of 2018)
- Community engagement

Costs and Funding Sources:

- Program budge: $1-1.5 million/yr for 7 years (~15% of annual capital budget)
- Funding source: revenue from city's antenna rentals

Location & Service Population

Madison is the state capital and 2nd largest city in Wisconsin.
Sitting on an isthmus, Madison is sometimes referred to as “The City of Four Lakes” given its location adjacent to Lakes Monona, Mendota, Waubesa, and Kegonsa.

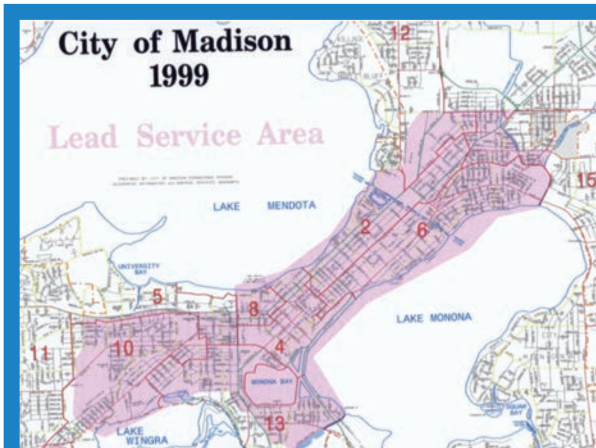
Madison is one of the fastest growing regions in the state with a 14% 10-year growth rate, nearly double the national average and nearly 6 times that of the rest of the state.[559]

Madison Water Utility

Madison Water Utility is a drinking water provider founded nearly 150 years ago.[560] Today, the utility is owned and operated by the City and serves more than 250,000 people in Madison and neighboring communities.[561] It is governed by a 7-member board under the general direction of the City’s Mayor and city council, known locally as the Common Council.[562] The utility Board is appointed by the Mayor and confirmed by the Common Council as well as the Director of Public Health.[563]

Lead Service Line Replacement Program

In 1991 the US Environmental Protection Agency adopted the Lead and Copper Rule (LCR)[564] requiring water providers to monitor drinking water at customer taps.[565] Among other elements, the Rule required utilities to take action to control corrosion when sampling indicates that more than 10% of customer taps have lead concentrations exceeding 15 parts per billion (ppb).[566] In 1992, Madison Water Utility conducted its first round of testing in accordance with the LCR revealing elevated levels of lead well above the 15-ppb action level at residential taps requiring it to take action.[567]



The utility evaluated a number of options for addressing lead and quickly learned that adding the chemicals usually employed to address elevated levels of lead in drinking water would not satisfactorily resolve the issue (adding the chemical orthophosphate would compound existing phosphorous pollution in the streams to which Madison discharges its wastewater).[568] Madison viewed the need to reduce lead levels in its drinking water holistically from source to tap to receiving water; practically, this meant identifying and replacing all lead service lines—no simple task.[569]

Program Summary

Madison's Lead Service Replacement Line program—the first of its kind in the U.S.—replaced 8,000 lead service lines over the course of a decade. But 80% of these, including all lead lines serving schools and apartment buildings, were replaced in the first six years of the program.

Madison's Lead Service Replacement Line program—the first of its kind in the U.S.—**was aimed at replacing all lead service lines in the City, most of which were on private property.**[570] In 2000, the City's Common Council adopted a groundbreaking ordinance to comprehensively address the issue by establishing (1) a local mandate that all lead service lines—whether on public or private property—had to be replaced within the decade;[571] and (2) a reimbursement program to cover at least some of the replacement costs to private parties, initially up to $1,000 (later increased to $1,500).[572] Failure to comply exposed customers to significant fines.[573] The Utility married the replacement mandate with an extensive outreach and education program including meetings and materials for homeowners on how to locate and test their service lines, and sent thousands of customer surveys to help them identify their lead service lines, as records of the piping material for property owners' laterals were not always available.[574]

In total, the community replaced nearly all lead lines in Madison **totaling 8,000 lines**, 5,600 of on private property; 80% of the replacements were finished in the first six years of the program, including all lead lines serving schools and apartment buildings.

Program Funding and Budget

The total cost of the program—largely completed in 2011—was about $15.5 million. Reimbursements to private homeowners totaled $3.8 million with an average reimbursement of $670.[575] The average cost of replacing each utility-owned lead line was about $2,000.[576]

A major financing challenge for the City was identifying a source of funds to cover the customer reimbursements because the Wisconsin Public Service Commission prohibited the use of ratepayer dollars for "private improvements." The City's efforts to remove this legal barrier were not successful, so it opted to fund the reimbursement portion of program entirely out of non-ratepayer dollars—revenues generated from leasing its water towers for cellular antennas.[577]

While a creative way of addressing the problem, Madison's experience is illustrative of a key challenge many communities may face in financing distributed infrastructure.
Well-intentioned limitations on using public dollars for private gain can go astray when actions on private properties accrue more to the public's benefit than the property owners.'

Lead Service Line Replacement Collaborative

The focus of the Lead Service Line Replacement Collaborative is to encourage communities around the country to develop and begin implementing plans for full replacement of lead service lines. The Collaborative's website includes several practical resources for communities that are available online:

https://www.lslr-collaborative.org/

Program Benefits and Performance Metrics

Benefits to Madison accruing from its lead line replacement program range from the obvious health and safety advantages of reducing local exposure to lead in drinking water to avoided costs in ongoing chemical treatment that saves the City $1 million annually. In addition, City leaders also recognize the value of various indirect benefits—building trust, community engagement, and an informed citizenry.[578] Madison's Lead Service Line Replacement program has been widely heralded as a success, putting the City in the national eye as a pioneer on lead in drinking water issues, particularly in the aftermath of the Flint, Michigan, crisis. Many cities across the country are now confronting similar challenges with lead lines on private property. As a result, a Lead Service Line Replacement Collaborative has been launched to support communities in addressing the issue on a voluntary basis.[579] And communities are becoming more sophisticated about looking at the broader social and economic benefits of replacing lead service lines. Earlier this year, **Minnesota released a report[580] estimating that investing $4 billion in eliminating lead in drinking water over 20 years would provide societal benefits of more than $8 billion** once the avoided loss of IQ points due to children's exposure to lead was appropriately considered.[581]

Conclusion

As national concern over lead in water grows, Madison stands as a model of local leadership mobilizing to address this critical health and water quality issue. It remains a foremost exemplar of how communities benefit when we broaden our collective vision about what constitutes appropriate public investments in decentralized infrastructure distributed across many properties throughout an entire community.

CONCLUSIONS & RECOMMENDATIONS

There are significant opportunities for water agencies and their leaders to deploy distributed, localized water infrastructure to address their unique water challenges, building on the experiences of communities already on the path to transforming their infrastructure for the 21st century. The case studies outlined above identify key lessons for deploying decentralized water infrastructure nationwide which we have distilled into a high level framework for implementing these strategies at scale. We have also identified 3 areas of further study, as detailed below.

10-Part Framework for Deploying Sustainable, Localized Water Infrastructure

It is beyond the scope of this initial analysis to provide a complete guide to widespread adoption of various localized water strategies. However, the case studies and interviews at the core of this paper suggest a 10-part decision making framework for deploying these strategies at larger scale. This guidance can be adapted and used by local communities as the basis for implementing localized water strategies that best fit the community's particular needs.

1. Identify the drivers for considering sustainable solutions.

A large number of immediate and longer-term community needs and goals can be drivers for public entities to consider investments in distributed solutions as supplements, or alternatives, to conventional infrastructure. A first step is clearly identifying the various drivers at work in a community and the types of onsite technologies, installations and practices most suited to addressing those issues.

There are many several—often overlapping—drivers motivating water utilities to explore localized solutions from very local (community demand) to global (climate change) considerations including but not limited to:

1. **Affordability**
2. **Aging water infrastructure**
3. **Basement backups**
4. **Building local resilience and supply**

5. Climate change
6. Combined sewer overflows
7. Community demand
8. Declining water supply availability and reliability
9. Desire for urban revitalization
10. Drought
11. Elevated levels of lead in drinking water
12. Environmental and sustainability concerns
13. Equity considerations
14. Flooding
15. Pollutant discharges in local waterways
16. Population growth
17. Public health and water quality concerns
18. Regulatory mandates
19. Slow groundwater recharge
20. Urban stormwater management

More than half of the case studies described here reported deploying localized infrastructure to address the challenges posed by a combination of at least three. In other words, localized strategies are serving multiple water management purposes. The most commonly cited drivers for localized infrastructure in the case studies we examined were climate change, declining water supply availability and reliability, drought, regulatory compliance, and urban stormwater management. The decision of the profiled communities to deploy localized infrastructure either to supplement their conventional infrastructure (or avoid expensive new investment in conventional approaches) to meet these fundamental challenges demonstrates sustainable, decentralized strategies can effectively serve the same functions as traditional infrastructure.

2. Identify appropriate models and data to assess potential performance.

While there may be more variables involved in estimating how well distributed strategies will perform in relation to more conventional centralized approaches, the case studies demonstrate that communities are finding there is sufficient data available to model potential performance with a relatively high degree of confidence. This modeling will allow communities to assess the ability of these solutions to effectively meet water management needs.

In particular, the data from the case studies show that localized options can perform well. For example, in its tenth year, Tucson Water's conservation program conserved more than 2.1 billion gallons (6,446 acre-feet), and the City is currently using water at the same level of use as in 1985, while population increased by more than 226,000 souls. This investment in conservation as a water supply has allowed Tucson Water to defer expanding the capacity of its water system and developing more expensive new centralized supplies. Philadelphia Water Department's investments in GI have reduced CSOs by 7 million gallons and, Milwaukee's GI program is expected to capture and store 740 million gallons of stormwater, eventually outperforming its Deep Tunnel by more than 200 million gallons. Looking to these and other examples can help water managers evaluate the risks involved with relying on localized water infrastructure, particularly because the many of case studies selected for this report chose decentralized options specifically to meet federal and/or state regulatory mandates.

3. Evaluate costs and benefits holistically—include financing options and multiple benefits.

The costs associated with public investment in distributed technology and systems will vary widely depending on numerous variables. For purposes of this Framework, we highlight two in particular: how these strategies are financed, i.e., using annual rate revenue or debt; whether and how cost-benefit analysis accounts for the economic value of key co-benefits that can flow from well-designed onsite programs. Obtaining a fair and accurate understanding of bang-for-buck from a ratepayer perspective will be enhanced by an analysis that captures costs and benefits comprehensively, enabling decision makers to determine the true affordability and rate implications associated with their potential choices.

Various studies, including the Pacific Institute's multi-benefits framework referenced above, are beginning to document that localized and other sustainable water management strategies are capable of providing multiple co-benefits that should be measured and incorporated into decision making. As detailed above, these include open space, improved public health, community engagement, and creating connection with nature, among many other benefits associated specifically with implementing decentralized water strategies. Pacific Institute's proposed framework includes 3 steps:

1. **Define "the problem" in a way that reflects a holistic approach and analyze the full range of costs and benefits, including benefits that cannot be easily monetized.[583]**

2. **Characterize benefits and costs both qualitatively and quantitatively and identify an appropriate baseline measurement as the point of comparison.[584]**

3. **Incorporate multiple benefits and costs into decision making using one or more of the growing number of frameworks.[585]**

Applying this framework to development of a localized water infrastructure program will help water managers make the case for increased investments in these solutions.

4. Incorporate distributed onsite systems into capital planning alongside conventional infrastructure.

Capital Improvement Plans are often a critical blueprint for public utility investment over the long-term. For many, if not most utilities, inclusion in these or similar planning documents is essential for any project to be considered eligible for capital financing. One of the surest ways for localized infrastructure to be treated on par with more conventional infrastructure approaches is to incorporate these solutions into capital planning. This shift in framing can open up the full range of available funding options (see below).

As detailed above, under GASB Statement 62, local utilities can account for distributed infrastructure as a regulated asset rather than an annual expense allowing these expenditures to be capitalized. These programs are not "give aways," they are public investments that provide long term benefits to the utility that accrue over the life of the debt. For example, rebates for water efficient appliances and fixtures add value to a utility's system by reducing water consumption over time, not only in the year that the rebate was issued. Assets that provide benefits overtime should be capitalized to ensure the costs are "matched" with benefits. The matching principle is important because the proper matching of expenses and revenues gives a more accurate appraisal of the results of operations, helps to avoid distortion of the financial position of the business, improves the quality of the financial statements, and ensures generational equity so that future ratepayers share in the costs of improvements that provide benefits over time. Further, the GASB interpretation guide uses water efficiency programs as an example of what a utility might choose to capitalize: "…certain period costs (for example, … conservation program costs of providing assets, such as low-flow shower heads, to customers) that are proposed for recovery in future rates."

5. Think broadly and creatively about financing options.

Many financing options available for conventional infrastructure can also be accessed to finance large-scale distributed systems, including but not limited to:

- **Municipal bonds, including revenue bonds, green bonds**
- **"De-risking" or performance-based debt-financing, e.g., environmental impact bonds**
- **State and federal loans, including SRF funds and WIFIA funds**
- **Federal grants, including WaterSMART**
- **Rate revenue**
- **Non-rate revenue**
- **Cost-sharing structures in collaboration with other public agencies**
- **Private philanthropy**

Leveraging one or more of these funding sources to scale investment in localized water solutions is the surest and most expeditios way to deploy adoption of these strategies broadly across a community and more fully realize their benefits.[586]

6. Incorporate stakeholder outreach and engagement in planning & implementation.

Decentralized strategies, by definition, require partnering with owners of various types of property throughout the community—streets, public buildings and parks, schools, institutions, businesses, industries and residences. Implementing onsite water strategies thus presents unique opportunities for community engagement, but also means that achieving widespread adoption of these strategies must include an intentional and well-resourced program to incorporate stakeholder outreach, education and communication at both the planning and implementation phases.

Key stakeholders include:

- Utility customers
- Sister agencies within the utility's service area or city
- Local nonprofits and community groups
- Area businesses such as landscapers, nurseries, plumbers

Such engagement can help managers identify and prioritize areas of the community most in need of localized solutions such as green infrastructure both from a water management and co-benefits perspective.

Taking this step also helps utilities build needed partnerships with community groups that are valuable to implementation and ongoing community engagement. For example, San Antonio Water System has had great success in working with area groups to reach customers in all parts of its service area. Los Angeles and Austin were able to develop long-term integrated water plans that represent the communities' needs and values by conducting rigorous public outreach and meeting the public where they were.

7. Identify project- and place-specific implementation challenges.

Like conventional infrastructure, distributed water infrastructure entails implementation complexities such as navigating legal, financial and accounting issues. In addition, different types of localized strategies can entail different types of risks; for example, onsite treatment and reuse systems raise public health issues; leak detection devices sometimes require professional installers raising training and liability challenges; bioswales, green roofs and urban trees require ongoing maintenance (see below). Implementation issues can be more easily addressed by identifying them as early as possible in planning and establishing a process to resolve them.

There are plenty of solutions for steering through these challenges, including creating intra-agency coordination through cost-sharing and other agreements,[587] setting regulatory mandates or establishing incentive programs to motive private participation,[588] formalizing ongoing operation and maintenance requirements through contracts, easements, or other mechanisms.[589] Exactly which challenges a community might face and how to overcome them will depend on community, project and occasionally state, specifics.

8. Identify internal capacity, gaps, and available support resources.

Not every utility will have the staff capacity and/or expertise to effectively design, finance, and implement significant localized infrastructure initiatives. A critical step is to evaluate where your city or utility may have gaps in information, resource, expertise or capacity to explore let alone implement newer approaches. Fortunately, there is a large and growing number of resources available to help utility leaders, management and staff navigate issues, from data analysis, to consumer and stakeholder outreach, to financing support, to project design, implementation and construction. WaterNow's Tap into Resilience online platform is a hub for exploring these resources and making connections to experts and potential partners. Many other resources are available as well.

9. Have a plan for ongoing maintenance.

There is a great deal of discussion, particularly around green stormwater infrastructure implementation, about how to ensure that investments in distributed systems are properly maintained to ensure functionality over time. Whether the best approach is to pass this responsibility on to property owners or for the utility to retain it will necessarily be situation-specific.

The case studies do, however, provide some guidance for mitigating this challenge, such as entering into operation and maintenance contracts with landowners. To ensure distributed infrastructure is properly operated and maintained, water managers need to identify staff dedicated to inspection, oversight, and/or monitoring at the outset of the program wherever possible and/or create a training program to build a cohort of third-party inspectors that report to the utility. Taking this approach allows water managers to keep better track of the performance of distributed strategies once they are installed, be responsive to operation issues, and have additional assurances that the anticipated water management benefits are fulfilled. In addition, this approach creates local jobs.

The additional costs associated with ensuring appropriate operation and maintenance staff may make a localized infrastructure program more expensive, but not necessarily . unattainable when compared with alternative approaches; all infrastructure requires maintenance.

10. Establish performance metrics and evaluation methods.

One of the best ways to build public, utility and decision-maker confidence in the efficacy of distributed systems is meaningful data demonstrating value and esatablishing that these investments are performing as intended.

Performance metrics vary according to the type of strategy employed and the type of data needed to evaluate whether the chosen strategy meets the community's particular water management challenge. As shown in the case studies, communities are employing a variety of performance metrics and evaluation methods.

There are also numerous resources available for utilities to establish consistent methods for collecting and recording performance across various metrics over time available on the Tap into Resilience website.

Recommended Areas of Further Study

As shown by WaterNow's research for this paper, there is a growing body of study of sustainable water management practices including distributed solutions. We have, however, also identified 3 areas in need of further study to help utilities build on current successes, which are described below.

1. Conduct and/or update analyses of emerging technologies.

Existing conservation, efficiency, and green stormwater infrastructure studies provide important insights into the benefits and opportunities for these sustainable management approaches. This body of research would, however, be even more useful if it were expanded or updated to include analyses of emerging technologies such as consumer-side of the meter leak detection devices, smart irrigation controllers, energy recapture systems, and atmospheric water generators.

While WaterNow identified some existing research on these innovative technologies,[590] we believe additional study of these systems effectiveness in addressing water management challenges and associated co-benefits is needed.

2. Expand scope of existing analyses to systematically evaluate regulatory compliance benefits of localized infrastructure.

As explained above, regulatory compliance was among the most commonly cited drivers the case study communities chose localized solutions. The case studies compiled here offer individual success stories, including, for example, Madison Water's coming into compliance with the Lead and Copper Rule and San Antonio Water System's work to meet Endangered Species Act requirements.

Our research indicates, however, that existing analyses of localized infrastructure benefits do not include a systematic evaluation of these strategies' ability to meet water quality and other regulatory requirements. Expanding the scope of existing analysis to include this information will help solidify distributed, onsite, localized infrastructure as core water management options thus fostering their widespread adoption.

3. Further evaluate how investment in localized strategies keeps rates reasonable and affordable.

Relatively recent studies have evaluated how investments in localized strategies like efficiency and conservation have kept rates reasonable and affordable. For example, the Alliance for Water Efficiency has evaluated the rate increases avoided as the result of conservation and efficiency investments in Westminster, Colorado, and Tucson, Arizona.[591]

Similar studies evaluating how these investments keep rates low and can address affordability issues for other communities representing a diverse range of demographics and program types are needed, however.

Conclusion

Water is the delivery vehicle for climate disruption in the United States. Water resource utilities – particularly the public entities serving the vast majority of the U.S. population – are on the front lines to ensure that their communities are safe, healthy, and resilient when it comes to water resources, and that these services are available and affordable for all. We have only just begun to realize how the new distributed water infrastructure can serve these functions while providing significant co-benefits, particularly to more vulnerable communities, in the form of increased local resilience, affordability, green space, economic development, community engagement, and more.

Hundreds of communities nationwide have been experimenting with distributed systems on a relatively small scale, and those profiled here are thinking bigger. We have the technology, the data, and the tools to take advantage of the opportunities that localized strategies present now.

What is needed is primarily a shift in our collective thinking about what constitutes "water infrastructure," and the leadership to invest and move forward accordingly.

Appendix A – Case Study Criteria

Case Study Criteria		Basis for Identified Criteria
Criteria 1	Water Provider Service Area	Water providers throughout the nation vary in size from very small to serving millions of people daily. A water providers size may impact its compliance with the Safe Drinking Water Act and ability to implement sustainability focused management programs. This study includes case studies from water providers of varying sizes in an effort to evaluate these differences.
Criteria 2	Localized Infrastructure	As public water utilities and agencies strive to ensure access to clean, safe, and reliable water, a new generation of localized water infrastructure solutions are coming online. Localized solutions include, but are not limited to, onsite water recycling and reuse systems, graywater systems, rain harvesting systems, green stormwater management practices, high-efficiency indoor appliances, customer-side leak detection, and efficient landscaping systems and strategies. Because these decentralized technologies and programs help to secure water supply, safeguard water quality, and manage stormwater runoff – often more affordably and with less environmental conflict as compared to traditional infrastructure – they are key elements of a sustainability focused water management program.
Criteria 3	Green Infrastructure	Green infrastructure, a sub-set of localized infrastructure, is a key way to integrate stormwater management into overall urban water management by using natural process to create healthier urban environments, keep pollutants out of surface waters, restore natural streams, wetlands, and riparian habitats, and recharge groundwater sources. Because green infrastructure is designed to reduce stormwater pollution and capture stormwater these programs are relevant to both water quality and quantity.
Criteria 4	Augments Water Supply	Certain localized strategies, integrated water management, and/or integrated land management programs are aimed at augmenting or making efficient use of water supplies, including reuse, tiered rates, high-efficiency indoor appliances, customer-side leak detection, ag to urban water transfers, and efficient landscaping systems and strategies. These are key elements of sustainability focused water management.
Criteria 5	Reducing Wastewater Volume and/or Stormwater Runoff	Certain localized strategies, integrated water management, and/or integrated land management programs are aimed at reducing the volume of wastewater and/or stormwater runoff, including onsite water recycling and reuse systems, graywater systems, rain harvesting systems, and green stormwater management practices. These are key elements of sustainability focused water management.
Criteria 6	Improves Drinking Water Quality	Certain localized strategies, integrated water management, and/or integrated land management programs are aimed directly at improving drinking water quality, including lead service line replacement programs. These programs likely have a direct impact on a water provider's compliance with the Safe Drinking Water Act.
Criteria 7	City-wide and/or Regional Program	Because many sustainability focused water management and/or land management programs take an integrated regional approach to addressing water quality and/or supply challenges, and many wastewater utilities encompass several communities with different drinking water providers, accounting for regional sustainability programs is relevant to evaluating an individual water provider's drinking water quality.

Appendix A – Case Study Criteria

Case Study Criteria		Basis for Identified Criteria
Criteria 8	Behavioral Change and/or Physical Project?	Sustainability focused water management can include both efforts to change water users' behavior through education and outreach programs and physical infrastructure projects, e.g., localized strategies. Often these elements go hand-in-hand, but it can be difficult to measure the success of behavioral programs given their subjectivity. This study includes case studies that employ both behavioral changes and physical projects in an effort to understand how these companion strategies impact drinking water quality and sustainability focused water management programs.
Criteria 9	Accounts for Equity & Affordability Issues	Localized strategies, integrated water management, and/or integrated land management programs can be designed to account for disadvantaged communities' ability to pay for and access clean water, and participate in efficiency elements of the overall management plan, e.g., rebates. These are key elements of equitable and affordable sustainability focused water management.
Criteria 10	Integrates Land Use and Water Planning	Sustainability focused water management can include integrating water and land use planning. These integrated programs link land use to wastewater, stormwater, or supply management and thus may impact drinking water quality.

Appendix B – Research Criteria

Research Criteria		Basis for Identified Criteria
Research Criteria 1	SDWA Primacy Agency	The Safe Drinking Water Act (SDWA) requires EPA to establish and enforce standards that drinking water systems must follow, including maximum contaminant levels or treatment techniques and monitoring and reporting requirements. EPA delegates primary enforcement responsibility (also called primacy) for water systems to states and Indian Tribes if they meet certain requirements. Most states are the SDWA primacy agency and have primary responsibility for implementing the act in their jurisdiction.
Research Criteria 2	Completed Source Water Assessment?	Surface water (streams, rivers, and lakes) or ground water (aquifers) can serve as sources of drinking water, referred to as source water. Source water assessments provide water utilities, community governments, and others with information needed to protect drinking water sources. The SDWA outlines six steps for states to follow when conducting source water assessments for public water systems, including identifying the source water protection area, conducting an inventory of potential sources of contamination, and determining the susceptibility of the water supply to contamination. Given the purpose and assessment criteria that overlaps with sustainable water management, whether a water provider is located in a state with a completed source water assessment is likely relevant to evaluating the impacts, if any, their sustainability focused water management program has on drinking water quality.
Research Criteria 3	Geographical Region	Geographical regions and watersheds across the country face varied water management challenges that require uniquely tailored sustainability focused management programs to combat those challenges. Considering strategies employed in these varied regions and watersheds is important to understanding their potential impact, if any, on drinking water quality in different locales facing different issues.

Appendix C – Performance Metrics

Metrics applicable to all types of localized infrastructure	Metrics applicable to water use efficiency & reuse	Metrics applicable to GI
Triple bottom line analysis to measure economic, social, and environmental benefits	Reductions in gallons per capita per day water use	Acres greened
Benefit-cost analysis	Amount of water saved through rebate programs	Gallons of stormwater captured
Cost savings to the utility	Acre-feet saved per year	Number of roof acres captured
Cost savings to customers	Potable water demand offset by reuse	Number of public green infrastructure projects installed
Avoided costs in choosing distributed versus centralized infrastructure	Demand for new water supplies offset by efficiency and conservation	Number of private green infrastructure projects built
Rates study to evaluate avoided cost impacts on rates	Amount of recycled water used annually	Water quality improvements
Number of rebates issued to residential, commercial, and other private parties	Square-feet of turf replaced	Local jobs and income created
Dollar amount of rebates issued to residential, commercial, and other private parties	Percent reduction in per capita per day water use versus population growth	Increase in property values
Number of utility staff trained	Demand evaluation using innovative data tracking and advanced metering systems	Air quality improvements
Number of customers engaged via workshops, events, trainings	Estimated yield from implemented supply options	Soil erosion reductions
Customer surveys and marketing studies to improve participation rates	Random control trial studies on outdoor water use to validate assumed water savings	Gallons of groundwater recharge
Market saturation studies	Evaluation of residential leaks and other indoor use patterns	Amount of land covered with tree canopy (under consideration by Tucson but not yet implemented)
Number of native plants planted	Evaluation of outdoor use patterns	Habitat value (under consideration by Tucson but not yet implemented)
Increase in energy efficiency	Number of products, i.e., high-efficiency appliances and fixtures, installed	Occurrence and type of animals using habitat created by green infrastructure

Appendix C

Metrics applicable to all types of localized infrastructure	Metrics applicable to water use efficiency & reuse	Metrics applicable to GI
Number of native plants planted	Evaluation of outdoor use patterns	Habitat value (under consideration by Tucson but not yet implemented)
Increase in energy efficiency	Number of products, i.e., high-efficiency appliances and fixtures, installed	Occurrence and type of animals using habitat created by green infrastructure
Greenhouse gas reductions	Number of rainwater harvesting and/or graywater systems installed	Numbers and demographics of contractors trained
Reductions in heat island effect	National indoor water use trends analyses	
	Water use benchmarking for buildings of a certain size (under consideration by Austin but not yet implemented)	

Notes

[1] America's Water Infrastructure Act of 2018, Pub. L. No. 115-270, 2018, https://www.congress.gov/bill/115th-congress/senate-bill/3021/text; "New Water Funding Authorized Under Massive House Bill," Water Finance & Management, September 17, 2018, https://waterfm.com/new-water-funding-authorized-massive-house-bill/; see also, Erik D. Olson and Mae Wu, "New Water Infrastructure Bill: A Positive Step," Expert Blog, Natural Resources Defense Council, October 10, 2018, https://www.nrdc.org/experts/mae-wu/new-water-infrastructure-bill-positive-step; Senate Report 115-294—America's Water Infrastructure Act of 2018 (Washington, DC: US Senate Committee on Environment and Public Works, 2018), https://www.congress.gov/115/crpt/srpt294/CRPT-115srpt294.pdf; "U.S. Congress Passes America's Water Infrastructure Act," Highlights, Water Environment Federation, November 25, 2018, https://news.wef.org/u-s-congress-passes-americas-water-infrastructure-act/.

[2] "PFAS Contamination of Water," State of Rhode Island Department of Health, last visited November 1, 2019, http://health.ri.gov/water/about/pfas/. PFAS are "perfluoroalkyl substances," very stable manmade chemicals with properties that allow them to repel both water and oil, often associated with the Teflon chemical found in non-stick pans, cleaning products, paints, food packaging, firefighting foam, and many other products.

[3] "Meet Communities: Case Studies," WaterNow Alliance, last visited November 1, 2019, https://tapin.waternow.org/-meet-communities/#casestudies; "Project Accelerator," WaterNow Alliance, last visited November 1, 2019, https://waternow.org/our-work/our-work-projects/project-accelerator/.

[4] There are many ways of defining "sustainability." For purposes of this paper, this term is used to mean: Providing safe, healthy, and affordable water services for people while preserving the integrity of water resources and the environment for future generations. See "About," WaterNow Alliance, accessed August 20, 2019, https://waternow.org/about-us/.

[5] For purposes of this paper, the term resilience is defined to mean: The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions. See "About," WaterNow Alliance.

[6] See Debra Knopman et al., Not Everything Is Broken: The Future of U.S. Transportation and Water Infrastructure Funding and Finance (Santa Monica: RAND Corporation, 2017), 57, https://doi.org/10.7249/RR1739.

[7] The US EPA uses the term "publicly owned community water system" to refer to publicly owned drinking water providers over a certain size. Andrea Kopaskie, "Public vs Private: A National Overview of Water Systems", The Environmental Finance Blog, UNC School of Government, last modified October 19, 2016, http://efc.web.unc.edu/2016/10/19/public-vs-private-a-national-overview-of-water-systems/; Safe Drinking Water Information System, Community Water Systems Publicly Owned Report as of 2018 Q3, accessed on November 19, 2018, https://ofmpub.epa.gov/apex/sfdw/f?p=108:7:::NO:RP,RIR::; Safe Drinking Water Information System, Community Water Systems Privately Owned Report as of 2018 Q3, accessed on November 19, 2018, https://ofmpub.epa.gov/apex/sfdw/f?p=108:7:::NO:RP,RIR::.

[8] See, e.g., ASCE's 2017 Infrastructure Report Card: Drinking Water (Reston: American Society of Civil Engineers, 2017), https://www.infrastructurereportcard.org/cat-item/drinking-water/; Alexander Quinn, Kevin Feeney, and Humberto Castro, The Economic Benefits of Investing in Water Infrastructure (Oakland: US Water Alliance, 2017), 1, http://thevalueofwater.org/sites/default/files/Economic%20Impact%20of%20Investing%20in%20Water%20Infrastructure_VOW_FINAL_pages.pdf; See, "Information About Public Water Systems," US EPA, last visited November 5, 2019, https://www.epa.gov/dwreginfo/information-about-public-water-systems; The US EPA defines a community water system (CWS) as, "a public water system that supplies water to the same population year-round."

[9] See, e.g., Anthony Craig Arnold, "Water Privatization Trends in the United States: Human Rights, National Security, and Public Stewardship," William and Mary Environmental Law and Policy Review 33 (2009): 793–794, http://ssrn.com/abstract=1407720.

[10] ASCE's 2017 Infrastructure Report Card: Drinking Water.

[11] Small water systems fragmentation has been identified by the US Water Alliance and others as a major access and equity issue; 83% of the water utilities in the US serve populations of less than 3,330 people, "and an astonishing 55 percent serve less than 500 people." Kevin Shafer and Radhika Fox, An Equitable Water Future, (Oakland: US Water Alliance, 2017), 13, http://uswateralliance.org/sites/uswateralliance.org/files/-publications/uswa_waterequity_FINAL.pdf.

[12] See, "Enforcement and Compliance History Online: Facility Search Results," US EPA, accessed on January 10, 2019, https://echo.epa.gov/facilities/facility-search/results. Exactly 19,795 facilities according to the U.S. Environmental Protection Agency ECHO database.
[13] Quinn, Feeney, and Castro, The Economic Benefits of Investing in Water Infrastructure, 2; Primer for Municipal Wastewater Treatment Systems (Washington, DC: US EPA, 2004), 4, https://www3.epa.gov/npdes/pubs/primer.pdf.
[14] "Report Card History," American Society of Civil Engineers, accessed on August 23, 2018, https://www.infrastructurereportcard.org/making-the-grade/report-card-history/.
[15] Fragile Foundations: A Report on America's Public Works (Washington, DC: National Council on Public Works Improvement, 1988), https://www.infrastructurereportcard.org/wp-content/uploads/2017/03/1988-Fragile-Foundations-ExSum.pdf.
[16] Fragile Foundations, 1.
[17] ASCE's 2017 Infrastructure Report Card: Drinking Water.
[18] 1998 Report Card for America's Infrastructure (Washington, DC: American Society of Civil Engineers, 1998), https://ascelibrary.org/doi/pdf/10.1061/9780784478899; see also, "Report Card History."
[19] 1998 Report Card for America's Infrastructure.
[20] "Report Card History."
[21] Knopman et al., Not Everything Is Broken, 29-30, 39. "Per capita spending by local communities has more than doubled in real terms from $45 in 1977 to upwards of $100 per person in 2014 (2014 dollars)." See Quinn, Feeney, and Castro, The Economic Benefits of Investing in Water Infrastructure, 3-5.
[22] Knopman et al., Not Everything Is Broken, 38, 60.
[23] Nicole DuPuis and Christina K. McFarland, Paying for Local Infrastructure in a New Era of Federalism: A State-by-State Analysis (Washington, DC: National League of Cities, 2016), 3-5, https://www.nlc.org/sites/default/files/2016-12/NLC_2016_Infrastructure_Report.pdf.
[24] Nathan Musick, Public Spending on Transportation and Water Infrastructure, 1956 to 2017 (Washington, DC: Congressional Budget Office, 2018), https://www.cbo.gov/system/files?file=2018-10/54539-Infrastructure.pdf.
[25] Ibid.
[26] Debra Knopman (Principal Researcher, RAND Corporation), interview with Caroline Koch (Water Policy Director, WaterNow Alliance), January 10, 2019.
[27] Musick, Public Spending on Transportation and Water Infrastructure; Knopman, interview with Koch, January 10, 2019.
[28] Quinn, Feeney, and Castro, The Economic Benefits of Investing in Water Infrastructure, 1-3. In particular, the ASCE Report Card issued in 2013 estimated that an additional $55 billion per year in capital spending is needed for drinking water and wastewater infrastructure. The US Water Alliance estimates that the "US needs to invest a total of $123 billion per year in water infrastructure over the next 10 years (in current 2016 dollars) to achieve a good state of repair" for existing water and wastewater infrastructure. 2013 Report Card for America's Infrastructure (Reston: American Society of Civil Engineers, 2013), last accessed November 5, 2019, https://doi.org/10.1061/9780784478837. The American Water Works Association (AWWA) estimates that investment needs for buried drinking water infrastructure total more than $1 trillion nationwide over the next 25 years (assuming pipes are replaced at the end of their service lives and systems are expanded to serve growing populations).
[29] Quinn, Feeney, and Castro, The Economic Benefits of Investing in Water Infrastructure, 2, http://thevalueofwater.org/sites/default/files/Economic%20Impact%20of%20Investing%20in%20Water%20Infrastructure_VOW_FINAL_pages.pdf.
[30] Buried No Longer: Confronting America's Water Infrastructure Challenge (Denver: American Water Works Association, 2011), 12.
[31] Knopman et al., Not Everything Is Broken, 65-66; Knopman, interview with Koch, January 10, 2019.
[32] Knopman et al., Not Everything Is Broken, 60; Shadi Eskaf, "Four Trends in Government Spending on Water and Wastewater Utilities Since 1956," The Environmental Finance Blog, UNC School of Government, last modified September 9, 2015, http://efc.web.unc.edu/2015/09/09/four-trends-government-spending-water/. As explained above, funding from programs such as State Revolving Funds still leverage local dollars because they provide loans that recipients must repay.
[33] See, e.g., Bruce Babbitt, "Dams Are Not Forever" (remarks at Ecological Society of America Annual Meeting, Baltimore, MD, August 4, 1998), http://www.sci.sdsu.edu/salton/DamsAreNotForever.html. Noting 75,000 dams have been built in the U.S. at a rate of one per day since the Declaration of

Independence was signed. See also, Optimizing the Structure and Scale of Urban Water Infrastructure: Integrating Distributed Systems (Racine: The Johnson Foundation at Wingspread, 2014), 2, 7-10, https://www.johnsonfdn.org/sites/default/files/reports_publications/CNW-DistributedSystems.pdf.

[34] Optimizing the Structure and Scale of Urban Water Infrastructure, 2; Samuel Tabory et al., Policy Responses to Emerging Topics in Urban Sustainability: Distributed and Localized Infrastructure in Cities—Science-Policy Dialogue Report No. 1 (Minneapolis: Sustainable Healthy Cities Network at the Humphrey School of Public Affairs, 2018), 8, http://www.sustainablehealthycities.org/research/policy-responses-to-distributed-and-localized-infrastructure-in-cities/; Sharlene Leurig Ceres and Jeremy Brown, Bond Financing Distributed Water Systems: How to Make Better Use of Our Most Liquid Market for Financing Water Infrastructure Acknowledgements (Boston: Ceres, 2014), 10, https://www.ceres.org/sites/default/files/reports/2017-05/Ceres_WaterBondFinancing_082814.pdf.

[35] Optimizing the Structure and Scale of Urban Water Infrastructure, 3.

[36] Ceres and Brown, Bond Financing Distributed Water Systems, 7.

[37] Ibid, 4.

[38] Ed Harrington, Go Green: Muni Bond Financing for Distributed Water Infrastructure, ed. Rowan Schmidt and Cynthia Koehler (Tacoma: Earth Economics, 2018), 6, https://waternow.org/go-green-muni-bond-financing-for-distributed-water-solutions/.

[39] See, e.g., Kim Castleberry, "5 Ways Cities Are Preparing for a Dry (or Flooded) Future," Natural Resources Defense Council, last modified August 31, 2015, accessed December 6, 2018, https://www.nrdc.org/stories/5-ways-cities-are-preparing-dry-or-flooded-future; see also, Ceres and Brown, Bond Financing Distributed Water Systems, 10-11.

[40] Jennifer Hoffner, Hidden Reservoir: Why Water Efficiency Is The Best Solution For The Southeast (Washington, DC: American Rivers, 2008), https://www.americanrivers.org/conservation-resource/hidden-reservoir/; see also, Tom Chesnutt et al., Landscape Transformation Study: 2018 Analytics Report (Chicago: Alliance for Water Efficiency, 2018), http://www.allianceforwaterefficiency.org/Landscape-Transformation-Study.aspx.

[41] Candice Rupprecht et al., Water Conservation Program FY 2017-18 Annual Report (Tucson: Tucson Water and City of Tucson, 2018), 16, Table 4, https://www.tucsonaz.gov/files/water/docs/FY17-18_TW_Conservation_Report_FINAL.pdf. Rebates issued to a total of 58,496 people for high efficiency toilets and clothes washers in a service area of 720,000 customers. See also, "MNWD DISTRICT GOALS FOR FY 2017-18 & FY 2018-19" (Meeting handout, Moulton Niguel Water District, February 12, 2018), 4, https://www.mnwd.com/app/uploads/2018/02/021218-LRPS-Handouts.pdf. Stating that 5 million square feet of turf has been replaced in a service area of 37 square miles.

[42] Peter Mayer and Rebecca Smith, Peak Day Water Demand Management Study (Chicago: Alliance for Water Efficiency, 2017), 6, https://www.allianceforwaterefficiency.org/sites/www.allianceforwaterefficiency.org/files/highlight_documents/Peak-Day-Water-Demand-Management-Study_FINAL.pdf; see also, "How It Works," Rachio, last visited November 5, 2019, https://www.rachio.com/how-it-works.

[43] Mayer and Smith, Peak Day Water Demand Management Study, 27-28.

[44] "Leak Detection Pilot Study," WaterNow Alliance, last visited November 5, 2019, https://waternow.org/our-work/our-work-projects/leak-detection-pilot-program/. In partnership with several cities in the San Francisco Bay Area, WaterNow is conducting a 3-year pilot study to evaluate the water savings impacts from customer-side-of-the-meter technologies.

[45] "Green infrastructure is an approach to water management that uses natural systems—or engineered systems that mimic natural processes—to reduce water pollution and flooding, enhance overall environmental quality and provide utility services." Green Infrastructure Portfolio Standard (Washington, DC: American Rivers, The Center for Neighborhood Technology, and The Great Lakes and St. Lawrence Cities Initiative, 2017), 1, https://www.nlc.org/sites/default/-files/SCI%20Documents/Guide_CNT_UpgradeYourInfrastructure_2012.pdf. Green Infrastructure Municipal Handbook (Washington, DC: US EPA, 2008), https://www.epa.gov/green-infrastructure/green-infrastructure-municipal-handbook. For additional green infrastructure resources, EPA has compiled a handbook. See also, Water Infrastructure Improvement Act, Pub. L. No. 115-436, Section 5(a), https://www.congress.gov/bill/115th-congress/house-bill/7279/text?q=%7B%22search%22%3A%5B%22hr+7279%22%5D%7D&r=1. Defining "green infrastructure" as "the range of measures that use plant or soil systems, permeable pavement or other

permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters."

[46] By "downspout disconnection" we mean the process of disconnecting roof downspouts from sanitary or storm sewers.

[47] "Glossary," WateReuse, last visited November 5, 2019, https://watereuse.org/educate/water-reuse-101/glossary/. "Black water" or "domestic wastewater" is wastewater originating from toilets, urinals, and/or kitchen counters (i.e., kitchen sinks and dishwashers).

[48] Danielle Mayorga, Making the Utility Case for Onsite Non-potable Water Systems (Washington, DC: National Blue Ribbon Commission for Onsite Non-potable Water Systems, 2018), 7 http://uswateralliance.org/sites/uswateralliance.org/files/publications/NBRC_Utility%20Case%20for%20ONWS_032818.pdf.pdf; "Glossary," WateReuse.

[49] "About Graywater Reuse," Greywater Action, accessed August 20, 2019, https://graywateraction.org/graywater-reuse/.

[50] "Rainwater Harvesting," Greywater Action, accessed August 20, 2019, https://graywateraction.org/rainwater-harvesting/.

[51] Noah Garrison, Christopher Kloss, and Robb Lukes, Capturing Rainwater from Rooftops: An Efficient Water Resource Management Strategy that Increases Supply and Reduces Pollution (New York: Natural Resources Defense Council, 2011), 11-16, https://www.nrdc.org/sites/default/files/rooftoprainwatercapture.pdf.

[52] Robin Abell et al., Beyond the Source, ed. Andrew Myers and Meghan Snow (Arlington: The Nature Conservancy, 2017), ES 1 https://www.nature.org/content/dam/tnc/nature/en/documents/Beyond_The_Source_Full_Report_FinalV4.pdf.

[53] Abell et al., Beyond the Source, 38-39.

[54] "What You Can Do," Land Trust Alliance, last visited November 5, 2019, https://www.landtrustalliance.org/what-you-can-do/conserve-your-land/questions; see also, New Strategies for America's Watersheds (Washington, DC: The National Academies Press, 1999), 246-247, https://doi.org/10.17226/6020.

[55] Abell et al., Beyond the Source, 39.

[56] "Introduction to Lead and Lead Service Line Replacement," Lead Service Line Replacement Collaborative, accessed October 5, 2019, https://www.lslr-collaborative.org/intro-to-lsl-replacement.html.

[57] Ray Sterling et al., State of Technology for Rehabilitation of Wastewater Collection Systems (Washington, DC: US EPA, 2010), 4, https://nepis.epa.gov/Adobe/PDF/P1008C45.pdf; Private Sewer Laterals (Boston: US EPA, 2014), 1, https://www3.epa.gov/region1/sso/pdfs/PrivateSewerLaterals.pdf.

[58] Ray Sterling et al., State of Technology, ES-v.

[59] Other federal regulatory drivers include the Endangered Species Act, the Resource and Recovery Act, and the Comprehensive Environmental Response, Compensation, and Liability Act.

[60] James Salzman, "The Past, Present and Future of the Safe Drinking Water Act," UCLA School of Law, Public Law Research Paper, no. 19-37 (2019): 3, https://escholarship.org/uc/item/06b035kv.

[61] Salzman, "The Past, Present and Future," 5. Safe Drinking Water Act programs are delegated to states so long as they meet the "primacy" requirements by, in part, adopting drinking water regulations at least as stringent as federal regulations. See also, William E. Cox, "Evolution of the Safe Drinking Water Act: A Search for Effective Quality Assurance Strategies and Workable Concepts of Federalism," William & Mary Environmental Law and Policy Review 21, no. 1 (1997): 69, 70, 79-80, https://scholarship.law.wm.edu/wmelpr/vol21/iss1/3.

[62] Cox, "Evolution of the Safe Drinking Water Act," 82.

[63] Ibid.

[64] Amy Barrilleaux (Public Information Officer, Madison Water Utility), phone interview with Caroline Koch, November 28, 2018.

[65] 33 U.S.C. § 1251.

[66] 4 Environmental Law Practice Guide, § 18.01.

[67] 4 Environmental Law Practice Guide, § 18.01.

[68] 33 U.S.C. § 1362(6).

[69] Pub. L. No. 115-436, Section 5(b), accessed March 15, 2019, https://www.congress.gov/bill/115th-congress/-house-bill/7279/text?q=%7B%22search%22%3A%5B%22hr+7279%22%5D%7D&r=1

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[70]The Economic Impact of Green City, Clean Waters: The First Five Years (Philadelphia: Sustainable Business Network of Greater Philadelphia and Green Stormwater Infrastructure Partners, 2016), https://econsultsolutions.com/wp-content/uploads/2016/02/SBN_FINAL-REPORT.pdf.

[71] The Economic Impact of Green City, Clean Waters, 6-7; Marc Cammarata (Deputy Commissioner, Philadelphia Water Department) and Kelly Anderson (Watershed Protection Program Manager, Philadelphia Water Department), phone interview with Caroline Koch, December 3, 2018.

[72] Karen Guz (Conservation Director, San Antonio Water System) and Darren Thompson (Director of Water Resources), phone interview with Caroline Koch, October 30, 2018.

[73] Guz and Thompson, phone interview with Koch, October 30, 2018.

[74] Ali Poosti (Division Manager, City of Los Angeles), Lenise Marrero (Assistant Division Manager, City of Los Angeles), and Azya Jackson (Environmental Engineer, City of Los Angeles), phone interview with Caroline Koch, December 18, 2018. The City currently relies heavily on imported water.

[75] Kevin Critendon (Assistant Director, Austin Water), Drema Gross (Water Conservation Division Manager, Austin Water), and Marisa Flores-Gonzalez (Senior Planner, Austin Water), phone interview with Caroline Koch and Lindsay Rogers (CO Basin Program Manager, WaterNow Alliance), December 17, 2018.

[76] Guz and Thompson, phone interview with Koch, October 30, 2018.

[77] Ibid.

[78] Sarah Diringer et al., Moving Toward a Multi-Benefit Approach for Water Management (Oakland: Pacific Institute, 2019), 5, https://pacinst.org/wp-content/uploads/2019/04/moving-toward-multi-benefit-approach.pdf; see also, e.g., Greg Kats and Keith Glassbrook, Delivering Urban Resilience (Washington, DC: Capital-E, 2017), 5, https://www.nlc.org/sites/default/files/2018-02/reportsummary11-17_0.pdf; Quinn, Feeney, and Castro, The Economic Benefits of Investing in Water Infrastructure; Erik Ndayishimiye and Matthew Stieg, Public Trees for Public Good: An Assessment of Urban Forestry Management and Practices in Los Angeles County, ed. Deborah Bloome et al. (Beverly Hills: TreePeople, 2017), https://www.treepeople.org/sites/default/files/pdf/publications/LA%20County%20UF%20Mgt%20Report.pdf.

[79] See, e.g., The Economic Impact of Green City, Clean Waters.

[80] Hoffner, Hidden Reservoir, 11.

[81] Peter Mayer, Water Conservation Keeps Rates Low in Tucson, Arizona: Demand Reductions Over 30 Years Have Dramatically Reduced Capital Costs in the City of Tucson (Chicago: Alliance for Water Efficiency, 2017), 5, 21, https://www.financingsustainablewater.org/sites/www.financing-sustainablewater.org/files/resource_pdfs/Final_AWE_tucson_cosnrates-az-web3.pdf.

[82] Ibid, 5.

[83] Sarah Diringer et al., Moving Toward a Multi-Benefit Approach to Water Management (Oakland: Pacific Institute, 2019), 19, https://pacinst.org/wp-content/uploads/2019/04/moving-toward-multi-benefit-approach.pdf.

[84] Ibid.

[85] David Wolfe, "Monarch Butterflies Are Migrating In Record Numbers, But They Are Still At Risk," Commentary, The Dallas Morning News, November 2, 2018, https://www.dallasnews.com/opinion/commentary/2018/11/02/monarch-butterflies-migrating-record-numbers-still-risk.

[86] See, e.g., Quinn, Feeney, and Castro, The Economic Benefits of Investing in Water Infrastructure; Abell et al., Beyond the Source; Matt Chadsey, Zachary Christin, and Angela Fletcher, Central Puget Sound Open Space Valuation (Tacoma: Earth Economics, 2015), https://openspacepugetsound.org/sites/default/files/final-report/appendices/E_OPEN-SPACE-VALUATION/Earth-Economics-ROSS-ESV-2015-Final-Report.pdf.

[87] David Mitchell, Thomas Chesnutt, and David Pekelney, Transforming Water: Water Efficiency as Infrastructure Investment (Chicago: Alliance for Water Efficiency, 2017), 6, https://www.allianceforwaterefficiency.org/sites/www.allianceforwaterefficiency.org/files/highlight_documents/AWE-Transforming-Water-Report-Final-2017.pdf.

[88] See, Diana Bauer et al., The Water-Energy Nexus: Challenges and Opportunities (Washington, DC: US Department of Energy, 2014), 7, 9-19, https://www.energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf; see also, generally, "Energy-Water Nexus Crosscut," US Department of Energy, accessed March 5, 2019, https://www.energy.gov/energy-water-nexus-crosscut.

[89] Claudia Copeland and Nicole T. Carter, Energy-Water Nexus: The Water Sector's Energy Use (Washington, DC: Congressional Research Service, 2017), 6, https://fas.org/sgp/crs/misc/R43200.pdf.
[90] Katrina Jessoe et al., Spillovers from Behavioral Interventions: Experimental Evidence from Water and Energy Use (Berkeley: E2e, 2017), 12, 24, https://e2e.haas.berkeley.edu/pdf/workingpapers/WP033.pdf. This study was conducted by the Energy Institute at Haas at the University of California, Berkeley, the Center for Energy and Environmental Policy Research at the Massachusetts Institute of Technology, and the Energy Policy Institute at Chicago, University of Chicago.
[91] Abell et al., Beyond the Source, VII.
[92] Diringer et al., Moving Toward a Multi-Benefit Approach, 26, 27,32, 34-35; Jeanne Cole et al., "Centralized and Decentralized Strategies for Dual Water Supply: Case Study," Journal of Water Resources Planning and Management 144, no. 1 (2018): 1–11, https://doi.org/10.1061/(ASCE)WR.1943-5452.0000856.
[93] DuPuis and McFarland, Paying for Local Infrastructure. The National League of Cities has done a 29-state survey of how local entities pay for infrastructure.
[94] Certainly, bonds and loans are paid for using rates, fees, and other utility revenue streams. We have listed these as separate financing categories because bonds and loans can finance localized water infrastructure strategies over time and on a much larger scale than can be achieved when using annual operating budgets funded only with rates, fees, etc.
[95] Ceres and Brown, Bond Financing Distributed Water Systems, 15.
[96] Cynthia Koehler, "Part 3: Financing the Future of Water Infrastructure Just Got a Whole Lot Easier: Capital, Cash and Scale," The WaterNow Alliance Blog, WaterNow Alliance, last modified May 22, 2018, https://waternow.org/financing-the-future-of-water-infrastructure-just-got-a-whole-lot-easier-part-3-capital-cash-and-scale/.
[97] Cynthia Koehler, "Part 3: Financing the Future of Water Infrastructure Just Got a Whole Lot Easier: Capital, Cash and Scale," The WaterNow Alliance Blog, WaterNow Alliance, last modified May 22, 2018, https://waternow.org/financing-the-future-of-water-infrastructure-just-got-a-whole-lot-easier-part-3-capital-cash-and-scale/.
[98] See, generally, Ceres and Brown, Bond Financing Distributed Water Systems.
[99] See, Koehler, "Part 3: Financing the Future of Water Infrastructure." WaterNow and a coalition of partner organizations were instrumental in persuading GASB to issue this guidance. See, generally, Harrington, Go Green: Muni Bond Financing for Distributed Water Infrastructure, for more information on this policy clarification and how to use bond proceeds to debt finance distributed infrastructure.
[100] Tap into Resilience, WaterNow Alliance, accessed August 20, 2019, https://tapin.waternow.org/.
[101] "Water/Wastewater Pooled Bond Program," Public Finance Authority, 2018, https://www.pfauthority.org/finance-programs/waterwastewater-pooled-bond-program/.
[102] Ibid.
[103] Bob Spencer (Program Manager, Seattle Public Utilities) and Kelly O'Rourke (Conservation Planner, Seattle Public Utilities), phone interview with Caroline Koch, December 7, 2018.
[104] Ibid.
[105] Ibid.
[106] Green Bond Principles: Voluntary Process Guidelines for Issuing Green Bonds (Boston: Ceres, 2014), https://www.ceres.org/sites/default/files/reports/2017-05/Green%20Bond%20Principles.pdf.
[107] See, generally, Green Bond Principles.
[108] See, generally, Green Bond Principles.
[109] "Media Release – Global Launch of New Climate-Based Water Resilience Criteria," Climate Bonds Initiative, May 22, 2018, https://www.climatebonds.net/media-release-global-launch-new-climate-based-water-resilience-criteria.
[110] Ibid.
[111] "San Francisco Public Utilities Commission Green Bonds – A First," Green Infrastructure Leadership Exchange, July 11, 2016, http://giexchange.org/san-francisco-public-utilities-commission-green-bonds-a-first/.
[112] Ibid.
[113] "Environmental Market Opportunities."

[114] "Sharing Risk, Rewarding Outcomes: The Environmental Impact Bond," Quantified Ventures, October 31, 2018, http://www.quantifiedventures.com/environmental-impact-bonds.
[115] Ibid.
[116] "Environmental Market Opportunities."
[117] "Environmental Market Opportunities"; "DC Water, Goldman Sachs and Calvert Foundation Pioneer Environmental Impact Bond," Goldman Sachs, September 29, 2016, https://www.goldmansachs.com/media-relations/press-releases/archived/2016/dc-water-environmental-impact-bond.html.
[118] "Environmental Market Opportunities"; "DC Water, Goldman Sachs."
[119] "Case Studies: Atlanta Dept. of Watershed Management," Tap into Resilience, WaterNow Alliance, last visited November 10, 2019, https://tapin.waternow.org/resources/coming-soon-atlanta-department-of-watershed-management/; "Atlanta: First Publicly Offered Environmental Impact Bond," Quantified Ventures, last visited November 10, 2019, http://www.quantifiedventures.com/atlanta-eib.
[120] "Learn about the Clean Water State Revolving Fund (CWSRF)," US EPA, last modified February 20, 2019, https://www.epa.gov/cwsrf/learn-about-clean-water-state-revolving-fund-cwsrf.
[121] Ibid.
[122] ARRA Clean Water State Revolving Fund Green Project Reserve Report (Washington, DC: US EPA, 2015), 2, https://www.epa.gov/sites/production/files/2015-04/documents/arra_green_project_reserve_report.pdf; see also, Funding Water Efficiency Through the State Revolving Fund Programs (Washington, DC: US EPA, 2003), 2-8, https://bit.ly/2XDvmPU.
[123] ARRA Clean Water State Revolving Fund, 2.
[124] Ibid, 9.
[125] State of California Drinking Water State Revolving Fund and The Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1 – Chapter 5, Section 79724) Intended Use Plan State Fiscal Year 2018-2019 (Federal Fiscal Year 2018 Capitalization Grant) (Sacramento: State Water Resources Control Board, 2018), https://bit.ly/2F4TR1n; Commonwealth of Virginia Drinking Water State Revolving Fund Program Intended Use Plan for the DWSRF FY2019 Capitalization Grant (Richmond: Virginia Department of Health, 2018), http://www.vdh.virginia.gov/content/uploads/sites/14/2018/08/FY2019-IUP-9-16-18.pdf; Anita Maria Thompkins to DWSRF Branch Chiefs & Regional Coordinators Regions I-X, memorandum, "Clarification of Drinking Water State Revolving Fund Eligibility of Service Line Replacement on Private Property," May 9, 2016, Drinking Water Protection Division, Office of Ground Water and Drinking Water, https://www.epa.gov/sites/production/files/2018-09/documents/memo_-_clarification_of_dwsrf_eligibility_of_service_line_replacement_on_private_property.pdf; "State Efforts to Support LSL," Environmental Defense Fund, last visited November 10, 2019, https://www.edf.org/health/state-efforts-support-lsl-replacement. We note that the inability to use rate revenue to pay back SRF loans may be a barrier for some utilities' accessing SRF loans.
[126] "How the Drinking Water State Revolving Fund Works," US EPA, last updated July 15, 2019, https://www.epa.gov/drinkingwatersrf/how-drinking-water-state-revolving-fund-works; "Learn about the Clean Water State Revolving Fund (CWSRF)."
[127] "Learn about the Clean Water State Revolving Fund (CWSRF)."
[128] WIFIA applies "under customized terms to creditworthy water and wastewater projects of national and regional significance." "Learn About the WIFIA Program," US EPA, last modified May 28, 2019, https://www.epa.gov/wifia/learn-about-wifia-program#overview.
[129] "Learn About the WIFIA Program."
[130] Ibid.
[131] Ibid.
[132] Jorianne Jernberg (Director, WIFIA Program, EPA), phone interview with Caroline Koch, April 16, 2019.
[133] "WaterSMART Water and Energy Efficiency Grants," US Bureau of Reclamation, last updated August 14, 2019, https://www.usbr.gov/watersmart/weeg/.
[134] Ibid.
[135] "Water Marketing Strategy Grants," US Bureau of Reclamation, last updated August 14, 2019, https://www.usbr.gov/watersmart/watermarketing/index.html.
[136] "Small-Scale Water Efficiency Projects," US Bureau of Reclamation, last updated August 14, 2019, https://www.usbr.gov/watersmart/swep/.

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[299] Rupprecht, Water Conservation Program,12-14, 19-41; "Tucson Audit Program," City of Tucson, last visited October 17, 2019, https://www.tucsonaz.gov/water/tucson-audit-program.
[300] "Free Toilet Replacement for Low-Income Homeowners," City of Tucson, last visited October 17, 2019, https://www.tucsonaz.gov/water/low-income-high-efficiency-toilet-rebate.
[301] "Rainwater Harvesting Grant/Loan Program," City of Tucson, last visited October 17, 2019, https://www.tucsonaz.gov/water/rainwater-harvesting-grant-loan-program.
[302] Rupprecht, Water Conservation Program, 6, 19, 25, 27, 29, 32.
[303] Rupprecht, Water Conservation Program, 21.
[304] Rupprecht, phone interview with Koch and McPherson, December 13, 2018.
[305] Rupprecht, phone interview with Koch and McPherson, December 13, 2018; Rupprecht, Water Conservation Program, 43, 45.
[306] Rupprecht, Water Conservation Program, 6.
[307] Rupprecht, phone interview with Koch and McPherson, December 13, 2018; Rupprecht, Water Conservation Program, 7.
[308] Rupprecht, Water Conservation Program, 6, 7, 19, 43, Appendix A.
[309] Ibid, 43, Appendix A.
[310] Ibid, 6.
[311] Ibid, 11.
[312] Ibid, 6.
[313] Mayer, Water Conservation Keeps Rates Low, 21.
[314] Rupprecht, Water Conservation Program, 9.
[315] "Annual water savings are calculated for each program by multiplying the number of fixtures replaced with an average annual savings number." Rupprecht, Water Conservation Program, 15.
[316] Rupprecht, Water Conservation Program, 9,10. Tucson Water is also considering additional performance metrics to incorporate the broader One Water goals of the rainwater and stormwater programs, including the amount of land covered with tree canopy, surface temperatures and habitat value.

[317] "Austin: Geography and Climate," City-Data, last visited October 15, 2019, http://www.city-data.com/us-cities/The-South/Austin-Geography-and-Climate.html; Laurel Martinez, "Top 10 Lakes in the Austin Area to Visit this Summer," Texas Hill Country, June 8, 2016, https://texashillcountry.com/10-best-lakes-austin-area/.
[318] Jocci Howard Bear, "Austin Weather & Climate," About via Internet Archive Wayback Machine, last modified 2007, last visited October 17, 2019, https://web.archive.org/web/20070118231257/http://austin.about.com/od/weatherenvironment/a/weather.htm.
[319] Bear, "Austin Weather & Climate."
[320] "Community Facts: Austin city, Texas," US Census Bureau, last visited October 17, 2019, https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml; "Austin, Texas Population 2019," World Population Review, last visited October 17, 2019, http://worldpopulationreview.com/us-cities/austin-population/.
[321] "Community Facts: Austin city, Texas."
[322] "Austin Water History," City of Austin, last visited October 17, 2019, http://www.austintexas.gov/department/water-and-wastewater-history.
[323] Water Forward: Integrated Water Resource Plan (Austin: Austin Water, 2018), 2-4, http://www.austintexas.gov-/sites/default/files/files/Water/WaterForward/Water_Forward_Plan_Report_-_A_Water_Plan_for_the_Next_100_Years.pdf.
[324] Water Forward: Integrated Water Resource Plan, 2-4, 7-1.
[325] Ibid, 2-2.
[326] Ibid, 1-3; Kevin Critendon (Assistant Director, Austin Water), Drema Gross (Water Conservation Division Manager, Austin Water), and Marisa Flores-Gonzalez (Senior Planner, Austin Water), phone interview with Caroline Koch and Lindsay Rogers (CO Basin Program Manager, WaterNow Alliance), December 17, 2018.
[327] Ibid, 1-2, Figure 1-1; Critendon, Gross, and Flores-Gonzalez, phone interview with Koch and Rogers, December 17, 2018.
[328] Ibid, 1-3; Critendon, Gross, and Flores-Gonzalez, phone interview with Koch and Rogers, December 17, 2018.
[329] Ibid, 1-3; Critendon, Gross, and Flores-Gonzalez, phone interview with Koch and Rogers, December 17, 2018; Texas state law requires integrated water management plans be based on a 50-year timeline, so Austin's plan was a deliberate decision to go beyond that level of planning to best incorporate anticipated climate change impacts.
[330] Critendon, Gross, and Flores-Gonzalez, phone interview with Koch and Rogers, December 17, 2018.
[331] Ibid.
[332] Water Forward: Integrated Water Resource Plan, 1-1.
[333] Ibid, 3-1.
[334] Ibid, 3-2.
[335] Ibid, 3-2.
[336] Ibid, 3-2, 3-9. This public engagement was key to equitably reflecting the diversity of Austin's population and Austin Water's customers.
[337] Critendon, Gross, and Flores-Gonzalez, phone interview with Koch and Rogers, December 17, 2018.
[338] Ibid, 5-1 – 5-8.
[339] Ibid, 5-1 – 5-8, 6-17 – 6-23, 7-3.
[340] Emlea Chanslor, "Austin Water Announces Workshop on Water Reuse Systems: Input on Future Ordinance Requirements Sought," City of Austin, June 13, 2019, https://www.austintexas.gov/news/austin-water-announces-workshop-water-reuse-systems-input-future-ordinance-requirements-sought. Utility staff is also exploring whether to require large developments to submit water balance applications.
[341] Critendon, Gross, and Flores-Gonzalez, phone interview with Koch and Rogers, December 17, 2018. Austin's water conservation and efficiency programs began 35 years ago in 1983. Initially, the utility relied on "old school" conservation measures such as toilet replacement programs. As the City's Austin's needs evolved, so did its approach to conservation and efficiency. Beginning in 1991, the city started offering rebates for all types of water efficient appliances and fixtures as well as a free efficient toilet program. By 2010, Austin Water began phasing out these programs given their success and 92% market saturation. "Texas Water Conservation Scorecard: City of Austin Water & Wastewater," Texas Living Waters Project, last visited October 17, 2019, http://www.texaswaterconservationscorecard.org/?id=4. Indeed, Austin Water's conservation programs are highly rated by the Texas Living Water Project with a score of 90 out of 100 in 2017.

[342] Water Forward: Integrated Water Resource Plan, 6-1 – 6-23.
[343] Ibid, 1-4, 9-2, 9-5.
[344] Ibid, 9-17 – 9-18.
[345] "Seattle: Geography and Climate," City-Data, last visited October 17, 2019, http://www.city-data.com/us-cities/The-West/Seattle-Geography-and-Climate.html.
[346] "Community Facts: Seattle city, Washington," US Census Bureau, last visited October 17, 2019, https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml.
[347] "Seattle, Washington Population 2019," World Population Review, last visited October 18, 2019, http://worldpopulationreview.com/us-cities/seattle-population/.
[348] "Water," City of Seattle, last visited October 18, 2019, https://www.seattle.gov/util/MyServices/Water/index.htm; "Drainage and Sewer," City of Seattle, last visited October 18, 2019, https://www.seattle.gov/util/MyServices/DrainageSewer/index.htm; "Residential Rates," City of Seattle, last visited October 18, 2019, https://www.seattle.gov/util/MyServices/Rates/index.htm.
[349] 2019 Water System Plan Summary (Seattle: Seattle Public Utilities, 2018), http://www.seattle.gov/util/cs/groups/public/@spu/@water/documents/webcontent/1_072555.pdf.
[350] "Water," City of Seattle; "Water System Overview," City of Seattle, last visited October 18, 2019, http://www.seattle.gov/util/MyServices/Water/WaterSystemOverview/index.htm; 2019 Water System Plan Summary.
[351] Spencer and O'Rourke, phone interview with Koch, December 7, 2018; Water Consumption Continues Its Downward Trend as Regional Population Grows (Seattle: Seattle Public Utilities, 2016), 1.
[352] Spencer and O'Rourke, phone interview with Koch, December 7, 2018.
[353] Ibid.
[354] Ibid. A new state plumbing code also supported SPU's water efficiency programs.
[355] Water Use Efficiency Guidebook, 3rd ed (Tumwater: Washington State Department of Health, 2017), https://www.doh.wa.gov/portals/1/Documents/Pubs/331-375.pdf. The State Department of Health subsequently adopted the Water Use Efficiency Rule (WAC 246-290) to implement the MWL efficiency requirements. As part of the process to comply with the State Water Use Efficiency Rule, the Saving Water Partnership utilities update regional policy objectives for water conservation and set a six- year regional goal. Rich Gustav, Preserving the Customer Conservation Ethic: 2013-18 Regional Water Conservation Strategies and Actions of the Saving Water Partnership (Seattle: Seattle Public Utilities Resource Conservation Office, 2012), http://www.crwsd.com/download/general_documents/wuer1318.pdf.
[356] Gustav, Preserving the Customer Conservation Ethic.
[357] SPU's free toilet program for income-qualified customers is unique, as it was implemented following a directive from Seattle City Council prompted by a citizen-lead initiative. This program has two express aims: (1) water conservation and (2) reducing water bills for low-income households.
[358] Spencer and O'Rourke, phone interview with Koch, December 7, 2018.
[359] "About Us: Goals and Mission," Saving Water Partnership, last visited October 18, 2019, https://www.savingwater.org/about/.
[360] Sharlene Leurig and Jeremy Brown, Bond Financing Distributed Infrastructure: How to Make Better Use of Our Most Liquid Market for Financing Water Infrastructure (Austin: Ceres, 2014), 11, 16, https://www.ceres.org/sites/default/files/reports/2017-05/Ceres_WaterBondFinancing_082814.pdf.
[361] Leurig and Brown, Bond Financing Distributed Infrastructure, 16.
[362] Spencer and O'Rourke, phone interview with Koch, December 7, 2018. SPU's budget for its outreach and education programs was $500,000 in 2018 and increased to $900,000 in 2019. While SPU's spending on its rebate programs comes out of its capital budget; education and outreach programs are funded from the utility's operating budget.
[363] Water Consumption Continues, 1.
[364] Spencer and O'Rourke, phone interview with Koch, December 7, 2018.

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[365] 2019 Water System Plan, vol. 1, (Seattle: Seattle Public Utilities, 2018), http://www.seattle.gov/Documents/Departments/SPU/Documents/SPU%202019%20WSP%20Volume%201.pdf.

[366] 2019 Water System Plan.

[367] Green City Clean Waters: The City of Philadelphia's Program for Combined Sewer Overflow Control Program Summary, amended, (Philadelphia: Philadelphia Water Department, 2011), 2, http://www.phillywatersheds.org/doc/GCCW_AmendedJune2011_LOWRES-web.pdf.

[368] "Average Annual Precipitation by State," Current Results Publishing, last visited October 18, 2019, https://www.currentresults.com/Weather/US/average-annual-state-precipitation.php.

[369] Green City Clean Waters.

[370] Brief History of the Philadelphia Water Department (Philadelphia: Philadelphia Water Department), 1, last accessed October 18, 2019, https://www.phila.gov/water/educationoutreach/Documents/PWD_History.pdf.

[371] Julia Rockwell, The Climate Change Adaptation Program (Philadelphia: Philadelphia Water Department), last accessed October 18, 2019, https://www.phila.gov/water/PDF/CCAP_OnePagerExt.pdf; Brief History of the Philadelphia, 2.

[372] Alfred Lubrano, "Philadelphia's Population Increased in 2017, But It's Not All Good, According to Census Data," The Philadelphia Inquirer, March 22, 2018, https://www.philly.com/philly/news/philadelphia-population-census-data-20180322.html; Green City Clean Waters.

[373] "Community Facts: Philadelphia city, Pennsylvania," US Census Bureau, last visited October 17, 2019, https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml; Kayla Fontenot, Jessica Semega, and Melissa Kollar, Income and Poverty in the United States: 2017 (Washington, DC: US Census Bureau, 2018), https://www.census.gov-/content/dam/Census/library/publications/2018/demo/p60-263.pdf.

[374] "Drinking Water," City of Philadelphia, last visited October 18, 2019, https://www.phila.gov/WATER/WU/DRINKINGWATER/Pages/default.aspx; 2017 Drinking Water Quality Report (Philadelphia: Philadelphia Water Department, 2018), https://www.phila.gov/water/wu/Water%20Quality%20Reports/2017-Water-Quality-Report.pdf.

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[376] Federal Register: Part VII, Combined Sewer Overflow (CSO) Control Policy, Federal Register vol. 59, no. 75 (Washington, DC: US EPA, 1994), https://www.epa.gov/sites/production/files/2015-10/documents/owm0111.pdf.

[377] Howard Neukrug (Executive Director, The Water Center at Penn), interview with WaterNow Alliance, March 9, 2019.

[378] Green City Clean Waters, 3.

[379] Ibid, 1.

[380] Ibid.

[381] Neukrug, interview with WaterNow Alliance, March 9, 2019.

[382] Ibid.

[383] Stormwater Management Guidance Manual, v. 3.1 (Philadelphia: Philadelphia Water Department, 2018), https://www.pwdplanreview.org/upload/manual_pdfs/PWD-SMGM-v3.1-20180701.pdf.

[384]Stormwater Management Guidance Manual.

[385] Elizabeth Couillard et al., "Philadelphia's One-Water Approach Starts with Source Water Protection," Journal – American Water Works Association 107, no. 4 (April 2015): 67-68, https://doi.org/10.5942/jawwa.2015.107.0061. Because the stormwater policies and green stormwater infrastructure being demonstrated in Philadelphia are also relevant to suburban and rural communities upstream in the source watersheds PWD also offers tech¬nical support and shares solutions these upstream communities as they work to meet the requirements of the National Combined Sewer Overflow Control Policy and Municipal Separate Storm Sewer Systems. This regional effort is part of PWD's One Water approach and source watershed protection plan.

[386] The Economic Impact of Green City, Clean Waters: The First Five Years (Philadelphia: Econsult Solutions, 2016), 15, https://econsultsolutions.com/wp-content/uploads/2016/02/SBN_FINAL-REPORT.pdf; Stormwater Management Guidance Manual.
[387] Ibid.
[388] "Stormwater Tools: Which Stormwater Tool is Right for You," Philadelphia Water Department, last modified March 14, 2019, https://www.pwdraincheck.org/en/stormwater-tools-home. The amount of the cost assistance provided depends on the stormwater management tool. For example, PWD covers nearly the full cost of downspout planters and provides up to $2,000 for rain gardens, depaving, or permeable pavers. To evaluate the effectiveness of residential GSI installations, participants agree to allow PWD staff to inspect the stormwater management tool installed on their property on an approximately monthly basis.
[389] Philadelphia Water Department, "Rain Check" (presentation, November 2, 2018).
[390] Ibid.
[391] Philadelphia Water Department, "Green City Clean Waters" (presentation to advisory committee, May 2018).
[392] Ibid.
[393] Green City Clean Waters. The total Green City, Clean Waters program budget is $2.4 billion. In addition to the GSI investments, PWD has committed $345 million to treatment plant upgrades and $420 million in flexible funds that could be used for targeted gray infrastructure or additional GSI as appropriate over the life of the program.
[394] Philadelphia Water Department, "Green City Clean Waters." Since the program began in 2012 PWD has awarded $90 million in grants.
[395] Marc Cammarata (Deputy Commissioner, Philadelphia Water Department) and Kelly Anderson (Watershed Protection Program Manager, Philadelphia Water Department), phone interview with Caroline Koch, December 3, 2018.
[396] The Economic Impact of Green City, 19.
[397] Ibid.
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[400] Ibid, 22.
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[402] Green City Clean Waters.
[403] "About Us," MMSD, last visited October 18, 2019, https://www.mmsd.com/about-us.
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[405] "About Us," MMSD; Kevin Shafer (Executive Director, MMSD), phone interview with Caroline Koch, November 28, 2018.
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[407] "History," MMSD.
[408] Fresh Coast Green Solutions.
[409] Shafer, phone interview with Koch, November 28, 2018.
[410] Shafer, phone interview with Koch, November 28, 2018; Kevin Shafer, interview with Cynthia Koehler (Executive Director, WaterNow Alliance), October 15, 2019.
[411] Shafer, phone interview with Koch, November 28, 2018.
[412] Regional Green Infrastructure Plan (Milwaukee: MMSD, 2013), https://www.mmsd.com/what-we-do/green-infrastructure/resources/regional-green-infrastructure-plan.
[413] Regional Green Infrastructure Plan.
[414] Shafer, phone interview with Koch, November 28, 2018; Shafer, interview with Koehler, October 15, 2019.
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[416] "Sewer School: An Intro to Our Pipes," City of Milwaukee, last visited October 18, 2019, https://city.milwaukee.gov-/commoncouncil/District10/Stormwater-and-Sewer-Capacity.htm#.XZz4ey2ZNR0.
[417] Regional Green Infrastructure Plan.

[418] Shafer, phone interview with Koch, November 28, 2018.
[419] Regional Green Infrastructure Plan, 19; Shafer, phone interview with Koch, November 28, 2018.
[420] 2019 Operations and Maintenance and Capital Budgets (Milwaukee: MMSD, 2019), 174-175.
[421] 2019 Operations and Maintenance, 161, 174-175; Shafer, phone interview with Koch, November 28, 2018.
[422] "Non-member billings come from ten communities outside the District's legal boundary but within the District's service area." 2019 Operations and Maintenance, 11, 88; Shafer, interview with Koehler, October 15, 2019.
[423] Regional Green Infrastructure Plan, 9, 54.
[424] Ibid, 54, 56-58.
[425] Ibid, 54, 59-61.
[426] "Eugene: Geography and Climate," City-Data, last visited October 18, 2019, http://www.city-data.com/us-cities/The-West/Eugene-Geography-and-Climate.html.
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[428] "Stormwater Fees," City of Eugene, last visited October 18, 2019, https://www.eugene-or.gov/467/-Fees-and-Charges
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[430] Therese Walch (Public Works Water Resource Manager, City of Eugene) and Chelsea Clinton (Sustainability Manager, City of Eugene), phone interview with Caroline Koch, December 6, 2018; Deborah Evans et al., "Preface" in Comprehensive Stormwater Management Plan (Eugene: City of Eugene, 1993), http://www.livabilitylane.org/files/Eugene_Stormwater_Plan.pdf.
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[433] "NPDES Municipal Stormwater Permit"; Stormwater Management Plan (Eugene: City of Eugene, 2012), 1-1, https://www.eugene-or.gov/DocumentCenter/Home/View/13245.
[434] Council Ordinance No. 20521, Council Bill No. 5105, An Ordinance Concerning Stormwater Management; Amending Sections 9.0500, 9.4780, 9.6790, 9.6791, 9.6792, 9.6796, 9.6797, 9.8030, 9.8055, 9.8090, 9.8100, 9.8215, 9.8220, 9.8320, 9.8325, 9.8440, 9.8445, 9.8515, and 9.8520 of the Eugene Code, 1971; and Providing for An Effective Date; see also Eugene Municipal Code § 9.6792(1).
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[464] Sullivan and Simson, 2017-2018 Overview and Accomplishment Report, 2; Combined Sewer Overflow Control Program: 2017 Annual CSO and Consent Decree Report (Seattle: King County Wastewater Treatment Division, 2018), 22, https://www.kingcounty.gov/~/media/services/environment/wastewater/cso/docs/annual-reports/2017_CSO-CD-Annual-with-cover-letter.ashx?la=en.
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