Catalyzing the Transformation of U.S. Water Infrastructure
About The Johnson Foundation at Wingspread

The Johnson Foundation at Wingspread, based in Racine, Wisconsin, is dedicated to serving as a catalyst for change by bringing together leading thinkers and inspiring new solutions on major environmental and regional issues. Over the course of 50 years, The Johnson Foundation at Wingspread has inspired consensus and action on a range of public policy issues. Several organizations have roots at Wingspread, including the National Endowment for the Arts, National Public Radio, the International Criminal Court and the Presidential Climate Action Plan. Building on this legacy, The Johnson Foundation at Wingspread has set a new, strategic mission designed to achieve greater, more sustained impact on critical environmental issues. Launched as part of this new direction is Charting New Waters, an alliance of leading organizations calling for action to avert the looming U.S. freshwater crisis.
Catalyzing the Transformation of U.S. Water Infrastructure

Convening Report

Meeting Convened by
The Johnson Foundation at Wingspread
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The Johnson Foundation at Wingspread
Letter From the Director

*What can water infrastructure contribute to both mitigating climate change and adapting to its impacts?* That’s the question we posed to a group of partners from a broad variety of disciplines and geographies who came together at Wingspread in April 2013 to focus on the intersection of urban water infrastructure and climate change.

Here at The Johnson Foundation at Wingspread, we are moving into the next phase of Charting New Waters. It builds upon the collaboration and partnership that we’ve enjoyed since setting off on this course in 2010 with our initial *Call to Action*.

Our hope is to catalyze the widespread adoption of more sustainable and resilient water infrastructure systems across the U.S. We’ll do this by focusing on what we do best – bringing together partners like you to explore the issue, combined with our commitment to synthesize and disseminate information, insights and strategies that emerge from the convenings.

*Charting New Waters: Catalyzing the Transformation of U.S. Water Infrastructure* emerged from the rich content explored in April. In the ensuing pages you’ll find The Foundation’s perspective on the challenge at hand, along with an emerging framework for a continuum of change.

This framework seeks to optimize existing systems, transition our infrastructure toward resiliency and eventually transform it. We see this as a continuum of change as we move toward a new paradigm and approach to water infrastructure for the 21st century and beyond. In addition, we have prioritized an initial set of recommended priority activities for progressing along this pathway that emerged from our convening:

- **Expand** understanding of vulnerability
- **Develop** greenhouse gas emission inventories
- **Strengthen** collaboration between researchers and implementers
- **Advance** widespread adoption of green infrastructure
- **Create** systems for ecosystem services valuation
- **Recover** resources from “waste”
- **Promote** targeted decentralization
- **Embrace** and adopt smart technologies
- **Integrate** water resources management at nature’s scale

We are committed to keeping the conversation going outside the walls of Wingspread. Alongside this report, we invited five participants to contribute additional thoughts to our new online dialogue, *Inspiring Solutions*. I encourage you to take some time to read what’s presented here and, if you haven’t yet, to also take a moment to visit *Inspiring Solutions* to gain additional perspective on how we can best invest our future water dollars.

Our exploration of freshwater challenges has taken us to Denver, Boston and other regions of the country, as well as deep into the details of financing and to the halls of Congress. Looking to the future, our water infrastructure problems are pressing, yet the potential for innovative solutions couldn’t be more exciting.

As we embark on this next phase of Charting New Waters, we are not doing it alone. I remain grateful for your continued partnership and collaboration and thank you for your sustained engagement and participation.

Thank you for joining us on the journey. I look forward to seeing you soon.

Lynn Broaddus
Director, Environment Programs
The Johnson Foundation
Introduction

The latest phase of Charting New Waters is focusing on U.S. water infrastructure. Specifically, this work aims to catalyze the widespread adoption of more sustainable and resilient water infrastructure systems in the United States. It is focused on synthesizing and disseminating information that helps local, state and national leaders set a course for and navigate decisions regarding the construction, financing, management and maintenance of sustainable and resilient water infrastructure for the future.

The first meeting of the latest phase of Charting New Waters focused on the intersection between urban water infrastructure and climate change. Participants with a wide range of expertise and perspectives on water, waste, infrastructure and governance explored the ways in which advances in water infrastructure can help communities address climate change and its impacts. In addition to identifying promising opportunities to mitigate climate change and address climate adaptation needs, the group emphasized the significant impact that climate shifts will have on our water resources. They stressed the need to look at the future of our water infrastructure systems within the context of a changing climate and increasingly variable and erratic weather conditions and water availability. From the discussion, a broad conceptual framework for catalyzing the widespread adoption of more sustainable and resilient water infrastructure is emerging.

Partnership in Action

As The Johnson Foundation seeks to accomplish the goals set forth for this phase of Charting New Waters, we look forward to engaging the robust network of water experts, practitioners, advocates, users and decision makers who have worked with The Foundation on U.S. freshwater issues since we began our exploration in 2008. Throughout this phase, our core focus will be on convening diverse interests and perspectives to examine different aspects of how water infrastructure can be re-imagined, redesigned and/or managed differently to generate beneficial environmental, economic and social outcomes. As always, our convenings will seek to frame and tackle specific issues and challenges in ways that will complement and add value to the ongoing efforts of our colleagues and partners who are also working to lead the nation toward more sustainable and resilient water infrastructure systems. And, we look forward to working with partners to elevate the visibility of and increase understanding around the issues we address, so that we might encourage decision makers at the local, regional and national levels to accelerate movement toward the water infrastructure of the future.

The diverse participants who gathered at Wingspread in April 2013 — including individuals from utilities, the private sector and nongovernmental organizations (NGOs), as well as elected officials — agreed that the impacts of climate change will pose increasingly frequent and severe threats to communities around the country. They also agreed that revamping our water infrastructure offers a dynamic opportunity for improving resilience and adaptation to climate change, while also offering promising climate mitigation solutions and generating economic and social benefits.
of more sustainable and resilient water infrastructure systems in the United States began to emerge.

The balance of this document lays out The Johnson Foundation’s perspective on the challenge at hand, a framework for change, an initial set of priority recommendations and our vision for the path forward for Charting New Waters.

The Challenge at Hand

Our nation’s water infrastructure is in crisis. It faces the profound problems of aging components, stressed natural systems and outdated technology. Drinking water, wastewater, stormwater and groundwater systems are struggling to meet current needs and are ill-equipped to handle the impacts of climate change. Across the country, most built systems are highly centralized and vulnerable to single-point system failures, while overflows of combined stormwater and sanitary sewer systems continue to regularly contaminate water bodies in hundreds of municipalities. In communities across the nation, water facilities are consuming significant energy to operate, while wastewater treatment plants are not taking full advantage of emerging technologies that convert waste streams into productive resources, such as fuel for energy generation. Fragmented and inflexible governance structures as well as substantial financial and public perception challenges are inhibiting the implementation of technological, management and policy innovations that hold the potential to generate environmental as well as economic and social benefits for communities.

Nevertheless, the sense of urgency to enhance the sustainability and resilience of water infrastructure is increasing, driven by growing awareness of our aging water systems and mounting evidence of the impacts of climate change on them. Hurricane Sandy and other extreme weather events have made our water infrastructure more visible, but there is still not enough awareness of the severity of the problems facing our water systems, or of available innovations that can enhance the sustainability and resilience of these systems. As opportunities to upgrade or revamp systems arise, decision makers would be wise to consider the need to adapt to both acute, episodic events (e.g., natural or man-made disasters) as well as slow, chronic trends (e.g., population growth or decline, drought). The application of triple-bottom-line analytical methods that consider environmental, economic and social outcomes can help decision makers determine a robust picture of the best water infrastructure solutions for their utility or community and help to build public support for capital investment.

Drinking water, wastewater, stormwater and groundwater systems are struggling to meet current needs and are ill-equipped to handle the impacts of climate change.

More than 2 billion gallons of sewage overflowed from the Bay Park Sewage Treatment Plant in East Rockaway, N.Y., due to damage inflicted by Hurricane Sandy.
**Framework for Change: Moving Toward Transformation**

**PHASE I**

**Optimize Existing Systems**
Phase I includes increasing energy efficiency, reducing physical vulnerability and improving overall management of legacy infrastructure systems where and when possible, within the scope of typical operations. Example actions include: replacing old water system pumps with state-of-the-art, high-efficiency pumps; relocating plant switchboards and generators away from basements and other areas at risk of flooding; installing comprehensive monitoring systems that enable better tracking of system operations and identification of leaks; and coordinating operations and maintenance planning across municipal departments to increase efficiency and reduce costs.

**PHASE II**

**Transition to More Resilient Systems**
Phase II involves incorporating proven innovations into legacy systems, to move them beyond the scope of typical operations while enhancing adaptive capacity and mitigating climate change where possible. Example actions include: incorporating green infrastructure into municipal stormwater management; linking decentralized water treatment and distribution nodes into the grid; connecting anaerobic treatment processes and/or renewable energy generation to wastewater treatment systems; developing anticipatory post-disaster recovery and rebuilding plans; and leveraging market forces to encourage water use efficiency among utility customers.

**PHASE III**

**Implement Transformative Systems**
Phase III involves seizing opportunities to implement and demonstrate the technology, best management practices and multiple benefits of “new paradigm” water infrastructure systems. Key characteristics of sustainable and resilient new paradigm systems include: right-sized, wisely sited facilities; decentralized, co-located water treatment and energy generation facilities; closed-loop systems; resource recovery and water reuse; integrated management of drinking water, wastewater and stormwater; use of triple-bottom-line accounting procedures that consider ecosystem services; full-cost pricing; and robust financing mechanisms.
Navigating Toward the Water Infrastructure of the Future

Participants in The Johnson Foundation’s April 2013 convening emphasized that the water sector is still in a relatively nascent stage of implementing new innovations, with much experimentation underway. Innovation is occurring in how water infrastructure is designed, financed, constructed, managed and maintained, but frequently on small scales or in isolation. With extensive legacy systems already in place, utilities and municipalities face a range of challenges in making transformational changes to a new paradigm for water infrastructure. Some are in a position to make small tweaks, while others may be able to take larger incremental steps and still others are designing and implementing entirely new systems.

Challenges vary at the local level, so a range of options is needed to increase resiliency on a regional and national scale. A definitive set of solutions does not exist, but models and guidance for advancing sustainable and resilient water infrastructure are emerging. Based upon the success stories and latest innovations discussed in the April 2013 meeting, we offer a framework for moving toward the water infrastructure of the future in a way that encourages new ideas and context-sensitive solutions over prescriptive recommendations (see page 4).

The Framework for Change

Climate change is forcing water utilities to rethink how their systems are constructed, managed and maintained. Regardless of the age or current condition of a municipal water system, there are steps utilities and communities can take to enhance the sustainability and resilience of their facilities. One may think of the transformation framework on page 4 as a continuum of change – from tweaking outdated legacy systems to implementing “new paradigm” systems like those in Battery Park City in New York City. This continuum reflects the reality of incremental change while encouraging movement toward transformation, change that doesn’t necessarily have to occur in a linear fashion. This framework recognizes three phases through which water infrastructure can be converted into what the United States needs the 21st century and beyond.
Water infrastructure can play a significant and dynamic role in both mitigating climate change and adapting to its impacts.

Decentralized Water Treatment and Reuse

Battery Park City is a 92-acre redevelopment area in New York City that includes five residential water reuse systems serving six LEED-certified apartment buildings. (LEED stands for Leadership in Energy and Environmental Design and is the leading certification program for green buildings.) The wastewater and rainwater recycling systems employ hollow-fiber, micro-filtration water treatment membranes, ultraviolet light disinfection and biological nitrogen removal to comply with New York’s direct reuse standards. The Solaire, one of the six apartment buildings, was the first building in New York to incorporate water reuse; it now recycles 25,000 gallons of wastewater per day. The treated water is reused for flushing toilets in the 293-unit building, as well as for cooling tower make-up water, laundry and garden irrigation. Compared to similar-sized residential buildings in the city, the Solaire consistently uses 48 percent less water and discharges 56 percent less wastewater. Battery Park City can serve as a model for scaling water conservation and reuse projects in urban redevelopment and campus settings.5

Getting to Transformation: Initial Recommendations

The group convened by The Foundation in April 2013 agreed that water infrastructure can play a significant and dynamic role in both mitigating climate change and adapting to its impacts, while simultaneously generating economic and social benefits. Participants pointed to a variety of real-world examples in which emerging or proven innovations have been implemented at small scales (i.e., at the site or development scale rather than community- or watershed-wide). To facilitate movement along the continuum, we must foster the development and implementation of a variety of tools that will help leaders break the inertia and make more sustainable and resilient decisions about water infrastructure investments. Key tools include systems thinking, triple-bottom-line analysis, public-private partnerships, robust, real-time data and new utility business models. To ultimately achieve transformation, we must break down barriers to promising solutions and innovation; celebrate, amplify and scale-up successes; and harness the energy of visionary leaders and the power of collaboration to forge partnerships and commitments that will spark widespread adoption of more sustainable and resilient water infrastructure systems in the United States.

This convening generated a set of recommendations, described on the following pages, that are focused on advancing the implementation of water infrastructure climate mitigation opportunities and/or catalyzing action on climate adaptation needs. These recommendations coincide with priority activities for progressing along the continuum of the Framework for Change.
Expand Understanding of Vulnerability

Water and wastewater utilities need a better understanding of how vulnerable their water systems are to the impacts of climate change – most notably, impacts such as intense rainfall events and prolonged droughts. An improved understanding of vulnerability would help to inform decision making about capital investments and day-to-day management practices that could enhance utilities’ ability to adapt to climate change. The industry would benefit from a common framework that provides guidance and criteria, as well as practical tools and training, for conducting climate vulnerability assessments. The water sector can draw upon vulnerability assessment work already completed, or ongoing, by utilities in Seattle, San Francisco, New York City, Boston and Tampa. Existing tools that could inform the development of a broadly applicable framework and methodology include the American Water Works Association (AWWA) J-100 RAMCAP Standard for Risk and Resilience Management of Water and Wastewater Systems, as well as the U.S. Environmental Protection Agency’s Climate Resilience and Assessment Tool (CREAT) and Vulnerability Self-Assessment Tool (VSAT). While these tools are good starting points, water utilities would benefit from further testing, refinement and alignment of these tools. Utilities also need better sources of down-scaled climate data they can use to run models for their service areas. Another key challenge is encouraging utilities to carry out vulnerability assessments, which will require a concerted promotional effort and incentives to catalyze action.

Develop Greenhouse Gas Emission Inventories

Utilities must also have a baseline understanding of their own energy use and greenhouse gas (GHG) emissions to inform decisions about, and track the effectiveness of, mitigation measures. Water and wastewater utilities need a common set of best practices and recommended methods for conducting energy audits and GHG emission inventories, as well as related tools for reporting and communicating this type of information to ratepayers. Water and wastewater utilities could apply existing GHG inventory protocols, such as that developed by The Climate Registry. Related work on sustainability performance standards such as the STAR Community Index™, the Envision™ Sustainable Infrastructure Rating System and other work by organizations like the AWWA, the Water Environment Research Foundation and the Alliance for Water Efficiency may also offer applicable methods. Utilities need a simple, understandable tool that allows them to execute unit-level analyses of sources of GHG emissions and develop an accurate, system-wide inventory. Again, motivating utilities to conduct GHG inventories and feed the results into management decisions will require a concerted effort and incentives to act.

The Deer Island wastewater treatment plant in Boston Harbor was one of the first to implement a design informed by climate science. The Massachusetts Water Resources Authority raised the facility by nearly two feet during construction in the 1990s in response to potential sea-level rise.
Strengthen Collaboration Between Researchers and Implementers

Strengthening the connections between the technology research and development community and utility managers, who decide which mitigation and adaptation measures to pursue, would help facilitate the dissemination and implementation of emerging water infrastructure innovations. Testing new technologies at scale is a key challenge for the research and development community, which could be addressed through tighter collaboration with utility managers. However, managers are often reluctant to take risks that could affect their ability to meet regulatory obligations. Hence there is a need to also involve regulators in creating mechanisms that encourage utilities to test new innovations (e.g., a contest like the U.S. Department of Education’s Race to the Top), as well as forge connections with potential funders who can support at-scale testing of promising technologies.

Advance Widespread Adoption of Green Infrastructure

The use of green infrastructure as a water management tool is gaining momentum around the nation. In wetter regions it is becoming an integral piece of many municipalities’ stormwater and flood management strategies, while in drier regions new applications for groundwater recharge are emerging as an important piece of the water supply portfolio. Leveraging green infrastructure for source water protection is also a growing trend among drinking water utilities. Despite these developments, there remains great unmet potential. One possible mechanism for advancing the adoption of green infrastructure is to develop consistent performance-based and/or volume-based runoff control standards and integrate them into Municipal Separate Storm Sewer System (MS4) permits and Combined Sewer Overflow (CSO) Long-Term Control Plans (LTCPs). Other potential mechanisms for advancing adoption include integrating green infrastructure components into all public improvement projects, and/or promoting and expanding the use of permeable pavement as standard practice for low-traffic streets. Municipalities could also consider creating a permanent staff position that focuses specifically on understanding the ecology and ecosystem health of the community, which would facilitate the identification of opportunities to implement green infrastructure. We must systematically capture and disseminate lessons learned from successful projects to help raise the visibility of green infrastructure as an effective water management option with multiple benefits. Cities such as Philadelphia and Cincinnati are embarking upon major green infrastructure initiatives from which such lessons can be gleaned.9
Create Systems for Ecosystem Services Valuation
Assigning economic value to the services provided by natural systems will help to promote them as complementary or effective alternatives to built infrastructure. A first step is to identify, promote, protect and improve regional opportunities to use natural systems to store and treat water. Second, there is a need to account for those functions as assets on the balance sheets of utilities, so that utilities are able to fund the maintenance and expansion of natural systems in concert with built infrastructure assets. Any valuation system must look beyond urban boundaries, to rural systems that benefit or negatively impact the ecosystems that serve to support urban infrastructure. There is broad support and ongoing work focused on creating more uniform guidelines and methods for triple-bottom-line accounting, which promises to enhance the consistency and credibility of ecosystem services valuation. In addition, regional markets for ecosystem services should be explored to sustain and increase their value over time. Opportunities exist to build upon the work to date by communities that are pioneering ecosystem services markets, such as the Willamette Partnership in Oregon, as well as existing carbon market models.¹⁰

Recover Resources from “Waste”
A number of leading thinkers in the water sector are converging around principles of wastewater treatment and management that center on recovery and reuse of resources (primarily energy and nutrients) rather than the historic emphasis on pollutant dilution and/or removal. This approach has the potential to transform wastewater systems but requires a fundamental change in viewing “waste” as a resource to harvest and use productively. Communities should consider the following incremental steps for decreasing their waste and increasing resource recovery: separate source materials; avoid contamination (and dilution) of waste streams; implement new anaerobic technologies to treat human waste; implement technologies to generate electricity from biosolids; and extract reusable resources such as nutrients from sewage sludge for use as fertilizer. A few U.S. utilities – including the East Bay Municipal Utility District in Oakland and the Hampton Roads Sanitation District in Virginia – have begun making the transition from resource removal to resource recovery.¹¹ While life-cycle metrics for evaluating the benefits of these approaches are compelling, regulatory or market-based incentives are needed for catalyzing these changes at scale.

Decentralization is considered a key pathway to developing more dynamic water systems that integrate resource recovery, closed-loop systems, water services and electric power generation.

Promote Targeted Decentralization
Many experts see decentralized water infrastructure systems as a more sustainable and resilient option than conventional centralized systems. Decentralization is considered a key pathway to developing more dynamic water systems that integrate resource recovery, closed-loop systems, water services and electric power generation. In addition, having redundant systems across a
geographic area can increase the resilience of water utility services. Decentralization may not always be the best option, since systems must be designed to meet needs in specific contexts, but smaller, more adaptable systems can be an important complement or alternative to the centralized systems historically developed by municipal utilities. Decentralized systems may allow for incremental change in the absence of opportunities for the wholesale redesign of legacy systems. There is a need for decision support tools that help managers compare the long-term trade-offs of centralized versus decentralized approaches, and allow them to seize opportunities to implement decentralized systems (including green stormwater infrastructure) when it makes sense. Revised fee structures could also be used to incentivize decentralized systems.

**Embrace and Adopt Smart Technologies**

Actors in many sectors and the general public can work in concert with the water industry to raise awareness of and implement smart water and energy technologies. There is a growing range of information and communication technologies (ICTs) that enable businesses, managers and residents to understand and improve water use and energy efficiency, including home appliances, grid management tools, self-healing pipes and many other emerging innovations. When applied properly, ICTs create better feedback loops and enhance managers’ ability to monitor, control and verify system performance and make more informed management decisions. For example, DC Water in the District of Columbia has developed a state-of-the-art High Usage Notification Application (HUNA), which uses Automatic Meter Reading technology that allows the utility to perform real-time monitoring of water use and quickly identify and address leaks.¹²

**Integrate Water Resources Management**

At both the conceptual and implementation levels, we must promote the principles of managing all water as an integrated resource in concert with food, energy and transportation. The integration of drinking water, wastewater and stormwater agencies (or stronger coordination among them), along with integration among utility sectors and municipal departments, is an important element of a holistic approach to resource management and opens up possibilities for game-changing, co-beneficial solutions. Some utilities, such as the San Francisco Public Utilities Commission, have made strides in integrating different municipal services.¹³ Innovations that can stem from such integration include co-located wastewater and energy generation facilities that allow energy to be generated efficiently from sewage sludge. In some cases, it may be possible for wastewater plants to also serve as fueling stations for utility or municipal vehicles. However, fragmented institutions and incompatible regulatory requirements create hurdles that need to be removed to better facilitate integration among sectors.
Conclusion: The Path Forward

Charting New Waters will proceed with a multi-pronged, forward-looking strategy focused on inspiring leaders in different sectors to take actions that set a course toward the water infrastructure of the future. The Framework for Change outlined in this report highlights the fact that there are readily accessible, feasible actions that can be taken to enhance sustainability and resilience regardless of the context. What is possible depends ultimately on the variables at play in a particular community or region. The Foundation intends to vet, refine and build out the initial framework into a strategy that identifies means for moving systems along the pathway in ways that are sensitive to challenges and opportunities at the local level.

By leveraging The Johnson Foundation’s convening capacity, this phase of Charting New Waters will generate, synthesize and disseminate ideas about the characteristics of a new paradigm for water infrastructure and how to transition to it. Future convenings and engagement activities will focus on Phases II and III of the Framework for Change – i.e., Transition to More Resilient Systems and Implement Transformative Systems. Our primary emphasis will be on filling knowledge gaps and fostering connections between key issues and those stakeholders whose involvement is critical to achieving the goal of sustainable and resilient U.S. water infrastructure systems. Among the questions we intend to explore in future convenings are:

- What does it take to create the regulatory and financial flexibility necessary to test innovations?
- What kinds of incentives will motivate utilities to tackle fundamental building blocks for greater sustainability and resilience (e.g., vulnerability assessments, GHG inventories, etc.?)
- What role can stormwater play in urban water supply management?
- What are the opportunities to collaborate or coordinate with other sectors to implement infrastructure-related freshwater solutions?

We look forward to continued collaboration with our colleagues and partners to address these questions and others that will help chart the course to the water infrastructure of the future.

There are readily accessible, feasible actions that can be taken to enhance sustainability and resilience.
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Endnotes

1 A list of participants who attended the April 17–19, 2013, meeting is included in the Appendix.


6 See http://www.wucaonline.org for information about the Water Utility Climate Alliance, of which water utilities in Seattle, San Francisco, New York City and Tampa are members.


9 See http://www.phillywatersheds.org/what_were_doing/green_infrastructure for more information about the Philadelphia Water Department’s green infrastructure initiative and http://projectgroundwork.org for more information about Project Groundwork, a program of the Metropolitan Sewer District of Greater Cincinnati.

10 See http://willamettepartnership.org for more information about the Willamette Partnership.


12 See http://www.dcwater.com/highusage/default.cfm for more information about DC Water’s High Usage Notification and Automatic Meter Reading system.

13 See http://www.sfwater.org for more information about the integration of water, power and wastewater services at the San Francisco Public Utilities Commission.