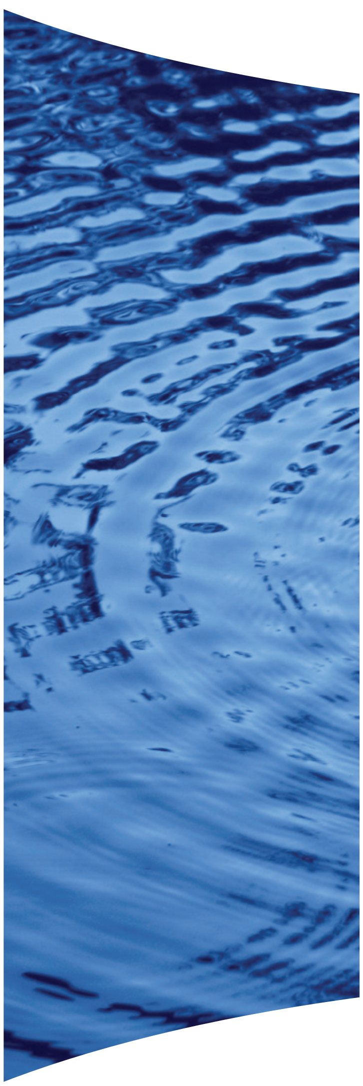
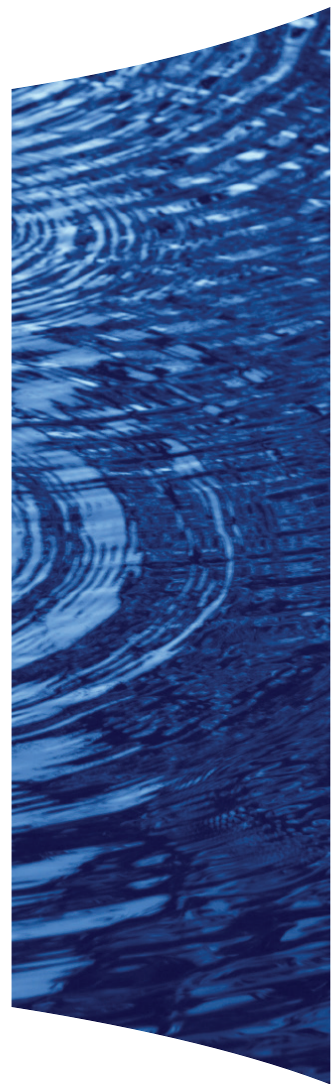
May 2014

Charting New Waters

Ensuring Urban Water Security
in Water-Scarce Regions of the United States





The Johnson Foundation
AT WINGSPREAD

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.

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Convening Report

Meeting Convened by
The Johnson Foundation at Wingspread
December 11–13, 2013

Contents

The Johnson Foundation AT WINGSPREAD

The latest phase of Charting New Waters is focusing on 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.

Partnership in Action

ReNUWIt and The Johnson Foundation worked in partnership to convene a meeting at Wingspread in December 2013 on the topic of urban water security in water-scarce regions of the United States. Meeting participants represented the diverse interests and perspectives The Johnson Foundation sets out to engage through Charting New Waters, including scientists, researchers, engineers, utility managers, federal and state regulators and members of advocacy groups. ReNUWIt and The Johnson Foundation are working to increase understanding of potential solutions to the nation's urban water security challenges and encourage decision makers at the local, regional and national levels to accelerate movement toward sustainable and resilient water infrastructure.

Conferences that Inspire Solutions

Letter from the Director

What implications does chronic or episodic water scarcity have for our nation's urban water infrastructure, and what impediments to new water supply options must be overcome to ensure water security for U.S. cities into the future? Along with our partners at ReNUWit, The Johnson Foundation assembled an array of experts from different parts of the country to examine these questions. We aimed to take the conversation about water scarcity and security beyond the typical place-by-place, crisis-by-crisis conversations to evoke broader thinking about what cities can do to transform their water supply infrastructure and management strategies. The conversation, held at Wingspread in December 2013, is summarized here in our latest Charting New Waters report.

Having lived most of my life in temperate regions of the United States, true water scarcity is not part of my personal experience. But the summer of 2012 brought heat and drought to Wisconsin that was a wakeup call for many. It seems that no place is immune to at least occasional episodes of water scarcity, and some regions of the country are in a chronic state of shortage. And all too frequently the proposed solutions focus on developing "new supply." But when you get down to it, the most sustainable approach is learning to be wiser with what we have. This report captures the outcomes of the December 2013 meeting in four main sections:

- **Principles** for water security,
- **Components** of a comprehensive conservation and efficiency strategy,
- **Innovative** water supply options, and
- **Building** the case for transformation.

Many of the technologies and management solutions highlighted in this report have been around for a long time, but have not necessarily penetrated all regions equally. What may be common practice in one area is quite novel in another. Similarly, the difference between water needs and wants is not easily defined. Is water for outdoor irrigation a need or a want? Is a four-minute shower luxuriously long, or harshly short? Is the public ready for directly reusing treated wastewater? And just how low can residential water use go without diminishing quality of life? Is 40 gallons per person a reasonable goal, or can we aim for the 25 gallons per person that some in the group testified was quite doable?

Needless to say, this conversation was not the final word on the subject. Whatever a region's source of water concern – be it chronic drought, dropping water tables, changes in snowpack or degradation of supply – one thing is for sure: These are tough problems that are best solved with collective, long-term thinking. That's what we tried to do with this report, and we hope that it can be of use in your work.

With thanks to all who participated in the meeting and the creation of this report,

Lynn Broaddus
Director, Environment Programs
The Johnson Foundation at Wingspread

Introduction

Demand for freshwater is exceeding natural supplies in nearly one in ten watersheds in the United States, an imbalance that is expected to continue and potentially increase as natural supplies decline in some regions.[1] Headline news routinely reminds us that vast regions of the country, encompassing many of our nation's largest urban areas, are at the mercy of vulnerable water systems. After three compounding years of drought, the state of California and the cities that drive its economy face critical water shortages and the need for new strategies.[2] Texas, a state that historically has grappled with low rainfall, is looking at a future with even more severe drought and depleted groundwater supplies.[3] Water challenges are not, however, limited to the arid West. Portions of the Southeastern United States, which generally has ample rainfall, are also struggling to meet demands for water from its growing population. For example, over-pumping of groundwater and rising sea levels resulted in saltwater intrusion into the aquifers that supply the Tampa Bay region in Florida and forced the area's water utility to diversify its supply portfolio.[4] In New England some municipalities have over-pumped groundwater to the point that rivers are drying up.[5] Cities, regions and the nation as a whole clearly need to embrace new solutions to ensure water security into the future.

In December 2013, The Johnson Foundation at Wingspread partnered with ReNUWIt (the National Science Foundation's Engineering Research Center for Re-inventing the Nation's Urban Water Infrastructure) to convene a diverse group of experts to examine technical, public policy, regulatory, research and other institutional opportunities and impediments to securing urban water supplies in water-scarce regions of the United States.[6] The discussions covered demand-side and supply-side strategies with a focus on optimizing the use of available water supplies in lieu of building new conventional infrastructure projects (e.g., reservoirs, pipelines). Agricultural transfers and water trading were acknowledged as potential solutions for some places, but were outside the scope of this discussion. This report presents The Johnson Foundation's synthesis of the information, insights and ideas shared during this convening.

Principles for Water Security

As with all water challenges, the best strategies for ensuring secure water supplies for the nation's water-scarce urban areas will be local and context-dependent. There are no one-size-fits-all solutions. Decision makers must carefully examine available options and develop a portfolio that makes sense for their region and city. Nonetheless, common principles can help urban water managers and other decision makers evaluate the available alternatives and invest in those that are most likely to result in a sustainable and resilient water supply. The following principles for water security can serve as a filter when evaluating options and set the stage for the discussion of solutions in the balance of this report:

- **Pursue efficiency and conservation first**
- **Develop a diverse supply portfolio**
- **Account for climate variability in long-term planning**
- **Invest in local water sources**

Pursue Efficiency and Conservation First

Before investing heavily in infrastructure to tap new water sources, urban water utilities should make a concerted effort to optimize the efficiency of their existing systems and invest in efficiency and conservation programs to influence their customers' plumbing hardware decisions and water-use behavior. Fixing leaks and better managing water pressure in the distribution and delivery system can reduce water loss, effectively making a substantial amount of "new" water available. Thorough efficiency improvement measures in conjunction with cost-effective conservation initiatives can help sustain water supply from existing sources, postpone or eliminate the need to invest in expensive supply development projects and return water to rivers and aquifers.

Develop a Diverse Supply Portfolio

Developing a diverse and flexible portfolio of water supply sources is arguably the most important principle for urban water security. Rather than building large systems that depend on a single supply source, water utilities can enhance flexibility and resilience by developing multiple sources. Systems that rely heavily or entirely on a sole water source are more vulnerable to drought, contamination and other disruptions. Tampa Bay Water is an example of a utility that has taken measures to ensure access to multiple supply options (including groundwater, surface water, desalination and nonpotable reuse of wastewater) and redundant connections within their overall supply system.[7] Tampa Bay Water's ability to switch between sources as demand and availability shift over time reduces the risk of service interruptions and makes the system and the region's water supply more secure.

Account for Climate Variability in Long-Term Planning

Water utilities typically employ historical data on the severity and frequency of droughts in long-term planning. Given new predictions about future climate variability (e.g., dry regions getting drier, wet regions becoming wetter), utilities should be prepared to revisit and adjust their long-term plans to ensure a consistent level of service. Planners need to establish appropriate planning horizons that go beyond current or near-term scarcity concerns while considering scenarios in which drought conditions could be worse than any seen historically. Moreover, utilities should consider the potential for climate change to affect demand as well as supply, as some regions could experience climate-driven population changes.

Common principles can help urban water managers and other decision makers evaluate the available alternatives and invest in those that are most likely to result in a sustainable and resilient water supply.

Invest in Local Water Sources

To the greatest extent feasible, future investment in urban water systems should be aimed at securing supply from local water sources under the control of the community. Utilities should also strive to balance water withdrawals with returns over time to help sustain reliable water supply for their particular service area, as well as support regional water availability for other cities, agriculture and ecosystems.

Navigating Toward the Infrastructure of the Future: Diversifying Urban Water Supply

Robust water supply solutions will leverage existing infrastructure while also investing in the infrastructure of the future, with each utility taking an approach that makes sense for its unique water supply and demand and infrastructure circumstances.[8] The Framework for Change presented below reflects a continuum of change for the transformation of U.S. water infrastructure – from optimizing existing systems to implementing new, transformative approaches – recognizing the reality that change most often occurs incrementally, but not necessarily in linear fashion. Specifically, it shows examples for each phase of change derived from the December 2013 convening.[9]

Figure 1: Framework for Change: Urban Water Security Examples

PHASE 1
Optimize

Image courtesy of iStock

Example: After an assessment of priority assets and a water audit, repair leaks and repair or replace severely degraded system components to reduce water loss and increase overall operational efficiency.

PHASE 2
Transition

Image courtesy of Inland Empire Utilities Agency

Example: Incorporate stormwater capture and managed aquifer recharge infrastructure into the water supply system. This strategy can provide nonpotable water for outdoor irrigation and augment local drinking water supplies while reducing polluted runoff into surface waters.

PHASE 3
Full Transformation

Image courtesy of ReNUWIt

Example: Reconfigure wastewater treatment by constructing networks of small-scale, distributed treatment plants that produce water of various quality levels to fulfill different purposes, including potable drinking water, at the site or neighborhood scale. Such systems offer flexibility for capital investment because they can be built in phases as development progresses and can be right-sized for the number of customers they serve. They can also reduce energy use and costs for treatment and distribution.

Components of a Comprehensive Conservation and Efficiency Strategy

Water supply planning and service delivery in water-scarce regions of the United States requires a combination of conservation and efficiency and supply development. As highlighted in the principles for water security and the Framework for Change on page 4, conservation and efficiency are the first areas on which water utilities should focus to extend existing supply. Conservation and efficiency strategies can take a variety of forms, but they are generally a challenge for water utilities because achieving water savings ultimately requires changing behavior and values. In addition, data regarding actual indoor and outdoor water use are frequently scant, which makes tracking the effectiveness of initiatives difficult and expensive. Nonetheless, the benefits of conservation and increased efficiency are well documented, with the resulting water savings constituting "new" local supply.

Generating substantial water savings from conservation and efficiency requires a broad strategy that encompasses indoor and outdoor water use and addresses the overall operational efficiency of the water delivery system. The strategy should include a balance of continual demand management measures along with emergency measures reserved for times of severe water shortage. While water supply crises tend to grab the public's attention and help garner cooperation in meeting conservation goals, research has shown that usage tends to creep back toward pre-crisis levels once the shortage breaks, unless changes in habits are rewarded and reinforced or become customary.[10] State law is one way to catalyze conservation and efficiency initiatives, as demonstrated by the California Water Conservation Act of 2009, which set a goal of reducing per-capita urban water use in the state by 20 percent by the end of 2020.[11] Regardless of whether a legal driver exists, it is important for utilities in water-scarce regions to maintain a comprehensive conservation and efficiency strategy comprised of the following elements:

- Optimize operational efficiency
- Encourage indoor water efficiency
- Stimulate outdoor water conservation
- Price water appropriately
- Inform customers about rationale for conservation measures
- Establish emergency response measures
- Engage partners to bolster utility efforts

Optimize Operational Efficiency

The first step water utilities can take to increase the security of their supply is to implement an asset management program and measures to increase the efficiency of their own operations. Through effective asset management, utilities can better track system components in need of repair and address those needs before the end of the components' useful lives.[12] Deploying information communications technology or smart sensors for leak detection and repair, for example, can reduce water losses from leakage and significantly bolster water supply, particularly when combined with annual water loss audits that sustain attention on the issue.[13, 14] DC Water in the District of Columbia, for instance 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. HUNA notifies customers by phone, text and/or email when the system detects a spike in usage.[15] Pressure management is another cost-effective and efficient strategy for controlling water losses from distribution systems.[16] In addition, infrastructure replacement is a critical component of operational efficiency, as it helps to ensure that new leaks in deteriorating parts of the system do not negate efficiencies gained in other areas.

Encourage Indoor Water Efficiency

Utilities can actively encourage reductions in indoor residential water use or allow reductions to occur through passive means. Passive demand management relies on the gradual replacement of outdated household appliances and fixtures, which occurs naturally over time. Water efficiency automatically improves as homeowners upgrade to products designed to meet current standards and codes, which are more water-efficient than their older counterparts.[17] While passive change makes a difference over time, utilities have a broad array of active demand management tactics at their disposal as well. Incentives such as rebates can be used to stimulate homeowners to replace inefficient appliances and fixtures, thereby accelerating retrofits that would have otherwise occurred passively over a longer timeframe. The WaterSense program of the U.S. Environmental Protection Agency (EPA) is the water sector counterpart to the EnergyStar program; it supports municipal-scale conservation by certifying water-efficient products and offering searchable databases of rebate offers across the nation as well as a database of WaterSense-certified products.[18] As an example, 20 water providers in the Atlanta area participate in the Metropolitan North Georgia Water Planning District's Single-Family Residential Toilet Rebate Program, which offers residential customers a $100 rebate on the purchase of toilets. Only approved, WaterSense-labeled toilets using 1.28 gallon per flush or less qualify for a rebate.[19]

While retrofitting existing homes and buildings is an important undertaking, new developments present opportunities to implement efficiency standards and plumbing codes that require high-efficiency appliances and fixtures from the outset. For example, certain water utilities are advocating for water ordinances that will require new developments to use the same amount or less water than existing developments in their service area. In 2013, Sierra Vista, Arizona, became the first community in the nation to adopt the U.S. EPA's WaterSense specifications for new homes.[20] Similar opportunities exist to influence commercial and industrial water demand. Since uniform building codes do not include a strong focus on water efficiency, water utilities must independently push for the institutionalization of such policies at the state or local level.

Stimulate Outdoor Water Conservation

Reducing outdoor water use presents perhaps the greatest challenges and opportunities for demand management. The majority of residential water use in many water-stressed communities is outdoor use, namely lawn watering, which means there is potential for significant water savings with altered behavior. However, the ways in which people use water outdoors on their property are often tied to deeply held values regarding personal liberty and aesthetics. Outdoor water needs and use also link with land-use planning and how cities grow, in terms of the design and size of homes and lots. Nonetheless, with the right strategy, there is potential for utilities to greatly extend water supplies through water conservation efforts aimed at outdoor use.

Altering landscaping practices can have a rapid and dramatic effect on water demand. Through education, outreach and incentive programs, utilities can provide ratepayers with a menu of low-water landscaping options suitable for their property – from low-irrigation lawns to complete xeriscapes with no lawn. In extreme situations, a municipality might consider banning lawn watering or lawns entirely. Utilities can also promote smart irrigation controllers to reduce unnecessary water use. These controllers act like thermostats for sprinkler systems, using local weather and landscape conditions to tailor watering schedules to actual site conditions.[21] For example, through its SoCal Water$mart program, the Metropolitan Water District of Southern California offers residential customers one dollar or more for every square foot of grass replaced with drought-tolerant landscaping, as well as rebates on water-efficient irrigation systems.[22] In addition to utilities or public agencies offering rebates, local planning departments can play a role by establishing land use codes that emphasize water conservation and developing communities in water-wise ways.

Price Water Appropriately

Well-designed rate structures and water pricing that reflects full operational and asset management costs can incentivize both indoor and outdoor water conservation, but generally outdoor use responds more quickly to price signals because of its discretionary nature. A 2013 water rates survey found that 65 percent of utilities in California were using inclining block rate structures to drive conservation, and 3 percent were using water budget rate structures, which are growing in popularity.[23] In 1991 the Irvine Ranch Water District (IRWD) in Irvine,

Figure 2: Ideas for Pricing Water to Stimulate Efficient Water Use

Image courtesy of iStock

As part of the December 2013 conference, a subset of participants developed the following ideas for pricing water to stimulate efficient residential, commercial and industrial water use:

- **Understand the utility revenue requirement** at the efficient level of customer demand, not just at the current or expected level of demand.
- **Collect more revenue than the revenue requirement** when demand is higher than the efficient level and where the excess revenue can then be used to fund water-efficiency programs to assist the inefficient customers. This must be done in a legal manner, which depends on state laws and is often complex. Also, the utility must be able to withstand periodic loss of revenue as demand declines without significant subsequent rate increases (e.g., by creating an adequate rate stabilization fund).
- **Set the top volumetric block rate** (or the single volumetric rate) high enough to drive water use down to the efficient demand level. Phased changes in the highest rate may be needed to get there without rate shock for customers. But failure to have a high enough rate at the volumetric margin means that pricing as a demand management technique is not being used effectively.
- **Establish excellent public communications** starting prior to implementation of the water pricing structure and continuously thereafter. At a minimum, the utility should explain the rationale behind the rates, how excess revenue or revenue shortfalls will be managed and that water-use efficiency is necessary to control long-term costs and rates.

For a discussion of water pricing strategies to maintain revenues while stimulating conservation, see *Declining Water Sales and Utility Revenues: A Framework for Understanding and Adapting, Alliance for Water Efficiency*, August 2012. Available online at: http://www.allianceforwaterefficiency.org/uploadedFiles/Resource_Center/Library/rates/Summit-Summary-and-Declining-Water-Sales-and-Utility-Revenues-2012-12-16.pdf.

For another discussion of water pricing strategies for conservation, see *Designing Water Rate Structures for Conservation and Revenue Stability,* University of North Carolina Environmental Finance Center, February 2014. Available online at: http://www.efc.sog.unc.edu/reslib/item/designing-water-rate-structures-conservation-and-revenue-stability.

California, instituted a water budget rate structure that was designed to reward customers who use water wisely and penalize inefficient water use. The five-tier structure allocates a reasonable amount of water to meet individual customer needs and property characteristics (i.e., number of occupants, size of irrigated area, climate). If a customer exceeds their allocated budget, the cost of water rises because the utility must purchase more expensive water to compensate for the overage.[24] After the IRWD implemented the tiered rate structure, average annual water use for residential customers decreased 7–8 percent.[25] Utilities must price water and design conservation-oriented rate structures carefully to ensure revenue stability and fairness as well as establish mechanisms to address affordability concerns for some customers.[26] Figure 2 on page 7 outlines principles, developed during the December 2013 Charting New Waters conference, for pricing water to stimulate efficient water-use behavior.

Inform Customers about Rationale for Conservation Measures

Demand management actions implemented by a utility should be supported by ongoing customer outreach and communications that clearly explain the rationale for the measures and the implications of doing nothing, as well as provide resources for action. Denver Water's award-winning "Use Only What You Need" campaign is a premier example of an effective demand management public information campaign. Initiated in 2006 with the aim of reducing customers' water usage 22 percent by 2016 from levels before Colorado's extreme drought of 2002, the campaign is comprised of billboards, bus signage and art installations. In conjunction, Denver Water offers an array of other programs and resources to stimulate conservation and efficiency among its residential and commercial customers, including a personalized water-use calculator, rebates, incentive programs, water audits, a car wash certification program, a soil amendment program and xeriscaping resources.[27] The communications campaign has evolved and continues today with the message of "Use Even Less." Denver Water customers now use about 18 percent less water than before the 2002 drought even when allowing for population for growth.[28]

Establish Emergency Response Measures

Utilities generally have standby measures for times of severe water shortage. Such measures can include mandatory restrictions on outdoor water use linked with the threat of punitive action (e.g., fines) and enforcement. In February 2014, for example, the city of Santa Cruz, California, instituted Stage 1 water restrictions, which forbade residents from watering lawns and gardens between 10 a.m. and 5 p.m., prohibited the draining and refilling of swimming

A Denver Water "Use Even Less" bus stop poster.

Image courtesy of Denver Water

pools, and required bars and restaurants to serve water only if specifically requested, among other measures. The city issued more than 800 citations to residents and businesses in the first days of the restrictions.[29] In cases of long-term exceptional drought, a local or state government may choose to ban most types of outdoor water use. In September 2007, for example, the state of Georgia imposed Level 4 drought restrictions that banned most types of outdoor water use in 55 North Georgia counties.[30]

Emergency demand management strategies typically require that a margin be maintained in the system for water savings in the case of an acute shortage. The need for such a margin causes some utility managers to raise concerns that continual conservation efforts will result in "demand hardening" – a hypothetical lack of future flexibility to institute water-saving measures that extend existing supply in times of shortage. No research to date has produced empirical evidence that demand hardening exists, yet it remains a concern. The concern implies a disincentive for encouraging conservation on an ongoing basis, but lack of flexibility would likely only occur if conserved water were reallocated to new growth rather than reserving it for times of scarcity.

Engage Partners to Bolster Utility Efforts

Water utilities must develop a broad strategy to engage partners that support and reinforce their own demand management tactics. Local planning departments and elected officials can be powerful allies in ensuring water-wise land use and community growth plans. Utilities can cultivate active support from the landscaping industry to help raise the visibility of conservation incentives and resources. For instance, the Texas Water Smart program is a public–private partnership largely sponsored by the landscaping industry that consists of nearly 300 businesses, associations, research organizations and state and local officials focused on raising awareness of ways homeowners and businesses can save water.[31]

Utilities can also engage the local business community in supporting demand management. Local chambers of commerce and economic development agencies can be useful in helping to manage the water footprint of a community because they influence the types of businesses that communities seek to attract. In El Paso, Texas, for example, the local business community worked with El Paso Water Utilities to facilitate a transition away from the water-intensive blue jeans washing industry toward less-water-intensive businesses.[32] Water-intensive businesses can also help manage demand in times of water scarcity. There may also be opportunities for water utilities to leverage energy utility conservation programs while raising awareness of the link between water and energy. A water utility may be able to leverage such partnerships, once established, to build coalitions in support of legislative efforts aimed at institutionalizing water efficiency. For example, Denver Water garnered support from the plumbing, wastewater and bathroom fixture manufacturing industries to advocate for and pass state legislation in Colorado that will prohibit the sale of plumbing fixtures that are not WaterSense certified.

Local planning departments and elected officials can be powerful allies in ensuring water-wise land use and community growth plans.

Innovative Water Supply Options: Opportunities and Challenges

The immediate and most obvious response to chronic or episodic drought is aggressive demand management, but to ensure long-term water security in a climate-impacted future, utilities must also build resilience into water supply storage and distribution infrastructure. The December 2013 group explored cutting-edge options that go beyond conventional infrastructure solutions, but suggested that utilities not abandon existing supply options entirely since water security is largely about diversification. Assuming water availability will remain constant or decrease in the regions of concern, participants focused on how cities can optimize their use of available water. A range of technological and management innovations are beginning to transform how urban water utilities and customers manage and use water. The December 2013 group discussed opportunities and challenges associated with the following options:

- Centralized water reclamation and reuse
- Urban runoff as supply
- Distributed water reuse
- Natural and engineered ecosystem services
- Desalination

Centralized Water Reclamation and Reuse

Reclaiming and reusing the same water multiple times is one of the most promising opportunities to extend existing water supplies and increase urban water security.[33] A variety of technologies and infrastructure systems exist today that can enable utilities to capture, treat and reuse water for multiple purposes, using either centralized or distributed systems. The most well-known centralized water reclamation and reuse facility in the United States is the Orange County Water District's (OCWD) Water Factory 21. Opened as a demonstration project in 1977, Water Factory 21 is a reverse osmosis treatment plant that converts reclaimed wastewater into drinking water for groundwater recharge. In 1991, after the plant met drinking water standards for many years, the OCWD received the first-ever permit from the California Department of Health Services allowing the reinjection of unblended, 100 percent reclaimed wastewater, with the stipulation that the facility continue to operate as a research and demonstration project.[34]

Despite the array of benefits water reuse offers, there remain several impediments to scaling up the adoption of such infrastructure systems. The most prominent challenge is negative public perception about the safety of reclaimed water, even though there is no scientific evidence that the intended uses of such water (potable or nonpotable) pose a threat to public health. However, perceptions are beginning to shift, as evidenced by the American Water Works Association's revised policy statement on the use of reclaimed water for supplementing public water supplies. The statement endorses the use of reclaimed water for indirect potable uses such as replenishing drinking water sources and managing aquifer levels, and suggests that direct potable reuse may be a viable option assuming appropriate treatment and public health safeguards.[35]

"Fit-for-purpose" or tailored water involves technologies and distribution systems that enable water utilities to tailor and direct water of different quality levels to safe and appropriate residential, commercial and industrial uses. The approach further leverages the shift away from the traditional default of treating all water to drinking water quality, and can be done with centralized or distributed systems. The West Basin Municipal District's Edward C. Little Water Recycling Facility in El Segundo, California, is a large, centralized plant that produces 30 million gallons of recycled, custom-made water of five different qualities daily that meet municipal, commercial and industrial nonpotable water needs (see inset for details). The only facility of its kind in the United States, it conserves enough drinking water to meet the needs of 60,000 households for a year, and has the flexibility to increase or decrease production of certain types of water depending on demand. In addition to conserving potable water supplies, fit-for-purpose systems can increase the efficiency of nonpotable water use, reduce energy consumption for wastewater treatment, reduce discharges of treated sewage and provide water to recharge groundwater aquifers.[36]

The lack of a regulatory framework for potable water reuse is another fundamental barrier to widespread adoption, as theoretically, potable reuse falls in between regulations stipulated by the Clean Water Act and the Safe Drinking Water Act. The U.S. EPA has provided extensive guidelines for nonpotable water reuse, but less guidance for potable reuse. In the absence of federal standards, Texas is moving forward with potable reuse using existing drinking water standards. More robust U.S. EPA guidance could advance the broader adoption of potable reuse.[37] Use of nonpotable reclaimed water (e.g., treated wastewater) is growing, but faces significant practical challenges because it is extremely expensive to retrofit existing water distribution systems and households with dual plumbing ("purple pipes").[38, 39] New development or major redevelopment projects present more attainable opportunities to design and implement dual systems, which could be linked with existing distribution systems. Establishing national standards for gray water may facilitate the broader adoption of dual distribution systems and increase public acceptance of water reuse.[40]

Delivering Tailored Water


Image courtesy ofWest Basin Municipal Water District

The West Basin Municipal Water District's Edward C. Little Water Recycling Facility (ELWRF) is the largest water recycling facility of its kind in the United States and was recognized by the National Water Research Institute in 2002 as one of only six National Centers for Water Treatment Technologies. The ELWRF is the only treatment facility in the country that produces five different qualities of "designer" or custom-made recycled water that meet the unique needs of the West Basin's municipal, commercial and industrial customers. The five types of designer water include:

1. Tertiary Water (Title 22), for a wide variety of industrial and irrigation uses;
2. Nitrified Water, for industrial cooling towers;
3. Softened Reverse Osmosis Water, which is secondary treated wastewater purified by micro-filtration, followed by reverse osmosis and disinfection, for groundwater recharge;
4. Pure Reverse Osmosis Water, for refinery low-pressure boiler feed water; and
5. Ultra-Pure Reverse Osmosis Water, for refinery high-pressure boiler feed water.

See http://www.westbasin.org/water-reliability-2020/recycled-water/water-recycling-facility for more information about the Edward C. Little Water Recycling Facility.

Urban Runoff as Supply

Cities may be able to leverage the rainfall they receive to supplement their locally controlled water supply. At the site level, rainwater can be captured and used with building-scale systems, while larger quantities of stormwater or urban runoff can be managed to gradually recharge urban aquifers. To effectively use urban stormwater runoff as water supply, city planners will have to reimagine how to design and build cityscapes, treating them as water infrastructure to capture, infiltrate and manage runoff. Increasing the permeability of the urban landscape with low-impact development and green infrastructure is a more dispersed approach to recharging aquifers and bolstering instream river flows. Some cities are also now working toward channeling mass quantities of stormwater into catchments in a more concentrated manner, the greatest challenge of which is storage. In some places where rainfall is sparse and comes in large bursts, storage facilities must be large enough to capture the bulk of major storms. Surface storage pits are the least costly option, but it's likely that most cities will have a limited number of sites with adequate capacity. Tanks and pumping systems are another storage option, but are extremely costly. In Burbank, California, the proposed Rory M. Shaw Wetland Park will convert a 46-acre construction debris landfill into a multipurpose park that will feature a storm drain system and large detention pond for stormwater capture, a wetlands area for stormwater treatment, and recreational open space. The treated stormwater runoff will be pumped to existing underground infiltration basins at an adjacent park for groundwater recharge.[41]

To effectively use urban stormwater runoff as water supply, city planners will have to reimagine how to design and build cityscapes.

In addition to physical constraints, some regulatory and policy barriers currently inhibit the widespread use of stormwater for supply. In Colorado, capturing rainwater and interrupting it from reaching surface waters conflicts with key tenets of state water law. In Texas, water intended for reinjection into aquifers must be of potable quality. Advancing the use of urban runoff as supply at scale will require policy and regulatory changes, as well as interjurisdictional coordination to develop effective institutional structures and management strategies. Moreover, by coupling stormwater capture with groundwater recharge, this supply source could contribute to a diversified portfolio, since it may then contribute significantly to water security in drought years.

Distributed Water Reuse

The integration of decentralized or distributed water treatment and delivery systems represents a new frontier in urban water security. As cities and utilities seek efficient, cost-effective solutions to water supply challenges, distributed systems that can be right-sized for different purposes, spatial scales and segments of ratepayers may become attractive alternatives to conventional, centralized capital projects. Distributed systems can be implemented along a continuum from those that are linked to centralized systems and serve several thousand customers, to those that serve households that are entirely off the grid.

New development on the outer fringe of urban areas offers opportunities to implement distributed systems and potentially create self-sufficient residential developments, rather than extending centralized systems. Distributed reuse technologies reduce pumping costs and could help meet increasingly stringent regulations that require developers to show that new development will have an adequate and sustainable water supply. Building-scale water reuse systems are beginning to emerge, such as the wastewater recycling system at the Solaire Building in New York City that recycles 25,000 gallons of water on-site 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.[42] Distributed technologies for tailored water are also under development. The Colorado School of Mines has developed a small-scale "package" wastewater treatment plant that can generate more than 6,000 gallons of nonpotable water a day; the water is suitable for irrigation in the summer, groundwater recharge in the winter and toilet flushing year-round.[43] Systems like this could potentially also produce potable water if fitted with different membranes or combined with other small "point-of-use" treatment systems that produce clean drinking water at the tap.[44]

The broad adoption of distributed systems hinges on overcoming the challenge of achieving economies of scale while ensuring dependable service, meeting environmental regulations and protecting public health (e.g., from waterborne illness) and safety (e.g., adequate pressurized water for firefighting). For instance, some commercial developers in Seattle are seeking to construct buildings with independent, closed-loop water systems, which is forcing Seattle Public Utilities and other public agencies to examine the regulatory implications of such projects as well as what backup water services they might require.[45] One potential management solution is that the existing water or wastewater utility could expand its infrastructure portfolio, range of services and management approach to encompass decentralized components, in addition to its more conventional systems. However, utilities must consider the possible costs associated with components of the centralized system that may no longer be needed (e.g., stranded assets). In terms of public safety in areas relying on decentralized water systems, it may be possible to use nonpotable reclaimed water for firefighting. The most likely scenario is that cities will begin to link distributed components with their existing centralized systems, creating a hybrid form of water infrastructure.

Natural and Engineered Ecosystem Services

While surface water, groundwater, wetlands and other natural ecosystems have long been used to provide urban water supplies, there remain untapped opportunities to integrate or mimic natural systems as part of urban water supply infrastructure. Water utilities can and should leverage the services provided by both natural and engineered ecosystems to diversify their water supply portfolios and supplement urban water supplies in innovative ways. These emerging practices point to a broader conception of urban water infrastructure that encompasses forests and wetlands, managed aquifer recharge and the integration of natural filtration processes. For example, a January 2014 study recommended that the state of Massachusetts adopt a land use planning scenario that labels forests "living infrastructure" that provide a range of benefits, including improved water quality and flood control.[46]

There remain untapped opportunities to integrate or mimic natural systems as part of urban water supply infrastructure.

Filtration provided by the vegetation in natural or engineered wetlands can provide passive water treatment that helps bring effluent-laden surface water back to drinking water quality and increase local control of urban water supply, while using very little energy and sequestering carbon. Since 1992, the OCWD has been operating one of the most sophisticated managed aquifer recharge systems in the world along the Santa Ana River in California. The extensive system uses both surface water diversions and treated wastewater to replenish a locally controlled groundwater aquifer.[47] First, about half of the base flow of the effluent-dominated Santa Ana River is diverted through the OCWD's Prado Constructed Wetlands, a system of 350 acres of treatment ponds that mimic the characteristics of natural wetland ecosystems. A network of levees, weirs and pipes control water flow through the ponds, where the water goes through a series of natural treatment processes that remove nitrogen and other pollutants such as pharmaceuticals from tertiary-treated wastewater.[48] The water is then returned to the main stem of the river, and downstream it is diverted again to the manmade Anaheim Lake, where the water percolates back into the aquifer under the urbanized part of Orange County.

In Aurora, Colorado, the Prairie Waters Project combines engineered and natural processes. Water is pumped from wells near the South Platte River and delivered to a manmade basin area where it is filtered by percolating through natural sand and gravel. The water is then piped to a state-of-the-art facility where it is treated to potable quality. Since 2010, this hybrid of natural and engineered treatment has allowed Aurora Water to convert effluent-dominated surface water from the South Platte River into drinking water supply. The project has enabled Aurora to further develop water resources to which it already owns rights, and the natural purification process eliminates waste discharges back into the river as well as greatly reducing the need for more energy-intensive filtration.[49, 50]

The key hurdles to the widespread use of natural and engineered ecosystem services to supplement water supply are technical, scientific and regulatory. Technical challenges include the need for adequate physical space as well as the need for sites with certain geographic and geochemical characteristics. Seasonal variability can pose scientific challenges in terms of gauging the rate of natural filtration processes, as the biological mechanisms at work tend to slow down during colder months, which could affect regulatory compliance. Therefore, certain regulations may require adjustment to account for the unique performance characteristics of natural water treatment processes.

The Peter D. Binney Water Purification Facility, part of Aurora Water's Prairie Waters Project.

Image courtesy of Aurora Water

Desalination

More utilities are turning to desalination as a "drought-proof" option for supplementing water supplies. In some coastal cities seawater desalination is being used. For example, Tampa Bay Water's plant produces 25 million gallons per day (MGD) of drinking water, and San Diego County Water Authority is on track to start producing 50 MGD of freshwater in 2016 with its Carlsbad Desalination Project.[51, 52] Inland water utilities are beginning to use technology to make brackish groundwater suitable for drinking. El Paso Water Utilities' Kay Bailey Hutchison Desalination Plant, the largest inland desalination plant in the world, produces 27.5 MGD of freshwater. The facility has diversified the utility's water supply portfolio and increased freshwater production by 25 percent.[53]

Desalination is a viable option in certain locations, but there are significant transaction costs to be considered. Initially there may be high design, permitting and construction costs, and then also high operating costs, with energy being the single largest expense involved in operating a desalination plant.[54] The cost of these facilities can become unsustainable if the projected water demand (and associated revenue) for which the plant was designed does not materialize. In addition, there are regulatory uncertainties associated with intakes that feed seawater desalination plants.[55] For example, environmental concerns about the impingement and entrainment of marine organisms in open ocean intakes caused the California Coastal Commission to delay a permitting decision for a desalination plant proposed to be built in Huntington Beach, with the Commission requesting further study of alternative intake designs.[56]

Urban Water Security: Building the Case for Transformation

Innovative demand management and water supply strategies have been implemented successfully in a number of places across the United States, but many cities in vulnerable parts of the country have yet to plan for sustainable and resilient water supplies in a climate-impacted future. Meeting participants emphasized that state regulators, mayors and other local decision makers need the support and encouragement of their constituents to pursue forward-looking water infrastructure projects, and that leading water utilities, technical experts and advocates should help cultivate that political buy-in. To build the case and change mindsets, the approach must illuminate the transformational possibilities that exist while attending to the practical realities decision makers face. Building a strong case for transforming urban water infrastructure to achieve water security in water-scarce regions of the United States requires that we:

- Demonstrate solutions
- Highlight compounding benefits
- Minimize financial and political risk
- Create policies that enable innovation

Demonstrate Solutions

Elected officials, utility managers and other decision makers in regions prone to chronic or episodic water shortages need to be informed about the range of water supply options available today. They need to see how these options work and understand why they are safe and cost-effective. The best way to achieve this understanding is through implementing and visibly promoting demonstration projects (for either demand management or supply side solutions) that are producing tangible results in the form of enhanced potable or nonpotable water supply. Demonstrations make the options real and help local decision makers become conversant about available technologies and management strategies. For example, public officials from around the world have visited Orange County's Factory 21 and returned home touting the technology and its benefits. That experience and knowledge equips them better to generate the public acceptance they

Elected officials, utility managers and other decision makers need to see how these options work and understand why they are safe and cost-effective.

need to proactively pursue innovative supply projects and to seize opportunities to push for innovation when water shortages occur.

Highlight Compounding Benefits

Discussion of the benefits of innovative water supply solutions must go beyond a commodity-oriented analysis. Rather than focusing solely on how much new water will result, the discussion needs to encompass the primary and secondary environmental, economic and social benefits that stem from a secure water supply and related infrastructure. First, water security can be directly tied to future economic vitality and the well-being of any community, and in fact these are the most powerful arguments for a diversified water supply. Tools are lacking to quantify social and environmental benefits, but it may be possible to develop qualitative criteria that expand the range of costs and benefits that communities consider when conducting water supply alternatives analysis. For example, criteria could be developed around aspects of community resilience (e.g., local control of water resources) and enhanced amenities and quality of life (e.g., new parks, green spaces or water features).

Financial incentives can help minimize risk and encourage decision makers to consider new options for diversifying their water supplies.

Minimize Financial and Political Risk

Elected officials and utility managers tend to be averse to taking risks that could expose them to financial pitfalls or political backlash from ratepayers. Financial incentives can help minimize risk and encourage decision makers to consider new options for diversifying their water supplies. For example, the Texas Water Development Board (TWDB) will issue loans under the State Water Implementation Fund for Texas program, with at least 20 percent of the allocated funds dedicated to conservation and water reuse projects. The program offers to subsidize up to 50 percent of the interest rate available to the TWDB for projects that meet criteria related to enhancing the resilience of local water supplies.[57] It is also critical to engage ratepayers in the consideration of water supply alternatives through transparent public involvement processes. In California, for instance, the Department of Water Resources mandates that all water suppliers providing more than 3,000 acre feet of water or serving more than 3,000 connections must develop an Urban Water Management Plan that assesses the reliability of water supplies over a 20-year time horizon.[58] By law, water providers are required to involve diverse stakeholders in the development of the plan, which fosters political support for future supply projects.

Create Policies that Enable Innovation

Regulatory compliance is another risk factor water utility managers must manage. Policies that create regulatory flexibility are crucial to building the confidence of risk-averse decision makers to pursue the implementation of innovative water supply technologies and strategies. At the federal level, emerging water supply solutions such as water reuse and managed aquifer recharge straddle the Clean Water Act and the Safe Drinking Water Act and demand examination of how to bridge the gap or create flexibility that will enable broader adoption. One possible mechanism could be to adapt the policy of regulatory assurances established by the U.S. Department of the Interior and U.S. Department of Commerce under the Endangered Species Act (ESA). That mechanism gives nonfederal property owners assurances that they will be exempt from future regulatory obligations if they take early action to implement conservation best practices to protect species that are proposed for ESA listing as threatened or endangered, are candidates for listing or are likely to become candidates in the near future.[59] If the U.S. EPA were to provide similar assurances regarding the implementation of validated water reuse and aquifer recharge systems, that could help accelerate their adoption.

State environment departments can also play an important role in fostering innovation. The Massachusetts Department of Environmental Protection (MassDEP), for example, created a tiered permitting process to encourage the use of state-approved innovative or alternative wastewater treatment technologies. To ensure that the unconventional systems will protect public health and the environment, MassDEP uses a three-tiered approval process for new technologies (piloting, provisional use and general use) and shares responsibility with local health boards for final approval of each installation. Efforts to create enabling policies at the municipal level include the Leaders Innovation Forum for Technology, a program of the Water Environment Research Foundation and Water Environment Federation that is exploring mechanisms that would allow multiple municipalities to pool resources and share the costs and risk associated with demonstration projects.[60]

Conclusion: Positioning for the Future

Water supply crises are looming in cities across the United States as populations grow, natural supply dwindles and climate change exacerbates trends already in motion. In many places it will take a severe crisis to catalyze a transformational leap. In others, visionary leadership may overcome inertia. Regardless, the water sector and decision makers need to be positioned to offer viable, validated solutions that will transform urban water infrastructure in water-stressed cities and put them on a path to long-term water security. To prepare for the moment of opportunity, water sector leaders need to develop a persuasive story about the potential severity of future water shortages, the consequences of a business-as-usual approach to water supply and demand planning, and the benefits of new water supply options. Demonstration projects will continue to create opportunities to conduct policy analysis and develop recommendations to establish the regulatory certainty water utilities and elected officials need to move forward with innovative projects. Perhaps the most important point to convey is that the sooner cities commit to investing in the water infrastructure of the future, the more cost-effective those investments will be, because the problems cities face today will only be more expensive to fix down the line.

The sooner cities commit to investing in the water infrastructure of the future, the more cost-effective those investments will be.

The December 2013 conference generated a number of thought-provoking questions that warrant concerted research and further exploration:

- What are the ultimate limits of conservation and efficiency? What is an attainable water demand management goal for utilities to strive for? For example, is it possible to achieve less than 30 gallons per day per capita for indoor use? What would it take to get there?

- What are the best ways to ensure the greatest conservation and efficiency in the outdoor use of water? What policy and technical options are the most feasible for reducing outdoor water use significantly on a long-term basis?

- How can the water sector use social science research methods to collect data and better understand ratepayers' attitudes toward water supply and toward their indoor and outdoor water-use behavior?

- What is the true state of the nation's water supply, especially groundwater levels? How much groundwater are we transferring to the ocean through wastewater discharge?

- Why are proven but unconventional water supply technologies not being implemented more widely in water-scarce regions of the United States? What are the most persuasive environmental, economic and/or social arguments to catalyze widespread adoption?

- How can urban water utilities integrate rural natural systems more explicitly under the rubric of urban water management and infrastructure? Could a broader approach facilitate both urban water security as well as watershed-scale environmental restoration?

The reality of diminishing water supplies in some of the nation's most populous regions demands creative thinking and problem solving. The December 2013 Charting New Waters conference generated practical ideas about how cities and utilities can think about and seek to achieve urban water security in the face of water scarcity. A variety of innovative demand management and water supply solutions are already in place and enhancing sustainability and resilience in communities across the nation. Now is the time to break down the remaining barriers to their adoption and ensure that urban water security is attainable everywhere.

Participants on the veranda of The House, The Johnson Foundation at Wingspread, December 13, 2013

Image courtesy of The Johnson Foundation at Wingspread

Appendix: Meeting Participants

December 11–13, 2013 Meeting

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