WATER RESOURCES UTILITY OF THE FUTURE

2015 Annual Report

NACWA

Water Environment Federation

WERF

WATEREUSE

Foreword

The National Association of Clean Water Agencies (NACWA), the Water Environment Federation (WEF), the Water Environment Research Foundation (WERF) and WateReuse would like to extend extra special thanks to the following individuals for their extensive contributions to this report:

- Tim Braun, Enterprise Architect, EmNet, LLC
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- Francesca McCann, Founder and President, Global Water Strategies, P_3 Advisory
- Marcelo Moacyr, President and Chief Executive Officer, Odebrecht Environmental, Inc.
- Logan Olds, General Manager, Victor Valley Wastewater Reclamation Authority, CA

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This publication was developed with the assistance of Kenneth Rubin, Managing Director, Rubin Mallows Worldwide Inc. and Managing Partner, American Infrastructure Holdings LLC.

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Executive Summary

In the summer of 2013, the National Association of Clean Water Agencies (NACWA), the Water Environment Federation (WEF), and the Water Environment Research Foundation (WERF) collaborated on *The Water Resources Utility of the Future: A Blueprint for Action.* The *Blueprint* coined the phrase, "Utility of the Future," to recognize for the first time, a fundamental shift in the way America's clean water utilities were beginning to define their role in society: from managers of waste to managers of valuable resources. Early movement towards the UOTF enabled the *Blueprint* to document examples of UOTF initiatives in energy and materials recovery and reuse, water reuse, green infrastructure, and a new openness on the part of clean water utilities to partner with developers of technology, design engineers, and the public and private finance community.

The Business Case for the Utility of the Future

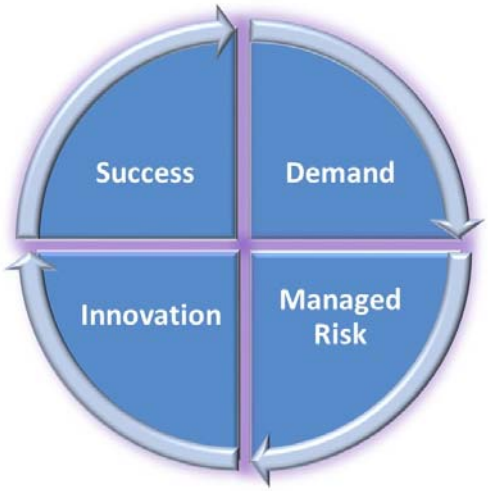
The business case for the UOTF was shown to be compelling. Utilities reduced costs, increased revenues, and helped build local economies, which in turn created demand for clean water services, increasing revenue even further. Utility leaders took on broader stewardship roles for their communities and local watersheds. The environment benefitted through cleaner effluent; reduced demand for carbon-based energy and fresh water; greatly reduced greenhouse gas emissions; reduced runoff and flooding by controlling more water at its source; greater beneficial reuse of biosolids; and creation of greener and healthier urban ecosystems. Communities also enjoyed multiple benefits in the form of economic expansion, increased local job opportunities, and higher tax receipts.

Emergence of an Innovation Ecosystem

This *2015 Annual Report of the Utility of the Future* updates UOTF accomplishments since 2013 and explores the newest horizons for innovation. But it also makes a key point – *clean water utilities do not make these sorts of transitions alone*. Innovation across the clean water value chain has occurred within an "innovation ecosystem" comprised of technology developers, consulting engineers and scientists, government, the finance community and a wide range of professional organizations that represent the clean water sector. In addition to the *systems effects* where clean water utilities innovate with the help of both partners and enablers within this ecosystem (see graphic at right), *network effects* also help utilities innovate based on the ideas and experiences of their peers.

The Innovation Ecosystem

These *systems and network benefits* are materially responsible for creating a virtuous cycle in which innovation leads to success, and success spreads across the sector leading to more adoption and enhanced demand for innovation. Increased demand stimulates technology development and engineering advances, which result in a growing portfolio of UOTF success. In a sense, this innovation ecosystem behaves like a market for innovation -- and like any market, it is fueled by demand. The cycle will continue as long as UOTFs continue to lead, to take risks, to collaborate, and to create demand. Sustained demand will have the effect of spreading innovation across large, medium, and small utilities from coast to coast and the cycle will continue.



Virtuous Cycle: Manage Risk, Innovate, Succeed, Demand

Recent Utility of the Future Initiatives

The pace of innovation in the clean water utility sector is on the rise and the value of making the UOTF transition is now much clearer than it was in 2013. Specifics of what to do and how to do it will continue to be defined utility by utility, but these decisions also have firmed up considerably since 2013. Some of the most exciting advances go beyond one-off initiatives to a complete embrace of utility-wide UOTF strategies that seek to optimize energy, nutrient, and water use and reuse; collaboration with non-traditional partners to secure lower-cost water quality gains; and integration across all built and natural assets at the watershed scale. Here, landowners are involved as key partners in green infrastructure solutions, the agriculture community is involved as a key partner in nutrient management, and building developers are involved as key partners in water retention and reuse. Collection infrastructure becomes an extension of treatment infrastructure, and advanced monitoring and control networks are used to manage all water within a watershed to meet customer needs as well as water quality goals.

Advances in Technology

Increased demand, faster adoption, and broadening awareness of UOTF initiatives have renewed investment in clean water technology development. In particular, we are seeing greater acceptance in the US of technologies and solutions from other countries. This is particularly true in anaerobic digestion and membrane-based processes. Real-time data networks are being used much more frequently to monitor and control entire collection and treatment systems in efforts to manage more flow at lower costs using existing infrastructure. Leading edge utilities are incorporating natural environmental resources like streams, ponds, and wetlands into their overall control networks reducing management costs even further while also delivering social and community benefits.

Engineering Consulting

Utility clients are increasingly asking engineers to manage risks, not avoid them. This greatly broadens engineers' license to innovate with bolder designs, broader choices of technology, and greater involvement in design-build and design-build-operate opportunities. To meet new client expectations, consulting engineers now have to collaborate more often within the innovation ecosystem, reaching out to community groups, technology developers, the finance community, and the government. This has tended to accelerate

knowledge transfer and the pace of technology adoption -- all positive outcomes for the UOTF. It also has resulted in solutions that deliver environmental and social benefits that reach more people.

The Finance Community

Innovations in clean water financing are occurring everywhere as finance institutions transition to meet demands of their UOTF clients. Two trends are most striking: more rational public finance structures and a growing level of comfort with true public-private partnerships. Examples of the former include the advent of the "century bond" concept to finance and spread the cost of 100-year infrastructure over the multiple generations that will enjoy their benefits; social impact bonds where so-called "impact investors" seeking social as well as economic returns are willing to risk their capital to promote what many consider unproven technologies and solutions as long as they deliver social good; and small systems financing by third party impact investors.

We also are seeing broadening applications of public-private partnerships beyond the traditional long-term concession type transactions where utilities own, but private investors do everything else: design, build, finance, operate, and maintain system infrastructure or major portions of it. "Bolt-on" projects are becoming popular where private vendors finance, build, own, and operate a separate capital facility as long as the utility agrees to a long-term contract to purchase the commodity – energy, water, fertilizer – that it produces. Community-based P3s engage a broad spectrum of community organizations, sometimes aggregated under a private third-party contract, to install and maintain green infrastructure at thousands of locations across a city.

Professional Organizations

Since 2013 the major professional organizations representing the clean water sector have made great strides in their UOTF programs. This includes NACWA, WEF, and WERF – all of which were involved in the original *2013 UOTF Blueprint* – as well as WateReuse, which focus on water reuse, a key option for the UOTF. NACWA's principal contribution has been in advocacy for UOTF matters at the federal and state levels, where it has been responsible in part for passage of key legislation, a more flexible regulatory regime, support for watershed-based initiatives, and focused funding where it is most needed. WERF has stepped up its LIFT technology innovation program and research funding considerably in areas that matter most to UOTFs: one-water management, green infrastructure, energy self-sufficiency, and technology innovation. WEF has done the same in areas such as utility leadership, technology innovation, energy and resource recovery, residuals and biomass, stormwater (e.g. through STEPP: Stormwater Testing and Evaluation of Products and Practices), green infrastructure, and evaluation of regulatory barriers to innovation. WateReuse and its research arm have funded more than 200 projects pertaining to water reuse over the last two decades and, in the last few years, have emerged strongly as a leader in direct potable water reuse.

Government: Going Beyond Regulation

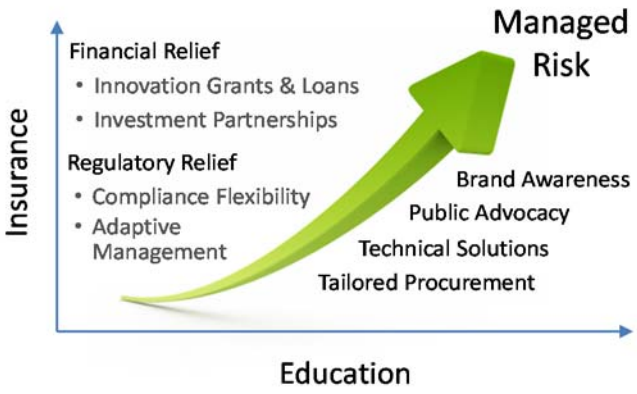
Aside from its traditional role in matters of environmental regulation, EPA and its state counterparts are increasingly supporting UOTF initiatives through targeted grants, technical assistance and guidance, and flexibility (in some cases) on permitting approaches and compliance periods. Some states are participating with local governments in programs that support UOTF initiatives with ordinances that require water use efficiency and reuse and/or green infrastructure. In recent years we have seen about a dozen new state and local centers of water technology development and commercialization, many with support from EPA's "Water Clusters" program, including one of the most advanced US consortiums in Milwaukee.

And EPA is not alone. The Department of Energy, the U.S. Department of Agriculture, the Department of the Interior's Bureau of Reclamation, the National Science Foundation, the U.S. Department of Commerce's National Oceanic and Atmospheric Administration, and the Department of Housing and Urban Development are all getting involved in supporting UOTF goals.

Looking Ahead

In just a few short years, the UOTF brand has been firmly established and momentum continues to build. Since 2013, we have observed broad penetration of UOTF initiatives across the top tier of the sector and formation of an "innovation ecosystem." An historic opportunity now exists to strengthen the systems and network effects within this ecosystem, which promise to deliver the next generation of water quality gains and community benefits at costs that customers are able and willing pay. The solution to how we do this is remarkably, but at the same time deceptively, simple: *enable utilities to take more risks.*

Insurance (risk sharing) and education are the two most important tools at our disposal to provide the space for managed risk taking. Insurance, in the form of shared financial responsibility and/or shared regulatory responsibility, relieves utility leadership and technology providers of bearing *all* the consequences of bold decisions. Education provides utility leadership confidence that bold new ideas can work in practice.



To shift some of the burden of financial recourse from UOTFs and therefore from their customers to others, we will need some combination of federal and/or state grants to effectively reduce capital exposure; true P3s where private partners risk their own capital to enable innovation; developers that push their technologies into the marketplace either directly or through channel partners like technology-forward consulting engineers; and institutional investors with a UOTF conviction that targets environmental and social impacts as well as economic returns.

With regard to regulation, we have observed that more regulation, especially of the "one size fits all" variety, is generally unproductive. It is inappropriate to back off water quality goals, but it is entirely appropriate to enable UOTFs to find innovative ways to meet them. When these conditions exist, we have observed that UOTF leaders tend to collaborate with, and encourage through whatever means at their disposal, cooperative behaviors of non-traditional partners like the agriculture community, homeowners, and developers.

In short, we must collaborate more. We must take – and manage – risk. We must ensure that all participants within the clean water innovation ecosystem broaden network effects to include utilities of all sizes. And we must strengthen system effects by engaging all participants – utilities, technology developers, consulting engineers, the finance community, and government – in UOTF successes. More than anything, this is the key lesson of the last two years documented in this *2015 Annual Report of the Utility of the Future*.

I. Introduction and Overview

Use of the term "Utility of the Future" draws attention to a profound change in the way today's clean water utilities have begun to think and act.

Traditionally, clean water utilities collected wastewater from homes and businesses, moved it as quickly as possible downstream, removed harmful pollutants, and discharged effluent and managed residuals in compliance with environmental requirements. The traditional utility saw itself and acted as an environmental and public health steward by managing potentially harmful waste streams.

In addition to their stewardship role, UOTFs see themselves as managers of valuable resources: water, energy, nutrients, organic solids, and their own real assets including land, buildings, and horizontal surfaces. By managing these resources effectively and efficiently, UOTFs can generate value for themselves, for the communities they serve, and for the environment. Innovation, entrepreneurism, and a new willingness to collaborate with others are fundamental to the creation of value.
In our initial work completed in mid-2013, NACWA, WEF, and WERF provided details and many specific examples of such innovation leading to value creation, including for example:

- Generation of renewable energy;
- Materials and nutrient recovery and reuse,
- Water and biosolids reuse,
- Energy generation, and
- Green infrastructure.

Since 2013 the phrase "Utility of the Future" has caught on, but more to the point, UOTF initiatives have grown substantially and today, examples can be found nationwide and at both large and small utilities.

Emergence of an Innovation Ecosystem

Multiple UOTF players are now coalescing to form what can best be described as an "innovation ecosystem." With clean water utilities at the center, the combined contributions of technology developers and providers, design engineers, management consultants, the finance community, regulators, professional associations, and governing boards produce a whole greater than the sum of their parts. Together, these enterprises create an environment of innovation that enables utilities to capitalize on the sum of all contributions (creating systems benefits available to the entire sector) as well as opportunities for learning among themselves (creating network benefits, also available to the entire sector).

How do they do this? There is little debate that over the last few years, clean water utilities have matured in their willingness to innovate. We have labeled the outcome, the "Utility of the Future," but while utility leadership has demonstrated increasing willingness to adopt new ideas and technologies, utilities have not made this transition in isolation. Developers have pushed hard to

get their technologies up to scale and replicated across the US market; the engineering community has responded with bolder designs; the finance community has shown a willingness to adapt its models to embrace new public, private, and public-private finance alternatives; and government regulators and other bodies have begun to experiment with more flexible approaches to meet legislative and regulatory mandates that also enhance local economic development and deliver green spaces. Utilities are partnering with others at the watershed scale, often bringing the public, industry, and agriculture together to support local actions and commitments to watershed protection efforts.

Working together as a system, all these entities enable utilities to be more innovative. In addition, clean water utilities are networking and learning from each other and from the professional organizations that promote and monitor advancements across the sector. These systems and network benefits are materially responsible for creating a virtuous cycle in which innovation leads to success, success spreads across the sector leading to more adoption and enhanced demand for innovation. Increased demand stimulates technology development and engineering advances, which result in a growing portfolio of UOTF success. The cycle continues.

Along the way, perhaps with a bit of a time lag to digest the new normal, both the regulatory and finance communities find it in their mandate and best interest to adapt to serve emerging demands from clean water utilities. Regulators are beginning to accommodate clean water utilities by de-risking UOTF initiatives that deliver water quality solutions beyond the borders of their own institutions and/or that need extended compliance periods to accommodate solutions with strong double and triple bottom line outcomes. The public finance community is similarly stretching traditional financial instruments to accommodate these new long-term, decentralized solutions. In an innovation ecosystem, impact investors in particular are increasingly supporting utilities that integrate technical, managerial, and financial solutions that deliver public benefits while enabling a reasonable return on private investment.

The UOTF transition has clearly begun, but as a nation, only a small fraction of utilities – the so-called early adopters – are engaged in this process. In particular, medium and smaller clean water utilities have yet to embrace many of the UOTF opportunities pioneered by some of their larger counterparts. The rest of the world is also moving along a similar trajectory, so there is much to learn not only from our own domestic networks, but from international networks. Ample opportunity exists for innovation and UOTF activity in the US well into the future.

Organization of this 2015 Annual Report

This *2015 Annual Report of the UOTF* highlights contributions since 2013 of six key sectors that together comprise the UOTF innovation ecosystem:

- Clean Water Utilities,
- Water Technology Developers,
- Engineering and Consulting Firms,
- Public and Private Finance,
- Federal, State, and Local Government, and
- Professional Organizations.

The final section of this *Annual Report* draws out the major insights from each of these sectors on what's working and where more help may be needed to accelerate innovation and deliver more value to utility customers, their communities, and the environment.

II. The Utility of the Future: Brand and Reality[1]

Many have written about the attributes of successful, progressive clean water utilities. And to be sure, attributes like bold leadership, analytical rigor, triple-bottom line decision making, and stakeholder engagement are key. But sitting at the core of an innovation ecosystem, perhaps the greatest strength of Utilities of the Future is their ability – and willingness – to share intellectual property. Collaboration unleashes powerful network benefits that are unavailable or at best, limited, to participants in most other types of markets. It transforms typically inward looking utility organizations into open laboratories whose results are shared and increasingly accepted quickly and widely across the sector. This section explores these concepts by examining the stories of several UOTFs. It also suggests ways to strengthen the power of shared intellectual property among like-minded enterprises. Finally, this section discusses ways to broaden penetration across the sector at any scale, but especially to push innovation more effectively to medium and small utilities.

Selling the Utility of the Future Brand

Why isn't wastewater sexy? It has all the right precursors: money, political intrigue, and a colorful history. Yet the sector remains relatively low profile. The UOTF brand changes all this – it enables managers of waste to rebrand themselves as managers of valuable resources and has the power to transform faceless public servants into involved community leaders and protectors of the environment and public health that provide services that people want and will pay for. It enables conservative equipment operators fixated on what has always worked to transition into technology-forward innovators that demand triple bottom line results from technology developers and design engineers.

UOTFs do this by exercising their central role in the innovation ecosystem and sharing their successful brand -- because their future depends on it.

Importance of Brand:
The Case of Bottled Water

In 2009 at the height of the recession Americans spent $21 billion on bottled water, a product that hardly existed a decade or so before that. Nationwide we spent only about twice as much that year, $46 billion, on all the water consumed in our homes and in commercial and industrial enterprises. The bottled water brand went from zero to $21 billion a year because it was pitched as safe, healthy, and convenient — pretty simple. Moreover, the competing product — centrally provided water — was never called unsafe or unhealthy, though bottled water marketing campaigns certainly implied this. Drinking water utilities for the most part did not interpret their mandate to differentiate their product on the basis of convenience. Whether or not bottling water is an opportunity for utilities is certainly open to debate, but the revenue implications are profound and more important, the branding lesson is critical: centrally supplied water is every bit as safe, healthy and tasty — more so according to many independent comparisons — as bottled water. The only difference is packaging and branding.

Drivers of Innovation in the 21st Century

A number of factors – regulations, fiscal pressure, and a changing climate, among the most important – will push UOTFs to take more risks and innovate going forward. Regulatory requirements have always pushed the sector to produce a better quality product and they will continue to play this role over the coming decades. The difference today, however, is that in the majority of watersheds, clean water utilities are not the major, or in many cases, even a significant source of water quality impairment. Where they are, regulations clearly will have a role in helping achieve statutory clean water goals. Where they are not, regulatory alternatives that enable

[1] NACWA, WEF, WERF, and WateReuse wish to thank Logan Olds for his contribution to this chapter.

UOTFs to work with other dischargers or that promote flexible and more innovative and lower cost approaches to utility compliance should take on a more important role.

Fiscal pressure will push utilities to better align costs and revenues, to seek new sources of revenue, and to reduce costs wherever possible. Prior work on the UOTF documented multiple examples of these outcomes. On the revenue side, examples abound in recovery of heat and energy in biosolids, reuse of treated effluent for non-potable and increasingly potable water supplies, extraction and conversion of nutrients in wastewater into fertilizers and soil conditioners, and use of land and buildings to house solar collectors and/or wind turbines to create electricity. In addition to continuous productivity improvement programs, on the cost side, UOTFs are experimenting with lower-cost procurement methods and innovative partnerships with private providers, treatment technologies from around the world and advanced monitoring and control technologies to minimize energy, chemicals, and labor costs.

Extreme weather events linked to climate change create all new challenges and opportunities for the UOTF. Increasing demands to handle wet weather flows and inundation of low-lying infrastructure will put increasing pressure on capital budgets and in some cases, only increased investment in civil works projects solve these sorts of problems. In other cases, however, UOTFs are increasingly turning to green infrastructure solutions to reduce costs and generate community benefits like green space, reduced urban flooding, and increased property values.

Recent UOTF Initiatives in the Clean Water Utility Sector

Consider the following utility examples to illustrate these points.

Large Utilities

City of Los Angeles – LA Sanitation. In its "Green Blue City of Los Angeles One Water Management Program," LA has taken one of the boldest and broadest UOTF approaches of any major US city. Working together, the LA Sanitation (LASAN) and its sister agency the LA Department of Water and Power (LADWP) are using their authorities to manage the city's wastewater, stormwater and drinking water as a single resource to maximize use of recycled wastewater, harvest rainwater, capture and reuse stormwater, restore local groundwater supplies, increase water conservation, and create green urban spaces. By 2034, imported water will be cut in half. Instead, recycled water will account for 8% of total water use compared to about 1% today; water conservation will reduce demand by 9%; stormwater reuse will account for 4% compared to nothing today; and local groundwater will be tapped for 16% compared to 11% today.

Like many large urban utilities, LA has enlisted the technical help of the engineering and consulting community, private developers, federal and state government, and the finance community. Use of technology like "smart" residential sprinkler controllers coupled with financial incentives promoting use of water conserving appliances will cut residential water use by about 50,000 acre-feet a year by 2030. Large-scale urban watershed stormwater capture and reuse programs will deliver another 62,400 acre-feet a year by 2025. Conversion of industrial land, parking lots, gravel pits, and other paved land parcels throughout the city – about 45 projects in the current plan – into wetlands, urban parks, greenways, and vegetative areas will help the city meet water quality requirements for local receiving waters, control urban flooding, create recreation and wildlife habitat benefits, reduce heat island effects, increase adjacent property values, and recharge the city's groundwater resources. City

leadership is supporting this initiative with among other things, a new ordinance that requires all private development in excess of 500 square feet to retain stormwater on site for beneficial use.

LASAN also generates about 7 million cubic feet of biogas from its anaerobic digesters at their Hyperion treatment plant, enough to meet all steam and power requirements to run the facility. In the first and only commercial pilot of its kind, LASAN has pumped about 260 million gallons of slurry biosolids about a mile underground into a depleted formation to use the earth's natural heat for rapid digestion. The pilot, which won the 2011 WERF award for excellence in innovation, has sequestered more than 19,000 tons of carbon dioxide (the equivalent of 4,500 cars worth of emissions in a year). It has also eliminated more than 16 tons of nitrogen oxide emissions and 15 tons of carbon monoxide as a result of reduced traffic from avoided trucking. Moreover, the pilot saves about $1.6 million in biosolids management costs and over time, will become a renewable source of methane to be used to generate electricity while reducing greenhouse gases on an on-going basis.

Cincinnati Metropolitan Sewer District. The Cincinnati Metropolitan Sewer District (MSD) has expanded its award winning Project Groundwork program aimed at reducing environmental and public health threats from wet-weather events to an even more ambitious "Communities of the Future" program. Project Groundwork, which won the US Water Alliance 2014 Water Prize, is a multi-year, $3 billion initiative including both traditional grey and new green infrastructure approaches that will save the city about $200 million over the next 20 years compared to a pure grey infrastructure CSO solution. Recognizing that a program of this magnitude has the potential to change the urban landscape, MSD is now reaching out to the community it serves to explore ways to re-imagine and plan for a city and its neighborhoods that uses less power, minimizes life-cycle costs, and creates more livable urban spaces. The plan also would seek to serve as a catalyst for investment in sustainable communities more broadly to include in addition to new ways of managing water resources, new forms of mass transit, energy use, building practices, land development, and solid waste management.

This program will do more than just "fix a sewer." MSD is using this opportunity to partner with community leaders and private developers to find smart, sustainable solutions that improve the quality of life in Cincinnati. MSD has devised a four-step program to work with other city service providers and the communities they serve: (1) data compilation and analysis of natural and built assets within the watershed; (2) identification of opportunities and constraints (as well as costs and benefits) to smart, sustainable solutions; (3) selection of grey and green infrastructure solutions in collaboration with public and private partners that maximize community benefits; and, (4) creation of the basic design and triple bottom line business case with city and community partners in preparation for implementation. As it reached out to the first few Communities of the Future, MSD drew on successful UOTF solutions from around North America: Kalamazoo, MI; Vancouver, BC; Seattle, WA; Hutchinson, KS; St. Paul, MN; Kansas City, MO; Oklahoma City, OK; Jeffersonville, IN; Lenexa, KS; Lowell, MA; Charlottesville, VA; and Indianapolis, IN.

DC Water. DC Water, the combined water retailer for Washington DC, and clean water wholesaler for the Washington DC metropolitan region, offers one of the best examples of cross-sector, international collaboration. With 60 tanker trucks of biosolids generated every day and limited space at their treatment plant, DC Water could not accommodate a standard anaerobic digester solution. Instead, they turned to a new Cambi digester technology from the UK that uses high pressure and temperatures to accelerate the digestion process using considerably less space, less time, and less energy to create methane. The challenge was to prove to DC Water's Board that the technology could work in the US

and at the unprecedented scale needed in DC. By partnering its own research team with local universities and smaller operating plants in the UK to prove the science and economics of a Cambi process at DC scale, DC Water convinced its Board to spend $460 million to build the first Cambi digester in the US. When it comes on line in 2015, DC Water's Cambi plant will generate 13 MW of energy and halve the volume of biosolids trucked offsite, saving the utility $10 million a year and reducing the utility's carbon footprint by one-third. Better still, the new process will be cash-flow positive in its first year of operation and will pay off the $460 million bond in 14 years. With a facility life of at least 50 years, ratepayers will enjoy decades of positive economic and environmental returns on their investment.

Hampton Roads Sanitation District. The Hampton Roads Sanitation District (HRSD) in Virginia Beach, VA, has implemented many UOTF innovations including biosolids reuse and advanced nutrient recovery, which were documented in the *2013 UOTF Blueprint*. Less well known is that the utility has saved the 17 localities and 1.6 million people it serves simply by thinking and acting regionally. The District and its localities became the focus of wet weather enforcement actions in 2005 and 2007. As each locality tried to preserve as much treatment capacity for their individual use it became clear that a regional approach was required. HRSD intervened with the regulators and was able to negotiate an extension on enforcement actions to allow for development of a regional compliance plan. Ultimately the District, in collaboration with its localities, accepted full responsibility for regional wet weather capacity in perpetuity which will save the ratepayers over $1 billion over the next 20 years. HRSD's environmental stewardship of the watershed in conjunction with their regulatory partners created the opportunity for all sides to benefit.

Medium and Small Utilities

Some medium and small utilities also are taking on UOTF initiatives. This is especially true of utilities that work closely with their governing boards enabling them to be nimble in the marketplace.

Victor Valley Wastewater Reclamation Authority. The Victor Valley Wastewater Reclamation Authority (VVWRA) in Victorville, CA began its energy production goals to stop paying $40,000 a month in natural gas bills, while at the same time flaring methane. One project built the foundation for the next. Today the 12.3 million gallons per day (MGD) conventional activated sludge facility nitrifies and denitrifies, has tertiary filtration and UV disinfection, and is energy positive. VVWRA no longer relies on natural gas and is producing more electricity from biogas than it can use on site. VVWRA accomplished this with the first US installation of a European technology, Anaergia's Omnivore high-solids digestion process, retrofitted into existing infrastructure, funded in part by the California Energy Commission's (CEC) Public Interest Energy Research (PIER) program. This technology tripled biogas production with no expansion of infrastructure capacity. And since the facility was built and is owned, financed, operated and maintained by the technology vendor, VVWRA had virtually no capital exposure.

Colorado River Municipal Water District in Big Springs TX. Other small utilities stand as examples of how drought conditions have created opportunities for direct potable reuse. After a decade of research and with considerable public endorsement, in 2013 the Colorado River Municipal Water District in Texas became the first public utility in the US to supply treated wastewater effluent at drinking water standards, in this case 2 MGD, as a source of direct potable water for their community. This $14 million microfiltration/reverse osmosis/ultra-violet disinfection plant supplies about 20% of the utility's raw water for further processing in its drinking water treatment plant. According to the National Academy of Sciences, a little more than one-third of all municipal wastewater discharged in the US could be

reused with no impact on existing water rights holders, substituting for some 27% of all centrally supplied drinking water in the US.[2]

Hill Canyon CA Treatment Plant. The 9.5 MGD Hill Canyon Treatment Plant (HCTP) serving Thousand Oaks, CA produces 15% of its energy needs from solar photovoltaics and the remaining supply from biogas, making the plant 100% energy self-sufficient and saving about $400,000 in electricity costs each year. The HCTP had government and private partners in these initiatives: both solar PV and biogas projects were funded by the California Public Utility Self Generation Incentive Program (SGIP) grants totaling $2,000,000. Both projects are owned by third-party private sector owners who designed, built, financed, own and operate the facilities (e.g., there were no public dollars spent constructing these projects). Moreover, HCTP takes in fats, oils, and grease from the surrounding community making about $400,000 a year in revenue from this service and boosting the plant's methane output. HCTP also sells nearly all of its effluent for agricultural irrigation, netting the plant another $1 million a year in revenue. Reclaimed water has substantial regional benefits by reducing groundwater pumping and preventing sea water intrusion in the Oxnard Plain.

Leadership, Collaboration, and Partnerships: Keys to the Innovation Ecosystem

What are the central opportunities and lessons emerging from these examples? It is certainly not a question of *whether to act* as there are ample incentives to do business differently. There are clear regulatory pressures, fiscal incentives, water scarcity concerns, and extreme weather events sufficient to move the entire sector. Moreover, it is not a question of *what to do* or *how to do it* – branding has been shown to be a powerful way to share information about methods and successes.

The main lesson is about the innovation ecosystem: the keys to continued innovation include more and better leadership, collaboration, and business partnerships. Subsequent sections of this *2015 UOTF Annual Report* explore what these concepts mean and how to use them.

[2] National Research Council, Water Science and Technology Board, National Academy of Science, *Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater,* The National Academies Press, Washington D.C., 2012.

III. Clean Water Technology: Development, Testing, Adoption[3]

Judging by the uptick in attention to technology innovation since 2013 from both government and the clean water professional organizations, it is clear that the pace of technology development and adoption is on the rise.

Subsequent sections of this *2015 UOTF Annual Report* cover technology innovation activities of the EPA, WEF, and WERF in such areas as energy from wastewater and biosolids, nutrient recovery and reuse, water reuse, renewable energy generation, and green infrastructure.[4]

This section will review in more depth the emergence of another class of technologies that offer great promise for effective and efficient wet weather solutions: real-time data networks. The net effect of these real time data networks can be dramatic: 80-90% reduction in dry and wet weather overflows, reduced CSO control costs by factors of 20-30, increased capacity utilization of existing infrastructure, and 30-40% reductions in capital expenditures to meet long-term control requirements.

Real Time Data Networks

Real time data networks enable clean water utilities to optimize the performance of all or portions of grey and green infrastructure as a network. Some networks also monitor and control natural and constructed ecosystems like streams, ponds, or wetlands as integrated components of a combined natural/built environment for control of wet weather flows. These networks typically monitor and upload via the cloud data on weather, flow, water quality and other parameters, which are then made available to smart decision support systems that take automatic actions or to operators that take manual actions based on system recommendations. Data are accessed typically via any web-enabled device or via the utility's existing SCADA system. Field monitoring devices like sensors or equipment actuators, especially in remote locations are powered by solar collectors.

Real-Time Data Networks

Real time data networks can be designed to generate productivity and performance improvements at three scales:

- The collection network alone,
- The collection network and treatment works as an integrated system, and
- All built and natural water and wastewater elements within a watershed.

In most utilities, collection systems represent 70-80% of all assets and they often represent the greatest untapped capacity to manage dry- and wet-weather flows and produce significant reductions in operating and capital budgets. Productivity enhancements in the collection system also can have profound clean water outcomes since wet weather flows account for much of the remaining water quality challenge at clean water utilities that have combined sewer systems or that are responsible for stormwater management. Because of these factors, many UOTFs focus first on real time data networks for collection systems.

[3] NACWA, WEF, WERF, and WateReuse wish to thank Tim Braun for his contribution to this chapter.

[4] See for example: http://www.nacwa.org/images/stories/public/2013-01-31waterresourcesutilityofthefuture-final.pdf

Typically, the next step is to integrate monitoring and control of the combined collection and treatment infrastructure. Some UOTFs are taking this one step further by including all grey and green infrastructure.

The most forward thinking of UOTFs often go well beyond the boundaries of their own infrastructure to address more efficient ways of managing water quality at the watershed scale. At this scale, monitoring and controls integrate the built environment with the natural ecosystem to achieve high performing, highly livable urban ecosystems, as well as influence upstream and downstream watershed behavior (agriculture/other cities).

To accomplish their objectives, these UOTFs deploy real time data networks to manage flow and quality using combined gray and green infrastructure, constructed and natural aquatic ecosystems, and low impact development. With the advent of real time data networks connected to flow, level and rain gauge sensors; the convergence of civil engineering and control systems engineering; real time control of gates, pumps, valves and other assets; and real time decision support systems that can deliver global watershed understanding, control and optimization – UOTFs that have been dreaming of these things are now empowered to bring these visions to life.

The following examples demonstrate how a handful of UOTFs have used real-time data networks to achieve remarkable outcomes.[5]

Metropolitan Sewer District of Greater Cincinnati

Metropolitan Sewer District of Greater Cincinnati (MSD) has one of the most challenging collection systems in the country. It overflows some 11 billion gallons of raw sewage into the Ohio River and its tributary waterways every year. US EPA has mandated that Cincinnati, like most combined sewer cities in the U.S., reduce overflow volumes at each CSO, with the objective of improving the water quality of all receiving waters in MSD's service area. The budget for MSD's 20-year Long Term Control Plan is roughly $3.5 billion.

The Superintendent of Watershed Operations for MSD set the agenda: to *operate the entire collection system as an extension of the treatment plant* – e.g., with the same level of real time data and controls as the treatment plant, to optimize available treatment capacity. Subsequently, she took her vision a step farther, "*We want to operate the entire watershed with the same level of understanding, control and optimization as we do at the treatment plant.*"

One extensive watershed project, for which MSD has commissioned design and is close to launching construction, is the Lick Run Valley Conveyance in the Lower Mill Creek basin. MSD will daylight several creeks and streams that were built over in the past, which will remove their flows from the combined sewer and free up treatment capacity at the plant. This project will recreate natural, surface waterways, enabling the ecosystem to restore itself and provide the community new green space to enjoy. After installation of real-time monitoring and control networks in the sanitary sewers and the newly created natural waterways, MSD will have real time understanding, control, and opportunities to

[5] The following companies contributed examples of their work in this field: American Structure Point, Arcadis, Black & Veatch, CDM Smith, CH2M, EmNet, GeoSyntec, Greeley and Hanson, Limnotech, McCormick Engineering, MWH Global, OptiRTC, TetraTech

optimize how the built environment (particularly the sewershed infrastructure) interacts and cooperates with the natural watershed. Once completed, this project will remove hundreds of millions of gallons of storm water from the sewer system while vastly improving watershed operations, water quality and livability of this critical basin in Cincinnati. The project is a lower cost alternative to the deep tunnel mitigation strategy originally prescribed in Cincinnati's long term control plan.

Figure 1 - Lick Run Valley Conveyance Project

In the winter of 2015 MSD completed a series of projects to update and improve the operating logic governing real time control (RTC) assets throughout the Lower Mill Creek basin. Several of the RTC sites showed improved performance on an isolated basis, as well as provided evidence of further enhanced return on investment, were MSD to manage all RTC assets on a coordinated basis. MSD will now coordinate and dynamically optimize the operation of all RTC assets throughout Mill Creek. When complete and operated as a network, RTC technology will reduce overflows by hundreds of millions of gallons a year at a cost 20-30 times less than traditional deep-tunnel solutions.

Another project in MSD's queue is to increase the diameter of underflow lines at as many as 51 CSO regulators in the 56 square mile Little Miami basin. MSD will outfit each of the underflow lines with automated valves, controlled on a coordinated, globally optimal basis in real time and in response to each storm event. While this effort is in the early stages, based on similar investments elsewhere in their own system and in South Bend Indiana (see below), MSD is confident annual CSO management costs will be on the order of $0.01- $0.05/gallon, or 20-30 times less than the cost of traditional approaches.

South Bend, Indiana

South Bend, Indiana, home to the University of Notre Dame, is also home to a real time decision support system (RT-DSS) that spans much of the city's 20 square miles of combined sewers, making it perhaps the most intelligent sewer system in the world. In 2008, the City of South Bend installed and commissioned a real time monitoring system of more than 120 sensor locations. In 2012, the city installed and commissioned a distributed, globally optimal real time control system consisting of 9 auxiliary throttle lines with valves. South Bend's RT-DSS enables operators to manage wet weather flows to maximize conveyance capacity via SCADA, smart phones and tablet PCs.

Since 2012, the city has added additional sensor locations and rain gauges bringing the total number to 142 sites. It also added automated gates at several stormwater retention basins to better control when and at what rate stormwater is released downstream into the combined system.

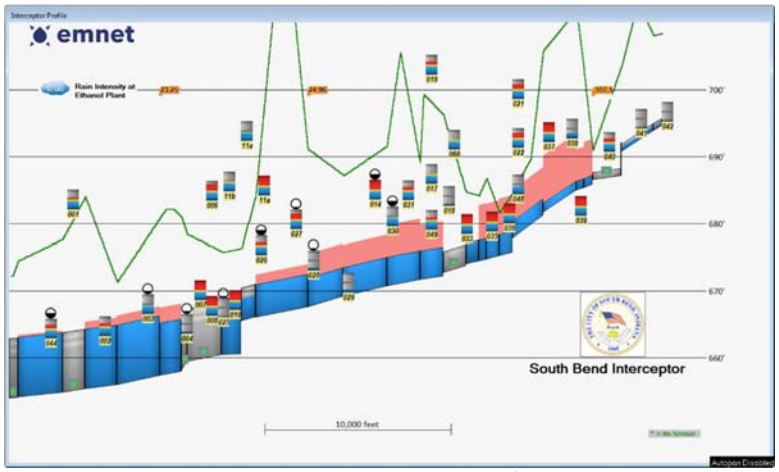


Figure 2 - South Bend's Interceptor Profiler Dashboard

From 2008 to 2014 South Bend eliminated illicit dry weather overflows (DWO) (previously 27 DWOs per year on average) and reduced its total CSO volume by roughly 70% or about 1 billion gallons a year in just the last 6 years. About half of the reduction in overflow comes from preventative maintenance and real time collection system understanding, delivered by the sensor network and user-interfaces. The remainder comes from the globally coordinated RTC system. The city also discovered through its RT-DSS that it was treating on average 10-12 MGD (roughly 25% of normal dry weather flows) of river water that was intruding the sewer system via CSO outfalls, a problem that has since been rectified with backflow prevention valves. This fix alone saved ratepayers more than $1 million a year.

The City believes there is much more benefit to be gained from the city's RT-DSS approach. In fact, in 2014 the City decided to seek modification of its consent decree with the Department of Justice and US EPA to allow the city to rewrite its long term control plan since it no longer needed half or more of the capital assets originally required. If successful, the city will reduce its CSO control budget by 50% or roughly $250-300 million.

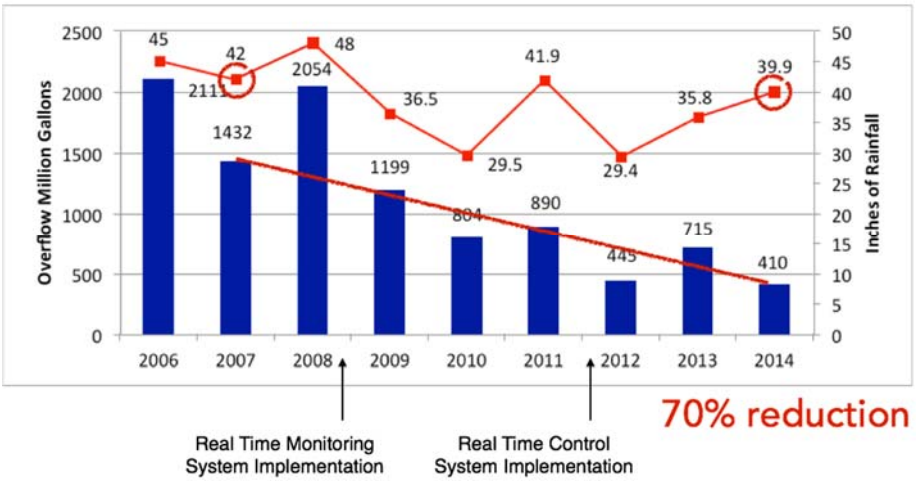


Figure 3 - South Bend annual rainfall versus overflow volume

The next phase of projects involves interconnecting trunk lines to one another upstream of the interceptor, which will create 5-10 MGD of additional conveyance capacity all the way to the plant,

where a large wet weather tank will attenuate flows to the plant. An RTC system of flow sensors and controllers to optimize in-line CSO weir heights will enable the city to greatly increase inline storage and conveyance of existing infrastructure.

Grand Rapids, Michigan

Grand Rapids, Michigan is one of the largest cities to transform their previously combined sewer system to a separated sewer system. The city has spent roughly $350 million over the last 17 years building new storm sewers and upgrading sanitary sewers to meet the city's Long Term Control Plan, as required by the Michigan Department of Environmental Quality. Having separated their sewers, Grand Rapids is no longer permitted any overflows whatsoever, so it is essential that the city observe and understand in real time the performance of its infrastructure and its effects on the health of local waterways.

To accomplish this, the city commissioned a sensor network of 120 Hach flow monitors and rain gauges to collect data in real time. This system processes and visualizes all data on a hydraulic dashboard, informs maintenance crews of grit buildup and other blockages forming in the sanitary system, and identifies areas and potential sources of infiltration and inflow.

The city uses LiquID Zero Angle Photon Spectrometers to monitor in real time 20 nutrients/pollutants at each stage of treatment at the wastewater treatment plant. With plant performance isolated by process, operators can trace precisely the water quality profile of effluent released into the Grand River.

The next phase of the LiquID project is to measure the real time water quality of the Grand River upstream and downstream of the city. Having comprehensive real time knowledge of the city's impact, positive or negative, on its watershed, will enable the city to optimize performance of its built infrastructure and deliver consistent water quality benefits to the community.

Columbus, Ohio

Years of modeling and planning to manage wet weather flows in Columbus resulted in *Blueprint Columbus*, the City's master plan for managing stormwater throughout the urban environment. It combines green and grey infrastructure with some of the most sophisticated real-time monitoring and control technology anywhere in the US. The Columbus real time decision support system (RT-DSS) will enable the city to observe and control how its infrastructure and the natural environment perform before, during, and after rain events so that operators can maximize conveyance, storage, and treatment infrastructure to save the city money while greening neighborhoods. The RT-DSS will be the platform to collect, concentrate and tune all operational knowledge, control logic and wisdom from operators, utility leadership and consultants.

The first phase RT-DSS design began by balancing excess flows from Columbus' Jackson Pike Wastewater Treatment Plant (WWTP), which treats combined sewer flows from the older/downtown area of the city, with its much larger Southerly Plant, which primarily treats sanitary flows from residential areas of the city. The interconnector sewer line between these plants serves as a dynamic conveyance and storage system. Travel times for flows from Jackson Pike to Southerly can exceed 2.5 hours, and so to optimize capacity at both plants with minimal risk of overflow, particularly at Southerly, a predictive algorithm processes, condenses, and delivers flow and storage data at various points in the network to operators at both plants recommending the ideal volume of flow to transfer.

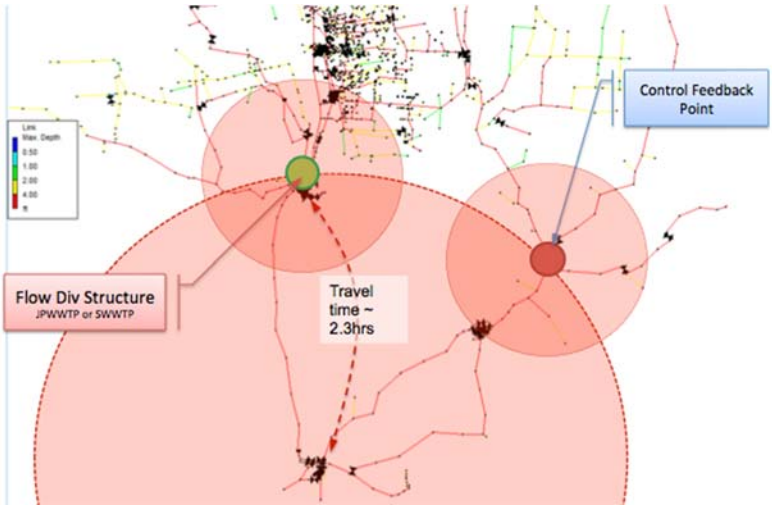


Figure 4 - Columbus Time Shift Optimization

In its next phase, Columbus' RT-DSS will globally optimize and control the entire collection system, extracting the highest level of conveyance and storage value from all assets, including the future deep tunnel system, storm tanks, inline storage locations, and neighborhood-based green infrastructure. Both WWTPs – the most expensive, complex and valuable assets owned by the utility – will be fully utilized and optimally managed in large part by tuning the collection system as an extension of the treatment plant. The RT-DSS also will minimize overflows and strategically select overflow locations to minimize environmental effects when such overflow is unavoidable. *Blueprint Columbus* provides for the management of the above grade and near grade urban landscape and cooperatively integrates into the services provided by the RT-DSS of near grade and deep underground gray infrastructure, namely the tunnel system. When complete, Columbus will be an exemplary model of a fully integrated and optimized urban watershed.

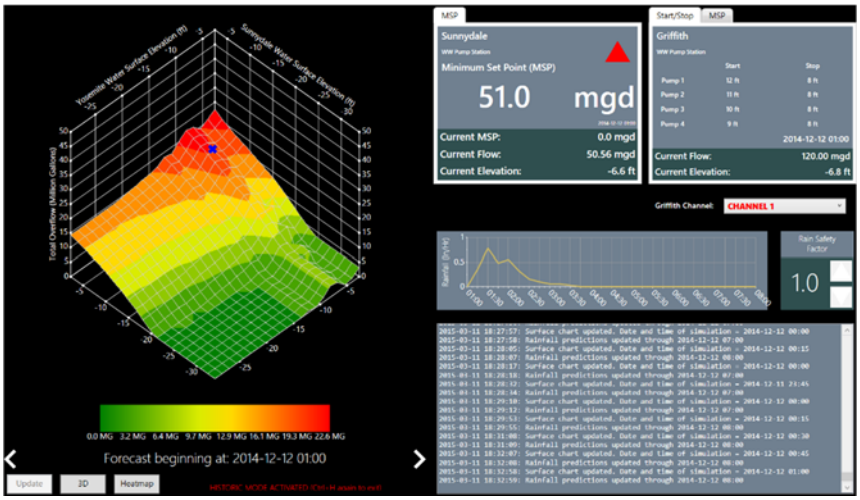


Figure 5 - Example of an RT-DSS control recommendation dashboard

St. Joseph, Missouri

The City of St. Joseph, Missouri owns and operates a Municipal Separate Stormwater Sewer System (MS4) and a combined sewer system (CSS). To control runoff to the city's CSS and prevent overflows to the Missouri River, the city's consulting engineers designed and constructed a natural storm water detention wetland and outlet works with OptiRTC's predictive, control product, OptiNimbus.

The constructed wetland was designed to attenuate peak flows and provide natural treatment of storm water while reducing CSO events. OptiNimbus, monitors precipitation forecasts and actively controls the water level in the wetland to hold runoff when possible, and drain the pond prior to rain events that could cause the site to overflow to the CSS. Monitoring and control technology are powered by a solar panel and connected to Opti's cloud platform via an on-site web gateway and cellular modem. Water is controlled through an electrically actuated quarter turn butterfly valve, which autonomously adjusts itself to control the volume of water and timing of the flow. System status and data, both real-time and historic, are displayed on a web dashboard accessible from any browser. The system reduces wet weather flows to the CSS by 85% by maximizing wet-weather capture.

Figure 6 – Solar powered controls

Figure 7 - Butterfly valve controls

Conclusion

Forward thinking UOTFs understand, operate, control, and optimize their entire collection system as an extension of the treatment plant. They understand the role of the collection system and treatment facilities as providers of intensive urban ecosystem services, processing and producing orders-of-magnitude more clean water than the natural environment could do so on its own. At perhaps the leading edge in technology, the most advanced UOTFs integrate the built environment within the natural watershed, monitoring and controlling both systems as a whole to produce even better clean water services at lower costs.

IV. Clean Water Consulting Engineers: Learning to Take More Risks[6]

Consulting engineers are one of the key links between technology developers and clean water utilities. As such, they have unique, early stage perspective on trends within the innovation ecosystem. According to a range of consulting engineers that contributed insights to this *Annual Report*, since 2013 municipal clients are increasing asking for, and the consulting engineering community feels increasingly comfortable delivering, technology-forward UOTF initiatives.

Overall, confidence in the UOTF is growing quickly along with experience. By working with clients and helping evolve these concepts, consulting engineers have helped enable utilities to "do more with less" and better utilize the resources available to the clean water sector; both key themes from the *Utility of the Future Blueprint.*

UOTF Trends Identified by the Consulting Engineering Community

Despite different specific experiences from one region of the US to another, the consulting engineering community agrees broadly on basic UOTF trends:

- Interest in building and broadening partnerships is growing rapidly;
- Clients are increasingly willing to entertain innovative designs and sustainable technologies from around the globe; and
- Utility leadership is pushing more frequently to manage risk and less frequently to avoid it.

Building Broader Partnerships and Engaging Community

UOTFs are increasingly building broader partnerships and creating a collaborative sense of community. Historically, the "community" in the clean water sector included utility operators and staff; government agencies and regulators; and engineering consultants, with minor engagement of the surrounding, local community. But as utilities expand their sphere of influence and engagement beyond the fence line to help achieve their mission, the clean water community is redefining itself to include consumers, sister government agencies and leaders, other types of utilities and industry, academia, nonprofits, and many more. With this larger community, engineering consultants note that utilities are now looking beyond their own economic self-interest to deliver social and community benefits as well.

UOTFs are also increasingly balancing risks with costs and levels of service. As a result, utilities have become more customer-centric, focusing on "customer buy-in" or expected levels of service for a given price. Through new efforts to educate them, utilities are able to provide customers with a sense of ownership and responsibility – even to help maintain infrastructure, such as in Milwaukee where distributed, green infrastructure is accessible and valued by the public. The Milwaukee Metropolitan Sanitary District (MMSD) contracted with AECOM, for example, to assist with neighborhood outreach for their green infrastructure program. AECOM engineers worked directly with the public, educating them on ways to use water more efficiently and ways to manage water locally to achieve better regional water quality. In turn, these efforts reduced urban runoff and overloading of collection

[6] NACWA, WEF, WERF, and WateReuse wish to thank Matt Ries, Barry Liner, Bri Nakamura, of the WEF staff and the following individuals for their contributions to this chapter: Andrew Salveson, Carollo Engineers; Art K. Umble, MWH; Deborah Houdeshell, Hazen & Sawyer; Ifetayo Venner, Arcadis; John Willis, Brown & Caldwell; Lynne Moss, CDM Smith; Matt Bond, Black & Veatch; Ralph "Rusty" Schroedel, AECOM; Scott Haskins, CH2M; and, Trevor Clements, TetraTech.

systems and treatment facilities. Similarly, many consultants emphasized the increasing importance of soliciting customer feedback during the design/planning phases of projects, to gather feedback on expectations for level of service.

Academics are increasingly entering the new utility "community." Consultants are now are looking to partner with academics to test technologies in real-life situations, often on site in partnership with clean water utilities. These partnerships often identify benefits in practice that technology developers cannot observe at the lab or bench scale.

Movement toward More Sustainable and Innovative Technologies Returns Excitement to the Profession

As UOTFs push to transform themselves, engineering consultants are faced with the new challenge of intermediating between technology developers and technology-hungry utilities. As a result, the pace of technology innovation has picked up considerably in the last half decade, as has the pace of technology adoption. This has occurred in some cases without, as in previous practice, a requirement that multiple reference sites demonstrate performance under a wide range of operating conditions. Instead, utilities are increasingly willing to pilot and then scale brand new technology if it meets their requirements. The result is a more nimble, responsive market for new technology and stronger market incentives for technology innovation. The consulting engineering community reports broadly that a new sense of innovation in finding ways to capitalize on valuable resources as opposed to disposing of harmful waste streams has brought a sense of excitement back to their profession.

Innovation and Collaboration at its Finest

Recent collaborations between consulting engineers and their clients have resulted in advances in technology in water reuse, energy capture from biosolids, and other UOTF initiatives:

- City of El Paso – Direct Potable Reuse
- WERF Research with University of Michigan on Anaerobic Biosolids
- WERF WaterWatch

Tasked More Frequently with Managing Risk, Not Just Avoiding It

Change of any nature can be unsettling, but in a traditionally risk-averse sector like municipal wastewater, which is responsible for the public's health and environmental protection, taking more risk is unusual. Nonetheless, engineering consultants note that this is exactly what their utility clients are asking for, provided that they carefully manage these risks. The shift from avoiding risk to managing risk has become very much a part of the Utility of the Future with most in agreement that through collaboration, utilities, engineers, technology developers, and the finance community are finding ways to generate benefits that exceed managed, properly allocated risks.

The changing nature of capital improvement plans (CIPs) reflect this new approach to risk management. Many clean water utilities are asking engineering consultants to undertake multi-disciplinary performance and risk assessment studies as part of CIPs, including benchmarking, performance improvement assessments, strategic planning, and risk-based asset management. By looking at the improvements as an assessment process, utilities are working to balance the risks of investment decisions, while taking into account the level of service to both the utility and the community. Increasingly, performance is measured in triple-bottom line terms, early in the capital

planning process, which enables ample time to plan and implement risk mitigation solutions. Capital decision making is quickly moving toward minimizing risk and cost of failure while maximizing community and environmental benefits.

Linking capital investment to risk management has resulted in the engineering consulting community developing new methods to assess and manage risk at both the enterprise and the individual asset levels. These tools draw engineering consultants deeper into the asset management processes within the utility. It also requires development and use of new tools such as real time monitoring, calibrated process models, smart decision models, and utility dashboards, which in turn, create linkages within the innovation ecosystem to technology developers.

From Engineering Problem-Solvers to Performance Management Consultants

Utilities are shifting from the traditional public utility "compliance at any cost" model in response to new environmental regulations, to one of proactively planning for the future. As a result, consulting engineers are noticing a shift in their role in the process. As explained by one consultant, engineers have shifted from engineering problem-solvers, to true performance management consultants.

The shift in consultants' roles is also observed in the context of project delivery. Increasingly, projects are no longer following the traditional Design-Bid-Build method, but are now turning to alternative methods of delivery such as Design-Build, Design-Build-Operate, and Design-Build-Operate-Maintain. The idea of "back checking" projects once they have completed construction to confirm that they are indeed delivering against designs has become a typical code of practice amongst engineers and utilities.

Going beyond just "back checking" to ensure continuous improvement, consultants are seeing new services such as Construction Management at-Risk (CMR), benchmarking, asset management, management consulting, and O&M services. And as previously mentioned consultants are now a vocal and contributing part to the strategic planning and analysis of Capital Improvement Projects (CIPs).

Encouraged by Language and Passion of Clients

As the shift towards the UOTF continues, engineering consultants are greatly encouraged by the language and passion they see from their clients. The UOTF concept is being picked up, demanded by some utilities and encouraged by many consultants. Looking to the future, a closer partnership between utilities and their consultants will help drive the shift to the UOTF, gaining momentum as UOTF initiatives deliver triple-bottom line benefits and lead to more sustainable utilities.

V. Public and Private Finance[7]

While the vast majority of financing in the clean water sector still comes from traditional sources – tax exempt municipal bonds, state revolving funds, and current revenue – leading edge utilities are working closely with public and private sources of funding to innovate there as well.
As investments move from waste to resource management and from grey to green infrastructure, so too must financial resources move to support the Utility of the Future. This section reviews some of the most innovative financial transactions over the last few years in three areas:

- Municipal finance;
- Federal program funding; and
- Public-private partnerships.

Further, it draws conclusions about the future direction of the finance community as part of the clean water innovation ecosystem.

Municipal Public Finance

Clean water finance in the US is slowly recognizing and innovating around two major worldwide trends in infrastructure finance: green bonds and Sustainable Responsible Investing (SRI). Green bonds are debt securities that raise money for environmental projects. SRI, often referred to as "impact investing" for short, considers environmental, social and corporate governance criteria to generate long-term competitive financial returns and positive societal impact. According to Moody's Investment Service, issuance of green bonds worldwide tripled to $37 billion between 2013 and 2014 and is expected to triple again to more than $100 billion in 2015.[8] In 2012 professional investment managers worldwide held $13.3 trillion in SRI securities. By 2014, that figure increased by 61 percent to $21.4 trillion.

Examples in the US clean water sector, several of which are highlighted below, are limited, but growing and impressive.

[7] NACWA, WEF, WERF, and WateReuse wish to thank Francesca McCann, Marcelo Moacyr, and Mark Kim for their contributions to this chapter.

[8] For details, see: Moody's Investor Service, Moody's: *Green bonds to blossom as global markets embrace more eco-friendly investments*, May 27, 2015, https://www.moodys.com/research/Moodys-Green-bonds-to-blossom-as-global-markets-embrace-more--PR_326218.

DC Water

DC Water, the regional clean water utility serving 2.2 million customers in the Washington DC metro area, has pursued both green bonds and social impact investing in perhaps the most innovative ways of any utility in the US.

DC Water: Leading Innovation in US Clean Water Finance

Serving 2.2 million customers in the greater Washington DC area, DC Water has pioneered two innovations in clean water finance:

- Taxable "Century Bonds"
- Social Impact Bonds

Century Bond. As part of DC Water's $2.6 billion Clean Rivers Project to control CSOs, the utility had planned deep tunnels with an estimated service life of at least 100 years. Until DC Water's new CFO, Mark Kim, a veteran investment banker and New York City Assistant Comptroller for Public Finance, found a more rational approach, the utility would have floated traditional 30-year tax-exempt municipal bonds to pay for this infrastructure and depreciated it on the books for perhaps 60 years. Kim's approach simply integrated finance and accounting with the realities of the physical assets and the benefits they would deliver to ratepayers. Working with DC Water's Board, the regulators, customers, and a host of consulting accountants and engineers to back them up, DC Water issued the first-ever environmental century bond, a taxable bond that spreads repayment over 100 years, ensuring that all generations that benefit from clean water will help pay for it. In addition to its attribute of intergenerational equity, DC Water's century bond was marketed to European investors as a "green bond" where demand for such issues is high among traditional and so-called "impact investors" who seek reasonable economic but also social returns. DC Water's green century bond attracted $1 billion in bids for a $300 million offering, which enabled the utility to increase its offering to $350 million and reduce its yield by 15 basis points to 4.81%, saving customers about $2 million a year.

Social Impact Bond. Following that, DC Water is now structuring the nation's first green infrastructure social impact bond to raise capital for the green infrastructure component of its wet weather control program. Having worked closely with US EPA, the Department of Justice, and the DC Government to propose modifications to DC's CSO Consent Decree to allow for green infrastructure and an extra five years for compliance as part of its control solution, DC Water turned to public finance innovators at Harvard University who provided the utility a grant to develop this new finance model. Again, the key was alignment of finance with technology, risk, and community impacts. Since green infrastructure was seen as new and "risky," the social impact bond allocates risk associated with green infrastructure's performance to those best suited to bear it and not, as would be the case in traditional finance, strictly to households and businesses in the service area. If DC's green infrastructure does not meet stormwater retention standards, DC Water does not have to repay investors. Social impact investors are so convinced that green infrastructure is a better solution than gray infrastructure that they are willing to risk their investment to prove it.

Medium and Small Utilities

Similar finance innovations can be found in small towns as well. In a unique effort to boost sales of its proprietary "Clearford One" solution to small towns and villages that need to replace failing septic tanks with a centralized treatment system, the Ontario Canada company, Clearford Water Systems has partnered with Zurich-based Signina Capital AG to raise $100 million from European impact investors

to finance 100% of the costs of conversion.[9] Homeowners and businesses that make the conversion pay only for the services they receive, so if for whatever reason Clearford's solution does not work, customers do not pay. This "Pay for Performance" offer, however, is backed by dozens of examples where the Clearford One solution has worked for years exactly as advertised. Clearford installs a smart digester – essentially a holding tank that digests solids using passive hydraulic mixing – for every household or commercial user. The tank allows only liquids to flow downstream through a small, sealed HDPE pipe network through pumping stations and to a treatment facility sized only for liquids (no solids and no infiltration or inflow), which cut costs by more than half compared to a traditional gravity sewer network. Solids are pumped and managed only once every 10-12 years, which also reduces costs compared to traditional solutions.

Other Examples of Green Bonds for Clean Water Finance

Four states have entered the green bond market since 2013: Massachusetts, New York, New Jersey, and California. Massachusetts issued $100 million in green bonds in 2013 and another $350 million in 2014. New Jersey issued $200 million in green bonds in 2014, largely for energy resilience projects including clean water infrastructure. The New York State Environmental Facilities Corporation, the state's SRF entity, issued $213 million in green bonds for water and wastewater in 2014.

New York City and Portland are both in the process of issuing new green bonds for clean water infrastructure as well as other green investments.

Federal Finance Innovations

Finance innovations also are emerging at the federal level, largely under programs of the US EPA, although the US Bureau of Reclamation manages about $1.5 million a year in 25% matching grants to cities for water reuse. EPA's most notable programs include:

Recent Developments in Federal Clean Water Finance Programs

- EPA's Water Infrastructure Resiliency Finance Center
- EPA's Water Infrastructure Finance Innovations Act (WIFIA)
- Qualified Private Infrastructure Bonds

Water Infrastructure and Resiliency Finance Center

In January 2015 the US EPA launched this new Center to help communities, municipal utilities, and private entities address water infrastructure needs with limited budgets. With a focus on public-private partnerships and federal credit enhancements, the Center aims to increase investment in clean water and promote economic growth through collaboration between the federal government, state and local governments, and the private sector.

Water Infrastructure Finance Innovations Act

When fully up and running, EPA will administer the Water Infrastructure Finance and Innovations Act (WIFIA), a five-year pilot program fashioned after a similar and successful initiative for transportation infrastructure. WIFIA will make low-cost federal loans and credit guarantees available to projects that include private partners as long as the project is publicly sponsored.

[9] For details, see: http://www.watertapontario.com/news/blog/clearford-innovative-financing-model/120

Qualified Private Infrastructure Bonds

The President's 2016 federal budget proposed a new financing instrument, Qualified Private Infrastructure Bonds (QPIBs), which serve to promote public-private partnerships. QPIBs make tax-free municipal debt available to projects with more than 10% private sector involvement. Such financing has been available before in the form of Private Activity Bonds (PABs), but those bonds came with two significant restrictions. First, while the interest earned on qualified PABs is exempt from federal income taxes, it remains subject to the alternative minimum tax (AMT). The American Recovery and Reinvestment Act (ARRA), also known as the stimulus package, temporarily exempted PABs from the AMT for two years, but that exemption expired in 2010. Second, PABs were subject to an annual volume cap established by federal statute. QPIBs remove both AMT and volume cap restrictions, making them more attractive to bond investors and more flexible for issuers.

Public Private Partnerships

Under the right circumstances, public-private partnerships can solve financing challenges that are more difficult when approached strictly from the public sector.[10] This is particularly true for UOTF initiatives where capital must be deployed for new technologies with little performance track record (at least in the US), where infrastructure is geographically dispersed as opposed to centralized, and where new capital assets in whatever form are added in blocks that are separable from existing assets.

Regardless of who finances a clean water investment, households and businesses ultimately pay for them. So compared to purely public solutions, ratepayers benefit from P3 solutions where they offer better clean water services at the same cost or the same services at lower costs.[11] Cost in this case must address both capital and operating elements and must take risk into account, since in many cases, when a private party agrees to partner with the public sector, it will take on risks that transfers potential public liability to the private balance sheet. For emerging P3 finance models to fully support UOTF initiatives they will have to take these considerations into account in ways that are transparent to utility leadership, ratepayers, and the public.

Evolution of Today's P3 Models

P3 practice in the US has evolved and adapted considerably to the structure and culture of US clean water utilities since the early days of "privatization" in the 1980s and 1990s. Today, the most successful P3 models are true partnerships. Three models are emerging:

- **Long-Term Concessions** – In this model used for several large capital projects recently, the public sector retains ownership of assets, but the private sector designs, builds, finances, operates, and maintains them under a long-term concession agreement that defines payments from the public to the private sector (or if a lease, payments from the private to public sector in

[10] There are many definitions of public-private partnerships, but as used here, P3 refers to a model where the public sector retains ownership of assets, but the private sector designs, builds, finances and/or operates and maintains a project, subject to contractual exchange of payments from the public to the private sector in return for delivery of defined levels, quality, and reliability of services. The key additional component is partial or full private sector financing.

[11] In some cases, particularly where a public utility is fiscally constrained but still must meet it regulatory obligations, P3 solutions may represent the most effective and efficient path to clean water goals. These instances are infrequent, however, and will not be addressed here.

exchange for rate revenue over the period) in return for delivery of defined levels, quality, and reliability of services.[12]

- **Separable "Bolt-On" Capital Projects** – another form of P3 is used generally for smaller projects to deliver specific technologies that can be "bolted on" to existing capital works. Project examples include energy generation, energy or nutrient recovery, and water recovery and reuse. In this model, the private partner typically owns the assets as well and delivers a commodity – electricity, fertilizer, or water, for example -- at a specific contract price over an agreed period of time. These assets may or may not revert to public ownership at the end of the contract period.
- **Community-Based P3s** – these P3s structures blend elements of traditional concessions to assure lower-cost delivery of program benefits and social benefits like engagement of local businesses, community groups, and others to generate employment and reinvestment in the local economy. These community-based P3s are emerging quickly especially to meet the needs of large green infrastructure programs.

Regardless of the model, key P3 features include an equitable allocation of cost and risk between partners where pre-defined costs represent savings compared to a purely public solution; risks for delivery of program benefits are fairly compensated and held by whichever partner is best equipped to bear them; and ratepayer assurance that they are receiving the best value that their money can buy. Examples of these models follow.

Rialto, CA

Facing significant deferred maintenance and an EPA Administrative Order to eliminate sanitary sewer overflows, the City of Rialto, CA competed and closed a 30-year P3 transaction for its water and wastewater systems with a private entity, Rialto Water Services LLC (RWS), a joint venture of Table Rock Capital and Veolia Environmental Services. RWS will operate and maintain the infrastructure and collect revenue from the city's water and sewer facilities. RWS must meet all performance standards set for both water and wastewater service delivery. It also must upgrade both systems over the first five years and has an option to make (and receive payment for) subsequent improvements if both partners agree. The city will keep ownership of all of the assets, but RWS takes all performance risks. RWS financed the P3 with a $146 million private placement of 30-year taxable bonds plus $26 million in equity from Table Rock and other investors. Rialto will use $27 million of these funds to retire outstanding utility debt. RWS will spend $41 million on capital improvements and Rialto will get another $30 million that it can use for other capital projects. RWS gets a monthly fee that includes a charge to support debt service and return on equity, operating and management costs and an escalating service fee. Rialto's City Council sets rates subject to a rate covenant that assures payment to RWS, but limits increases to 115% over the first five years with rate stability thereafter. While this is substantial, it is less than the increase that Rialto faced in the absence of a P3, and importantly, it provides certainty that the city's water infrastructure needs will be met.

[12] NACWA's *P3 Financing Dialogue* between roughly 40 public utilities and private service providers in June 2014 documented the emergence of these P3 models

Allentown, PA

In some cases, just the pursuit of a P3 has led to unexpectedly beneficial outcomes for the public partner. As have a growing number of cities, Allentown, PA faced the challenges of aging infrastructure, long-overdue capital improvements from deferred maintenance, and budget constraints. In addition, the city faced $160 million in unfunded pension liabilities and bill for the first $15 million that it could not pay. The P3 procurement attracted five private proposals and one from a public entity, the Lehigh County Authority (LCA). Allentown chose the best deal and contracted with LCA for a 50-year concession agreement for Allentown's water and wastewater facilities. Allentown received a $212 million upfront payment to stabilize its pension fund and $50 million a year from LCA for 50 years. Rate increases were capped at 2.5% a year for the first 20 years and 2% a year for the final 30 years. While in the end, Allentown ended up being a public-to-public transaction, the project is a good example of a P3 procurement structured as a long-term lease concession with significant financial upside for the public partner, and rate protection for Allentown customers.

San Antonio, TX

The San Antonio Water System (SAWS) P3 is one of the newest and largest public-private transactions in the US. Arranged via a competitive bidding process (9 respondents, 3 short-listed) followed by several years of negotiation, this 142 mile pipeline will bring groundwater from 3,400 privately negotiated leases with landowners six counties away to more than 162,000 city residents by 2020. The private partner, The Vista Ridge Consortium, a special purpose company formed by the Spanish developer, Abengoa and a second company, Blue Water who secured the water rights, will bear virtually all the up-front costs and risks including all project development, construction, operations, and maintenance costs. The city has no obligations until water is delivered, which ensures that its customers pay only for services delivered. Vista Ridge will invest an estimated $850 million of which about 10% is their own equity to build the well fields, pipeline, and treatment works to meet drinking water standards. SAWS will build about $100 million in supplementary treatment and interconnection infrastructure. Operating risk is shared by both SAWS and Vista Ridge, with SAWS' exposure to interest rates capped at 6.04% and their exposure to electrical demand (but not prices) is capped as well. SAWS negotiated a favorable termination clause in which they have the option to terminate the contract and collect $2 million from Vista Ridge if they fail to raise financing (commercial closing) within 30 months of negotiating the P3 agreement. SAWS pays Vista Ridge termination penalties if SAWS terminates after the financial close. After a 42-month construction period, the P3 agreement will last for 30 years. After that, title to the pipeline will revert to SAWS, who will enjoy another 30 years of supply from Blue Water if they choose to exercise it. To gain public acceptance, SAWS pitched the project as, "*tomorrow's water at today's rates*," so rates will increase by only 16%, on average, at the beginning of the project, but remain flat thereafter – a relatively unusual structure that underscores the flexibility possible in a creative P3 arrangement.

"Bolt-On" Capital Project P3s

Many of the UOTF examples presented in the utility section above and in the *2013 UOTF Blueprint* were implemented under a P3 structure, where the technology vendor designed, built, financed, owned, operated and maintained a separate facility in exchange for a long-term contract with the utility to purchase its product. That was the case in Victorville, CA (see page 16) where a private partner produces and sells power to the utility from methane produced on site. Hill Canyon, CA was similar, only with solar photovoltaics (see page 17). In the *2013 UOTF Blueprint*, similar P3 transactions were documented in Camden County, NJ (solar photovoltaics), East Bay Municipal Utility District, CA

(methane generated electricity), Hampton Roads Sanitation District, VA (nutrient recovery and fertilizer production), Clean Water Services, OR (nutrient recovery and fertilizer production), and many others.

Green Infrastructure Community-Based P3s

As an example of community-based P3s, consider the green infrastructure partnership underway in Prince Georges County MD. The County has partnered with a Rhode Island company, Corvais Group, who will form a project delivery company to help finance (up to 40%) and subcontract with local businesses and community-based organizations for the design, construction, and maintenance of a broad range of green infrastructure solutions to manage stormwater on 2,000 acres of County land. According to the County, integrating all elements of green infrastructure solutions under a single delivery partner has already reduced program costs by 40% over traditional pure-public solutions and could ultimately reduce costs by 50% to 60%.[13] As part of the P3, Corvais will put in place and assume delivery risk for some 50,000-60,000 local green infrastructure installations, which would have swamped the County's procurement capability (and accounts for much of the cost savings). Using local businesses and labor to carry out the program creates a stable local workforce and reinvests in the economy of the County. County stormwater fees are used to compensate Corvais over time based on a complex formula of base payments for substantial completion of individual projects, incentive payments for special initiatives, monthly or quarterly payments for on-going maintenance, and penalties for underperformance.

The Future of Clean Water P3s

Clearly there is no P3 mold, no norm. But recent P3s demonstrate that they can be an effective and efficient way for clean water utilities to meet infrastructure financing needs. P3s are particularly well suited for many types of UOTF initiatives since they often are separable capital assets involving specialized technologies that either generate revenue or reduce costs, either of which can be converted into compensation for private financing or private assumption of risk. With proper education and analytical tools to evaluate the P3 business case, UOTFs should expect to see more innovation around public-private finance for clean water capital. But, as expected during a period of rapid change, the path is unlikely to be smooth and considerable attention will be needed to assure that P3s meet both public and private expectations.

Small, but noticeable changes in procurement and project delivery processes seem to be indicating a new openness to partnerships. Increasing use of design-build and to a lesser extent design-build-finance-operate-maintain processes and similar alternatives offer utilities potential life-cycle cost savings and risk reduction. Executed properly, design-build processes can result in lower capital costs than design-bid-build since risks, and therefore costs, associated with the integrated process of designing and building infrastructure rest with the same entity.[14]

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[13] For details see: USEPA webcast transcript, *Building Green Infrastructure, Jobs, and Wealth: The Prince Georges County, Maryland Urban Stormwater Retrofit Public Private Partnership (P3) Model*, January 13, 2014. http://www.epa.gov/reg3wapd/pdf/pdf_watersheds/G3webcasts/2014-1-13/011314_Transcript.pdf

[14] For details, see: The Water Design-Build Council, *The Municipal Water and Wastewater Design-Build Handbook*, Third Edition, 2014.

When properly executed, integration of design, construction, operations, and maintenance, and where appropriate, finance as well (DBOMF for short), can result in even greater efficiencies. Some utilities may not be prepared to undertake these types of partnership-oriented procurement processes, since they require procurement and management process skills that they may not have. Also, because there is little familiarity with such an integrated process, DBOMF procurements can seem risky to some utilities. While such processes are used widely overseas and are more prevalent for transportation projects in the US than they are for water or wastewater projects here, we nonetheless are beginning to at least see them in the water sector (see the San Antonio Water System example above).

For DBOMF procurement to be successful, infrastructure owners specify principally service level objectives — e.g., average and peak capacities at a certain effluent quality that must be delivered, reliability metrics, regulatory requirements, and/or social and environmental objectives that must be met. Importantly, this process works best when objectives are specified in as simple and broad terms as possible given local circumstances so that suppliers can respond with integrated solutions that are innovative (less costly, higher quality, faster to implement) and utilities have more choices from which to select the solution that best meets their needs. Then they invite experienced and qualified entities to propose *Integrated Solutions* to meet those goals, knowing that if selected, they will have to design, build, operate, maintain and perhaps finance their solutions. A procurement process similar to the one below takes the project through to award.

Again, these integrated approaches may not be appropriate for every situation, but when properly designed and executed, they can stimulate innovative solutions, reduce costs on a life-cycle basis and shift risk to private partners.

VI. Professional Organizations[15]

Professional organizations link all members of the innovation ecosystem to each other through essential services like advocacy, research, knowledge sharing, and performance standard setting. In particular since 2013, the sponsoring organizations of the original *Utility of the Future Blueprint* – the National Association of Clean Water Agencies (NACWA), the Water Environment Federation (WEF), and the Water Environment Research Foundation (WERF) -- have made considerable progress on behalf of the clean water sector. WateReuse, an association and research foundation, have pushed the technical UOTF envelope through focused funding of wastewater reuse initiatives.

A fifth national organization, the Institute for Sustainable Infrastructure, also has played a focused role in linking members of the innovation ecosystem. They formulated a framework called Envision that evaluates community, environmental, and economic benefits of all types and sizes of infrastructure projects, including UOTF initiatives. Envision grades and gives recognition to infrastructure projects in planning, design and construction stages that use transformational, collaborative approaches to assess the sustainability indicators over the course of the project's life cycle. Envision provides an opportunity for infrastructure owners and designers to provide higher performing solutions by using a lifecycle approach, by working with communities, and by using a restorative approach to infrastructure projects. Over the last two years, more than 120 private companies have been qualified to use Envision.

NACWA

NACWA, the national advocacy voice for the municipal clean water community, took the lead in connecting the dots between key innovative trends taking place in water management, many of which centered on the profound move toward the utility as a resource recovery hub. This resulted in the collaborative launch in 2013 of *The Water Resources Utility of the Future: A Blueprint for Action.* Since this publication, NACWA has continually worked to promote the UOTF agenda to a broad audience – professional organizations, regulators, policymakers, state and regional groups, and utilities – through a multitude of platforms to increase engagement in and awareness of the UOTF. Through these efforts, the initiative has gained much attention with UOTF-style ideas, projects, conferences, even legislation and policies being enthusiastically embraced.

NACWA Outreach and Advocacy. To spread the UOTF agenda, NACWA has actively released reports, hosted and participated in conferences and webinars, and established committees and workgroups (e.g. the Industry of the Future, Clean Water Finance, and Water Reuse workgroups, as well as reconstituting its management committee as the Utility and Resource Management Committee) to encourage dialogue on these issues. Following the 2013 *UOTF Blueprint*, NACWA published *Today's Clean Water Utility: Delivering Value to Ratepayers, Communities, & the Nation* to make the business case for the UOTF. NACWA also released the *Water Resources Utility of the Future: A Call for Federal Action* trifold providing ten key advocacy goals to advance the UOTF agenda. NACWA has also devoted many blog posts on *The Water Voice* and articles in the Clean Water Advocate newsletter showcasing specific UOTF-style advancements and projects.

[15] NACWA, WEF, WERF, and WateReuse wish to thank Carrie Capuco, WERF; Matt Ries and Barry Liner, WEF; Adam Krantz and Amber Kim, NACWA; Julie Minton, and Stefani McGregor, WateReuse for their contributions to this chapter.

The Association has also promoted the UOTF through conferences and webinars as UOTF ideas and concepts expanded and developed. NACWA has hosted a three part *Charting a Path to the Utility of the Future Web Seminar Series* and spoken about the UOTF at various workshops and conferences around the country. NACWA's 2015 Utility Leadership Conference, *Financing, Funding & Rates for the Future,* focused on looking for new and innovative financing methods to fund the UOTF technologies and projects that public utilities are increasingly embracing. NACWA is also partnering on the 2015 American Water Summit: Scalable Solutions (October 2015) in Denver to further explore financing options such as leveraging more private capital to finance UOTF investments.

UOTF in the Regulatory, Legislative, and Legal Spheres. NACWA's work on the UOTF has led to the incorporation of UOTF ideas in the following regulatory, legislative, and legal arenas:

- Expansion of Clean Water State Revolving Fund (SRF) eligibilities to cover UOTF-style projects like green infrastructure, water and energy efficiency, water reuse and recycling, washed-based investments, and more in the 2014 Water Resources and Reform Development Act (WRRDA). WRRDA not only broadens the list of eligible activities, but also extends the SRF repayment time, requires a fiscal sustainability plan, and authorizes additional subsidization by the state. All of these changes provide utilities more flexibility to invest in more innovative UOTF-style projects.
- Cooperation with congressional offices to write and introduce legislation that would allow more flexibility and support for utilities to make infrastructure improvements in line with the UOTF. Three bills have been introduced so far in the 114th Congress: the Clean Water Affordability Act, which would codify Integrated Planning and help manage wet weather; the Innovative Stormwater Infrastructure Act, which provides grant funding for community-based stormwater projects; and the Water Infrastructure Resiliency & Sustainability Act, which would provide matching funds for resiliency projects.
- Interaction with EPA on the regulatory status of materials recovered from the wastewater treatment process. In particular, NACWA has met with EPA on a number of occasions to urge the Agency to consider the ramifications for existing installations and further use of innovative technology to recover struvite – a valuable phosphate that can be used as fertilizer - should the Agency determine that such recovered materials must be regulated under the existing Part 503 sewage sludge provisions.
- Launch of *The Green Infrastructure Collaborative* with representatives of over 25 partner organizations, the White House Council on Environmental Quality (CEQ), and eight federal agencies. The Collaborative aims to leverage efforts from all participating organizations to advance green infrastructure as a means of supporting water quality and community development goals.
- Efforts to further expand the use of water quality trading, including work to finalize and release the National Network on Water Quality Trading's "Options and Considerations" document. NACWA has also started to explore the possibility of targeted Clean Water Act amendments to ensure that clean water agencies can get credit for work they do with other dischargers in the watershed, including work upstream with agricultural dischargers to address nutrient pollution.

- Memorandum of Understanding with the National Milk Producers Federation to explore partnerships between clean water agencies and NMPF-member dairies to address nutrient pollution through on-field practices as well as through the deployment of anaerobic digestion, coupled with nutrient recovery technologies
- Preserving the ability of municipalities to choose the method of biosolids management that works best for their communities, including the option of land application. NACWA has successfully advocated on behalf of land application and in opposition to local bans in California and Washington state litigation, and is currently involved in a right-to-farm case in Pennsylvania.
- Active support in litigation over the final Chesapeake Bay TMDL to defend the watershed approach to achieve water quality improvements. NACWA played a key role in recent legal victories upholding EPA's inclusion of nonpoint sources in the TMDL. The Association has a long-standing commitment to a holistic watershed approach as the most equitable, cost-effective, and environmentally responsible way to achieve water quality improvement.
- Creation of NACWA's *Wet Weather Consent Decree Handbook: Negotiation Strategies to Maximize Flexibility & Environmental Benefit* provides NACWA members with cutting-edge information, analysis, and strategies on wet weather enforcement issues including negotiation, renegotiation, implementation, and modification of wet weather enforcement orders and decrees. The *Handbook* contains an entire section on emerging issues affecting the sector such as climate change, need for resilience, nutrients and contaminants of emerging concern.
- Defense of municipal stormwater programs and fees in court to help utilities promote innovative approaches to managing stormwater like green infrastructure, low impact development, onsite retention, etc., which provide additional environmental benefits to local communities and reduce water quality impairments from runoff.

WEF

The Water Environment Federation (WEF) is a not-for-profit technical and educational organization of 36,000 individual members and 75 affiliated Member Associations representing water quality professionals around the world. WEF has been instrumental in building the Utility of the Future knowledge base and in working with other professional organizations to convert knowledge into practice. WEF includes "driving innovation in the water sector" as one of its three Critical Objectives and since its partnership with NACWA and WERF in 2013 on the *Utility of the Future Blueprint for Action*, WEF has elevated the importance of innovation in the clean water sector through its partnership with ImagineH2O and BlueTech Research in special exhibits at the WEFTEC 2014 and 2015 Innovation Pavilions featuring cutting edge clean water products and services as well as its Water Innovation Prize program. WEF's special 2014 report, *Innovate,* captured the new momentum behind innovation at WEFTEC, especially on energy, nutrients, resilience, reuse, and stormwater.[16] WEF's Great Water Cities series of high-level discussions at WEFTEC and an annual summit brings together global water leaders and features many of the UOTF themes from a diverse set of perspectives.

[16] See: http://www.weftec.org/uploadedFiles/Program/Innovation_Showcase/Innov_Booklet%20proof_hires_.pdf

WEF also has made considerable progress highlighting and promoting innovation in many of the most important UOTF opportunities:

- Clean Water Utility Leadership,
- Technology Innovation,
- Energy and Resource Recovery,
- Residuals and Biosolids, and
- Stormwater and Green Infrastructure.

Growing Sector Leaders. Through monthly web-based meetings and annual face-to-face sessions, WEF's Water Leadership Institute encourages networking, innovation, entrepreneurship, and professional commitment from those individuals who will be leading the clean water sector into the coming decades. Recognizing that UOTF initiatives can require doing business differently, Institute topics delivered by peers who have pioneered these changes are geared to developing the knowledge and skills base to lead organizations through this change process.

Technology Innovation. The joint WEF/WERF, Leaders Innovation Forum for Technology (LIFT) program accelerates innovation and technology adoption in the clean water sector. LIFT has four main components: technology evaluation program that shares the risk and cost of demonstrating its performance in the field; policy, regulatory, and institutional reform needed to remove barriers to technology innovation and adoption; training, education and outreach relative to new technologies; and an informal forum for technology managers across the sector. Technologies under study currently address nutrient removal and reuse, digestion and energy removal from biosolids, energy from wastewater, and stormwater BMPs.

Energy and Resource Recovery. WEF promotes energy and resource recovery solutions and technologies through publications, workshops, webcasts, and networking through WEF's committees. WEF followed up on its seminal *Energy Roadmap* with energy and water specialty conferences and training sessions in 2013 and again in 2015. In 2014, WEF released its popular *Nutrient Roadmap*, exploring cost effective options for nutrient removal and reuse at clean water utilities and sponsored a Nutrient Symposium in the summer 2015.

Residuals and Biosolids. WEF operates the National Biosolids Program in partnership with NACWA and EPA and offers training and technical support to the clean water community focused on consistently producing a high-quality biosolids product for intended markets/end use options and promoting resource recovery while achieving and maintaining public and regulatory trust and acceptance. In their 2013 publication, *Enabling the Future: Advancing Resource Recovery from Biosolids*, WEF explored for the clean water sector, the unprecedented opportunities that now exist and are emerging for recovery and reuse of the organics, energy, and nutrients in biosolids. Following that, WEF published *Biogas Production and Use at Water Resource Recovery Facilities in the United States*, which documented in considerable detail, existing anaerobic digestion systems at US clean water utilities, as well as current uses of, and potential future opportunities for, using biogas produced by these facilities.

Stormwater and Green Infrastructure. To support its rapid growth in popularity across the clean water community and the equally fast pace of innovation in the field, WEF launched a Stormwater

Institute in 2015 to serve as a center of excellence on stormwater management and help coordinate technical information including research, books, manuals of practice, conference proceedings, training and networking opportunities, a certification program, journals, magazines, and news stories, and a monthly e-newsletter, the Stormwater Report. WEF also offers numerous technical manuals of practice, training sessions, and committees focused on stormwater and green infrastructure. To recognize best practices in this field, WEF is working with EPA and launched a new, national MS4 Recognition Program in 2015.

Water Infrastructure Finance and Innovations Act (WIFIA). WEF partnered with the American Water Works Association and the Association of Metropolitan Water Agencies to include in the 2014 Water Resources & Reform Development Act authorization for the EPA to establish the WIFIA program to provide low interest loans and loan guarantees for water, wastewater, stormwater, energy efficiency, reuse, desalination, aquifer recharge and rehabilitation projects with a minimum total project cost of $20 million (or $5 million for small communities). EPA has embraced the 5-year pilot program and, pending Congressional appropriations, plans to implement it as an additional infrastructure financing tool for projects.

WERF

The Water Environment Research Foundation (WERF) is America's leading independent scientific research organization dedicated to wastewater and stormwater issues. Over the last 25 years, WERF has funded more than $130 million in collaborative, peer reviewed water quality research. Through its on-going work on resource and energy recovery and reuse, technology innovation and adoption, excellence awards for innovation, and direct collaboration with NACWA and WEF on the 2013 *Utility of the Future Blueprint for Action*, WERF's role in the innovation ecosystem is focused on accelerating technology adoption and sharing information on performance of technology and processes that help make the Utility of the Future a reality today.

WERF covers virtually the entire spectrum of UOTF initiatives in one way or another, but four programs are perhaps the most noteworthy:

- One Water Management/Sustainable Integrated Water Management (SIWM),
- Green Infrastructure,
- Energy Self-Sufficiency, and
- Leaders Innovation Forum for Technology (LIFT).

One Water Management/SIWM. Managing all forms of water within a watershed as an integrated resource is the essence of the One Water concept. The one water approach integrates structural and non-structural initiatives in both urban and rural watersheds that treat all sources of water and water by-products as resources that can improve quality of life, largely through such measures as decentralized small scale systems, green infrastructure, and recycling and resource recovery, all implemented at a variety of levels from building to city scale. WERF's 28 case studies in their *Pathways to One Water: a Guide for Institutional Innovation* document the six key elements of a One Water approach, with practical examples of how cities and counties have achieved tangible triple bottom line results. Extending the One Water Concept at the watershed level, WERF's Sustainable Integrated Water Management (SIWM) initiative examines through research and case studies, potential offsets to

potable water sources through capture and reuse of graywater, stormwater, rainwater, blackwater, and foundation drainage as well as ways to meet water quality goals within a watershed by working with sources of runoff that are unregulated under the Clean Water Act like the agriculture community.

Green Infrastructure. WERF's research program helps communities to manage stormwater to help restore a more natural hydrograph from developed areas and protect the quality and quantity of downstream water sources. Research focuses on capturing triple bottom line or co-benefit values to help decision makers and community members understand the true strength of these investments. Also part of this program is research into metrics for maintenance of green infrastructure systems and ways to build peer-to-peer networks for practitioners to learn from each other.

Energy Self Sufficiency. WERF's energy research is focused on energy self-sufficiency for clean water utilities through both reducing energy demand and generating energy from wastewater to support plant operations, and ultimately to export and generate revenue. The 2012 *Energy Roadmap* captured all of these alternatives in a systematic program to help wastewater utilities plan and implement a wastewater energy program. Since then, the WERF energy research program has focused on more than a dozen energy efficiency and generation topics such as low-energy technology, cost-benefit analysis, triple-bottom line energy management approaches for biosolids, and in-depth case studies of the Utility of the Future energy analysis.

Leaders Innovation Forum for Technology (LIFT). WERF jointly supports the LIFT program with its sister organization, WEF (see above).

WateReuse

The WateReuse Association is a nonprofit trade association, which engages in legislative advocacy, conducts education and outreach, and provides an opportunity for organization and membership for the water reuse and desalination communities. The WateReuse Research Foundation is nonprofit, public benefit corporation, which conducts and promotes applied research on issues related to water reuse and desalination. These two organizations are known collectively as WateReuse.

Over the last two decades, WateReuse has funded more than 210 projects addressing a wide variety concerns surrounding the reuse of water. Over 155 reports have been published and are available now. In total, these projects have leveraged more than $66 million in cash and in kind contributions. In 2014 alone WateReuse committed $3.5 million to 19 new water reuse research projects, 14 of which focus on direct potable reuse (DPR), which arguably is WateReuse's major contribution to the Utility of the Future.

By 2016, California hopes to have the empirical evidence to develop statewide criteria for purified recycled water that is treated to drinking water standards and delivered without an environmental buffer. To support the effort, WateReuse launched the Direct Potable Reuse (DPR) Initiative in 2012 with the help of supporters that include water agencies, consulting firms, research organizations, and manufacturers. WateReuse partnered with the California State Water Resources Control Board, Southern California Coastal Water Research Project, the National Water Research Institute, and stakeholders to identify research that will facilitate more widespread use of recycled water, especially potable reuse.

In one example, Public Perception and Acceptance (WRRF-13-02), WateReuse is testing and preparing for distribution a wide range of educational materials aimed at public acceptance of DPR. Focus groups and surveys were conducted mid-2014 to develop key messages critical to educational, awareness and outreach efforts, and these were laid out in community and statewide communication plans, now available on-line. Outreach tools and informational collateral materials (FAQs, video edits, and white papers) will be available for utilities and other groups for use with their constituents, to educate and inform, and to expand their outreach and awareness programs.

Other DPR support projects focus on design and costs of treatment trains suitable for DPR, risk reduction and response concepts developed in other industries (structural/bridge, aviation/NASA) that can be adapted and applied to direct potable reuse, integrated sensor systems that will allow utilities to monitor and respond to changes in their DPR treatment trains in real time, DPR operator training and certification, product water delivery and mixing strategies/requirements, and planning for and responding to emergency scenarios and extreme weather events to ensure that reuse does not compromise public health. A new project, *Methodology for a Comprehensive Analysis (Triple Bottom Line) of Alternative Water Supply Projects Compared to Direct Potable Reuse*) will take previous work a step further by developing a TBL framework for an interactive tool to allow utilities to compare different water supply options.

WateReuse is working with their membership (utilities, technology developers and integrators, and consulting engineers, for the most part) on legislation, regulations, policies, and funding support for water reuse and recycling at the federal level and in nine states (CA, NV, WA, OR, AZ, CO, FL, TX, and ID).

VII. The Role of Government in Clean Water Innovation[17]

There is little argument that the traditional role of government in clean water matters is setting, assuring compliance with, and enforcing environmental regulation. But when it comes to innovation, government's role extends much more broadly than this. In fact, as a key participant in the innovation ecosystem responsible for transforming today's clean water utilities into Utilities of the Future, governments have essential roles enabling alternative compliance processes, reinforcing UOTF initiatives with supportive ordinances, providing government incentives to technology developers and funding clean water utilities and others within the innovation ecosystem, and providing a wide range of direct and indirect technical assistance to the sector.

This section first examines the role of the federal government in promoting clean water innovation. It then examines ways in which state governments do the same, with detailed examples drawn from the states of Wisconsin, California, and Oregon.

Federal Government

It is well documented that federal regulations (generally as implemented by the states) under the Clean Water Act create the foundation for utility investment in clean water infrastructure and programs. It is also well documented that since passage of the Clean Water Act more than 40 years ago, as a nation, clean water utilities have been highly effective in removing most of the harmful pollutants from municipal wastewater. In most places in America, municipal wastewater is not responsible for remaining impairment of our rivers, lakes, streams, and coastal waters. In many places, even zero discharge at clean water utilities would not result in materially cleaner receiving waters. Nonetheless, federal (and state) regulatory action on nutrients, wet weather flows and other pollutants continues and is forcing clean water utilities to do more with less.

Doing More with Less in Response to Federal and State Clean Water Regulatory Programs

In response to federal and state regulatory pressures, many clean water utilities have chosen UOTF initiatives instead of building more expensive treatment infrastructure:

- Discharge less by reclaiming and reusing more,
- Work with all dischargers within watersheds to achieve clean water objectives at less cost,
- Reduce cost and increase revenues through operating efficiencies, energy generation, sales of reclaimed resources, and partnerships with others, and
- If additional spending is the only way, at least optimize outcomes of that spending to benefit the community and the local economy.

Much more can be done, however, to increase federal (and state) financial support for clean water innovation as a way to balance Clean Water Act requirements.

EPA and their state counterparts are increasingly supporting UOTF initiatives through targeted grants, technical assistance and guidance, and consideration of more integrated permitting and compliance approaches.[18] Working with utility leaders and states, EPA issued its *Effective and Sustainable Practices Roadmap document in 2014*. This document, organized around the *Attributes of Effectively Managed Utilities*, endorsed by

[17] NACWA, WEF, WERF, and WateReuse wish to thank Bobbi Larson and Janet Gillaspie for their contributions to this chapter.

[18] See, for example, a recent EPA guidance document for communities interested in green infrastructure: http://www2.epa.gov/smartgrowth/enhancing-sustainable-communities-green-infrastructure

WEF, NACWA, EPA and other water sector associations, gives utilities a set of best practices to help them progress from simply being in compliance to embracing the goals of the UOTF initiative. EPA is also working with professional associations to take a fresh look at the EUM framework, to ensure it continues to help utilities address many of the opportunities in the UOTF. Some states are participating with local governments in programs that support UOTF initiatives with ordinances that require water use efficiency and reuse and/or green infrastructure. Since 2013, we have seen about a dozen new state and local centers of water technology development and commercialization.

EPA also is actively promoting innovation.[19] Of particular note is EPA's *Water Innovation Technology Blueprint* series, which outlines the business case for investment in new tools with a focus on ten promising market opportunities, supported by a series of technology innovation case studies.[20]

But in the end, guidance, toolkits, and case studies, however helpful, are not substitutes for a more innovative process that would engage all sources of water quality impairment in meeting objectives of the Clean Water Act. EPA's *Integrated Planning Framework* (see box at right) provides one pathway toward such innovation. This collaboration between EPA, state permit authorities, enforcement officials, and regulated communities is intended to use the flexibilities in both permits and enforcement to optimize water quality outcomes per dollar invested. EPA views ongoing consent decree negotiations as opportunities to work with municipal permittees that want to take a more integrated approach to their Clean Water Act (CWA) obligations and challenges. Principles and elements of EPA's *Integrated Planning Framework* serve as a guide for negotiating consent decrees to address multiple CWA obligations with the underlying goal of ensuring that the projects with the greatest environmental and human health outcomes are completed first. Integrated plans can incorporate a wide range of controls on non-point sources, water quality trading, green infrastructure, pollution prevention, and partnerships with any relevant entity that impacts or could help to address water quality issues within the community.

EPA's Integrated Planning Framework Helps Optimize Competing Clean Water Investments

Building on its 2011, Memorandum (and subsequent 2012 guidance) entitled Achieving Water Quality through Integrated Municipal Stormwater and Wastewater Plans, in 2014, EPA provided more than $300,000 to five communities to demonstrate the flexibility in its Integrated Planning Framework. The framework enables communities to optimize water quality outcomes of multiple competing investments by sequencing them within budget limitations and in response to their impact on affordability.

EPA, the states, and communities continue to develop more reasoned approaches to meeting water quality requirements in the face of multiple investments that exceed budgets and impose cost in excess of affordability norms.

This process innovation – of seeking the best water quality outcomes for every dollar invested – can be expanded to include other sources of impairment, while respecting obligations under the Clean Water Act.

In addition to EPA, at least three other federal agencies support grant programs that have helped and could significantly increase financial support for UOTF actions: the

[19] For details, see: http://www2.epa.gov/innovation/technology-innovation

[20] For details, see: http://www2.epa.gov/innovation/examples-innovation-water-sector

Department of Energy (DOE), the Department of Agriculture (USDA) and the Bureau of Reclamation (USBR) within the Department of the Interior.[21]

State and Local Government

While states and to a certain extent local governments also have major roles in traditional clean water regulatory programs, perhaps their most important contribution within the innovation ecosystem is in supporting non-traditional compliance approaches and supporting UOTF initiatives through innovation accelerator programs, supportive policies, and funding. In recognition of their own roles in an innovation ecosystem, city governments and clean water utilities are taking organizational steps as well like creating positions called "Director of Sustainability" or forming internal innovation teams.
State governments have begun to amend traditional regulatory and finance programs to accommodate innovation at the local level. While there are many such examples, three states stand out for having supported innovative clusters of programs at clean water utilities since 2013: Wisconsin, California, and Oregon.

Wisconsin's Adaptive Management Program. Since 2013, the State of Wisconsin has expanded its participation in and support for adaptive management as an alternative to strict point source controls. The State has produced an *Adaptive Management Handbook*, a *Manual on Water Quality Trading, Guidance for Implementing Water Quality Trading in WPDES Permits*, and a webinar series on the above. Wisconsin has backed these policy and guidance documents with technical material on water quality performance for non-point source options, a tool to estimate pollutant load ratios, and provided funding for pilot programs in these areas.[22] Several clean water utilities have participated in the Wisconsin program including: The Madison Metropolitan Sewerage District, New Water in Green Bay, Milwaukee Metropolitan Sewerage District, and the City of Oconomowoc Wastewater Utility. Adaptive management approaches seem to be popular in many non-regulatory environmental processes, but beyond Wisconsin and a few locations where limited water quality trading occurs, adaptive management has not spread as widely as it should.

California's Sustainability Initiative. California offers one of the most recent and potentially, most far-reaching state sustainability initiatives – accompanied by a substantial funding commitment – that engages California utilities as key partners. Public wastewater agencies are playing an important role in meeting 2020 state goals largely through UOTF initiatives such as water reuse, energy capture, renewable energy generation, and carbon sequestration while simultaneously accomplishing their core mission of protecting public health and the environment:

- Increasing the use of recycled water over 2002 levels by at least one million acre-feet per year;
- Reducing the release of short-lived climate pollutants, such as black carbon from transportation, methane, and F-gas emissions from refrigerants and aerosol propellants to the atmosphere;
- Meeting one third of the state's energy needs from renewable sources;
- Recycling 75% of the solid waste generated in the state;

[21] NACWA/WEF/WERF's 2013 *The Water Resources Utility of the Future: A Blueprint for Action* discussed these programs and ways to strengthen them. The reader is referred to this document for details.

[22] For all, see: http://dnr.wi.gov/topic/surfacewater/tools.html

- Achieving 1990 levels of carbon dioxide equivalent emissions; and
- Reducing the carbon intensity of transportation fuel by 10%.

In the area of recycled water, the City of San Diego has launched "Pure Water," a 20-year program to provide a safe, reliable and cost-effective drinking water supply for San Diego. The project will produce advanced treated recycled water, which will be stored in the City's San Vicente Reservoir, along with other sources of supply such as the Colorado River and local runoff. An initial 15-million gallon per day water purification facility is planned to be in operation by 2023. The long-term goal is to produce 83 million gallons of purified water per day to meet one third of San Diego's future drinking water supply needs by 2035.

Through a public private partnership with Cornerstone Environmental, the Las Gallinas Valley Sanitary District in Marin County is undertaking the Las Gallinas Valley Biogas Energy Recovery System (BERS) Project. Funded in part with a $1 million grant from the California Energy Commission's Alternative and Renewable Fuel and Vehicle Technology Program, the BERS project will demonstrate that digester gas can be treated for use in combined heat and power micro turbines and boilers at the facility, as well as conditioned into renewable natural gas (RNG) for distribution as a transportation fuel. Conversion of biogas into transportation fuel represents a significant opportunity to produce one of the lowest carbon fuels recognized by the California Air Resources Board through its Low Carbon Fuel Standards program. This project will provide invaluable information for other potential projects across the state and the country on both technology and cost effectiveness.

CA Initiatives to Finance Water Reuse to Battle Drought

In the face of an historic drought, the Governor, State Legislature, regulatory agencies and the voters have all stepped up to provide an infusion of funding for recycled water projects that can create new, reliable, local water supplies in the near term. In 2014, the State Water Board made available up to $800 million in very low interest (1%) loans to fund recycling projects that are ready to provide new water supplies within the next two years. Among the projects benefitting from the low interest loans is the Echo Water project being constructed by Sacramento County's Regional Sanitation District (Regional San). Regional San received $1.57 billion in financing—the largest State Revolving Fund loan in history—for this project that will treat and recycle wastewater to a "clean, natural state – much like an 'echo' returning to its original source."

The California electorate also adopted a $7.5 billion water bond in November 2014 that included $725 million in funding for recycled water, and the Governor's proposed FY 2016 budget would make $450 million of that funding available for loans and grants beginning this year.

Similarly, the City of San Mateo, located on the San Francisco Peninsula, has initiated a project to produce compressed natural gas from digester gas at its wastewater treatment plant and use this fuel source for its fleet vehicles to reduce the transportation-related emissions within the community. Approximately 100 cubic feet per minute of wastewater generated digester gas is available to sustainably produce up to 500 gasoline gallon equivalents (GGE) of biofuel every day, or approximately 160,000 diesel gallon equivalents (DGE) of biofuel every year. As with the Las Gallinas project, the California Energy Commission provided a $2.54 million grant to fund construction of the compressed natural gas facility.

In May 2015, California's Air Resources Board (CARB) issued its Short Lived Climate Pollutant Reduction Strategy Concept Paper. As the agency leading the effort to mitigate climate change impacts in California, CARB has recognized the utility of the future as a major partner in reducing short live climate pollutants. The strategy sees wastewater treatment as presenting "a tremendous opportunity to divert organics from landfills and utilize them for producing energy and soil amendments." Because treatment plants are often located close to population centers, potentially significant amounts of food and other organic waste streams can be diverted from cities and towns. The report also acknowledges that existing barriers limit or discourage wastewater treatment facilities from more fully recovering the energy and nutrient value that remains in organic waste. As tens of billions of dollars are invested in new infrastructure, the strategy calls for investments to transform the wastewater sector and its business model into one that focuses not only on water quality, but also on maximum resource recovery from a wide array of waste streams and potential end products.

In an example of local government inter-agency coordination in support of the UOTF, The City of San Francisco's Non-Potable Water Program combines efforts from the San Francisco Public Utilities Commission (SFPUC), the Department of Public Health (SFDPH), and the Department of Building Inspection (SFDBI). Established by Ordinance 195-12 adopted by the San Francisco Board of Supervisors, this program creates a regulatory framework and streamlined permitting process for commercial, multi-family, and mixed use developments in the City to collect, treat, and reuse alternate water sources (rainwater, stormwater, graywater, blackwater) for toilet flushing, irrigation, and other non-potable uses. SFPUC, the city's water and wastewater utility, provides technical assistance to developers. It also provides grants of up to $250,000 for a single building and $500,000 for projects shared by two or more buildings. SFDPH regulates water quality and monitoring requirements and issues the permits themselves. SFDBI oversees all matters of design and construction of these non-potable systems. To date eight projects have been undertaken, saving in total more than 10 million gallons a year with another 23 in various stage of planning.[23]

Green Solutions in Oregon. Promoting green solutions is natural for Oregon – partnerships with Federal and State agencies, local environmental public interest groups, and non-government organizations are important in moving from 'steel-and-concrete' type projects to natural treatment systems. Adjustments in Oregon's water quality regulatory program and its State Revolving Fund helped promote and fund natural treatment systems, green infrastructure, watershed management, and water quality trading in place of traditional projects.

Early in this transformation, Oregon ACWA[24] partnered with the Oregon Department of Environmental Quality (DEQ) to produce a report *Natural Treatment Systems – A Water Quality Match for Oregon's Cities and Towns*.[25] The report documents how natural treatment systems, including wetlands, tree farms, wastewater lagoon systems, recycled water programs, indirect discharge, and water quality trading, are a perfect match for meeting the wastewater treatment needs of many Oregon

[23] See: http://www.sfwater.org/Modules/ShowDocument.aspx?documentID=7089

[24] The Oregon Association of Clean Water Agencies (ACWA), formed in 1992, is a not-for-profit organization of Oregon's wastewater treatment and stormwater management agencies, along with associated professionals. It's over 125 statewide members are focused on protecting and enhancing Oregon's water quality.

[25] See: http://www.deq.state.or.us/wq/wqpermit/docs/natTreatSysWP.pdf

communities – often at a lower cost to the community due to lower initial installation costs and lower operating costs, including reduced chemical and energy bills.

Examples of innovations at the local level made possible by flexibility in state regulations and funding include:

- **Portland.** Like many communities in the nation, the City of Portland is transitioning from a grey utility to a green utility. The green infrastructure programs engineered into the overall design of its CSO control project -- including downspout disconnections, eco-roofs, tree planting, and green streets -- allowed Portland to reduce the size of the combined sewage overflow pipe that flows along and below the Willamette River, saving rate payers hundreds of millions of dollars. Portland will also be able to accommodate its increasing population with a smaller installed pipe size due to continued investments in green infrastructure.
- **Medford.** Two Oregon water quality permits incorporate water quality trading as a compliance strategy for meeting strict temperature limits. The Clean Water Services case was documented in the 2013 *UOTF Blueprint*. The City of Medford entered into a 10-year renewable contract with The Freshwater Trust to develop, finance, certify, register and maintain the restoration projects required to meet temperature limits in Medford's water quality permit. Under the agreement, 25 miles of the Rogue River will be restored with natural vegetation to provide cooling shade, along with other eco-system benefits. The $4 million estimated capital cost of the restoration program is almost one-half of the costs of other engineering options.
- **Roseburg.** The Roseburg Urban Sanitary Authority (RUSA) constructed its Natural Treatment System (NTS) to meet stringent Total Maximum Daily Load (TMDL) limits for the South Umpqua River. The TMDL reduced allowable phosphorus discharge from hundreds of pounds of phosphorus daily to a new limit of 3.4 pounds a day. Using natural systems on a nearby 340 acres, RUSA designed a system combining soil treatment, plant uptake, and nutrient storage in wetlands, farm lands and pastoral/forested areas to consume or store nutrients remaining in the treated effluent to meet all applicable state water quality standards. A conventional treatment plant upgrade to meet the effluent discharge limits was estimated to cost $100 million with an annual operations and maintenance cost of $6 million. RUSA was able to complete the NTS project, including land acquisition, for less than $10 million with an annual operations and maintenance cost of approximately $2 million. A strong partnership with the Oregon Department of Environmental Quality (DEQ) was critical to the program's success.

State/Local Water Technology Innovation Centers. Water innovation support programs can be found in many states and cities, many the result of business and academic leadership recognizing the need to accelerate the pace of water technology development and adoption. Most provide in-kind business support, funding, and/or business-to-business services. The biggest ones were financed with grants from the US EPA or Small Business Administration Cluster Program.[26] Examples include:

- **Massachusetts** – The MA Clean Energy Center finances a wide range of clean energy projects including those at clean water utilities in the state. In addition, they were instrumental in establishing the New England Water Innovation Network, which seeks to build a water

[26] For details, see: https://www.sba.gov/about-sba/sba-initiatives/clusters-initiative

technology cluster in Massachusetts by connecting technology developers with end users including the state's clean water utilities.

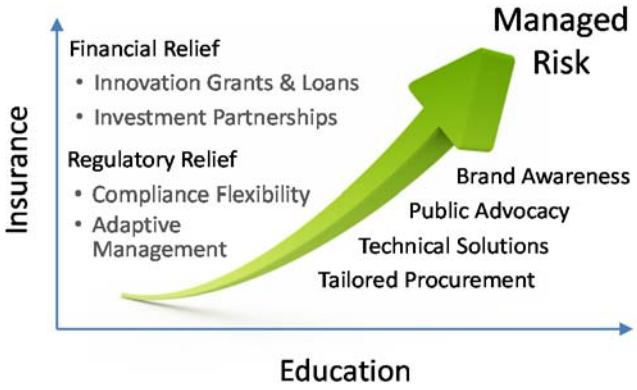
- **Colorado** – The Colorado Water Innovation Cluster links academia, technology developers, engineering consultants, and utility end users in the state through a series of initiatives designed to accelerate water technology development and adoption: integrated planning to achieve net-zero water, nutrient removal through real-time watershed monitoring, optimizing agricultural water use, and the water-energy nexus.
- **Indiana-Kentucky-Ohio (Confluence)** – The first of the Regional Water clusters under the Obama Administration's Regional Innovation Cluster Initiative, this tristate public-private partnership is using a $5 million US EPA grant to link technology developers to end users and bring new technology through a regional verification process instead of three separate state processes.
- **Milwaukee** – Under the auspices of the non-profit Water Council, academic, business, and civic leaders in Milwaukee are building a regional center of excellence in water that they refer to as the World Water Hub. In 2013 using a grant from the US SBA, the Water Council created the Global Water Center, a water research and business accelerator in a downtown office building. It provides physical facilities (meeting and lecture space, laboratories for prototype development, a water flow lab) to an integrated tenant roster (university, water technology developers, and engineers) creating an environment that is unavailable in one location anywhere else in the world. Next door is a new Global Technology Business Park, designated by the City as a mixed-use, urban office, educational research and technology zone focused on the international water sector.
- **Tucson** – Formed by the University of Arizona, Tucson Water, Pima County Wastewater, and local water technology companies, the Southwest Water Technology Cluster is designed to develop, test, and commercialize water technologies, and because of these activities attract new businesses to Arizona that can benefit from them.

VIII. The 2015 Innovation Ecosystem: Lessons for the UOTF in 2016 and Beyond

In just a few short years, the UOTF brand has been firmly established and momentum continues to build. Since 2013, we have observed broad penetration of UOTF activities across the top tier of the sector and formation of an "innovation ecosystem." An historic opportunity now exists to strengthen the systems and network effects within this ecosystem, which promise to deliver the next generation of water quality gains and community benefits at costs that customers are able and willing pay. The solution to how we do this is remarkably, but at the same time deceptively, simple: *enable utilities to take more risks.*

What Enables Utilities to Take Risks?

Insurance and education are the two most important risk mitigation tools at our disposal. Insurance spreads the financial costs of risk-taking from utility customers to others that can better afford and are more willing to bear them. Insurance also insulates, to a degree, utility leadership from bearing all of the political risk associated with making bolder decisions. While no decision can be risk-free – indeed management decisions should never be risk-free according to the principles of sound utility management – they can be shared differently to generate more innovation. Education helps leaders manage risks and make bolder decisions by providing examples of successful technology and process innovation. Education also helps leaders align decision processes with outcomes they value, like partnerships with others to reduce costs, increase revenues, and indeed, share risks.



Advocating, Educating, and Underwriting Innovation: Options for the Future

Based on this two-year review of progress since the *2013 Utility of the Future Blueprint*, NACWA, WEF, WERF and WateReuse have ample opportunities to continue their collaborative work supporting the clean water industry of the future. While this section is not intended to offer detailed policy or program recommendations, it does highlight the most important opportunities for advocacy, research, and education extracted from recent UOTF initiatives and raised by contributors to this *2015 UOTF Annual Report*.

Insurance

The word "insurance" is a catch-all for a wide variety of mechanisms that shift risk. Examples of UOTF innovation offer lessons on the value of financial incentives and regulatory processes, both of which act like forms of insurance since they help shift risk from innovators to others that can better bear them.

Financial Incentives. Financial incentives reduce the cost of failure if innovation is unsuccessful, but offer all or nearly all the benefit of success. Moreover, we can observe that they work in practice — government grants and loans, as well as innovative private financing were key elements of many UOTF initiatives between

2013 and 2015. Many of the most notable federal and state examples highlighted in this report can be extended and replicated across the country.[27]
In particular, the grant programs of the four federal agencies, EPA, DOE, USDA, and USBR have been particularly helpful in shifting the risk of technology adoption away from UOTF customers and speeding implementation of new, innovative technologies for water reuse, green infrastructure, materials and energy reuse, and renewable energy generation. Relatively small costs spread across the nation in the form of increased funding for these programs will be offset by orders of magnitude in terms of gains across the entire clean water innovation ecosystem.

Since 2013, we also have seen new sources of private financial incentives for innovation. Century bonds offered as taxable instruments act as private incentives in that they significantly reduce annual costs of servicing debt raised for clean water. Impact bonds directly shift technology risks (but not necessarily all capital risks) from customers to investors. Full-scale pilot projects offered by technology developers free of charge or with significant discounts to commercial prices shift technology and commercial risks associated with new technologies and solutions from public to private balance sheets.

True public-private partnerships structured as DBO and DBOFM projects can shift significant risk from the public to the private sector. This is especially true to the extent that procurement processes used to form these sorts of partnerships enable private providers wide latitude to propose innovative new solutions and utility owners wide latitude to select the best solution to meet their needs from among many choices.

Regulatory Incentives. Without question regulatory flexibility generates both process and technology innovation. Many examples of UOTF initiatives in recent years have demonstrated this, including the adaptive management processes in Milwaukee and Green Bay WI; water quality trading activities in Connecticut, Wisconsin, California, and Ohio; innovative enforcement orders to enable green infrastructure in Washington DC and Philadelphia among many other locations; and enabling alternative approaches to temperature and other TMDLs in Oregon.

But despite these examples and the promise of EPA's Integrated Planning Framework (see p. 42), regulatory flexibility has not expanded significantly since 2013, which is unusual given that we have observed significant gains virtually everywhere else in the innovation ecosystem. Regulatory flexibility remains a vastly underused tool that, if unleashed, will result in material gains in innovation across the clean water sector. We have in essence 50 state regulatory laboratories that could be a significant source of insurance enabling local innovation. This could be accomplished while fully maintaining, and improving where needed, water quality conditions across America. In fact, there is strong evidence that without additional regulatory flexibility, the nation can expect to lose some of the water quality gains that we have worked so hard to secure over the last several decades.[28]

[27] See for example: California's grant programs administered by the CA Air Resources Board, Energy Commission, Public Utility Commission, and Water Resources Control Board; Massachusetts' Clean Energy Center grants program; Indiana-Kentucky-Ohio (Confluence) grants program; Small Business Administration and EPA's Small Business Innovation Research grants program for water and wastewater; or US Department of the Interior, Bureau of Reclamation's Water Smart grants program.

[28] See, for example, National Association of Clean Water Agencies, *Collaboration for Healthy Watersheds: How the Municipal & Agricultural Sector are Partnering to Improve Water Quality*, January 2015; and *Controlling Nutrient Loading the US Waterways: An Urban Perspective*, 2011

Perhaps the most promising approaches are watershed scale processes that enable cooperation between clean water utilities and unregulated entities responsible for water quality impairment, notably agriculture, developers, and homeowners. Such approaches include adaptive management processes, more formal water quality trading programs, community-based solutions like green infrastructure, the LIFT *Creating the Space* effort, one-water integrated resource planning, and alternative green solutions to TMDLs. Legislative, regulatory, institutional and research pathways to innovate around these solutions were discussed in NACWA/WEF/WERF's 2013 *UOTF Blueprint for Action* and *Call for Federal Action* and the reader is referred to these documents for details.

Education

Efforts to educate the clean water community provide utility leadership confidence that bold new ideas can work in practice. Growing awareness of the UOTF "brand" since 2013 suggests that combined, education efforts of our national and regional clean water organizations and others are working. Technologies are spreading. Utility thought leaders are making bolder decisions.

The task going forward is to drive these trends even more broadly across the nation and, importantly, to all scales — large, medium, and small — within the sector. Logically, NACWA, WEF, WERF, WateReuse and their regional and state counterparts will continue to organize the following initiatives:

Brand Building. Continued support for concepts, processes, technologies, and successes of the *Utility of the Future*; a growing *Innovation Ecosystem*; and the *Systems and Network Benefits* to utilities, communities, and the economy. Initiatives include national and regional conferences and workshops; technical and guidance publications, newsletters, and videos; blogs and social networks; peer-to-peer sharing initiatives; testimony as part of legislative hearings and participation in legislative caucuses; and participation in regulatory and legal matters. One new concept that bears merit is an annual Innovation Prize Program, where for each segment of the innovation ecosystem, a competition is held for the most effective initiative, one each for technology developers, consulting engineers, clean water utilities, the finance community, and state and local government.

Public Advocacy. Continued advocacy and policy/economic/legislative support for initiatives at the federal, state, and local levels that support specific UOTF initiatives as well as innovation anywhere within the ecosystem. Many of these activities were discussed in NACWA/WEF/WERF's 2013 *UOTF Blueprint* and the reader is referred to this document for details.

Technical Solutions. Since the clean water sector is justifiably risk averse (its products are environmental and public health protection, so failure has high consequences), special emphasis is warranted on technology performance, adoption, costs, and reliability. WERF has been instrumental in this regard but they can only organize and fund what the sector supports. Accordingly, all members of the innovation ecosystem need to play their roles: EPA and the other federal agencies with clean water mandates (e.g. DOE, USDA, USBR) need to provide R&D funding; the consulting engineering community needs to sponsor and provide in-kind resources to collaborative research; clean water utilities need to pilot technologies generously; and all members need to share results broadly.

Tailored Procurement. This *2015 UOTF Annual Report* underscores that traditional procurement processes can impede innovation, especially the creation of integrated capital and operating solutions. A key part of the

education process going forward, therefore, needs to focus on how to use alternative procurement and program delivery approaches to increase innovation while respecting local procurement law.

Looking Forward

The lessons of the last two years are clear. We must collaborate more. We must take – but manage – risk. We must ensure that all participants within the clean water innovation ecosystem broaden network effects to include utilities of all sizes. And we must strengthen system effects by engaging all participants – utilities, technology developers, consulting engineers, the finance community, and government – in UOTF successes. More than anything, this is the key lesson of the last two years.