FIVE BIG GOALS FOR 2040

Goal 2

[water]

A Northwest Vision for 2040 Water Infrastructure

Innovative Pathways, Smarter Spending, Better Outcomes

the evergreen state college

Center for Sustainable Infrastructure

FIVE BIG GOALS FOR 2040

Water Supply
Wastewater
Stormwater

Integrated • Resilient • Sustainable • Affordable

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Table of Contents

Introduction and Overview

The Focus

Clean, readily available water is vital for any community to thrive. Local sewage and wastewater has to be processed to protect public health. And storm waters need to be managed to prevent local flooding.

A Northwest Vision for 2040 Water Infrastructure: Innovative Pathways, Smarter Spending, Better Outcomes paints a picture of how the Pacific Northwest can develop integrated systems to supply, purify, and manage water that are among the most sustainable and resilient in the world. At the same time, these systems must be affordable and beneficial to the people, today and tomorrow, who will pay for them: rich, middle-class, and lower-income people alike.

In the Northwest, like America as a whole, most communities boast water, wastewater, and stormwater infrastructure that was built last century, and was world-class when first installed. Those systems led to revolutionary improvements in public health and economic growth. But today much of last century's infrastructure is old, inefficient, prone to breakage, and vulnerable to earthquakes and climate disruptions. Billions of dollars will be needed to modernize our water infrastructure to serve the people that will live here in 2040.

Communities rely on water infrastructure systems to serve some of their most vital basic needs, such as providing people an uninterrupted flow of clean drinking water. Other important functions include removal of waste and pollutants, and flood prevention.

This report serves as a guide to rethink and reboot today's infrastructure investment strategies. It is a guide for water, wastewater, and stormwater decision-makers and policy-makers and their stakeholders – from their community and industry partners to, ultimately, the public and customers they serve. The immediate goal is smarter spending that achieves performance and cost excellence, and delivers more long-term community benefit – economic, environmental, and social – for each infrastructure dollar that is spent.

Five Big Goals for 2040

This report on water is the second in the "Five Big Goals for 2040" series, produced by the Center for Sustainable Infrastructure (CSI) at The Evergreen State College, to engage top Northwest thought leaders and innovators in mapping the path to achieve a shared and transformative 2040 infrastructure vision.

Broadly, CSI champions a new infrastructure investment paradigm by centering on long-range strategic foresight, new decision tools, and integration across systems for broadly-shared, long-term community value.

The fundamental premise of the Five Big Goals series is that, in a world of rapid change and growing challenges, we can no longer afford to simply replicate old infrastructure investment models. Innovation is required. Decisions made today have ramifications that will shape outcomes for decades to come, and the operating environment in that future will be different than today.

The series taps the region's leading infrastructure thinkers and innovators to broadly reimagine infrastructure systems, synthesizing their insights to provide guidance and inspiration for infrastructure decision-makers. Products are refined through review by high-level teams of experienced leaders.

Our framing report, *Infrastructure Crisis, Sustainable Solutions: Rethinking Our Infrastructure Investment Strategies*, drawing on interviews with 70 regional thought leaders and innovators, came out in late 2014. The report set "Five Big Goals for 2040" in energy, water, recycling, transportation, and integrated performance, as a conversation starter. To dive much deeper into energy, the first in our "Five Big Goals for 2040" series, *Rewiring the Northwest's Energy Infrastructure*, was issued early in 2016.

The aim of this report is to identify investment pathways to build world-class 2040 water infrastructure which performs better, at the same or lower cost, endures an earthquake or big storm with greater resilience, leverages innovative technology and best practices, and gives our kids a healthier

Introduction and Overview

environment. This is the kind of shared vision for Northwest leadership that Five Big Goals seeks to develop.

Approach for this Report

A Northwest Vision for 2040 Water Infrastructure brings together three main types of water infrastructure that by 2040 could be managed much more holistically, as integrated systems: 1) water supply; 2) wastewater treatment and recycling; and 3) stormwater and flood prevention.

The report is both aspirational and practical, finding points of alignment among a broad range of perspectives – the first attempt to construct a regional shared vision for the future of water infrastructure in the Northwest.

It focuses primarily on leadership by water infrastructure agencies and policymakers, but other players – non-profits, companies, foundations, investors, colleges, customers – are important partners in building a high-performance culture that can develop world-class water infrastructure systems in the Northwest.

The world of water infrastructure is diverse. This report focuses heavily on utility and government infrastructure decisions because they direct the bulk of the infrastructure investment dollar flow. The authors recognize that the big picture of water includes important issues outside the scope of this report, such as state water rights law, competition between water users, infrastructure finance tools, potential new federal infrastructure programs, regional water supply projections, state and local legal battles of the moment, and countless other important issues. Future versions or additional work can be done to incorporate innovations around these and other issues.

For this report, CSI formally interviewed over 40 West Coast water infrastructure leaders to invite their big picture, holistic insights on the key design question: *How can Oregon and Washington develop one of the most sustainable, resilient, and affordable water infrastructures in the world, spanning water supply, wastewater treatment, and stormwater management?*

Interviewees included utility managers, technical experts, engineering consultants, design innovators, non-profit leaders, tribal officials, and equity advocates. The group's expertise spans water supply, wastewater, stormwater, and flood management infrastructures.

Perhaps even more importantly, to test an initial synthesis an Executive Review Team of 27 experts and leaders provided detailed feedback on two drafts of this report in late 2016 and early 2017. This review was invaluable for ground-truthing the report's details, identifying important gaps, and significantly reshaping findings and recommendations toward something closer to a shared perspective. That said, the report's shortcomings, as well as its assertions, remain completely the responsibility of its primary author.

The findings of the process are presented in four sections that follow:

- Great Challenges Facing Water Utilities
- A New Model and Investment Discipline Emerging
- The New Investment Portfolio: More Choice, More Opportunity
- Smarter Spending: Checklist for Leadership

Key Takeaways

Between now and 2040, the Northwest will spend billions of dollars year in and year out to maintain, operate and modernize water, wastewater, and stormwater infrastructure. The multi-billion dollar question for the Northwest: *How do we generate the most long-term community value from these investments?*

A lot of Northwest water infrastructure is old, well past its design life. Rather than spending to simply replace the old, the new infrastructure investment discipline first considers alternatives, including innovative approaches to yield financial, social and environmental benefits simultaneously.

Our water utilities face a slew of big challenges: from aging infrastructure built decades ago; to costs to modernize that are too big for current local utility revenues; to infrastructure vulnerable to costly, even catastrophic, disruption from big earthquakes and extreme weather; to agency silos that discourage integrated and innovation solutions.

At the same time, water agencies are in a time of tremendous change and reinvention. New technologies and systems are emerging that can expand the solutions portfolio, but also change the business model for our utilities, while

Introduction and Overview

opening attractive new opportunities for residents, businesses, and builders. These new systems span all scales – from the building level to neighborhoods and districts, to city-wide, and to broader watersheds.

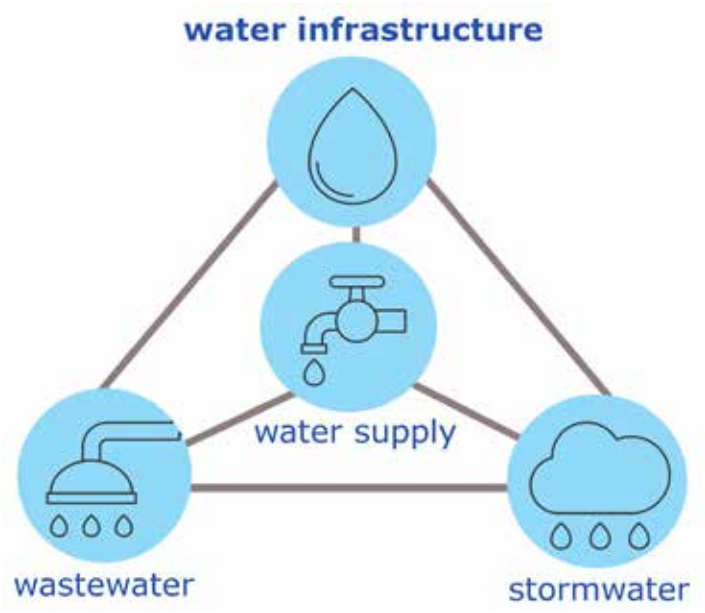
An emerging industry-wide movement known as "One Water" is breaking down silos to integrate supply, treatment, and stormwater sectors previously managed separately. And new investment tools are helping innovative water leaders to plan and spend smarter, both at the project level and system-wide. The prevailing theme is optimizing the community benefits – financial, social, and environmental – of infrastructure investment.

Integrated, multi-benefit projects and programs that bridge agency silos are key. They open opportunities for cost-share partnerships that can deliver each co-funding partner more value for their buck. For multi-benefit projects, water utilities can pool resources with a wide-range of potential cost-share partners, including other water agencies, energy utilities, health providers, carbon investors, transportation and economic development agencies, property insurers, social impact investors, and fish, wildlife, and parks managers.

Putting the pieces together, here's how world-class water infrastructure systems in the Northwest of 2040 will work better than today's:

- Water management will integrate across traditional silos and optimally blend traditional central facilities with networks of micro-infrastructure systems.
- Utility and government programs will build lean, high-performance cultures that reward innovation and performance, and value the triple bottom line.
- Water systems will be infused by smart technologies such as sensors and cameras that provide real-time information to achieve efficiencies throughout local systems.
- Central wastewater treatment plants will become community economic hubs, producing clean water, clean energy, rich soils, and valuable fertilizers.
- Utilities will develop more collaborative relationships with customers and neighborhoods.
- Utilities will advance their roles in watershed restoration, and forge creative cost-share partnerships for multi-benefit projects and programs.
- Regional collaboration and consolidation will grow. Small water utilities will partner to better meet the challenges.
- Utilities and governments will focus investment to build more resilient infrastructure.
- Policymakers will couple job creation programs with infrastructure strategies to grow sustainable jobs throughout the region.

The path to world-class 2040 water infrastructure in the Northwest has many moving parts. This report boils it down to an action checklist for water utility leaders and for state and local policymakers. To succeed, though, these leaders will need to cultivate valuable innovation partnerships with non-profit agencies, private companies, academic groups, and foundations.



The "One Water" paradigm helps utilities and regulators bridge the gap between separate silos and reap the financial, social, and environmental benefits of designing water infrastructure systems more holistically. An integrated vision of these systems often uncovers more affordable, resilient, and sustainable strategies. For example, utilities investing in water reuse and recycling must integrate their water and wastewater infrastructure operations.

The Great Challenges Facing Water Utilities

This section overviews important challenges that represent major forces in the operating environment for water infrastructure utilities, forces that they cannot control but to which they must respond.

Members of Ashland, Oregon's Planning Commission tour their local wastewater treatment plant. (Posted to Flickr by Derek Severson (CC BY-NC-ND 2.0) https://creativecommons.org/licenses/by-nc-nd/2.0/legalcode.)

The Social Compact for Utilities

This report focuses on water, wastewater, and stormwater agencies because they have been and will continue to be the chief investors on behalf of their ratepayers. They spend several billion dollars each year to develop, manage, and operate infrastructure systems serving the people and businesses of the Pacific Northwest.

But water utilities and agencies are in a time of tremendous change and reinvention. As water researcher David Sedlak has proposed, a revolution in water infrastructure is upon us, on the scale of the ancient Romans' development of long-range water transport, and the emergence of drinking water and wastewater treatment in the past two centuries. He calls it *Water 4.0*, with large changes in technology, a move to water recycling and energy recovery, and the spread of distributed systems. Facing the uncertainties of climate disruption and technology change, piling on top of revenue stresses and the need to replace aging infrastructure, it is hard to conceive of a time of greater challenges for those who manage our vital water infrastructure.

A key challenge for utility decision-makers today is that the set of tools and technologies to fix and rebuild water infrastructure is changing, at the same time that the region's hydrologic patterns of the past 100 years – around which utilities designed and sized their water infrastructure – no longer serve as a reliable guide to future Northwest hydrology because of the ways global climate change is disrupting weather patterns.

A quick snapshot of the history: Utilities were established and granted local monopolies, mostly last century, to supply essential water services equitably, to all the people and businesses in the community, reliably and affordably. In some cases, it took calamitous events. The Great Seattle Fire of 1889, in which 25 square blocks burned down, underscored the need for reliable water service and spurred development of public water supplies. Public health and safety are important reasons why we have centralized water systems and why they will remain relevant even as decentralized supply options emerge.

The social compact under which utilities were formed is grounded in the most basic fact about water: everyone has to have it. Utilities exist to secure the ready access to clean water that is essential to every person's life (drink, bathe, cook, clean…) and for every business, school, and agency. Water utilities also protect people against infectious disease and toxic exposure by managing waste and pollution in our water. And they help protect our homes and property from destruction by flood or fire.

Our water utilities exist to help secure these essentials for everyone in the community. Publicly-owned utilities are essentially a form of democratic government, formed among people to pursue shared ends that we can pursue better together than alone.

Because utilities collect money from all users of water services in their territory with the mission to supply affordable access to everyone, it is imperative utility leaders reinvest these revenues to optimize the community and system-wide benefits over the long-term.

But decision making is often opaque, underscoring the need for utilities to communicate and collaborate with their communities. To work properly, these institutions need to be accountable and responsive to people they serve, the environment, and to property rights holders.

As well utilities need to change and evolve as technology, and the needs and priorities of people, change. For example, the spread of distributed micro-infrastructure may well open new doors for utilities to provide maintenance services for systems that customers may own, and build networks of customer-owned technologies such as cisterns to manage water flows.

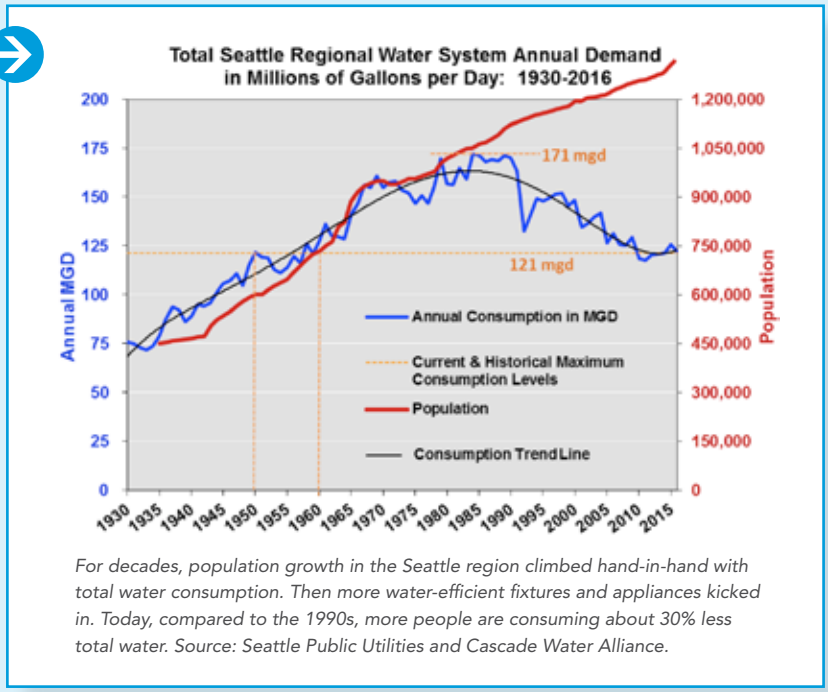
The Great Challenges Facing Water Utilities

Disruptive Efficiency Meets Aging Utility Business Model

Success can sometimes come with unexpected challenges. In the case of water, conservation success is challenging the revenue model for water utilities.

"Demand started to change radically in 1992," says Chuck Clarke, Chief Executive Officer of Cascade Water Alliance. "Since '92, in King County population is probably up roughly 30-35% and actual total water use is down 30%."

The trend has multiple sources. Washing machines, dishwashers, and showerheads are substantially more water-efficient than past models. A trend to urban density is reducing lawn watering needs. Usage-based rates provide incentives to conserve. In many regions, particularly drought-plagued places such as California, active efforts to engage citizens in conservation have significantly cut water consumption.



For decades, population growth in the Seattle region climbed hand-in-hand with total water consumption. Then more water-efficient fixtures and appliances kicked in. Today, compared to the 1990s, more people are consuming about 30% less total water. Source: Seattle Public Utilities and Cascade Water Alliance.

"We've got a finite resource yet we're able to use it with more and more people and economic development," says Jeff Clarke, General Manager of Alderwood Water and Wastewater District. "That's a really positive development."

But the challenge is declining revenues. "There is a business model and rate structure question for utilities," says CH2M Vice President, Liz Kelly. "If the rate structure is heavily based on consumption and we incentivize lots of conservation, that can create a revenue problem for the utility."

Chuck Clarke says water managers operated under the assumption "money will continue to roll in and growth will keep revenues going up. It's taken the industry a long time to realize that's not really true… and it's created some pretty serious dislocation."

Judi Gladstone, Corporate Policy Director with Seattle Public Utilities, points out that most of the cost to supply water to users is not for the water itself, but for the infrastructure to deliver it. Chuck Clarke notes that, "The fixed costs for the infrastructure are 80-90%. You think about water utilities and a lot of it is crews, maintaining infrastructure sitting in the ground. On the revenue side, it's almost all variable (based on consumption), so when demand began going down that created a shortfall."

That raises questions about how water is valued and rates are set. "In the U.S., we're coming into a repair-and-replacement cycle for infrastructure," says Michael Mucha, Chief Engineer and Director for the Madison Metropolitan Sewerage District (and former public works director in Olympia, Washington). "We undervalue water, so we haven't yet figured out how to pay for this. Many other countries charge more – they've put a value on water commensurate with what's needed to supply clean water."

The rise of building-scale water systems broadens the challenge for utilities. "You'll see technology changes related to capturing water and processing it at the home and building level," CWA's Chuck Clarke says. "Technology will be there at a low cost, and that can create significant dislocations for utilities. If you reduce water demand (from the utility) by another 30% by 2030, that'll have huge consequences for utility balance sheets."

The Great Challenges Facing Water Utilities

The Equity Challenge ~

Utility leaders must also look for – and invest in rectifying – patterns where businesses, schools, and people in disadvantaged and rural neighborhoods are most exposed to the hazards of breakdowns in our water infrastructure.

When floods strike a community, it's often on bottomlands where lower-income people and communities of color tend to live, precisely because the higher risks of such areas translate into lower real estate values. When lead is discovered leaching from pipes into water supplies, it disproportionately hits children and families in those communities.

Witness Flint, Michigan. In 2014 the city switched to water supplies from the Flint River to reduce costs. But the water had corrosive effects on aging lead pipes in the city. Lead leached into the urban water system, elevating levels in children's blood past health standards. High lead exposure attacks the brain and nervous system of children. The crisis resulted in criminal charges against public officials.

"Disproportionate impacts are something I think utilities are just starting to think about," says Jennifer Devlin with Portland Bureau of Environmental Services (Portland BES).

"Public infrastructure systems designed to serve communities are affected by the larger context of institutional racism in the United States, where the systems are set up to serve the rich, with people of color at the bottom less well-served," adds Anita Yap, Founding Partner of MultiCultural Collaborative. "You can't really talk about environmental issues without talking about equity – understanding the community impact. And you really need to understand the long-standing nature of the equity problems."

Rising water service rates also pose equity challenges. The infrastructure needs documented in this section are forcing many utilities to raise their rates. But this challenges people with limited budgets, including seniors, disabled and other low-income populations.

Says Colin Bailey, Executive Director of the Environmental Justice Coalition for Water, "So many systems of our governance are really challenged to their core by income inequality. Utility costs are climbing and when a significant segment of the population can no longer afford it, you start to erode the basic social contract because people can't access the basic dignities of life – water and sanitation."

First responders can be paralyzed by earthquakes or flooding in 'super storm' events, like this ambulance stranded by Hurricane Sandy in Hoboken, New Jersey. (Posted to Flickr by Alec Perkins (CC BY 2.0) https://creativecommons.org/licenses/by/2.0/legalcode.)

The Great Challenges Facing Water Utilities

The Jade District: One Neighborhood's Lens on a New Infrastructure Vision

As the Northwest's water infrastructure continues to evolve, how might changes at the industry level impact people on the neighborhood level?

The Jade District, located in Southeast Portland, can serve as an excellent example. It is one of the most diverse neighborhoods in the state of Oregon, a vibrant community that currently serves as a landing spot for many immigrants. The district features amazing cuisine, close-knit communities, and some strong local institutions. However, incomes are lower than average and some key infrastructure is lacking, leading to stark economic and health disparities.

According to latest data, about 47% of residents are people of color and 55% are categorized as low income. Fifteen percent live in linguistic isolation. In terms of the built environment, the neighborhood is known for incomplete streets and few parks. The U.S. Forest Service recommended level of coverage for urban tree canopy is 40% – the Jade neighborhood averages just 21%, with some areas even less. On the not-so-distant horizon, the threat of involuntary displacement due to rising property values looms large, as rents are continuing to increase and Portland's urban core expands.

If the Jade District of 2040 is going to be a healthy, equitable, and sustainable neighborhood, a holistic approach to community development that includes water infrastructure will be critical over the next two decades.

First, the built environment of the neighborhood will look different. If green infrastructure is prioritized, agencies and utilities will find ways to integrate more deeply into the community, investing for co-benefits such as local economic vitality, resilience, carbon savings, recreation, and beauty. There will be more tree canopy, public parks, and small scale water infrastructure sites. Neighborhood residents have been asking for spaces to bring their grandchildren, practice tai chi, or garden. While this is what they are asking for; green infrastructure can help meet these needs and contribute to better water and air, flood control, and public health as well.

As the neighborhood becomes a more pleasant place to live, the consequences of this desirability must be addressed so that current residents are able to stay and enjoy these new benefits. This will require strong public planning, deep investment in affordable housing, and a focus on creation of green jobs that are filled by local residents. Smart infrastructure investment not only helps control rate increases and keep vital water services affordable for residents and local businesses, infrastructure spending translates into good-paying local jobs. Building and maintaining new distributed micro-infrastructure, from constructed wetlands to cisterns and building-scale treatment systems, will require both construction and maintenance workers. This can benefit economically challenged communities if neighborhood residents are the ones filling these jobs. As rents continue to rise, so must the income of our residents.

Disaster preparedness is typically lacking in the most vulnerable neighborhoods. Smart investment helps vital water services resist catastrophic breakage and recover more quickly when earthquake or climate disaster strikes. However, neighborhood resilience is much more than infrastructure. True resilience comes from an organized community, able to work together during a crisis. This will require additional care to strengthen social networks, especially in diverse neighborhoods.

At the end of the day, how the Jade District neighborhood will look and work in 2040 will be affected by the values and principles of local water infrastructure decision-makers. Neighborhood residents are not going to be talking about stormwater management, public utilities, or carbon savings. They are going to be talking about lack of parks, how expensive rent is, and how difficult it is to get their kids to school or get to their jobs. Decision-makers should take care to listen these concerns and adapt their strategies in their spheres of influence to truly serve the community.

By Duncan Hwang, APANO (Asian Pacific American Network of Oregon)

The Great Challenges Facing Water Utilities

Infrastructure Deficit: It's Both Money and Capacity

Really Old Systems Need Modernization ~

Many systems are reaching the end of their design life, or are beyond it. According to a 2016 National Infrastructure Advisory Council (NIAC) report on water sector resilience, "(W)ater has an aging infrastructure that requires massive reinvestment to upgrade pipes, mains, and equipment. Many assets are nearing or beyond their expected lifespan, leading to roughly 240,000 water main breaks and between 23,000 and 75,000 sanitary sewage overflows per year in the United States."[1]

Demands for investment are large. The NIAC estimates the gap between existing funding and that needed to restore water infrastructure nationally to maintain current service levels ranges from $400 billion to nearly $1 trillion.

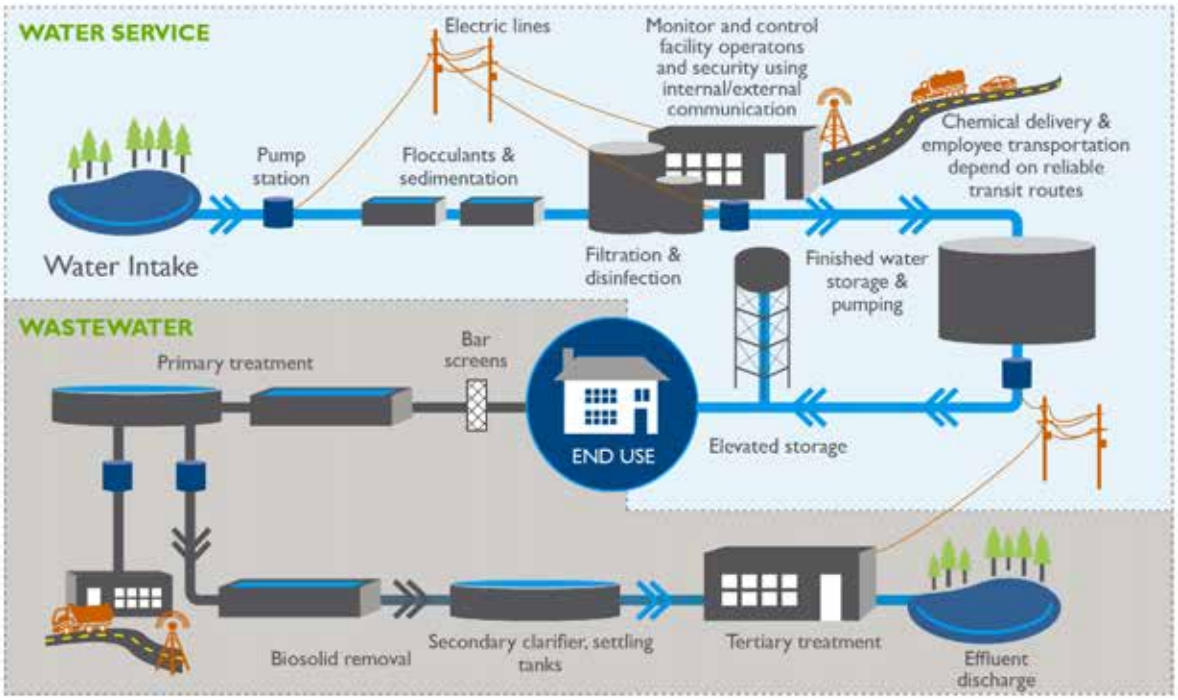
1 National Infrastructure Advisory Council, "Water Sector Resilience Final Report and Recommendations" (Dept. of Homeland Security, June 2016).

But raising the extra revenue from ratepayers to fill the investment gap may be difficult. The NIAC notes, "(M)ost state and municipal decision-makers are constrained by long-held expectations by customers for water as a low-cost, affordable service that does not account for true lifecycle costs." A key part of the problem is that, "Nearly all water infrastructure assets are out of sight and historically reliable, leading to an underappreciation of the criticality of water services and the infrastructure that deliver them."

"The scope and scale of the problem brings us to the finance challenge," notes Steve Adams, Director of Urban Resilience at the Eugene, Oregon-based Institute for Sustainable Communities. "What is the local tax or rate base and what are the kinds of financing? Do we have sufficient bonding capacity at the local and state level that will be required to retrofit and rebuild our aging infrastructure?"

On the other hand, Steve Moddemeyer, Principal and infrastructure innovation expert with CollinsWoerman architects, asserts, "We really need to use existing spending more wisely; there's quite a bit of money being spent now that's not effectively addressing the critical issues that we have."

Typical Water and Wastewater Infrastructure



Centralized infrastructure has been the hallmark of modern water management. Large reservoirs supply a network of pipes leading to water users. Another latticework of pipes carries wastewater to large centralized treatment plants. Along each route are a sequence of sophisticated facilities. Source: United States Department of Homeland Security.

The Great Challenges Facing Water Utilities

Whether existing dollars can be repurposed to meet the need or new funding sources are required is still up for debate, and will vary for each utility. But all agree that federal funding to assist local water agencies is far less than in the halcyon days of the mid-20th century. Jeff Clarke of the Alderwood Water and Wastewater District suggests the remaining federal support skews toward big city projects. "Most of the funding Congress has recently made available for water and wastewater projects is for big $20-million-plus projects. That helps with mega-projects in big cities, but for most districts that doesn't do anything."

In response to the deterioration of federal and state support for local infrastructure, some leading utilities have made the difficult but crucial transition to secure their financial independence.

Bruce Roll, Watershed Management Director for Hillsboro, Oregon-based Clean Water Services, describes it as a "transition to rate-based local funding for capital improvements and maintenance." In other words, the utility builds its long-term plan to repair, rebuild, operate, and maintain the system, estimates the total cost, and designs a transition to higher rates so that the local system can be sustained by local ratepayer dollars.

As part of a system-wide, holistic management program, this should be one of the gold standards for utilities: A local system sized to successfully serve the local ratepayers at a sustainable cost for which they are able to pay full freight. Not surprisingly, early adopters tend to be larger utilities that have a bigger pool of ratepayers paying into the system (just as insurers can provide better coverage at lower cost when insuring a larger pool). These utilities also can afford high-capacity professional staff, with technical and financial expertise, and back them in pursuing innovation.

For smaller utilities, the transition can be daunting. Their smaller staffs are often fully occupied with the challenges of maintaining aging systems, with maintenance budgets that have been squeezed for years running. In many cases, 'bigger-is-better' federal funding last century helped build centralized facilities too big for the local community to afford to maintain and replace.

The gap between big and small towns comes out in the contrast between two Oregon communities. Portland 20 years ago was confronted by water quality mandates to separate stormwater and

Rapid Growth Complicates Water Planning

The challenge of planning for future water infrastructure is complicated by a rapidly growing population. Driven by an attractive quality of life, Washington saw the nation's fifth highest population growth rate in 2016, followed by Oregon at sixth. Washington, now home to seven million people, will add one million by 2025 and grow to nine million by 2040, the state Office of Financial Management projects.[1/2] Oregon's population is 4 million, and is projected to reach 4.5 million by 2025 and 5.2 million by 2040.[3]

Seven new people are already making the Puget Sound region home each hour, notes Steve Whitney, senior program officer at Bullitt Foundation. "With the combination of population pressures and climate change, there are a whole lot of drivers there for worrying about our water infrastructure."

Growth of Northwest communities poses challenges to water systems needing to keep up with demand and extend systems to newly developed areas. Whether newcomers live in sprawling suburbs or more compact communities impacts the cost of water infrastructure services significantly. A recent study in Canada found that the yearly cost to provide each household water, wastewater, and stormwater infrastructure in a low-density suburban city is more than four times as much as a high-density city, and about twice as much as a mid-density city.[4]

Oregon and Washington both have policy frameworks that aim to rein in sprawling land development, yet the spread of low-density development continues to take a toll on local government and utility budgets for vital services and infrastructure.

Already with today's population and climate, especially during dry and drought years, water supplies get stretched and competition sharpens between cities, agriculture, hydropower generators, and fish and wildlife. The Northwest's Tribes, as sovereign nations, have a powerful, treaty-protected interest in clean water and healthy salmon and shellfish. Water system managers will need to continue to be responsive to the needs of their tribal neighbors, as they simultaneously plan for uncertain population growth.

1 State Population Forecast 2010-2040, Office of Financial Management, Forecasting and Research Division, No. 16, 2016 http://www.ofm.wa.gov/pop/stfc/stfc2016/stfc_2016.pdf (viewed Jan. 3, 2016).

2 The Nation's Fastest-Growing States, Realtor Magazine, Dec. 21, 2016.

3 Forecasts of Oregon's County Populations and Components of Change 2010-2050, Office of Economic Analysis, Department of Administrative Services, State of Oregon, March 28, 2013.

4 Angie Schmitt, "Sprawl Costs the Public More Than Twice as Much as Compact Development," Streetsblog USA, March 5, 2015.

The Great Challenges Facing Water Utilities

sewage. The combined sewer-stormwater system mixed the two and dumped unacceptable levels of raw sewage into water bodies during storms. No state or federal funds were forthcoming. Portland took on the task with its own customer revenue, and found innovative ways to incorporate green infrastructure.

"Portland is fortunate that we have the customer base to cover this level of financing," says Jane Bacchieri, Watershed Services Manager for Portland BES. "We don't have federal dollars anymore for investing in these systems."

Cathy Kellon, Working Waters Program Director at Geos Institute, tells the contrasting story of Oakland, a southwest Oregon community with a population of 927 and a lot of water system challenges. Major flooding in Calapooya Creek recently clogged the city's drinking water intake with sediment. Efforts to flush it have proven unsuccessful, draining the city's cash reserves, and while they work towards a durable solution, they are relying upon a temporary fix using PVC pipe and an irrigation pump. The wastewater treatment plant needs to be updated and expanded to meet newer regulatory requirements. Aging conveyance pipes under the streets

Water infrastructure aged past its design life causes, "roughly 240,000 water main breaks and between 23,000 and 75,000 sanitary sewage overflows per year in the United States," says U.S. Department of Homeland Security's National Infrastructure Advisory Council.

have crumbled in some spots, creating sinkholes and threatening to undermine the railroad grade that goes through town. And Calapooya Creek, source of the town's drinking water and recipient of its wastewater outflow, suffers low water flows in late summer and early fall.

In spite of these big infrastructure challenges, "They are looking at some innovative, integrated solutions," Kellon says. Instead of replacing the intake one year and then replacing the wastewater treatment plant in five years while getting to the leaks under streets whenever they can, community leaders and residents have mapped out an approach that efficiently fixes several of these issues at once. This integrated strategy will ensure more water reaches the Calapooya during the late summer when native fish need it most, by employing a coordinated mix of green and gray infrastructure. "They have a really lovely vision for what's possible which is more aligned with nature and their community values. But they don't have the time or budget to move that vision forward."

Kellon notes that the current estimate for implementing their vision is $7 million. It's a reasonable price tag compared to similar projects in major urban areas but that translates to roughly $1,000 a year for a family of four in Oakland, if spread over 30 years. Raising rates that much in a community where household income averages around $40,000[2] could hit many local families hard.

State and federal funding programs exist to help towns like Oakland. However, funding tends to fall into silos of drinking water, waste water, and storm water which can create several hurdles and administrative burdens. As a result, "It's simply easier and more efficient for Oakland to look at their water system problems in an isolated and piece-meal fashion," says Kellon. "There is opportunity to create really cool, innovative, integrated and holistic solutions in these small communities. The real barrier to change is resources, not a lack of ideas or interest."

21st Century Solutions Require New Expertise

The emergence of new, integrated solutions offers opportunities to help bridge the investment gap, if systems can be developed to bring capacity and resources to communities such as Oakland. In fact, a growing portfolio of new technologies and best practices could reduce the cost of modernizing water infrastructure systems, while increasing their resilience in the face of hazards and improving environmental performance significantly.

The 21st century solutions portfolio requires a very different set of tools from the traditional ones taught in civil engineering schools. The new technologies and best practices range from the small scale that can be distributed widely – including smart technologies, green infrastructure, and micro-systems – to large-scale system-wide planning and strategies that span whole watersheds and bring together multiple utilities and cities.

There may be a "silver lining" in the underinvestment of recent years, says Scott Haskins, a Senior Vice President and Director of Strategic Consulting with the global engineering firm CH2M. "Had we really been building infrastructure at

2 U.S. Census Bureau, "American FactFinder," accessed February 6, 2017, https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

The Great Challenges Facing Water Utilities

This Manchester, Washington downtown park is a stormwater facility in disguise. With an eye-catching nautilus spiral design, it is a gathering place that fits with the local character and showcases views of Puget Sound. It provides another important function: reducing polluted rainwater runoff draining into the Sound. The project was funded by Kitsap County and Washington Department of Ecology. Source: Kitsap County Public Works.

the same pace as in the 30 years after World War II, we'd have built a lot of big, wasteful, environmentally insensitive, overly redundant, and costly infrastructure."

Utility leaders need to bring expertise in state-of-the-art innovation into their infrastructure investment decision-making. But that is another key capacity challenge, especially for smaller communities.

There are over 16,000 wastewater systems in the U.S., with the majority small, poorly capitalized, and less able to adopt best practices and innovation than the larger, well-resourced systems, according to Chris Taylor, former Director of the West Coast Infrastructure Exchange and now at Google Fiber. "To get these innovations more widely adopted," he says, "we need a way to get smaller systems to regionalize or collaborate in some other way to achieve scale."[3]

On the other hand, "small systems may not have money to set aside for deliberate innovation programs, but people that work there have just as much capacity to innovate as medium and large systems," says Liz Kelly of CH2M. "In fact, with limited resources sometimes they have to innovate more, just to get by, than systems with more money."

Small communities are certainly capable of innovation. The City of Manchester, a community of 5,000 people on the Olympic Peninsula, boasts a terrific example of a green infrastructure facility that doubles as a major community asset. Initiated by Kitsap County's Public Works Department in 2012, it is both an advanced stormwater treatment facility and a public park nested in downtown Manchester. It features an eye-catching spiral "nautilus" design, 4 interconnected treatment cells planted with a mix of rain-tolerant plants, and 18 distribution channels to uniformly distribute incoming water to the 4 cells. The project team consulted with the community throughout the process, which steered design toward a gathering place that fits with the local character and showcases views of Puget Sound.[4]

The many small water and wastewater districts are typically governed by a board of elected directors. With a great many director positions held by late-career or retired people, a new generation of leaders, with innovative thinking and strong training, needs to be encouraged to run for board positions. They will need robust skill-building and peer-to-peer networks to share effective collaboration models.

3 Rhys Roth, Infrastructure Crisis, Sustainable Solutions, Center for Sustainable Infrastructure, http://evergreen.edu/sites/default/files/sustainableinfrastructure/docs/CSI-Infrastructure-Crisis-Report.pdf.

4 "Kitsap County Combines Innovative Stormwater Infrastructure with Beautiful New Community Gathering Space," Center for Sustainable Infrastructure Blog, August 7, 2016, http://blogs.evergreen.edu/sustainableinfrastructure/2016/08/07/kitsap/.

The Great Challenges Facing Water Utilities

New 21st Century Water Infrastructure Solutions

The new portfolio of infrastructure solutions is described more fully in *The New Investment Portfolio* section (page 29). This portfolio includes many systems that are new to the market, just starting to establish a track record of performance in the field. But in the next decade, they will be deployed in a variety of contexts, build their performance track record, and grow the ecosystem of companies and professionals with expertise in their design and operations. In the energy sector, clean technologies like wind and solar power systems are on astonishing trajectories for improving cost-performance that have made them competitive with traditional energy resources quite quickly. Whether or not innovative water technologies will achieve similar adoption rates, we can expect continuous improvements in cost and performance over the next decade.

Three of the most important and exciting categories of 21st century solutions:

Smart is Beautiful

Information technology is increasingly infusing water systems. Sensors in pipes and equipment provide real-time situational awareness of conditions, enabling just-in-time asset repair and replacement. Control systems allow operators to see inside pipes and monitor pumps from a control center. As a result, they can often fix problems by sending out wireless commands, and deploy field staff in a much more targeted and efficient way than in the past.

Within buildings, sensors in appliances and fixtures can provide detailed usage information that informs and enables conservation efforts. On the landscape, remote sensing and GIS systems compile data sets, map key parameters like carbon sequestration, watershed land cover, and water levels, monitor conditions of existing infrastructure, and present data maps visually to support integrated decision-making. Likewise, home and commercial customers are now in a better position to manage their water efficiency, levels of service, time of day consumption, and on-premise system maintenance – benefiting both their own bottom line and overall community water management.

Green Complementing Gray

For water infrastructures at all scales – regional, city, district, and building levels – green infrastructure can reduce overall system costs by augmenting the traditional 'gray' infrastructure, such as pipes, pumps, and centralized treatment. Strategies include a wide-range of nature-mimicking measures that are good for clean water and for helping prevent flooding. They range from engineered bioswales, green roofs, and constructed wetlands to investments that preserve and enhance open space, tree canopy, streamside habitats, mountain headwaters, and other natural systems.

Green infrastructure is part of what makes cities more livable for people. Green solutions generate widely shared benefits, such as improved health, new companies and jobs, recreational opportunities, fish and wildlife enhancement, and carbon sequestration. This opens the way for cost-sharing with other agencies and utilities around mutual benefit, making more projects affordable. Also, "green infrastructure maintenance and management increases opportunities for job training programs; healthy work that contributes to social cohesion," says Deb Guenther of Mithun. "Social cohesion is widely considered to be the most critical resilience strategy for neighborhoods that must adapt to natural disasters or disturbance."

Micro-Infrastructure Solutions Emerging

Micro-infrastructure solutions mean distributed technologies and projects that deliver value in small increments. Micro-infrastructure can be deployed in low-cost, low-risk chunks compared to traditional centralized facilities. These systems could add up to significant system-wide value when deployed widely across neighborhoods and even regional watersheds.

Firms at the leading edge of the dynamic green building movement are now building and retrofitting commercial buildings to achieve "net-positive" water performance. These buildings capture more water on-site than the building's occupants use, discharging it only after processing it to be clean for many uses. Cisterns to harvest rainfall on-site, rain gardens and green roofs, can slow stormwater runoff and help reduce the burden on the local drains and pipes during big storms. Some micro-infrastructure systems can better serve several buildings or even a neighborhood. Utilities will play the lead role by integrating small systems to optimize benefits for the larger system and by paying customers and private partners for value delivered.

The Great Challenges Facing Water Utilities

Risk and Resilience

Infrastructure systems are vulnerable to a variety of natural and human hazards, from extreme weather events, landslides, tsunamis and earthquakes to toxic spills and terrorist or cyber-attack. And when they happen, public attention can focus, powerfully if episodically, on infrastructure vulnerabilities and on the need for more resilient systems.

Resilient systems are less 'brittle,' meaning less vulnerable to catastrophic failure than standard systems, and recover to restore service more quickly in the event of disruption. The U.S. Department of Homeland Security's National Infrastructure Advisory Council says, "The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event."[5]

Northwest water infrastructure is especially vulnerable to destruction by earthquakes and climate disruption.

Earthquakes ~

In the Northwest, one of the most geologically active regions in the world, major seismic events are inevitable. The Cascadia Subduction Zone running parallel to the coast, where the oceanic plate grinds under the continental plate, is capable of triggering earthquakes of great power. Fault lines running closer to the surface through cities including Seattle, Tacoma, Portland and Everett can generate temblors that are far less intense than Cascadia quakes, but epicenters within cities will produce highly destructive events.

It is by no means certain the Northwest will be hit with a highly destructive earthquake in the next few decades. A 2016 analysis by a team of international researchers forecasts the odds of a major rupture along the Cascadia Subduction Zone off the coast of central and northern Oregon at 15-20% in the next 50 years, and 10-17% off Washington and British Columbia.[6]

Though such a destructive quake is far less than certain, the consequences might well be catastrophic. The Water Supply Forum servicing Snohomish, King, and Pierce Counties finds seismic events are the greatest disruption risk facing regional water systems, notes Chuck Clarke of the Cascade Water Alliance. Though these counties are among the wealthiest in the state, the Forum estimates that it would take 7 to 30 days to restore 90% of water service after a Cascadia quake.[7]

5 National Infrastructure Advisory Council, Critical Infrastructure Resilience Final Report and Recommendations, September 8, 2009.

6 David Stauth, "Subduction Zone Earthquakes off Oregon, Washington More Frequent than Previous Estimates," Oregon State University News and Research Communications, August 5, 2016.

7 Water Supply Forum Regional Water Supply Resiliency Project Earthquake Vulnerability Assessment Technical Memorandum, Snohomish, King, and Pierce Counties, Washington, April 11, 2016, p. 1-3.

Distributed Solutions for Earthquake Resilience

Diversifying water supply sources can help get more people and businesses back to normal sooner after a major quake. The Water Forum identified the lack of connection between Washington's King and Snohomish counties as a critical gap, and points to an intertie pipeline between Seattle, Bellevue, and Everett as a solution. Cost would likely be in the hundreds of millions.

"Right now, water isn't allowed to pass between King and Snohomish counties," Alderwood's Jeff Clarke notes. "What happens if we have a major fault open up in Snohomish that disrupts Everett's water supply? Will we have a broader integrated system? Most likely when the big one hits we'll have one or two systems down." Sri Krishnan, Clarke's Finance Director at Alderwood, notes, "We think about resilience not as 'hardening' but flexibility. The standard should be for water coming in from at least two different sources from independent directions in the event of an emergency."

Clarke notes that the San Francisco Bay Area has built flexibility into its pipelines from the Hetch Hetchy reservoir in the Sierras. "It's a very expensive project, but probably very cheap in the long run."

Steve Moddemeyer, Seattle-based infrastructure resiliency expert, proposes adding a distributed solution. "Rather than only trying to solve the problem at the macro-scale, what if you put a well at every elementary school, which you don't turn on until the quake happens? The cost is only about $10 million to do 100 neighborhood schools." Says Moddemeyer, "Wells are more resilient to earthquakes than pipelines. They can be switched on and serve people across the geography quickly after a quake because schools are in every neighborhood." Onsite storage in numerous rain barrels or cisterns would also add resilience, he adds. "You probably want to do all three: rain barrels, wells, and the intertie."

The 2011 Tohuku magnitude 9.0 subduction quake off the northern Japan coast cut off water service for 40 days. After a 2011 surface quake in Christchurch, New Zealand, it took 40 days to restore service. The 1995 Kobe, Japan temblor, similar to what a Seattle event might trigger, left some water customers without service for 60 days.[8]

8 Ibid, p. 6.

The Great Challenges Facing Water Utilities

Cascades snowpack at its typical April 1 peak has already diminished 20% compared to the 1950s. The continuation of this trend could seriously impact water supply. (Photo by Walter Siegmund via Wikimedia Commons (CC BY-SA 3.0) https://creativecommons.org/licenses/by-sa/3.0/legalcode.)

Climate Disruption ~

The legacy systems we have today for managing water flows are sized to handle the deluges and droughts of the past – typically the event the historical record suggests only occurs once or twice in a century, the 50- and 100-year flood. But a changing climate is disrupting natural hydrologic cycles and, in turn, the assumption that the future will track with the past, a concept known as stationarity.

"Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity – the idea that natural systems fluctuate within an unchanging envelope of variability – is a foundational concept that permeates training and practice in water-resource engineering," wrote a group of water scientists in a seminal 2008 paper.[9]

"In view of the magnitude and ubiquity of the hydroclimatic change now under way," they concluded, "…we assert that stationarity is dead and should no longer serve as a central, default assumption in water-resource risk assessment and planning. Finding a suitable successor is crucial for human adaptation to changing climate."[10]

Depending on the time of year, the Northwest faces climate challenges of both too much water, and too little. Like much of the rest of the West, the region has built itself on natural infrastructure supplied by high mountain ranges that capture and hold precipitation as snowpack. The snowpack acts as a reservoir that releases water during the Northwest's dry season in late spring and summer, driving hydropower, feeding agriculture, and sating the thirst of communities large and small. Snowmelt also ensures that salmon find streams with enough water at sufficiently cool temperatures during spawning seasons.

But global warming is changing that assumption of stationarity. It is pushing warmer air to higher elevations, and at earlier times of the year. Cascades snowpack at its typical April 1 peak has already diminished 20% compared to the 1950s. Hotter temperatures cause more precipitation to fall as rain rather than snow, and alter the timing of streamflows at critical points of the year. By around 2050, spring snowmelt is projected to begin three to four weeks sooner, moving peak runoff earlier and likely reducing crucial summer river flows, raising the risk of water scarcity in summer.[11]

A related climate threat is increased and more severe fires. Early snowmelt is depriving forests of moisture during dry months, thus leading to a documented increase in wildfires. Such fires dump ash and increase the erosion of sediment into water supplies. High intensity fires also impair the ability of soils to absorb rainfall into groundwater.

At the opposite end of the seasonal cycle, climate disruption threatens more flooding in winter and spring. Rain-on-snow events with their rapid runoff have generated some of the region's greatest floods. Jane Bacchieri of Portland BES notes, "We'll have flashier, more intense storm systems. That is going to impact our plans for meeting Endangered Species Act requirements (for fish runs)."

For cities and towns near the sea, water infrastructure that is now safe could be flooded as ocean levels rise, especially when peak tides coincide with big storms. Already, parts of Olympia's downtown are inundated at high tide events that take place once or twice a year. A sea level rise of four feet by 2100, somewhat less than many recent forecasts, would increase flooding downtown to 440 events a year, according to city projections. Even at two feet of sea level rise, 160 downtown flood events are expected. The city is considering actions to reduce the impacts, including elevating and flood-proofing buildings, elevating roads and landscapes, regrading downtown, modifying storm drainage, and creating flood barriers and walls.[12]

9 P. C. D. Milly et al, Stationarity Is Dead: Whither Water Management? Science, 01 Feb 2008: Vol. 319, Issue 5863, pp. 573-574DOI: 10.1126/science.1151915.

10 Ibid.

11 U.S. Environmental Protection Administration, Climate Change Impacts – Climate Impacts in the Northwest, https://www.epa.gov/climate-impacts/climate-impacts-northwest#Water (viewed Oct. 25, 2016).

12 Sea Level Rise Update, City of Olympia, Feb. 9, 2016, http://olympiawa.gov/city-utilities/storm-and-surface-water/sea-level-rise.aspx. (viewed Nov. 17, 2016).

The Great Challenges Facing Water Utilities

Green Infrastructure for Effective Climate Response

With climate disruption intensifying water cycle extremes, natural systems supply vital water retention capabilities and add valuable resilience to water infrastructure systems. But "many of the climate response strategies in my view are myopic and won't get the job done," says Bill Gaffi, CEO of Clean Water Services, a water agency that serves the Tualatin River basin of Oregon. "We need to be holding water for months, not minutes. We've turned many of the urban tributaries into swiss cheese. We need them to have water in summer months far beyond what's being talked about – we need to restore natural functions to these tributaries."

Planning for water management on a large scale is important, but distributed efforts can also have a valuable impact. Trees retain significant amounts of stormwater, and new designs for rights of way incorporate trees, permeable surfaces, and bioswales that collect and filter water run-off from roads. Green roofs also absorb stormwater.

Green infrastructure has other important climate benefits.[1] For example, it can help keep cities cool as summer heat escalates. Manchester, England could keep temperatures steady under climate projections by adding 10% tree cover. Toronto could cut the downtown urban heat island effect by 3.5° Fahrenheit by greening half the area's flat roofs, researchers estimate.

An additional benefit is improved carbon sequestration, helping draw climate-accumulating carbon dioxide from the atmosphere through 'biocarbon' capture in vegetation and soils. One study found green infrastructure efforts across the greater Portland metropolitan region could double biocarbon storage rates to over 485,000 tons per year.

Green infrastructure also saves energy. Philadelphia's program to shift half of stormwater treatment to green systems is expected to reduce electricity sector carbon emissions by 1.1 million tons over 40 years. Los Angeles County green infrastructure is projected to add enough local groundwater supplies to serve up to 500,000. The amount of electricity saved is equal to the demand of 20,000 to 64,000 homes.

1 Rhys Roth, Natural Infrastructure: A Climate-Smart Solution, Climate Solutions, 2013, p. 4-5.

Regulations in Flux

Water is essential for virtually all life forms, along with access to food and oxygen. Nothing is more fundamental to human well-being than access to clean water.

One key challenge for water infrastructure is that people, naturally enough, care deeply about having a safe, dependable water supply, as well as safe management of wastewater and stormwater. As we learn more about threats to safe, reliable water, regulators and regulations try to keep up to better protect people.

The future of state and federal water regulations that aim to protect public health, natural assets, and sound management of public systems is unclear. On the one hand, the new federal Administration and Congress enter 2017 with a priority of reducing regulations. On the other, new research continues to shed light on health effects from the cocktail of pollutants entering our water systems. Once these contaminants enter the public system's waters, they become the responsibility of the utility to manage them.

Because future regulations are uncertain, some utilities are looking to prevention strategies that keep contaminants from entering public waters in the first place. Other new practices and technologies – including distributed, smart, and green solutions – could process contaminants at lower cost.

Charged with protecting public health, regulators are understandably strict enforcers of the rules, but they also need to find ways to support innovation. In proof-of-concept pilot projects, regulators can measure performance against overriding goals for achieving better regulatory outcomes more affordably.

Green builders aiming for 'net-positive' water buildings and districts are butting up against barriers of public perception and policy. "As builders, we're thinking about how to turn problems – stormwater, wastewater – into resources," says Kathleen Smith of the International Living Futures Institute. "But a lot of solutions are actually illegal now in many jurisdictions – you're not allowed to capture rainwater, you're not allowed to treat graywater and reuse it onsite, not allowed to treat blackwater at all. Or you are required to hook up to the larger sewer system, to the water supply system."

Regulatory agencies face their own capacity constraints, though, in part because regulatory budgets can be attractive targets for politicians looking to make cuts. Responding to proposals to try something new, to customize a safe learning opportunity, requires special attention from skilled regulatory professionals.

The Great Challenges Facing Water Utilities

Water infrastructure planners are increasingly looking upstream for cost-effective 'green infrastructure' solutions that protect and restore watersheds to help filter water supplies, prevent flooding, and cool streams that receive wastewater.

Regulatory agencies whose budgets barely keep pace with workload, will have little flexibility and capacity to test innovative approaches.

A Thousand Points of Pollution ~

Looking back, when the federal Clean Water Act (CWA) passed in its modern form in 1972, it triggered a water quality revolution. Major polluters faced new limitations on discharges, while water treatment facilities were massively upgraded. The nation's waters became substantially cleaner.

But today, we face new challenges. At the time of CWA passage, "80% of the pollution was point source," says Sanjay Kapoor, Principal with s2 sustainability consultants of Seattle, meaning pollution came mostly from large facilities that were relatively easy to regulate. "At this point, it's roughly inverted, with 80% of the pollution now non-point. The nature of the pollution problem is now a distributed problem."

For example, one of the greatest pollution problems confronting Puget Sound is the stew of toxins picked up by rain water that runs off paved surfaces, roads and parking lots in particular. "Vehicles produce a lot of pollution," says John Stark, who leads Washington State University's Washington Stormwater Center. "Brake dust brings a lot of copper. Antifreeze is very toxic. Tailpipe emissions like polyaromatic hydrocarbons are heart toxicants in humans and fish."

"We've got the point sources under control, with permits for wastewater treatment effluent. The CWA has been very successful in cleaning up the worst of the worst, but we still have problems," says Jane Bacchieri of Portland BES. "There is greater understanding that in order to protect water quality and meet regulation, we need to control the nonpoint pollution in some way."

New non-point pollutants dubbed 'Contaminants of Emerging Concern' by the Environmental Protection Administration are coming to the fore. "A lot of the standards in the Clean Water Act don't address new constituents like the pharmaceuticals and fire retardants that we're finding in the wastewater stream, and that can endanger vulnerable populations," notes Anita Yap, of the MultiCultural Collaborative.

In response, EPA standards have become tighter. For wastewater treatment plants this has meant significantly greater costs than a decade or two ago, but these centralized plants are now facing diminishing health return on investment.

Water manager Michael Mucha points out, "We've reached the end of the cost curve and are at an inflection point, particularly with wastewater. Now we're removing so much of the pollutants that very small additional improvements come at very, very high cost."

Sarah Ogier, Senior Strategic Policy Analyst with King County, Washington's Wastewater Treatment Division, sees challenges coming to her industry. "The Northwest is seeing increasingly stringent standards that set expectations for some chemicals at levels which are even below lab analysis detection levels."

Chemicals from a variety of sources can enter the utility's system and thus become the responsibility of the utility to treat. "If the region has any hope of achieving ambitious environmental outcomes, much greater upstream efforts will be required," says Ogier, meaning preventing pollution at its source, before it enters the public water systems. "Downstream permit standards alone will not deliver the desired environmental and health outcomes."

The Great Challenges Facing Water Utilities

Confronting the challenge of non-point and new pollutants requires addressing basic structural assumptions. "We continue to seek centralized solutions to distributed problems, and that is fundamentally incoherent," argues Sanjay Kapoor.

"Traditionally we've gone down the road of 'we can do whatever we want, and someone will come and clean it up,'" Kapoor notes. "What that leads to is huge capital infrastructure spending on giant wastewater treatment plants. And with that approach we're always going to be playing catch-up with the latest new contaminants. Treatment is going to continue to lag behind because the system, by definition, is focused on downstream, rather than tracing upstream to address the source of the pollution. We need a fundamental rethink."

Paul Fleming, who focuses climate resilience efforts at Seattle Public Utilities (SPU), calls out another challenge: "The need for regulations that adapt to a changing climate, just as the management of water systems need to adapt." The Water Utilities Climate Alliance, composed of 10 of the nation's largest water utilities including SPU, is working on "flexible and adaptive regulations" to meet the climate challenge, Fleming says.

"The bottom line," says Scott Haskins, "is that infrastructure needs must be prioritized so that 20% of the investment solves 80% of the identified problems; and investments where very marginal return are being achieved drop down the priority list."

The Key Role of Tribes in Water Management

Native tribes have a critically important role in Northwest water. Treaties that commit the federal government to protect traditional sustenance right to fisheries and wildlife provide a powerful tribal voice in management of river flows. It is backed by numerous Supreme Court decisions and resulting requirements for tribal consultation.

The potency of tribal treaty rights was brought home in 2016. The U.S. Army Corps of Engineers cancelled the massive Cherry Point coal export terminal near Bellingham, Washington because the project would violate the treaty fishing rights of the Lummi Nation contained in the 1855 Treaty of Point Elliott.

"Because of our treaty rights to salmon, we're in a politically opportune position to strong-arm the agencies to do the right thing," says W. Ron Allen, Tribal Chair and Chief Executive Officer of the Jamestown/S'Klallam Tribe. "Many of these agencies would tend to want to soft pedal in deference to the pressures from local mayors, developers, and constituencies. I think a lot of people appreciate our sovereignty and treaty rights that we're able to leverage, because they don't have that ability or influence."

Tribes have growing capacity to both influence water management decisions, and to implement best practices on their own reservations. They also bring to the table traditional indigenous views of obligations to preserve nature for future generations. They are the original proponents of what is now called sustainability.

"At Quinault, we're adapting and mitigating at the same time," says tribal President Fawn Sharp, who is also Vice-President of the National Congress of American Indians (NCAI). "Adapting to the 'New Normal,' and adopting practices to reduce carbon emissions. A lot of scientists are now recognizing the value of indigenous practice. We need to rediscover that brain trust of indigenous knowledge, as well as new technologies, to discover a lot of new ways that work."

The tribe is relocating an entire village due to sea level rise, Sharp says. "There are elders that tell stories about how they could stand at the bank and have a whole football field between them and the ocean. Now the ocean is right up at the bank."

The new village is being made with low-carbon cross-laminate timber, and aims at a biomass facility for heating. "We see this as an opportunity to create a carbon neutral community," Sharp says.

Tribal governments have evolved in recent decades into much stronger and better advocates for responsible natural resource management, says Jamestown S'Klallam CEO Allen, who also serves as Treasurer for the NCAI. "We have indigenous values that we consider norms and we bring those into our interactions with state governmental entities. Our standards are higher than other norms."

Tribes are leveraging resources from new businesses developed in recent years such as gaming, resorts, and golf courses to build tribal governance capacities. "The tribes' ability to influence the political decision-making around water, wastewater, and stormwater has exponentially increased because of the growth and development of our governmental capacity," Allen says. "We're much stronger now in governmental capacity compared to 20 or 30 years ago."

A New Model and Investment Discipline Emerging

The water industry is experiencing a set of profound changes going to the fundamentals of how water, wastewater, and stormwater infrastructure are managed and local water-related needs are met. In response, an industry-wide movement known as "One Water" is integrating supply, treatment, and stormwater sectors previously managed separately. By breaking down silos, "One Water" utilities are finding new opportunities such as water recycling. Utilities are also finding ways to integrate more deeply into their communities, forging partnerships to invest for multiple benefits such as local economic vitality, resilience, carbon savings, and recreation and beauty.

Leading water decision-makers are also adopting a new investment discipline for smarter spending. The goal: to get more long-term community value from their infrastructure investments, both at the level of each capital project and system-wide. And innovators are reaching out to other agencies to identify cost-share partnerships for projects and programs that deliver each partner more value for their buck.

The portfolio of technologies and solutions available to water infrastructure decision-makers is expanding. The integrated One Water model and the new investment discipline put the new portfolio to work for a more sustainable, resilient, cost-effective, and beneficial water future.

New Model: One Water – Busting Silos to Optimize Value

Water management traditionally has not been done in an integrated manner. Instead it is divided in silos. One utility provides fresh water to customers, while another manages waste treatment. Often stormwater management exists in yet another silo, while flood control operates in yet another, each with their own set of siloed regulations and regulators. An emerging movement in water management seeks to break down those silos to integrate all these aspects. It is called "One Water."

"I think at the top level what is really transforming the water industry is the 'One Water' thinking," says Michael Mucha. "Looking at one molecule of water that falls as rain, becomes stormwater, feeds into surface water bodies or groundwater, supplies our homes and businesses with water, then enters the wastewater system." Under Mucha's leadership, Olympia, Washington merged drinking water, stormwater and wastewater into one department. "That made it so much easier to choose optimal solutions to recycle water and do other integrated solutions."

"Silo-ing is a key issue and a barrier to achieving positive results – both for quality and availability," Sanjay Kapoor says. "When we map our systems to hydrological cycles, we need to have an end-to-end view. Without that we won't be able to identify the significant opportunities, whether for cost savings or innovation, as the opportunities lie beyond the siloed purview of one entity. That means successful utilities won't operate in the same way in the future as they do now."

At the national level, the US Water Alliance is championing One Water. "We convene stakeholders from across the country to advance creative solutions to our most pressing water challenges" says Radhika Fox, CEO of US Water Alliance. "To us, One Water means bringing together forward-thinking drinking water and wastewater utilities, along with environmental groups, agricultural interests, philanthropies, community organizations, the private sector, and others who appreciate that the only way to make progress on complicated water issues is through partnership."

Infrastructure System Silos

Our communities are heavily invested in many infrastructure systems but for the most part they are managed separately and are uncoordinated. Courtesy of CollinsWoerman.

A number of advanced utilities are surging forward with the One Water vision, and launching deep, long-term, comprehensive transformation of their water infrastructure. These include mid-scale utilities such as Mucha's in Madison, Wisconsin, Cedar Rapids Utilities Department, Tucson Water,

A New Model and Investment Discipline Emerging

and Hillsboro, Oregon-based Clean Water Services, as well as large metropolitan utilities including Washington, DC; Los Angeles, and San Francisco.

Seattle was an early leader. In 1997, Seattle Public Utilities (SPU) combined water supply, wastewater, and stormwater functions, according to Scott Haskins, who held wide-ranging executive management positions at SPU prior to joining CH2M. "And in conjunction, we did much more," says Haskins. "SPU implemented 'Triple Bottom Line' business case evaluation for all capital investments, created a sustainability focus and organization internally, implemented low-impact development (LID) and other green initiatives, negotiated new permits, and reduced water use."

The Los Angeles Department of Water and Power is another widely-regarded model. Developed in conjunction with hundreds of stakeholders, their One Water strategy brought together planning for drinking water, wastewater and

San Francisco is an early adopter of integrated, innovative water management, placing efficiency and sustainability at the strategic core of utility business planning since at least 2008. (Photo by Grossbildjaeger via Wikimedia Commons (CC BY-SA 3.0) https://creativecommons.org/licenses/by-sa/3.0/legalcode.)

San Francisco Puts the New Model into Action

The San Francisco Public Utilities Commission (SFPUC) has pioneered the new water model and investment discipline since at least 2008, when it placed sustainability at the core of its strategic business planning.

SFPUC manages a water system stretching over seven counties, from the foothills of the Sierras to the San Francisco Bay, which provides water to 2.6 million greater Bay Area residents. It also manages a 900-mile long collection network that feeds sewage and stormwater to three wastewater treatment plants.

SFPUC's Sustainability Strategic Plan enables coordination across business lines and whole-system planning and decision-making. It specifies five organization-wide, long-term strategic goals and a detailed set of 'key performance measures' to organize, track, and benchmark progress. The agency is investing aggressively to upgrade its extensive systems to achieve greater resiliency for the long haul, especially to the very real threats of earthquakes and drought. It has completed 90% of the projects in a $4.8 billion program to upgrade its regional and local water systems, consisting of 35 in-city projects and 48 regional projects.

Those regional projects invest urban resources in rural communities, spreading the economic benefits of infrastructure investment. In addition, SFPUC's Watershed and Environmental Improvement Program is spending $50 million over 10 years to protect and restore the rural watersheds where San Francisco's water originates.

On the wastewater side, the City's 100-year-old sewer system is in severe disrepair, and after eight years of in-depth analysis and public input, SFPUC is launching a program to upgrade, replace, and seismically retrofit the aging system. Investment decisions are shaped by "triple bottom line" analytics that calculate the economic, environmental and social costs and benefits of competing investment options.

Under the leadership of Paula Kehoe, SFPUC's Director of Water Resources, San Francisco is a national R&D leader in micro-infrastructure systems to collect, treat, and reuse water in commercial buildings. Working closely with health regulators, Kehoe's program approves advanced technologies to convert rainwater, stormwater, and wastewater into non-potable water resources for use onsite.

SFPUC also led the creation of "A Step-by-Step Guide for Developing a Local Program to Manage Onsite Water Systems", and is a leading voice in the national Blue Ribbon Commission for onsite water systems.[1] Judson Greif, Deputy Director of the US Water Alliance, which hosts the Commission, notes that Portland, Seattle, and representatives of Oregon and Washington are also represented on the commission.

1 US Water Alliance, "Blueprint for Onsite Water Systems," September 2014, http://uswateralliance.org/initiatives/commission/.

A New Model and Investment Discipline Emerging

stormwater, with a unified focus on water recycling and conservation. As a result, Los Angeles was able to postpone $500 million in traditional capital spending. Low-impact development to control stormwater on site was widely implemented. A 20% water use reduction was achieved ahead of schedule. The utility now recycles four percent of its water and plans to purify another 11% to inject into local aquifers. The ultimate goal is to reduce reliance on water imported from increasingly unreliable sources such as mountain snowpack.[1]

The State of California is reflecting One Water principles when it creates incentives to break down silos. Felicia Marcus, Chair of the California Water Resources Control Board, cites state funding for interagency collaboration on solutions. "It's resulted in an impressive record of projects. When the engineers across jurisdictions sit down together to focus on problem solving, they're very good at finding solutions across the silos." The state also offers permitting support for projects that provide water quality and other co-benefits through green infrastructure.

One Water resonates with many tribal nations as well. "As tribes, we need to lead by example and invest in the alternatives," suggests W. Ron Allen, tribal council chair and CEO of the Jamestown/S'Klallam Tribe. "It's changing your whole paradigm. It's water, wastewater, stormwater – reuse, cleaning, and recycling water – this reduces your use of water in deep aquifers. It's all part of a new world paradigm. And our tribe is moving in that direction."

New Investment Discipline and Tools

Collectively our water, wastewater, and stormwater agencies in the Northwest will spend many billions of dollars on infrastructure through 2040 on behalf of the public. Nationally, U.S. utilities spent more than $100 billion each year to maintain, operate, and build water and wastewater infrastructure between 2008 and 2014, according to the Congressional Budget Office.[2] Based on the population share of Oregon and Washington, the Northwest is spending over $3 billion a year on water and wastewater infrastructure. Stormwater and flood control agencies spend at a similar large scale.

As stewards for these large flows of public dollars, it is a paramount responsibility for our water infrastructure decision-makers to optimize long-term community value generated by these investments.

The new investment discipline screens spending decisions more rigorously than in the past. New tools are available

1 One water, one future for L.A., Brown and Caldwell, 1 Water, February 16, 2016.

2 Congressional Budget Office, "Public Spending on Transportation and Water Infrastructure, 1956 to 2014," March 2015.

The Hands On Children's Museum in Olympia, Washington shares space with the LOTT Clean Water Alliance's WET Science Center and the East Bay Public Plaza. The site is a restored 14-acre brownfield featuring engaging informational exhibits and a recreational water feature, fed by Class A Reclaimed Water, designed to mimic a natural stream. LOTT builds community support with education programs woven into its operating facilities.

A New Model and Investment Discipline Emerging

to do this at both the project level (value planning) and system-wide scale (asset management 2.0). Screening investments more rigorously requires some new investment in smart planning. But good advanced planning can pay off by generating investment savings and benefits much greater than the cost of planning. Considering projects that bridge silos and deliver wide-ranging benefits can also open potential for 'profitable' collaborations which pool resources for watershed solutions that benefit many agencies.

Value Planning: Rethink Spending on Capital Projects ~

Value Planning is a business practice to help ensure utility and public works funds for capital projects are spent effectively and efficiently, and produce more value for the system and the community over their lifecycle. It can uncover better solutions for proposed capital projects – but the key is to apply it upstream, before any project is locked into a particular approach.

Value Planning involves asking many questions to clarify the underlying problem and to challenge preconceptions about how to solve perceived problems. The process costs a little more up front, but is saving ratepayers many millions of dollars more and delivering projects with lower risk and better environmental and equity performance.

> "More fully informed and integrated planning will be done early on in the project life cycle, because this is when smart problem definition and creative solutions can really make a difference."
>
> *Liz Kelly,*
> *Vice President of CH2M*

Liz Kelly, a Vice President with global engineering firm CH2M, predicts that by 2040, "We'll recognize the value of early, integrated planning and sustainable and resilient systems." Says Kelly, "More fully informed and integrated planning will be done early on in the project life cycle, because this is when smart problem definition and creative solutions can really make a difference."

Seattle Public Utilities (SPU) is a pioneer of value planning. The key to their approach is that, before committing to a standard solution to a specific problem, SPU assembles an interdisciplinary team to brainstorm alternative solutions, and evaluate business cases for the most promising options, based on lifecycle cost and performance.

The interdisciplinary teams "include people not close to the issue that often come up with novel options or just ask 'dumb questions' that get people thinking differently," says Jenny Bagby, SPU's Director of Corporate Services. "We have many examples where this has happened."

Bagby shares one example, exemplifying why framing the problem correctly is essential. The project was originally framed as the 'Phinney Ridge Pump Station,' based on a consultant recommendation to build a new pump station with water mains at a cost of $4-5 million. But the interdisciplinary team reframed the problem more accurately as 'Phinney Ridge Low Pressure,' affecting about 140 homes. They discovered that individual booster pumps in homes or installed in the sidewalk could address the low pressure problem for under $1 million.

SPU economists rigorously compare the most promising options identified by the team, monetizing the full range of benefits and risks over the project lifecycle, ensuring cost, risk, environment, and equity performance are considered.

Chuck Clarke, former SPU Director, remembers how value planning was launched under his leadership. "We created a model for proposing capital projects that required business cases. At the time, there were hundreds of millions of dollars in projects in the queue. I sent a memo that said there is no queue, there is no capital project list. We're starting fresh."

The strategy informed a decision about whether to bury city reservoirs or protect them with floating plastic covers. The latter was cheaper over a 20-year replacement timeframe, but the long-term community open space benefits of undergrounding outweighed that consideration. That resulted in creation of major new community assets, such as Cal Anderson Park on Seattle's Capitol Hill.

Clarke also cites the bridge replacement program in the Cedar River watershed, a vital Seattle water source. "I was told that when replacing the bridges, they had to be built to city standards, even though the bridges would only be used a few times a week. That was overkill, and much more expensive, compared to the actual need there," explains Clarke. "There are choices like that embedded in all these systems."

A New Model and Investment Discipline Emerging

Whole System Optimizing: Tools to Improve Community ROI

Utilizing value planning and asset management, decision-makers in the Northwest can develop water systems that perform and serve the public better, at the same or lower cost than standard strategies, endure an earthquake or big storm better, and give our kids clean, safe water and a healthier environment.

Indeed, the potential to deliver wide ranging community benefits extends well beyond improving the infrastructure systems of single-purpose utilities. Community value streams range from economic development and community revitalization, to better fish and wildlife habitat, healthier, greener urban neighborhoods, and cost savings for multiple infrastructure systems including energy and transportation.

Here are three tools to maximize community benefits when utilities do value planning and asset management:

Screen Options with the Triple Bottom Line

Triple Bottom Line (TBL) accounting quantifies and compares not only the financial, but also the social and environmental, costs and benefits of competing investment options. TBL enables decision-makers to compare a more complete picture of community value streams that each project or program alternative offers. In a TBL tutorial for *Water Online*, Robert Raucher writes: "As implied by the name, the impacts are organized and portrayed according to three bottom lines:

- **Financial:** reflecting the cash flow implications for a utility, such as revenues gained and expenditures or other costs incurred. This is similar to a traditional accounting style bottom line, as might be reported in a utility's fiscal annual report.
- **Social:** reflecting impacts on the broader community, such as public health and welfare, water system reliability, contributions to employment or other community values, affordability, and so forth.
- **Environmental:** reflecting impacts to watersheds and other ecosystems, carbon footprints, and other consequences for natural systems."[1]

1 Robert S. Raucher, "Using a quantitative triple bottom line approach to make a strong business case," Water Online, June 2013.

Consider Integrated, Silo-Bridging Solutions

Integrated solutions benefit more than one infrastructure system and, at the same time, deliver a generous range of other economic, social and environmental benefits. Integrated solutions take many forms. "We have a generational imperative to reimagine our infrastructure systems," says Nan McKay, former Chair of the Puget Sound Action Team. "We've got to break through institutional silos and find innovative solutions that connect systems for the greatest community-wide benefit for the long-term."

Other utilities – water-related, transportation, energy – can invest jointly in integrated solutions that deliver cost-effective benefits to each partner agency. Other potential public and private co-investors are in the market to 'buy' particular co-benefits, such as forest fire control, agricultural efficiency, economic development and job creation, positive public health outcomes, wildlife and landscape conservation, and recreation.

Put Upstream Solutions on a Level Playing Field

Sometimes the most effective infrastructure investment will reduce the burden on the local 'gray infrastructure' system of pipes, pumps, and treatment facilities. That's why infrastructure planners and investors need to consider 'upstream' solutions – like conservation, green infrastructure, smart technology, micro-infrastructure, and pollution prevention – on a level playing field with traditional 'gray' facilities.

Upstream solutions can reduce peak flows, which are expensive to manage, and prevent pollution from entering public water systems. Often it's cheaper to cut down on pollution before it gets into public waterways than it is to remove it from the water at the treatment plant.

A New Model and Investment Discipline Emerging

Asset Management 2.0: Transform System-Wide Planning ~

Asset Management revamps the system-wide investment strategy looking years ahead. It is aimed at prioritizing the most cost-effective investments and manage risk to serve everyone in the community for the long-term. The practice offers a comprehensive perspective to strategically target operations, maintenance, and capital spending.

Alderwood Takes the Long View

One innovative utility has reprogrammed its planning and financial approach to managing its assets for a truly long-term time horizon. Alderwood Water and Wastewater District, serving 245,000 customers in mostly unincorporated parts of south Snohomish County, Washington, has developed a 100-Year Capital Improvement Program (CIP).

> *"We're putting pipes in the ground for 80 or more years, so we should have a long-term perspective," says Alderwood's General Manager Jeff Clarke. "We shouldn't take short cuts today to save 10 bucks if it'll cost us $100 down the road. The 100-Year CIP is one way we're planning for the long term."*

Alderwood's Capital Projects Manager, Paul Richart, plotted all water and sewer pipes installed since the 1930's and projected their life spans based on material. This provides a projection of when replacement projects will be needed. The District is also pursuing maintenance efforts to extend those timelines.

The District has adopted a "living" comprehensive plan, which is designed to be continuously updated with the latest population, usage, and facility condition data so that it is always a current source to inform maintenance and replacement decisions.

A major goal of the coming year is to use the 100-year CIP process to assess true needs to replace infrastructure over the next decade, and then develop staffing and capital proposals to efficiently carry out such a program.[1]

1 2016-2017 Adopted Budget, Alderwood Water & Wastewater District, January 2016.

Asset management requires knowledge of actual conditions of pipes, pumps, and other facilities to make the optimal investments for the long-term benefit – over a 30-to-100-year horizon – of the whole system. "You don't treat all the assets the same," CH2M's Scott Haskins says. "You apply science to inform risk-based decision making to treat the more critical assets differently than less critical ones."

For example, Cascade Water Alliance director Chuck Clarke suggests that, "If you don't really know the condition of your assets, you may defer back to the manufacturer's specs, but that may have no relation to the actual condition of a given run of pipe." Says Clarke, "If I have a pipe that is serving 10 people, I may not worry at all about a rupture. But with a pipe that is serving 10,000 people I may replace it early."

Traditional asset management tools uncover investments that control the total cost of ownership over the lifecycle of the system's infrastructure assets. Next-generation 'Asset Management 2.0' adds several crucial advanced practices to the discipline, including 'Triple Bottom Line' accounting, integrated silo-bridging solutions, and upstream solutions.

Two other advanced Asset Management 2.0 practices:

- Value adaptive strategies that perform well in a variety of future conditions, and that boost infrastructure resilience. When planning for a dynamic, uncertain future, smart long-range strategies must work well in a variety of future conditions. Since hydrology in the Northwest is no longer predictable, resilience planning will shift from designing around a 50- or 100-year storm to setting time-to-recovery goals to ensure critical systems can recover quickly after a disruptive event. (See sidebar on the next page).

- Treat natural systems as an asset on the balance sheet, on par with traditional gray infrastructure, based on the value 'green infrastructure' services provide the utility system. As David Batker, CEO at Earth Economics, points out: "We need to change accounting rules so that green infrastructure's value is fully recognized on the bottom line of the balance sheet. Right now, its value as an asset is counted as zero."[3]

3 Rhys Roth, Infrastructure Crisis, Sustainable Solutions, Center for Sustainable Infrastructure, http://evergreen.edu/sites/default/files/sustainableinfrastructure/docs/CSI-Infrastructure-Crisis-Report.pdf.

A New Model and Investment Discipline Emerging

Adaptive Strategies: Because the Future Will Be Different

In an era of rapid technological change and the death of 'stationarity' – when the conditions of the past can no longer predict conditions of the future – water utilities must shift to more adaptive and flexible planning tools.

The key to adaptive strategies is putting in place solutions that allow flexibility through time. "That nimbleness and ability to be adaptive is an important challenge because technology and capability is advancing quickly," says Deb Guenther, Partner with Mithun, the Seattle-based design firm.

One tool that enables flexibility is scenario planning, in which several alternative pathways are envisioned, and strategies are developed that perform well and control risk across a range of possible futures. CH2M executive Scott Haskins says, "You make sure short-term investments will be good decisions regardless of which scenario comes to pass. It leads to just-in-time investments, conservation, better use of existing assets, reclaimed water, and the like, rather than building a big dam."

In May 2016, a broad-based Disaster Recovery Collaborative convened by Boulder County, Colorado adopted arguably the nation's most advanced tool for designing resilient infrastructure. The disaster collaborative was led by Steve Moddemeyer, Seattle-based designer and key advisor to the Center for Sustainable Infrastructure. The tool they developed, a Resilient Design Performance Standard[1], includes three steps to resilience-building infrastructure decisions by the County and its cities and towns:

1) Set time-to-recovery goals for infrastructure using the National Institute of Standards and Technology's (NIST) Community Resilience Planning Guide.

2) Apply a Resilient Design Performance Standard Checklist to guide project teams during pre-design.

3) Prepare triple-bottom line business cases for the top project and program alternatives under consideration.

1 CollinsWoerman Project Brief, Resilient Design Performance Standard for Boulder County, Cities and Towns.

Pooling Resources for Shared Solutions ~

"There are huge opportunities to link different sectors together," comments Michael Sanio, director of sustainability for the American Society of Civil Engineers. "Rather than looking at water as separate from energy and transportation, why don't we look at building community infrastructure in an integrated way?"

Looking for integrated solutions that bridge silos and deliver multiple benefits opens opportunities to pool resources with other agencies that are charged with investing in the other co-benefits. It is not only water supply, wastewater, and stormwater agencies that can benefit by coordinating plans. Economic development agencies, health providers, energy utilities, carbon investors, and fish, wildlife and parks managers all could collaborate with water utilities to co-fund mutually beneficial projects and programs. That kind of partnering can enable more work to get done, and provide each partner more value every dollar they invest.

"If you're a utility, you don't want to pay for other people's benefits," says Scott Haskins, Senior Vice President and Director of Strategic Consulting at CH2M. "Yet the best decisions are those that take Triple Bottom Line (financial, environmental, and social cost-benefit analysis) into account. The best strategies will find ways to coordinate projects and investments, and to allocate costs to the various benefiting parties."

The City of Spokane has developed an integrated Clean Water Plan that will cost less money, better protect the Spokane River, and provide greater community benefits. (Photo by Sbenak via Wikimedia Commons (CC BY-SA 3.0) https://creativecommons.org/licenses/by-sa/3.0/legalcode.)

Spokane, Washington's Integrated Clean Water Plan is a remarkable example, integrating street rehabilitation, pedestrian improvements, and parks, with sewer line and water main replacements, and green stormwater infrastructure.

A New Model and Investment Discipline Emerging

The integrated plan costs less and delivers better community benefits than standard programs managed separately.[4]

Hillsboro, Oregon's Clean Water Services (CWS) offers a collaborative model to restore watershed function across the landscape pooling urban and rural resources. For example, CWS, an urban wastewater utility, pools funds with U.S. Department of Agriculture to support the local conservation district work with rural landowners. Case in point: Local farmers seeking Federal Farm Bill monies are able to leverage local resources from CWS and other partners to help match federal dollars. This approach creates an integrated delivery mechanism that meets multiple objectives at the same time.

"We can't work at the landscape scale without pooling resources. We are restoring three times as much as we would otherwise," says Bruce Roll, who manages watershed programs for CWS. "It started 10 years ago as all about shade" to moderate elevated stream temperatures, Roll says. "But I discovered there are a lot of other monies there that can allow you to work on broad landscape design and restoration, so we're bringing together millions of dollars of other sources. Somebody has to serve as the backbone that assembles all those pieces."

4 "Wastewater Integrated Plan," City of Spokane, Washington, accessed February 8, 2017, https://my.spokanecity.org/publicworks/wastewater/integrated-plan/.

More local beauty and more equitable distribution of urban greenspace are among the community benefits of investments in neighborhood green infrastructure, often a key component of integrated water management plans. (Uploaded to Flickr by Center for Neighborhood Technology (CC BY -SA 2.0) https://creativecommons.org/licenses/by-sa/2.0/legalcode.)

Consolidate? Collaborate? It Can All Be a Little Scary

For hundreds of small water and wastewater utility districts in the Northwest, the constraints of a very small professional staff and ratepayer base can make modernization difficult to undertake.

For some of these utilities, the best way to serve their customers may be to become part of a larger utility. "One of the features of the next 20 years will be consolidation," says Jeff Clarke. "People will need to consolidate or die."

But the West's spirit of independence is an important factor, Chuck Clarke says. "When everybody in the East got tired of the state and federal government running their lives, they moved to the West and said, 'We want more control of decision making.' So they set up all these special districts. The West has a proliferation of special districts, each with their own board and elected officials, with local loyalty. When you start talking regional consolidations, you threaten to take that local control away, so you have to be very sensitive to that."

"Consolidation is a scary word for a lot of little utilities because they like their independence and fear losing control," Liz Kelly says. "The boards of directors for very small utilities may be resistant to consolidation, but I think the business case will grow more compelling with time for combining very small utilities and combining water and wastewater and stormwater utilities into one."

Cascade Water Alliance (CWA) represents a working model of collaboration without actual mergers. CWA supplies water to 350,000 homes and 20,000 businesses, and coordinates planning. It is governed by five cities and two sewer districts in a joint municipal utility corporation. "If they had said you have to give your independent water supplies or utility departments to CWA, that wouldn't have flown," says Chuck Clarke, CWA's CEO. "At the end of the day you have to get out of your box of having total control to look at regional solutions." Legislation passed in 2012 makes it easier for Washington-state entities to form such corporations.

A New Model and Investment Discipline Emerging

New Vision: World-Class by 2040

This new model for integrated community infrastructure, combined with the expanding portfolio of technologies and systems available to water infrastructure planners, gives shape to a new vision of the Northwest's water future.

Expect technologies and best practices to continue to evolve, sometimes in surprising ways. But from today's vantage point, here is a snapshot of success; how Northwest water infrastructure will work and work better in 2040 than today:

Water management will integrate across traditional silos and optimally blend legacy central facilities with networks of micro-infrastructure systems.

Agencies that manage water, wastewater, and stormwater systems will join forces for mutual benefit. New investment tools will enable smarter spending, at both the project level and system-wide. The prevailing theme is optimizing the community benefits – financial, social, and environmental – of infrastructure investment. The legacy central systems will be complemented by a diverse network of micro-infrastructure systems: homes and buildings that harvest rainwater, blackwater from toilets treated or composted onsite or in neighborhood systems, reclaimed water recycled nearby, green infrastructure to catch stormwater.

Utility and government programs will build lean, high-performance cultures that reward innovation and performance, and value the triple bottom line.

Getting lean starts with establishing clear, achievable goals and targets that align with system-wide goals. Utilities and government programs will adopt performance measures, risk containment metrics, and continuous improvement processes. They will report progress in real-time via performance dashboards. Spending decisions will be shaped by "triple bottom line" analytics that calculate the economic, environmental and social costs and benefits of competing investment options.

Water systems will be infused by smart technologies that provide real-time information to achieve efficiencies throughout local systems.

Utilities will no longer do maintenance and replacements of pipes, pumps and other equipment based on a schedule, but will adjust programs based on actual system conditions. Leakage and water quality emergencies will immediately come to light. Utility operators will increasingly operate systems remotely, providing flexibility to respond to downpours and other dynamics. Customers that want to cut their utility payments can reduce and adjust the timing of their water usage using smart home apps that integrate information from sensors in fixtures and water-using equipment.

Central wastewater treatment plants will become community economic hubs, producing clean water, clean energy, rich soils, and valuable fertilizers.

Wastewater will be purified to be the cleanest source of water available, blended in with other water supplies. Some recycled water will be infiltrated through soils or pumped below ground to recharge aquifers and groundwater flows. Wastewater treatment plants will become energy self-sufficient by maximizing efficiency, recycling heat, and producing power from their own biodigester, solar, and wind machines. A range of valuable soil and fertilizer products will be produced from the nutrients flowing into the wastewater system, and treatment plants will accept other organic waste streams, like food waste, from the community to enhance biogas energy production and compost value.

Utilities will develop more collaborative relationships with customers and neighborhoods.

Building owners will collaborate with utilities to manage runoff, for example, by making space in cisterns when large storms are approaching. Utilities will help builders install small-scale water treatment systems to conserve capacity in the larger regional system, and utilities will tap major sewer lines to pull heat for use in clusters of commercial buildings. Utilities will support installation of rain gardens on customer properties to reduce stormwater flows, and help customers adopt smart technologies to manage their water usage to conserve water and shift demand when needed. Customers and neighborhood stakeholders will be meaningfully engaged in public awareness efforts, and infrastructure decisions at every stage.

Utilities will advance their roles in watershed restoration, and forge creative cost-share partnerships for multi-benefit projects and programs.

From mountain headwaters to farm lands in local areas, water utilities of all types pay attention to watershed conditions and invest in upstream restoration to ensure quantity and quality of water supplies and other beneficial ecosystem

A New Model and Investment Discipline Emerging

services. Utilities will work with farmers, landowners and land managers in and beyond their service territories, making investments in forest and riparian restoration that provide tremendous savings over gray infrastructure. They will partner with local farmers to reduce water use and polluted runoff. Green infrastructure, in particular, will pool funds from a diversity of sources, reflecting its multiple benefits for recreation, fish and wildlife, health, carbon sequestration, flood prevention, and reduction of pollution from roads.

Regional collaboration and consolidation will grow. Small water utilities will partner to better meet the challenges.

Collaboration and planning will cross utility boundaries with development of regional forums that mesh autonomy and cooperation. Utilities will work together to plan at the watershed scale, and pool resources for multi-benefit projects and programs. Some smaller utilities will access more financial and technical capacity by creating Joint Operating Agreements or even merging with neighboring utilities.

Utilities and governments will focus investment to build more resilient infrastructure.

Recognizing that Northwest water infrastructure is especially vulnerable to destruction by earthquakes and climate disruption, decision-makers will focus on building systems over time that resist cascading, system-wide breakdowns, and that recover quickly after a disaster. Spending decisions will be guided by scenario planning that evaluates several alternative pathways, each designed to perform well and control risk across a range of possible futures. Distributed micro-infrastructure projects that can be deployed in small chunks will provide valuable flexibility and ability to course-correct through time.

Policymakers will couple job creation programs with infrastructure strategies to grow sustainable jobs throughout the region.

Infrastructure jobs are a pillar of the national economy; over 1 in 10 jobs is an infrastructure job. A great retirement wave is barreling down on the infrastructure sector today, at the same time as operator jobs are becoming more high-tech. Policymakers will address this challenge by partnering with the industry, colleges, and labor. They will invest together to build the skilled training pipeline to develop tens of thousands of next generation workers and leaders. Special focus will create pathways out of poverty and bridge the urban-rural divide.

Photo: Deschutes Valley Park in Tumwater, Washington features a children's play area, restroom, parking, interpretative areas, and a scenic overlook...all on top of a LOTT Clean Water Alliance reclaimed water storage tank. Photo courtesy of LOTT Clean Water Alliance.

The New Investment Portfolio – More Options, More Opportunities

Northwest water systems in 2040 may look and work much differently than today. Providers of water, wastewater, and stormwater infrastructure will spend billions between now and then to operate, maintain, repair, upgrade, and expand these systems. Major forces in the operating environment are driving them toward different decisions and business strategies. New technologies and systems are emerging that can change their solutions portfolio and open attractive new choices for residents, businesses, and builders.

These investment options span and connect water supply, wastewater, stormwater, and other infrastructure to create efficiencies and deliver benefits for multiple systems. And they span all scales – from the building level to neighborhoods and districts, to city-wide, and to broader watershed scales.

The upper tier of this Roman aqueduct transported water over vast distances in ancient times. (Photo by Emanuele via Wikimedia Commons (CC BY-SA 2.0) https://creativecommons.org/licenses/by-sa/2.0/legalcode.)

Many of these solutions are generally early in the adoption cycle, with limited field installations to provide a cost and performance track record, and relatively few utility personnel have experience with these innovative new systems. But we can expect that over the next decade, the track record will fill out and cost-performance will improve. In the energy sector, for comparison, installed costs for several key technologies have dropped by 40% or more in 8 years, while continuing to improve performance.[1]

Modernizing our aged infrastructure may not be cheap, but a world-class water infrastructure for Oregon and Washington in 2040 can be more affordable than rebuilding with the standard infrastructure approaches of the past, and much more sustainable, resilient, and integrated. And it can deliver a wide-range of co-benefits for the economy, public health, quality of life, equity, and environment of the community.

This section overviews the emerging technologies and systems that are expanding the utility investment portfolio and reshaping the future of water infrastructure.

The Quick History That Gave Us Today's Water Infrastructure

Highly sophisticated water systems date to ancient times. Beginning in 2500 BC, Harappan communities in the Indus River valley captured and managed rainfall to overcome long dry seasons, and transported wastewater in ways not equaled by European cities until modern times. Mesopotamian civilizations developed extensive irrigation networks. But the first comprehensive water system was created by the Romans, says David Sedlak, Co-Director of the UC Berkeley Water Center and a national leader in reinventing water infrastructure.

Rome is still associated with the aqueducts it built to transport water, some even still used today. The Roman system brought water into cities to urban pipes that fed homes, fountains and the all-important baths, a center of Roman culture. Sedlak calls this Water 1.0.

Water 2.0 came much later, in the late 1800s, with discovery that microbes from human waste were the source of many common diseases, including cholera. Water filtration systems, using materials such as sand, emerged to treat the dangerous pathogens, with cities such as Lawrence, Massachusetts and Hamburg, Germany taking a leading role. Soon engineers learned to add chemicals, such as chlorine, to the treatment process. In 1902, Middelkerke, Belgium became the first city to flow chlorine continually into its entire water supply.

Sedlak's Water 3.0, primarily a 20th century revolution with origins in the late years of the 19th, brought more comprehensive treatment of wastewater. Treatment had reached about half of U.S. systems by 1940. Federal funding in the postwar era lifted that figure to 98% by 1972.[2]

1 Rhys Roth, Rewiring the Northwest's Energy Infrastructure, Center for Sustainable Infrastructure, The Evergreen State College, 2016.

2 David Sedlak, Water 4.0: The Past, Present, and Future of the World's Most Vital Resource, Yale University Press, New Haven & London, 2014.

The New Investment Portfolio – More Options, More Opportunities

Centralized infrastructure has been the hallmark of modern water management. Large reservoirs supply a network of pipes leading to water users. Another latticework of pipes carries wastewater to large central treatment plants. Pipes, sometimes the same ones, carry stormwater away to water bodies or treatment plants. In fact, many of the public health and environmental gains of the past century have come with moving away from localized systems such as septic fields that pollute groundwater, and wells that may be contaminated with pathogens and toxics.

Water 4.0 is the revolution in progress. It is addressing new challenges and concerns, such as a wide range of new chemical pollutants, and the changes in water cycles caused by climate change. It has both centralized and decentralized aspects. In the centralized arena, a higher level of purification allows water recycling, while treatment plants are increasingly seen as sources of water, energy and resources. The legacy centralized infrastructure will not be abandoned, but complemented, by decentralized technologies to harvest, treat, and manage water at the building and neighborhood levels, Sedlak writes[3] To successfully integrate decentralized technologies into the larger system, utilities will need to develop new ways to engage customers as partners and collaborators.

The Changing Utility Investment Portfolio

The gains of centralized infrastructure are not to be downplayed, and these systems will continue to play an important role. At the same time, one of the most profound shifts in water management may be a turn to incorporate a more diverse set of strategies to optimize the use of water resources. These include smart technologies, green infrastructure, emerging micro-infrastructure systems, and strategies to turn wastewater plants into resource factories and to diversify local water sources.

Smart Tech: No Longer Flying Blind ~

As with other large societal infrastructures, advanced information technology is coming to water operations. It is providing a far higher level of situational awareness and the ability to dynamically operate systems in real time. This makes possible smarter and more strategic asset management decisions, and provides early alerts to problems inside pipes and pumps.

The declining cost of sensors, cameras and the wireless communications needed to create integrated networks is giving managers new windows into the condition of infrastructure and real time operation data. Says CH2M's Liz Kelly, "Sensors can understand, for example, if corrosion is attacking a water pipe or a pump is overheating or if wastewater collection pipe is filling up with debris underground."

"The increasing cost-effectiveness of sensors and sensor networks is providing the ability to identify leaks and where the next blow-out will be," comments Tom Howard, Executive Director of the California Water Resources Control Board.

Technology is playing an increasing role in asset management strategies. Instead of replacing infrastructure on a schedule, real-time information points to priority investments based on actual conditions.

Diana Adami, Manager of the Freer, Texas Water Control Improvement District, checks the status of the Arsenic Removal System Absorber vessels using a graphical computer interface, an example of a SCADA system. (Photo by U.S. Department of Agriculture via Wikimedia Commons (CC BY 2.0) https://creativecommons.org/licenses/by/2.0/legalcode.)

"You can place sensors that help you determine the optimum time to repair and replace your various physical assets," notes Scott Haskins. "You don't have to send crews out. Technology allows you to collect data remotely and keep track of the condition of a pump or pump station to tell you the best time to show up to do maintenance or repair, or to replace those assets. As things get older the costs go up for capital replacement, but you want to replace 'just in time'. You want to do the right things at the right time to achieve the lowest lifecycle cost."

SCADA systems (which stands for Supervisory Control and Data Acquisition) assemble data from many points on the system to provide a unified picture of operations, while also sending signals to equipment in the field to make changes and adjustments in operation. These capabilities can be paired with decision support software, leading to much greater performance from each piece of infrastructure.

Liz Kelly says, "This is all about becoming more nimble. With increased population and more times of extreme weather, we're pushing our systems to the limit a bit more, so the

3 Ibid, p.278

The New Investment Portfolio – More Options, More Opportunities

more we can use technology to operate through those times when we're at risk of going out of bounds, the better."

Technology is entering at the customer level as well. Water agencies are moving to smart meters that enable leak detection and can interface with customer-side water management apps to help customers conserve or shift demand to off-peak times. By 2012, 5.5 million smart water meters were deployed in the U.S., around one-quarter of the number in the electric power sector. Between 2015-20, driven by first-generation smart meter replacements and higher water rates, $2 billion in smart meter investment is projected by Bloomberg New Energy Finance, nearly doubling the total invested through 2012.[4]

In 2016, Walla Walla, Washington's city council voted unanimously to issue $6.3 million in general obligation bonds to pay for installation of nearly 11,000 customer smart meters. A major goal of the project is to detect sources of water leaks because the city estimates it is losing 29% of its potable water supply to leaks, well above the goal of 10% set by the state's Department of Ecology.[5]

4 Jeff St. John, Report: $2B in US Smart Water Meters by 2020, Greentech Media, May 14, 2013.

5 Alfred Diaz, "Smart Water Meters Will Make Their Way to Walla Walla, Wash.," GovTech, June 10, 2016.

Water managers are also coming to rely on information from space. Remote sensing technologies such as NASA's GRACE, the Gravity Recovery And Climate Experiment, are playing greater roles. The GRACE satellites record variations in Earth's gravity field, including changes in gravity created by changes in groundwater storage.

"The impact of GRACE technology has been significant in terms of groundwater management, especially at the regional level," says Geos Institute's Cathy Kellon. "Remote sensing technology and assessment methodologies are going to become more prevalent in natural resource management. Every year, it's getting more affordable, and it's also getting more precise. With GRACE we can map aquifer losses and gains. With LIDAR we can estimate carbon storage by individual plants in a city park. We don't need to rely exclusively on field crews to collect data. The trick will be having the analytic prowess needed to make use of all the data coming in."

Green Infrastructure ~

Green infrastructure, a powerful trend in the water industry, is broadly defined as the use of vegetation and natural features to assure water supplies and manage stormwater.

Green infrastructure strategies can complement the legacy system by taking some of the burden off the system of pipes, pumps, and treatment facilities, the "gray"

Green infrastructure, including street-side bioswales and urban trees, can play an important role in stormwater management while providing multiple community benefits, often at a lower cost compared with traditional "gray" infrastructure. Source: United States Environmental Protection Agency.

The New Investment Portfolio – More Options, More Opportunities

structure, often at lower cost than using traditional infrastructure alone.[6]

"Green infrastructure solutions can be applied on different scales, from the house or building level, to the broader landscape level," notes American Rivers. "On the local level, green infrastructure practices include rain gardens, permeable pavements, green roofs, infiltration planters, trees and tree boxes, and rainwater harvesting systems. At the largest scale, the preservation and restoration of natural landscapes (such as forests, floodplains and wetlands) are critical components of green infrastructure."[7]

Within utility service territories, neighborhood-level examples include:

- Bioswales, engineered features along streets, in parking lots, or building sites, that capture rainwater and channel it through vegetation and rich, water-retaining soils;
- Rain gardens, landscape depressions that are installed with plants and rich soils to collect water flowing off rooftops and pavement and allow it to infiltrate into the ground;
- Green walls and green roofs planted, often with grasses, to capture stormwater;
- Urban wetlands, preserved or created, that hold stormwater and cleanse it through natural action;
- Rebuilding the tree cover in urban neighborhoods can contribute significantly to storm water retention, particularly during heavier, short-lived storm events.

At the largest scale, headwaters forests are naturally created green infrastructure that is crucial for downstream water supplies. Preserving these forests and reducing wildfires that pollute waters are important for overall water supply sustainability. Healthy rural watersheds, and especially restoring streamside habitat, flood plains, and wetlands can ensure water quality and reduce flood hazards.

The World Resources Institute studied six U.S. cities that saved 60% on their water infrastructure investment using green infrastructure strategies.[8] At the same time, green infrastructure investments spread benefits throughout the community. Important community co-benefits extend from stormwater and flood management to protection of clean water supplies, local climate control and energy savings, biocarbon capture, cleaner air, improved wildlife habitat, and enhanced beauty and health in urban communities.

Mt. Tabor to the Willamette

Portland's Tabor to the River program covers a 2.3-square-mile watershed between Mt. Tabor and the Willamette River. Since the pipe and drainage system was deployed around a century ago, the area has lost much tree cover and added rooftop and pavement, so storm flows are greater than the original design can handle. Local flooding and sewage backflows into basements are the consequence. The area's combined sewer-stormwater system also carries sewage overflows into the river.

The City's Bureau of Environmental Services (BES) looked at two options: a "gray" alternative to address the problems with hard infrastructure alone, and another that mixed in green strategies. The former would have cost $144 million. Green projects cut the cost to $81 million.

The gray element refurbished 81,000 sewer pipe feet. To catch water before it flows into the pipes, BES supported 500 new green streets, 3,500 new trees, and efforts to remove invasive plants and improve wildlife habitat.[1] The agency also funded rain gardens on 100 customer properties, with owner maintenance written into property deeds.

"We've realized that pipes aren't our only solutions," Jane Bacchieri says. "In many areas, we have opportunity to use natural systems to apply an 'avoided cost' approach to control volume, flows, and some treatment. We deploy green measures based on the specific need and opportunity in each place."

The program entailed a level of customer and neighborhood engagement that was new for BES, as well as far greater internal integration between work divisions. So it was done as a pilot project that proved successful. "We're now using this approach in multiple areas in the city, so it's not a pilot anymore," Bacchieri says. "It's part of how we do business."

"Green infrastructure has been a game-changing tech," she adds. "Where I think it will continue to be game-changing is integrating with traditional engineering approaches."

6 Todd Gartner, World Resources Institute, ""A Critical Moment to Harness Green Infrastructure – Not Concrete – to Secure Clean Water," January 10, 2013; http://www.wri.org.

7 What is Green Infrastructure?, American Rivers, https://www.americanrivers.org/threats-solutions/clean-water/green-infrastructure/what-is-green-infrastructure/ (viewed Jan. 6, 2017).

8 World Resources Institute, "Natural Infrastructure for Water."

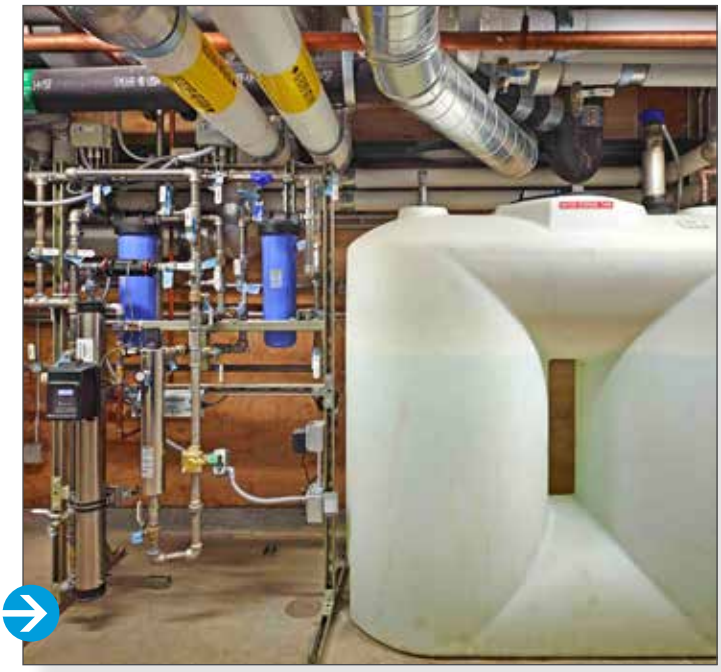
1 Portland Bureau of Environmental Services, Tabor to the River Program, https://www.portlandoregon.gov/bes/47591 (viewed Oct. 27, 2016).

The New Investment Portfolio – More Options, More Opportunities

Coming Soon?: The New Micro-Infrastructure ~

The typical centralized water infrastructure of today provides solutions at the systems scale. Water is piped in, often from distant sources, to large reservoirs, and then to customers. Wastewater is piped from customers to massive treatment plants. Stormwater is taken into drains and pipes that channel it to water bodies, or in many cities into the central treatment plant, often many miles away.

New small-scale "distributed" approaches are emerging, some reviving old practices in new ways, such as building cisterns that capture rainwater for on-site use and buffer stormwater flows. Green roofs and on-street bioswales catch and hold rainwater before it goes down drains. Technology for purifying and recycling wastewater at building and district scale is becoming more mature and beginning to build a track record to demonstrate reliability and cost-effectiveness. New building scale graywater toilet flush systems are now available and the plumbing code is being updated to provide standards to facilitate these new systems.



The dynamic 'green building' sector is driving a global market for micro-infrastructure systems that can capture, purify, and manage water on site. The Bullitt Center In Seattle is a world-class example. (Photo by Benjamin Benschneider, Uploaded to Flickr by Brad Kahn (CC BY-NC 2.0) https://creativecommons.org/licenses/by-nc/2.0/legalcode.)

Already some utilities are partnering with customers and actually paying homeowners (as Seattle does), or rebating their stormwater charges (as Portland does), to install "RainWise" micro-infrastructure projects, such as rain gardens and cisterns, says Peg Staeheli, Principal Landscape Architect with MIG|SvR. "RainWise-type programs in cities and counties throughout the Northwest are one of the strategies they are using to prevent combined sewer-stormwater overflows and for creek zone restoration."

By 2040, Liz Kelly says, "There will be more distributed localized treatment and storage in homes, in developments, in small business districts. There will be stormwater treatment, storage of stormwater and possibly wastewater onsite, so that the flow-through of a utility system that has limited capacity can be better managed."

Forward-looking utilities are already embracing decentralized strategies to reduce the risk of costly overbuilding. "Building one large centralized treatment facility is not always the most cost-effective solution," says Mike Strub, executive director of the LOTT Clean Water Alliance, based in Olympia, Washington. "Our communities chose a decentralized approach to managing growing wastewater treatment needs into the future. Capacity projections in the late 1990's during our long-range planning process would have had LOTT building a treatment plant twice the size that we now project we need," says Strub. "Building small increments of treatment capacity instead, in the form of satellite reclaimed water plants, has helped our communities avoid over-building and stranding investments."

"We don't need to build as much new centralized wastewater treatment capacity," Sanjay Kapoor says. "Where possible we should redeploy those monies to encourage distributed pollution management. Look at the hydrological cycle – the way water is provided by nature is distributed, so distributed solutions are aligned. I don't think we need to shut off the existing water systems. But we should migrate toward distributed systems and let's see if we can stay within the ecological footprint of the place where we're living – if we can sustain ourselves with the water available locally."

The Green Building Movement: Disruptive Force for Water Management

In less than two decades, the green building movement has profoundly influenced the building and construction field. The U.S. Green Building Council, for example, now boasts over 12,000 member organizations, over 200,000 certified building professionals, and 90,000 certified commercial projects in 164 countries.

Today the concept of the Living Building represents, arguably, the leading edge of the green building movement. The idea is that buildings are designed to mesh with their natural environments to enable them to produce more energy and water than they use, as well as to manage wastes pollution-free.

Bullitt Center in Seattle is a world-class example of a Living Building. Besides producing more energy than it uses with a rooftop solar array, the building created by the Bullitt

The New Investment Portfolio – More Options, More Opportunities

Foundation is a model for the net-zero water building. The Center is designed to supply 100% of domestic water needs from rain captured on the roof and stored in a 52,000-gallon basement cistern. Human waste is treated in composting toilets, while the "graywater" from sinks, showers, and washing machines is filtered in sequence through a constructed wetland and two bioswales. Efficiency plays a key role. Bullitt Center uses just one gallon per square foot for every 20 used in a conventional office building. At this writing, the Center is waiting final approval on use of cistern water for drinking.

Another small-scale technology for purifying wastewater is the membrane bioreactor, which employs a multiple stage filtration process. A membrane screens out solid material, and then liquids are biologically processed. They can fit in basements of large buildings such as high-rise office towers. At this point the technology can produce water of high enough quality for non-potable uses such as landscape irrigation or toilet flushing.

"We can make water reuse pencil out within a 100-unit building in Seattle right now," says Steve Moddemeyer. "Why not water reuse in every new apartment building?" Peg Staeheli points out, "This is important because the typical 5-7 story urban building going up these days is 80-100 units."

> "I think the key is integrating systems, where all the systems are linked together and feed each other, and are working together to provide infrastructure services that are more beneficial to the neighborhood and more cost-effective."
>
> *Chuck McDowell*
> *Mithun*

San Francisco may be the nation's R&D leader in micro-infrastructure systems to collect, treat, and reuse water at the building and district scales. The City's Non-Potable Water Program "creates a regulatory framework and streamlined permitting process for new commercial and mixed-use development to tap on-site water resources" for non-drinking water use, according to Paula Kehoe, SFPUC's Director of Water Resources.

Working closely with the city's Department of Public Health, SFPUC's approved portfolio of onsite water resources available to developers includes rainwater harvest, stormwater collection, graywater (bathroom sinks, showers, laundry), blackwater (kitchen sinks and toilets), and 'nuisance groundwater' that floods basements. Launched in 2012, the micro-infrastructure technologies have proven so effective that by November 2016 all new developments in the city were required "to install onsite water systems to treat and reuse available alternative water sources."

SFPUC has led by example. It's headquarters building uses about 60 percent less water than an office building of a similar size, utilizing a technology called the "Living Machine" that treats and reclaims all the building's wastewater onsite – about 5,000 gallons per day. In addition, the building boasts a 25,000-gallon cistern to harvest rainwater.

To harvest stormwater on residential properties, downspouts are disconnected from the sewer system and flows channeled into barrels or into gardens planted in water soaking vegetation. Barrels store water in high rain months for uses such as gardening. A quarter-inch rainfall on a 1,400-square-foot roof will supply 210 gallons.[9]

District Scale

In some cases, optimal solutions will be found one scale up, at the district or neighborhood scale. Kathleen Smith of the Seattle-based International Living Future Institute notes, "There are situations where it doesn't make sense to do things building by building. There are situations where you want to do things on a district or a neighborhood scale."

For example, Dockside Green in Victoria, British Columbia, a 15-acre development that meshes homes and businesses, captures all community sewage for bioreactor treatment into water for irrigation, toilets and local stream flow.

Not everyone agrees that the district scale is best for wastewater treatment. "I think you'll need a scale where you can manage the technical requirements for public health," Felicia Marcus, who heads the California Water Resources Control Board, says. "That will increasingly be a big deal as you're dealing with endocrine disruptors and the like. With recycled water, you're dealing with a high concentration of pathogens and other contaminants. I think there's a dialogue about what the right economy of scale is for wastewater treatment. I think there's an argument for central management."

9 The Seattle Rain Barrel, A Service of the Seattle Conservation Corps, http://www.seattle.gov/util/cs/groups/public/@spu/@conservation/documents/webcontent/cos_004351.pdf (viewed Nov. 17, 2016).

The New Investment Portfolio – More Options, More Opportunities

But green builders are pushing against what they perceive as institutional barriers to innovation. Kathleen Smith cites an example of a seven-story commercial and office project near downtown Seattle on which her International Living Futures Institute is engaged. The developers want to achieve net-positive water, the building generating more than it uses. But just relying on rainwater is a challenge when water- intensive retail uses such as coffee shops are included. A bioreactor and constructed wetland will supply water for non-potable uses, but more than can be used on site. A bus garage next door could use the graywater for cleaning, thus allowing net-positive water on a system scale. But crossing property lines that way is not yet legal.

"I think the key is integrating systems, where all the systems are linked together and feed each other, and are working together to provide infrastructure services that are more beneficial to the neighborhood and more cost-effective," says Chuck McDowell of Mithun.

Another cautionary note: some roles for the central system cannot now be replicated at the building scale, such as the requirement that sufficient water supply and pressure exists to combat fires. "Fire fighters use really high pressure to fight a fire, which requires a lot of volume in big spurts," says SPU's Judi Gladstone. "That requires larger pipes and more storage, so fire flow capacity drives the system sizing in many cases. And I am not aware of another way at this point to provide fire flow capacity without oversizing the infrastructure to meet that need."

Bullitt Center also boasts 'the world's only six-story composting toilet system.' The waterless system converts solid waste into compost using aerobic digestion. (Uploaded to Flickr by Derek Severson (CC BY-NC-ND 2.0) https://creativecommons.org/licenses/by-nc-nd/2.0/legalcode.)

Water is Energy

Saving water saves energy. That is because drinking water and wastewater operations alone consume an estimated 3-4% of all energy in the U.S.[1] When California mandated a 25% cut in water consumption during the historic drought of 2015-6, analysts were shocked to discover the electricity saved by meeting the water conservation targets. It equaled the combined impact of all the energy efficiency programs offered by the state's major electric utilities combined – at about one-quarter the cost.[2]

Water systems consume a lot of energy, but can also be tapped for energy. For example, wherever water flows downhill through pipes there is potential energy, and new in-pipe turbine technology, such as that pioneered by Portland-based Lucid Energy, could make it profitable for water utilities to tap it. Forward-looking communities are also pulling out waste heat embedded in the wastewater flowing through sewer pipes to meet nearby hot water and space heating needs.[3]

Wastewater utilities have even greater opportunity to harvest energy. In Oregon, for example, the City of Gresham's wastewater treatment plant, serving over 100,000 people, was city government's biggest energy consumer 10 years ago with energy costs of $50,000 a month. Today the plant produces as much energy as it consumes and has zeroed out its energy costs. The plant is energy efficient, and it produces 92% of the energy it uses from biogas, tapping the methane generated by the organic matter in sewage, as well as fats, oils, and grease that it collects from Portland-area restaurants and food establishments. The remaining 8% of the plant's energy demand is supplied by one of the Pacific Northwest's largest solar arrays. In all, the sustainable energy retrofits are expected to repay the capital costs in 8 years, and then generate net profit for many years to come.[4]

1 "Energy Efficiency in Water and Wastewater Facilities," U.S. Environmental Protection Agency, State and Local Climate and Energy Program, 2013.

2 Tara Lohan, "Water Conservation Saves Energy in California," Water Deeply, June 8, 2016.

3 Rhys Roth, Rewiring the Northwest's Energy Infrastructure, Center for Sustainable Infrastructure, 2016.

4 "Energy Independence: How the City of Gresham Uses Biogas and Solar Energy to Fuel Wastewater Operations", Planet Veolia North America, April 21, 2015.

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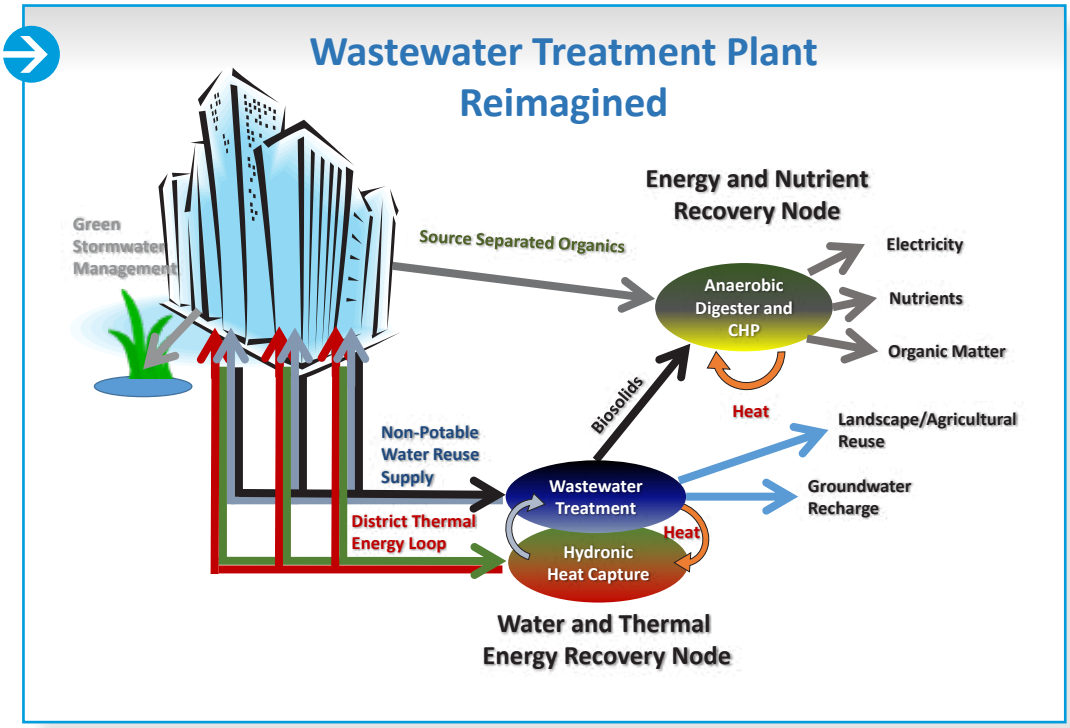

Wastewater treatment plants in the years ahead can become integrated community economic hubs that produce and distribute a variety of valuable clean products, including not just water, but clean power and heat, as well as nutrients and rich soils. Source: Natural Systems Utilities and CRWA.

Turning Wastewater into High Value Resources ~

Wastewater, also known as sewage, is rich in organic nutrients, minerals, and energy, and new technologies are making it possible to reimagine the future of treatment plants in our communities. By 2040, many wastewater utilities may be serving as integrated community economic hubs that produce and distribute a variety of clean products – not just water, but power and heat, as well as valuable nutrients and rich soils.

Energy – In any community, the wastewater treatment plant is one of the largest energy consumers. But our wastewater is rich in energy potential. Infrastructure innovation expert Steve Moddemeyer notes that wastewater treatment plants "have more calories of energy flowing through them than they use – so there are a number of researchers looking at how to change wastewater plants into clean water and energy factories."

Sewage contains a lot of organic matter, mostly food digested by the human population. Increasingly common are biodigesters that produce methane from sewage. Methane can be burned as natural gas to produce electricity. Michael Mucha's Madison, Wisconsin water utility provides 35% of wastewater treatment electricity with digesters. The organization at the time of writing is working on an agreement with the city to divert thousands of tons of food waste to the plant. "At that point, we think we'll produce 100% of our electricity," Mucha says.

Alternatively, methane can be fed into natural gas pipelines. King County, Washington sells methane from its biodigesters into the regional natural gas system for use by multiple users including natural gas-powered vehicle markets. "Methane from our solids digesters helps contribute to our strategy for carbon-neutral waste water operations, says Sarah Ogier of the King County Wastewater Treatment Division.

Another potential energy resource is the water heated for showers, dish washing, laundry, and industry that streams into sewer pipes, carrying energy in the form of waste heat. Utilities such as Madison and DC Water use heat exchangers to retrieve this thermal energy from sewage flows. Madison has a new staff building that is heated and cooled by wastewater. DC Water's new headquarters is being constructed over a pumping plant to capture heat flow.

Moddemeyer considers tapping the larger sewer pipes running throughout our cities practical with planning. "Wastewater plants have the opportunity to think about not just the plant but the whole collection system," he says. "They need to do energy plans identifying redevelopment or growth areas where high flows in their bigger collection pipes can be tapped to heat and cool clusters of new buildings on a district-scale."

Fertilizers and Nutrients – The organic leftovers from wastewater processing can be cleaned and processed into fertilizer and soil amendment products that the industry now calls biosolids. "There's a lot of research that has been done to indicate that urban organics, minus metals and other contaminants, aka 'biosolids', can be effectively used as a fertilizer, enhancing agriculture production," Michael Sanio of the American Society of Civil Engineers says. "We need to close the cycles. We can't just label urban organics as a hazardous waste – we need to bring that organic resource back to productive land."

The New Investment Portfolio – More Options, More Opportunities

King County 'closes the loop' by converting wastewater biosolids into a high-quality fertilizer and soil amendment for Washington farmers. Source: King County Wastewater Treatment Division.

In addition to biosolids, minerals and nutrients can be pulled from the wastewater stream that are important ingredients in commercial fertilizer. King County's Sarah Ogier suggests, "In the future, it is likely that more plants will be extracting valuable nutrients and minerals such as phosphorus and magnesium in the form of struvite." Struvite can buildup in pipes, narrowing the opening, so removing struvite could turn a maintenance problem into a revenue stream.

It's the urine component of wastewater that drives struvite buildup in pipes. Pete Muñoz of Biohabitats sees toilet systems emerging to divert urine into a separate collection system to recover fertilizer feedstock. "We see potential for this to expand greatly in the next few decades," says Muñoz, "especially in office buildings, schools, and stadiums."

Water Recycling – Treated wastewater has typically been put back into nearby streams, rivers or seas. But recycling water is a growing trend, putting this cleaned up water to use for 'non-potable' uses, like landscape irrigation, toilet flushing, cleaning and laundry, bathing, and even for refilling depleted groundwater aquifers. Some wastewater meets Pure Water standards – safe for any use, even drinking water.

In Hillsboro, Oregon, Clean Water Services envisioned a way to overcome the "ick factor" associated with water recycling. CWS invented the Pure Water Brew concept in 2014, offering beer brewers free water from its Tigard treatment plant. By 2016, brewers entered 40 beers in the 3rd Annual Sustainable Water Challenge/Pure Water Brew competition.[10]

"Our water is of such high purity, they don't have to deal with the preprocessing they have to do with tap water," says Bruce Roll. "It makes you wonder why we're not thinking about using recycled water for tap."

Currently, little recycled water is blended with drinking water. To keep recycled water separate from the drinking water supplied to homes and businesses, recycled water is delivered through separate, parallel 'purple pipe.' Chris Webb with Herrera, a consultancy focused on water and ecological restoration, suggests that states require all new buildings in areas over a certain population density to be purple pipe-ready and plumbed to harvest rainwater. Purple pipe should also be installed as standard procedure during routine road construction and maintenance. "If you put it in wherever you are digging up the street anyway or building a new street, it might cost you, say, $60/linear foot, whereas if you have to dig up the street just to add the purple pipe it can cost you 10 times that much."

Oregon micro-brewers entered 40 beers in the 2016 Pure Water Brew Challenge. Brewers were supplied free recycled water by Clean Water Services (CWS), Hillsboro's wastewater utility. They discovered this water is so pure, they could skip some preprocessing steps. Courtesy of Clean Water Services.

10 Clean Water Services, 2016 Pure Water Brew Competition Winners Turn Former Sewage to Brewage, Sept. 9, 2016, http://cleanwaterservices.org/newsroom/2016/2016-pure-water-brew-competition-winners-turn-former-sewage-to-brewage/ (viewed Nov. 7, 2016).

The New Investment Portfolio – More Options, More Opportunities

Microbiomes: From Our Bellies to Our Treatment Plants

None of us are alone in our bodies. Each one of our human cells is accompanied by 10 microbes that do vital work such as digest our food.

Food writer Michael Pollan notes, "These bacteria, which number around 100 trillion, are living (and dying) right now on the surface of my skin, on my tongue and deep in the coils of my intestines, where the largest contingent of them will be found, a pound or two of microbes together forming a vast, largely uncharted interior wilderness that scientists are just beginning to map."[1]

This microbiome has implications for wastewater treatment. Microbes from our guts make it through the sewer pipes into treatment plants, where they continue to do their work of digesting organic compounds.

Steve Moddemeyer notes, "If we understand how these species interact and communicate with each other via secretions – 'let's clump or break apart' – you can evolve a much better wastewater treatment process. When they clump, it's defensive – it's effective against chlorine, for example, because in a clump only the outer layer is killed off."

The curve in genomic mapping capabilities is exponential, and this is extending to the microbiome. In fact, more than 99% of the gene code in our bodies is the microbiome, a frontier only beginning to be explored, according to Pollan.

"In the next 20 years, I believe we'll develop a much more sophisticated understanding of how they communicate, so that we can manipulate them to clean wastewater at different scales," Moddemeyer says. "It could even be at the scale of the tank at the back of the toilet. That's the biggest driver of change in the next 20 years that people are not aware of or anticipating. It's going to really rock the way that we treat water."

1 Michael Pollan, Some of My Best Friends Are Germs, New York Times, May 15, 2013, http://www.nytimes.com/2013/05/19/magazine/say-hello-to-the-100- trillion-bacteria-that-make-up-your-microbiome.html (viewed Nov. 17, 2103).

A potentially disruptive discovery, mapping the microbiome of the human gut could soon transform how we treat and purify wastewater. (Uploaded to Flickr by Mankato WWTP 036 (CC BY-NC 2.0) https://creativecommons.org/licenses/by-nc/2.0/legalcode.)

Diversifying Local Water Supplies ~

Water researcher David Sedlak points out that U.S. water infrastructure supplies millions of urban customers with 'imported' water transported great distances. "In the 20th century, we literally spent trillions of dollars building infrastructure to get water to our cities," he says.[11]

Sedlak advocates that cities wean themselves from imported water as a resilience strategy in the face of the earthquake threat, climate disruption, and competition over water. He offers four key strategies to shift a city's water supply by tapping new, local sources of water:

1) **Capture stormwater** that falls within city limits during the rainy season and store it in underground aquifers for use in the dry summer when it's needed most.
2) **Recycle water** to Pure Water standards to blend into the city's drinking water supply. Purifying wastewater can be done in two ways: either via a two-stage cleansing process of 'reverse osmosis' followed by 'advanced oxidation', or in an engineered treatment wetland followed by percolation down to underground aquifers.
3) **Conserve water through smart landscaping** – this is the 'virtual tap' – because in many cities outdoor water use consumes half the supply, and better landscaping can cut outdoor water use in half.
4) **Desalinate saltwater** – but that's a last resort because it is energy-intensive, even though a desalinization plant today uses half the energy per gallon of water produced as 25 years ago.

11 "David Sedlak: 4 Ways We Can Avoid a Catastrophic Drought," Maven's Notebook, accessed February 6, 2017, https://mavensnotebook.com/2016/08/09david-sedlak-4-ways-we-can-avoid-a-catastrophic-drought/.

The New Investment Portfolio – More Options, More Opportunities

Sedlak believes with these four strategies, many cities can zero out their water imports. But for most Northwest cities, a reasonable goal may be to significantly diversify their sources of water supply by tapping a portfolio of innovative local sources.

Conserving and replenishing groundwater stored in aquifers could be another important strategy. Several methods exist, including surface spreading, infiltration pits and basins, and injection wells. Injection wells are not typically used unless surface infiltration is impractical.[12] New research by Stanford University's Water in the West program, "shows that groundwater recharge is a cheaper alternative to surface storage."[13]

Watershed Collaboration

Waters flow downhill, and watersheds can cover large landscapes within which numerous cities, towns and utility districts are nested. Communities often draw their water supplies from rural sources far beyond their boundaries, and in big rain storms cities and towns can be threatened by floodwaters originating upstream.

Healthy watersheds represent a natural infrastructure that supplies water services of great value at low cost. Over the next 25 years, utilities may increasingly find that investing in preserving and restoring watersheds can be a cost-effective substitute for some spending on bigger pipes, pumps, and filtration plants.

Says Bullitt Foundation's Steve Whitney, "Our natural capital assets have enormous value that should be recognized and stewarded. Let's not think of land conservation just as recreation alone, but let's acknowledge it as infrastructure with wide ranging benefits. It's crucial to recognize the implications of land use for water management."

"If we do anything to try to make this region more resilient, to make cost-effective decisions, start with nature," Whitney adds. "Account for natural assets, account for their benefits. The minute you lose a natural capital asset, then you have to build something. There's no substitute for 'do no harm' with natural capital."

California Governor Jerry Brown recently signed a bill into law that does just this, recognizing the state's source watersheds as water system infrastructure and critical components of the state water system. Assembly Bill 2480 will protect watersheds feeding the Shasta and Oroville reservoirs that supply drinking water to over 28 million people. California has had policies in place that helped to maintain their built water infrastructure like dams and levees, but until now had no mechanism for ensuring the health and functioning of their natural water infrastructure. "This law will make sure that the source of our water is treated just like other basic infrastructure that Californians depend on, such as roads, dams and power supplies," said Laurie Wayburn, President of Pacific Forest Trust. "We can now move forward on putting a comprehensive system in place to restore and conserve these landscapes that are so critical to a safe and secure water supply."[14]

Protecting Headwaters, Restoring Watersheds ~

It all starts high in the watershed, where intact forests at the headwaters provide invaluable ecological services, including catching and storing water. In a time when global warming will continue to reduce snowpack, the sponge effect of forested land will grow in importance for water supplies downstream.

Restoring natural watersheds can be an alternative strategy to spending money on new gray infrastructure, supplying similar services at lower cost. (Photo by Bureau of Land Management Oregon and Washington via Wikimedia Commons (CC BY 2.0) https://creativecommons.org/licenses/by/2.0/legalcode.)

"It's all about restoring and protecting the sources of our water supplies in the West," says Kimery Wiltshire, director of Carpe Diem West, "It's those headwater forests. That's the source of over 60% of our water in the American West. You can't separate out the water that comes from these mountain forests and the groundwater. They are connected systems in many places. Groundwater is fed by surface water."

Her group brings together stakeholder tables to build consensus on collaborative actions across the upper

12 US EPA, "Aquifer Recharge and Aquifer Storage and Recovery," Policies and Guidance, accessed February 6, 2017, https://www.epa.gov/uic/aquifer-recharge-and-aquifer-storage-and-recovery.

13 "Recharge: Groundwater's Second Act," Water in the West, accessed February 6, 2017, http://waterinthewest.stanford.edu/groundwater/recharge/.

14 Laurie Wayburn, "Forest Watersheds Are Part of State's Water System, Says CA Governor," Pacific Forest Trust, September 27, 2016, https://www.pacificforest.org/press-release-watersheds-bill-signed/.

The New Investment Portfolio – More Options, More Opportunities

watersheds. Stakeholders include local utility managers and public officials, state agencies, environmentalists, researchers and the U.S. Forest Service (USFS), manager of most western headwaters lands.

Restoring forests entails removal of old logging roads, which dump sediment into streams, as well as fixing culverts to allow fish passage and reduce blockages. Some forests require thinning to avert catastrophic fires. With USFS budgets increasingly consumed by wildfire suppression, Carpe Diem West is working on ways to fund restoration. Local water utilities can be a source.

An innovative example is the Forest to Faucet Partnership between Denver Water and the USFS. Landslides following a 2002 wildfire, largest in Colorado history, clogged a key reservoir with ash and sediment. Recovery cost the utility $40 million. Says former Denver Water Board President Ron Lehr, "We realized water doesn't come out of the stream—it comes out of the forest." So the utility in 2010 joined with USFS in a $33 million program, with costs evenly shared, to do fire risk reduction treatments on close to 40,000 federal forest acres over five years. It is the largest example of such as collaborative project with the USFS.[15]

Cities Rethink Stormwater and Flood Prevention ~

Cities and towns are wrestling with aging pipe and drain infrastructure. When it fails in a big storm, floods can do significant economic damage. Increasingly, communities are finding that capturing rain, slowing it down, and soaking it into soils can help extend the life and control replacement costs for their legacy infrastructure.

Many communities have combined systems that channel stormwater into sewer pipes to be carried to the wastewater treatment plant. In big rain storms the pulse of water can overwhelm the treatment plant's capacity, sending raw, untreated sewage into the environment. Integrated and green solutions are important new tools for a new generation of decision-makers. In King County, Washington, for example, Sarah Ogier says "some of the biggest infrastructure investments we anticipate by 2030 (currently estimated at $1.43 billion) will be to address basins with combined sewer-stormwater overflows (CSOs)." King County has developed, "a diverse toolkit for managing CSOs so we can use the right approach in the right place," Ogier continues. "That includes green stormwater infrastructure where feasible, sustainability elements, considering equity and social justice throughout the planning and design process, and incorporating innovative strategies where possible."

15 Carpe Diem West, Healthy Headwaters Success Story: Denver, Colorado – Seeing the Forest for the Water, p. 1-2.

Restoring Floodplains in Orting

Orting, Washington sits in a fertile valley between two major rivers, the Carbon and the Puyallup, that have often brought floods to the Cascades foothills community. Levees and dikes were last century's preferred tool to mitigate the impact. But replacing these aging facilities was overdue, raising the question of whether rebuilding those structures would be the smartest investment economically and environmentally.

The City of Orting, along with Pierce County, stepped up as pioneers of a different approach, says Jessie Israel, Puget Sound conservation director for The Nature Conservancy (TNC), by implementing an integrated planning and design approach that TNC calls 'Floodplains by Design'. "Their project design met the need for both improved flood protection and salmon habitat, and added green space and new recreational trails for the community," she says.

"We have spent the last 100 years removing nature from our cities and putting in hardscape," explains Israel. "How do we now look forward to make this a pivot point for the next 40 to 100 years, to bring integrated nature back into our communities in functional ways that help us treat water, manage flooding, keep our communities cooler, have better air quality? All of these are great things that nature can help us do if we're smarter about cities."

In the case of Orting, the answer was to restore a more natural river flow. The City, along with Pierce County, received funding to implement the project, completed in 2012. Back in 2009, thousands evacuated during a flood. A similar high-water event shortly after the floodplain improvements required no evacuations.

"The project helps protect the town of Orting from flooding, and it provides wonderful greenspace for the town," Israel says. It also addresses salmon recovery needs more holistically, spurring "a great 'a-ha' moment for the state," she says. Since 2012 the state has provided nearly $80 million for similar projects, now being implemented in 29 places, and protecting $100 million in property from floods.

"Green infrastructure brings beauty into our communities, elevating stormwater from a regulatory conversation to more of a quality of life conversation," Israel concludes.

The New Investment Portfolio – More Options, More Opportunities

The town of Orting, Washington partnered with The Nature Conservancy to become a leading innovator in the Floodplains by Design program. (Photo by Ingawh via Wikimedia Commons (CC BY-SA 3.0) https://creativecommons.org/licenses/by-sa/3.0/legalcode.)

The City of Spokane faced a daunting price tag to comply with requirements to prevent untreated sewage from flowing into the Spokane River during storm events. The standard response, building a bigger water treatment system, would cost $450 million. Instead Spokane developed an Integrated Clean Water Plan, with major investments in green infrastructure, to deliver a cleaner river faster, but at a significantly lower cost of about $310 million.[16] The City plans "to integrate street rehabilitation, water main replacement, park improvements, sidewalks, sewer pipe upgrades, and pedestrian/bike lanes or trails with our Integrated Plan projects. We want projects that have multiple benefits for our citizens."[17]

Communities are also taking a fresh look at levees and dikes built to control river systems, finding that pulling back the confinements and restoring natural floodplain functions can deliver overall benefits. Yakima County in central Washington and its partners, for example, are undertaking a variety of levee setbacks, habitat improvements, and infrastructure modifications to restore and enhance the Yakima River floodplain.[18] Another example is in Orting, Washington. (See sidebar on page 40.)

Oregon and Washington are leaders in the 'Low Impact Development' movement which utilizes green stormwater infrastructure to counter the impacts of pavement and rooftops in new developments, but increasingly to retrofit existing neighborhoods, too. A recent U.S. EPA report highlighting 17 case studies[19] explains:

> *"One of the most exciting new trends in water quality management today is the movement by many cities, counties, states, and private-sector developers toward the increased use of Low Impact Development (LID) to help protect and restore water quality. LID comprises a set of approaches and practices that are designed to reduce runoff of water and pollutants from the site at which they are generated. By means of infiltration, evapotranspiration, and reuse of rainwater, LID techniques manage water and water pollutants at the source and thereby prevent or reduce the impact of development on rivers, streams, lakes, coastal waters, and ground water."*

The majority of case studies EPA reported on projected significant capital costs savings compared to conventional stormwater approaches, ranging from 15 to 80 percent, with a few exceptions in which costs were higher. However, in most of those cases, "significant savings were realized due to reduced costs for site grading and preparation, stormwater infrastructure, site paving, and landscaping."

Chris Webb, associate engineer with Herrera Environmental Consultants, says that making new development meet low-impact standards is only part of the solution. "Retrofitting is more difficult, but really necessary and compelling when you've got all the conflicts and challenges of coming into an existing neighborhood. In the urban environment, there are always space challenges." One example of successful retrofitting is in the Barton basin of West Seattle. Completed in the summer of 2015, the project consists of 93 "roadside rain gardens" spread over a 64-block project area, and makes use of a cost-effective design to achieve regulatory objectives while adding significant community co-benefits. As a result of this project, the discharge of untreated sewage and stormwater is projected to decline from 4.3 million gallons per year in the Barton basin to 0.5 million on average.[20]

New designs for 'permeable pavements' that allow water to seep into the ground can be another part of the solution. "We have the largest stormwater demonstration project in the country here, and part of that is a permeable pavement

16 Integrated Clean Water Plan – Draft; CH2MHill, March 2014; http://www.spokanewastewater.org.

17 "Wastewater Integrated Plan," City of Spokane, Washington, accessed February 8, 2017, https://my.spokanecity.org/publicworks/wastewater/integrated-plan/.

18 Gap to Gap Floodplain Restoration and Enhancement Plan – Technical Memorandum, Anchor QEA, Prepared for Yakima County, WA, January 2014.

19 "Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices", US Environmental Protection Agency, https://www.epa.gov/sites/production/files/2015-10/documents/2008_01_02_nps_lid_costs07uments_reducingstormwatercosts-2.pdf.

20 Green solutions in concert with public interests: Profiling the Barton combined sewage overflow control project by Bennet Harbaugh. Center for Sustainable Infrastructure, February 2016, http://evergreen.edu/sites/default/files/sustainableinfrastructure/BartonCSO.pdf.

The New Investment Portfolio – More Options, More Opportunities

demonstration," notes John Stark of WSU Puyallup's Washington Stormwater Center. Cisterns, rain barrels, and green infrastructure can also capture and slow stormwaters down to buffer the impacts of downpours.

Modernizing Irrigation ~

Irrigated agriculture is one of the largest water users. Together, Oregon and Washington account for 5.8% of the nation's irrigated farmland.[21] About 61% of freshwater withdrawals in Washington go to farm irrigation.[22] In Oregon, 77% of the value of the state's agricultural produce comes from irrigated crops, and nearly 80% of water use in Oregon is for agricultural irrigation.[23]

Clearly, strategies to make irrigation more efficient are crucial to ensuring adequate water supplies overall, particularly in a time when climate disruption is reducing snowpack on which summer irrigation flows depend.

Because irrigation for farming makes up the largest share of water usage in Washington and Oregon, tools that improve its efficiency can have some of the greatest region-wide benefits. Photo by Peggy Greb, courtesy of USDA.

One of the challenges is evaporation and leakage from open canals.[24] Replacing canals with pipes can cut these losses, while also increasing water pressure in ways that allow farmers to remove pumps. That pressure can also drive mini-hydroelectric generators that produce electricity revenues to offset the costs of piping. Farmers Irrigation District in Hood River, Oregon began such conversions in 1985, eliminating 1,450 individual pumps by 2013. The district conserved 67.4 million gallons of water, enough to serve home use of over 50,000 people. Between 1995 and 2013, the district produced enough electricity to power 2,000 homes for 30 years. The District estimates its green carbon-free power production prevented 52 million pounds of carbon dioxide emissions, while the district reduced its own costs by $2.3 million.[25]

The Farmers Conservation Alliance (FCA) is an Oregon-based group that supports irrigation modernization. FCA was founded in 1985 to disseminate an innovative technology to screen fish from irrigation intakes, and now operates a comprehensive water management program. The fish screen work moved FCA into the holistic management effort. The group found that "putting a modern piece of technology into an infrastructure that's 75 years old (is) the equivalent of asking a truck from the 1970s to get 95 mpg," says O'Shea-Davies. It was an appropriate step for only around 20% of farm diversions. "So we developed our Irrigation Modernization Program to help irrigators more holistically."

It is currently working with around a dozen irrigation districts and their farmers, using tools such as GIS/Lidar mapping and hydrologic models to inform efforts. "We're helping them with holistic water management – helping them to navigate everything in order to modernize their system," says FCA Executive Director Julie O'Shea-Davies. "We're creating a series of methodologies and processes so that we can replicate this with others, adapt the lessons learned and processes to other regions – engineering, planning, even communications strategy."

According to O'Shea-Davies, "This can be a really beautiful win-win for irrigated ag and the environment. It can also save them a lot of money in reduced pumping fees and in operations and maintenance. We know irrigators that have pumping bills of $1,500 up to $20,000 a month. For the environment, the benefits are that the system consumes less energy, potentially produces clean energy, and keeps more water and fish in the stream."

21 Background: How Important is Irrigation to U.S. Agriculture?, U.S. Department of Agriculture, Economic Research Service, http://www.ers.usda.gov/topics/farm-practices-management/irrigation-water-use/background/

22 R.C. Lane, Estimated Water Use in Washington, U.S. Geological Survey, 2005 http://pubs.usgs.gov/sir/2009/5128/ (viewed Nov. 9, 2016)

23 Making Water Work: Strategies for Advancing Water Conservation in Oregon Agriculture: Executive Summary, Oregon Environmental Council, January 2012. http://www.oeconline.org.

24 Farmers Conservation Alliance Irrigation Modernization FAQs.

25 Farmers Conservation Alliance Irrigation District Case Study, Farmers Irrigation District; Les Perkins, Cumulative Watershed Impacts of Small-Scale Hydroelectric Project in Irrigation Delivery Systems: A Case Study, Prepared for Energy Trust of Oregon and Bonneville Environmental Foundation, June 2013, p.19.

Smart Spending: Checklist for Leadership

Between now and 2040, the Northwest will spend billions of dollars each year to operate, maintain, and modernize water-related infrastructure. The multi-billion dollar question for the Northwest: *How do we generate the most long-term community value from these investments?*

And to do that, how can we best shift spending decisions toward 21st century solutions and break the inertia of conventional approaches?

This section boils it down to offer the five most important things for water utility leaders to do, and the top five leadership actions for policymakers.

The focus in this section on utility leaders – who supply water, purify wastewater, and manage stormwater – is because these utilities are the main stewards of community water infrastructure and they manage the biggest streams of financial resources in the water infrastructure sector. These agencies collect large volumes of revenue from ratepayers and, in turn, spend it to operate, maintain, repair, and build vital water-related systems.

The focus on policymakers – leaders with state and local governments, with some reference to the federal role – is because they help guide and influence most if not all infrastructure investment. The job of policymakers is to represent the best interests of everyone, from a vantage point above the silos. Their influence is wide-ranging: they can set policy, offer incentives, create rules and regulate performance, invest directly in infrastructure systems, convene multi-agency partnerships to jointly fund projects, and more.

Water decision-makers will determine how billions of dollars in the Northwest are spent each year. Thousands of such investment decisions will determine the shape of Northwest water infrastructure in 2040.

For utilities and government leaders to succeed, though, they will need valuable innovation partners, including non-profit agencies, private companies, academic groups, and foundations. "These groups are often more nimble than public institutions and launch innovations, typically at a small scale, that become the proof-of-concept for solutions that can scale up for wider application," says Kathleen Wolf, Research Social Scientist with the University of Washington's College of the Environment.

Top Five Things for Water Utilities to Do

Modernizing water infrastructure to optimize value will require water, wastewater, and stormwater agencies to break from past practices and embrace tools for smarter decision-making already employed by advanced utilities.

For water, wastewater and stormwater utilities and agencies, the top five things to do are:

1) Implement the New Investment Discipline

2) Get on a Glide Path to Rate-Based Financing

3) Bridge Silos and Forge Creative Cost-Share Partnerships

4) Commit to Capacity and Innovation

5) Tap Private Innovation

Implement the New Investment Discipline ~

This may be the most important immediate step for water infrastructure providers. The purpose is to step back to rethink spending by applying new tools for cross-silo planning to achieve greater long-term return-on-investment (ROI) for the community. Community ROI considers cost, benefit, and risk for the utility over the lifecycle of the investment (typically 30 years), and it factors in the local economic, social, and environmental value generated as well.

The two key tools of the new investment discipline are value planning and asset management 2.0. These tools bring innovation to the flow of the major capital projects that utilities invest in year-by-year, and develop optimal strategies for the long-term health of the utility's system as a whole.

Both the strategies were outlined in more detail in *A New Model and Investment Discipline Emerging* section. *To summarize:*

Value Planning is a business practice to help ensure utility and public works funds for capital projects are spent effectively and efficiently, and produce more value for the system

Smart Spending: Checklist for Leadership

and the community over the lifecycle of the investment. It can uncover better solutions for proposed capital projects – but the key is to apply it upstream, ahead of even the predesign stage, before any project is locked into a particular approach.

Asset Management revamps the system-wide investment strategy looking years ahead. It is aimed at prioritizing the most cost-effective investments to maintain and operate infrastructure, and manage risk, to serve everyone in the community for the long-term. The practice offers a comprehensive perspective to strategically target operations, maintenance, and capital spending; it requires knowledge of the actual conditions of pipes, pumps, and other facilities.

State-of-the-art value planning and asset management 2.0 include several crucial advanced practices to ensure infrastructure investments generate better long-term community value. These best practices include:

- Use Triple Bottom Line metrics in cost-benefit evaluations.
- Seek integrated, silo-bridging solutions and cost-share partnerships.
- Consider innovative, upstream alternatives on a level playing field with traditional capital project options.

In addition, asset management 2.0:

- Treats natural systems as an asset on the balance sheet, on par with traditional gray infrastructure, based on the value 'green infrastructure' services provide the system;
- Favors adaptive strategies that perform well in a variety of future conditions, and that boost infrastructure resilience.

Get on a Glide Path to Rate-Based Financing ~

In many cases, federal funding of the last century helped utilities build large centralized facilities. In the decades since, many utilities did not set aside funds to replace this infrastructure after it reached its design life, preferring to keep rates low and hoping that federal funding would be there to rebuild.

Now much of this infrastructure is in need of replacement. Rapidly growing cities are in a better position to afford the cost, with a larger pool of ratepayers and old facilities making up a smaller proportion of their whole system. For suburban and small communities, the cost to build and replace old facilities may outstrip the ability to pay with current revenues. To transition to long-term financial sustainability, these communities may need to consider a more diverse portfolio of smaller-scale solutions.

For financial security in the long run, all utilities and stormwater providers should adopt a plan to get on a path toward rate-based financing of their infrastructure renewal needs, while addressing affordability and social equity issues. That will require raising rates (while buffering low-income families from the impact) as part of a long-term financial plan, and also designing infrastructure systems to a scale that is appropriate and affordable to local ratepayers.

This approach may be more difficult for smaller utilities in less prosperous communities, so these communities should be priorities for federal and state support. But that support should be contingent on water governance that commits to the new investment discipline, bridging silos, and building their capacity for innovation.

Bridge Silos and Forge Creative Cost-Share Partnerships ~

Modernizing severely aged infrastructure can be a daunting financial prospect for many water agencies. But they don't have to do it alone. Green infrastructure strategies, in particular, can advance the goals of many agencies, so by pooling resources each can gain more value for their investment. Customers and companies, too, can bring resources to the table if utilities can craft policies to harness and reward their investment for system-wide benefit.

The move to green infrastructure involves water agencies and community partners in new ways that provide broader benefits. As Bobby Cochran points out, green investments lead to better water quality, air quality, flood control, public

Water utilities that embrace smart spending foster innovation, work well with government, and forge partnerships with customers, companies, and non-profits. Courtesy of King County Wastewater Treatment Division.

Smart Spending: Checklist for Leadership

health and more. Kathleen Wolf describes such approaches as, "co-design for co-benefits." This approach aggregates investment for smart, multi-benefit, silo-bridging solutions from other agencies looking to purchase outcomes that matter to them. These co-investors seek specific measurable benefits in their particular sector, including transportation, recreation, fish and wildlife, energy, carbon, and health care outcomes. By pooling resources, each partner can purchase more result per dollar invested.

Numerous examples are highlighted in this report. Another model is the upper Willamette Basin where multiple entities pool resources to protect and restore the McKenzie River Watershed, sole source of drinking water for 200,000 Eugene-area residents. Pure Water Partners provides financial support to landowners to reduce water use, improve and preserve water quality, and create wildlife habitat. The partners pooled $150,000 from the Oregon Watershed Enhancement Board and $124,000 from Eugene Water and Electric Board for a 2014-15 pilot project with 15 private landowners.[1] Together they did native plantings and invasive species removal, set aside riparian buffers, cut chemical and fertilizer use, and built better soils with composting.

An example led by a non-profit organization is the Floodplains by Design partnership, initiated by The Nature Conservancy (TNC). Floodplains by Design focuses on reducing flood risk and restoring rivers. TNC believes that by, "transforming how floodplains are managed on a landscape scale, we can support thriving communities and a healthy environment." In Washington state, the partnership has completed 29 projects on 10 major floodplains. It has helped protect 25 communities by building 5 miles of new state-of-the-art levees and restoring natural river processes along 10 miles of rivers. The partnership also built recreational trails on five different rivers. The state legislature's investment of $80 million has been more than matched by other funding partners which have contributed $100 million.[2]

Paul Fleming of Seattle Public Utilities suggests another potential cost-share example: "Developing an open space plaza that 10 days out of the year provides stormwater functionality. That could be an opportunity for parks and water to come together." Another, suggests Fleming, is for transportation and stormwater agencies to team up. "Transportation is the largest source of stormwater pollution," he notes, and green infrastructure work on streets not only benefits stormwater management, but also the pedestrian environment for transportation.

1 McKenzie Watershed Voluntary Incentives Program Pilot Project: A report to the Oregon Watershed Enhancement Board, Eugene Water & Electric Board, McKenzie Collaborative, Aug. 31, 2015, p. 1-4.

2 "Floodplains by Design," accessed February 8, 2017, http://www.floodplainsbydesign.org/.

Health Dollars for Green Infrastructure

One potential investor in green infrastructure only beginning to be explored is the massive health care sector. The challenge is to quantify the health benefits of green in ways that can leverage funding from that sector. University of Washington social science researcher Kathleen Wolf notes, "We know from 40 years of research that the experience of nearby nature improves healing in hospitals, reduces ADHD symptoms, improves productivity in offices, and reduces stress response. It's important in cities because they can be stressful places, and chronic stress can compromise immune system health."[1]

Deb Guenther, Landscape Architect and Partner at Mithun, suggests, "Green infrastructure is so critical because it appeals to our souls and our shared cultures. Green relief from the city is something people instinctively need and want."

"Start with the most vulnerable populations," says Anita Yap of MultiCultural Collaborative. "They are a huge indicator. If we get improvements for them, the whole community will benefit and it will address multi-generational, chronic inequities," she says. "For that we need strong leadership, because it's difficult."

Wolf sees increasing interest in the human health benefits of urban nature from agencies such as National Institutes of Health and Center for Disease Control, as well as insurers. "Health insurers are looking at community investment strategies to improve health and reduce costs," Wolf says. "Health is now nearly 18% of U.S. GDP so even small increments of improvement can have enormous benefit. Kaiser Permanente is beginning to look at how they might invest cost-effectively to benefit health."

In East Multnomah, Willamette Partnership is exploring ways to bring health dollars into the picture to "enable Medicaid to pay for parks," Bobby Cochran reports. "So we need to provide very clear health measurements that verify that the trees will do what we say they'll do."

1 Green Cities, Good Health, University of Washington, http://depts.washington.edu/hhwb/Top_Introduction.html (viewed Nov. 11, 2016).

Smart Spending: Checklist for Leadership

'Charismatic' Credits for Carbon, Stormwater, and Equity

In the past 10 years $700 million in carbon credits have been sold in the U.S. and $4.5 billion across the globe. But, notes Mark McPherson, not one of those dollars has gone into the nation's urban trees.[1]

McPherson leads a new national nonprofit based in Seattle, the Urban Forest Carbon Registry, which is creating an offset credit protocol to fill that gap. It could bring new resources to rebuild urban tree canopies, especially in disadvantaged communities, that provide multiple benefits.

"Urban trees store carbon, intercept stormwater, stabilize steep slopes, provide bird and wildlife habitat, clean particulate pollution, and improve public health," McPherson notes. "And they deliver these ecosystem services in cities and towns, where 80% of the population lives and works."

Meanwhile, residential and commercial development is felling the urban tree canopy in many communities. Lower-income and people of color communities typically already have less tree cover to start. Budget-strapped cities push street tree maintenance to the bottom of priorities. McPherson sees an opportunity to leverage the growing voluntary carbon market to meet the need for green in cities.

The Urban Forestry Carbon Registry has developed a bundled credit that includes quantified multiple benefits – CO2 storage, stormwater retention, air quality, and cooling. The draft protocol, in essence the rulebook for gaining credits, was released in late 2016.[2]

A challenge is pricing. "Urban forest projects are much more expensive to do, so we are creating a premium product – the urban green credit – at a premium price," says McPherson. He sees potential in demand by companies for 'charismatic credits' that provide social as well as multiple environmental benefits, plus the valuable urban media exposure many companies want. "Connecting the urban forest world with the carbon world is challenging. But these kinds of new connections may help all of us connect ecosystem services with new funding sources."

1 Mark McPherson, Urban Forest Carbon Registry Works to Create New Revenue for City Trees, The Center for Sustainable Infrastructure Blog, Nov. 8, 2016, http://blogs.evergreen.edu/sustainableinfrastructure/2016/11/08/ufc/#more-641 (Viewed Nov. 22, 2016).

2 The protocol is available at the Urban Forest Carbon Registry website: http://www.ufregistry.org. (Viewed Nov. 22, 2016).

Commit to Capacity and Innovation ~

Water, wastewater and stormwater agencies are charged with investing large sums of money on behalf of ratepayers to provide valuable services over the long-term. Doing this right requires serious advanced planning and investment practices. That means investing in people with expertise and empowering them to innovate.

For larger agencies with robust staff teams, committing to capacity-building will look different than for smaller ones. These larger entities should adopt policies to require value planning and asset management, and clearly encourage innovation. They should also fund the necessary professional development and training, and support peer-to-peer networking and skills exchange.

The Water Utilities Climate Alliance and the Blue Ribbon Commission for On-Site Water Systems are two examples of peer-to-peer networks for water infrastructure leaders. Another is the Water and Wastewater Agency Response Network (WARN), a network of utilities helping other utilities respond to and recover in emergencies. WARN also provides valuable post-disaster reports, such as the WARN Superstorm Sandy After-Action Report.[3]

For green infrastructure practitioners, programs like SITES, SalmonSafe, and Green Roads facilitate knowledge transfer, according to Deb Guenther, a landscape architect and partner at Mithun, an integrated design firm in Seattle and San Francisco. "These programs highlight and share best practices. They are the instigators of the market," she says.

For utilities and agencies with a smaller customer base and limited staffing, advance planning and investment expertise should precede major spending, as it pays to 'look before you leap.' A commitment to smart planning needs to be expressed in budgets, including a willingness to spend a little more up front on people to achieve greater ROI on major capital projects that should pay dividends for decades to come. Smaller utilities governed by elected boards also need to help Board Members keep their knowledge base and skills up-to-date, and to recruit innovative thinkers and leaders to run for these elected board positions.

Tap Private Innovation ~

Private engineering and design firms play a major role in repairing and rebuilding water infrastructure systems,

3 National Infrastructure Advisory Council, "Water Sector Resilience Final Report and Recommendations" (Dept. of Homeland Security, June 2016), https://www.dhs.gov/sites/default/files/publications/niac-water-resilience-study-draft-06-09-16-508.pdf.

Smart Spending: Checklist for Leadership

Companies, non-profits, and colleges attract talented innovators. Public infrastructure agencies can tap this talent through smart partnerships.

working under contract to water utilities. New partnership models can unlock significant innovation capacity from the private sector. But not all such partnerships are created equal, and some schemes to access private investment in public infrastructure had poor outcomes and unforeseen consequences. Others, such as cost-share strategies to pool resources from multiple agencies and private investors for green infrastructure projects, when each investor purchases a benefit stream from a flow of multiple benefits, can work well.

Performance-Based Infrastructure

A new model called Performance-Based Infrastructure (PBI) can deliver positive outcomes for projects of relatively large scale, as the complexities of design and delivery can offer opportunities for innovation. PBI is a form of public-private partnership, a general concept that has received escalating interest in an era of aging infrastructure and financial constraints.

According to Scott Boardman of the West Coast Infrastructure Exchange, PBI is a project delivery method that keeps assets in public ownership and consolidates responsibility for the key phases of a project's full life cycle – design, construction, and maintenance – into a performance-based contract with a private partner.

This consolidation of responsibility, with its emphasis on payment for performance, can create important public benefits compared to traditional project methods: design and construction innovations, shorter design and construction timelines, improved cost and schedule certainty, lower total life cycle costs, and long-term performance guarantees. PBI procurements can also include elements of private sector financing and operational responsibility.

Partnerships British Columbia is a global leader in PBI. Partnerships BC is charged with helping the province navigate infrastructure development options for complex capital projects to deliver the highest value to its public sector clients. So far, according to *Governing Magazine*," it appears to be doing just that, racking up a record number of projects that are finished on schedule and at significant savings to taxpayers."

According to Portland-based PBI expert Karen Williams, "Finding the right projects that will really generate benefits via this model takes careful analysis. The best practice is a Center of Expertise like Partnerships BC that helps all the jurisdictions apply best practices to this process. Our report to the Legislature recommends how to do this for Oregon."[4]

Tapping Private Investors for Multi-Benefit Projects

For infrastructure projects that offer multiple benefits, a number of distinct stakeholders, such as utilities, insurance companies, government agencies, and communities may stand to benefit. Nick Wobbrock, Co-Founder and Partner of Blue Forest Conservation, believes private capital, such as investments made by foundations and pension funds, can provide the upfront funding to implement such projects, and get paid back by stakeholders based on value delivered. That economic value can be quantifiable and measurable, or based on approved standards, and can be in the form of more resilient infrastructure, lower fire risk to infrastructure, lower risk for insurers, or positive environmental outcomes, for example.

Private capital can also bear the risk of successfully implementing the project and delivering on projected performance metrics, says Wobbrock. "For utilities that are under a high level of scrutiny and are appropriately risk averse," he says, "private capital that both funds projects and assumes performance risk may allow utilities to engage in projects that may otherwise be too difficult to undertake."

Infrastructure-related opportunities include:

- The Forest Resilience Bond to fund forest restoration and reduce catastrophic wildfire in source watersheds, under development by Blue Forest Conservation.
- The DC water bond to improve storm water with low impact green infrastructure developed by Quantified Ventures.
- Water quality trading credits and projects to fund land owners for erosion control practices.

4 Partnerships BC: www.partnershipsbc.ca; Report to the 78th Legislative Assembly of Oregon, The Oregon Innovation in Infrastructure Task Force, December 30, 2013.

Smart Spending: Checklist for Leadership

Top Five Things for Water Policymakers to Do

Northwest communities are grappling with a range of water infrastructure challenges, from escalating costs to managing old and decaying systems, to intensifying health, demographic, and environmental stresses. At the same time, a growing segment of the population is experiencing economic stress and struggling to pay water and other bills.

Leaders with state and local governments have extensive influence and their leadership can help optimize water, wastewater, and stormwater infrastructure spending in many ways.

Customers as Collaborators

Water customers today typically interact with the system by turning on a faucet or flushing a toilet. A more interactive relationship is coming in the future.

"There's a concept that's emerging for water utilities," says CH2M's Scott Haskins. "Water as a service, rather than water as a commodity. It's not just selling water to customers, it's basically providing a fuller range of water service, all the way to the tap and points of utilization."

One service, provided by the diffusion of sensor technology, is real time data on water use down to the fixture level, allowing customers to monitor use and optimize for greatest efficiency. Customers gain control of their water usage, utilizing smart apps, but can tap utility incentives for conserving water or shifting demand off of peak times when water demand is high.

Real-time knowledge can harness the public, "enabling people to participate in resource protection to a much bigger degree," says Nancy Stoner, Water Program Director at Pisces Foundation. Water users could help utilities control demand at critical periods, and offer feedback identifying water quality issues. Companies like Water Smart are positioning to help utilities engage with their customers in ways that reduce costs, protect revenues, and increase customer satisfaction.

For utility efforts to prevent pollution from entering public waters, customers have a critical role to play. But engaging the full spectrum of the community isn't easy. "It doesn't matter who pours the oil down the storm drain," points out Jennifer Devlin with Portland BES. "So, if we're currently working with affluent people, or watershed councils or schools, then we also need to really focus on the other groups. But it can take serious work to engage any community that you are not already good at engaging."

For utilities to embrace their customers as collaborators, though, "You have to get over the mindset that very dispersed facilities, especially when some are in private sector hands, can't be managed to serve utility purposes," Judi Gladstone of Seattle Public Utilities (SPU) says. "In my mind, there's a lot of conversation that needs to happen to open people's minds to the possibilities."

Networks of cisterns cooperatively managed could help regulate stormwater flow. SPU's Paul Fleming points to the million-gallon cistern at Gates Foundation headquarters in Seattle used to irrigate a green roof and flush toilets. Fleming poses, "What if there was an agreement with us for managing the cistern so they still get the functionality they need, but when we see a storm coming we could clear out capacity in the cistern to absorb stormwater?"

"With distributed systems, we may have opportunity to leverage private dollars for actual larger system benefit," suggests Fleming. South East Water in Australia is doing this now, "optimizing daily decisions on stormwater and wastewater flows and treatment by, in part, utilizing the storage capacity of and controlling the discharge from cisterns on private property," according to CH2M's Scott Haskins.

Alternatively, "SPU might contract with local businesses that aggregate cistern capacity among multiple buildings," suggests Haskins, "according to performance requirements set by the utility."

On-site systems also open the potential to diversify the services offered by utilities to include maintenance of micro-infrastructure systems at the customer level. "If you see more onsite systems generating potable water onsite, you can imagine us providing a service of maintaining those systems," Fleming says. "That's another example of a potential collaborative agreement," especially for commercial customers with larger systems.

"This building does need someone to maintain the systems and do the testing," said Kathleen Smith of the International Living Futures Institute, from her office in the Bullitt Center. "That could be a service provided by the utility. That could be one model for how utilities can maintain viability in the 2040 future."

Smart Spending: Checklist for Leadership

Like utilities, they don't need to do it alone. A variety of community partners can launch initiatives to pilot innovative new approaches, and regional collaboration can enable multiple agencies to invest together to achieve efficiencies, resilience, and mutual benefit.

Policymakers need to establish a clear vision and overarching policy principles. By adopting "lean management" performance goals and metrics, they can steer investment toward integrated infrastructure systems that best benefit quality of life and prosperity for all. They need to help local communities modernize their infrastructure, train a new generation of water infrastructure workers, and build local capacity to effectively manage and pay for right-sized water systems locally. State and federal agencies also need to reconsider their regulatory strategies to focus on results while allowing some flexibility for utilities to get better results through innovative means.

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Align on Principles ~

The Center for Sustainable Infrastructure (CSI) coordinates a coalition of partners, dubbed the "Future of Washington Infrastructure," advocating a smart, coordinated state infrastructure strategy for Washington State.

Ted Sturdevant, former director of the Washington Department of Ecology, is coordinating the coalition for CSI. The group has developed a set of principles, in close coordination with the Association of Washington Cities and our other partners:

Build the right thing. Community infrastructure is expensive, lasts a long time, and matters to people's pocketbooks and quality of life. When we build it, we should build it right. We can't afford to let program silos, insufficient planning capacity, unwise financial incentives, or a one-size-fits-all approach force us to build the wrong things. Let's enable innovation and information sharing to maximize value and minimize costs, including using natural systems to augment traditional gray infrastructure.

Take good care of what we build. Let's get the most time and value out of our infrastructure investments. Before we invest in infrastructure projects, we should put in place feasible, long-term financial and asset management approaches that promise a long, resilient life of maximum value.

Provide the right tools for the right communities. Different communities have different needs, risks, capacities, and circumstances. Infrastructure programs should provide support appropriate to communities' unique financial, planning, and management capacities, to meet their unique needs. And funding programs should provide the flexibility for communities to package multiple funding sources without impairing the project's value, cost-effectiveness, or resilience.

Leverage private investment. In a time of constrained public funding and growing infrastructure needs, we should engage with private sector partners to maximize project delivery efficiencies and preserve projects' value to the public.

Maximize federal investment. State and local budget constraints are seemingly ever-increasing. It is imperative that the state infrastructure strategy include maximizing the use and leveraging of federal infrastructure dollars.

Make our infrastructure investment programs smarter, and keep them smarter. Without overarching goals and strategies for infrastructure investment, we encourage program silos and obstacles that make it harder for communities to get maximum value for scarce infrastructure dollars.

Also, because infrastructure spending is a cornerstone of the economy, it is important to align jobs, economic development, and infrastructure strategies. And because it is vital for everyone to have affordable access to clean water and sanitation, policymakers need to ground policy in an equity principle, like The Human Right to Water (see next page).

Set Goals, Get Lean ~

Every level of government has numerous programs, created and operated separately, that intend to bolster infrastructure. Policymakers need to provide a clear strategy for the many state and local infrastructure programs to align with, using 'lean government' management processes to focus continuous improvement and track progress on key metrics, transparent to all. Policymakers should also foster regional collaborations that align multiple government agencies and innovation partners in pursuit of policies, programs, and projects to advance the Northwest vision.

Smart Spending: Checklist for Leadership

Lean fosters a high-performance mentality. "Getting lean also means getting more efficient, eliminating waste, stream-lining processes, becoming more productive," says Scott Haskins of CH2M. "This alone can save 5-30% in cost for operations and maintenance, and supporting systems."

Strategic Goals: Policymakers should ground infrastructure policy in a vision for meeting the needs of communities by developing infrastructure that fosters healthy, prosperous, resilient, sustainable, and equitable outcomes. Infrastructure investment should deliver more value, multiple benefits, better asset and risk management, and improved cost-effectiveness.

Policy makers might set broad strategic goals that target system-wide outcomes such as:

- Percentage of utilities that are utilizing asset management and value planning as core business practices.
- Pooling resources by multiple agencies, and with private capital where appropriate, to do projects with mutual benefits is commonplace, standardized, and simple.
- Percentage of utilities that consider upstream and micro-infrastructure solutions on a level playing field with traditional gray infrastructure approaches.
- Percentage of utilities that are financially healthy with stable revenues and no serious maintenance and replacement backlog.
- Number of people from disadvantaged communities graduating from skill-based worker training pipelines who fill high-priority water infrastructure jobs.
- Percentage of neighborhoods that can recover water and wastewater service within three days of a large-scale earthquake or storm.
- Percentage of households that pay no more than 1.5% of household income (the current California standard) for each water service.

An example of a principle-based state policy is California's Human Right to Water bill, Assembly Bill 685, signed in 2012. It centers on the principle that "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes." Colin Bailey of the Environmental Justice Coalition for Water, a primary leader of the Human Right to Water campaign, says the bill is "the product of compromise, but complemented by a series of planning, finance, agency authority, and water affordability bills, it has moved the needle forward."

Lean Government: Also at the heart of any infrastructure leadership strategy should be continuous improvement of the infrastructure systems of communities, with transparent performance dashboarding to clearly communicate real-time results gained from investment of public resources.

A leading Northwest example of an infrastructure funding agency that is a national model for reform is Washington's Transportation Improvement Board. TIB's 'Lean Government' approach aims to maximize results on each dollar of spending, ensure strategic alignment of program objectives with statewide goals, support asset management for small communities, and enable performance measurability and transparency.

Each state and local infrastructure program should get lean by establishing clear, achievable goals and targets that align with system-wide goals. Each should adopt performance measures, risk containment metrics, and continuous improvement processes. Each should create a transparent Performance Dashboard. And state infrastructure programs should actively support capacity building in local utilities and agencies to develop their own Lean Government approach.

Regional Collaboration: A range of regional collaboration models are highlighted in this report. More such collaborations are needed to enable utilities, agencies, and elected leaders to plan together for the future of their shared watersheds. "You've got to look at the entire watershed system, not just treat each city as a separate, stand-alone system when you've got other cities upstream from you," Jane Bacchieri of Portland BES notes.

"One of the biggest challenges that we're going to face is how does one bring about a more collective vision for our shared future," says Clean Water Services CEO Bill Gaffi.

"Within the watershed geography you have a variety of public and private entities managing land," says Bullitt Foundation's Steve Whitney. By 2040, Whitney envisions "much less fragmented planning and managing of land and water." He foresees regional collaboration tables enabling jurisdictions to establish priorities together that maximize community benefits across objectives such as public health, social equity, economic development, biodiversity conservation and climate resilience. Whitney sees value in collaboration among different agencies: "The idea of one big region-wide funding bucket is not realistic because there are so many sideboards for every flavor of money."

Two stellar Northwest examples of regional collaboration and regional governance are:

- **Puget Sound Regional Council** (PSRC) brings together the counties of the central Puget Sound (King, Pierce, Snohomish and Kitsap), along with dozens of cities and towns, ports, tribes, and transit agencies. These jurisdictions collaborate to plan, develop policies, and make decisions about important issues, specifically growth planning, regional transportation investment, and economic development.

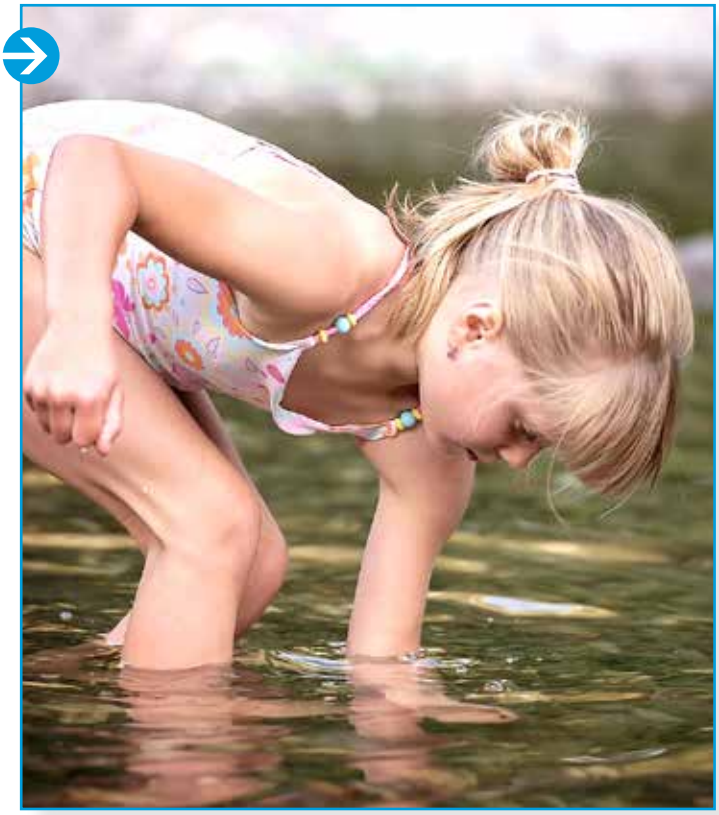
Smart Spending: Checklist for Leadership

- **Oregon Metro** was created over 30 years ago – the nation's first directly elected regional government – to provide regionwide planning and coordination to manage growth, infrastructure, and development issues that cross jurisdictional boundaries. This innovative agency encompasses Clackamas, Multnomah, and Washington counties, the City of Portland and 23 other cities, and is governed by an elected Metro Council.

Regulate to Performance, Manage for Outcomes ~

Water system regulation often is prescriptive, laying down specific pathways to accomplish intended goals. In a time when technologies are rapidly changing, when solutions are becoming more distributed, and when hydrological conditions are changing in unpredictable ways, regulations should be structured more around the endgame than the route, a different model in civil engineering.

"Right now, engineering standards are very prescriptive, telling you exactly how to size your facilities based on the assumption that future environmental conditions will be within the range we saw in the past century," notes Michael Mucha. Performance standards instead "define how you want your infrastructure to perform over time."



Public health and safety is the most vital performance standard for water infrastructure, but others such as affordability, equity, and resilience are also of great importance.

Examples of performance standards (including some leadership examples):

- **Resilience** – time of recovery after a disaster (Boulder County's resilience checklist tool).
- **Affordability** – maximum percentage of income that lower-income customers pay for any water services (California's current standard is 1.5% of income).
- **Public Health** – temperature of and sediment in rivers from which cities draw drinking water, or minimum green space acreage per household for disadvantaged neighborhoods (The Mariposa Healthy Living Initiative[5]).
- **Equity** – measurable progress to replace vulnerable or hazardous infrastructure (e.g. pipes leaching lead in schools) that disproportionately impacts disadvantaged populations (King County's Equity Impact Review process and tool[6]).
- **Emergency Supplies** – percentage of population that will have access to approved alternative water supply in the event of a multi-day disruption event.
- **Financial Sustainability** – measurable progress toward a system that can be paid for over the long-term by local ratepayers (Clean Water Services, Cascade Water Alliance).
- **Fair Governance** – best practices are deployed to meaningfully engage community stakeholders in decisions at every stage; and decision-making is accessible, transparent, and accountable.

Finally, we need to move past adversarial relationships between regulators and regulated, to collaboration. "We have gotten so deadlocked in traditional positions of us versus them," Sanjay Kapoor says. "I would submit that successful regulation adopts the position that we're all in this together, and what we're trying to achieve is common public good. Regulation will be necessary, but we also have to provide safe harbor for innovators in this arena, so that regulations do not become barriers to the solutions we need."

Kapoor authored a report for Washington Business Alliance, *Better Design, Better Outcomes*, that calls for outcomes-based stormwater regulation, and more work on upfront design, including low-impact development that captures stormwater on site, and broader cost-benefit analysis that reflects the value of ecosystem services.[7] He proposes "living laboratory" pilot projects that provide regulatory waivers, in which governments redirect regulatory and enforcement resources toward developing solutions that might deliver better system outcomes.

5 Mithun Inc. and Denver Housing Authority, "The Mariposa Healthy Living Initiative," October 2012.

6 "Tools and Resources," King County, accessed February 8, 2017.

7 Sanjay Kapoor, Better Design, Better Outcomes: Applying Lean Design to Stormwater Regulation, Washington Business Alliance, Feb. 2014.

Smart Spending: Checklist for Leadership

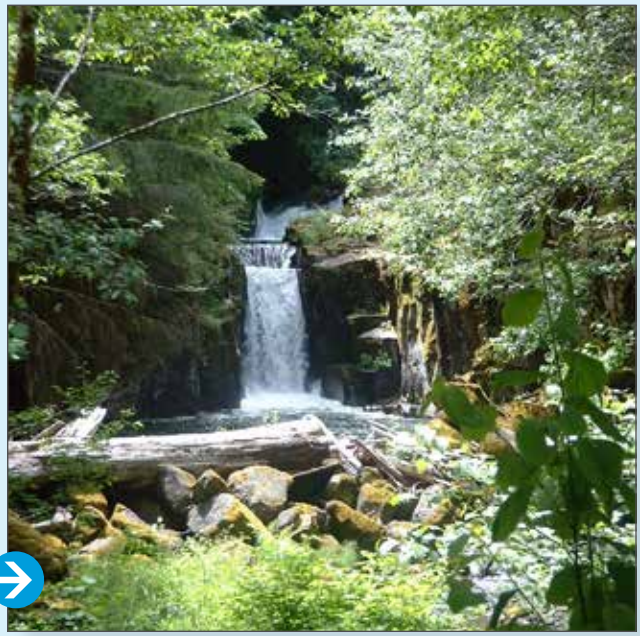
Clean Water Services – Regulatory Innovation Delivers Results

"Municipalities have trouble looking upstream from their communities in order to reduce risks," says Cathy Kellon of Geos Institute. "Whose job is it to look upstream when you don't own the property or when you need to engage with property owners who aren't even residents of your town?"

Clean Water Services (CWS) of Hillsboro, Oregon has decided it is their job. The wastewater treatment agency serves over 560,000 customers in the Tualatin River watershed. CWS provides a forward-looking model for investment in watershed restoration as a green infrastructure strategy.

CWS treatment plants provide a substantial portion of summer Tualatin River flow. Discharge was going into the river at temperatures beyond regulatory limits for fish. Chiller facilities would have cost $60-$150 million, and up to $6 million annually in operating costs. That figure includes $2 million for electricity. Instead, CWS applied for and in 2004 gained the first National Pollution Discharge Permit for a municipal, integrated, watershed-based approach. The Oregon Department of Environmental Quality allowed CWS to meet regulatory requirements with a trading mechanism. Landowners in agricultural zones along the river were supported to restore riparian areas, planting trees that reduced temperatures by increasing shade. The savings over the hard infrastructure route were spectacular. Restoration cost $4.3 million by 2007, a fraction of the chiller's cost.[1] CWS was also able to leverage millions more from local state and federal sources. The effort has restored 110 river miles across 25,000 acres.

"We've been able to establish a unique regulatory framework that allow us to redistribute our limited resources to those areas having the highest ecological value and at the same time create the resiliency needed for climate change and urban growth," says Bruce Roll, director of the CWS Watershed Management Department. "This model is really about recreating ecological function – it's not a one-off where we install, then maintain. If we only look through the lens created by engineering the built world, then we will continue to see costly one-off green infrastructure pilot projects that will never deliver at the landscape scale.



Restoration of the Tualatin River resulted in improved ecological function as well as spectacular cost savings for wastewater infrastructure. Photo by Elyteragli via Wikimedia Commons.

The landscape program delivered by CWS starts with the question, 'How would Mother Nature plan, design, and implement a project?'"

Restoration entails collaborative work with landowners to ensure long term stewardship and restore watershed health. "We made a decision years ago that it can't be command and control, it has to be woven together tightly with community values," says Roll. "There are now more than 35 community partners involved."[2]

The CWS "Tree for All" program works across the watershed, in urban and rural communities. The original goal was to plant one million trees in 20 years. With broad community partnerships, this program is now able to plant more than two million in a single year and is averaging 10 river miles of restoration annually.

CWS is showing today how water utilities of the future will work, becoming lead agencies in watershed restoration by building partnerships that realize multiple benefits for the community.

1 Basma A. Mohammad and Emily Dietrich, Ecosystems Services Case Study: Clean Water Services, Tualatin River, Washington, Institute for Sustainable Solutions, Portland State University.

2 "Tree for All," accessed February 6, 2017, http://www.jointreeforall.org/.

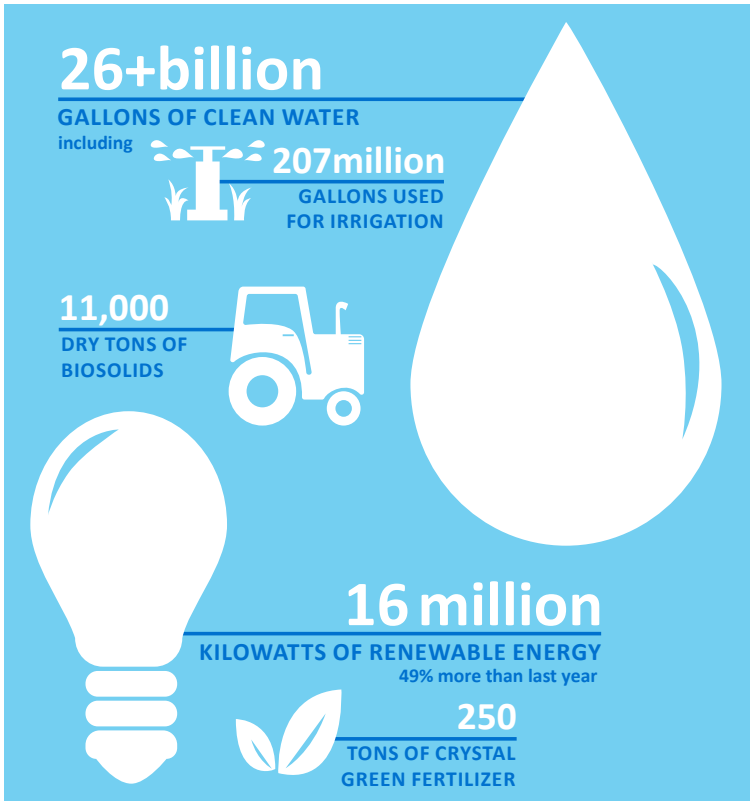
Smart Spending: Checklist for Leadership

Support Local Capacity Building ~

State and federal funding for local capacity building can achieve a wonderful, long-term return on investment when it helps utilities build their capacity to spend infrastructure dollars smarter. *Specifically, state and federal capacity funding should target grants and incentives to:*

- Help locals adopt value planning and asset management 2.0 as core business practices. The result: Infrastructure spending will gain more value from each dollar spent.
- Fund interagency collaboration to uncover and implement integrated, silo-bridging solutions, as the California Water Resources Control Board does. The result: Innovative new solutions are developed that save money for multiple agencies.
- Build the talent pipeline for workers and train decision-makers. The result: Next-gen workers will be trained into quality utility jobs, and leaders will learn lean management.
- Cost-share pilot projects that are well-conceived and have potential for wide applicability. The result: Innovative technologies and practices will be tested, their effectiveness measured, and a culture of continuous improvement advanced.
- Give special priority to rural districts and disadvantaged neighborhoods and communities. The result: The benefits of quality infrastructure will reach people living in places where life is hardest.

In addition, government should join with the utility community to support knowledge diffusion. Much has already been learned, sometimes the hard way, by practical on-the-ground experience. No one understands the challenges water managers face better than other water managers. Systematizing knowledge transfer between the region's utilities is a force multiplier for building sustainable water systems throughout the region. This could take the form of circuit riders, technical assistance, and grants to hire expertise. And it can mean mentoring arrangements between the region's advanced utilities and others seeking to implement best practices and new technology pathways. Nimble non-profit and community partners may emerge to offer valuable, innovative programs.



Converting Waste Into Resources and Value

Leading utilities track performance in pursuit of continuous improvement. They develop new efficiencies, resources, and value streams. They're also engaged with their community, actively educating kids and adults, and aiming to make their spending accessible, transparent, and accountable. Clean Water Services saved over 26 billion gallons of water through recycling in just a single year.

Source: Clean Water Services.

Smart Spending: Checklist for Leadership

Weaving Wastewater With Community, LOTT Builds 'Educated Ratepayers'

Two core values animate the innovative work of the LOTT Clean Water Alliance: producing multiple community benefits, and cultivating educated ratepayers.

LOTT operates regional wastewater treatment and reclaimed water systems serving three cities – Lacey, Olympia, and Tumwater – in north Thurston County, Washington.

It's innovative capital projects are designed to do double duty as public recreation amenities that showcase community sustainability. For example, at the Hawks Prairie Recharge Basins site, LOTT created a series of constructed wetland ponds, walking trails, benches, and informational kiosks to showcase reclaimed water as a resource safe enough to support a vibrant natural ecosystem. The site is a favorite with local birding clubs, dog walkers, and other residents. From the wetland ponds, the reclaimed water flows into shallow basins and infiltrates into groundwater.

At another site, LOTT partnered with the City of Tumwater to locate a reclaimed water storage tank within a city park. The storage tank was built into a steep hillside and provides the foundation for the park, creating a scenic overlook into the Deschutes River Valley below. The site features play structures, benches, and water-themed public art, all set atop a storage tank that is effectively hidden in plain view. The tank stores up to one million gallons of Class A Reclaimed Water, enabling the City of Tumwater to use reclaimed water for irrigation at the Tumwater Valley Golf Course and conserve groundwater for other uses.

LOTT builds community support for its core functions with a proactive education program interwoven with its operating facilities. "We want to raise educated ratepayers who understand what happens to water and how they can help," says Mike Strub, LOTT's Executive Director. "They understand why infrastructure is important. They are interested in working here." The heart of LOTT's education program is the WET Science Center, at LOTT's core operations hub in downtown Olympia, housed in a certified LEED platinum building. The science center is open to the public and houses interactive displays focused on the science and importance of clean water, wastewater treatment, reclaimed water, water conservation, and more.

LOTT partners with all three local school districts to incorporate WET field trips into the districts' formal science curriculum, connecting tens of thousands of local school children with water science, building a water-informed community for the future. "When we built this site, we wanted to come out from behind the fence and become part of the community," says Strub.

Co-located with the non-profit Hands On Children's Museum, hugely popular with local families, the first thing visitors see at the WET Center is a reflecting pond and fountain. Across the street, LOTT created a public plaza with a unique recreational water feature designed to mimic a natural stream. Both are fed by Class A Reclaimed Water. Bronze sculptures of salmon, crayfish, and otter encourage waders to explore the stream and get up close and personal with recycled water, reinforcing the message that this water is a safe, sustainable, and valuable resource.

LOTT is going further to invest in training young adults interested in technical careers with LOTT. Like virtually all infrastructure sectors, LOTT is facing a wave of retirements over the next decade without a ready pool of qualified professionals to fill the gap. Running a treatment plant requires specialized technical know-how that can take years to develop.

To counter this potential crisis, LOTT initiated a comprehensive knowledge management and succession planning program. One part ties back to education by including a focus on career options in LOTT's educational programming, encouraging young adults to view wastewater careers as the highly technical and rewarding jobs that they are.

LOTT's leaders are even considering a role as a learning center, what Strub only half-jokingly calls "LOTT University," to develop a broader pool of qualified professionals that can benefit other water utilities throughout the region.

Smart Spending: Checklist for Leadership

Strategically Invest in Infrastructure Jobs ~

Infrastructure spending and investment is a cornerstone of our economy, and building world-class, integrated infrastructure for the Pacific Northwest can create tens of thousands of quality jobs. In 2012, according to a Brookings study,[8] infrastructure jobs accounted for 11% of national employment. Infrastructure jobs can provide pathways out of poverty because barriers to entry tend to be low – only 12% of infrastructure workers have a bachelor's degree or higher, for example. These jobs offer better wages compared to other occupations, paying over 30% more to workers at lower ends of the income scale.

State and local policymakers should develop a jobs strategy centered on modernizing our infrastructure, building the next generation workforce, and harnessing economic development to bridge the urban-rural divide. Renewing our water systems is a key component of an infrastructure jobs agenda.

At the time of this writing, there is robust bipartisan discussion of new federal investment in infrastructure renewal. Details of a package that could be adopted, though, are not yet on the table. For Northwest communities and states, a pro-active strategy to modernize infrastructure should be more effective, compared to a passive, wait-and-see approach, at leveraging complementary federal funding under whatever new national infrastructure investment program may come.

Leverage Sustainable Water Infrastructure for Green Jobs

While the promise of green jobs has largely focused on clean energy, the transition to sustainable water infrastructure provides large opportunities to create green jobs as well. Pacific Institute has identified 136 occupations that can grow with this transition.[9] The possibilities for new employment are broad ranging, from retrofitting buildings and landscapes for water efficiency, to creating green infrastructure for stormwater management, to building and maintaining systems that capture and reuse rainwater on site, to environmental remediation.

"Water and decentralized water infrastructure create a whole other area for green jobs creation," says Kathleen Smith of the International Living Futures Institute. "These decentralized systems require more maintenance and continuous testing. That is an opportunity to create jobs with basic technical training. That's exciting to me because it intersects social justice and sustainability."

Infrastructure jobs are a pillar of the American economy, making up 10% of national employment. Investment in modernizing water infrastructure can be highly effective at creating jobs, not just in big cities but suburban and rural communities. (Uploaded to Flickr by World Bank Photo Collection (CC BY-NC-ND 2.0) https://creativecommons.org/licenses/by-nc-nd/2.0/legalcode.)

"How you actually install that green stuff can economically benefit disadvantaged communities," notes Bobby Cochran of Willamette Partnership. "You can do workforce development to help the high school kid in a small town or a disadvantaged urban neighborhood get on a path toward technical training, higher education and engineering."

People in rural and suburban communities stand to benefit, as well as urban, because investments in water sector green jobs are highly effective, Pacific Institute finds. An investment of $1 million in any of these opportunities produces:

- 10-15 jobs in alternative water supplies;
- 5-20 in stormwater management;
- 2-22 in urban conservation and efficiency;
- 14.6 in agricultural efficiency and quality; or
- 10-72 jobs in restoration and remediation.[10]

8 Beyond Shovel-Ready: The Extent and Impact of U.S. Infrastructure Jobs, Brookings, May 8, 2014.

9 Eli Moore et al, Sustainable Water Jobs: A National Assessment of Water-related Green Job Opportunities, Pacific Institute, Jan. 2013, p.4.

10 Ibid.

Smart Spending: Checklist for Leadership

Roger Gray, former General Manager of the Eugene Water and Electric Board, suggests that old and new infrastructure will exist side-by-side for many years, but even old job classes are getting more high tech. "A water treatment plant operator requires eight years of training. You might call it a trade-type job, but it requires the equivalent of four years of college and a lot of technical training on top of that," says Gray. "More and more jobs have to be computer literate on top of their historic capabilities; I think it's an opportunity for education and industry to work together." More technical and vocational training will be needed, he argues. "We need some big thinking around that."

Strategies to Bridge the Urban-Rural Divide

The gap between urban and rural America has never seemed greater. Cultural divergences and battles over natural resources, including water, have set up tall barriers. But urban water utilities have profound interests in watershed health, from local river and stream systems to high-mountain headwaters, connecting them to rural communities and drawing their water infrastructure dollars upstream onto rural landscapes.

Green infrastructure investments in the rural landscape provide new revenues for landowners and public lands agencies, and employment for natural resource workers in small towns that have long suffered high unemployment rates. The more that water utilities can re-gear investments to include gray and green infrastructure upgrades throughout the broader watershed, beyond their service boundaries, the more urban and rural people will join in common interest.

Another example ripe for state and federal infrastructure funding: irrigation modernization. Most water used in Oregon and Washington goes to irrigate crops, and tremendous efficiencies are possible. Summer streamflows for fish and hydropower will become increasingly stressed as warmer temperatures eat into mountain snowpack. Modernized irrigation technologies that use water much more precisely can help the region conserve water, while cutting operating costs and boosting profits for farmers and their irrigation districts. Fish screen technology developed by the Hood River Irrigation District can increase low-impact hydroelectricity production, while benefiting fish. Because of the multiple economic and environmental benefits, irrigation modernization is an ideal goal for pooling local, state, federal and private funds.

Workforce development efforts should focus opportunities for pathways out of poverty through water sector green jobs. Utilities need to be local community catalysts, working with local institutions such as high schools, community colleges, and union apprenticeship programs to develop the pipeline for green jobs in water. The combined opportunity for environmental and social benefit is great, but will require strong leadership to achieve.

Bring on the Next Generation of Leaders

As with other utility sectors, an aging workforce is opening the door to a new generation of utility leadership. Notes Liz Kelly, "The new generation workforce is much more accustomed to smart technologies and will have more of an expectation of smart, integrated decision-making. So as the old-school decision-makers retire out – that's a driver and an opportunity."

"We are seeing the beginnings of a changing of the guard, a new generation of decision-makers," says Kimery Wiltshire. "We're definitely seeing more women and people of color. But it does tend to be engineers, rather than people that are good at rethinking the business culture and decision-making approaches."

Michael Sanio points to change in engineering culture itself, beginning with his organization, the American Society of Civil Engineers. "We decided we're really going to work to help engineers be leaders in their communities. We're encouraging engineers to become part of the political process, to be involved at the local level, so that they understand the constraints, but can also influence in a positive way the design, construction and operation of infrastructure for the benefit of the community. Engineers can look at things system-wide in a way the general public may not see."

"Engineers must engage earlier, at the 'big picture' stage of planning processes, rather than after projects have been scoped," says Sanio. "In 2040, engineers will be advocates to help communities develop the future that they envision. And engineers will be trained and rewarded to do just that," he says. "By 2040, you will routinely have the various disciplines working together in a collaborative way for the best interest of the community."

At the same time utilities need to hire engineers with big picture advocacy skill sets, they also need to bring in people trained in other disciplines important to investment decision-making and reforming business practices and culture. Scott Haskins of CH2M sees, "a movement away from relying so exclusively on engineers, and toward a greater role for public administration, scientists, urban planners, and community engagement specialists, as well as technical and skilled trades."

Conclusion

We face great challenges. Big and important infrastructure assets – water supply, wastewater treatment, and flood control facilities – built several decades ago, are overdue for replacement. Already, Northwest water utilities spend several billion dollars a year, and more will be required to modernize crumbling systems. But many Northwest families and communities are stressed economically, and in poor position to afford higher utility bills.

The civil engineer's playbook of the 20th century is dialed into large centralized facilities, sized based on the core assumption of stationary climate. But the hydrologic cycle in the 21st century is now unstable, due to global climate change. That means our water systems, mostly sized based on historical records, are vulnerable to big storms and drought. As a hotspot for seismic activity, Pacific Northwest water infrastructure is also dangerously vulnerable to major earthquakes.

The risks are serious, because water services are so important to people's lives and to the economy.

But we also face great opportunities. The Pacific Northwest can become a global leader in 21st century water infrastructure by embracing a new investment discipline to guide the billions of dollars we spend each year.

Every time that Northwest infrastructure providers develop long-range plans, decide capital budgets, configure projects, and design solutions, it represents an opportunity to optimize community return-on-investment. Each investment can make progress toward systems that are locally affordable, more resilient, protective of the natural environment, and beneficial to the community.

Bold, strategic leadership and smart planning are required from water utilities, agencies, policymakers, and their community partners for the Northwest to become a world leader in innovation. A new portfolio of water infrastructure solutions is expanding the choices available, opening exciting new opportunities for innovation. Many of these new approaches save money for the local utility, but also offer multiple benefits for health, environment, prosperity, and community.

Those co-benefits are valuable and a range of other agencies and industries are seeking cost-effective opportunities to 'buy' these benefits. Building cost-share partnerships that enable them to co-invest in projects and programs will be one of the key challenges and opportunities for the Northwest to realize the 2040 vision presented in this report.

Another key opportunity is to leverage the billions of dollars in infrastructure spending for jobs and economic development. The economic opportunities span urban, suburban, and rural communities, and so can be supported by conservatives and progressives alike.

People matter. A vision for world-class water infrastructure in the Northwest is exciting. It can inspire and attract a new generation of workers and innovators to the field, talented people whose dedicated work will be essential to turning vision into reality across Northwest watersheds and communities.

Photo: Dockside Green, a mixed-use neighborhood in Victoria, B.C., treats its own sewage onsite and uses recycled water in toilets and for irrigation. (Uploaded to Flickr by jayscratch (CC BY-ND 2.0) https://creativecommons.org/licenses/by-nd/2.0/legalcode.)

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Our Infrastructure Future

I am deeply indebted to the many innovators, thought leaders, and experts who took valuable time from their busy schedules to patiently coach me on the intricacies and challenges of rethinking our water infrastructure investment strategies.

A Northwest Vision for 2040 Water Infrastructure *is the second in the Center for Sustainable Infrastructure's "Five Big Goals for 2040" series. The Five Big Goals reports build alignment around a vision for how our infrastructure systems will work in 2040, and show how we can rethink near-term investments to get where we want to go in the longer term.*

Infrastructure investments across our energy, water, transportation, and waste management systems add up to a generational legacy. This series offers a special opportunity to think forward 25 years and fully reimagine our infrastructure systems.

The key to achieving and evolving the 2040 vision is the innovative spirit and work of the Northwest's infrastructure decision-makers, leaders, advocates, and partners. My hope is these reports provide inspiration and guidance to both current and future Northwest innovation leaders.

— Rhys Roth

FIVE BIG GOALS FOR 2040

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