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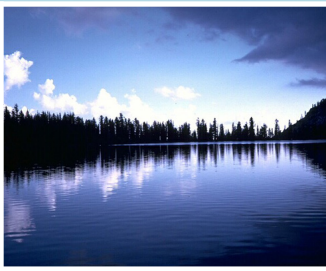

Promoting Technology Innovation for Clean and Safe Water

Water Technology Innovation Blueprint—Version 2

U.S. Environmental Protection Agency
Office of Water

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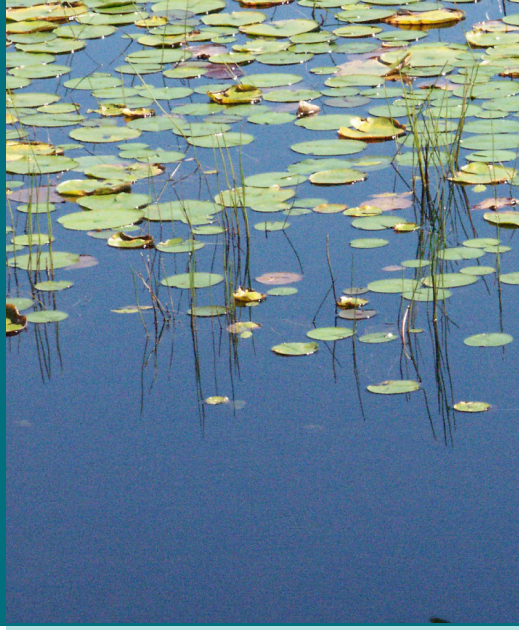
Contents



Overview

Our freshwater resources are limited and face mounting pressures from drought, flooding, pollution, population growth, and competition from many uses (e.g., ecosystem protection, drinking water, agriculture, energy production, recreation). Technology innovation can help address our water challenges and put us on a more sustainable path while supporting economic growth. The U.S. Environmental Protection Agency (EPA) aims to be a catalyst to promote and support technology innovation to protect and ensure the sustainability of our water resources.

On March 27, 2013, EPA's Office of Water issued the *Blueprint for Integrating Technology Innovation into the National Water Program,* which highlighted EPA's initial ideas and plans for advancing technology innovation across various water programs. This document expands on those ideas and frames the business case for water technology innovation; identifies "market opportunities" where technology innovation could help solve water challenges; provides examples of emerging innovation pioneers; identifies tools for assessing water risk; and frames a more robust set of actions that EPA will take to promote technology innovation for clean and safe water.

In the past year, EPA has widely communicated the goals and opportunities of the technology initiative, engaging a broad spectrum of partners and stakeholders. For example, Acting Assistant Administrator for Water Nancy Stoner has visited many innovation pioneers to raise awareness of very promising efforts to solve water resource challenges cheaper, faster and using less energy. Efforts to promote and foster technology innovation will continue to be dynamic and evolving.

For purposes of this document, technology innovation is defined as:

> *The development and deployment of new technologies and processes; new applications of existing technology; production changes; and organizational, management and cultural changes that can improve the condition and sustainability of our water resources.*

In short, this includes: (1) new technologies; (2) new management approaches (e.g., regional coordination); or (3) techniques that increase the efficiency of existing systems (e.g., sensors and controls).[1]

"Every American deserves clean and safe water; we will achieve that goal by supporting the advancement and use of innovative technologies to meet challenges and seize opportunities in the water sector."

—EPA Administrator Gina McCarthy

"Technology innovation can accelerate progress toward our goals of clean and safe water. EPA and many stakeholders will strive to support technology innovation to solve water resource problems… cheaper, faster and using less energy!"

—EPA Acting Assistant Administrator for Water Nancy Stoner

The Business Case for Technology Innovation for Water

> "Despite consistently growing public awareness and recognition, water continues to be under-appreciated and undervalued. We need fundamental change in the way we manage, utilize and view our finite water resources."
>
> —From the TechKNOWLEDGEy Strategy Group's *2013 Water Market Review: Growing Awareness, Growing Risks,* 2013[2]

Clean and safe water is essential for public health and healthy ecosystems, for the nation's economic well-being, and for the welfare of our families and communities. In the United States, a significant amount of water is used every day. For example, in 2005 almost 330 billion gallons of freshwater was withdrawn for use:

- 29.4 billion gallons per day was withdrawn for domestic use.
- 19.2 billion gallons per day was withdrawn for industrial and mining use.
- 138.8 billion gallons per day was withdrawn for use in farming (including agricultural and horticultural irrigation, livestock, and aquaculture).
- 142 billion gallons per day was withdrawn to produce energy in thermoelectric power plants.[3]

Water, uses of water resources, and the services to provide clean water play a significant role in economies around the world. For example, the value of the global water market—control and cleanup of water—is estimated at $500 billion per year.[4] Many aspects of the U.S. economy also depend on large supplies of water:

- In 2012, the total revenue for the domestic U.S. water and wastewater industry was $139 billion.[5]
- In 2011, 44 million anglers spent $48 billion to fish in U.S. waters.[6]
- In 2007, irrigated crops accounted for 55 percent of the total value of U.S. crops.[7]
- In 1999, the beverage industry used 12 billion gallons of water to produce $58 billion worth of products.[8]

Water Resource Challenges in the United States and Globally

Water resources in the United States and globally are facing many challenges—both in quality and quantity—due to a number of growing issues, such as population growth, development and climate change. Innovative technologies offer the promise to address these challenges more cost-effectively and expeditiously.

Water Scarcity: Aquifers are being depleted at a much higher rate than natural precipitation and ground water recharge is refilling them. As of February 2014, over 36 percent of the continental U.S. is experiencing moderate to severe drought conditions.[9] A fifth of the world's people, more than 1.2 billion, live in areas of physical water scarcity.[10] Some predict that half of the world's population will live with chronic water shortages by the year 2050.[11]

Water Quality: Many of the nation's coastal waters, estuaries, rivers, streams and lakes remain impaired as a result of pollution and/or physical alterations. For example, according to the 2008–2009 EPA National Rivers and Streams Assessment (NRSA), 55 percent of the nation's river and stream miles do not support healthy populations of aquatic life, with phosphorus and nitrogen pollution being just one of the problems.[13] Increases in population and land development present additional challenges such as increased stormwater runoff from impervious surfaces. Declining source water quality poses challenges for conventional water treatment plants in meeting drinking water standards.

Aging Infrastructure: America's water and wastewater infrastructure is aging. The American Society of Civil Engineers gives the current water and wastewater

> "Water is an essential commodity: human life—and indeed all life on earth—depends upon it. Water is also a critical input to production in a number of economic sectors.…Every sector of the economy is influenced in some way by water."
>
> —From EPA's *The Importance of Water to the U.S. Economy Synthesis Report,* 2013[13]

infrastructure a grade of "D."[14] There are an estimated 240,000 water main breaks per year in the United States. Assuming every broken pipe needs replacing, the cost over the coming decades could exceed $1 trillion.[15] Wastewater systems experience approximately 75,000 sanitary sewer overflows annually, discharging 3 to 10 billion gallons of untreated wastewater, leading to some 5,500 illnesses due to exposures to contaminated recreational waters.[16] Estimates of costs for wastewater and stormwater needs exceed $298 billion,[17] while drinking water needs exceed $384 billion[18] over the next 20 years.

Climate Change Impacts: Climate change is exacerbating the challenge of protecting water resources, ecosystems and our water infrastructure. According to the EPA *National Water Program 2012 Strategy: Response to Climate Change,* the negative impacts on water resources take a variety of forms. Warmer air, warmer water and changes in precipitation patterns increase water pollution problems. More extreme weather events (e.g., flooding) can have devastating impacts on water and wastewater infrastructure and aquatic systems. Rising sea levels will alter ocean and estuarine shorelines, and the increased frequency, severity and duration of drought will affect public water supply, agriculture, industry and energy production uses. Warmer water and changing flows alter aquatic biology. Many, or all, of these things combine to change the availability of drinking water.[19]

> "During the next 10 years, many countries important to the United States will experience water problems—shortages, poor water quality, or floods—that will risk instability and state failure, increase regional tensions, and distract them from working with the United States on important US policy objectives."
>
> —From the National Intelligence Council's *Global Water Security,* 2012[20]

Access to Water and Sanitation: About 783 million people worldwide do not have reasonable access to clean and safe water for consumption, and about 2.5 billion do not have access to basic sanitation.[21]

Tools to Assess Water Supply Risk and Vulnerability

A variety of tools has been developed for use by companies, utilities, planners and others to assess current and future water risks. With a greater understanding of the risks, these players then often seek technical or institutional innovation. Some examples of tools that address either water availability and/or water quality risks include:

> "In communities all around the world, water supplies are coming under increasing pressure as population growth, climate change, pollution, and changes in land use affect water quantity and quality."
>
> —From the National Academy of Sciences' *Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater,* 2012[22]

- **Global Water Tool (World Business Council for Sustainable Development)**—Designed for companies and organizations to map their water use and then assess risks relative to their global operations and supply chains.
- **Aqua Gauge (Ceres)**—A way for companies to assess, improve and communicate their corporate-wide water risk management approach.
- **Watersketch Toolbox (Finnish Environment Institute)**—Offers information and practical tools and methods for sustainable river basin planning and management.
- **Local Water Tool (GEMI)**—Intended for companies and organizations to evaluate the external impacts, business risks, opportunities and management plans related to water use and discharge at a specific site or operation.
- **CREAT, Climate Resilience Evaluation and Awareness Tool (EPA)**—Organizes available climate data and guides users through a process of identifying threats, vulnerable assets and adaptation options to reduce risk.
- **Aqueduct Water Risk Atlas (World Resources Institute)**—Intended for companies, investors, governments and communities to better understand where and how water risks are emerging around the world.
- **Sea Level Rise Tool For Sandy Recovery (NOAA)**—Provides a set of map services to help communities, residents, and other stakeholders consider risks from future sea level rise in planning for reconstruction following Hurricane Sandy.

An inventory of other water tools and their use, as well as other information, is available at http://water.epa.gov/infrastructure/watersecurity/techtools/index.cfm.

Market Opportunities for Technology and Institutional Innovation

Our water resource and sustainability issues represent market opportunities for technology and institutional innovation and to promote economic growth. Descriptions of the most pressing needs and promising opportunities are outlined below.

1. Conserving and Recovering Energy

Much of the country's water and wastewater infrastructure was constructed at a time when energy costs were low; therefore little was invested in energy efficiency or energy generation. Similarly, traditional agricultural practices could take advantage of opportunities for energy savings (e.g., more efficient drip irrigation systems) and nutrient recovery. Energy conservation and recovery in the water and agriculture sectors have significant promise:

- Approximately 2 percent of the nation's total energy consumption, (69.4 billion kilowatt-hours) is used for drinking water and wastewater treatment services.[23]
- Wastewater treatment plants have an estimated 400 megawatts (MW) of biogas-based electricity generating capacity and approximately 38,000 million Btu per day of thermal energy generating capacity.[24]
- AgSTAR estimates that there are 8,200 U.S. dairy and swine operations that could support biogas recovery systems, collectively able to generate more than 13 million MWh per year and displace about 1,670 MW of fossil-fuel-fired generation.[26]

> "The US has the potential to realize the benefits of advanced water and wastewater strategies on a national scale. Achieving this, however, will require engaging engineering, financial, and political leadership to crystallize an actionable national water agenda, strengthen the mechanisms that mitigate sector fragmentation and deliver a supportive policy framework."
>
> —From Ernst and Young's *The US Water Sector on the Verge of Transformation,* 2013[25]

▶ Technology Innovation Challenge and Aspiration:

Imagine a future when water, wastewater and agricultural activities can cost-effectively generate as much energy as they consume!

2. Recovering Nutrients

Excess nitrogen and phosphorus is one of the leading causes of water pollution across the nation.[27] Point sources (e.g., municipal wastewater treatment facilities,

Innovation Highlight: Utility Harnesses Hydropower

The Massachusetts Water Resources Authority (MWRA) harnesses energy via an in-line hydroelectric turbine and generator. The hydroelectric system extracts the kinetic energy of potable water as it travels down-gradient from the treatment plant to a network of tanks. MWRA's system has a capacity of 200 kilowatts, of which 25 percent is used onsite by the utility and 75 percent is exported back to the grid. More information can be found at http://www.mwra.state.ma.us/05energy/pdf/2012/011812-energystaffsummary.pdf.

Innovation Highlight: Dairy Farm Goes Energy Positive

Brubaker Farm, a 900-head dairy in Lancaster Country, Pennsylvania, captures methane from manure digestion and produces electricity to provide power to the farm and sell excess back to the grid, enough to power 150–200 homes. Waste heat from the generator heats water for the farm and is used to dry digested solids for bedding for cow comfort. More information can be found at http://www.usdairy.com/~/media/usd/public/brubakercasestudy.ashx.

Innovation Highlight: Utility Extracts Nutrients from Wastewater

The Hampton Roads Sanitation District (HRSD) Struvite Recovery Facility in Virginia recovers phosphorus from wastewater recycle streams. The recovered phosphorus is transformed at HRSD's Nansemond facility into a commercial fertilizer. More information can be found at http://www.ostara.com/sites/default/files/Ostara-Hampton-Roads-Case-Study.pdf.

concentrated animal feeding operations) and nonpoint sources (e.g., agricultural activities, urban stormwater runoff, septic systems) contribute to nutrient pollution of surface and ground water. Approximately 14,000 water bodies are affected by nutrient pollution throughout the United States.[28] Every state in the U.S. has nutrient-impaired waters that have the potential for serious health and ecological effects (e.g., harmful algal blooms, oxygen dead zones, unhealthy drinking water).[29]

Nutrient treatment and recovery technologies are being used at muncipal wastewater treatment plants, but implementation has been slow due to complexities in deployment, high energy use, and overall high costs. New techniques are needed to reduce and recover nutrients at substantially less cost and with a reduced carbon footprint.

► Technology Innovation Challenge and Aspiration:

Imagine if we could recover nutrients from human and animal wastes and convert them into marketable commodities before they negatively impact surface and ground water!

3. Improving and Greening of the Water Infrastructure

There is a critical need to rehabilitate the nation's water and wastewater infrastructure, the costs of which are estimated at $682 billion ($384 billion for drinking water infrastructure[30] and $298 billion for wastewater and stormwater infrastructure[31]). There is an expanding array of technologies and techniques available for assessing,

Innovation Highlight: The Greening of Our Cities

Philadelphia established the Green City Clean Waters program in 2010. The city has removed 10,000 square feet of impervious paving and has begun installation of green street blocks throughout the city. Sixteen green school projects have been completed and private businesses are now engaged in approximately 300 greening projects. The city also has an incentive program for stormwater billing that grants a nearly 100 percent credit for green retrofits. More information can be found at http://www.phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan.

Onondaga County and the city of Syracuse's "Save the Rain" campaign began in 2009 and is a comprehensive plan to clean up and restore Onondaga Lake and its tributaries, including a strong outreach effort to educate the general public on ways to lessen the overflow of sewage into Onondaga Lake. The program includes construction of innovative gray and green infrastructure, including the War Memorial Arena, with a 15,000-gallon cistern system, the first system in the country designed to use harvested rainwater for a hockey rink. One of the key elements of Save the Rain is transparency. Every project advanced through the program has a unique Web page where the public can review the project design elements, cost and stormwater capture objectives. More information can be found at http://savetherain.us/.

rehabilitating and retrofitting wastewater, drinking water and stormwater infrastructure.

Green infrastructure, referred to by some as blue-green infrastructure or natural Infrastructure, is based on the principles of natural systems to build or rebuild our infrastructure to achieve an array of objectives such as stormwater management, improved water reuse, climate adaptation and resilience, improved habitat and biodiversity, less heat stress, improved air quality, and greater aesthetic value.

► Technology Innovation Challenge and Aspiration:

Imagine if we could vastly expand the use of green and natural infrastructure to improve the nation's water infrastructure while also achieving a broad array of environmental, social and economic benefits by designing with nature in our urban environments!

4. Conserving and Eventually Reusing Water

Competition for water resources and diminished resources because of drought are driving the need for water conservation, efficiency, and reuse. In order to create a more sustainable water future, cities and states are encouraging water conservation as a way to reduce demand. Water reuse technologies have also been implemented in numerous locations in the United States and throughout the world. For example, Israel reuses 70 percent of its domestic wastewater.[32]

Innovation Highlight: The World's Largest Potable Reuse System

The Ground Water Replenishment System (GWRS), operated by the Orange County Water District, is the world's largest planned indirect potable reuse project. The system recycles treated wastewater from the Orange County Sanitation District using a three-step purification process to produce a near-distilled-quality water that exceeds all state and federal drinking water standards. Operational since January 2008, this state-of-the-art water purification project produces 70 million gallons per day, which is enough water to meet the needs of nearly 600,000 residents in north and central Orange County, California. Each day, approximately 35 million gallons of the GWRS water are pumped into injection wells to create a seawater intrusion barrier, and another 35 million gallons are pumped into the district's percolation basins in Anaheim, where the water naturally filters through sand and gravel to the deep aquifers of the ground water basin. More information can be found at: http://www.gwrsystem.com/the-process.html.

Innovation Resource: EPA WaterSense Program Saves Water

WaterSense, a partnership program by EPA, is helping to sustain and protect the nation's water supply by fostering the development and use of water-efficient products, new homes and services. WaterSense brings together a variety of stakeholders to promote the value of water efficiency, encourage innovation in manufacturing, and decrease water use and reduce strain on water resources and infrastructure. More information can be found at http://www.epa.gov/watersense/index.html.

In light of growing populations and climate change, conserving water can help communities meet future needs. Many technologies exist to help consumers save water in the home and office. In addition, with the need for water infrastructure upgrades and replacements estimated at hundreds of billions of dollars, technologies that help water utilities reduce water loss, fix leaks and prioritize main replacement not only improve water efficiency, but can also mitigate some portion of those costly infrastructure needs.

Technologies currently exist to provide treatment for varying levels of water reuse such as irrigation, industrial use, gray water applications, and indirect and direct potable reuse. There is a vast potential for additional technology development and application to conserve and reuse water resources. The nation's 15,000 municipal wastewater facilities discharge approximately 32 billion gallons of water every day.[33] Water reuse and repurposing can serve to reduce pressure on other sources of fresh water, such as ground water (which 44 percent of the population depends on for drinking water).[34]

▶ Technology Innovation Challenge and Aspiration:

Imagine if we could increase water reuse to support the water needs of our burgeoning population!

5. Reducing Costs and Improving Techniques for Water Monitoring

Newer monitoring technologies, such as improved water quality sensor technology, remote sensing and satellite imagery, hold opportunities to generate substantially more data at lower cost. New sensor technology coupled with improved telemetry and information technology can make data on water quantity and water quality available for a broader range of applications. Sensor and laboratory advances also provide opportunity for reducing the overall cost of water quality monitoring. New tools are being developed to store, communicate, analyze and visualize the vast data streams. Currently, less than 30 percent of the nation's surface water bodies are assessed by EPA, states or tribes, partly because of the high cost of traditional fixed-station water quality monitoring.

▶ Technology Innovation Challenge and Aspiration:

Imagine collaborative monitoring efforts that provide low-cost, watershed-scale, real-time data on water quality and quantity that facilitate protection and wise use of our water resources!

Innovation Highlight: Proliferation of Remote/Continuous Monitoring

The National Great Rivers Research and Education Center (NGRREC) is working to create a network of monitoring buoys for real-time, continuous water quality data on the Mississippi, Missouri and Illinois Rivers. More information can be found at http://www.ngrrec.org/.

Researchers at Clemson University are building the "Intelligent River" to provide real-time monitoring, analysis and management of water resources. More information can be found at http://www.clemson.edu/public/ecology/.

Wireless Waterway is a project commissioned by the Port of Pittsburgh that will use the latest monitoring and information technology to manage the water resources in real time so commerce and recreation along the Pittsburgh Waterfront are easier for everyone. More information can be found at https://www.wirelesswaterways.com/.

The Jefferson Project is a collaborative effort between Rensselaer Polytechnic Institute, IBM and the FUND for Lake George (New York) to develop a lake environmental monitoring and prediction system to provide a real-time understanding of lake health. More information can be found at http://fundforlakegeorge.org/solutions/the-jefferson-project.

The Hudson River Environmental Conditions Observing System (HRECOS) is a network of real-time monitoring stations on the Hudson River Estuary. HRECOS is a collaborative effort between multiple agencies, including the New York State Department of Environmental Conservation, USGS and NOAA, among others. More information can be found at http://www.hrecos.org.

The River and Estuary Observatory Network (REON) is an effort between Clarkson University's Beacon Institute for Rivers and Estuaries and IBM to use real-time monitoring technologies to better understand the Hudson River ecosystem from the headwaters in the Adirondack Mountains to the ocean. More information can be found at http://www.bire.org/river-and-estuary-observatory-network/.

6. Improving Performance of Small Drinking Water Systems

Small drinking water systems consistently provide safe, reliable drinking water to their customers; however, many small systems also face a number of challenges:

- Over 94 percent of the more than 156,000 public water supply systems are small, each serving fewer than 10,000 people.[35]
- In its fifth report to Congress in 2011, EPA identified a total infrastructure need of $64.5 billion for small drinking water systems throughout the country.[36]
- Very small drinking water treatment systems (serving fewer than 500 people) have the highest percentage of health-based violations of all system sizes (74 percent).[37]

A 2006 report from EPA's Inspector General[38] identified these challenges as: (1) lack of financial resources, (2) aging infrastructure, (3) difficulties obtaining financial assistance, (4) cost of scale, (5) management limitations, (6) lack of long-term planning, (7) system operator issues, and (8) challenges with understanding and/or compliance with regulations.

Innovation Highlight: Use of Gray Water as Makeup for Cooling Towers

The Public Service Enterprise Group's Linden Generating Station does not currently employ a cooling water intake structure. Instead, the Linden Generating Station uses reclaimed wastewater from the nearby Linden Roselle Sewerage Authority (LRSA) for all its cooling water needs. Approximately 4 of the 11 million gallons per day of treated wastewater from LRSA is pumped to the Linden Generating Station. After being used for cooling, any remaining water (e.g., cooling tower blowdown) is pumped back to LRSA for treatment again. More information can be found at http://www.pseg.com/info/environment/ps_caring.jsp.

▶ Technology Innovation Challenge and Aspiration:

Imagine the deployment of new cost-effective and affordable technologies that substantially improve the technical and financial capacity of small drinking water systems!

Innovation Resource: National Center for Innovation

The EPA Office of Research and Development (ORD) recently sought applications to establish a National Center for Innovation in Small Drinking Water Systems. The Center will research and develop innovative and sustainable technologies and approaches to improve the sustainability of small systems. More information can be found at http://www.epa.gov/ncer/rfa/2013/2013_star_drinkingwater.html.

Innovation Resource: CREAT—A Tool for Improving Resiliency

EPA has developed the Climate Resilience Evaluation and Awareness Tool (CREAT), a software tool to assist drinking water and wastewater utility owners and operators in understanding potential climate change threats and in assessing the related risks at their individual utilities. CREAT provides users with access to the most recent national assessment of climate change impacts for use in considering how these changes will impact utility operations and missions. CREAT allows users to evaluate potential impacts of climate change on their utility and to evaluate adaptation options to address these impacts using both traditional risk assessment and scenario-based decision-making. More information can be found at http://water.epa.gov/infrastructure/watersecurity/climate/creat.cfm.

7. Reducing Water Impacts from Energy Production

Vast amounts of water are used each year for energy production in the United States. A considerable amount of water is used to cool thermoelectric power plants, grow feedstock and produce biofuels, and extract oil, coal and natural gas. Further, the polluted water discharges from energy production poses difficult challenges for effective management.

Opportunities exist for innovative solutions to not only alleviate the potential water quality impacts from energy production activities, but also provide for more efficient and cost-effective energy production. For example, beneficial reuse of produced water may be an attractive opportunity for oil and gas production wells located in water-scarce regions, where limited freshwater resources exist and the potential costs for produced water discharge are high.

▶ Technology Innovation Challenge and Aspiration:

Imagine the United States continuing its journey toward securing energy independence without threat to surface or ground water quality and quantity!

8. Improving Resiliency of Water Infrastructure to the Impacts of Climate Change

In 2012, Super Storm Sandy affected approximately 60 million people and caused approximately $50 billion in damage, primarily across the Northeast. Affecting

Innovation Highlight: Adapting to Climate Change and Water Reuse

The Emerald Coast Utilities Authority (ECUA) saw its Main Street Wastewater Treatment Plant inundated by Hurricane Ivan in 2004. With the help of funding from FEMA and other sources, the treatment plant was replaced and located outside the city of Pensacola and away from the coastal plain. The Central Water Reclamation Facility was rebuilt using treatment technology that can enable the reuse of 100 percent of the nearly 22.5 million gallons per day (average flow) treated at the facility. More information can be found at http://www.ecua.fl.gov/services/wastewater-services.

Innovation Highlight: Reinventing the Toilet

The Bill and Melinda Gates Foundation challenged universities to design toilets that capture and process human waste without piped water, sewer or electrical connections, while capturing useful resources. The Foundation's Water Sanitation and Hygiene Program strives to spur change to improve worldwide drinking water while reducing sanitation-related problems. More information can be found at http://www.gatesfoundation.org/What-We-Do/Global-Development/Water-Sanitation-and-Hygiene.

Innovation Highlight: Using Roleplaying to Manage Watersheds

The University of Virginia (UVA) Bay Game is a computerized simulation based on the Chesapeake Bay watershed. The watershed simulation allows players to take the roles of stakeholders, such as farmers, developers, watermen and local policy-makers, and make decisions about their watershed. More information can be found at http://www.virginia.edu/vpr/sustain/BayGame/about/.

more than 690 drinking water and wastewater utilities, it showed how vulnerable our water infrastructure can be to extreme weather/climate events. With almost $600 million of funding provided by Congress, EPA is working with the states of New York and New Jersey to build new, more resilient infrastructure.

On November 1, 2013, President Obama issued an executive order that prompts actions to enhance the nation's preparedness and resilience to extreme events and climate change. The increasing occurrence of extreme events, such as floods, drought and storm surge, underscores the need to utilize new technologies for planning how and where to rebuild existing or build new infrastructure with greater resiliency.

▶ Technology Innovation Challenge and Aspiration:

Imagine if we could protect our water infrastructure from the effects of extreme weather and climate change!

9. Improving Access to Safe Drinking Water and Sanitation

Despite technological advances on many fronts, hundreds of millions of people worldwide still lack access to the most basic of needs—clean drinking water and sanitation facilities.

- In 2011, approximately 768 million people worldwide (more than twice the population of the United States) relied on unimproved drinking water sources with significant threats of contamination.[39]
- At the end of 2011, 2.5 billion people worldwide lacked access to improved sanitation facilities[40] and more people had a mobile-cellular phone subscription than a toilet.[41]

▶ Technology Innovation Challenge and Aspiration:

Imagine if access to safe drinking water and sanitation practices—basic human needs—were no longer responsible for deaths and illness worldwide!

10. Improving Water Quality of Our Oceans, Estuaries and Watersheds

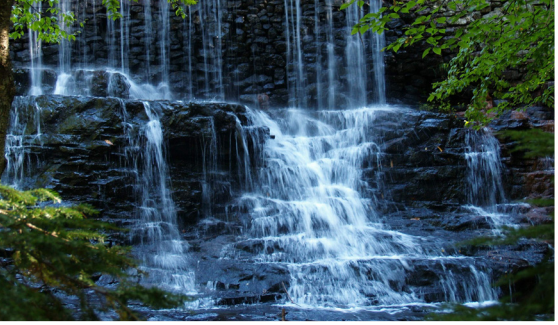
Less than half of the nation's lakes, rivers, streams and coastlines achieve a level of quality to safely allow for their intended uses (e.g., potable water supply, ecosystem protection, swimming, fishing). Similarly, ocean waters and the nation's ground water are also vulnerable to pollution and experiencing impacts from anthropogenic sources.

Because watersheds are defined by natural hydrology, they represent a logical basis for managing water resources. Assessments at watershed levels allow for efficient identification of the types of stressors that affect a watershed, as well as the controls and actions required to protect or restore the water resource.

Innovation in approaches, tools and techniques that can be used to improve and maintain the health of our nation's waters can drastically help address point and nonpoint sources of pollution, help rebuild ecosystems, restore waters, and address threats from invasive species and other impacts.

▶ Technology Innovation Challenge and Aspiration:

Imagine a holistic, integrated watershed-based approach to water quality and water quantity management, which maximizes ecosystem restoration!



Putting It All Together: Achieving Water Sustainability

It is difficult to envision sustainable solutions to our water challenges without technological innovations, such as the distinct opportunities identified above. While these water resource challenges and market opportunities are framed as individual pursuits, ideally, many of these can be achieved in an integrated manner. So, for example, in the case of a traditional municipal wastewater treatment facility, imagine a utility that generates energy; captures nutrients for resource recovery; sells their water for reuse; generates half the volume of biosolids; emits substantially less greenhouse gases; uses green and natural infrastructure to manage stormwater, mitigate climate impacts and provide aesthetic cityscape benefits; and contributes to a comprehensive watershed monitoring program in partnership with a diverse set of partners. Just imagine if we put all of the pieces together!

> "Business has a critical role to play in applying its expertise and experience in developing, implementing and scaling-up, through partnerships, watershed focused solutions."
>
> —From WBCSD's *Sharing Water: Engaging Business,* 2009.[42]

A Path Forward: Actions to Promote Technology Innovation

Our water resource and sustainability issues present significant market opportunities for new technology, new thinking and enhanced economic growth. EPA will be a positive contributor with utilities, industry, investors and entrepreneurs to support technology innovation for clean and safe water. Below are example actions EPA will take to support our common quest for water sustainability.

Advocate for Technology Innovation

EPA's National Water Program will be an active advocate for technology innovation.

- The National Water Program will ensure that this issue is a "front and center" topic with our regions and state partners. EPA's National Water Meeting with the regions and states will include a focus on technology innovation and ways the program can foster innovation.
- In April 2012, EPA released its *Technology Innovation for Environmental and Economic Progress: An EPA Roadmap* report (http://www2.epa.gov/envirofinance/innovation). The Roadmap sets out a vision for technology innovation and outlines support strategies for technology development and deployment. The Office of Water will be an active advocate and participant on the Agency Technology Innovation Network.
- The Office of Water will maintain a network list of key EPA innovation contacts (both at headquarters and in regional offices) for each of the market opportunity areas to foster collaboration and coordination within EPA and externally.
- The Office of Water will continue to work with the Office of Research and Development on a number of technology-innovation-related programs and initiatives, including implementation of the Safe and Sustainable Water Research Strategy. For example, the Office of Water will support implementation of the "Nitrogen and Co-pollutant Research Roadmap" to review the Agency's current nutrient research, assess gaps, and prioritize future research directions to reduce nutrient pollution nationwide.
- The Office of Water will support the regional water technology innovation clusters in their efforts to promote technology innovation, including efforts to verify emerging technologies, research and pilot promising technologies, and provide awards to encourage innovation. More information about the exciting efforts of the regional technology clusters can be found at http://www2.epa.gov/clusters-program.

Communicate Actions and Successes

The Office of Water will showcase and celebrate examples of technology innovation aimed at highlighting or solving water resource issues through a website focused on water innovations. The Administrator, Deputy Administrator and other senior leadership within EPA will continue to showcase examples on innovation successes through site visits across the United States.

Create the Regulatory Space to Foster Technology Innovation

There are many barriers to innovation that are often cited (e.g., institutional, cultural, financial, regulatory). EPA will consider ways in which its regulatory activities can reduce barriers to, or encourage incentives for, technology innovation. Following are example actions that EPA will take, in cooperation with our EPA region and state partners:

- Update the Effluent Limitations Guidelines and Standards Program to more explicitly consider sustainable and innovative technologies when developing national standards for controlling water discharges. Stepping back and asking a broad set of questions about the best available technology might include consideration of energy use, sludge generation and disposal, process changes or green chemistry alternatives, water conservation and reuse opportunities, and byproduct and pollutant recovery prospects.
- Explore ways in which NPDES permits could be tailored to foster technology innovation within existing legal

and regulatory authorities. Examples of permitting innovation might include watershed-based permitting, opportunities to foster process optimization or use of existing excess treatment capacity, derivation of long-term average limits for nutrients, opportunities to explore alternative technologies and performance testing of those technologies, or implementation of integrated planning as outlined in the Stoner-Giles memo of June 5, 2012.[43]

- Provide technical support to overcome barriers and allow for the use of innovative technology (e.g., ways to advance "Utility of the Future" concepts). This might include considering energy, carbon sources, greenhouse gas generation, and water and biosolids reuse in a holistic, systems approach.
- Continue to foster and promote consideration and use of green and natural infrastructure to achieve a broad set of environmental, social and economic objectives.
- Participate and contribute to efforts by external parties such as the Water Environment Federation, American Water Works Association and others to explore regulatory and/or policy strategies to identify and overcome barriers to the acceptance of innovative and new technology.
- Continue to collaborate with the Department of Commerce under the Environment and Technology Working Group and Environmental Trade and Technology Advisory Committee in promoting technology-based policies internationally, as well as promoting the environmental technologies exporters' online portal (https://new.export.gov/envirotech/toolkit).

Support for Speeding Delivery of Proven Technologies

The Office of Water will examine ways to address the ongoing challenges expressed by technology developers for bringing new technologies to market. Technology providers face a complex system of state and local requirements that can discourage acceptance, adoption and use of new technologies. For example, by engaging and supporting independent third-party technology evaluation efforts, EPA aims to continue to help bridge the gap between technology development and implementation for water-related technologies. EPA's Office of Water will:

- Evaluate the opportunities to support the growing demand for technology assessment and performance demonstration/verification of a spectrum of water-related technologies (e.g., independent third party).
  - Participate in development of the Water Environment Federation (WEF) and Water Environment Research Federation (WERF) Leaders Innovation Forum for Technology, (LIFT), WEF's Stormwater Testing and Evaluation for Products and Practices (STEPP) workgroup, and other promising technology evaluation efforts.
  - Coordinate with other domestic and international efforts, including:
    - The Interstate Technology and Regulatory Council (ITRC), a state-led coalition working to advance the use of innovative environmental technologies and approaches.
    - The Water Research Foundation (WRF) has partnered with Isle Inc., an independent consultancy that

Innovation Highlight: Third Party Technology Evaluation

The Water Environment Federation and Water Environment Research Foundation have established LIFT (Leaders Innovation Forum for Technology), a program designed to enable technology evaluations for municipal and industry end-users to share the cost of conducting demonstrations to accelerate adoption of new and innovative technologies. More information can be found at http://www.werf.org/lift.

Innovation Highlight: High-Efficiency Ultraviolet Disinfection System

Several drinking water utilities, together with the Water Research Foundation, are working to pilot a high-efficiency UV system. The UV system uses a highly reflective chamber with claims of over 99 percent reflectance of 254 nm UV generated. The low-pressure UV system will be compared to the existing medium-pressure UV system at the water treatment plant. The research will evaluate the reliability and effectiveness of the technology for Cryptosporidium inactivation, maintenance requirements, and operation and maintenance costs.

Innovation Resource: Potential Funding Opportunities to Support Technology Innovation

There are a number of potential funding and other resources available to assist in the research and development of innovative solutions to water-resource-oriented issues and challenges. Examples include:

Small Business Innovation Research Program (SBIR)—SBIR encourages domestic small businesses to engage in research that has the potential for commercialization. Through a competitive awards-based program, SBIR enables small businesses to develop, and take to market, technologies that help EPA meet its mission of protecting human health and the environment."

Science to Achieve Results (STAR)—STAR is EPA's primary competitive grants program for funding extramural research in environmental science and engineering for universities and nonprofit organizations.

Small Business Technology Transfer (STTR)—STTR expands funding opportunities in the federal innovation R&D arena. Central to the program is expansion of the public/private sector partnership to include the joint venture opportunities for small businesses and nonprofit research institutions.

Clean Water State Revolving Fund (CWSRF)—Under the CWSRF, EPA provides grants or "seed money" to states to capitalize state loan fund programs that provide low-interest-rate loans with flexible terms to fund water quality protection projects for wastewater treatment, nonpoint source pollution control, and watershed and estuary management.

Strategic Environmental Research and Development Program (SERDP)—SERDP is the Department of Defense's (DOD's) environmental science and technology program, planned and executed in partnership with DOE and EPA, that issues an annual solicitation for proposals from the federal government, academia and industry.

Environmental Security Technology Certification Program (ESTCP)—ESTCP provides funding for the demonstration of environmental technologies pertinent to DOD priorities.

Conservation Innovation Grants (CIG)—CIG is a voluntary program intended to stimulate the development and adoption of innovative conservation approaches and technologies, awarding competitive grants to non-federal governmental or nongovernmental organizations, tribes or individuals.

Office of Energy Efficiency and Renewable Energy (EERE) Financial Assistance Programs—Through financial assistance, EERE provides funding for renewable energy and energy efficiency research and development.

Development Innovation Ventures (DIV)—DIV holds a quarterly grant competition for innovative ideas, pilots and tests them using cutting-edge analytical methods, and scales solutions that demonstrate widespread impact and cost-effectiveness.

Additional information related to funding opportunities can be found on the Office of Water Funding and Grants Web page at http://water.epa.gov/grants_funding/home.cfm.

accelerates the market uptake of emerging technologies by introducing them to potentially interested water utilities during the pre-commercial stages of development.

  - Continue to support efforts such as the Confluence Water Technology Innovation Cluster (http://watercluster.org/wordpress/), where state regulators with Ohio, Kentucky and Indiana recently signed a groundbreaking cooperative agreement that allows the Confluence to work with companies to complete testing that can be approved by all three states at once—dramatically speeding time to market.

- The Office of Water will support EPA's ongoing efforts and programs supporting the development and implementation of innovative water-related technologies, such as the Aging Water Infrastructure Research Program (http://www.epa.gov/awi/) and STAR grants, fellowships and research contracts under the Small Business Innovative Research Program (http://www.epa.gov/ncer/).

Facilitate Financing and Funding Opportunities

EPA recognizes the critical role that funding and financing play to support the development and implementation of technology. Examples of actions EPA's Office of Water will take include:

- Support innovative financing efforts for water, wastewater and stormwater, including green and natural infrastructure.

Innovation Highlight: Utility Goes Energy Positive

More than a decade ago, East Bay Municipal Utilities District (EBMUD) in California began accepting organic wastes from local food processors, food growers and livestock producers to better utilize the excess capacity in its existing anaerobic digesters. The result has been a doubling of biogas production. Along with the revenue generated from tipping fees, the increase in biogas production enabled EBMUD to fund a renewable energy system that generates more power than the facility needs. In 2012, EBMUD's wastewater treatment plant became the first in North America to be a net energy producer. More information can be found at http://www.ebmud.com/water-and-wastewater/environment/wastewater-energy.

Innovation Highlight: Reinventing Urban Water Infrastructure

ReNUWIt is a multi-institution research center for re-inventing the nation's urban water infrastructure, focusing on safe, sustainable urban water infrastructures enabled by technological advances in natural and engineered systems, and informed by a deeper understanding of institutional frameworks. The research center works in close partnership with utilities, water service providers, equipment manufacturers and international research partners to convert great ideas into practical and sustainable solutions. More information can be found at http://renuwit.org/.

- Consider funding of innovative projects that address virus and multiple contaminant treatment at very small drinking water systems.
- Promote public-private partnerships for meeting infrastructure needs.
- Support innovative financing efforts for water, wastewater and stormwater, including green infrastructure. Special consideration will be made for funding of innovative projects that address virus and multiple contaminant treatment at very small drinking water systems.

Partner and Leverage Action with Others

EPA will support a broad spectrum of partners who have a critical role in fostering technology innovation, including, for example:

- **Partner with States and Tribes:** The EPA Office of Water will work closely with our state and tribal partners on steps to foster technology innovation, including ways to offer regulatory flexibilities for innovation and reciprocity for technology assessment and verification.
- **Partner with Other Federal Agencies:** EPA will work with other federal agencies to leverage resources to support innovative technology. For example, EPA is partnering with the Department of Energy to leverage opportunities to advance innovation in the water-energy nexus space.
- **Support Partnership Agreements and Memoranda of Understanding (MOUs) for Innovation:** The EPA has the ability to enter into partnership agreements and MOUs that foster innovation. As an example, EPA joined the Partnership on Technology Innovation and the Environment in 2012 to accelerate the development, adoption, deployment and export of technologies that protect health and the environment while growing the economy and creating jobs.[44] Also, EPA has recently established an MOU with Imagine H2O to identify and foster innovative water technologies that show promise, if implemented, in developing sustainable water supplies and watersheds.[45]
- **Support Water Technology Innovation Clusters:** EPA's Office of Research and Development has the lead for supporting and networking with other water technology clusters. EPA's National Water Program will also remain active and help communicate the efforts and accomplishments of the clusters and work in collaboration with research and the cluster leaders.
- **Assess the Science of Remote Sensors and Emerging Watershed Monitoring Networks:** EPA will work with the U.S. Geological Survey, NASA and other partners to assess the state of the science of remote sensors and remote sensing technology and the capability of emerging watershed-based monitoring networks to provide real-time water information.

- **Promote Integrated Watershed Monitoring Networks:** The EPA Office of Water will explore partnerships with the business community, watershed groups and others to build water quality and water quantity monitoring data systems to organize information on and characterize on a watershed scale.
- **Contribute to Third Party Dialogues:** External partners have played a crucial role in convening discussions among a broad range of stakeholder groups to explore and pursue different aspects of water technology and sustainability. For example, as part of their Charting New Waters Initiative, the Johnson Foundation at Wingspread has convened key experts on several emerging water issues. EPA will actively engage in these kinds of progressive dialogues that include balanced and diverse representation.
- **Support Export Programs and Increase Demand and Market Opportunities for U.S. Technologies and Services:** EPA with other federal agencies (e.g., Department of Commerce and the U.S. Trade Development Agency) will continue to advance economic development in partner countries by providing technical assistance and capacity building that supports legal and regulatory reform related to commercial activities and infrastructure development, establishing industry standards, and participating in other market-opening activities. These technical assistance programs facilitate favorable business and trade environments for U.S. goods and services.

Support Research, Development, and Demonstration Projects

The EPA Office of Water will continue to support research, development and deployment of technologies to support and address the water challenges articulated above. The EPA Office of Water will also support continued grants to early stage companies through its own and through Small Business Innovation Research.

A Cross Section of Views and Actions About Innovation in the Water Sphere

Since the release of the March 2013 "Blueprint," EPA has continued to engage with a broad cross section of utility, business, investment, and academic leaders and practitioners to understand the dynamics and opportunities that restrain or foster the pursuit of technology innovation. We clearly recognize that there are direct roles and activities that EPA's National Water Program can engage in. Just as importantly, there are crucial roles that others can take, including states, utilities, the private sector, NGOs and citizens. The following is a short sampling of examples and perspectives from various sources on the technology innovation landscape that have helped to shape this document and inform the actions that EPA will take. These are just examples.

- **American Water Summit—Accelerating Change:** On November 5–6, 2013, over 300 attendees representing diverse interests including public and private utilities, finance and investors, consultants, and others participated in discussions related to driving performance, promoting the value of water, creating new financial models and incentives for investment, and recognizing water as a driver for economic growth.
- **Water Environment Federation (WEF) CEO Roundtable (2012):** On October 1, 2012, WEF convened a discussion with 16 CEOs and then Administrator Lisa Jackson and Acting Water Assistant Administrator Nancy Stoner. They identified four key needs for innovation: (1) promoting public-private partnerships, (2) technology evaluation and sharing of performance data, (3) willingness among regulatory agencies and utilities to take greater risks to support pursuit of innovation, and (4) better communication and education of the public.
- **Utility of the Future:** In 2013, the National Association of Clean Water Agencies (NACWA), in collaboration with the Water Environment Research Foundation (WERF) and WEF, released *The Water Resources Utility of the Future…A Blueprint for Action.* Among other things, these organizations have fundamentally redefined the business case and role for the traditional "wastewater treatment utility" to one that emphasizes resource recovery (water, nutrients and energy).
- **U.S. Water Alliance:** The U.S. Water Alliance has been a key catalyst for fostering and demonstrating innovation and water sustainability through their annual "One Water Leadership Summit" and "U.S. Water Prize." Their quest for a national water vision with "one water" at its core has led to roundtables and workshops among diverse stakeholders and decision-makers, emphasizing the value of water and the urgency of integration and leadership at multiple levels
- **U.S. and World Business Council:** The U.S. and World Business Council for Sustainable Development (USBCSD and WBCSD) have been key innovation catalysts in the business community. They have convened critical dialogues and issued key papers (i.e., "Water: Facts and Trends," "Water Valuation, Building the Business Case," and "Sharing Water: Engaging Business") that encourage businesses to engage in water valuation practices and become involved in the equation of healthy watershed management.
- **The Water Research Foundation** published *Water Quality Impacts of Extreme Weather-Related Events* in 2014. Based on actual utility case-studies, the report outlines actionable steps water utilities can take to prepare for changing weather patterns.
- **The American Water Works Association,** in its 2013 *State of the Water Industry Report,* highlights the challenges and opportunities faced by the water sector as assessed by experts at utilities, in government and among manufacturers.
- **Regional Technology Clusters:** Regional water technology innovation clusters exist in various locations across the United States (and internationally). They include interconnected firms, supporting institutions, local governments, business chambers, universities, investors and others that work together in a particular geographic area to promote economic growth and technological innovation. Clusters foster collaboration between many different groups and provide a variety of advantages in developing innovative technologies that build on the geographic area's strengths and interests. Several formal and emerging clusters exist. More information can be found at http://www2.epa.gov/clusters-program.

For More Information

Please visit http://www2.epa.gov/innovation/watertech for more information about technology innovation in the water sphere and for an electronic version of this document.

EPA welcomes discussion, comments and feedback. Comments can be directed to Jeff Lape, Deputy Director, Office of Science and Technology, Office of Water, U.S. EPA, MC-4301T, 1200 Pennsylvania Avenue, Washington DC 20460. Jeff's email is lape.jeff@epa.gov and his phone is (202) 566-0480.

"Innovative technology can play a significant role in solving many of the water-related problems facing the U.S. and also providing opportunities for economic development. The preponderance of evidence demonstrates that environmental protection and economic progress go hand-in-hand. President Obama said that the U.S. will win the future by out educating, out innovating, and out building competitors."

—From EPA's *Fiscal Year 2014 National Water Program Guidance,* 2013

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